Integrating Military Unmanned Aircraft into the National Airspace System: An Application of Value-Focused Thinking and Enterprise Architecting

by

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ABSTRACT

The research presented in this thesis presents a methodology compatible with the Department of Defense (DoD) Capability-Based Assessment (CBA) process for analyzing and recommending appropriate enterprise architectures for the challenge of integrating Unmanned Aircraft Systems (UAS) in the national airspace system (NAS). Thesis organization is sub-divided into four sections. Section I provides the introduction, context, and recent efforts of the UAS airspace integration challenge and the underlying motivations driving the increased desire to see UAS better integrated into the NAS. Section II details the methodology used in the analysis by extending various value-focused, lean enterprise constructs using rigorous object process methodology (OPM) to describe and build alternative enterprise architectures. Section III applies the methodology to the UAS airspace integration problem specifically with the development and selection of a preferred enterprise architecture and a recommended transformation plan. Section IV concludes with a discussion on extending the methodology for specific application back into the CBA process, the issues involved in creating an executable model for enterprise architecting, and final thoughts on the iterative nature of the methodology and the need to further refine the initial results with the UAS airspace integration enterprise decision makers.

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EXECUTIVE SUMMARY

Context

The Global War on Terror (GWOT) shifted the military emphasis from traditional warfare to irregular warfare. Traditional warfare focused primarily on having the force structure needed to destroy enemy capability at Strategic, Operational and Tactical levels. In the GWOT context, the emphasis is now on finding small, highly maneuverable, asymmetric threats [1, 2]. The result is the Combatant Commander's rapidly increasing demand for specific, time-sensitive and actionable information from Intelligence, Surveillance, and Reconnaissance (ISR) assets.

Unmanned Aircraft Systems (UAS) provide a significant and flexible ISR capability to meet this growing demand [3] at significantly lower cost than would otherwise be expended for an increase of more traditional manned ISR aircraft. This is a significant factor to the Air Force, operating with the oldest flying airframes in its history and attempting to recapitalize its force structure [4]. The impact of these factors is an exponential growth in the numbers of UAS platforms procured over the past 5 years.

The rising numbers and growing importance of UAS missions creates a burgeoning need for UAS airspace access that challenges existing DoD restricted airspace capacity. This is increasing the pressure to ensure UAS are more fully integrated into the U.S. national airspace system (NAS) for operations and training from home garrison bases. Without integration, assured separation from other air traffic demands non-standard margins in space and time. In consequence, UAS are poor stewards of scarce airspace today. As flying operations increase, their "airspace consumption" is highly disproportionate to the growth in flight hours. This further complicates an already dense air traffic picture the Federal Aviation Administration (FAA) is attempting to manage while also ensuring the safety of the airspace.

Several organizations responded to the need to better integrate UAS operations in the NAS. These included an effort by the National Aeronautics and Space Administration (NASA) called Access 5 that incorporated representation from across industry and government; the creation of an UAS Program Office within the FAA; the stand-up of a sense-and-avoid standards body by the FAA federal advisory committee RTCA; the establishment of a Joint Integrated Product Team by the Military Services' UAS program managers; the initiation of an UAS Task Force by the Air Force; and the creation of an unmanned warfare office with an air component under the Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)). All of these efforts engaged at some level on increasing the degree to which UAS operations and training integrate into the NAS, and several of them are on-going initiatives. To date, none of these efforts successfully increased the degree of airspace integration beyond the existing baseline established by the FAA's Certificate of Authorization/Waiver (COA) process.

Purpose and Scope

The purpose of this research is to investigate, develop, and implement a value-focused methodology compatible with the existing DoD Capability-Based Assessment (CBA) process to provide an avenue for assessing the issues associated with defining an UAS airspace integration

(AI) enterprise, and the required value delivery needed to move the activity forward within the previously described context. The scope of this research is limited to Level 3-5 UAS flown by the Air Force (i.e. MQ-1, MQ-9, and RQ-4 platforms) at medium to high altitudes. In every other regard, this research addresses the value definitions across the entire spectrum of UAS AI enterprise decision makers (ACC, FAA, and Air Force acquisitions) needed to move UAS AI forward.

Methodology

The methodology implements frameworks from several different disciplines and research. An overarching value-focused approach provides the framework for the analysis, drawing heavily upon work by Keeney [5] and Murman et al. [6]. The unifying approach is the three-phase, value-creation model by Murman et al. The three stages to value-creation are value identification, value proposition, and value delivery.

Value identification focuses on defining the enterprise purpose and the most important stakeholders in the enterprise, called enterprise decision makers. In this research, an enterprise is an integrated entity that efficiently creates value for its multiple stakeholders (e.g. the UAS AI enterprise comprised of the user, the developer, and the regulator acting in concert to restore maneuver). An "extended enterprise" consists of the enterprise under investigation as well as the additional organizations laterally or above the focus enterprise contributing or constraining on-going activities. An example is the Global Strike Task Force (GSTF) extended enterprise composed of not only the UAS AI enterprise, but also other organizations contributing to Global Strike like fighter aircraft enterprises, higher headquarters, and senior leadership). Vertical value alignment between enterprise and extended enterprise is accomplished using a structured enterprise purpose statement framework developed by Crawley [7]. Enterprise stakeholder's are identified and ranked using a modified stakeholder saliency approach described by Grossi [8] and implemented using the decision maker model put forward by Ross [9]. Horizontal value alignment implements a modified X-matrix approach based on the work of Stanke and Nightingale [10].

Value propositions use the enterprise architecting method advanced by Nightingale and Rhodes [11] to generate alternative means of delivering value. This approach is a full-dimensional analysis across eight different aspects of an enterprise with the focus of creating a lean, value-delivering enterprise. Analytical rigor is enforced through the use of QFD analysis and Object Process Methodology first put forward by Dori [12] and modified for system architecting use by Crawley [13]. Alternative architecture evaluations use the Software Engineering Institute's Architecture Tradeoff Analysis Method (ATAM) [14], supplemented with additional criteria from Crawley [7] and Wagenhals et al. [15].

Value delivery is the final stage in the value creation framework. The approach in this thesis implements the Enterprise Transformation Roadmap model described in Nightingale and Srinivasan [16]. The ATAM method provides additional insights into sensitivity and tradeoff points in the architectural design that provide high-leverage activities for architectural change at the enterprise level. Specific, concrete action for a transition plan results through the definition of the desire future state of the enterprise during the value proposition stage and implementation considerations provided by the Enterprise Transformation Roadmap framework.

Application

Data collected from various organizations across the Air Force, DoD, and FAA provided insight into UAS AI enterprise needs and challenges. UAS AI enterprise organizations interviewed included representation from the UAS user community, the UAS acquisition (engineering and budget) community, the relevant policy offices within Headquarters Air Force and the Office of the Secretary of Defense, and the appropriate offices within the FAA operations and safety divisions.

Value identification used the enterprise purpose statement and stakeholder saliency frameworks described in the previous section. Vertical value alignment results from a restatement of the UAS AI enterprise purpose statement to focus on restoring the principle of maneuver to UAS platforms with the stated goal of enabling global strike at the Global Strike Task Force (GSTF) extended enterprise level. Maneuver, as a principle of war, is where air weapons systems have historically excelled through freedom of navigation and global access. UAS platforms today tend to diminish this hallmark advantage of airpower as they expand in the force structure.

The three primary groups of UAS AI enterprise decision makers are ACC, the FAA, and the Air Force acquisition community. The X-matrix provides horizontal value alignment with significant insights on enterprise performance, behavioral characteristics, and metrics. The enterprise value definitions require not only specific performance attributes, but also a defined process in which to deliver those performance attributes (i.e. enterprise behavior).

Three primary alternative enterprise architectures emerged from the value proposition stage. The first architecture focused on process-centric activities, the second architecture on product-centric efforts, and the third architecture combined strong points from the first two architectures. The third architecture proved to provide the best all-around value delivery assessment by integrating the need for a strong criteria-driven governance structure (i.e. a process or rule-based decision method) with the funding benefits that accrue with focusing on specific platform implementations.

The value delivery activity demonstrated a clear need to create a 2-year, budget-driven plan that focuses on time-certain delivery of incremental UAS maneuver gains. The UAS AI enterprise and the GSTF extended enterprise assess the incremental value delivery of the effort. Explicit recommendations detailed in the next section describe specific steps drawn from this research for delivering value.

Consolidated List of Research Findings and Near-Term Recommendations

A list of the "Top 5" research findings and near-term recommended actions resulting from this effort summarizes the hardest hitting results of this research. The research findings provide the context for implementing the near-term "tactical" recommendations that follow.

Research Findings

This summary of the research findings provides a succinct statement of the insights the methodology developed in this thesis provided in the analysis of the UAS AI effort. No ubiquitous claims to validation or extensibility result from this research; however, the methodology did prove useful in the following ways:

1. **The deployed methodology provides a clean interface to the existing DoD Capability-Based Assessment (CBA) process.** The results and implementation recommendations appear to align well with Air Force and DoD organizational structures and responsibilities. In addition, the recognition of CBA as a value-based approach resulted in significant insights and extensions to the current CBA processes based on the broader value-focused literature and theory.
2. **The enterprise purpose framework and the X-matrix analysis yield well-aligned value structures both vertically and horizontally across the Global Strike Task Force (GSTF) extended enterprise and the UAS AI enterprise, respectively.** Disconnects between the UAS AI enterprise and the broader GSTF extended enterprise were highlighted. Using the X-matrix to assess the internal UAS AI enterprise provided key insights into needed development of specific attributes and metrics to align disparate decision maker perspectives within the enterprise. The coherency established by the value alignment in both dimensions provided a basis for accomplishing the more detailed analysis for the enterprise architecting effort.
3. **Unarticulated assumptions come to the forefront of the analysis, and several doctrine-to-activity disconnects were highlighted.** The combined insights resulting from the value alignment activities described above, coupled with the more detailed and rigorous analysis using the Object Process Methodology (OPM), served to highlight the interactions that were present (or lacking) between various elements of the enterprise. By requiring a clear articulation of what these interactions actually look like, as opposed to what people often mistakenly took for granted, disconnects between the doctrinal elements related to flying UAS (what was said) could be contrasted with the activities that were actually implemented (what was done). These insights provided a rich source of information for where barriers might exist to moving the UAS AI effort forward.
4. **The need for a consolidated position at the GSTF extended enterprise level on the constraints under which the UAS AI activity should operate surfaced as a major hurdle to creating value.** This insight resulted from the enterprise purpose statement analysis and an assessment of the vertical alignment in the value structure. This information, coupled with the explicit interactions described by the architecture OPM, highlighted the following: the current move to push additional capability onto UAS platforms is occurring without a clear trade having been conducted on the impact those platforms' capabilities bring (or don't) to the global strike capability of the larger Air Force force structure. The research methodology provided clear insights into the need for this discussion at the GSTF extended enterprise level to specify the resource expenditures for restoring maneuver to UAS.
5. **Rigorous implementation of the methodology provides strong and clear linkage between the delivery of the GSTF extended enterprise value definition (i.e. global strike) and the specific, concrete actions the UAS AI enterprise must accomplish to realize the desired level of maneuverability.** The Enterprise Transformation Roadmap provided a robust approach for translating the GSTF Extended enterprise values driving the UAS AI enterprise into a concrete, time-phased roadmap grounded in details and practical implementation considerations. It is through the Enterprise Transformation Roadmap the transition is made from subjective (but needed) expressions of value definitions (i.e. restore maneuver) to concrete, specific, and actionable plans that can be

implemented, assessed, and modified to take into account the relative success of a set of activities (i.e. implement joint-led teams).

In summary, the methodology as implemented in this research provides a natural interface to the existing DoD CBA process, yields vertically and horizontally aligned activities, pushes assumptions and interactions to the forefront of the discussion, establishes the strategic issue(s) that must be addressed to flow value, and connects subjective values directly to specific, actionable effort needed to deliver the desired value.

Near-Term Recommendations

With the previous research findings as context, the following "Top 5" describes the near-term, "tactical" activities needed to move the UAS AI activity in the right direction for realizing the desired value of both the UAS AI enterprise (restore maneuver) and the GSTF extended enterprise (enable global strike). The list is in roughly the order of highest-to-lowest priority.

1. **The UAS airspace integration purpose statement must clearly link military capabilities (i.e. global strike), where the principal shortfall is maneuver, and the need to integrate UAS into the airspace.** Solutions will be more difficult to resource if there is a perception that UAS airspace integration is the end goal as opposed to enabling the relevant mission area. Unmanned aircraft are national security programs tied directly to projected military capability, and framing the airspace integration issue in the same light is important to elevating the discussion to the appropriate level. A proposed UAS AI purpose statement connecting the desired military capability with airspace integration is provided as follows:

   The purpose of the airspace integration enterprise is to restore the principle of maneuver to operations by integrating UAS into civil airspace using a full spectrum approach of policy, procedures and materiel system equipage while enabling needed UAS training and operational missions and meeting the contextual constraints (political, cultural, organizational, resource, etc) necessary to successfully deliver incrementally meaningful levels of value.
2. **Implement a senior leadership engagement plan to specify the constraints** the Air Force and DoD have on the effort to restore the principle of maneuver to UAS platforms (i.e. Non-Recurring Engineering costs, production numbers, limited or niche mission areas assigned to UAS, the maneuver of the overall force, etc). Elucidating these constraints within the broader context of "enabling global strike" puts a handle on the strategic issues for senior leadership to engage on. Communicating the value of restoring the principle of maneuver will be most effective through an analysis of Air Force capability delivery and the ramifications of current UAS policy and practices on the Air Force's ability to deliver "global strike" to the Combatant Commander. Once the constraints are clearly established, they should be implemented in concert with a "Simple Rules" strategy of a few key processes and a couple of critical criteria (i.e. decision rules or processes—see Recommendation #4) to govern the overall enterprise effort across Air Force, DoD, and FAA decision makers.
3. **The enterprise must produce a resource-constrained approach** providing an incremental product delivery the decision makers within the UAS AI enterprise, and the GSTF extended enterprise will consider worthy of investment, while also meeting the intent of the limitations brought out in Recommendation #2. This means active engagement with all of the enterprise decision makers to ensure the development of a

properly scoped, "revolving" two-year plan, providing an increase in value from the end user's perspective (i.e. how has global strike capability increased because of these expenditures of resource?).

4. **The absence of clear end-state, performance objectives requires the establishment of decision criteria and processes to effectively direct UAS AI enterprise activities.** Recommendation #4 expands on the need for enterprise governance decision criteria in the face of unspecified, final objectives or outcomes (the current condition in which UAS AI efforts are operating). Day-to-day activities needed for UAS AI enterprise unity of effort depend on clearly established governance criteria for teams or activities facing unspecified performance objectives or requirements [17]. More complex systems or activities require simpler (and fewer) rules for effective decision-making (see reference [18] for further expansion of this topic). As decisions arise, the only meaningful way to make consistent progress is to have a consensed set of priorities or criteria against which the enterprise has agreed to make resource and materiel related decisions. While seemingly straight forward, this approach is largely absent from past and present efforts.
5. **Limit the number of active decision makers on any one given enterprise effort** to less than 10, and preferably no more than six or seven, by segmenting the scope of activities into specific subsets of the problem the enterprise can work in parallel. Additional analysis shows the rapid decrease in activity effectiveness with an increase in the number of decision makers beyond the prescribed six or seven recommended for this effort [19]. One approach to implementing this recommendation would be to have the Air Force work all of the early operational aspects for the Level 3-5 UAS, have the Army work all of the early operational aspects for the Level 0-2 UAS, and have the Navy work all of the broader systems engineering aspects to the problem. These would be accomplished as largely independent efforts (and consequently involve fewer decision makers), but lessons learned and process related information would be communicated back out at the full UAS AI enterprise level. This would also allow each service to conduct activities within the constraints established by their respective services while still contributing to the UAS AI enterprise effort.

In summary, implementation of near-term actions include redefining the UAS AI enterprise purpose, engaging senior leadership to clearly specify constraints, initiating a cyclical, 2-year plan to operate under these constraints, establishing the appropriate governance decision criteria, and limiting the total number of decision makers on any one given effort.

Wrap-Up and Future Work

Application of the methodology developed in this research extends beyond the current application of UAS airspace integration to the DoD CBA process itself. A discussion with respect to specific recommendations for implementing a rigorous approach to CBA examines the feasibility of extending the current methodology for use in the CBA process. Additional discussion is devoted to the challenges of creating an executable model of the framework developed in this methodology to extend into early conceptual and detailed product design activities. Emphasis on iterating with the UAS airspace integration enterprise decision makers to validate the value structures developed in this analysis and to provide a sanity check on implementation recommendations is foundational to the approach outlined in this research. This is the next step in putting the results of this analysis to practical use.

TABLE OF CONTENTS

Abstract 3

Executive Summary 5

Table of Contents 11

Table of Figures 15

List of Tables 19

Acknowledgements 21

Biographical Note 23

Section I: Preliminaries 25

Foreword 25

Thesis Organization 25

Chapter 1 – Strategic Backdrop 27

The Global War on Terrorism 28

United States Air Force Context 32

The Rise of Unmanned Aircraft Systems 34

Accessing Airspace 39

Impact on the Federal Aviation Administration 43

Chapter 1 Summary 47

Chapter 2 – Introduction to UAS and Airspace Integration 49

A Brief History of Unmanned Aircraft 49

Recent Efforts at UAS Airspace Integration 55

Chapter 2 Summary 68

Section II: Methodology 71

Chapter 3 – Thesis Scope & Literature Review 73

Thesis Scope 74

Department of Defense Capability-Based Assessments 78

Sorting and Categorizing Approaches 84

Value-Focused, Lean Thinking 86

Architecting as a Means to an End 93

Pulling It All Together: The Overarching Analytical Approach 102

Chapter 3 Summary 103

Chapter 4 – Building the Enterprise Value Structure 105

Building Enterprise Purpose Statements 105

Conducting Stakeholder Analyses 113

Building the Value Structure 119

Chapter 4 Summary 120

Chapter 5 – Assessing Enterprise Value Alignment 123

A Lean Perspective on Flowing Value 123

Using the X-Matrix to Assess and Create Value Alignment 124

Driving Value Alignment with Metrics 128

Chapter 5 Summary 132

Chapter 6 – Creating and Selecting Enterprise Value Propositions 133

Understanding and Bounding the Tradespace Challenge 134

Tying Architecture Development to Value Definition 138

Putting Rigor into Enterprise Architecture Development 139

Enterprise Architecture Selection Approach 147

Chapter 6 Summary 156

Chapter 7 – Delivering Enterprise Value 157

Getting from Here to There: The Enterprise Transformation Roadmap 157

Connecting the Dots: Using Points of Leverage to Focus Transformation Efforts 159

Making Progress: Metrics and Stable Intermediate Forms 161
Chapter 7 Summary 162
Section III: Application 165
Chapter 8 – Data Collection and Analysis 167
Knowing Who to Talk To: Iterating on Purpose and Stakeholder Identification 168
Knowing What Questions to Ask: Structuring the Data Collection Interview 169
Knowing When to Stop: Evaluating Data Saturation 171
Knowing What to Look For: Data Analysis 173
Knowing What to Do Next: Implications for the Value Structure 184
Chapter 8 Summary 191
Chapter 9 – UAS Value-Creation Analysis 193
UAS AI Enterprise Intent and Purpose Statement 193
UAS AI Enterprise Stakeholder Analysis 205
UAS AI JIPT Value Structure and Alignment 208
Chapter 9 Summary 218
Chapter 10 – UAS Value Proposition Creation and Selection 219
Contextual Assessment of Enterprise Architecting Views 219
QFD Analysis 232
UAS Enterprise Alternative Architectures 235
Candidate Architectures: Views Held in Common 237
Candidate Architectures: Differing Views 244
Insights from Architecture 1 and 2 Evaluations 258
Architecture 3: Product-Informed Process 261
Final Architecture Description 264
Chapter 10 Summary 266

Chapter 11 – UAS Enterprise Transformation Plan 267

Connecting the UAS OPM with the Enterprise Transformation Roadmap 267

Enterprise Transformation Plan 270

Consolidated List of Research Findings and Near-Term Recommendations 282

Chapter 11 Summary 287

Section IV: Wrap-Up and Future Work 289

Chapter 12 – Further Research and Final Thoughts 291

Methodology Extensions 291

Tradespace and Executable Model Extensions 296

Final Thoughts 306

References 309

Appendix A – Current Military UAS Categories 319

Appendix B – UAS Airspace Integration Stakeholders 321

Appendix C – Stakeholder Saliency Determination 337

Appendix D – COUHES Approval 341

Appendix E – UAS Interview Questionnaire 345

Appendix F – Data Collection Results 351

TABLE OF FIGURES

Figure 1-1. Traditional vs. Irregular Warfare. 29
Figure 1-2. Challenges facing the DoD. 30
Figure 1-3. Demand vs. Availability for ISR Capabilities 31
Figure 1-4. Air Force Level 3-5 UAS Considered for Enterprise. [25, 26] 35
Figure 1-5. Mission Area Prioritized Across UAS Type. 36
Figure 1-6. DoD UAS Flight Hours (Inset) and Funding Trends. 37
Figure 1-7. Aircraft and UAS Class A Mishap Rates (Lifetime), 1986-2006. 38
Figure 1-8. FAA ATO Data on Number of COAs Submitted/Forecasted for UAS. 42
Figure 1-9. On-Time Arrival Performance, National (January-December, 2007). 44
Figure 1-10. The NextGen Operational View 46
Figure 2-1. Early Schematic of Balloon Use for Dropping Bombs. [38] 50
Figure 2-2. Picture of the Sperry Aerial Torpedo, 1918. [38] 52
Figure 2-3. Picture of the Denny RP-1, 1935. [38] 53
Figure 2-4. Picture of a V-1 Rocket from World War II. [38] 53
Figure 2-5. Picture of Navy Gyrodyne QH-50. [40] 54
Figure 2-6. Access 5 Focus on HALE UAS Mission. 57
Figure 2-7. Access 5 Organizational Structure and Stakeholders 58
Figure 2-8. JIPT Two-Track Approach. 62
Figure 2-9. JIPT Organizational Structure. 64
Figure 2-10. OSD(AT&L) UAS Task Force Organization. 65
Figure 2-11. JIPT Requirements Flow-Down Process. 67
Figure 2-12. JIPT Activity Model. 68
Figure 3-1. A Synthesis of the Lean Enterprise Value Framework. 76
Figure 3-2. Rumsfeld Memo Initiating Current CBA Process. 81
Figure 3-3. Simplified Diagram of Major CBA Inputs, Analyses, and Outputs. 83
Figure 3-4. A Synthesis of the Lean Enterprise Value Framework. 88
Figure 3-5. Graphical Depiction of Enterprise Dimensions. 95
Figure 3-6. Enterprise Problem Space. 96
Figure 3-7. Enterprise Architecting Framework and Views. 100

Figure 3-8. Methodology Roadmap. 102
Figure 3-9. Generalized Model for Value Creation. 103
Figure 4-1. Determining Enterprise Purpose Statement Context 108
Figure 4-2. Enterprise Purpose Statement Form. 110
Figure 4-3. Example Set of Analysis Iterations with Inputs and Outputs Identified. 111
Figure 4-4. Enterprise Purpose Statement Verification and Validation Model. 112
Figure 4-5. Stakeholder Identification and Salience Framework. 114
Figure 4-6. Stakeholder Identification Methodology. 116
Figure 4-7. MATE Decision Maker Role Hierarchy. 118
Figure 5-1. X-matrix Structure. 125
Figure 5-2. PSM Measurement Activity Framework. 131
Figure 6-1. Methodology Roadmap. 134
Figure 6-2. Attribute-to-Enterprise View Mapping (QFD) Matrix. 138
Figure 6-3. Adapted Enterprise Architecting Framework. 140
Figure 6-4. Architecture Generation Model using Object Process Methodology. 143
Figure 6-5. Architecture Tradeoff Analysis Method Framework. 148
Figure 6-6. Notional Relationship between Ranking Method, Effort and Confidence. 150
Figure 6-7. General X-matrix Template Revisited. 151
Figure 6-8. Example of an ATAM Utility Tree Analysis. 152
Figure 6-9. An Architecting Process from Wagenhals et al. 154
Figure 7-1. Enterprise Transformation Roadmap. 158
Figure 7-2. Interfacing the OPM Model with the Enterprise Transformation Roadmap 160
Figure 8-1. Organizations & Individuals Interviewed for Data Collection Effort 169
Figure 8-2. ACC/A3 Value Delivery Assessment of COA Process. 174
Figure 8-3. AJR-36 Value Delivery Assessment of the COA Process. 175
Figure 8-4. Differing Enterprise Perspectives on Safety. 186
Figure 8-5. Differing Enterprise Perspectives on Hurdles. 187
Figure 8-6. Differing Enterprise Perspectives on Other Stakeholders. 188
Figure 8-7. Enterprise Perspective on the Need for Advocacy. 189
Figure 8-8. Enterprise Perspective on Approach. 190
Figure 8-9. Enterprise Perspective on the End-State. 191

Figure 9-1. JIPT Mission Statement Analysis. 194
Figure 9-2. Initial UAS Enterprise Purpose Context Analysis. 196
Figure 9-3. Understanding Impact of Maneuver on Enterprise Context. 200
Figure 9-4. Iterated Enterprise Purpose Context Framework. 202
Figure 9-5. Final UAS Enterprise Purpose Context Framework. 203
Figure 9-6. Final UAS Airspace Integration Enterprise Purpose Statement. 204
Figure 9-7. Stakeholder to Decision Maker Process 207
Figure 9-8. UAS Enterprise Value Structure Depicted in an X-matrix. 208
Figure 9-9. X-matrix Assessment of COAs using Redefined Purpose and Stakeholders. 210
Figure 9-10. ACC/A3 Value Delivery Assessment of COA Process. 211
Figure 9-11. AJR-36 Value Delivery Assessment of the COA Process. 212
Figure 9-12. Actual and Forecasted Number of COAs 213
Figure 9-13. X-matrix Evaluation of UAS AI Enterprise. 217
Figure 10-1. Joint FAA/OSD Approach to Regulating UASs. 221
Figure 10-2. Variables Impacting Choice between Project vs. Functional Structure. 226
Figure 10-3. Characteristic Product/Industry Life Cycle Phenomena. 229
Figure 10-4. Capturing Value from Innovations 231
Figure 10-5. "Active" UAS Airspace Integration Enterprise Views. 235
Figure 10-6. UAS Enterprise Architecture OPM 236
Figure 10-7. Process Focused Enterprise Architecture. 245
Figure 10-8. Product Focused Enterprise Architecture 253
Figure 10-9. Product-Informed Process Enterprise Architecture. 261
Figure 10-10. Comparisons of Alternative Architectures Scoring Results 262
Figure 11-1. Using the OPM View to Identify Sensitivity and Tradeoff Points. 268
Figure 11-2. ATAM Concept Interactions. 269
Figure 11-3. Enterprise Transformation Roadmap. 270
Figure 11-4. Phase I of the Transformation Plan. 273
Figure 11-5. Phase II of the Transformation Plan 274
Figure 11-6. Example of Detailed Program Plan from JIPT Effort. 279
Figure 12-1. Methodology Extension to CBA using DOTMLPF for "Views". 292
Figure 12-2. OPM Connection between Architecture and Materiel Design using MATE 293

Figure 12-3. Enterprise Architecting-to-DOTMLPF Framework Mapping. 295
Figure 12-4. Notional Hybrid Enterprise Architecture Modeling Framework. 297
Figure 12-5. Estimated Utility Curves for UAS Airspace Integration Attributes 299
Figure 12-6. Utility vs. Cost for UAS Airspace Integration Architectures. 301
Figure 12-7. UAS Airspace Integration Architecture Tradespace Plot. 304
Figure 12-8. UAS Airspace Integration Tradespace Plots for Specific Mechanisms. 305

LIST OF TABLES

Table 4-1. Stakeholder Saliency Evaluation. 117
Table 5-1. Example of Goal-Question-Metric Methodology. 129
Table 8-1. Data Collection Saturation Analysis. 172
Table 8-2. Consolidated Responses for "Key" Enterprise Stakeholders. 178
Table 8-3. Consolidated Responses for Required Enterprise Resources. 179
Table 8-4. Barriers to UAS Airspace Integration. 181
Table 9-1. UAS Enterprise Stakeholder's and Saliency Ratings. 206
Table 10-1. QFD Assessment of Views-to-Attributes Mapping. 233
Table 10-2. Three Approaches to Strategy. 249
Table 10-3. Architecture 1 Scoring Results. 252
Table 10-4. Architecture 2 Scoring Results. 257
Table 10-5. Architecture 3 Scoring Results. 263
Table 12-1. UAS Airspace Integration Architecture Design Choices. 300
Table 12-2. Relationship Between Attributes and Design Variables (Mechanisms) 302

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And to the brilliant minds that I have had the pleasure of taking some small measure of insight and learning from over the past year. Donna, you have redefined the meaning of "academic rigor" for me, and I will carry the frameworks for thinking about problems that you have instilled in me into everything that I do in the future. Thank you for your investment in making this research stand on its own two feet from a methodology standpoint. Debbie, to you I owe the credit of bringing the power of value-focused thinking into tangible and pragmatic reality. Thank you for the opportunity to roll up the sleeves and get my hands dirty trying to do something real in the midst of all the theory. JK, whether you realize it or not, you have perhaps influenced my approach to applying lean enterprise thinking to the world of UAS airspace integration more than any other single individual. You have a tremendous gift for making complex things simple, and this research does not do your inputs justice as I typically can figure out how to make simple things seem complicated.

To the Systems Engineering Advancement Research Initiative crowd—Adam, Nirav, Matt, Lauren, Deb, Jen, Hugh, and Andrew—thanks for sharpening my thinking as only those who

have to implement the theoretical can do. You have added to my tool chest of frameworks in abundance. Matt, I will forever look at the world of systems architecting differently after our jaunt together through Crawley's class. Don't forget the little people on your blazing trail to the top!

To the Lean Advancement Initiative enterprise architecting aficionados—Jorge, Doug, Chris and Chris—thanks for including the mere Master's student in your pontifications about advancing the state of the art. You have influenced my thinking in several dimensions. Caroline, thanks for the occasion reprieve from the academics and the discussions that wound their way into the philosophical.

Finally, to the System Design and Management Cohorts of 2007 and 2008 who took me in as their own despite the fact that I didn't have the decency to start the program with either one of them. To Pat for giving me enough rope to hang myself with and letting me jump into the curriculum mid-stream. Your flexibility has been a blessing, and your dedication to improving the curriculum is without parallel. Chris, I owe you on too many fronts to even begin to list them all here. Thanks for taking the bull by the horns and straightening out the mess I made on more than one occasion with tuition and fees! To a couple of the smartest guys I'll ever know—Stephen and Nags—thanks for all of the insights over the past year. You never fail to amaze me with your talents and abilities. Call me when you decide to go into the start up business! To my fellow military cohorts in crime—Kristina and Mike—thanks for all the ways you contributed to this work both directly and indirectly in all of the group projects we did together. I can only hope to have the chance to team up with you again out in the "real world." And to Alyson, thanks for not letting me forget about the human side of things. Your courage in the face of adversity has been an inspiration.

BIOGRAPHICAL NOTE

Luke Cropsey was born in the summer of 1973 in Ann Arbor, MI. His childhood years were anything but typical as his parents left the U.S. for Africa via a two-year stop in Canada as medical missionaries when Luke was 7 years old. Returning to the States at the age of 16 and entering his final year of high school, Luke was more comfortable swinging off vines than navigating his way through a mall.

Luke entered the U.S. Air Force Academy in the summer of 1991 and graduated as a distinguished graduate in 1995 with a Bachelor of Science degree in engineering mechanics. While at the Academy, Luke was also active as a sailplane instructor pilot in the soaring program, and he was a regular at Saturday night Officer's Christian Fellowship Bible studies. Immediately after graduating, the Air Force sent Luke to Michigan State where he completed a Master of Science degree in materials engineering in 1996. The highlight of his year in grad school was marrying the love of his life, Heather.

For the next six years, Luke left a trail of destruction and carnage in his wake with jobs at the Air Force Research Lab assessing the lethality of next generation conventional warheads, and then moving in 1998 to San Antonio, Texas, to work at the USAF Force Protection Battlelab doing blast and fragment mitigation work against large terrorist vehicle bombs. This tour saw the arrival of the first of four, Maegan, in 1999. After blowing things up for six years, the Air Force decided to ship Luke to Washington D.C. to do something more conventional with his skills.

In the fall of 2001, Luke arrived on the doorstep of the National Reconnaissance Office where the Air Force's plans for a boring desk job backfired terribly. Luke spent the first couple of years in the Advanced Systems and Technology Directorate working on some of the most cutting-edge technologies in the world. In early 2004, Luke was selected as one of the NRO's legislative liaisons and spent the next two Congressional cycles responding to inquiries from the Hill, writing congressional testimony, and shuttling program managers down and back to Washington D.C. In 2002 and 2004, he and Heather added Molly and Ethan to the growing ranks of little Cropsey's running around the house.

September of 2005 saw a move to Dayton, Ohio, where Luke first took up the subject of unmanned aircraft systems (UAS) at the 303rd Aeronautical Systems Wing, the Air Force's materiel provider of UAS platforms. Luke also had the opportunity to work directly with the Air Force and DoD's capability-based assessment and planning process as the Wing's chief of strategic integration. The two years in Dayton culminated in the dramatic arrival of the fourth and final addition to the family, Emily, who couldn't wait for the pleasantries of the delivery ward to make her appearance. Instead, Luke had the opportunity of a lifetime delivering his own daughter less than a mile from the hospital.

With so much excitement, it was time to move on. The Air Force selected Luke as the 2007 Massachusetts Institute of Technology Lean Aerospace Initiative (now Lean Advancement Initiative) Fellow and shipped him off to Cambridge, Massachusetts, in August of 2007 for a year of more training and education where he also enrolled in the System Design and Management program. After successfully completing his course of study at MIT, Luke will be

joining the European Command Joint Staff in Stuttgart, Germany where he will be attached to the Information Operations Directorate. He will occupy his free-time with taking in the sights and sounds of the Continent with his family, and for those that may be wondering, there are no plans for any further additions to the current brood of four...topping the last performance would be problematic, and it's best to go out on a high note.

SECTION I: PRELIMINARIES

Foreword

The author had the privilege of working the issues surrounding the integration of military unmanned aircraft systems (UAS) into the national airspace system (NAS) from January 2006 through August 2007. The author's role in this effort was as the deputy Air Force lead for the UAS Airspace Integration Joint Integrated Product Team (JIPT) which is described in some detail in Chapter 2. In the capacity of deputy lead, the author had the opportunity to manage and shape the day-to-day strategy, organization, and activities of the JIPT as the Tri-Service UAS airspace integration effort was launched in late 2005 and early 2006.

This first-hand knowledge of the rationale, motivations and decisions of those engaged in the airspace integration activity provides a rich context for the analysis that follows. From one perspective, this thesis can be seen as the author's pursuit of a methodology that provides a more effective and efficient approach to solving the complex issues surrounding the UAS airspace integration (AI) challenge. Tied to this desire to address the immediate airspace integration issues is the broader use context and the intent to align the research methodology to the existing policies and practices of the DoD's capability-base assessment (CBA) process.

The context in which the UAS AI effort operates is very fluid with few anchor points in which to ground the activities taking place. There is no reason to think the situation will be any less fluid moving into the future. The intent of this thesis is to provide an applied framework for understanding the dynamic nature of the environment in which the UAS AI activity operates, and, in turn, to recommend an approach to future activities that will be robust to the changing backdrop of politics, policies, funding, and technological advancements.

Thesis Organization

The content of this thesis is organized into four sections. Section I details the preliminary information needed to understand the backdrop in which the UAS AI effort is occurring. A summary of the Global War on Terror (GWOT), U.S. Air Force (USAF), and Federal Aviation Administration (FAA) strategic drivers provides placement for the airspace integration activity within the broader national-level context. This is followed by a more in-depth treatment of

recent UAS airspace integration activities that have occurred over the past five years. Section I also contains a brief history of UAS development for those that may not have any prior domain knowledge in this field. Introducing the UAS AI problem in this way provides a concrete description of the real-world motivation for looking at the issues surrounding UAS AI in more detail. It also sets the conditions for the search for an appropriate methodology for attacking the problem.

Section II develops the methodology to comprehensively assess and address the generalized challenges associated with creating value in complex stakeholder enterprises in a methodical and rigorous manner. This section starts with a definition of the scope of this thesis, followed by a literature review of the existing methods and practices for accomplishing the objectives of this research. A methodology is then developed by which an enterprise can be defined, assessed, and engineered for maximum value delivery to the key decision makers within the enterprise. Major elements introduced in this section include value-focused thinking and enterprise architecting.

Section III applies the general method developed in Section II directly to the UAS AI effort. The section begins with a comprehensive review of the data collected through extensive interviews with various stakeholders across the airspace integration enterprise, and then launches directly into the mechanics of how the theory looks in practice. Concrete, specific direction is provided for how the UAS AI effort should be refocused and scoped to better deliver the value definitions provided by the enterprise stakeholders.

Section IV concludes by examining future extensions to the methodology as well as the application space. This includes a discussion on the issues surrounding the creation of executable models. From an application standpoint, the idea of using the same methodology for a consistent and rigorous way of doing capability-based assessments is examined, explicitly integrating the DoD framework of Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) into the approach.

CHAPTER 1 – STRATEGIC BACKDROP

"...There is nothing new under the sun."
—Ecclesiastes 1:9b

Man did not make it past generation number two before Cain killed Abel, and it went downhill from there. [20] The history of warfare is, in one respect, the history of the human race. The current times are no exception to this age-old struggle of one people against another. Certain fundamental principles of war elucidated millennia ago have withstood the test of time. Central among these tenets is the need to know both yourself and your enemy in order to secure victory. [21] Advances in technology and innovation have simply provided new methods and tactics for accomplishing them with more effectiveness and efficiency than the enemy, accelerating the Observe, Orient, Decide, Act (OODA) loop by compressions in time and space. [22]

This chapter lays out the general context against which the UAS airspace integration (AI) effort is taking place. The military aspects of this backdrop are emphasized, limiting the scope to addressing the specifics associated with achieving military (specifically Air Force) UAS integration into the NAS. This chapter is organized by describing the strategic conditions associated with the Global War on Terrorism (GWOT), followed by a more detailed look at the United States Air Force (USAF), the rise of UAS usage, UAS access to airspace challenges, and the Federal Aviation Administration (FAA) efforts to cope with growing UAS activities.

In a general sense, Chapters 1 and 2 collectively provide the underlying motivation and basis for the methodology that follows in Section II. It is the combination of the dynamic context described in this chapter, coupled with the inability of recent efforts (at least to date) described in Chapter 2 to address the airspace integration complexities well enough to establish a sustainable approach to the problem that ultimately provided the impetus for this thesis. This introductory and background material is introduced first because taken as a whole it defines the size of the problem the methodology must be capable of addressing. What follows in Chapter 1 introduces five strategic drivers and provides the backdrop for the remainder of the work in this thesis.

The Global War on Terrorism

The United States military has seen continuous combat action for almost seven years, following close on the heels of the 11 September 2001 attacks against the World Trade Center in New York City, NY, the Pentagon in Arlington, VA, and United Airlines Flight 93 which crashed in Somerset County, PA. The shift in threats from the old Cold War era force-on-force engagements with another superpower to the current conflict with rogue actors employing highly asymmetric tactics (e.g. terrorism) created a major change in the way the U.S. military prosecutes its mission.

The Cold War environment was one in which two major superpowers dominated the political and military scene. In this contest of wills between the U.S. and the U.S.S.R., the focus was on the defeat of a peer competitor with substantial forces of comparable capabilities to those of our own. The consequence of this environment was the investment of significant resources and energy in the ability to defeat the enemy in classic, set-piece battle formations (the issue of nuclear deterrence and the policy of mutually assured destruction notwithstanding).

With the demise of the U.S.S.R. and the rise of terrorism, the emphasis shifted. No longer is there as much emphasis placed on defeating near-peer competitors. Instead, the focus is now on neutralizing highly asymmetric threats that avoid direct force-on-force confrontation whenever possible. In order to be effective against these very small (sometimes a single person), highly agile and mobile threats, the entire thrust of military resources began to shift to the arduous task of finding the threat. Once found, the effort to neutralize the threat is usually a relatively small-scale military operation.

As an illustration of how the focus of energy and resources has shifted from the Cold War to the current GWOT effort, consider Figure 1-1. "Traditional" forces in this illustration relate directly to the Cold War era tactics and strategies that were an integral part to the large force structure buildup previously described. Much was made of postulated Soviet capabilities, and the ensuing arms race is testimony to the premium that was put on fielding highly capable forces. In contrast, the "Irregular" warfare depicted in Figure 1-1 is synonymous with the terrorist tactics favored in the current GWOT conflict. The preponderance of the effort is clearly focused on "finding" the enemy as opposed to "finishing" him off. [2]

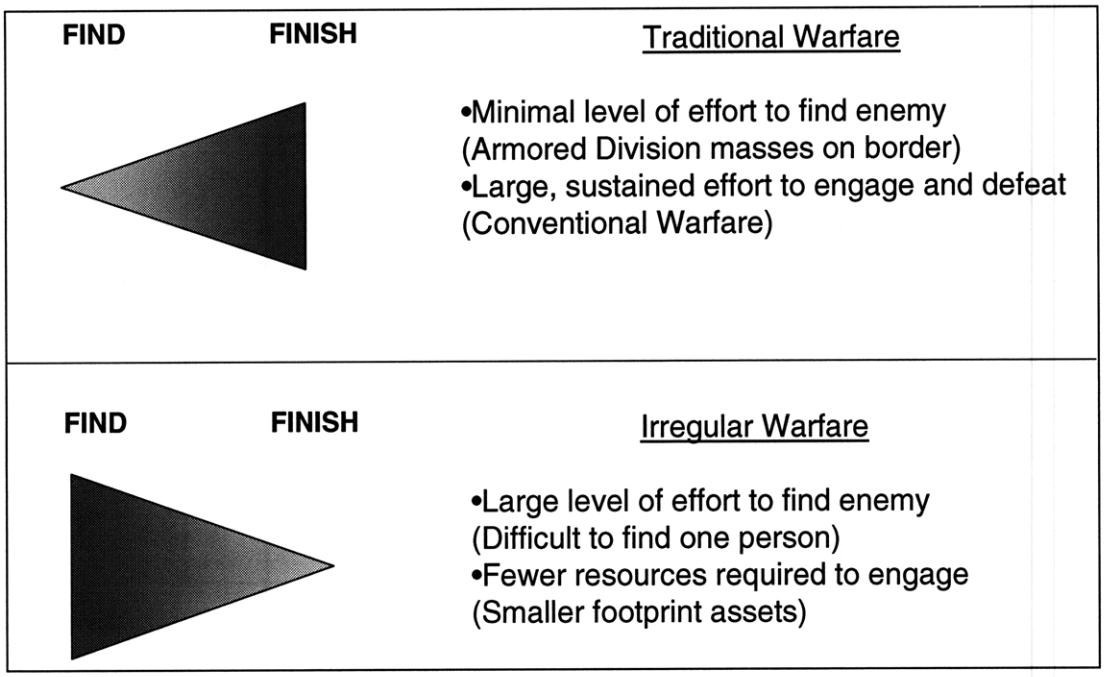


Figure 1-1. Traditional vs. Irregular Warfare.

From a broader perspective, the 2006 DoD Quadrennial Defense Review (QDR) classified the challenges the U.S military would face into four distinct categories: 1) Traditional challenges, 2) Irregular challenges, 3) Disruptive challenges, and 4) Catastrophic challenges. Figure 1-2 depicts the military's current capabilities within this overarching framework. The existing force structure is clearly weighted heavily in favor of the traditional, force-on-force challenges that were associated with the Cold War era threat. [1]

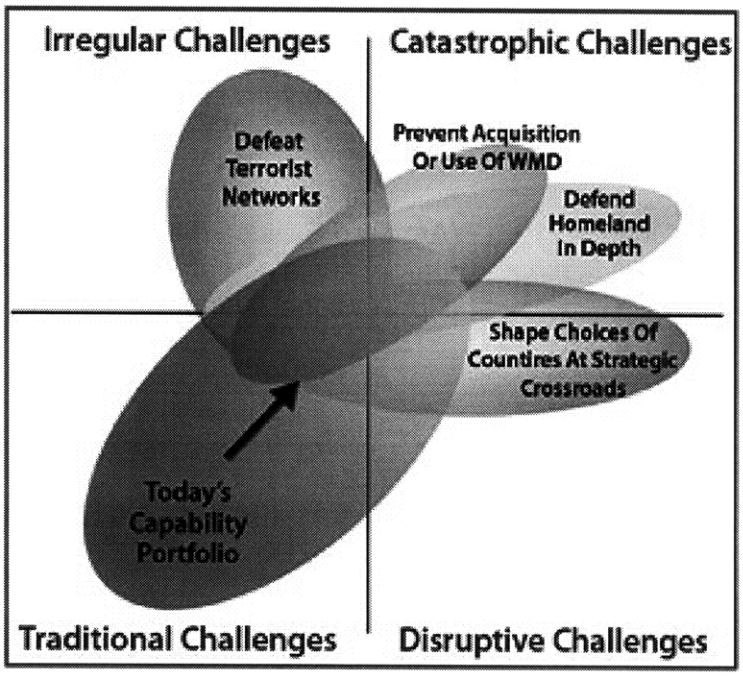


Figure 1-2. Challenges facing the DoD.

The reason for this center of mass in military capabilities is perhaps obvious, but it is worth discussing in explicit terms because it has a direct bearing on the development of UAS capabilities described later. The sheer enormity of the investments that were made over almost five decades continues to exert a significant amount of influence on current military force structure. This legacy force structure cannot simply be mothballed for the simple reason that the emergence of another traditional peer or near-peer competitor requiring these assets is not only possible, but even likely (consider the situation in China, North Korea, or Iran). This kind of force structure cannot be reconstituted overnight, and consequently, resources must be allocated to preserving the existing capability at some minimal level of readiness as a safeguard to the future.

The catch is to consider how best to meet the additional challenges depicted in Figure 1-2 while maintaining some level of traditional capability without completely bankrupting the nation in the process. Considering the shift in the focus for combating terrorism, it would seem that specific attention is needed on the "find" end of the spectrum. This was borne out in spades when the Office of the Secretary of Defense (OSD) went about systematically ascertaining the global Intelligence, Surveillance, and Reconnaissance (ISR) needs of the military. Figure 1-3 depicts

the results of the study, and it clearly demonstrates the need for additional capability within the ISR (think "find") mission area. [23]

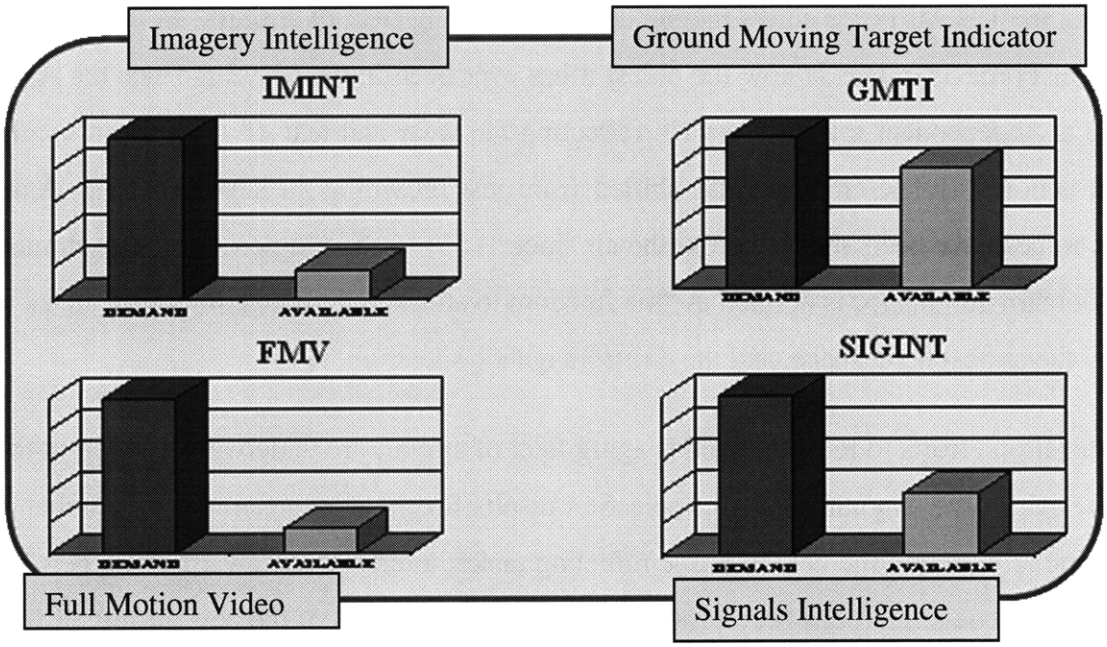


Figure 1-3. Demand vs. Availability for ISR Capabilities.

In a more recent survey, the Carnegie Endowment for International Peace and the Center for a New American Security conducted a far ranging survey of over 3,400 officers ranging in grade from Major/Lt Commander to General Officer/Flag Officer ranks. [24] The survey polled both retired and active duty officers from every branch of the military. When asked what the two most important things the U.S. government needs to do to win the war on terror, 38% said an increase in special operations forces and 73% said better intelligence capabilities are needed—including "more robust diplomacy, developing a force of deployable civilian experts, and increasing foreign aid programs."

When discussions concerning the need for ISR arise, the military mind naturally goes to "taking the high ground" as a time tested principle of war. In recent times, this mission has fallen squarely on the Air Force as one of its primary mission areas, whether accomplished from airborne assets or from space. With the need for additional ISR capabilities clearly established, the conversation now moves to the Air Force context specifically, and the issues the service is dealing with in their efforts to support the combatant commander (COCOM) in the war on terror.

United States Air Force Context

Against this global ISR need for effectively prosecuting the irregular warfare of combating terrorism, the US Air Force enters the picture with an aging fleet of aircraft. In fact, the average age of Air Force airframes is now the oldest it has ever been in the 61 years since the Air Force became an independent military service, reflecting the wear and tear of 17 years of continuous combat action. [4] The emphasis has shifted from just providing air superiority (no American ground forces have been attacked from the air since 1953) to ensuring cross-domain dominance. Cross-domain dominance is defined as "the freedom to attack and the freedom from attack in and through the atmosphere, space, and the electromagnetic spectrum." [4]

Modernization efforts to recapitalize this aging fleet of aircraft are underway. In fact, in the past year, the Air Force announced source selection results for the next generation of combat search and rescue aircraft and the next airborne refueling tanker aircraft. The award of the new combat search and rescue aircraft has been protested, as well as the award of the new air refueling tanker contract to a Northrop Grumman/BAE partnership by Boeing. In addition, there are also major cost overruns occurring in several major space acquisition programs, and the Air Force has had less than its historical good standing with Congress on the fiscal front.

In addition to dealing with an aging aircraft fleet in serious need of recapitalization, the Air Force is continuing to support operations in both Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) in Afghanistan and Iraq respectively. This results in a high priority for mission capable aircraft for on-going efforts in both locations. The result is a continuing acceleration of the rate at which aircraft are wearing out, and this in turn limits the overall useful life expectancy current force projections and modernization plans are built against.

As substantial as the challenges are to the Air Force, the Army and Marines are in even worse shape, especially as it pertains to their overall manpower status. In an effort to relieve some of the operational stress on these two services, Congress authorized a shift in manpower from the Navy and Air Force over to the Army. This essentially reduces the total end-strength of the Air Force. To compound this draw down, the Air Force has also attempted to reshape its remaining force structure to better meet the shifting threats and required expertise to meet them. In fact, the Air Force stood up an entirely new major command in September of 2007, Cyber Command, "to

provide combat-ready forces, trained and equipped to conduct sustained operations in and through the electromagnetic spectrum, fully integrated with air and space operations." [4] According to Gen Moseley, former Chief of Staff of the Air Force (CSAF), "Our objective is to provide flexible options to the decision-makers to deter, deny, disrupt, deceive, dissuade, and defeat adversaries through destructive and non-destructive, lethal and non-lethal means."

In characterizing the current environment in which the Air Force must operate, Gen Moseley listed the following "salient features of this increasingly complex, dynamic, lethal, and uncertain environment":

- Violent extremism and ethnic strife—a global, generational, ideological struggle
- Proliferation of weapons of mass destruction and empowering technologies
- Rising peer competitors with voracious appetites for resources and influence
- Predatory and unpredictable regional actors
- Increasing lethality and risk of intrusion by terrorist and criminal organizations
- Systemic instability in key regions (political, economic, social, ideological)
- Unprecedented velocity of technological change and military adaptation
- Availability of advanced weapons in a burgeoning global marketplace
- Exponential growth in volume, exchange and access to information
- Surging globalization, interconnectivity and competition for scarce resources
- Dislocating climate, environmental and demographic trends

The former CSAF goes on to describe how adaptive competitor actions translate into new warfighting concepts, capabilities and doctrines designed specifically to counter U.S. strengths and exploit weaknesses.

"The following are illustrative of the advances being made:

- "Generation 4-plus" fighter aircraft that challenge America's existing "4th Generation" inventory—and, thus, air superiority—with: overwhelming numbers and advanced weaponry; sophisticated integration of electronic attack and advanced avionics; emerging low-observable technologies; and progressive, realistic, networked training

- Increasingly lethal, integrated air defense systems (IADS) that threaten both our Airmen and aircraft, and could negate weapons used to suppress or destroy these systems
- Proliferation of surface-to-surface missiles with growing range, precision, mobility, and maneuverability—capable of delivering both conventional and non-conventional warheads
- Proliferation of unmanned aircraft systems (UAS) capable of conducting low observable, persistent, intrusive missions in both lethal and non-lethal modes
- Resurgence of offensive counterspace capabilities
- Increasing ability of even marginal actors to surveil the disposition of U.S. and allied assets through commercially available and widely accessible means
- Attacks through cyberspace are already creating tactical, operational and strategic effects at low cost and with relative impunity"

In summarizing the Air Force objectives moving into the 21st century, Gen Moseley provides the following conclusion: "The Air Force must safeguard our ability to: see anything on the face of the earth; range it; observe or hold it at risk; supply, rescue, support or destroy it; assess the effects; and exercise global command and control of all these activities."

The Rise of Unmanned Aircraft Systems

Onto this kaleidoscope of shifting threats, ascendant powers, aging platforms, and an economy that is increasingly fragile comes the next frontier in aviation—unmanned aircraft systems. While by no means a new development, their widespread use within the military in primary combat roles is only just beginning to emerge. This is in part due to the advances made in UAS capabilities and the evolution in strategy and doctrine needed for their effective employment with the existing force structure.

In discussing UAS, it is important to understand what category of platform is actually under consideration. The term "UAS" is applied ubiquitously to all types of unmanned platforms, ranging in size from the Battlefield Air Targeting Camera Autonomous Micro-Air Vehicle (BATCAM) weighing in at less than 1 pound to the Global Hawk RQ-4 at 32,000 lbs. [3] Smaller UAS are typically used in various roles supporting ground forces or for local area surveillance as part of the organic equipment that small units have under their direct control.

This class of UAS, typically referred to as small unmanned aircraft systems (SUAS) is defined as those under 10 pounds and are capable of being hand-launched. [3] For the purposes of this report, only Level 3-5 Air Force UAS will be considered, specifically, MQ-1, MQ-9, and RQ-4 (See Figure 1-4 below).

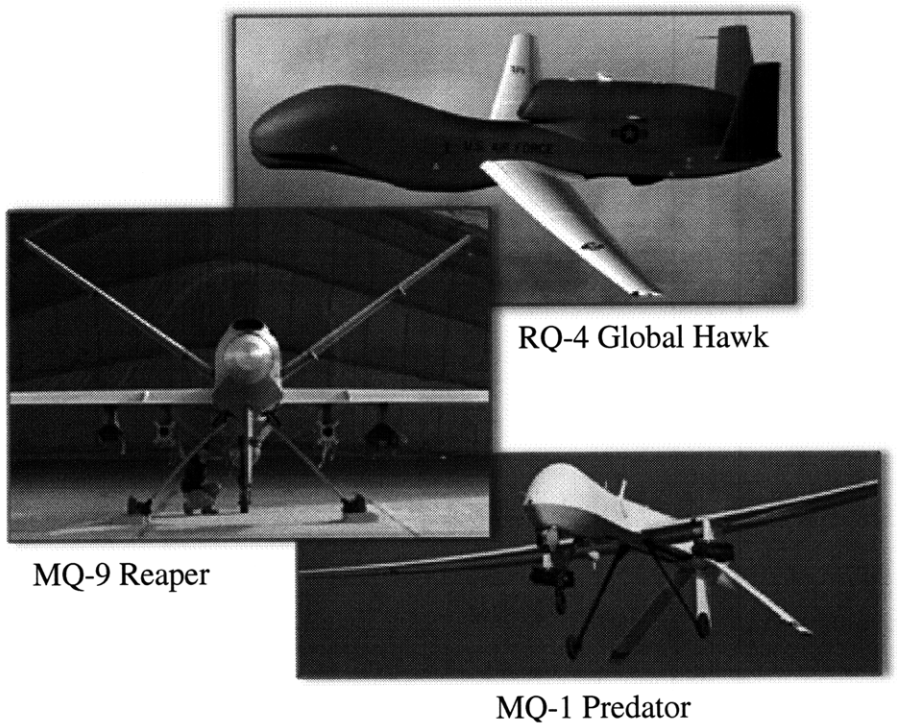


Figure 1-4. Air Force Level 3-5 UAS Considered for Analysis. [25, 26]

OSD reported the results of a survey conducted to prioritize UAS mission areas with respect to their intended operational use (See Figure 1-5). The telling nature of this summary is that across all operational contexts, the first and second priorities are in the reconnaissance, and precision target location and designation mission areas. [23] These are followed closely by signals intelligence and battlefield management. Already there is a strong degree of correlation between the types of active UAS mission area operations and Gen Moseley's summary of what the Air Force must be capable of providing in global operations.

Mission	Unmanned Aircraft Class			
	Small	Tactical	Theater	Combat
1 - Reconnaissance	1	1	1	1
2 - Precision Target Location and Designation	2	2	2	2
3 - Signals Intel	7	3	3	4
4 - Battle Management	3	4	5	6
5 - Communications/Data Relay	8	6	4	7
6 - Chem/Bio Reconnaissance	5	5	9	8
7 - Combat SAR	4	7	8	9

Figure 1-5. Mission Area Prioritized Across UAS Type.

In fact, the growing use of UAS in reconnaissance and in precision target location and designation has contributed significantly to their growth in both numbers and the budget expended to procure more of them in ever increasing quantities. Figure 1-6 depicts the almost exponential growth seen in both budget and numbers over the past decade. In fact, the combined UAS assets of the military have flown over 500,000 combat hours in the combined Afghanistan/Iraqi theaters since the GWOT campaign was launched seven years ago. [23]

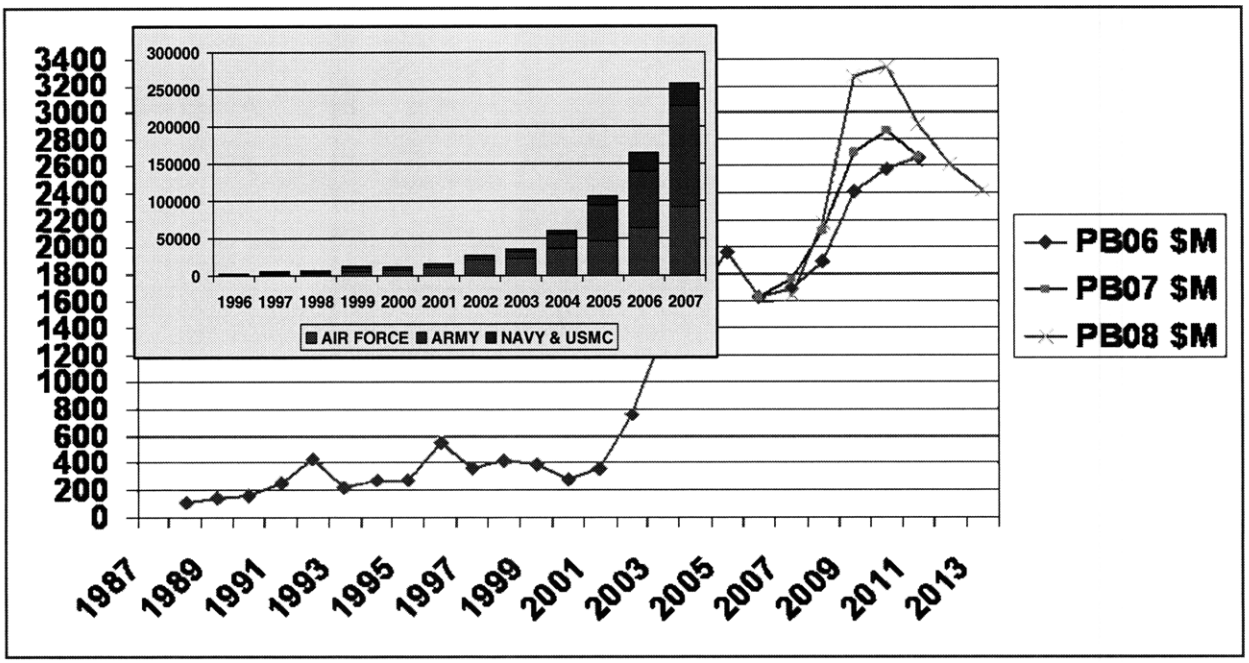


Figure 1-6. DoD UAS Flight Hours (Inset) and Funding Trends.

As the numbers, complexity, and importance of these Level 3-5 UAS have continued to increase, the quality and operational experience associated with them has also risen. Figure 1-7 demonstrates the continuing decline in the number of Class A and B mishaps per flight hour reported for a number of different types of UAS. [3] The Air Force categorizes UAS mishaps as aviation mishaps when the UAS is operating as an aircraft (as opposed to being carried as cargo). A "Class A" mishap is categorized as any accident resulting in more than $1M in damages and/or a fatality or permanent total disability. [27] For comparative purposes, the mishap rate for the comparable number of hours flown for an F-16 Fighting Falcon and U-2 Dragon Lady are also shown on the graph. The reliability of Air Force Level 3-5 UAS appears to be at equivalent rates to those of manned aircraft at similar stages of development.

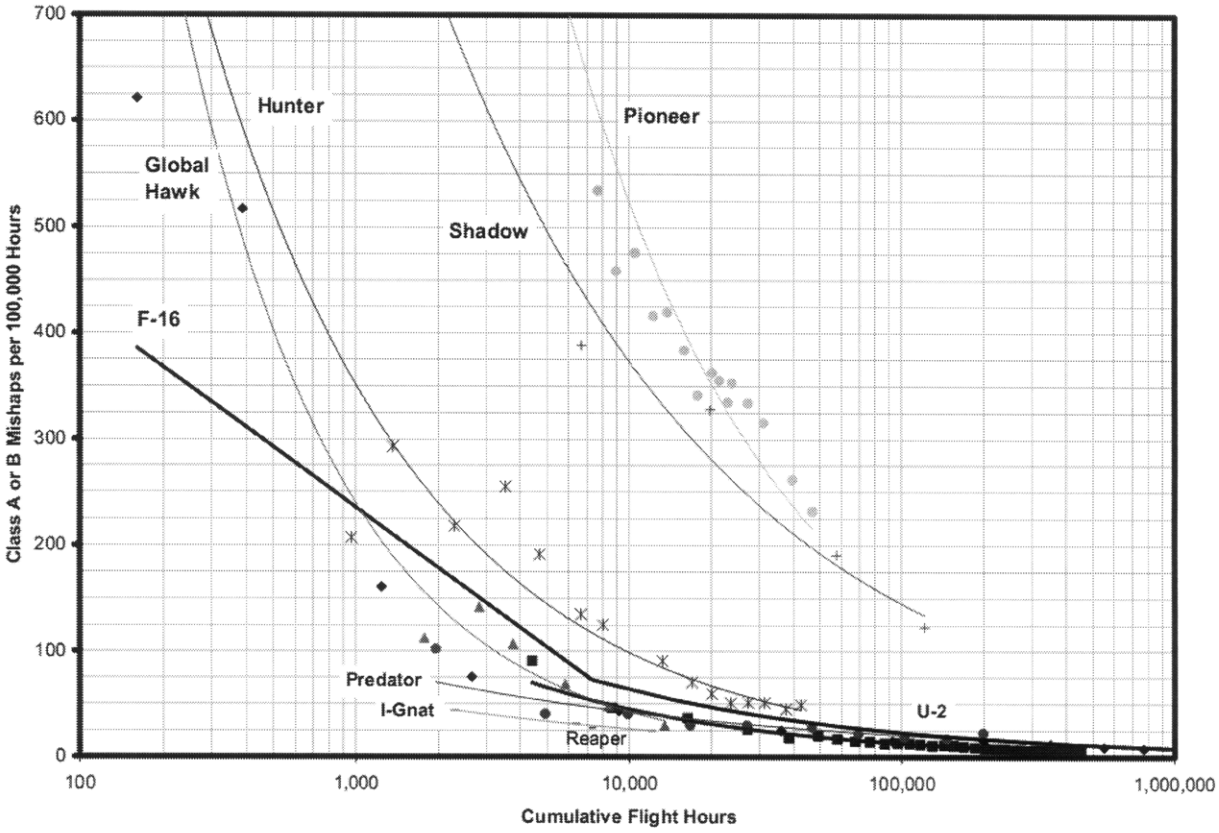


Figure 1-7. Aircraft and UAS Class A Mishap Rates (Lifetime), 1986-2006.

The question of military utility was unequivocally answered from the author's perspective in an interview with a UAS pilot recently returned from duties as part of the Combined Air Operations Center (COAC) managing the operation of air assets. He attested to the significant contributions UAS were making at the operational level. [28]

To tie the GWOT, Air Force, and UAS context together in a more explicit fashion, the Level 3-5 UAS currently in such high demand provide a cost effective mechanism by which the Air Force can meet the growing need to apply capability to the "find" aspects of irregular warfare. The unique capabilities of a UAS to remain aloft and over the battlefield for extended periods provide a "persistence" to delivered ISR products heretofore unavailable to warfighters. As warfighters come to rely on the capabilities the UAS platform provides them during wartime, the demand for their services increases, and they become more and more integrated (and consequently critical) to successful military operations—especially in the irregular warfare context.

As alluded to before, UAS proliferation also provides a much more cost-effective path to increasing the "find" capability of the Air Force. UAS can be modified and tested much more easily and rapidly because they represent a significantly lower degree of overall risk in the event of failure (at least from a military operations perspective). If an asset crashes, there is the loss in the physical platform, but barring the event that the aircraft actually crashes into a person on the ground, there is no loss of human life as a result of the mishap.

In conclusion, the Level 3-5 UAS capability is an all-around winner from the Air Force perspective. It provides a mechanism for rapidly increasing the type of combat capability needed to realize significant portions of Gen Moseley's vision to "see anything on the face of the earth; range it; observe or hold it at risk; supply, rescue, support or destroy it; assess the effects; and exercise global command and control of all these activities." It is no wonder, then, that the numbers of assets and the budget allocated to their procurement has skyrocketed in the past seven years. In fact, their use has now gone from the exclusive province of the active duty force and is now spilling over into Air National Guard units from one coast to the other.

Accessing Airspace

There are two immediate implications from the rapid explosion on the number of UAS and their growing importance to the DoD: training requirements and operations. Up until 2006, nearly all of the Air Force UAS training requirements were being met within what is called "segregated airspace." This segregated airspace is categorized as restricted military airspace by the Federal Aviation Administration (FAA), and the Air Force provides air traffic management for the operations being conducted within it. It is called restricted airspace because civil air traffic is prohibited from flying through the airspace in the course of normal operations. Consequently, there is only cooperative air traffic within this airspace, allowing the Air Force air traffic controllers to monitor where everyone is and ensure appropriate separation between manned and unmanned aircraft operations.

Active duty units receiving UAS assets were historically located within or very near these chunks of restricted airspace. It was a relatively straightforward matter for them to coordinate and secure the restricted airspace they needed for training purposes. Two things occurred that complicated this picture. First, the sheer number of students that needed to be pushed through

the training pipeline grew considerably as the number of UAS in operation increased and new operational squadrons and wings were stood up. This stretched the available restricted airspace capacity to the limits. Second, the decision was made to replace some Air National Guard assets with UAS units. This decision was made largely within the political context, and not with an eye toward the limitations of trying to train and operate UAS assets within the broader national airspace system structure. As a consequence, none of the proposed Air National Guard UAS units had readily available access to restricted airspace, even if there were still remaining capacity in the restricted airspace to conduct these additional training missions.

The other inherent problem with the use of restricted airspace for training missions is the lack of diversity in the environment afforded to the student. This is true from both the pilot's standpoint as well as the sensor operator/analyst's perspective. To provide more capable crews to the warfighter, and to shorten the spin-up time once a new crew began actual operations, a representative target environment is needed to train against. The terrain located within the available restricted airspace has significant limitations in this regard.

The second major development with respect to the impact on airspace requirements was the decision to standup a UAS main operating base (MOB) for Global Hawk within the continental United States (CONUS). This meant UAS would no longer be operating within restricted airspace, but rather transiting nonsegregated airspace managed by the FAA's air traffic organization (ATO) en route to the operational objective area. In addition, Global Hawk would also need to fly through international airspace once it left U.S. airspace, and be capable of complying with international flight standards agreed to by treaty.

The practical ramification of these events was a significant increase in the number of requests by the Air Force for access to nonsegregated portions of the NAS. The catch with these requests was (and still is) the fact that current USAF Level 3-5 UAS are not capable of flying in compliance with all of the regulatory requirements for flight in the NAS. The most often cited example of this shortfall is the requirement found in §14 CFR 91. Paragraph b of section §91.113 requires the following:

> "(b) *General.* When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained

> by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear." [29]

The obvious shortfall is how the person operating the UAS will "see and avoid other aircraft" in the normal course of UAS operations through nonsegregated airspace. A more thorough treatment of this challenge is presented in Chapter 2. For the purposes of the discussion here, it is sufficient to simply point out that the request to operate UAS in their current configuration outside of restricted airspace presented a problem the FAA needed to address—how to authorize UAS flights not fully compliant with regulatory requirements.

The upshot of this situation was the decision to use the Certification of Authorization/Waiver or COA process to provide approvals by exception. Through this mechanism, the FAA can prescribe operational limitations or put procedural mechanisms in place to mitigate the safety concerns associated with the UAS operation in nonsegregated airspace. The number of requests for COAs landing on the FAA's doorstep has increased substantially in the past four years, to the point where the FAA actually implemented an online COA application process in 2007 for UAS operational requests to mitigate some of the impact. [30]

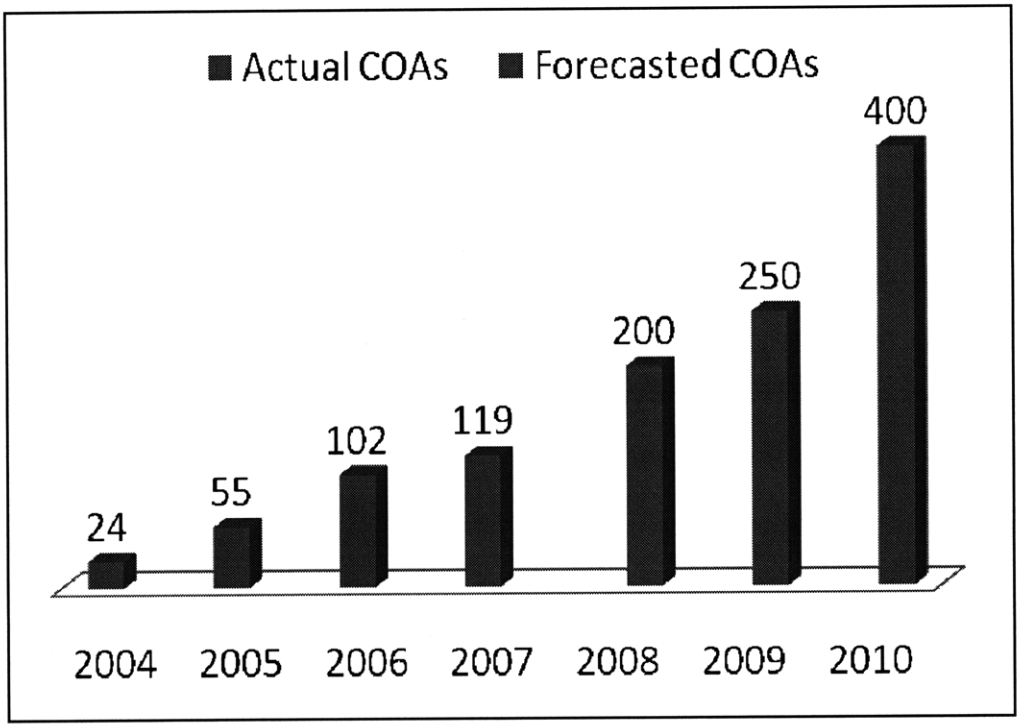


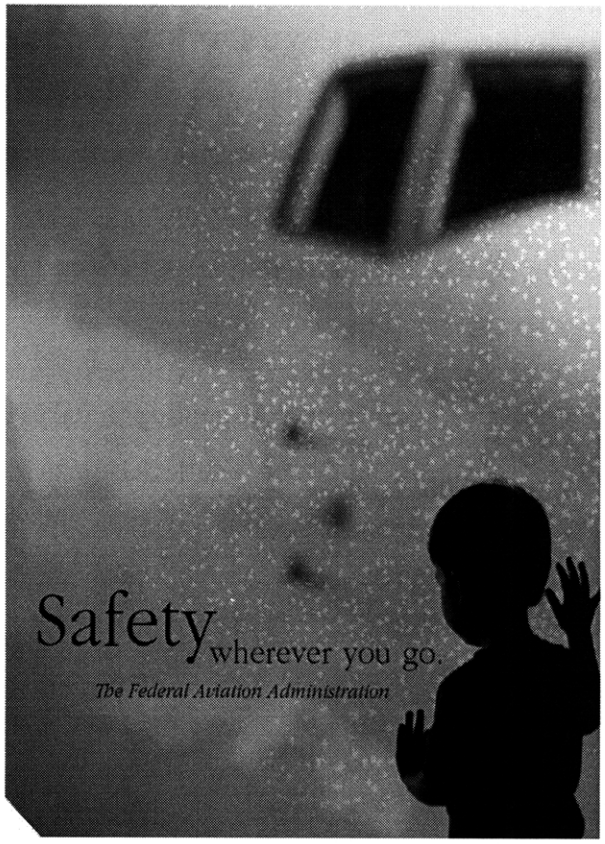
Figure 1-8. FAA ATO Data on Number of COAs Submitted/Forecasted for UAS.

It is worth pointing out that the COA process is intended for non-standard types of approvals, and there is no intention on the part of the FAA to turn the current COA baseline into a "normal" mechanism by which to secure operation approval for UAS flights. Published lead times for COAs are 60 days, and the authorization is only good for a maximum of one year (by law). It can be revoked at any time by the FAA if there is reason to believe the safety of the operation is in question, and upon expiration, the COA must be renewed before UAS flight operations can resume.

In summary, the issue of airspace access for training and operational UAS missions is a growing area of concern for both the DoD and the FAA, and there is no clear solution in-hand at present. The system today is handling the current UAS requirement, but it is unclear how long the pace can be sustained as the DoD continues to increase the operational tempo of deploying UAS assets, the number of COA requests increases to accommodate the growing requirements, and as the airspace continues to become more congested in both the segregated and nonsegregated airspace domains.

Impact on the Federal Aviation Administration

The growing pressure for more UAS access is only one of the many factors the FAA is attempting to deal with as it tries to manage the complexities of the NAS. The 2008-2012 FAA Flight Plan, titled "Charting a Path for the Next Generation," lays out their strategic imperatives:



"These are basic truths: aviation is safer than ever, capacity must expand to meet demand, and we must be good environmental stewards. The FAA's plan to redesign America's aviation system supports each of these in a way that will keep things running smoothly to 2025 and beyond." [31]

A fuller review of the flight plan will reveal four primary goals the FAA has as it moves into the future: 1) Increased safety, 2) Greater capacity, 3) International Leadership, and 4) Organizational excellence. Of these goals, the first two dominate the political context in which the FAA is operating with respect to the UAS airspace integration effort.

Safety is the North Star that rises above the ranks of all the other considerations on the horizon. The FAA culture is completely dominated and undergirded by a safety conscious mentality that has been nurtured and instilled in the institution over decades of operation. It is fundamental to every aspect of the FAA's ethos, and the word "safely" can be used almost without exception in describing any aspect of the FAA's activities or intent. Ensuring a safe flying environment within the NAS is the overriding purpose of the organization.

Within the FAA, the Aviation Safety organization (AVS) is the primary office of responsibility for ensuring a high-level of safety is maintained in the NAS. According to the Aviation Safety Fiscal Year 2007 Business Plan, the singular mission of the AVS organization is "to promote aviation safety in the interest of the American public and the millions of people who rely on the

aviation industry for business, pleasure, and commerce." In order to fulfill this mission, the AVS organization directs and manages safety programs that fall into three primary areas: 1) Continued Operational Safety, and per their own document, this is "AVS's most important function (and one that AVS will never compromise)…", 2) Standards and Policy, and 3) Certification. [32]

The AVS 2007 Business Plan also lists and comments on the 2008-2012 FAA Flight Plan, and it specifically calls out the first goal, Increased Safety, as the one for which the AVS organization as a whole is the goal lead for the entire FAA organization, while it provides a supporting role in the accomplishment of the other 3 objectives. Thus, the AVS organization collectively is intensely focused on the issue of aviation safety in every aspect of its operations, and it seeks to improve the safety of the National Airspace System (NAS) through multiple initiatives and activities.

If the issue of safety dominates the FAA landscape, the question of capacity is gaining rapidly on the safety position. The statistics reported by the Department of Transportation Bureau of Transportation Statistics say that for calendar year 2007, a near record 26.58% of all flights by major airlines in the U.S. were delayed, cancelled, or diverted. [33]

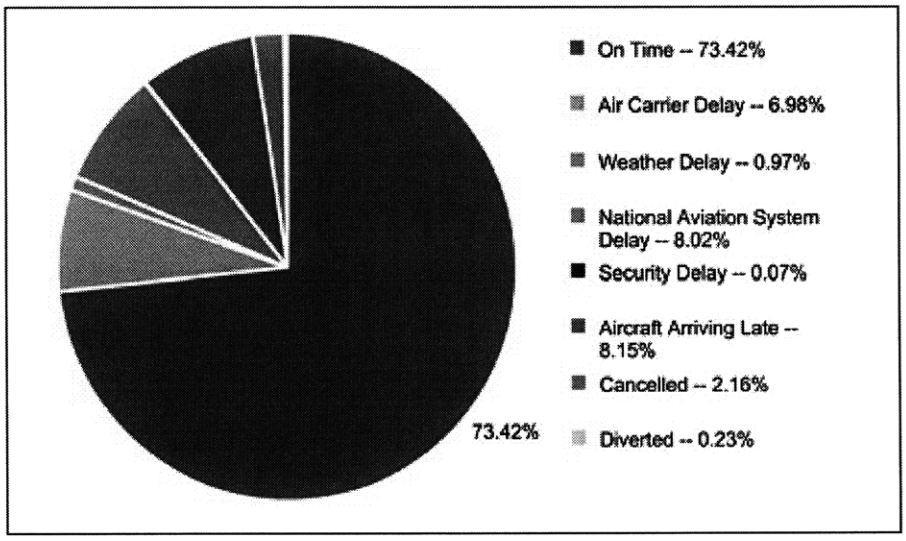


Figure 1-9. On-Time Arrival Performance, National (January-December, 2007).

Taking up this theme, the New York Times ran an Associated Press article on 6 February 2008 that investigated the U.S. airline industry performance further in 2007. The AP investigation found that the only year with a worse overall performance for on-time arrivals was in 2000, but if

outright cancellations are excluded, 2007 was the worst year on record with 24.2% of flights arriving late. [34]

To the FAA's credit, the difference in the volume of air traffic between 2000 and 2007 is substantial. In 2000, there were 31% fewer total number of flights than in 2007, and the demographics are continuing to change as more and more airlines shift to smaller, regional jet service and fewer larger aircraft. [34] When viewed in this manner, the FAA has had a herculean task on their hands just to limit the overall performance degradation to as little as it has been in the past couple of years.

The nation has not been oblivious to the need for an overhaul and revamping of the NAS infrastructure and enabling processes. In 2003, President Bush signed the "Vision 100" legislation (Public Law #108-176) that established the mandate for the design and deployment of an air transportation system that would meet the demands of the nation in the year 2025. The bill also established the Joint Planning and Development Office (JPDO) to carry out this mission. Out of this activity, the Next Generation Air Transportation System (NGATS or NextGen) program took shape. [35] The 2005 NextGen Vision briefing articulates eight key capabilities the new system will need to provide in order to meet the demands of 2025:

- Network-Enabled Information Access
- Performance-Based Services (now Performance-Based Operations and Services)
- Weather Assimilated into Decision Making
- Layered Adaptive Security
- Broad-Area Precision Navigation (now Position, Navigation and Timing Services [PNT])
- Aircraft Trajectory-Based Operations
- Equivalent Visual Operations (EVO)
- Super Density Operations

The JPDO effort is a joint initiative of the Department of Transportation (DOT), the Department of Defense (DoD), Department of Commerce (DOC), Department of Homeland Security (DHS), National Aeronautics and Space Administration (NASA), and Office of Science and Technology Policy (OSTP) in the White House. The NextGen goals are to retain U.S. leadership in global aviation, ensure safety, ensure our national defense, expand capacity, protect the environment,

and secure the nation. The JPDO's role is to establish a transformation path for the air transportation system to realize these goals and provide the required capability. [35]

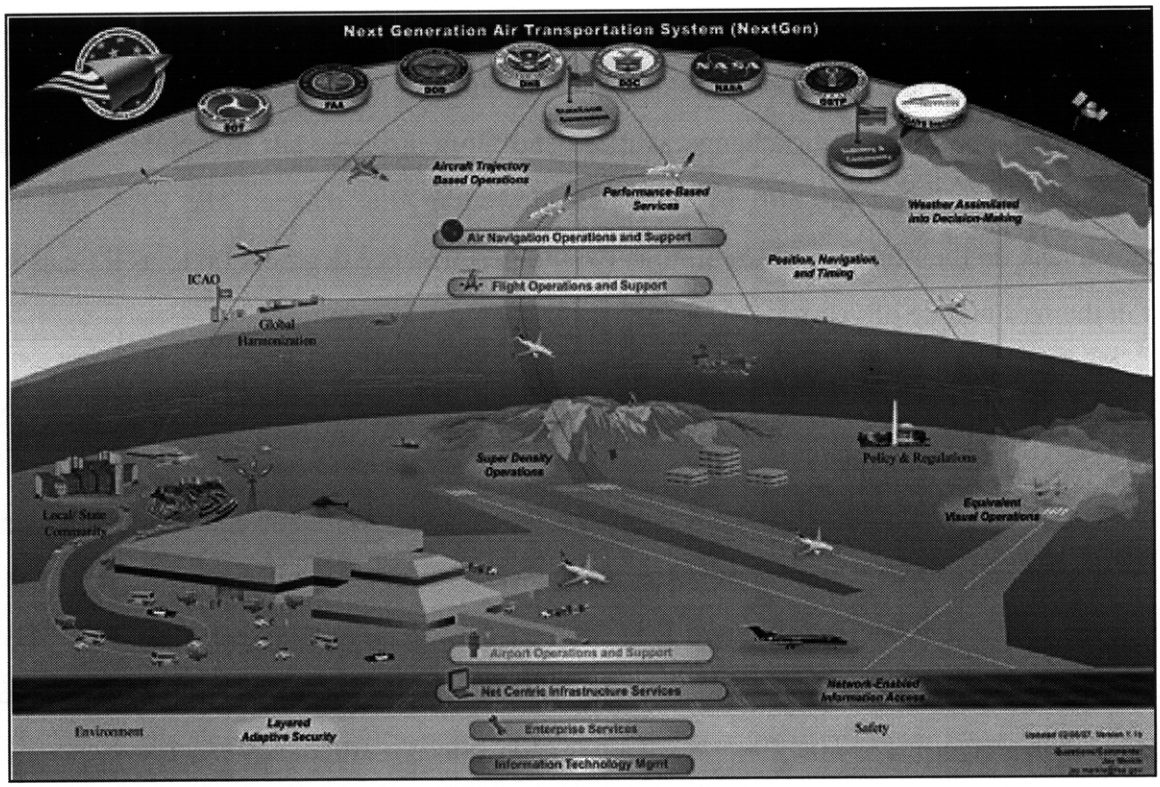


Figure 1-10. The NextGen Operational View.

What makes the FAA's task in all of this so much more difficult is the need to maintain the safety of the NAS even as it is in the process of transforming it to meet the demands of tomorrow. This is further complicated by a culture that has traditionally assessed the safety of an operation or process based largely on their expertise and knowledge of their people as opposed to an objective performance-based set of measures.

The Safety Management System (SMS) the FAA is in the process of implementing would change this type of evaluation significantly. [36] The ATC specialist performs the safety assessment but is now augmented with a team approach when appropriate, coordinated with impacted organizations, and applying a formal safety risk management process. The results are a more standardized and complete set of documentation with continuous verification and monitoring of procedure and any required mitigations.

In short, the FAA is not only attempting to deal with the rapidly growing number of requests for military COAs to operate UAS outside of restricted airspace, there is also a tremendous amount of political pressure on the FAA to maintain the existing rate of accidents (note that this actually requires an increase in the overall safety of the system as the number of aircraft and flights continues to rise) and to increase the capacity of the NAS to meet current and future demand projections. All of this must take place in a safety culture that is attempting move out of "expert" based judgments and into a more formalized objective performance-driven process. The stakes for making sure the NextGen effort is accomplished correctly are tremendous, and the public is becoming increasingly impatient with a perceived degradation in the quality of air transportation services. And like everyone else, the FAA is underfunded and undermanned to do the job the way they think they need to.

Chapter 1 Summary

The five strategic drivers just described illustrate the dynamic environment in which the UAS airspace integration enterprise is operating. These strategic drivers include the Global War on Terror, the United States Air Force, the Rise of UAS, Accessing Airspace, and the Federal Aviation Administration. Each of these drivers impacts the issue of UAS airspace integration directly, and each of them influences and affects the others. The result is a complex set of interactions that provides the backdrop against which the UAS airspace integration effort operates. Ultimately, a solution for the UAS airspace integration challenge must address these broader issues if a sustainable effort is to be launched.

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CHAPTER 2 – INTRODUCTION TO UAS AND AIRSPACE INTEGRATION

"We have just won a war with a lot of heroes flying around in planes. The next war may be fought by airplanes with no men in them at all."

—General Hap Arnold

United States Army Air Forces

VJ Day, 1945

Over 60 years ago, General Arnold had the vision to see the potential impact that aircraft flying without pilots could have on the face of warfare. The U.S. military is just now beginning to realize the fruits of General Arnold's vision of the future with the platforms that are being fielded and the changes in doctrine that are occurring to exploit their capabilities more fully.

Chapter 2 picks up where Chapter 1 left off by diving into the details of the historical development of UAS and the recent efforts at integrating them into the NAS. The purpose of Chapter 2 is two-fold. First, it provides the reader with a brief history of unmanned aviation to ground the methodology and application discussion following in Sections II and III. Second, the chapter provides a discussion on recent efforts over the past five years targeted at UAS airspace integration. This overview is intended, in conjunction with Chapter 1, to provide the reader with a broad sense of the context motivating this research. It should also provide a sense for the robustness needed in any methodology development to adequately address the scope and number of issues that must be handled in a full treatment of the subject, not the least of which is a large number of different organizations engaged on the topic.

A Brief History of Unmanned Aircraft[1]

"On August 22, 1849, the Austrians, who controlled much of Italy at this time, launched some 200 pilotless balloons against the city of Venice… Some of the bombs exploded as planned but the wind changed direction and blew several balloons back over the Austrian lines. This is, by most accounts, the first recorded action of its type." [37]

[1] Author's Note: Unless otherwise referenced, this section is taken almost directly and in its entirety from Laurence "Nuke" Newcome's book, Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles, and a summary article he wrote for Defense News in 2003.

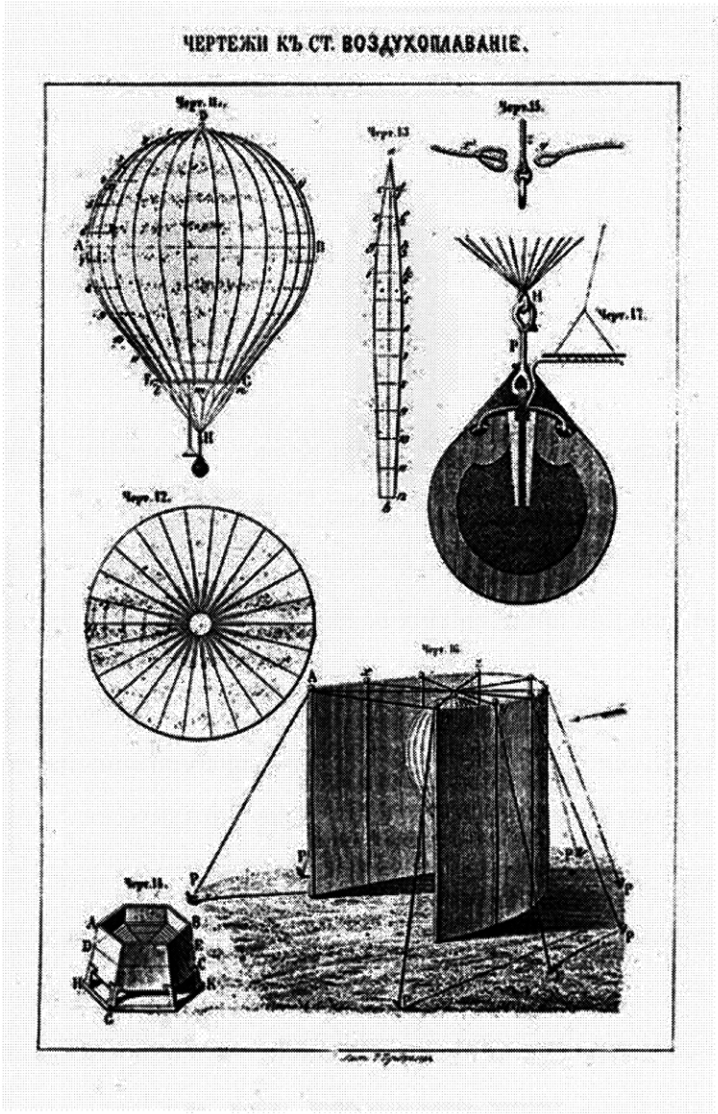


Figure 2-1. Early Schematic of Balloon Use for Dropping Bombs. [37]

And so began the advent of unmanned aerial platforms in a wartime role. What should be instructive in the above information is the fact that militaries have actively considered how to employ unmanned systems of all types and sizes for well over the past 160 years. The limitation has not been on the theoretical application of these assets, but rather, on the technological capability to realize their full potential. The quote at the beginning of this chapter from General Arnold demonstrates the extent to which thinking had progressed by the end of World War II with respect to unmanned aircraft systems. We are only just now, 60 years later, beginning to understand the true extent of their potential capabilities and uses.

In its broadest definition, unmanned aircraft systems are those that are capable of aerodynamic flight without a human on board. As Newcome points out,

> "Starting from its roots as an 'aerial torpedo', the forerunner of today's cruise missiles, its family tree has branched to include guided glide bombs, target drones, decoys, recreational and sport models, research aircraft, reconnaissance aircraft, combat aircraft, and even exotic astroplanes, aircraft designed to fly in the atmospheres of other worlds. Unmanned aircraft in these first two branches are widely referred to today as 'precision guided munitions' (PGMs) and in the last four as 'unmanned aerial vehicles' (UAVs)." [38]

Over the past several years, those class of platforms described by Newcome as unmanned aerial vehicles have been re-designated as "unmanned aircraft systems" in recognition of the fact that the air vehicle portion of the unmanned capability is just one subsystem of a whole integrated suite that enables the air vehicle portion to operate as desired. The broader definition of UAS explicitly includes the air vehicle, the ground station, the communications, command and control, and other supporting infrastructure needed for the UAS to carry out its intended function.

The development of UAS capability hinged on the concurrent development of three critical technologies: automatic stabilization, remote control, and autonomous navigation. Elmer Ambrose Sperry was the first person that attempted to address all three in a single unmanned aircraft design. He delivered his first purpose-built unmanned aircraft to the Navy in 1919. While the overall effort failed in terms of the Navy context (unmanned aircraft with which to launch torpedoes), the development leading up to it resulted in the singular accomplishment of the first successful flight of a powered unmanned aircraft on 6 March 1918—the unmanned aircraft equivalent to the Wright brothers' flight at Kitty Hawk some 15 years earlier.

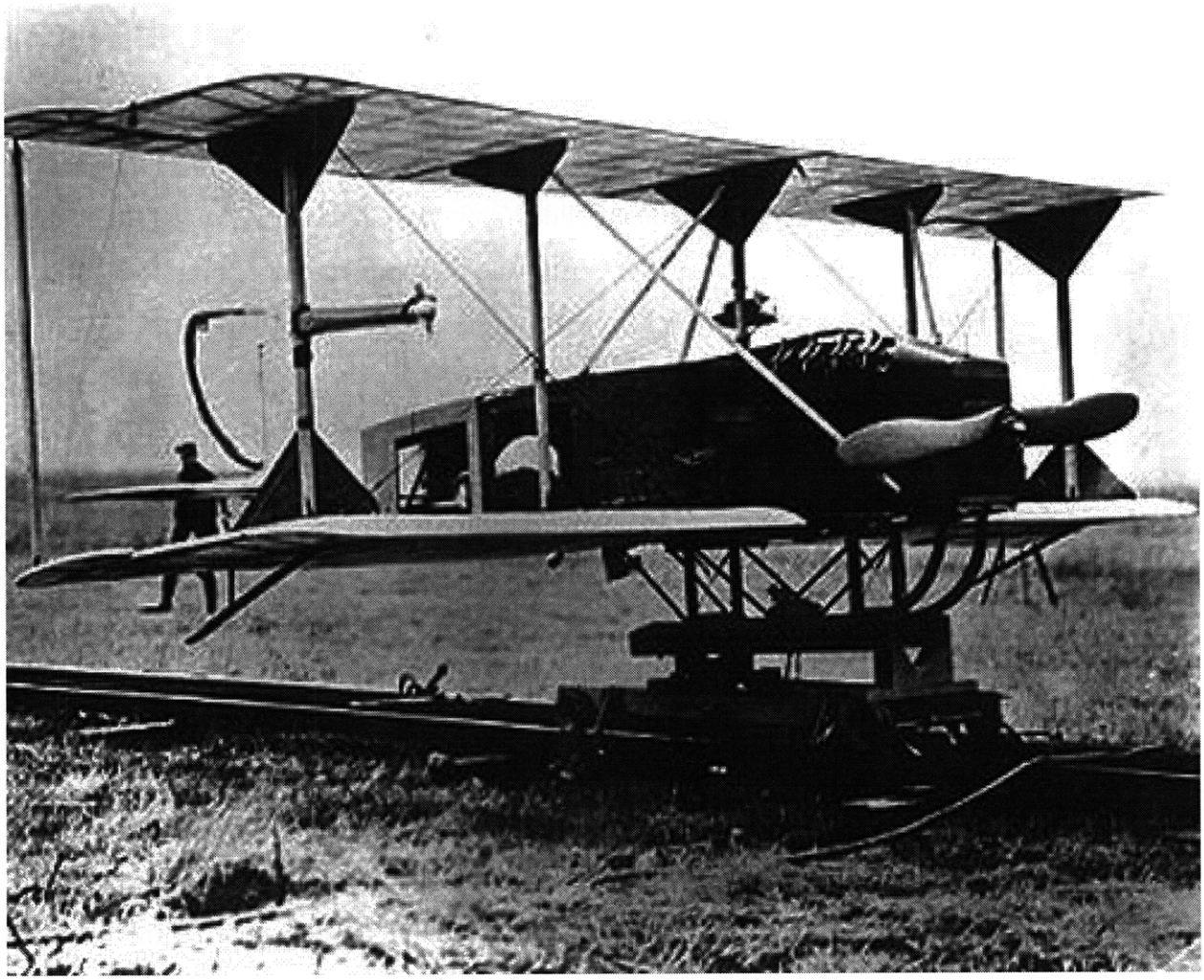


Figure 2-2. Picture of the Sperry Aerial Torpedo, 1918. [37]

By 1924, an aircraft had been launched, operated through a series of 50 different commands, and landed all by remote control. By the 1930's, target drones were being flown by both the U.S and Britain as spin-offs of early cruise missile efforts. By the end of the decade, there were hundreds of these target drones being flown as target practice for anti-aircraft gunnery training. In the U.S. Army, target drones sprang from the new hobby of RC model planes, introduced by Reginald Denny, who ran a Hollywood hobby store as a sideline to his acting career. Denny modified his model plane design to meet the Army's training needs and sold over 15,000 of them to the Army before and during World War II.

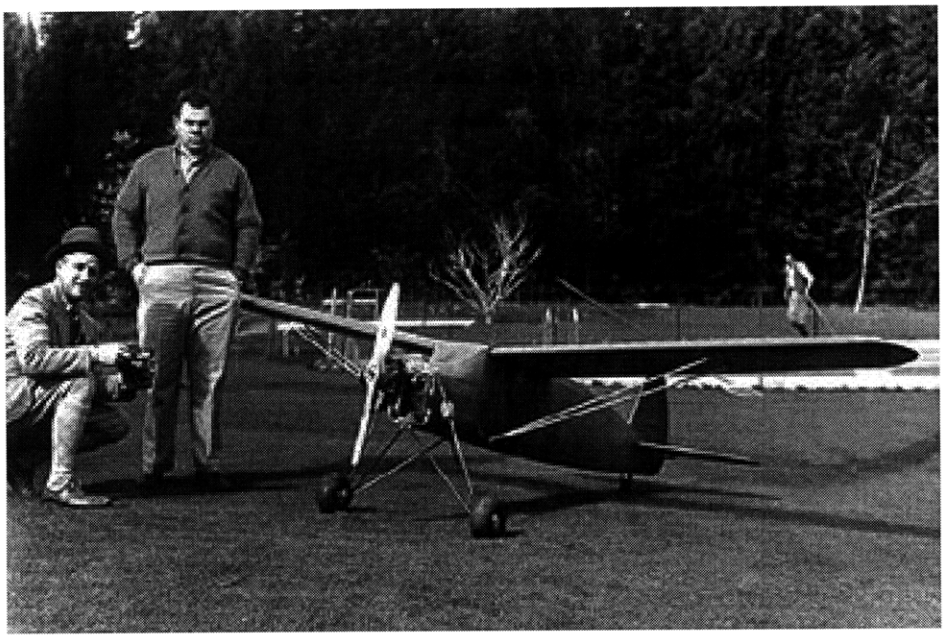


Figure 2-3. Picture of the Denny RP-1, 1935. [37]

It was Germany's work during the course of World War II that significantly advanced the state of the art, primarily in the area of precision guided munitions and the development of the V-1 cruise missile. A 1944 British assessment comparing the cost to the Germans of waging the V-1 campaign against the cost of its impact on the Allies concluded the V-1 offered a 4 to 1 return on its investment, thus cementing the role of cruise missiles in future wars. [39]



Figure 2-4. Picture of a V-1 Rocket from World War II. [37]

The 1950's saw the advent of the reconnaissance drone for military use, and the growth in these platforms was explosive over the next couple of decades. It was also during this timeframe that the inertial navigation system was finally perfected, and the third and final technological key to realizing the full potential of UAS was finally unlocked. Charles Stark Draper of MIT led the

effort to develop this capability to provide self-contained navigation and guidance from the end of World War II right up to its use on the Apollo moon flights.

Contrary to popular belief, the recent use of Hellfire missiles from Predators over Afghanistan and Iraq did not introduce the strike role to UAS. That was done when the Navy's Gyrodyne QH-50 drone helicopter demonstrated it could carry and employ anti-submarine torpedoes in 1962. This same UAV subsequently carried a mini-gun and dropped an assortment of small munitions in covert operations over Vietnam in the late 1960s. In 1972, the Air Force's Have Lemon program demonstrated the delivery of Maverick and Stubby Hobo missiles from unmanned *Firebee* UAVs for potential use in the suppression of enemy air defenses (SEAD) role.

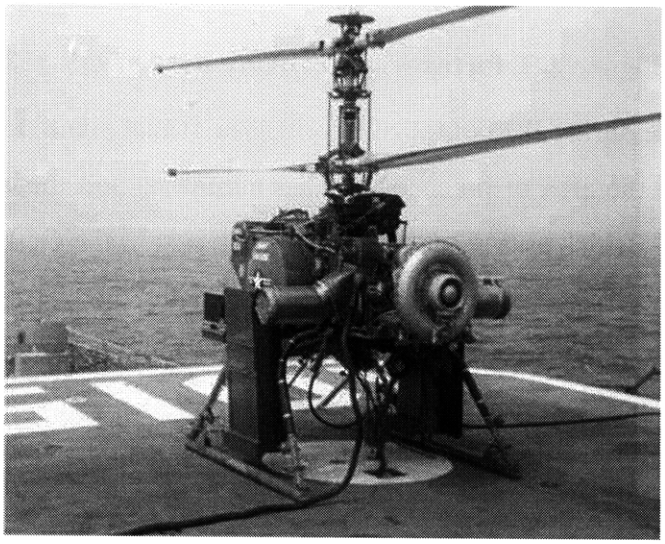


Figure 2-5. Picture of Navy Gyrodyne QH-50. [40]

As it approaches its own centennial, unmanned aviation can point to an impressive list of accomplishments:

- 1918 First flight by a powered unmanned aircraft (Curtiss Sperry Aerial Torpedo)
- 1923 First radio controlled flight (RAE *1921 Target*)
- 1933 First UAV used in the target drone role (Fairey *Queen*)
- 1943 First use of a PGM in combat (Fritz)

- 1944 First use of a cruise missile in combat (Fieseler Fi 103 "V-1")

- 1946 First UAV used in the science research role (Northrop QP-61)

- 1959 First UAV used in the reconnaissance role (Northrop SD-1 *Observer*)

- 1960 First untethered flight by an unmanned helicopter (Gyrodyne QH-50)

- 1962 First UAV used in the strike role (Gyrodyne QH-50)

- 1998 First trans-Atlantic crossing by an unmanned aircraft (Insitu *Aerosonde*)

- 2001 First trans-Pacific crossing by an unmanned aircraft (Northrop Grumman *Global Hawk*)

Reference Appendix A for a full listing of the current UAS categorization scheme in use by the U.S. military for domestic operations. Current UAS capabilities have built on the long-line of 90 years worth of engineering briefly captured in this quick UAS history overview. The capability of these platforms only continues to accelerate at ever increasing rates. The UAS under consideration in this thesis, the Predator MQ-1, Reaper MQ-9, and the Global Hawk RQ-4 represent UAS that are in heavy use by the Air Force today. As described in Chapter 1, their access to a broader category of nonsegregated airspace is quickly becoming a priority for both training and operational missions.

Recent Efforts at UAS Airspace Integration

Several noteworthy efforts have been undertaken in the past five years to make inroads into the challenging problem of getting broader UAS access to nonsegregated airspace. This thesis will refer to these efforts as UAS airspace integration (AI) efforts, and in general, they target the integration of UAS into the NAS for the purpose of conducting routine operations on the same general footing as manned aircraft. As a consequence, their general scope of activities and purpose for being roughly parallel that of the UAS AI enterprise currently "under construction" in this analysis. Understanding where and how these efforts fit into the picture provides a detailed and more thorough understanding of the issues associated with airspace integration

generally, and may provide insight relevant to the enterprise architecting effort for the desired future state of the effort.

Access 5

The first major UAS airspace integration effort was launched in the spring of 2004 when the National Aeronautics and Space Administration (NASA) Dryden Flight Research Center announced the launching of a new government-industry program called the High Altitude, Long Endurance (HALE) Remotely Operated Aircraft (ROA) in the NAS program. The intent of the program was "...to recommend the policies, procedures, and functional requirements that will ensure HALE UAVs operate as safely as other routine users of the national airspace system... We will initially be limiting our focus to UAVs that routinely operate above 40,000 feet altitude. As we gain experience, we intend to expand our focus to UAVs that routinely fly above 18,000 feet." [41]

The NASA HALE ROA in the NAS effort was initially funded as part of NASA's Vehicle Systems Program in the agency's Aeronautics Enterprise, with a planned budget of about $103 million through fiscal year 2008. The effort was to be staged in four sequential steps starting with the highest flying UAS platforms and subsequently expanding the airspace accessed in each subsequent phase. The effort built off a previous NASA project called the Environmental Research Aircraft and Sensor Technology (ERAST) project which focused on the development of airframe, propulsion and control system technologies for high-altitude, long-endurance UAVs that could serve as platforms for NASA's Earth Science Enterprise. [41]

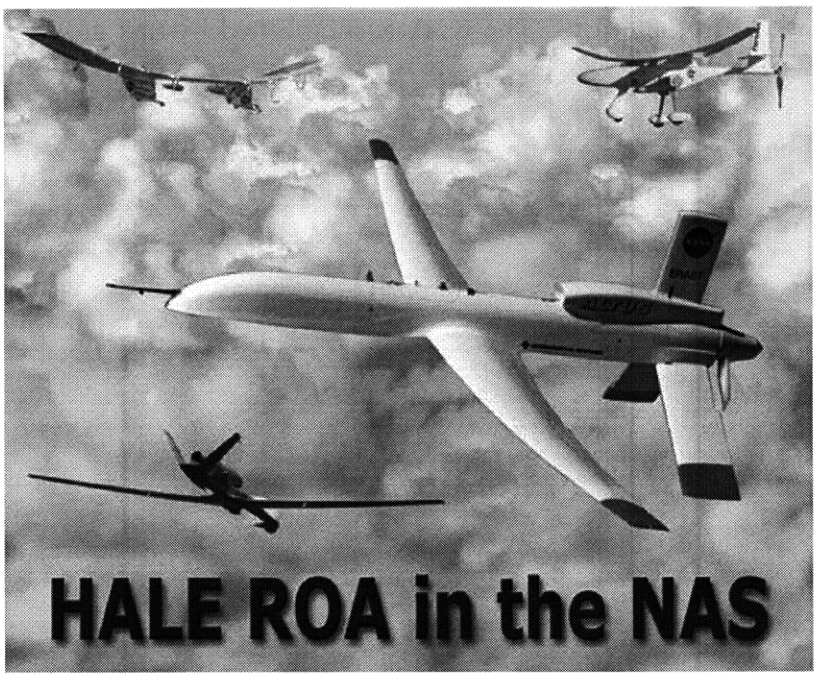


Figure 2-6. Access 5 Focus on HALE UAS Mission.

The effort initially gained critical mass through the efforts of six aerospace firms with a direct interest in development of civil as well as military uses of uncrewed aircraft – Boeing, Lockheed Martin, Northrop Grumman, AeroVironment, General Atomics Aeronautical Systems and Aurora Flight Sciences. These six companies formed the UAV National Industry Team, known as UNITE, in 2002, and were responsible for bringing the joint government-industry proposal forward to NASA for further consideration. The joint project between NASA, the DoD, the FAA, DHS and UNITE was called the Access 5 project. [41]

Unfortunately, this effort proved to be short-lived when funding was terminated by Congress in the 2006 Budget, retroactively cutting the funding off for Access 5 at the end of September 2005. A final report listing the Access 5 accomplishments was required by February of 2006. There was some speculation at the time that the NASA Administrator, Michael Griffin, may have initiated the action as NASA shifted its focus to the Mars mission in an effort to free up additional budget for the space program. [42]

A major accomplishment of this effort, however, was the relatively wide participation of the previously named agencies in the Access 5 program. Figure 2-7 depicts the inter-agency

organizations involved in the effort. The work accomplished by this group provided an initial point of departure for the efforts that followed.

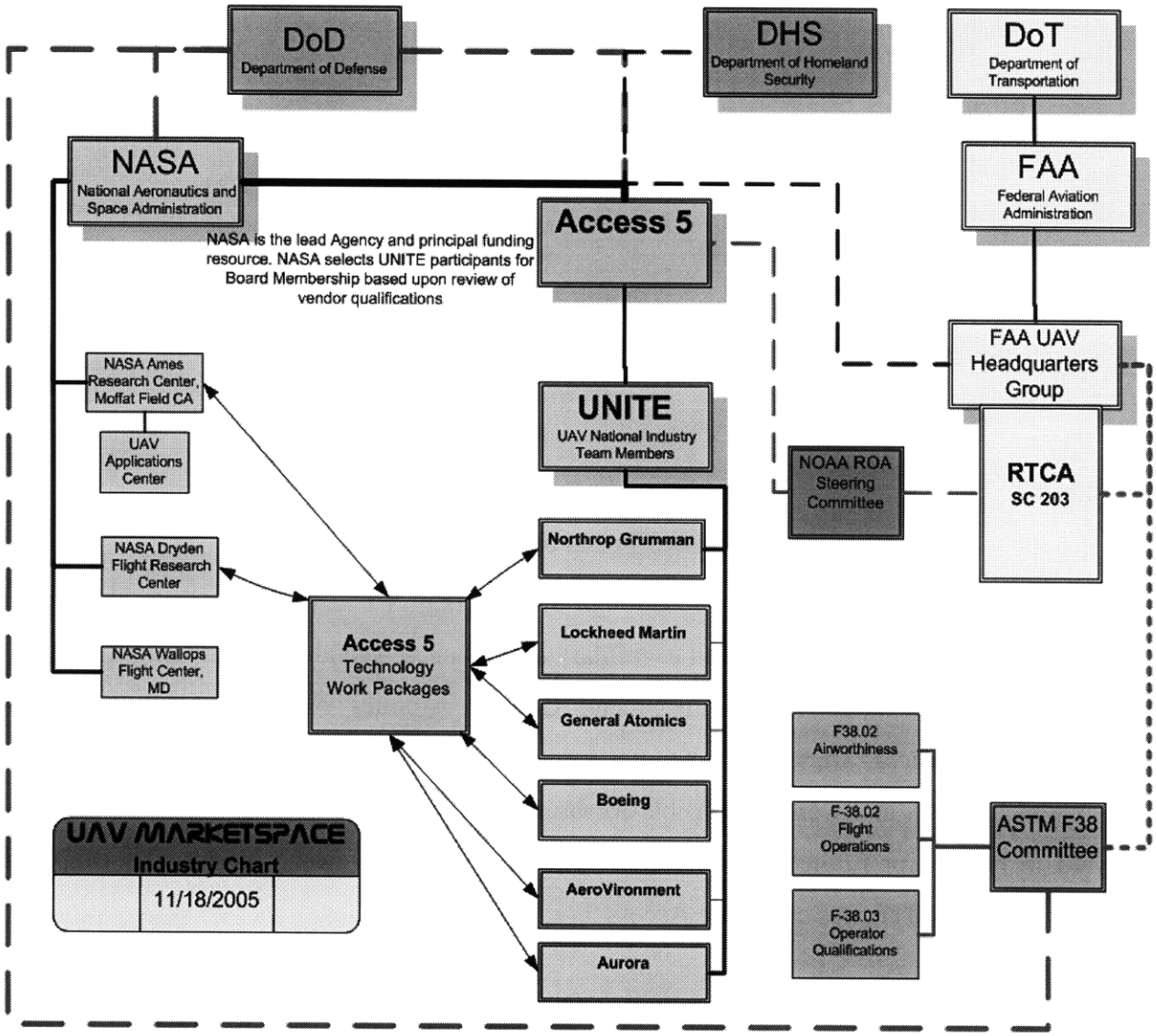


Figure 2-7. Access 5 Organizational Structure and Stakeholders.

RTCA-Special Committee 203

Hard on the heels of the Access 5 termination, the FAA's federal advisory committee, the RTCA, was asked to stand up a special committee to create Minimum Aviation System Performance Standards (MASPS) for UAS; Command, Control and Communication MASPS for UAS; and Sense and Avoid Systems MASPS for UAS. [43] The RTCA responded to this direction by creating the Special Committee (SC) 203 on 19 October 2004. Per the RTCA website [44], the RTCA activity is described as follows:

> "RTCA, Inc. is a private, not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management (CNS/ATM) system issues. RTCA functions as a Federal Advisory Committee. Its recommendations are used by the Federal Aviation Administration (FAA) as the basis for policy, program, and regulatory decisions and by the private sector as the basis for development, investment and other business decisions."

Underneath of the RTCA organization, various special committees (SC) are established to pursue specific, issue-oriented products. These SCs are the primary organizational elements by which the RTCA carries out its mandate. The SC-203, entitled *Minimum Performance Standards for Unmanned Aircraft Systems and Unmanned Aircraft*, has the afore mentioned goals of developing the associated MASPS for UAS; Command, Control and Communication; and Sense-and-Avoid.

Per the SC-203 Terms of Reference, "SC-203 recommendations will be based on the premise that UAS and their operations will not have a negative impact on existing NAS users." [43] The Special Committee itself is comprised of an incredibly diverse cross-section of interested parties from across the aviation community (see Appendix B for a complete listing of SC-203 participants). Essentially, nearly all of the work the RTCA does is accomplished by volunteers that are interested and/or concerned about the subject or issue under investigation. Per the SC-203 publications the following guidelines pertain to the manner in which the SC-203 operates:

> "As with all Federal Advisory Committee activities, Special Committee meetings are publicly announced and open to participation by anyone with an interest in the topic under consideration. During Special Committee meetings, volunteers from government and industry explore the operational and technical ramifications of the selected topic and develop consensus-based recommendations. These recommendations are then presented to the RTCA Program Management Committee, which either approves the Special Committee report or directs additional Special Committee work." [44]

The complexity of the SC-203 task created some initial turmoil on the effort in terms of how to even frame an approach to working on the myriad of issues associated with the three MASPS the terms of reference required. The Committee was finally able to settle on an approach, and they

have since published the *Guidance Material and Considerations for Unmanned Aircraft Systems* document with an overarching programmatic framework for moving forward.

The all-volunteer nature of the SC-203 activities is both a blessing and a curse. On the one hand, it provides an excellent forum in which to generate broad community support and consensus for how the standards for regulating the operation of UAS in the NAS should be pursued and developed. The result once the process is completed should be a solid base of support the FAA can point to as it begins its own internal rule-making process. It also provides a richer solution set from which to draw possible approaches to the problem given the broad diversity of the participants in the process.

Unfortunately, the effort is not funded. As a volunteer organization, progress can only be made at the rate people are willing to volunteer time and/or resources to further the effort. This aspect becomes especially problematic as the effort moves out of the theoretical and into the applied domain. In order to validate or otherwise substantiate the standards being proposed, some level of testing and evaluation will be needed. This data collection effort will ultimately require the expenditure of significant resources for further progress to be made on the SC-203 front.

In an effort to close this shortfall, the SC-203 looked to create a set of relationships with current UAS operators to coordinate approaches and to eventually get access to data. The primary UAS operator at this point is the DoD. The SC-203 is looking expressly to the DoD UAS Airspace Integration Joint Integrated Product Team (JIPT) for help in acquiring the data they need to continue the MASPS development effort.

DoD UAS Airspace Integration Joint Integrated Product Team

The DoD UAS Airspace Integration Joint Integrated Product Team (referred to hereafter as the "JIPT") is an effort that was formally initiated in the fall of 2005 by the Navy, Army, and Air Force UAS materiel program managers. These three O-6s recognized a common shortfall in their ability to meet user specifications requiring UAS that were capable of operating in a routine, integrated fashion both in the NAS and in international civil airspace.

The effort was initially sparked by a series of events in which the Global Hawk program spent considerable resources to integrate the TCAS system on the RQ-4 platform under an agreement

with the regional FAA offices in Sacramento for operations out of Beale AFB, CA. At that time, Certificates of Authorization/Waiver approvals, or COAs, were reviewed and approved at the regional level. Prior to Global Hawk operations commencing at Beale AFB, however, the FAA decided to pull the COA approval authority back to the FAA headquarters-level over some concerns about the degree of consistency and insight the FAA had into these operations. [30]

The practical result of this action was that the FAA headquarters review of the Global Hawk COA resulted in the determination that the procedures and equipment agreed to at the regional level were not sufficiently safe for the operation to be approved. The review further determined the TCAS capability was not only insufficient, but the Air Force could not even turn TCAS on due to FAA concerns over the impact that communication lags might have on the resolution advisories the system generated and the time required for pilots to actually cause a course change in the UAS flight path.

This created an understandable degree of consternation and frustration on the Air Force side of the equation. Shortly thereafter, the Global Hawk program manager was promoted to the job of managing the entire materiel UAS portfolio for the Air Force. With the events of the Global Hawk experience still fresh in his mind, the Reconnaissance Systems Wing commander (now designated as the 303d Aeronautical Systems Wing or 303 AESW) began to consider how best to go about avoiding another such incident in the future. In this frame of mind, he contacted his counterparts in the Navy and Army to ascertain the extent to which this was a problem for the other services. All three found themselves facing the same overarching issues, and they agreed to tackle the problem jointly.[45]

The JIPT effort was the realization of their combined commitment to resolving the growing issues they each faced with producing UAS capable of integration with the NAS. The original charter for this group stated the following as the JIPT mission:

> "The JIPT will develop the standards, policy, and enabling technology necessary to; (1) integrate unmanned aircraft operations with manned aircraft operations in non-segregated airspace, (2) integrate resources and activities with Industry, and other airspace regulatory authorities to achieve greater alignment with DoD goals and objectives, (3) ensure compatibility and interoperability of global access enabling technology and air traffic

control procedures and (4) provide the necessary documentation to effect changes in the global air traffic control systems. This mission will be accomplished through establishment of Sub-IPT's (SIPT's) comprised of appropriate DoD subject matter experts, working cooperatively with external stakeholders to meet user and airspace controlling authority goals and objectives." [46]

The effort was led by the three O-6s, and they each appointed a deputy to serve as the day-to-day managers for the JIPT's strategy and activities (of which the author was one). After an initial meeting in the fall of 2005, and approval of the charter in December 2005, the overall strategy for proceeding was agreed to in March 2006. Figure 2-8 depicts this overall strategy. The key point to this approach is that it employed a two-track methodology. The first track was focused on developing a common DoD-FAA assessment process for near- to mid-term operations that would extend the existing COA process. The second track was geared toward the far-term "file-and-fly" level of integration and paralleled the efforts of the SC-203 in many respects. [47]

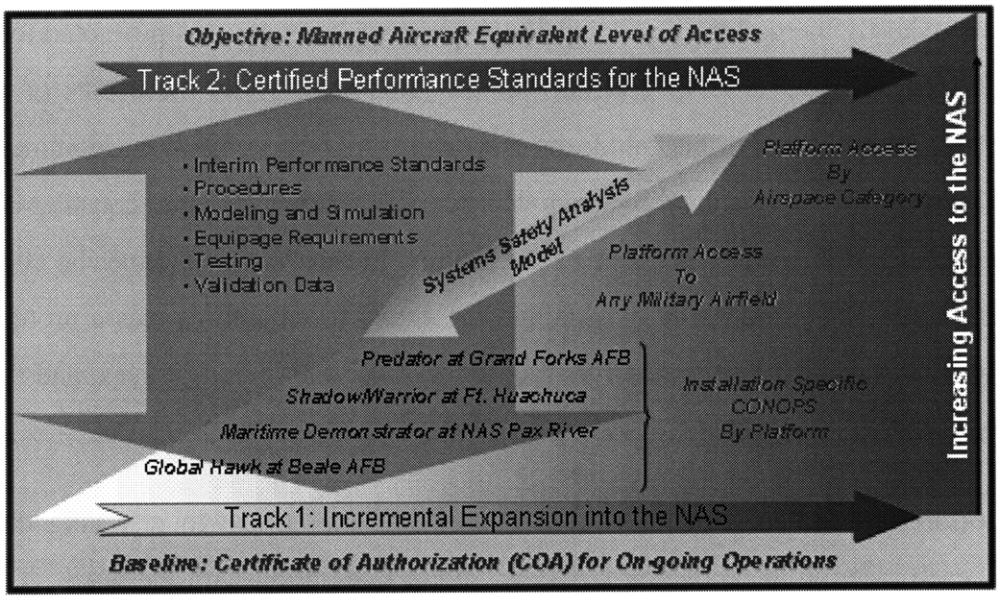


Figure 2-8. JIPT Two-Track Approach.

This overarching construct found wide, general approval among the participating JIPT organizations, including the FAA's Unmanned Aircraft Program Office, AIR-160. The FAA stood up the AIR-160 office in the fall of 2005 to provide an FAA focal point for the growing UAS activity, and to interface directly with DoD and Industry to address the growing needs and requirements of these types of aircraft. The AIR-160 office also provided the needed UAS

expertise to assist the AIR-200 office with conducting the appropriate UAS experimental aircraft certification inspections required civilian industry to obtain approvals to operate UAS in the NAS.

The organizational structure of the JIPT is depicted in Figure 2-9. The primary organizational structures, as called out in the JIPT charter, were the SIPT's and their focus on specific aspects of developing airspace integration performance standards. These SIPT's were assisted and integrated in their activities through various Activity Centers (AC's) that would collect the individual needs and requirements from each SIPT and synthesize an integrated plan for that particular activity set. Note that the number of external stakeholders involved in the JIPT activities was fairly manageable; however, the number of internal organizations rapidly grew to a significant number of different activities that proved to be both unwieldy and inefficient given the "virtual" environment in which the activity was attempting move forward.

As in the other cases, the funding for this effort was an issue. In essence, the three O-6's leading the effort collectively decided they needed to take the required dollars "out of hide" since the effort had not been specifically funded in the existing budget. The requirements existed for the work, but up to this point, there had been no allocation of money to the problem of airspace integration—at least at the materiel solution provider's level. All told, the JIPT planned an initial budget of ~$3M in 2006 (of which they actually received on the order of $550K). The funding did begin to pick up in 2007 with the previously requested amount of $3M, and in addition, there were more funds applied from an international source that brought the total up to approximately $6M in funding for 2007.

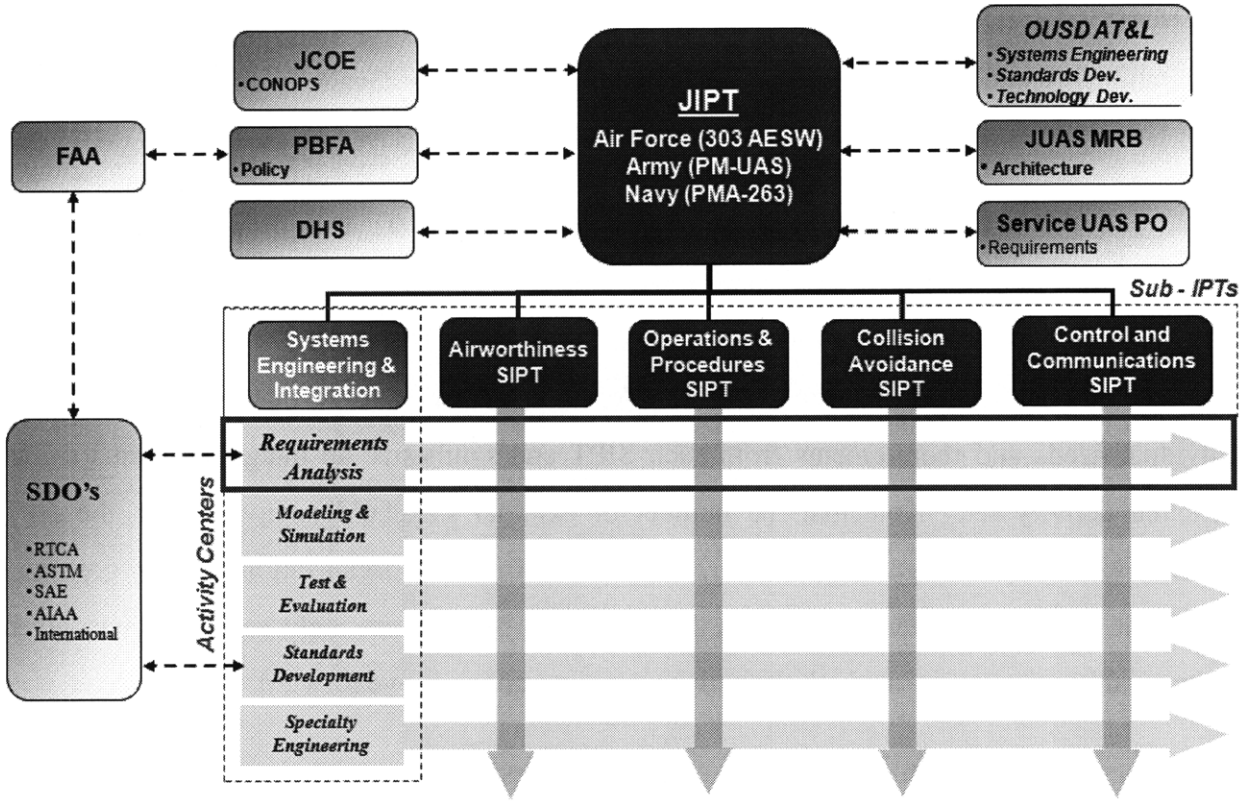


Figure 2-9. JIPT Organizational Structure.

In the course of attempting to develop the appropriate solution space, however, the JIPT ran into a series of issues that led them to a broader problem set. Things finally came to a head at a leadership meeting held in Atlanta, GA, in May of 2007 where the deputy leads discussed the need to make a decision to either turn the JIPT into a simple coordination function, in which case the effort was significantly over funded, or to turn it into a full-fledged program to tackle the issue of airspace integration in its entirety. If this were the case, the effort was woefully underfunded to achieve the desired ends.

The result of this meeting was the decision to cost out and brief the need for a full-fledge program to complete the airspace integration activities. The initial cost estimates used comparative analysis with other technology standards development efforts with the FAA resulting in cost figures in the billions of dollars. This information met with considerable resistance from both the internal and external JIPT stakeholder community, and this course of action was subsequently killed by combined OSD and service-level direction (see below discussion regarding the USD(AT&L) effort).

Office of the Secretary of Defense for Acquisition, Technology and Logistics, UAS Task Force

On 13 September 2007, Under Secretary of Defense, Gordon England, signed a memorandum standing up an USD(AT&L) led effort to address various aspects of the UAS challenge. [48] The organization of this UAS Task Force is depicted in Figure 2-10. [23] One of the Task Force IPT's was the Airspace Integration IPT. With the emergence of this Task Force and the specific standup of an airspace integration IPT, the previous JIPT effort could now be dovetailed into this effort. Initial plans were put in place to formally transition the leadership of the JIPT effort under this new task force. Those plans came to an abrupt halt the last week of March 2008 when Air Force leadership made the decision that the JIPT effort needed to remain within Service channels. [49]

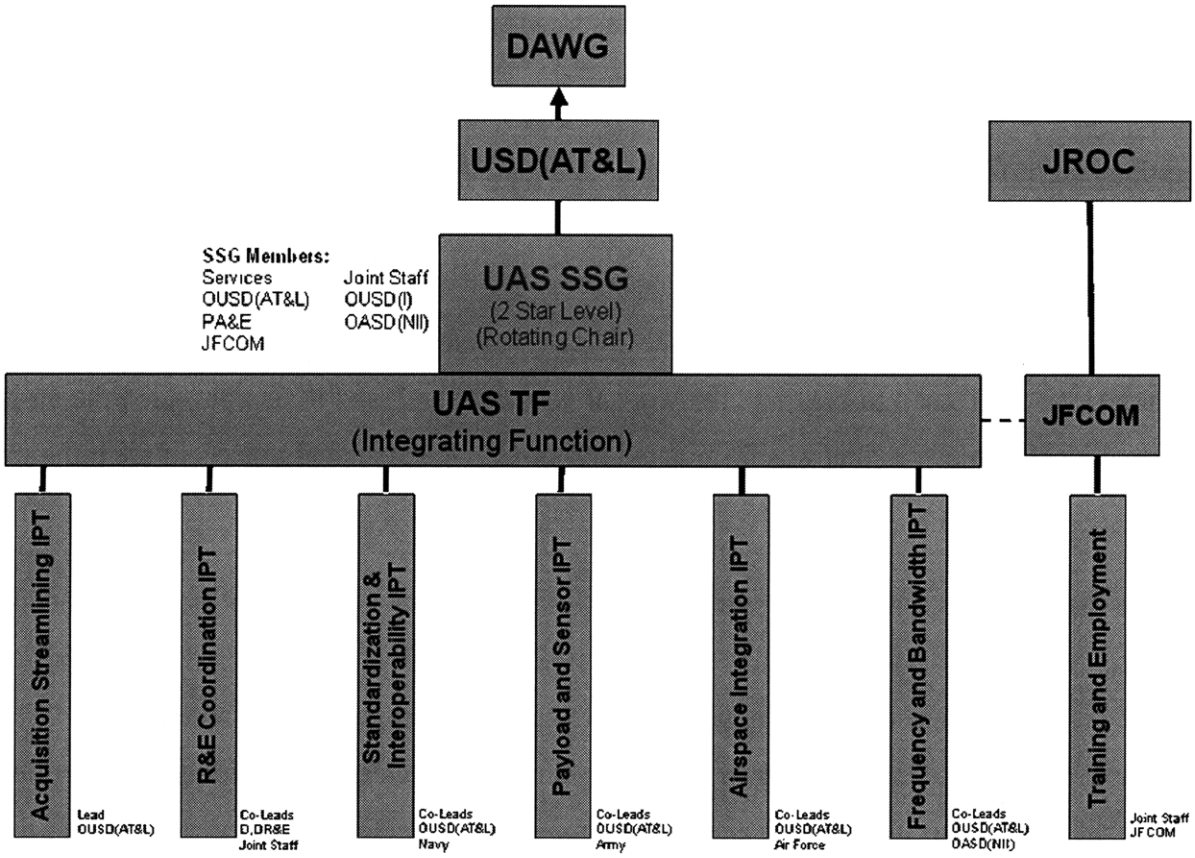


Figure 2-10. USD(AT&L) UAS Task Force Organization.

In February 2008, the JIPT was part of an update briefing to the UAS Senior Steering Group (SSG) in which the overall JIPT approach, cost, and structure was once again briefed, this time to a combined two-star level review. As a result of the briefing, Mr. David Ahern, the

USD(AT&L) Portfolio Systems Manager, redirected the UAS Task Force IPT and the JIPT to begin looking at a point solution approach to the problem rather than one that attempted to solve the problem generally for all types of Level 3-5 UAS. At this time, the outcome of how this will ultimately play out in funding and direction for the airspace integration effort is unknown.

Implications of Past and Current Efforts

With the backdrop provided in Chapter 1, and the preceding discussion concerning the recent UAS AI activities, it should be apparent that the context in which this issue is being addressed is both varied and under a constant state of change. The fluid nature of the problem has largely frustrated the efforts of those attempting to move the issue forward. The situation is further complicated by a slow but steady shift in the expectations of those employing UAS for broader and less restrictive mechanisms for securing access to wider chunks of airspace.

From a comparative analysis standpoint, the JIPT effort is the closest activity to the airspace integration enterprise defined later in this report. A detailed assessment of the most recent JIPT efforts reveals several important aspects of the context element in the UAS AI arena. First, the JIPT expended a considerable amount of resources against the accomplishment of systems engineering tasks. Figure 2-11 illustrates the overall systems engineering requirements flow-down model the JIPT used to organize the work it accomplished, and it also provided the basis for the analytical framework that was formulated for moving the technical aspects of the program forward.

While this activity was, and is necessary, it is not sufficient for a successful bounding of the current problem. As Norman and Kuras of the MITRE Corporation point out in their analysis of system of systems engineering, the traditional systems engineering approach requires that "The specific desired outcome must be known a priori, and it must be clear and unambiguous (implied in this is that the edges of the system, and thus responsibility, are clear and known)." [50] In the case of both the JIPT and the earlier Access 5 effort, this boundary condition for successful systems engineering was never ultimately established. In the fluid context in which the UAS AI activity is occurring, the traditional systems engineering effort is a necessary, but not sufficient, activity for a workable solution. This observation is one of the driving motivations behind the need for a full enterprise architecting effort described in Chapter 3.

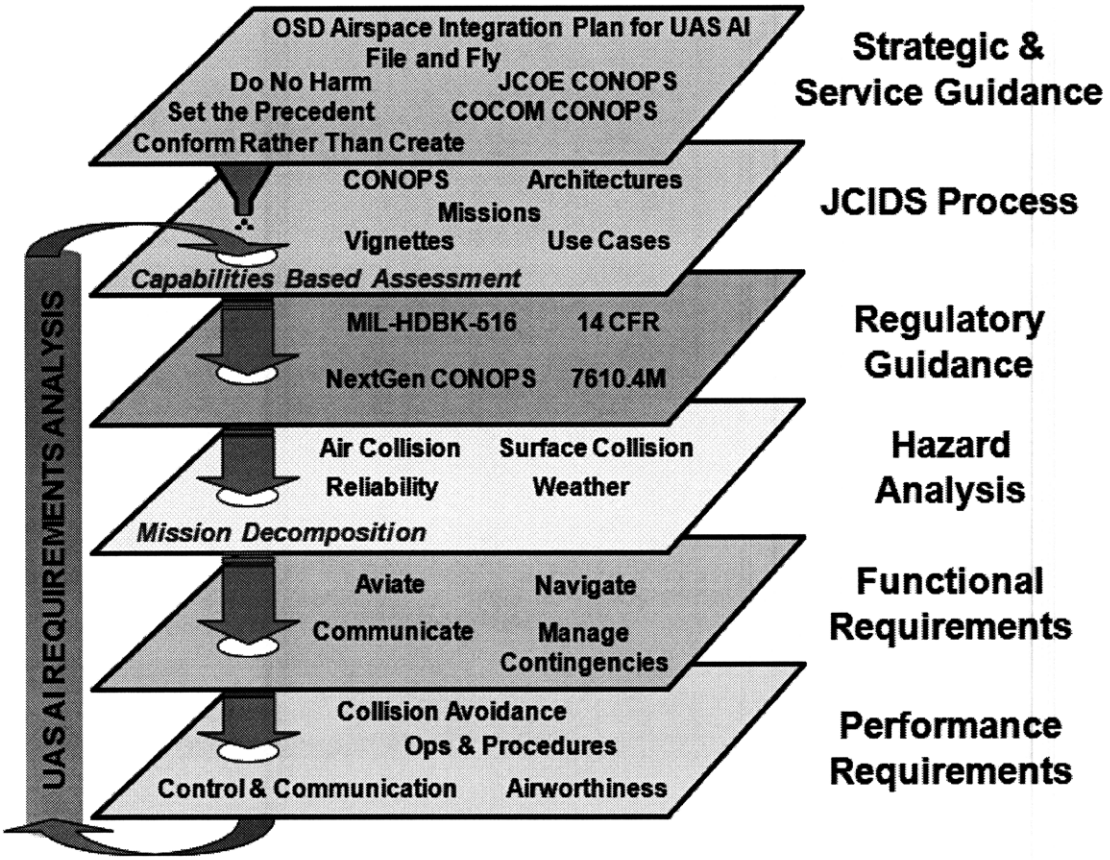


Figure 2-11. JIPT Requirements Flow-Down Process.

This is not to diminish or otherwise trivialize the significant technical hurdles that must be overcome in order for UAS airspace integration to become a reality. If the current assumptions concerning policy and regulation remain in force, there will need to be substantial investments in additional research and development (R&D); modeling, simulation, and analysis (MS&A); prototyping; testing and evaluation (T&E); and production article verification and validation before UAS airspace integration becomes "routine" rather than by exception. Traditional systems engineering will be central to this portion of the effort. In fact, the JIPT had an excellent model for pursuing this path within the systems engineering activity. Figure 2-12 depicts the activity model that by design mirrors the integrating activities from the organizational structure of the JIPT (reference the far left Activity Centers in Figure 2-12). [47]

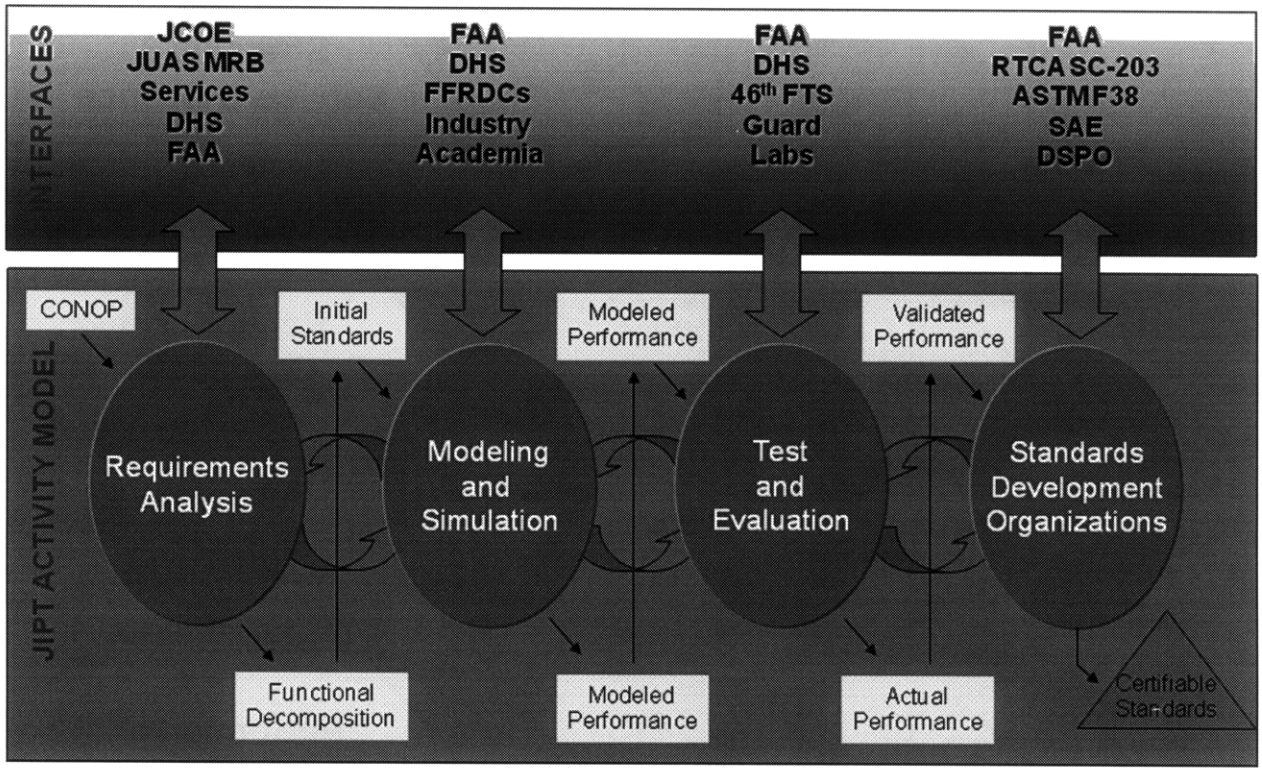


Figure 2-12. JIPT Activity Model.

Finally, there are also huge differences in the cultural aspects the organizations involved in this activity bring to bear in their interactions. There are three major communities engaged in the dialogue for moving things along: the materiel provider, the UAS operator, and the regulator. All three of these decision makers bring a unique perspective and understanding of the problem that shapes the way they approach the issues and the activities undertaken to reduce their uncertainty in the outcomes. These cultural differences are fundamental, and they drive behavior in a pathological fashion on many of these airspace integration challenges. What one organization does to reduce its own uncertainty in many cases increases it for one, or even two, of the other decision makers. As a result, actions of any one decision maker tend to work at cross-purposes to the objectives of the broader enterprise. These differences show up in spades when the organizational objectives and processes are compared to one another (see Chapters 8 and 9 for a detailed discussion of these factors).

Chapter 2 Summary

The detailed review of recent airspace integration activities presented in this chapter provides the specifics for understanding how the strategic backdrop described in Chapter 1 plays out at

specific organizational levels with respect to the airspace integration topic. Specifically, the past shortfalls and lessons learned from these efforts provides a significant degree of insight into the issues and tensions that must ultimately be resolved for a practical solution to take hold. The brief treatment of UAS history augments this understanding by grounding the discussion in a clear historical context and providing further clarity on the highly technical nature of UAS evolution over the past 160 years.

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SECTION II: METHODOLOGY

The task now shifts to an understanding of how the UAS AI effort should be scoped and a decision made on the methodology to be employed for a solution. The results must suffice for the purpose of both the methodology development as well as the application of that methodology to the UAS AI problem.

Specifically, Chapter 3 discusses the manner in which the context presented in Section I will be assessed to determine the boundaries of the UAS AI enterprise (to be defined) and a brief review of the more relevant literature on the challenge of formulating a solution in complex stakeholder enterprises. The approach must also conform to the DoD capability-based assessment (CBA) process. Chapter 4 begins the development of the methodology in earnest by formally developing the framework for arriving at an enterprise purpose statement and conducting a stakeholder analysis to identify the key decision makers in the enterprise. Chapter 5 builds the tools for assessing the degree of value alignment in the enterprise to provide direction to the enterprise architecting effort that follows in Chapter 6. Chapter 6 anchors the method with a rigorous development for building alternative enterprise architectures and evaluating them collectively for the best overall approach. Section III concludes by putting forward an approach for transforming the enterprise from the current state to the one described by the preferred architecture developed through the process described in Chapter 7.

The objective of Section III is to clearly lay out the theoretical basis for the analysis of the UAS AI enterprise that is detailed in Section IV. Aggregating the methodology together independent of the application provides for a more generalized context and a better way to discuss future research and application extensions in Section V. It also keeps the application in Section IV tightly focused on the key operational aspects needed to make the UAS AI activity successful without the distraction of having to concurrently develop the method as it is applied. In other words, either specific interests in the methodology or the detailed application to the UAS airspace integration problem can inform where you jump to next in this thesis.

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CHAPTER 3 – THESIS SCOPE & LITERATURE REVIEW

"A mind once stretched by a new idea never regains its original dimension."
—Oliver Wendell Holmes

The value in a literature review is the uncovering of possibilities, alternative approaches, and different ways of structuring information or data to help frame an issue or problem. The curse is sifting through the information, collecting the occasional nugget, and assembling them into an approach that will bear the fruit of solutions or opportunities to approach problems from a different direction. The preceding two chapters have outlined the context and nature of the problem. This chapter seeks to assemble the tools needed to weigh the relevant factors, create alternatives, and select an optimal solution.

Things rarely proceed in a linear fashion. The development of an analytical framework for this thesis was no exception to this observation. In fact, in some ways the methodology presented in this thesis is the result of the past three years worth of work and experience in several different fields. Much like life that has a tendency to happen to you while you are in the midst of planning something else, the structure for this thesis emerged almost as the result of several sidebar conversations and tangents the author had over the course of investigating and researching other approaches that ultimately didn't make the cut.

In something of a departure from the classical literature review in which the inquiring mind enters without preconceived solutions, the assessment outlined in this chapter is targeted at solving the very specific problem outlined in Chapter 2 with the additional constraint that whatever method is ultimately implemented for this portion of the problem needs to be consistent, at least in principle, with the current DoD approach to assessing and selecting programs to add to the force structure. The net effect is a set of specific constraints on the search for a methodological approach that is broad enough to treat the full spectrum of issues facing the UAS AI enterprise (a definition for the UAS AI enterprise will be defined shortly) while aligning well with current DoD methodology for program planning and selection (the CBA process).

Two key insights inform the literature review task in light of the above criteria. First, traditional systems engineering needs to be supplemented with a more robust way of accounting for the

context changes that occur while also doing a better job of connecting the product development process with the broader value structure (or need) of the UAS AI enterprise (recall the discussion from Chapter 2 concerning the JIPT systems engineering effort). Second, a thorough analysis of the DoD capability-based assessment (CBA) process reveals a value-focused process hidden under the cloak of other terminology. The literature review hunt will therefore concentrate on uncovering methodologies that will provide a way to gain more insight into the dynamic enterprise context, directly link product development with enterprise value, and conform to a value-focused approach for dealing with the issue in the broadest sense.

Before plunging headlong into this pursuit, however, two issues need to be nailed down in more detail to bound the problem to something manageable without compromising the usefulness or applicability of the result to the UAS airspace integration problem. The first is a discussion of the scope of this thesis as it relates to both the extent of UAS platforms and activities considered as well as the organizations involved. The second is to explain how the DoD CBA process works and its underlying connection with value-focused thinking. These two issues are each addressed in turn before turning to the literature review itself.

Thesis Scope

Enterprise Identification Framework

Clearly, the UAS airspace integration activity is set against a very rich and complex backdrop of organizations, national priorities, politics, and processes. In addition, the scope of UAS capabilities represents an extremely diverse and broad range of performance parameters, ranging in size from just a few ounces to those coming in at over 32,000 lbs. The scope of stakeholders discussed further in Chapter 4 can arguably range from individual units within the DoD, to each of the Services, to intergovernmental agencies, to industry, and even international airspace management organizations. A framework for considering how to address this scope is required.

The approach used for defining the enterprise in this report is the one developed by Murman et al. in Lean Enterprise Value (LEV). [6] LEV categorizes enterprises in the following manner:

> "We identify three distinct levels of aerospace enterprises based upon the level of entity being considered: *program* enterprises, *multi-program* enterprises, and *national and international* enterprises. Not surprisingly, they are interconnected and interdependent."
>
> "...The most elemental unit of aerospace business activity is the program, a collection of activities that produce a particular product, system, or service that is delivered to the customer and that generates revenue...A distinguishing characteristic of program enterprises is that they have accountability for cost, schedule, and performance of the product, system, or service."
>
> "...Business organizations and government agencies responsible for executing multiple programs are *multi-program* enterprises. Such enterprises provide the leadership and enabling infrastructure necessary for program execution."
>
> "...the collection of *all* entities that contribute to the creation and use of aerospace products, systems, or services can be seen as a *national* or an *international* enterprise."

As Figure 3-1 illustrates, each enterprise level can be thought of as a crosscutting entity through the value-creation framework. From a scoping perspective, this report will address the issue of UAS airspace integration at a multi-program level. As pointed out previously, the three specific programs that will be addressed for this report include the MQ-1 Predator, MQ-9 Reaper, and the RQ-4 Global Hawk. Limiting the scope of the enterprise in this fashion reduces the overall size of the enterprise to a single class of UAS being operated by a single military service. A more formal statement of the UAS AI enterprise will be developed in Section III; for now, the UAS AI enterprise definition can be generally described as the organizations and activities needed to integrate the MQ-1, MQ-9, and RQ-4 UAS platforms into the NAS.

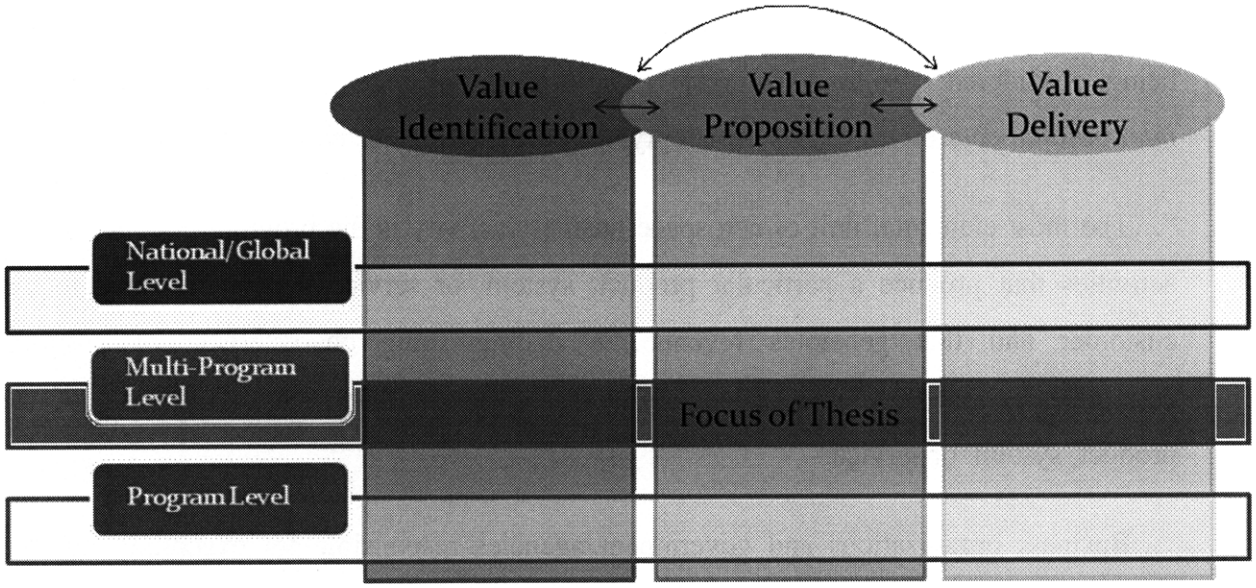


Figure 3-1. A Synthesis of the Lean Enterprise Value Framework.

In addition, these platforms are also the most technologically mature, are in current operational use, and have the greatest degree of capability of any UAS in routine use today. As such, they represent the first platforms on which a more integrated UAS airspace access capability is likely to be implemented and assessed. In this regard, they provide "pathfinder" activities for Level 3-5 UAS that will follow. Also, their current use provides a concrete way to translate the theoretical development of the UAS AI enterprise value structure into a specific set of actionable recommendations for these platforms moving into the future, making the future vision state and transformation plan both tangible and grounded in current realities.

At this juncture it is appropriate to address the fact that the LEV methodology used to scope this effort is not the only framework for considering how best to approach this problem. The problem could have been scoped just as well by addressing any number of other criteria. The advantages that accrue from using the LEV approach are two-fold. First, the programmatic basis of the distinctions is a natural fit to the way in which DoD conducts business, which is program focused. The services budget and plan around programs, the President's budget is submitted largely on a program-centric structure, and perhaps more to the point, Congress authorizes and appropriates funding based on a program perspective. As a result, the program is "king" when it comes to how dollars are allocated, defended and redistributed.

In the second instance, the LEV methodology is also a lean, value-focused approach to scoping the problem, providing an overarching framework for integrating the results back into the DoD CBA process and minimizing the potential for disconnects in the proposed methodology in this thesis and the practical implementation constraints within the DoD context. This aspect of the LEV method will become clearer in the discussion on the CBA process later in this chapter.

Enterprise Organizational Scope

In the specific case of this effort, the organizational scope will be exclusively on the interactions between Air Combat Command (ACC), the Air Force acquisition community, and the FAA and their attempt to arrive at a state in which value delivery to each stakeholder organization is sufficiently high to warrant continued participation in the UAS AI enterprise. Within each of these organizations, there are several key offices that are directly and actively working the issues highlighted in the previous chapters. These specific offices will be further detailed in the stakeholder analysis section of Chapter 9. The enterprise as a whole is referred to as the "airspace integration" enterprise throughout the remainder of this thesis, and it necessarily includes each set of stakeholders from ACC, the Air Force Acquisition community, and the FAA. The basis for scoping the thesis content to just examining these three major stakeholder organizations is also detailed in the stakeholder analysis section of Chapter 9.

As an on-going effort, the airspace integration activity (as embodied in the JIPT) has a history and de facto process for accomplishing tasks. What complicates the picture is while the JIPT is focused on the integration of UAS into the NAS, these same organizations also interact at an operational level (but in different roles) to get actual UAS missions in the NAS off the ground and into the air. This can be somewhat confusing to both participants and those looking in from the outside because while the organizations are the same, and because the end result of the airspace integration effort should result in an operational mission, the methods and purposes for which an activity is being undertaken are very different and are controlled by different offices within each of the above organizations.

Thesis Scope Summary

In summary, *the scope of this thesis can be described as the development and application of a suitable methodology for the purpose of creating a viable UAS AI enterprise that is flowing value*

to all of the key decision makers in the enterprise where the enterprise is constrained to only addressing the needs of ACC, the Air Force acquisition community, and the FAA with respect to the operation of MQ-1, MQ-9, and RQ-4. The specifics on the enterprise purpose are taken up in Chapter 9 where the UAS AI enterprise will be rigorously defined and the purpose and participants detailed.

Department of Defense Capability-Based Assessments

Before looking into the literature for appropriate methods and tools for assessing the issues laid out in Chapters 1 and 2, the additional constraint for a method that is compatible with the DoD CBA process is enumerated. This section is a very brief overview of what the DoD CBA process looks like for informing the literature review effort that follows. From a purely theoretical standpoint, imposing this constraint on the methodology upfront restricts the space in which solutions are sought. While this may in fact be true from a purely academic or theoretical standpoint, it fails to address the realities associated with actually implementing solutions in an existing framework that mandates conformance for an organization the size of DoD. For the specific issues addressed in this thesis, the time sensitivity for solutions dictate the practical approach to the issues because the time associated with changing DoD policy and infrastructure required for an entirely new or different approach to how DoD does planning and procurement is measured in decades.

The Rationale for Considering Capabilities-Based Assessments

As the title for this research suggests, the focus is on the *application* of value-focused thinking and enterprise architecting approaches. The decision to use these two methodologies (developed and defended in the next section of this chapter) is tied into the system architecting principle for design selection that Crawley articulates as the need to ensure that "decomposition of form maps to team, stations, and flow." [51] In other words, the architecting of the analysis should result in a product that is congruous with the existing structures in which the results will need to be assimilated and ultimately affected.

The issue that naturally arises with the application of this system architecting principle is "What is the structure I need to accommodate in the architecting of the solution?" In the case of the DoD, the approved structure for accomplishing the kind of analysis associated with the questions

of this thesis is the Capability-Based Assessment (CBA) process as implemented through the Joint Capabilities and Integration Development System (JCIDS). This means formulating the results of this analysis in such a manner that the methodology and results will be compatible with the CBA and JCIDS constructs to maximize the potential for implementation.

Again, the question may arise with respect to how important this aspect of alignment to existing "teams, stations, and flow" really is to the broader application of value-focused thinking or enterprise architecting. As alluded to in the previous section, if the objective of this research were focused on expanding the theoretical foundations for either of these topics, then the author will readily admit the above discussion has little bearing on the problem; however, the objective of this thesis is much more focused. As detailed in the previous section, the thesis scope is an assessment of the various factors contributing to the UAS airspace integration endeavor associated with MQ-1, MQ-9, and RQ-4, and to recommend an approach that will provide the highest likelihood of delivering value to the UAS AI enterprise.

The practical ramifications of this objective is the need to ensure the theoretical methodology employed in the analysis will produce results compatible with the practical realities for how DoD mandates the assessment and execution of programs. If the issue is thought of as one in which the academic thesis approach needs to be interlaced with the DoD analytical framework, then the question is how to accomplish this interface resulting in a theoretically sound analysis on the academic front and at the same time produce results transferable to the DoD for implementation. This provides the rational for understanding the CBA process before proceeding further with the development of the theoretical basis of this thesis.

Capabilities-Based Assessment Overview

A brief description of the CBA process follows. The reader is referred to the appropriate references for a more in-depth treatment on the subject. Specifically, the following are provided for DoD guidance on the JCIDS process and conducting a CBA: CJCSI 3170.01F [52]; CJCSM 3010.02B [53]; CJCSM 3170.01C [54]; JROCM 062-06 [55]; DODAF Vol 1: Definitions and Guidelines [56]; White Paper on Conducting a Capabilities-Based Assessment (CBA) Under the Joint Capabilities Integration and Development System (JCIDS) [57]; and the CBA User's

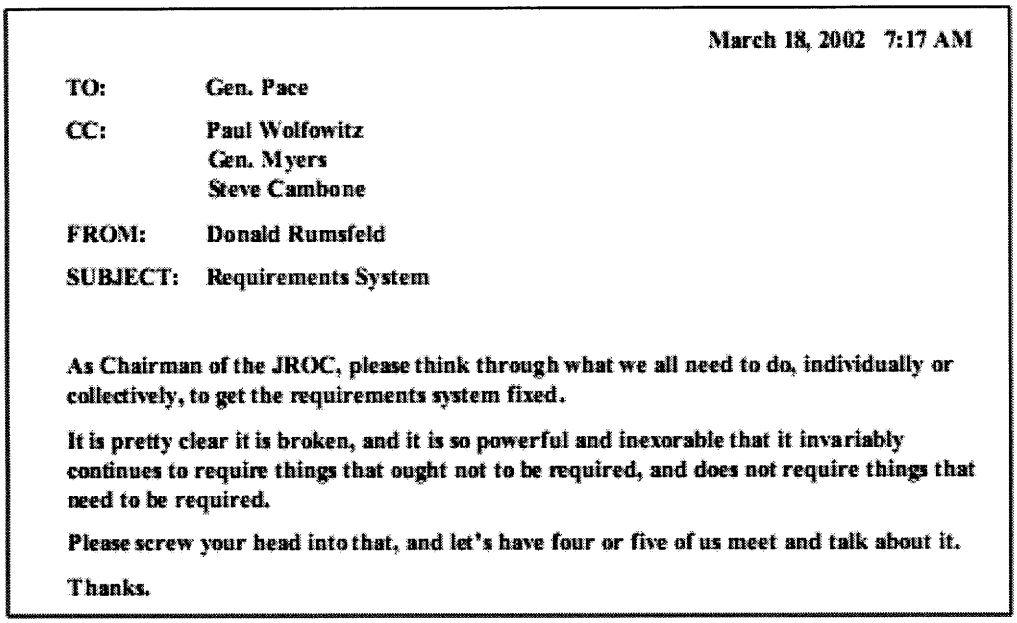
Guide, Ver 2 [58]. Additional information on the motivation behind the JCIDS process can be found in the *Joint Defense Capabilities Study Final Report.* [59].

The CBA User's Guide version 2, published by the Joint Chiefs of Staff (JCS) J-8 Force Structure, Resources, and Assessments Directorate in December 2006 [58], references the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01F, *Joint Capabilities Integration and Development System (JCIDS)* [52], when defining the structure of a CBA. According to CJCSI 3170.01F:

> "The CBA is the JCIDS analysis process that includes three phases: The FAA [functional area analysis], the FNA [functional needs analysis], and the FSA [functional solutions analysis]. The results of the CBA are used to develop a JCD (based on the FAA and FNA) or ICD (based on the full analysis)."

While this definition certainly describes what a CBA is with respect to its structure, it does not provide insight into what it is intended to accomplish.

To get at the underlying basis for why the JCIDS process uses CBA, the origins of the current analysis structure must be examined. Before the implementation of CBA, the DoD operated on a requirements-based approach to determine needs. [58] The Joint Requirements Oversight Council (JROC) was the ultimate body in this system for deciding what went forward in system. The system was revamped under Secretary of Defense Rumsfeld because of widespread dissatisfaction with this process. The effort that ensued as a result of a March 2002 memo (see Figure 3-2) from Secretary Rumsfeld to General Pace, Chairman of the Joint Chiefs of Staff, produced three principles that formed the basis of JCIDS: 1) *Describing needs in terms of capabilities, instead of systems or force elements*, 2) Deriving needs from a joint perspective, from a new set of joint concepts, and 3) Having a single general or flag officer oversee each DoD functional portfolio (emphasis added). By the summer of 2003, JCIDS was up and running. See the *Joint Defense Capabilities Study Final Report* for further information on the motivations behind JCIDS. [59]



March 18, 2002 7:17 AM

TO: Gen. Pace

CC: Paul Wolfowitz
Gen. Myers
Steve Cambone

FROM: Donald Rumsfeld

SUBJECT: Requirements System

As Chairman of the JROC, please think through what we all need to do, individually or collectively, to get the requirements system fixed.

It is pretty clear it is broken, and it is so powerful and inexorable that it invariably continues to require things that ought not to be required, and does not require things that need to be required.

Please screw your head into that, and let's have four or five of us meet and talk about it.

Thanks.

Figure 3-2. Rumsfeld Memo Initiating Current CBA Process.

The governing instruction for JCIDS was revised six times in the first three years of operation, and the debate continues on what exactly a "capabilities-based approach" is; however, the three basic principles upon which JCIDS was established have remained constants in this evolving process. The emphasis in this research is on Principle #1 because it provides the basis upon which the linkage between the CBA process and the methodology in this research is built. While capability has yet to be defined (see the next paragraph), notice that it stands in contrast to systems or force elements. In a broader sense, Principle #1 is also an indictment against an "alternatives-based" approach to determining needs. As previously mentioned, the shortfalls associated with this approach were the primary drivers for change in the previous system that gave rise to the CBA process.

The CBA User's Guide [58] elaborates on the first foundational principle with the following commentary:

> "One of the major frustrations of the previous requirements processes was that solutions were introduced to the system without any higher-level rationalization. The intent was to replace statements such as 'we need a more advanced fighter,' with 'we need the capability to defeat enemy air defenses.' The latter statement provides the rationalization for needs, and also allows for competition among solutions."

Two aspects of this commentary are worth pointing out with respect to bringing better definition to the idea of a "capabilities-based approach." First, the focus and weight of the effort is on the elicitation and rationalization of the *needs* associated with the execution of military operations. The second is that the articulation of the need is the basis for assessing and selecting solutions. By inference, this means that a capabilities-based approach will not be predicated on an alternatives-based methodology. Alternative-based approaches jump directly into the solution space (e.g. "we need a more advanced fighter"), and as just pointed out, the focus in CBA is on a needs-based definition (i.e. "we need the capability to defeat enemy air defenses"). It is only after the needs are adequately defined and prioritized that the quest for solutions should begin.

With the understanding of the underlying motivations behind CBA, the CJCSI 3170.01F [52] definition of a capability is as follows:

> Capability - The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks. It is defined by an operational user and expressed in broad operational terms in the format of a joint or initial capabilities document or a joint doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) change recommendation. In the case of materiel proposals/documents, the definition will progressively evolve to DOTMLPF performance attributes identified in the capability development document and the capability production document.

Parsing the above definition, capabilities can be summarized as the ability to achieve a desired *effect* expressed in an *operational context* (specified standards and conditions) using the *full DOTMLPF performance attributes* through *any combination of means and ways* to perform a set of tasks.

The CBA definition previously given "as the JCIDS process by which an FAA, FNA, and FSA are accomplished," can now be broken down into the steps required to define the appropriate effect, operational context, performance attributes and tasks. Figure 3-3 provides a simplified view of how the CBA process breaks down by FAA, FNA, and FSA. [58]

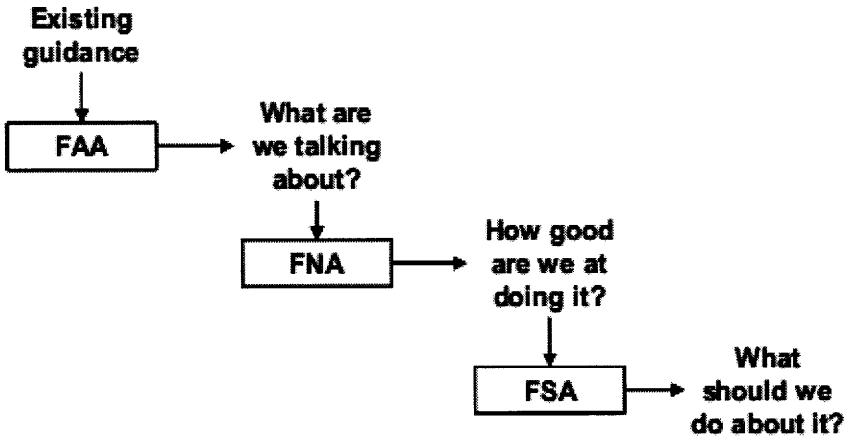


Figure 3-3. Simplified Diagram of Major CBA Inputs, Analyses, and Outputs.

The CBA User's Guide sums up these steps as follows:

> The FAA synthesizes existing guidance to specify the military problems to be studied. The FNA then examines that problem, assesses how well the DOD can address the problem given its current program, and recommends needs the DOD should address. The FSA takes this assessment as input, and generates recommendations for solutions to the needs.

The end-result of this process is a clear linking of the military need expressed in terms of the required effect and operational context, and the alternative solutions by which the need can be met. The merit of each solution is judged on the extent to which it produces the performance attributes defined across the full DOTMLPF spectrum.

For the purposes of providing alignment between the CBA process and the analytical method used in this research, the quest is for a theoretical approach focused on defining the desired effect (think intent) articulated within an operational context (think scenario) and defined by a full spectrum of performance attributes (think definition of success). Once these are in hand, a methodology is needed to populate the solution space (think concept generation) for ways and means of meeting these performance attributes and selecting the best overall design (think assessment criteria).

Capability-Based Assessment Summary

The upshot of the above discussion is the need for a methodology that will focus on the elicitation of needs, context, and attributes. This is the underpinning strength of the CBA

process and the thrust behind the first principle of the JCIDS framework. The search for an appropriate methodology for this research can now be summarized as the pursuit of appropriate frameworks and tools that will meet the intent of the JCIDS CBA process while providing sufficient scope to address the full breadth of the UAS AI enterprise activity set.

The remainder of this chapter is dedicated to an investigation into the literature for a methodology that will meet the above stated requirements. As was pointed out previously, this approach deviates somewhat from the standard literature search, but the objective is to produce an immediately viable approach that can be implemented quickly within the existing framework.

Sorting and Categorizing Approaches

The literature review is attacked on two sequential fronts. The first is to narrow down the relevant methodologies on the broader CBA requirements that focus on the need and use context space, and then hit the second gate of needing the exercise of the methodology to be robust enough to handle the full scope of the UAS AI enterprise challenges. The CBA requirement leads straight to the door of value-focused thinking.

As Keeney points out in Value-Focused Thinking: A Path to Creative Decisionmaking, the manner in which a person looks for a way to meet a need can be categorized as either *alternative-focused* or *value-focused* in the way the problem is approached. [5] Keeney describes the typical situation as follows:

> "Many books have been written about decision making. They tell us how to solve decision problems. They do not tell us how to identify potential decision opportunities. They tell us how to analyze alternatives to choose the best one. They do not tell us how to create alternatives. They tell us how to evaluate alternatives given some quantitative objective function. They do not tell us how to articulate the qualitative objectives on which any appraisal of alternatives must rest." Preface, pvii

This observation goes to the very heart of the problem Secretary of Defense Rumsfeld was driving at in his memo to General Pace detailed in the previous section on the CBA process. To delve into the details further, Keeney describes alternative-focused and value-focused thinking in the following way:

"Most people do not like problems, and since decisions are problems to most people, they typically do not create their own decision problems. Instead, decisions problems are usually thrust upon them by others or by happenstance...Once the decision problem is imposed from outside, the so-called solving begins. Typically, the decision maker first focuses on alternatives, until either an appropriate set of alternatives or one acceptable one is found, and only then begins to concentrate on objectives or criteria to evaluate the alternatives. I refer to this general problem-solving approach as *alternative-focused thinking*. Focusing on alternatives is a limited way to think through decision situations. It is reactive, not proactive...This standard mode of thinking is backward, because it puts the cart of identifying alternatives before the horse of articulating values."

"It is values that are fundamentally important in any decision situation. Alternatives are relevant only because they are means to achieve your values. Thus, your thinking should focus first on values and later on alternatives that might achieve them. Naturally, there should often be iteration between articulating values and creating alternatives, but the principle is "values first." Such thinking, which I refer to as *value-focused thinking*, can significantly improve decision making because the values guide not only the creation of better alternatives but the identification of better decision situations. These better decision situations, which you create for yourself, should be thought of as *decision opportunities* rather than as decision problems." Preface, p vii-viii [5]

This excerpt from Keeney's preface clearly draws the line between these two methods of approaching a problem. It is just as clear that the approach required by the CBA process is a value-focused thinking approach. Keeney goes on to describe the most important characteristics of value-focused thinking as follows:

"...value focused thinking suggests a different paradigm for addressing decisions from the standard alternative-focused thinking paradigm. It is different in three important ways. First, significant effort is allocated to articulating values. Second, this articulation of values in decision situations comes before other activities. Third, the articulated values are explicitly used to identify decision opportunities and to create alternatives. A value-

focused orientation will help you to create better decision situations with better alternatives, which should lead to better consequences." Preface, p ix.

"Value focused thinking essentially consists of two activities: first deciding what you want and then figuring out how to get it." Chapter 1, p4

"Values are principles used for evaluation. We use them to evaluate the actual or potential consequences of action and inaction, of proposed alternatives, and of decisions. They range from ethical principles that must be upheld to guidelines for preferences among choices." Chapter 1, p6-7

"Ethics, desired traits, characteristics of consequences that matter, guidelines for action, priorities, value tradeoffs, and attitudes toward risk all indicate values... Thinking about values is constraint-free thinking. It is thinking about what you wish to achieve or what you wish to have. Thinking of desirable alternatives is also constraint-free thinking. Selecting among alternatives, however, is constrained thinking." Chapter 1, p7

Value-focused thinking, then, provides the rich methodological basis for a general approach that will satisfy the CBA constraint for *"describing needs in terms of capabilities, instead of systems or force elements."* The task now becomes one of finding an implementation of value-focused thinking that will provide the breadth needed to fully address the UAS AI enterprise challenges.

Value-Focused, Lean Thinking

Arriving at Lean Thinking

As it turns out, there is a large body of literature and a host of vying methods for actually implementing a value-focused methodology. The various methods that were examined for this research that make claims of one sort or another concerning their ability to "transform" an enterprise included such methods as Lean Thinking, Six Sigma, Total Quality Management, Agile Manufacturing, and Reengineering. A full review of these various methods with respect to one another is developed in detail by others. For a published comparison of Lean Thinking and Six Sigma, Lean Six Sigma for Service by Michael George provides a good compare and contrast. [60] For a fuller analysis across the entire waterfront of tools, the reader is referred to a paper in progress by Dr. Kirkor Bozdogan entitled "A Comparative Review of Lean Thinking,

Six Sigma and Related Enterprise Process Improvement Initiatives" available through the Lean Advancement Initiative at the Massachusetts Institute of Technology for an in-depth comparative analysis of these alternative approaches. [61] Dr. Bozdogan reaches the following conclusion in his analysis:

> "A main conclusion of the paper is that Lean Thinking provides an overarching intellectual architecture for the various systemic change initiatives, wherein they share common roots, augment each other in significant ways, and generally comprise mutually-complementary approaches. The various differences among them are dwarfed by their common characteristics. Taken together, under the overall umbrella of Lean Thinking, they are rapidly merging into a unified framework for bringing about fundamental enterprise-wide change." [61]

Dr. Bozdogan concentrates specifically on the relative strengths and complementary aspects of lean Thinking and Six Sigma (complementing the perspective by George in Lean Six Sigma) with the following observations concerning the two methods:

> "In particular, Lean Thinking and Six Sigma share important common features. These include focusing on the customer, reducing variation, continuous improvement, collaborative relationships, proactive leadership and data-and-fact-driven management... There are also some differences between Lean Thinking and Six Sigma. Lean Thinking strives to optimize the entire enterprise value stream, by providing a holistic perspective. Such a holistic 'systems' perspective provides an important unifying framework guiding specific improvement initiatives. Lean Thinking encompasses a unified, mutually-reinforcing, set of enterprise-wide principles and practices at all levels, linking the board room to the factory floor and providing an end-to-end view of all enterprise operations spanning a defined enterprise's entire value stream. By contrast, Six Sigma, despite efforts in recent years to evolve it into an integrative management system, largely stresses a generic problem-solving approach employed to implement discrete improvement projects... In the final analysis, however, Six Sigma complements Lean Thinking. This is already being recognized by a growing number of companies that have adopted integrated Lean-Six Sigma change initiatives, combining Six Sigma quality with lean speed." [61]

The result of this comparative analysis for the purposes of this research is the conclusion that Lean Thinking provides the broadest, most holistic approach to addressing enterprise-wide value considerations. As was previously pointed out in the "Thesis Scope" section of this chapter, the additional advantage in using the Lean Enterprise Value (LEV) framework is the program-centric perspective. This provides an additional degree of alignment with the DoD CBA process that many of the other methods lack since most are focused on specific improvement initiatives instead of the broader program-level considerations.

Detailing the Lean Enterprise Value Model

It is appropriate at this juncture to describe the LEV framework in some additional level of detail. The synthesized framework used in this research is reproduced in Figure 3-4 for convenient reference. When this framework was discussed previously, only the left-hand, vertical axis was discussed (recall the previous discussion was centered on scoping the content of the thesis). The top, horizontal axis is the current focus.

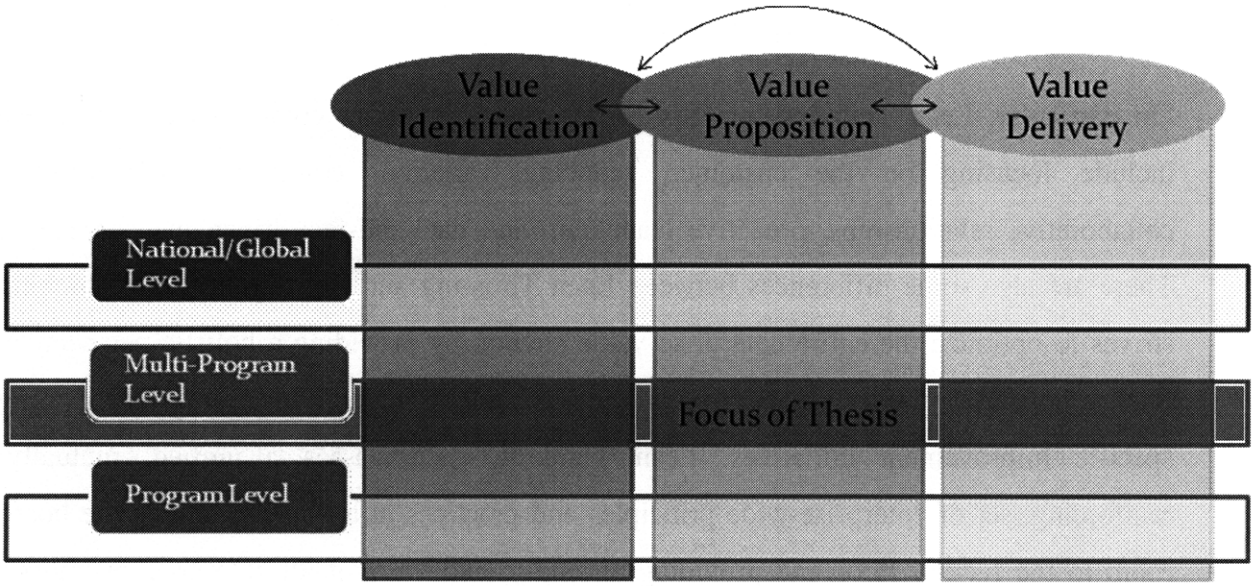


Figure 3-4. A Synthesis of the Lean Enterprise Value Framework.

The first thing to define more specifically is the word "value." The best place to start in these instances is to consult the dictionary on the common meaning of the word itself. The American Heritage Dictionary defines value as follows [62]:

val·ue: (vāl'yōō) n.

1. An amount, as of goods, services, or money, considered to be a fair and suitable equivalent for something else; a fair price or return.

2. Monetary or material worth: the *fluctuating value of gold and silver.*

3. Worth in usefulness or importance to the possessor; utility or merit: *the value of an education.*

4. A principle, standard, or quality considered worthwhile or desirable: "The speech was a summons back to the patrician values of restraint and responsibility" (Jonathan Alter).

To get a better sense for the use of the word in our current context, consider several definitions from various sources within the Lean Thinking community. These definitions will build on what Keeney provided for the concept behind value within a value-focused thinking framework.

Womack and Jones in Lean Thinking point out that "value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specified product (a good or service, and often both at once) which meets the customer's needs at a specific price at a specific time." Liker in The Toyota Way puts it more simply by saying, "The first question… is always '*What does the customer want from this process?*'" (emphasis in the original). [63] Murman et al. in Lean Enterprise Value define value as *"how various stakeholders find particular worth, utility, benefit, or reward in exchange for their respective contributions to the enterprise."* (emphasis in the original) [6] For the sake of moving forward with a common definition of value, the Murman et al. definition will be used through the remainder of this thesis as a concise statement for what is meant by "value". The remainder of the value-creation framework from Lean Enterprise Value (denoted hereafter as simply "LEV") can now be addressed with a consistent definition of value established.

LEV begins the discussion of *value identification* with the following observations:

> "The first phase in our framework involves identifying the stakeholders and their value needs or requirements – what negotiation theorists sometimes refer to as underlying

'interests.' Economists might see 'utility functions' here. Importantly, many aspects of value identification in this stage involve reciprocal 'exchanges' that must take place between stakeholders even to identify the desired value. This is where determining the 'right job' begins."

"The process commences with the identification of stakeholders...After the stakeholders have been identified comes a first attempt to understand what part of the project or process adds value for them and what kinds of exchanges are required to provide that value. This is quite complex."

The actual implementation of a method for accomplishing this task is the subject of Chapter 4 and it encompasses the job of defining the enterprise purpose and conducting the appropriate stakeholder analysis to determine who the relevant decision makers are within the defined enterprise. Looking ahead to the issues surrounding the formulation of an operational model to exercise alternative enterprise architectures (to be defined in the next section), it is worth pointing out that Keeney and LEV overlap directly in this phase of the LEV value-creation framework, especially with respect to the idea that values can be captured using 'utility functions'. This will be addressed in more detail in Chapter 6, but from a methodology development standpoint, this is worth drawing the reader's attention to at this point to strengthen the intellectual tie between Keeney and LEV.

Once the value identification phase is complete, the LEV framework moves on to describing the *value proposition* phase. A description of this phase in the value creation framework follows:

"The objective of the value proposition phase is to structure value streams based on the stakeholders' value propositions so that people, groups, and enterprises will contribute their efforts or resources to the value streams in those ways from which they can, in turn, derive value. This is critical to value delivery, since stakeholders will probably discontinue contributing when they receive no value."

"During this phase, different stakeholders structure explicit or implicit 'value exchanges' – sometimes referred to as 'agreements' or 'deals'... The agreements in themselves mean nothing until they are put into a structure to deliver on the promises. The fields of

> sociology, psychology, and economics tell us that the incentives in these agreements are pivotal… Stakeholders need to be able to see that their value needs are met."

Creating a value proposition that allows value to flow to each of the UAS AI enterprise decision makers is perhaps the most challenging aspect of this entire endeavor. To address these complexities in the most holistic manner possible, enterprise architecting techniques will be used in a rigorous architecture creation and tradeoff analysis approach to generate alternative value propositions that provide the required tradespace to flow value within a highly constrained set of formal boundaries (formal in the sense of the "form" the solutions must interface with). As an emerging field of research, the enterprise architecting literature is still developing out of its history in the information technology domain. The next section in this chapter introduces the enterprise architecting subject to familiarize the reader with the overarching concepts and approach. The key point to remember is that this research employs enterprise architecting as the means by which to develop the value propositions (especially the 'structure') as described by the LEV framework.

The final phase of the LEV value-creation framework is *'value delivery.'* This phase is summarized as follows:

> "The implementation phase, *value delivery*, is the most familiar in the context of lean practices and principles. Here is where value is delivered both to the various stakeholders who participate in the value stream and to the end user when the product, service, or improved capability is received. This is where all of the promises, both explicit and implicit, are kept."
>
> "Delivering value by conveying benefits to stakeholders requires the interconnected chain of activities that we call the 'value stream'. Excessive focus on delivering value to the end user or any other single stakeholder creates 'dysfunctional' value streams that ignore other stakeholders. Value delivery as we mean it depends on adding value at every step along the value stream."

Chapter 7 discusses how the methodology in this phase is implemented using the Enterprise Transformation Roadmap developed by the Lean Advancement Initiative. Ultimately, execution

of this Roadmap delivers the aforementioned value to the enterprise decision makers. At the conclusion of the analysis, the results must be actionable and produce the attributes valued by the enterprise.

An Eye Towards Executable Models

The scope of this research was previously described in terms of the program extent (i.e. different UAS platforms addressed) and the organizations involved in the UAS AI enterprise. A further word on scope is appropriate at this point. In addition to the number of UAS platforms and organizations, this research is further limited in the extent to which the methodology developed will be implemented into an executable model. In other words, the research will take the methodology to a rigorous, qualitative level, but a working, executable model is beyond the resources available for this thesis.

With that said, Chapter 12 will describe methodology extensions that need to be made to the approach developed in the remainder of this section. This is where the observations on the overlap between the LEV value-creation framework and the Keeney value-focused thinking framework come to the forefront. As an application of the methodology developed by Keeney, multi-attribute utility theory (MAUT) is used to build models of the value space to assess alternatives. A specific implementation of this approach is the Multi-Attribute Tradespace Exploration (MATE) methodology as developed and articulated by Ross. [9, 64] For additional applications of the MATE methodology, see references [65-68].

The use of MATE to this point has been limited to an examination of the tradespace surrounding the early conceptual design of products. There is current research underway that seeks to extend the use of MATE to the full programmatic concerns of cost, schedule, and risk in addition to the technical performance of the product. Unfortunately, this work will not be complete in time to inform this research; however, it is worth projecting forward in time to anticipate a situation in which MATE could reasonably be extended to the domain under investigation in this research. With this in mind, the value-creation framework from LEV is modified slightly to conform to the needed information for a MATE analysis. Although not all of this information will be collected for this research, putting the collected data in an easily digestible MATE format will facilitate the creation of a crude model presented in Chapter 12.

This rounds out the discussion on the quest for a methodology that conforms to the DoD CBA process and way of thinking. As described, the value-focused thinking approach advocated by Keeney, with specific implementation direction using the value-creation framework described in LEV, focuses the effort on a clear understanding of the end needs to be addressed. Only after a clear understanding of these needs and the characterization of value from the perspective of each enterprise stakeholder does an examination of possible solutions occur. The only remaining task prior to the development of the specific instantiation of an approach that weaves these two frameworks together is the introduction of enterprise architecting principles.

Architecting as a Means to an End

Recall that enterprise architecting is the means by which the value propositions described in LEV are generated in this research. The driving motivation behind the use of enterprise architecting in this role is the need to address the second constraint of the methodology development activity, namely an approach that would be sufficiently robust for the full spectrum of issues the UAS AI enterprise needs to address. While the LEV value-creation framework provides an excellent overarching approach to this problem, it lacks the rigor needed to fully address the complexities of the airspace integration problem in a systematic fashion. Fortunately, the enterprise architecting method has grown directly out of the research conducted by the Lean Advancement Initiative, motivated by the need for a holistic, end-to-end enterprise perspective on value creation. As a result, it already fits neatly inside of the existing LEV value-creation framework and Enterprise Transformation Roadmap process.

Enterprise architecting (EA) is admittedly a field in the nascent stages of development, and the reader may be inclined to consider the context for the term within the relatively narrow confines of information technology (IT). Despite the historical roots to IT, EA is a much broader field, encompassing everything from external political motivations, to strategy, to product or service development activities. Before proceeding further, a definition of EA is needed to focus the discussion and remove ambiguity about what EA encompasses.

Definitions

Consider first the word 'enterprise' as a modifier to 'architecture.' Consider the following definitions:

American Heritage Dictionary: en·ter·prise (ĕn'tər-prīz') n.

1. An undertaking, especially one of some scope, complication, and risk.
2. A business organization.
3. Industrious, systematic activity, especially when directed toward profit: *Private enterprise is basic to capitalism.*
4. Willingness to undertake new ventures; initiative: "Through want of enterprise and faith men are where they are, buying and selling, and spending their lives like serfs" (Henry David Thoreau). [69]

Merriam-Webster's Dictionary of Law [70]

: an economic organization or activity; *especially* : a business organization

Black's Law Dictionary [71]

:one or more persons or organizations that have related activities, unified operation or common control, and a common business purpose

Lean Enterprise Value [6]

A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices.

From these definitions, an enterprise is clearly composed of multiple entities that are at least tangentially aligned for some common purpose that is of some scope and complication. While the common dictionaries typically orient around a business organization, the LEV definition provides the more generalized concept by focusing on value delivery as the basis around which the enterprise functions with the additional distinction that it functions as an integrated entity.

Nightingale and Rhodes [11] shed additional light on the nature of the 'enterprise' by defining the basic components of the enterprise as structure, behavior, and value. Figure 3-5 illustrates these components as the various dimensions defining the enterprise 'cube'.

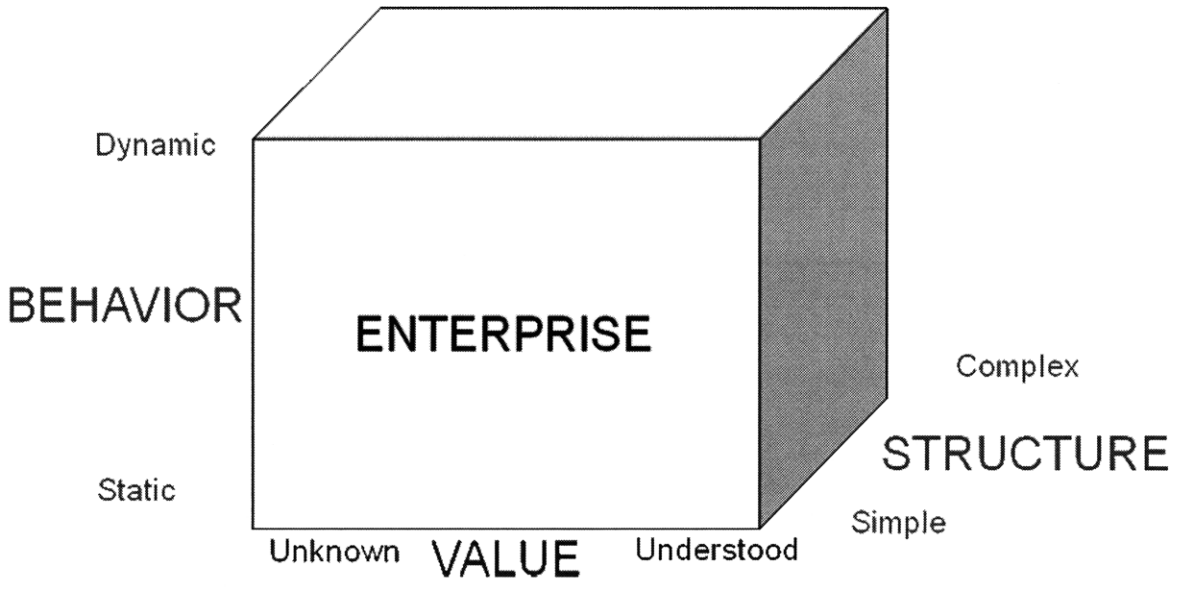


Figure 3-5. Graphical Depiction of Enterprise Dimensions.

The complexity of an enterprise begins to emerge as the full range of the potential values along each of these three axes is considered. It is precisely for this reason the enterprise architecting approach is employed for the UAS airspace integration challenge. The EA methodology, while still an emerging field, deals explicitly with the kind of complexity brought about by the interactions of these three dimensions, two of which (behavior and value) can be very 'soft' and hard to define in any quantitative sense. Nightingale and Rhodes go on to define the 'enterprise problem space' by enumerating the major variables considered in each of the dimensions (see Figure 3-6). [11]

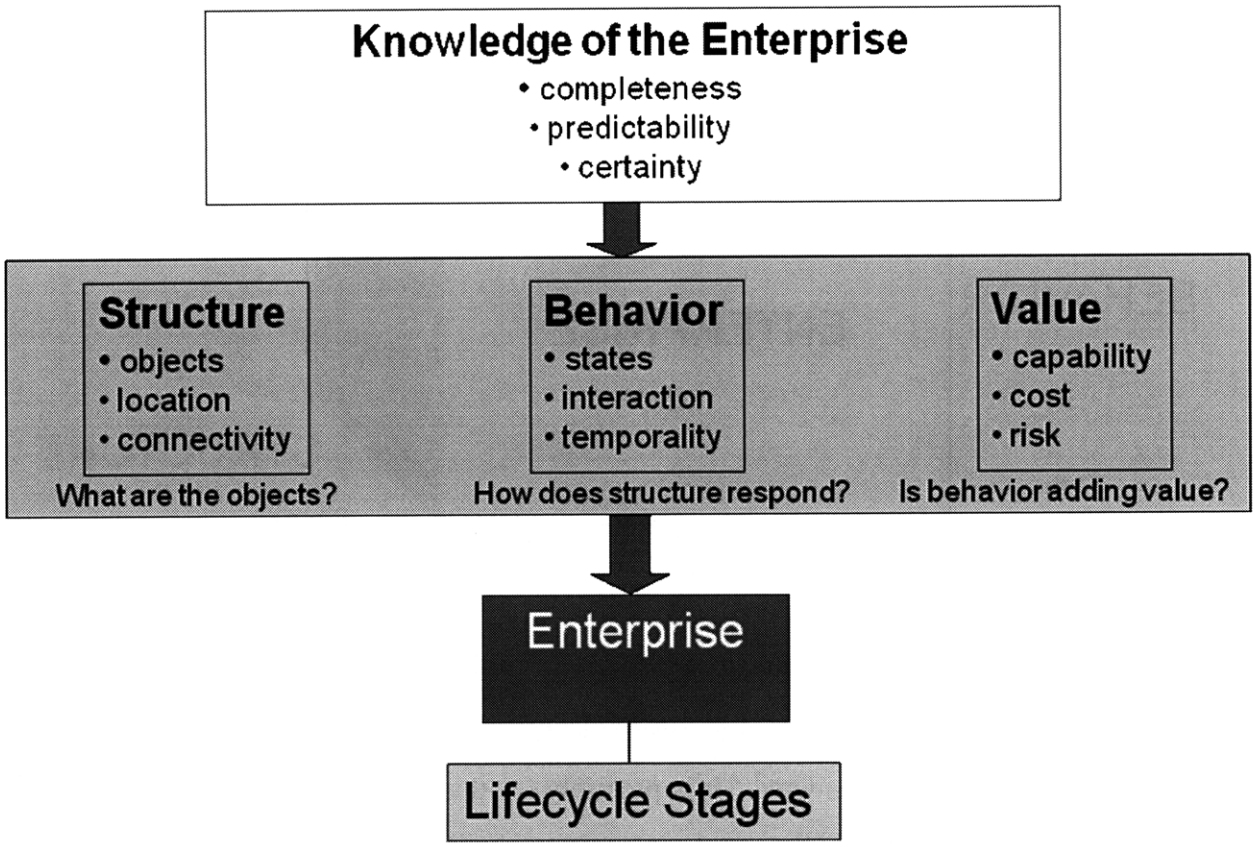


Figure 3-6. Enterprise Problem Space.

With an appreciation for the definition, scope, and potential complexity all tied up in the word 'enterprise', the second element of EA can be explored, that of 'architecting'. The richness of the literature surrounding this aspect of EA is as deep as it is broad. The following definitions are provided for architecting, architecture, and architect:

Rechtin and Maier [72]

Architecting: the art and science of designing and building systems.

American Heritage Dictionary [73]

ar·chi·tec·ture (är'kĭ-tĕk'chər) n.

1. The art and science of designing and erecting buildings.
2. Buildings and other large structures: the low, brick-and-adobe architecture of the Southwest.
3. A style and method of design and construction: *Byzantine architecture.*

4. Orderly arrangement of parts; structure: the architecture of the federal bureaucracy; the architecture of a novel.
5. *Computer Science* The overall design or structure of a computer system, including the hardware and the software required to run it, especially the internal structure of the microprocessor.

Webster's Ninth New Collegiate Dictionary [74]

ar·chi·tect. 1: one who designs buildings and advises in their construction 2: one who plans and achieves a difficult objective

ar·chi·tec·ture. 1: the art or science building; *specif*: the art or practice of designing and building structures and esp. habitable ones 2 a: formation or construction as or as if the result of conscious act b: a unifying or coherent form or structure 3: architectural product or work 4: a method or style of building

Several aspects emerge with respect to the idea of architecting or architecture. Almost all of the definitions contain some element of both 'art' and 'science'. All of them also contain the ideas of structure, design, or purpose. Enterprise architecting's closest parallel is that of systems architecting. Rechtin and Maier get at the dual art/science nature of system architecting by describing art as that part of the process that "is nonanalytic, inductive, difficult to certify, less understood…It is a process of insights, vision, intuitions, judgment calls, and even 'tastes'." In contrast, the science side of system architecting is "analytic, deductive, experiment-based, easily certifiable, well understood, and widely taught in academia and industry."

Rechtin goes on to enumerate architecting and the role of the architect in the following way:

> "The essence of architecting is structuring …bringing form to function, bringing order out of apparent chaos, or converting the partially formed ideas of a client into a workable conceptual model…. key techniques are balancing the needs, fitting the interfaces, and compromising among the extremes."
>
> "The system architect's task is to bring structure in the form of systems to an inherently ill-structured unbounded world of human needs, technology, economics, politics, engineering, and industrial practice. The architect, therefore, is not a 'general engineer,' but a specialist

in reducing complexity, uncertainty, and ambiguity to workable concepts. The systems engineer, in contrast, is the master of making feasible concepts work." [75]

Crawley brings the concept of architecting and the role of the architect home with the following observations [76]:

"Architecting occurs at three identifiable scales:

- Architecting a product to transfer to a customer (the reference scale)
- At a smaller scale, architecting an element of a product (i.e. a system for an internal 'customer')
- At a larger scale, which encompasses considering the product within a family, and in the context of the technology, design and manufacturing competence of the enterprise."

"Architecting is universal:

- It applies to products (the reference case)
- It applies to technical design and manufacturing processes
- It applies more generally to process and organizations
- It applies to any endeavor in which humans participate as a creative force"

"The Role of the Architect:

1) The architect drives ambiguity from the upstream process by defining the boundary of the "product/system" which constitute the system and its design and implementation process.

2) The architect creates the concept for the system, consisting of internal function and form.

3) The architect manages the evolution of complexity so that goals are met and function is delivered, while the system is comprehendible to all during its design, implementation, operation and evolution.

Both Rechtin and Crawley bring out the innate sense of how fuzzy things are in the architecting space. Both hit on the key concepts of complexity, ambiguity, and uncertainty as well as the inherently creative aspects of the architect's role. Crawley provides an additional degree of

tangibility to these concepts by explicitly calling out both the scale at which architecting is accomplished, and the specific role the architect plays in the design process.

Enterprise Architecting Framework

With the above discussion as background, 'enterprise' and 'architecting' are melded together into a single construct called 'enterprise architecting'. For this research, the definition and framework advanced by Nightingale and Rhodes will be used as the basis for defining EA and the activities that surround it [11]:

> *"Applying holistic thinking to design, evaluate and select a preferred structure for a future state enterprise to realize its value proposition and desired behaviors."*

Notice how cleanly this definition of EA fits within the broader value-creation framework detailed previously. Recall that the EA approach is the primary mechanism by which to create and evaluate alternative value propositions. This corresponds directly with the definition proposed by Nightingale and Rhodes. Also note that this definition includes the complexity of the previous definitions for enterprise and architecture by rolling these elements up into the idea of a "holistic" approach to the problem. In addition, all three dimensions of the enterprise are explicitly captured in the way structure, value and behavior interact in the definition.

What follows is a very brief overview of the EA framework developed by Nightingale and Rhodes. The overarching framework is depicted in Figure 3-7. There are eight predominant "views" or aspects from which the enterprise as a whole is seen.

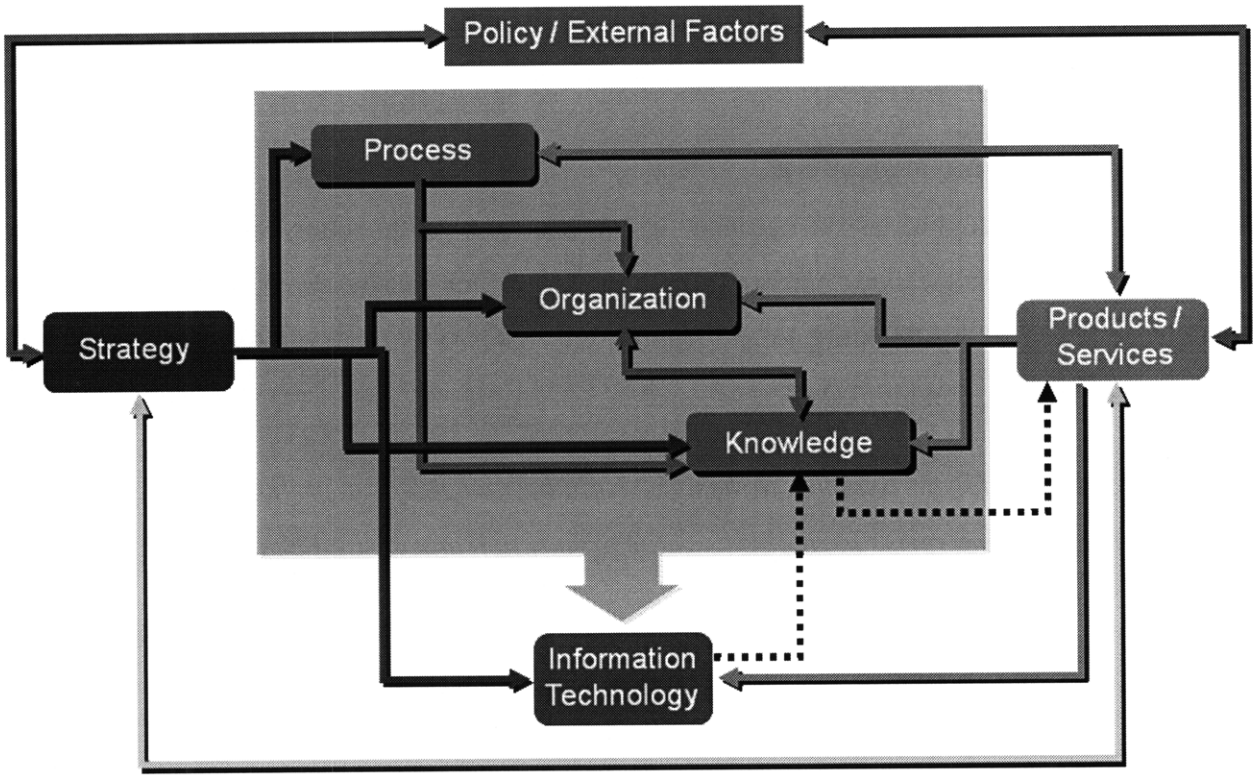


Figure 3-7. Enterprise Architecting Framework and Views.

Each of these views is defined as follows:

Strategy: This view represents goals, vision and direction of the enterprise and includes the business model and competitive environment. [77]

Process: This view represents the core processes by which the enterprise creates value for its stakeholders. [77]

Organization: This view represents organizational structure as well as relationships, culture, behaviors, and boundaries between individuals, teams and organizations. [77]

Knowledge: This view represents the implicit and tacit knowledge, capabilities, and intellectual property resident in the enterprise. [77]

Policy/External Factors: This view represents the external regulatory, political and societal environments in which the enterprise operates. [78]

Information: This view represents the information needs of the enterprise, including flows of information as well as the systems and technologies needed to ensure information availability. [78]

Product: This view represents the products produced by the enterprise. [78]

Services: This view represents the services of the enterprise, including services as a primary objective or in support of products. [78]

It is important to note that while each of these views can be considered independently, this defeats the intent and purpose of the "holistic" approach to EA. Nightingale and Rhodes provide the following direction on how to integrate each of the views in concert with one another [79]:

"Architectural Views CAN NOT be developed separately!
- Their organic structure is different when separated and developed individually
- Must be analyzed collectively rather than individually

Interrelationships Among Architectural Views
- Some views directly influence (drive) other views
- Some views directly interact with one another and drive performance in both directions

Other views serve as the performance enablers
- Alignment across views is critical to achieve Enterprise performance"

The effect of applying this methodology is to view the entire enterprise "through" or from the perspective of that particular view. In other words, the 'strategy' view assessment is not done from the perspective of how the strategy is viewed from the enterprise, but rather what the enterprise (and the other views collectively) should look like when viewing it through the lens of strategy. This is a fundamental distinction, and one that is easy to lose conducting the analysis.

The final point to bring out is that the EA activity should be directed towards achieving the desired interaction states between the views, not as an effort to design the views in and of themselves. This requires an additional level of abstraction in the mind of the architect because the interactions are the effects caused by the design choices in each of the views. Further, these interactions are an emergent property of the enterprise as a whole. The extent to which any one

view impacts the broader enterprise behavior depends heavily on how coupled that particular view is to other views for the problem under consideration. The bottom line is the architect should be architecting for a desired behavior or outcome of the enterprise, not to achieve some specific structure or form.

Pulling It All Together: The Overarching Analytical Approach

The remainder of the methodology section details the specifics of how the LEV value-creation framework is implemented in this research. Each chapter builds more or less on each major phase of the value-creation framework introduced in this chapter: value identification (Chapter 4 and 5), value proposition (Chapter 6), and value delivery (Chapter 7). As a roadmap to the methodologies incorporated in each phase of the value-creation framework, Figure 3-8 provides a visual reference for how the remainder of Section II is laid out.

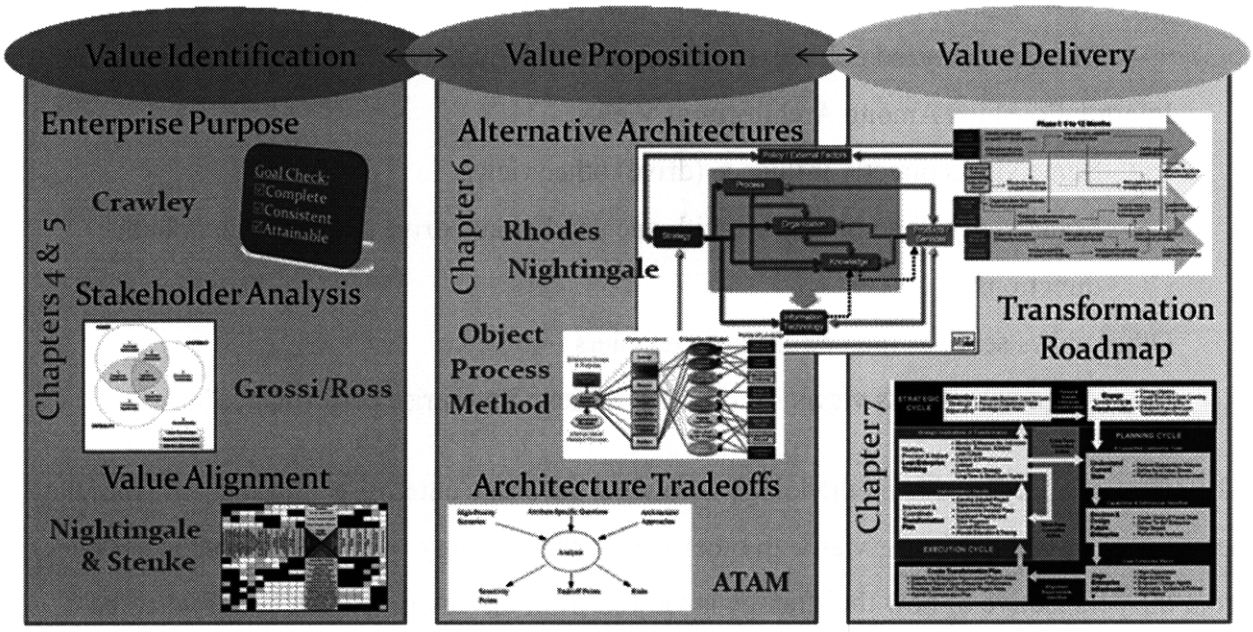


Figure 3-8. Methodology Roadmap.

In the most general sense, the objective of the methodology is to provide a concrete linkage between the value structure and the engineering of the enterprise with explicit treatment of the context. Figure 3-9 provides the most general view of these interactions.

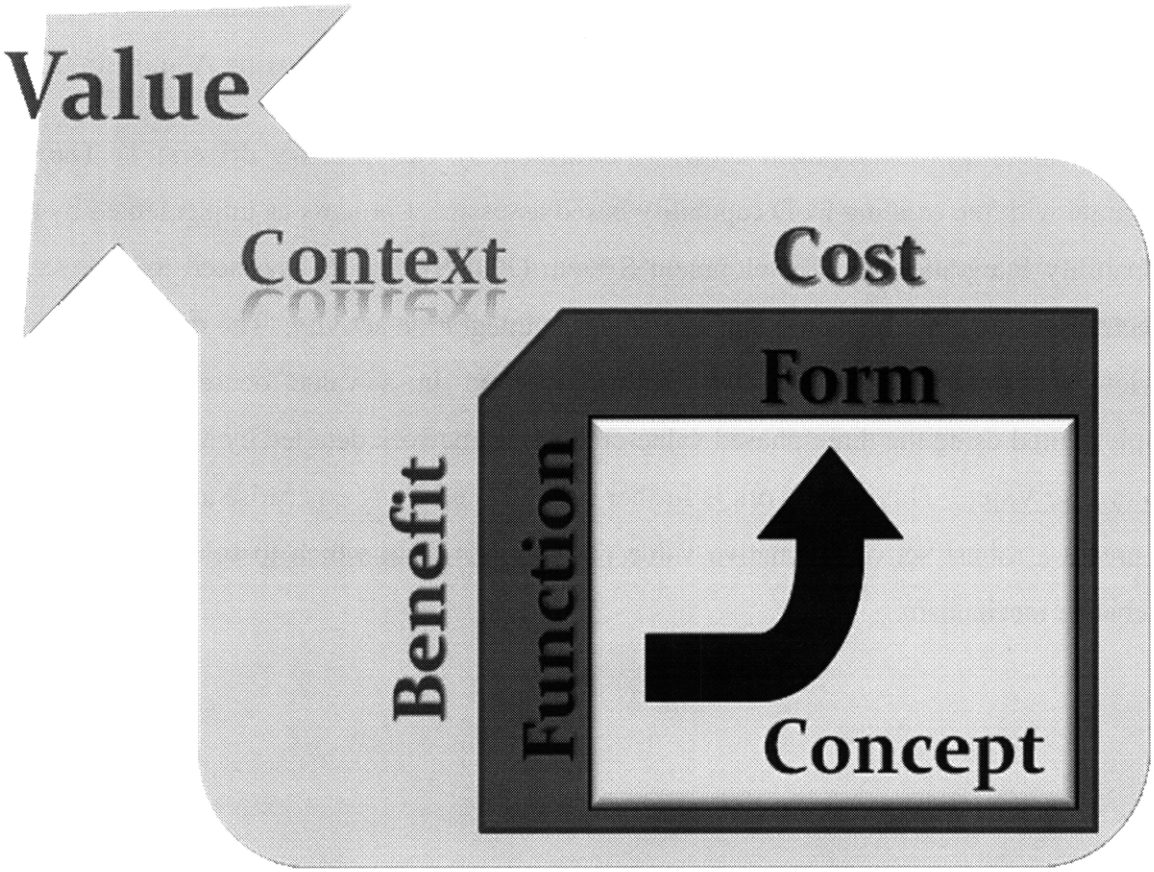


Figure 3-9. Generalized Model for Value Creation.

In this construct, the 'blue' box represents the classic role of the architect in turning functional needs into a form that can meet the needs. The degree of functionality is ultimately the basis on which the benefit of the system is perceived, and the form drives the cost associated with the delivery of the associated function through the particular concept the architect has chosen. Whether or not this benefit-to-cost result creates 'value' from a stakeholder perspective will depend to a significant degree on the context in which both the system and the stakeholder are operating, and the perceived 'value' will shift as the context changes, effectively capturing the dynamic nature of value delivery.

Chapter 3 Summary

The scope of this thesis is limited to addressing the issues of three specific Air Force UAS platforms, the MQ-1, MQ-9, and RQ-4, comprising a multi-program enterprise level of analysis.

Organizationally, the research will focus on three primary groups of stakeholders: Air Combat Command, the Air Force acquisition community, and the Federal Aviation Administration.

The methodology development effort is informed by two primary drivers: 1) The need to integrate with the existing DoD capability-based assessment process as implemented by the Joint Capability Integration and Development System (JCIDS), and 2) The need to address the full spectrum of factors influencing the UAS airspace integration activity. The result of the literature review, constrained by these two factors, resulted in a value-focused approach that is implemented using the three-phased value-creation framework detailed by Murman et al. in Lean Enterprise Value. This framework is further strengthened using enterprise architecting principles to create a robust set of alternative value propositions from which to select a preferred value exchange mechanism.

CHAPTER 4 – BUILDING THE ENTERPRISE VALUE STRUCTURE

You can keep a few people happy all of the time, some of the people happy most of the time, but you can't keep everyone happy all of the time.

—Anonymous

The thrust of this chapter is to lay out the specifics for identifying enterprise value. Complicating this task is the realization that the enterprise value definition is a function of the enterprise stakeholders who collectively define the purpose of the enterprise and its principle aims (hence the rational for the opening quote of the chapter—make sure the "few" you decide to keep happy all of the time are the right stakeholders!). Unfortunately, the enterprise stakeholders cannot be definitively defined until the enterprise purpose is well-articulated. The coupled nature of this problem requires regular and consistent feedback in the method employed to generate both the enterprise purpose statement and the list of relevant stakeholders. The iterative nature of the methodology proposed in the following chapters is a fundamental aspect to ensuring the value definition is captured correctly. Without this consistent feedback from enterprise stakeholders, the enterprise architect can quickly wander off the path to value delivery.

From a chapter organization standpoint, a method for building an enterprise purpose statement is examined first, followed by the implementation of a method for conducting stakeholder analysis. Once the enterprise purpose statement and stakeholders is defined, the enterprise value definition (referred to as the enterprise 'value structure' to convey the idea that it must be assembled from individual stakeholder perspectives) can be articulated and described. These value definition descriptions take the form of attributes a particular stakeholder associates with the delivery of the desired value, and by which the stakeholder measures the degree to which value is provided by the enterprise.

Building Enterprise Purpose Statements

Enterprise Purpose Statements: Motivation and Definitions

The approach adopted for ensuring the development of a meaningful enterprise purpose statement is one advance by Crawley as part of the system architecting activity. [7] The key distinction is that while Crawley articulates the following approach for product systems, the use

in the current research context is at the enterprise level. Crawley articulates the motivation for what he calls 'system problem statements' (and what this research will refer to as 'enterprise purpose statements') with the following comments:

> "The identification of a single or a small (concise) set of humanly solvable, representative (of true success), attainable (within resources & technology), consistent and complete goals is vital to resolving ambiguity and creating a path for enterprise[2] success."

This statement for why enterprise purpose statements are important needs to be unpacked a bit further by examining what is meant by the following words: humanly solvable, representative, attainable, consistent and complete. The following definitions provide clarity to what is intended by adhering to these enterprise purpose statement qualifiers:

> Humanly Solvable: "Solvability" implies that the goals are comprehensible by the person reading them. The purpose statement should enhance the problem solver's ability to find a right solution by providing enough information without constraining creativity (in other words, the "The Problem Statement should not design internal systems").
>
> Representative: A purpose statement or goals are representative when the delivery of the purpose statement or goals results in an enterprise declaration of 'success'. This only occurs if the enterprise purpose answers a real need (in the context in which it is operating) and ultimately determines if the enterprise will be a success in reality. If the enterprise purpose statement is in fact representative, then the delivery of the enterprise purpose or goals is a tradable surrogate for success.
>
> Attainable: Implies that all enterprise goals can be reached within technology limitations, and also meet development schedule, resource, and risk goals. This requires a concept and (at least crude) models of all metrics which appear in the enterprise purpose statement to test in "analytical" verification. Attainability has a large risk component, and in general, is much easier to assess for derivative products and much more difficult for clean slate

[2] Author's Note: The word 'enterprise' has been substituted for Crawley's original word of 'system' in this definition. Otherwise, the definition is unchanged from Crawley's original statement.

designs. When goals are not attainable there are two options: de-scope goals or add resources. The option chosen depends on the context and the enterprise.

Consistent: A measure of whether product goals are internally contradictory or not. Can sometimes be checked by thorough logical examination (requirements review, walk through, etc), but in other cases, consistency can only be checked analytically with reference to some model. In these cases, automation of the enterprise purpose and goals can help. This check on enterprise purpose statements often requires a concept to resolve, since enterprise purposes or goals which are contradictory within one concept may still be consistent.

Complete: An assessment of whether the enterprise purpose statement has adequately captured all of the significant stakeholder value definitions. The enterprise purpose statement should provide for the delivery of all of the key value attributes of the enterprise stakeholders. If there are important value attributes missing from the enterprise purpose statement, the purpose statement is incomplete and no longer representative, putting "success" a risk.

In adapting the Crawley criteria for use within the value-focused thinking construct outlined in Chapter 3, it is apparent that both the 'humanly solvable' and 'representative' criteria described above should be accounted for simply as an outgrowth of using a value-creation framework. In other words, attention to detail while eliciting the value and attribute characterizations from enterprise stakeholders should result in the creation of an enterprise purpose statement that is both humanly solvable and representative. If it fails either of these tests, serious reconsideration of the validity of the value characterization itself should result, and stakeholders re-engaged to ensure value definitions are accurately characterized (i.e. that the values are correct and the attributes describing them are in fact what the stakeholder uses to assess the extent of value delivery).

The practical ramification of the above observations is to limit the enterprise purpose statement evaluations to primarily an assessment of the statement's attainability, completeness, and consistency. With this understanding of how to assess the validity of an enterprise purpose

statement, a framework for understanding the context and framework for an enterprise purpose statement can be addressed.

The Enterprise Purpose Statement Framework

Putting the enterprise purpose statement into the appropriate context is a key aspect to getting the enterprise activities scoped to the appropriate level. There is also a need to understand how the enterprise purpose statement connects to both the broader context above it and the details of the enterprise activities below it. Crawley describes the approach to arriving at an understanding of these contexts as "1 up, 1 down". [7]

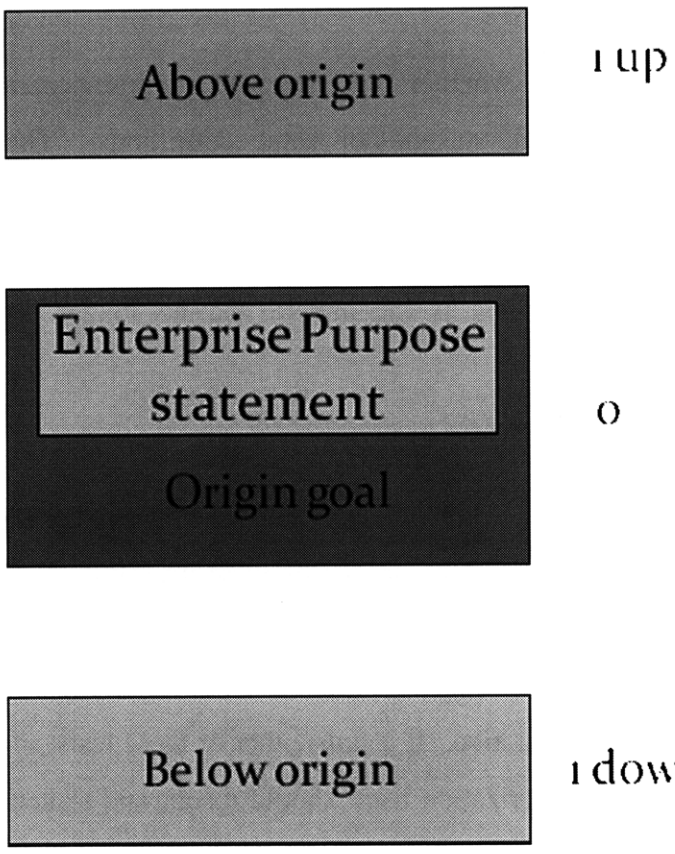


Figure 4-1. Determining Enterprise Purpose Statement Context.

In this construct, the Enterprise Purpose Statement is the dominant objective of the enterprise, but it may not capture all of the detail needed to completely describe the interfaces with the objectives one layer deeper in detail. This additional layer of detail is captured in the 'Below Origin' box labeled "1 down." An investigation at this more detailed level of granularity may bring aspects of the Enterprise Purpose Statement to light that were not considered previously

but that may be important for the enterprise to move forward. In contrast, the 'Above Origin' box labeled "1 up" provides the contextual information in which the enterprise is operating. It sheds light on the motivation and pressures the enterprise must address and resolve in order to be successful in the "big picture". It is in the process of examining this "1 up" level that many of the political and organizational constraints come to light. This should also help capture any other major upstream influence on the enterprise to ensure that the enterprise adequately captures and addresses these issues. To frame the assessment in a different metaphor, the 'Origin Goal' can be thought of as a single stock, the 'Above Origin' as the portfolio of stocks of which the enterprise is just one of many, and the 'Below Origin' as the detailed financial statements describing the health or transaction details of the enterprise.

Putting the enterprise into its appropriate above/below context is perhaps the most important and oft overlooked step to ensure the enterprise purpose statement is appropriately scoped and the value structure is vertically aligned. If the enterprise purpose statement is too narrow, there will not be enough tradespace in which to architect a set of value propositions that will sufficiently satisfy all of the stakeholders. On the other hand, if the scope is too large, the focus of the effort runs the risk of dilution and the opportunity for real impact at the desired level may be lost. If the enterprise context is understood in both the up and down directions, the enterprise purpose statement can be modified appropriately to either include additional scope when needed or to restrict the enterprise purpose statement further to better focus the effort. *This entire effort can be described as aligning the enterprise value structure in the "vertical dimension."*

In practice, getting the enterprise purpose statement right can make up for a host of missteps later in the analysis or in the execution of a transformation plan. A strong, properly focused enterprise purpose statement is even more pivotal when the enterprise is distributed organizationally, geographically, or culturally. On the other hand, a poorly scoped enterprise purpose statement that fails the three tests of attainability, completeness, and consistency will wreak havoc on even the best functioning teams with all of the appropriate tools. Research by Katz suggests that one of the most critical factors to a team's success is having a common definition of the problem they are supposed to be solving. [19] In essence, a good enterprise purpose statement is just that—a definitive response to the all too frequently asked question of "Why are we here again?"

The Enterprise Purpose Statement Form

Advancing a formal method of writing an enterprise purpose statement helps capture all of the above considerations in a consistent manner that addresses the primary evaluation criteria of attainability, completeness, and consistency. Figure 4-2 captures the major elements of a system purpose statement as advanced by Crawley and adapted to the enterprise purpose statement.

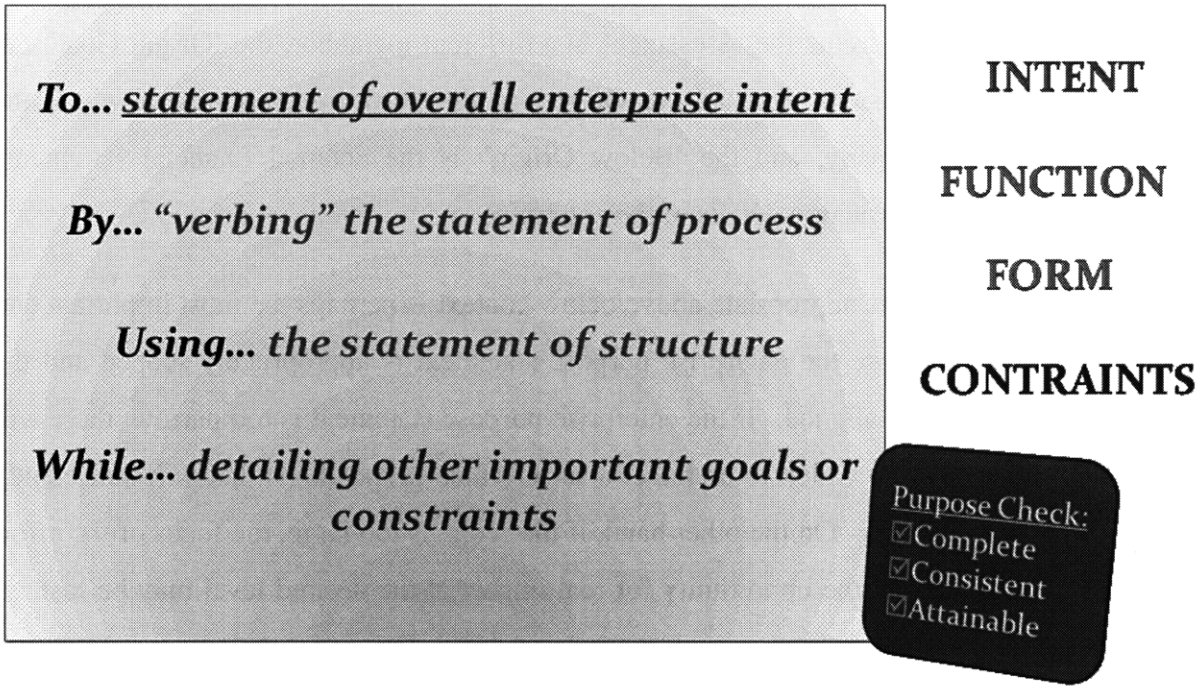


Figure 4-2. Enterprise Purpose Statement Form.

It should be noted up front that the entire enterprise purpose statement outlined above cannot actually be written down until the enterprise has been architected. At a minimum, the enterprise intent must be specified based on the enterprise stakeholder inputs. It may also be possible to list the major constraints or other important goals the enterprise must address in the course of parsing the purpose statement. A formulation of the function and form of the enterprise is actually the point of conducting the analysis that follows. The tendency is to postulate the function and form up front in the analysis, but this defeats the entire purpose of what follows. It is far more effective to leave these as open as possible at the initial phase of the analysis and to iterate through the entire methodology until convergence results across all four dimensions of the purpose statement. Once again, the importance of placing the enterprise within the appropriate context boundaries to get a solid grasp of the enterprise scope is emphasized. Without a good

position from which to start, achieving convergence on the enterprise purpose statement across the stakeholder community will require more iterations than time or money will allow. If done correctly, good convergence should result after just two or three passes through the analysis framework. A deeper domain knowledge and/or a stronger feedback loop with the enterprise stakeholders could reduce the iteration count further. Figure 4-4 provides an example of the information that would likely result with each iteration through the methodology developed in Chapters 4-7.

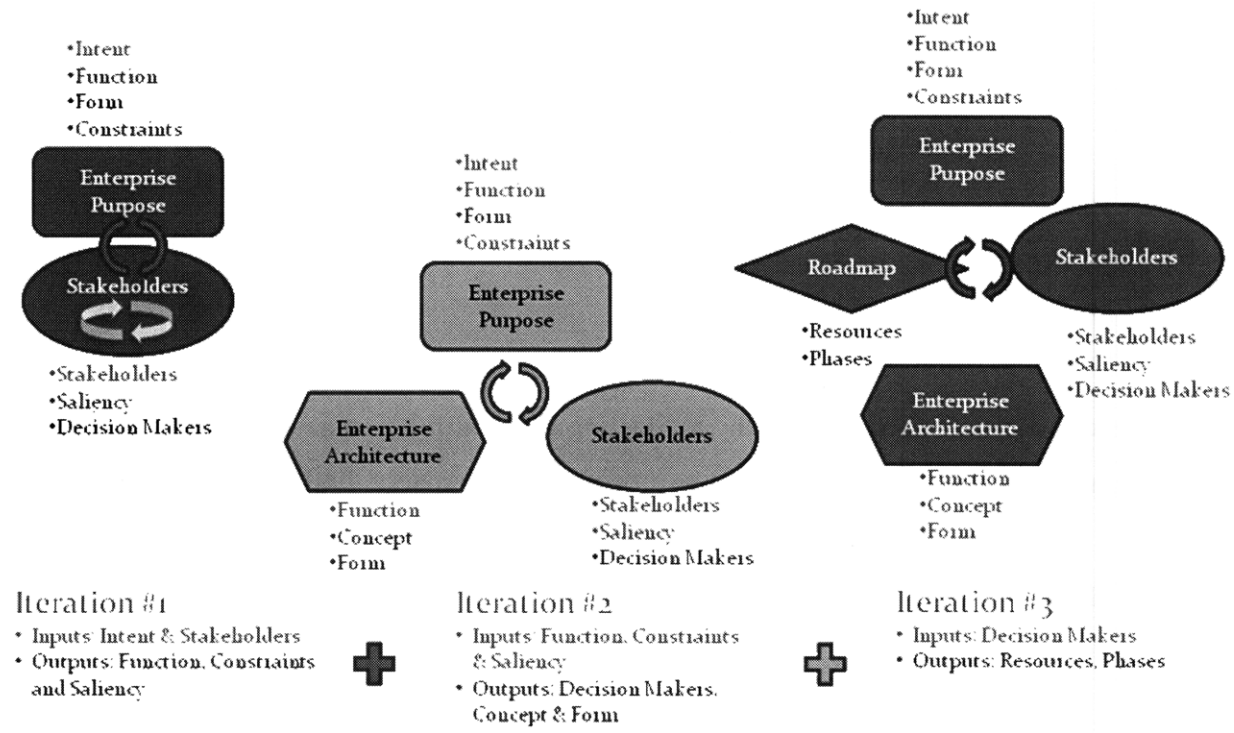


Figure 4-3. Example Set of Analysis Iterations with Inputs and Outputs Identified.

Note that in the case of the initial stakeholder analysis, there are also internal iterations within that portion of the analysis to achieve the outputs specified for the overall iteration. This will be developed more fully in the next section.

As a tool to help assess and evaluate the extent to which the enterprise purpose statement fulfills the intended function, Crawley suggests the verification and validation exercise depicted in Figure 4-4. [7]

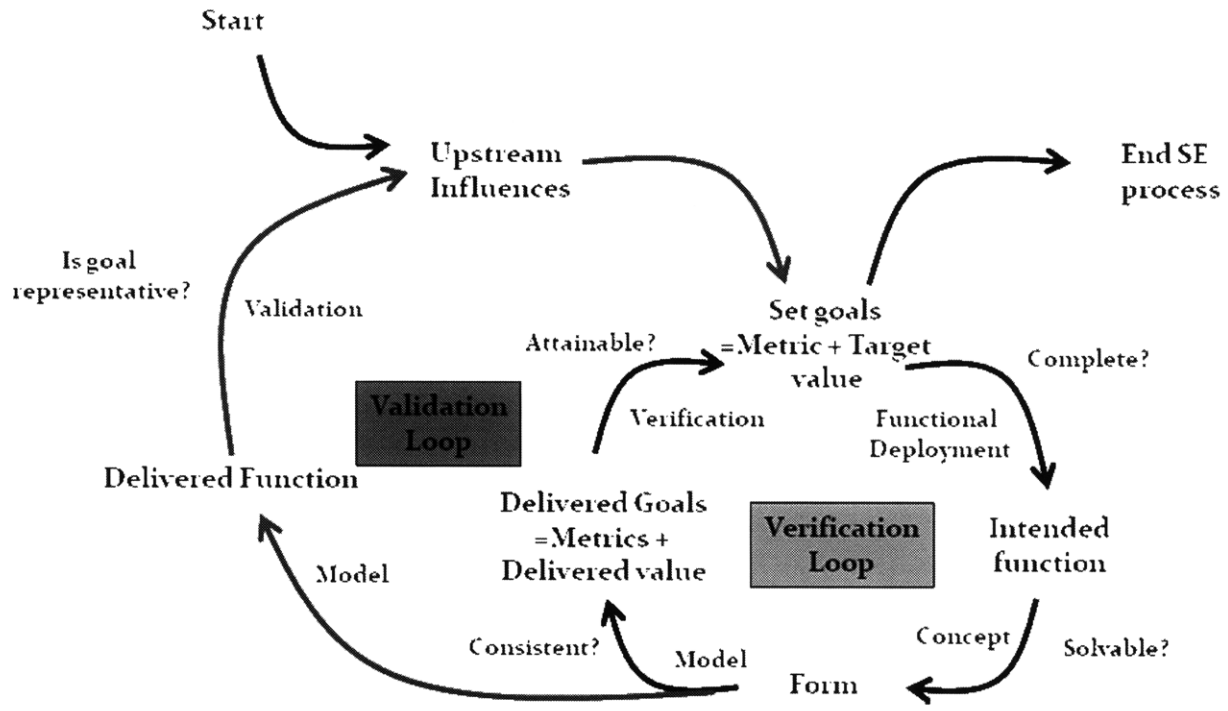


Figure 4-4. Enterprise Purpose Statement Verification and Validation Model.

Given the current state of the research, conducting a full validation assessment is not possible beyond a mental walk through of the results since the area of building and implementing executable models of enterprise architectures is still in development. If the process outlined above is followed, the enterprise purpose statement should at a minimum comply with the events around the verification loop.

Summary on Enterprise Purpose Statements

In conclusion, Crawley provides several general guidelines to help formulate better purpose statements. These recommendations include the following:

– Challenge, expand, contract and think creatively about enterprise purpose statements
– State enterprise purpose statements in need-goal-function format
– State enterprise purpose statements clearly, concisely, in solution neutral form, and aligned with human problem solving strategies
– Capture intent, so people understand why
– Define the enterprise boundary consistent with the enterprise purpose statement

Consistently applying the framework developed in the previous discussion, coupled with a dogged determination to get this portion of the analysis correct, will pay dividends time-and-again as the effort advances.

Conducting Stakeholder Analyses

An important aspect to account for in a methodology development effort attempting to put structure into an inherently soft and fluid context such as defining enterprise purpose and stakeholders is the need for a flexible approach. This comes to the forefront when the interaction between the enterprise purpose statement and stakeholder analysis are considered. Because these two aspects of the enterprise are so tightly coupled, they need to be pursued in tandem, not in a serial process. Unfortunately, the limitations of the written word require them to be presented in a sequential manner. Ideally, the enterprise purpose and stakeholder analysis begin as parallel efforts with some initial understanding of both to help converge on an appropriate scope and bound to both issues. With the enterprise purpose statement framework in place, the stakeholder analysis methodology is now addressed.

Defining Stakeholder Saliency

To understand and assess the stakeholders associated with an enterprise, it is helpful to employ a methodology that allows for a consistent categorization and treatment of various kinds of stakeholders as it relates to their ability to influence or control enterprise activities. The model that will be used in this report will be one developed by Ignacio Grossi in his 2003 thesis entitled "Stakeholder Analysis in the Context of the Lean Enterprise." [8] In particular, the stakeholder salience model that Grossi developed (an extension of the model presented by Mitchell, Agle, and Wood [80]) will be used to assess the relative ordering and ranking of stakeholders as they relate to the airspace integration framework (See Figure 4-5).

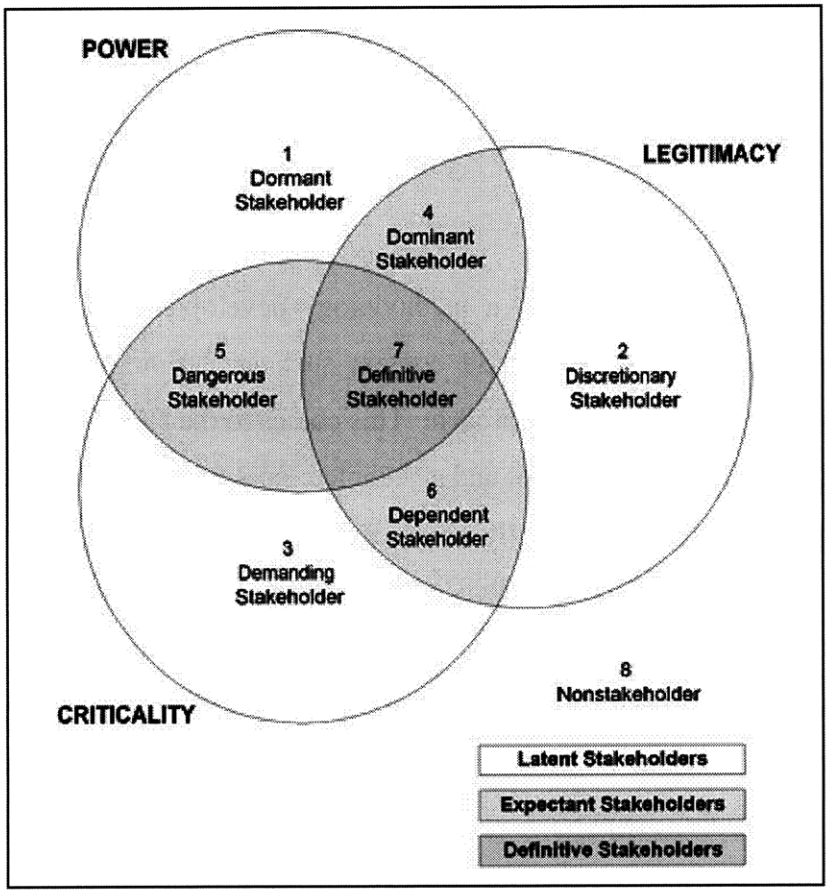


Figure 4-5. Stakeholder Identification and Salience Framework.

Grossi makes use of the stakeholder model developed by Mitchell, Agle, and Wood that ascribes the dimensions of power, legitimacy, and criticality to the stakeholder analysis space. The interactions between these three dimensions are depicted in Figure 4-5. The following excerpt from Grossi provides additional clarification on what is meant by each of these terms:

> "A stakeholder demonstrates *power* in its relationship with an enterprise when it has or can gain access to coercive, utilitarian, or symbolic means to impose its will (or the will of others) in the relationship. Coercive power is that related with the use of physical resources of force, violence, or restraint. Utilitarian power is that based on the exchange of material or financial resources. Symbolic power is that based on symbolic resources – normative symbols, like prestige and esteem; and social symbols, like love and acceptance."
>
> "*Legitimacy* is defined as 'a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of

norms, values, beliefs, and definitions' (Mitchell, Agle, and Wood, 1997; cf. Suchman, 1995). Legitimacy and power can exist independently or can be combined to create authority (power that is attached to a position that others perceive as legitimate)."

"Urgency, according to Mitchell, Agle, and Wood, is the necessary attribute to provide their stakeholder identification model with dynamic characteristics. Urgency exists when two conditions are met: (1) when a relationship or claim is of a time-sensitive nature and (2) when that relationship or claim is important or critical to the stakeholder operations and/or strategies. Instead, we prefer to identify this urgency attribute as *criticality* since this term involves both urgency (time sensitivity) and importance sub-attributes. In this way, some claim that is perceived as important but still not urgent can be considered as relevant, and vice versa. This distinction will allow us, for example, to identify and incorporate stakeholders with whom an enterprise defines long-term strategic issues (e.g. strategic alliances) that are of keen importance to the entire enterprise system."

"Any of the attributes of power, legitimacy, and criticality are dynamic in nature, each one constituting a variable that can adopt different values according to the environment and the particular circumstances an enterprise is traversing. Also, all these attributes are socially constructed, not objective reality – meaning that they are subject to multiple and different perceptions. Moreover, the actual presence of one or more of the attributes does not mean either that the stakeholder or the managers are conscious of the level of those attributes, or that they are willing to act on the inferences that are possibly made from them." [8]

This model provides a detailed approach for identifying and categorizing each enterprise stakeholder. The task now moves to the need to indentify who these stakeholders are that need to be classified.

Identifying Stakeholders

Grossi presents a stakeholder identification model in his work that is illustrated in Figure 4-6. [8] Notice that the entry point for this model is the identification of the "enterprise system level value" definition. For the purposes of this analysis, this block is the enterprise purpose statement from the previous section.

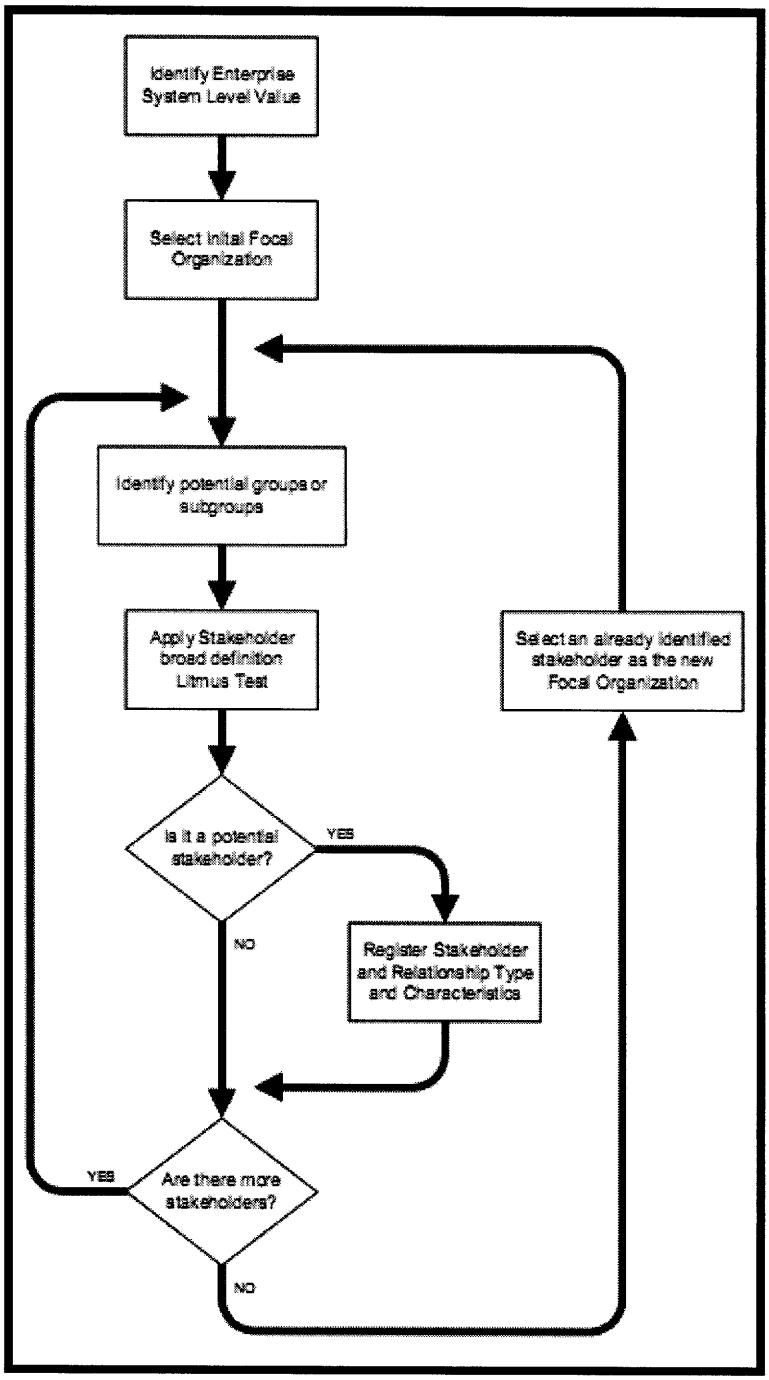


Figure 4-6. Stakeholder Identification Methodology.

The only modification to the Grossi model that should be made is an additional check beyond just the "focal organization" to include a re-assessment of the enterprise purpose statement as previously described. In this way, the stakeholder and enterprise purpose statement can be

rapidly iterated to achieve the desired convergence between the enterprise purpose statement and the stakeholders considered internal to the enterprise.

Once the enterprise stakeholder set is fully enumerated, the saliency of each stakeholder must be assessed. To accomplish this stakeholder evaluation, Grossi developed a detailed set of considerations to help quantify each stakeholder's score on the power, legitimacy and criticality scale. Appendix C provides the detailed assessment criteria for completing the saliency index score for each stakeholder. Table 4-1 provides a template for recording and tabulating the results of this analysis. Depending on the size of the potential enterprise stakeholder pool, an initial qualitative screening may be appropriate to bound the problem to a reasonable number of stakeholders. This will be discussed further in the 'Application' section.

Stakeholder	Criticality Factor	Power Factor	Legitmacy Factor	Salience Index
Stakeholder 1				
Stakeholder 2				
Stakeholder 3				
Stakeholder 4				
Stakeholder 5				
Stakeholder N				

Table 4-1. Stakeholder Saliency Evaluation.

The enterprise stakeholders are categorized and ranked based on their saliency index. This provides a powerful tool for rigorously identifying which stakeholders are the most important within an enterprise context. It also provides a way to interface a large pool of enterprise stakeholders to the methodology used by Ross in the MATE value elicitation process. [9] The current MATE arrangement implements the construct depicted in Figure 4-7. By focusing on a narrower subset of the most important stakeholders in an enterprise, characterized by Ross as "decision makers", the analysis focuses on those stakeholders with the highest saliency to enterprise success. Extending the MATE approach to a larger number of stakeholders is an area of active research.

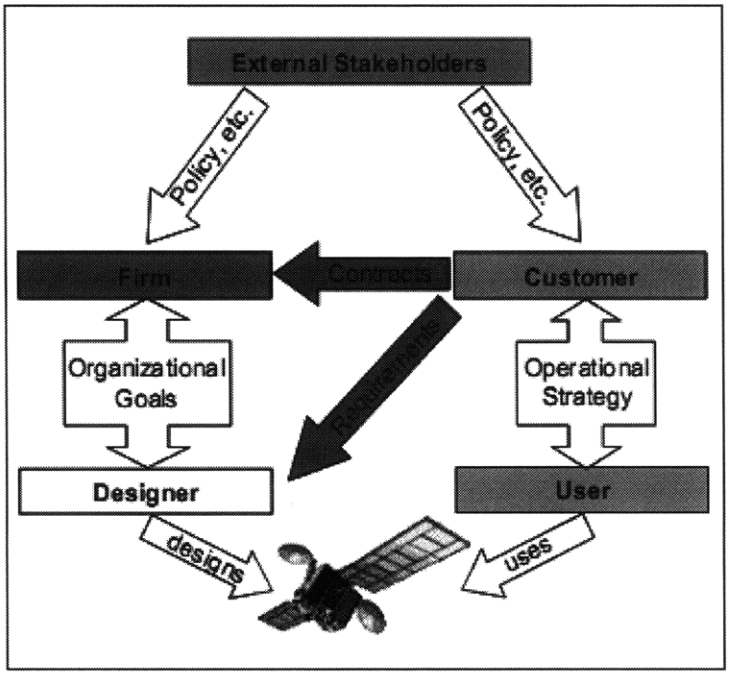


Figure 4-7. MATE Decision Maker Role Hierarchy.

Ross provides the following description of the decision maker categories depicted in Figure 4-7:

> "Level 0 decision makers are classified as External Stakeholders. These stakeholders have little stake in the system and typically have control over policies or budgets that affect many systems. An example of an External Stakeholder for a space system is Congress or the American people."
>
> "Level 1 decision makers include the Firm and the Customer. The Firm role includes those who have organizational stakes in the project and manage the Designers. This decision maker may have stakes in multiple projects, but has specific preferences for the system in question. An example of a Firm is an aerospace company. The Customer role includes those who control the money for financing the project. According to (Martin 1997) [81], the Customer 'is an individual or organization that (1) commission the engineering of a system, or (2) is a prospective purchaser of an end product.' This decision maker typically contracts to the Firm in order to build the system and provides requirements to the Designer."
>
> "Level 2 decision makers include the Designer and the User. The User role has direct preferences for the system and typically is the originator of need for the system. (Need can

> originate within an organization, such as the Firm, as well)... An example of a User is a scientist or warfighter. The Customer typically has preferences that balance product performance meeting User needs, cost of the system, and political considerations. The Designer role has direct interaction with the creation of the system and tries to create a product that meets the preferences of the Firm, Customer, and User roles. An example of a Designer is the system engineer within the aerospace company building the system. The arrows in the figure [Figure 4-7] depict the predominate direction of information flow, though some reverse flow does occur (requirements push-back, for instance)."

With the joining of methodologies from Grossi and Ross, a robust framework for a large number of enterprise stakeholders can be assessed in a straightforward fashion and then the most important stakeholders in the enterprise (referred to hereafter as simply "decision makers) can be matched to the Ross model. This opens the door for direct use of the extended work already available in structuring the value elicitation and attribute definitions from the enterprise decision makers.

Building the Value Structure

With a clear understanding of the enterprise purpose and decision makers resulting from an initial iteration through the above-described process, construction of the value structure is possible through a structured data collection process. As mentioned previously, the term 'value structure' as used in this research refers to the value definition, attributes, metrics, and ranges the enterprise decision makers consider in their evaluation of "success". Books have been written on the nuances of eliciting individual value definitions. Even a cursory treatment of the social sciences literature on this is well beyond the scope of the current effort. The bottom line is the need for an approach that is implementable. As alluded to in the previous section, MATE provides that framework for this research.

A detailed, step-by-step approach for constructing the enterprise value structure can be found by referring to Appendix A of Ross's 2003 master's thesis. [9] For the sake of brevity, the outline of the MATE value elicitation approach is provided below.

1. Identify Need
2. Define Mission

3. Define Scope
4. Identify All Relevant Decision Makers
5. Identify Constraints
6. Propose Attribute Definitions (User, Customer, Firm)
7. Nail Down Attribute Definitions (User, Customer, Firm)

Note that the MATE framework extends fully into the analytical model space for the design of technical systems. These additional steps are not included in the above list. In the case of the enterprise architecting challenge, executable models are not currently available, so this portion of the MATE framework is not used in the approach implemented in this research.

The specifics of the MATE value elicitation methodology provide the basis on which to structure the data collection effort. This is important because without a framework for exploring enterprise decision maker value space, the individual attempting to arrive at an understanding of the decision maker value definition can quickly become overwhelmed with data that may or may not be suitable for a value assessment. Using a semi-structured interview process that takes the MATE framework and contextualizes the questions being asked of the decision makers, a specific set of questions can be generated that can help focus the data collection effort and peel back the information layers to reveal the core value definitions of a decision maker. Further observations with respect to the data collection aspects of the methodology are addressed in Chapter 8.

Chapter 4 Summary

Starting down the value creation path involves a highly coupled assessment between the enterprise purpose and the enterprise stakeholders. In order to converge on the appropriate enterprise purpose statement and stakeholders, these two efforts must be undertaken together and then iterated to ensure they produce a clearly defined enterprise intent and set of decision makers. To ensure sound enterprise purpose statements result, an approach is adapted from Crawley to structure and assess enterprise purpose statements. Grossi's approach to determining stakeholder saliency is used to bring order to potentially large enterprise stakeholder pools, and then connected to the approach advanced by Ross using the MATE methodology. The value structure is elucidated by implementing the front end of the MATE process.

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CHAPTER 5 – ASSESSING ENTERPRISE VALUE ALIGNMENT

"You can't push on a rope."

—Persian Proverb

With a clear understanding of the individual enterprise decision maker value definitions resulting from the process described in Chapter 4, the challenge moves to understanding how these values are either aligned or misaligned within the enterprise. An enterprise with misaligned values is an enterprise trying to "push on a rope"—a whole lot of energy can be expended by the individual decision makers with no apparent result at the enterprise level.

This chapter provides an overview of the process used for assessing the degree of enterprise decision maker value alignment, correcting misalignments, and using metrics to understand and drive enterprise behavior. This portion of the analysis provides critical insights for what follows in Chapter 6, and the information gleaned in this portion of the analysis is used directly in the enterprise architecting effort that follows. Without an understanding of how the enterprise value structures between decision makers are aligned, it is difficult, if not outright impossible, to construct enterprise architectures that have any significant hope of creating lasting enterprise value.

A Lean Perspective on Flowing Value

One way to think through the enterprise value alignment challenge is to treat value as a quantity that should 'flow' through the various decision maker organizations. Womack and Jones [82] as well as Murman et al. [6] discuss the idea of value flowing continuously through an organization. They describe the idea of "value streams" within an enterprise and highlight the importance of eliminating waste through the use of value stream maps. Womack and Jones describe a value stream map in the following way:

> "A value stream map identifies every action required to design, order, and make a specific product. The actions are sorted into three categories: (1) those that actually create value as perceived by the customer; (2) those which create no value but are currently required by the product development, order filling, or production systems; and (3) those actions which don't create value as perceived by the customer and can be eliminated immediately."

> "Make Value Flow Continuously. Once the third type of wasteful actions along the value stream have been eliminated to the maximum extent possible, the way is clear to go to work on the remaining, non-value-creating steps through the use of flow, pull, and perfection techniques."

The value-creation framework described in Chapter 3 is designed expressly for creating this value flow in an organization. As Murman et al. point out in LEV, "...mapping the value stream is not the complete story in value creation. Focusing value stream mapping on one process area or program rather than at the enterprise level can lead to optimization of a part at the expense of the whole." Specifically, the value definitions between decision makers may be such that what is classified as "waste" by one decision maker in the process may be adding value from another's perspective—one man's junk may potentially be another man's treasure. Indiscriminate waste elimination at the local process level may result in a local improvement that actually reduces the overall value flow in the enterprise as a whole. An approach is needed for understanding the enterprise objectives, values, attributes and metrics in a way that provides for an assessment of the extent to which decision makers' views of value align.

Using the X-Matrix to Assess and Create Value Alignment

The tool of choice used in the methodology presented in this research is an adaptation of the "X-matrix". The X-matrix is a tool developed by Stanke and Nightingale to aid in conducting value stream mapping exercises described in the previous section. [10] Essentially, the X-matrix provides a way of assessing the degree of correlation between an enterprise's strategic objectives, values, attributes[3] and metrics. Essentially, the X-matrix is a sequence of Quality Functional Deployment Matrices connected together where the value of a cell is determined by the overall degree of correlation that exists between the two variables that meet in that cell. Figure 5-1 provides an example of the X-matrix structure. The primary axes lay out the principle elements of the enterprise value structure. The boxes between the axes are coded white, yellow and blue to depict the qualitative assessment of the strength of the correlation between the two variables that meet in that square. For instance, the box that maps "Strategic Objective 1" to

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[3] For this analysis, the original X-matrix dimension of "processes" as described by Stanke and Nightingale has been replaced with "attributes".

"Value 1" is coded blue in Figure 5-1. This means an assessment was made between the enterprise strategic objective and the value under consideration, and a high degree of correlation is believed to exist between that value and the extent to which the enterprise successfully meets that strategic objective. Correspondingly, a yellow box indicates a weak correlation, and a white box no correlation.

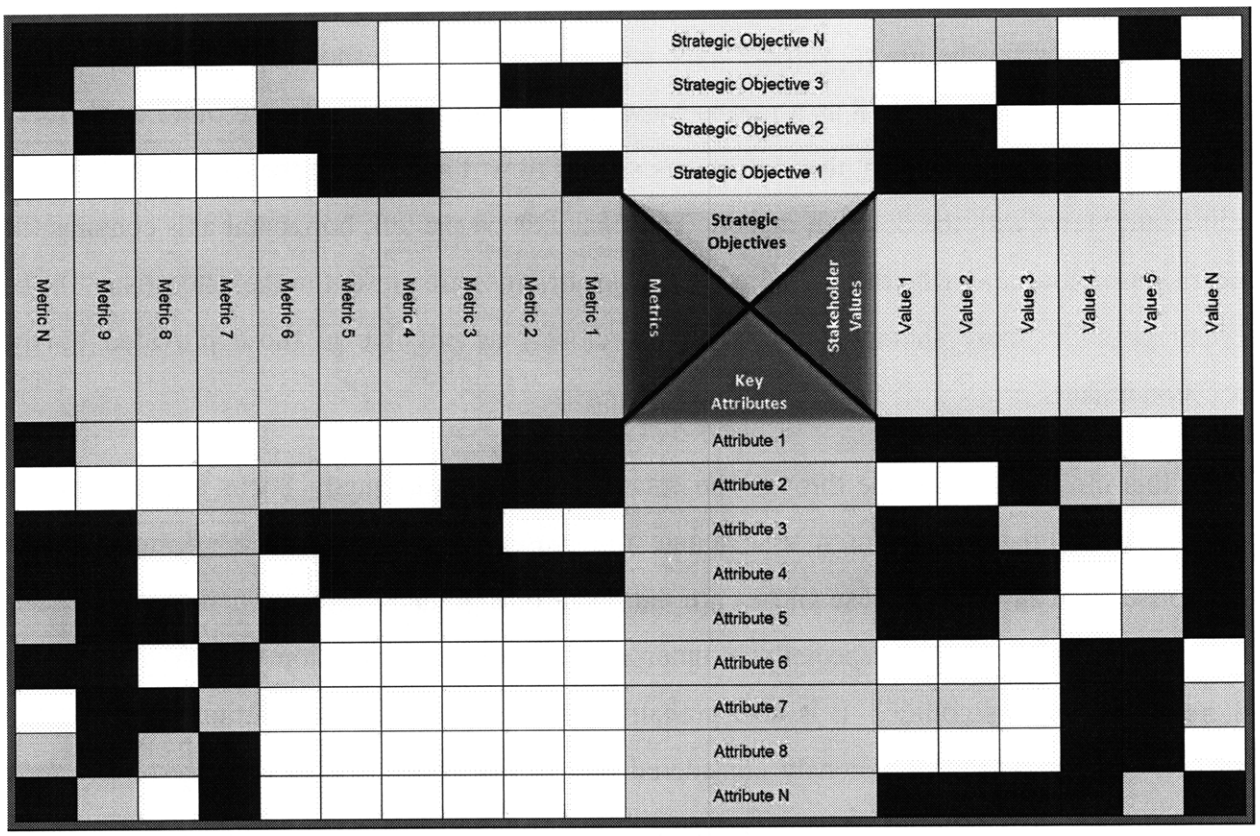


Figure 5-1. X-matrix Structure.

It is important to point out for the purposes of the analysis that the entries made to the X-matrix should be those assessed as primary drivers for each of the enterprise stakeholders. In other words, they represent a "superset" of the objectives, values, attributes and metrics for the entire enterprise. If there is some doubt as to the importance of a particular variable, include it in the analysis.

Practically speaking, the X-matrix is used in several different ways to evaluate enterprise value alignment. For the analysis in this research, the following convention is observed. The analysis starts by examining the value structure data elicited as part of the activities described in Chapter 4 and pulling out the primary enterprise purpose and/or goals as they are identified in the

enterprise purpose statement and enumerating them on the top, vertical axis. These should represent what the enterprise values should be based on the data collection effort, not what they might be currently within the organization. Next, the values articulated by the enterprise decision makers are listed on the right, horizontal axis of the matrix. Once again, these should be derived directly from interview data. Right or wrong, these are the values each decision maker indicated as primary in their assessment of what they care about in the enterprise outcomes. The attributes follow on the lower, vertical axis, and they should correspond directly to the things each decision maker indicated as a means by which they assessed the degree of value delivery previously articulated. Again, these attributes should flow directly from the data elicited during value interviews with the decision maker. The final axis on the left, horizontal axis contains the metrics used for measuring the extent to which the attributes are present in the enterprise. To the extent possible, these should also conform as closely as possible to those provided by the decision makers.

Once this initial pass is made through the data, a review is warranted. Focus attention on the consistency of the metrics used to evaluate the presence of one or more attributes in the enterprise. Because all of these entries are the result of individual decision maker preferences, there is a high possibility (especially in enterprises with diverse decision makers) that two or more of the metrics collide. It is also probable that before the data elicitation interview, the decision maker did not consciously considered the metrics in use within the enterprise. As a result, metrics may not exist or be very casual in their relationship to the attributes and strategic objectives.

As a result of metrics often being overlooked or poorly engineered for the desired behavior or output of the enterprise, the enterprise architect will often need to harmonize the metric inputs. When the harmonization results in a change in a metric, there should be a strong feedback loop with the impacted decision maker to ensure the change is acceptable. The problem becomes more challenging if there are contradictory attributes or values. If this occurs, the enterprise architect should consider how the enterprise scope or boundary can expand or contract in a way that would allow a resolution of the apparent contradiction. Regardless, a change in either the attribute or value definitions will require detailed and explicit discussion with the affected decision maker since the architect does not "own" these quantities.

Resolution of any potential disconnects between decision maker specified value structures provides the opportunity to flow value in the enterprise. Without this resolution, creating enterprise-wide value will be extremely difficult if not outright impossible. Each of the four axes on the X-matrix represents what "should be" if the enterprise is to successfully flow value. The extent to which value flows is tied to the correlation information for the "As-Is" state of the enterprise. For value alignment to occur, there should be at least one or more paths around the entire sequence of objective – value – attribute – metric axes that is strongly correlated. If this strongly correlated path does not exist, the value flow through the enterprise will be weak at best, and non-existent at worst. In this way, the value structure of the enterprise is established in the "horizontal dimension" much as the enterprise purpose statement ensures value is aligned vertically.

The creation of the "As-Is" X-matrix provides a very simple visual for understanding what is typically a complex set of interactions between each aspect of the value structure within an enterprise and between decision makers. By implementing the desired set of inputs to each of the four X-matrix axes, the architect can rapidly identify those aspects of the enterprise that need focused attention versus those that appear to working. The assumption made at this point is that the existing condition of the enterprise is a result of its current architecture. To create an aligned enterprise that will flow value across the decision makers, the enterprise will need to be architected in a way that addresses the shortfalls and continues to emphasize the strengths of the current enterprise architecture. The mechanics of how this is accomplished is in the next chapter.

As an aside, for those instances in which an existing enterprise is being examined to try to improve operations that are already on-going (vice standing up a 'clean slate' enterprise), the Enterprise Value Stream Mapping and Analysis (EVSMA) methodology put forward by Stanke and Nightingale should be used to understand and evaluate the existing enterprise value state. [10] Once a clear picture of the existing enterprise value stream is laid out, much of the upfront work with enterprise purpose and stakeholder analysis will be addressed, and the assessment can pick up at the value alignment step detailed here.

Driving Value Alignment with Metrics

Metrics are critically important in driving value in an enterprise. The choice of enterprise metrics will completely dominate many other decisions made further upstream in the value context. Metrics provide the most basic mechanism for evaluating enterprise value delivery. They represent the day-to-day encounter of measured value. As important as metrics are in driving enterprise behavior, a brief aside on how to use metrics to align enterprise value is in order.

In one sense, you can think of the attribute-metrics pair as analogous to the carrot-and-stick approach if the metrics are not carefully thought out and implemented. The attributes the enterprise desires as characteristics of the value definition provide the positive motivation for expending the energy needed to secure them. On the other hand, the metrics that are employed for measuring those attributes become the ruler by which people are measured, and because the metrics tend to be much more concrete than attributes, human behavior will naturally default to optimizing on what is measured, not necessarily on the intended attribute the metric is supposed to measure. Modifying a now well known adage, Lou Gerstner, former CEO of IBM responded to a question about major drivers in enterprise change by saying, "People don't do what you expect, they do what you inspect." [83]

In practice, selecting good metrics for an enterprise can be extremely difficult. To aid in this task, the Goal-Question-Metric approach is presented as a method that is consistent with the value-focused perspective taken in the methodology for this research. According to Basili et al. [84], the method can be described as follows:

> "The Goal Question Metric (GQM) approach is based upon the assumption that for an organization to measure in a purposeful way it must first specify the goals for itself and its projects, then it must trace those goals to the data that are intended to define those goals operationally, and finally provide a framework for interpreting the data with respect to the stated goals. Thus it is important to make clear, at least in general terms, what informational needs the organization has, so that these needs for information can be quantified whenever possible, and the quantified information can be analyzed as to whether or not the goals are achieved."

Table 5-1 provides an example of how the Goal-Question-Metric approach is implemented in a situation in which the enterprise desires to see better timeliness in their change request processing. Notice this model fits nicely in the value-focused approach by substituting "goal" for "values", "question" for "attributes", and "metrics" are common to both frameworks. For additional details on implementing the GQM approach see reference [84].

Goal	Purpose Issue Object (process) Viewpoint	Improve the timeliness of change request processing from the project manager's viewpoint
Question		What is the current change request processing speed?
Metrics		Average cycle time Standard deviation % cases outside of the upper limit
Question		Is the performance of the process improving?
Metrics		$\frac{\text{Current average cycle time}}{\text{Baseline average cycle time}} * 100$ Subjective rating of manager's satisfaction

Table 5-1. Example of Goal-Question-Metric Methodology.

Tying the GQM approach directly to the research at hand, consider the development of the metrics associated with the attribute of "Meets Safety Thresholds" introduced in the X-matrix shown in Chapter 9 for the UAS airspace integration enterprise. Using the GQM approach, the following metrics are developed:

Goal	Purpose Issue Object (process) Viewpoint	Meet Threshold Safety From the FAA's viewpoint
Question		How is the current threshold measured?
Metric		# of accidents per flight hour
Question		What would provide a leading indicator for how safe operations are before there is an accident?

Metric	# of deviations from Air Traffic Control Directions # of exceptions to standard aircraft performance requirements

In the above example, the goal of the effort was to meet a given threshold safety level. To accomplish this objective, the manner in which the threshold is established had to be determined (# of accidents per flight hour) and then the question of how we could measure safety without having an accident (a leading indicator) was asked with the resulting metrics of # of deviations from ATC direction and # of exceptions to standard aircraft performance requirements. These metrics are now directly tied to the attribute they are intended to measure in a concrete and systematic manner.

McGarry et al. provide additional practical guidance from the software community on implementing an effective measurement framework. [85] They provide the following measurement principles that should be considered when implementing metrics efforts:

- Use Information Needs and Objectives to Drive the Measurement Requirements
- Define and Collect Measures Based on the Technical and Management Processes
- Collect and Analyze Data at a Level of Detail Sufficient to Identify and Isolate Problems
- Implement an Independent Analysis Capability
- Use a Systematic Analysis Process to Trace the Measures to the Decisions
- Interpret the Measurement Results in the Context of Other Project Information
- Integrate Measurement into the Project Management Process Throughout the Life Cycle
- Use the Measurement Process as a Basis for Objective Communications
- Focus Initially on Project-Level Analysis

McGarry et al. call their approach the Practical Software Measurement or PSM framework for establishing an effective measurement system. Figure 5-2 (adapted from McGarry et al. 2002) provides an overview of the overarching PSM framework.

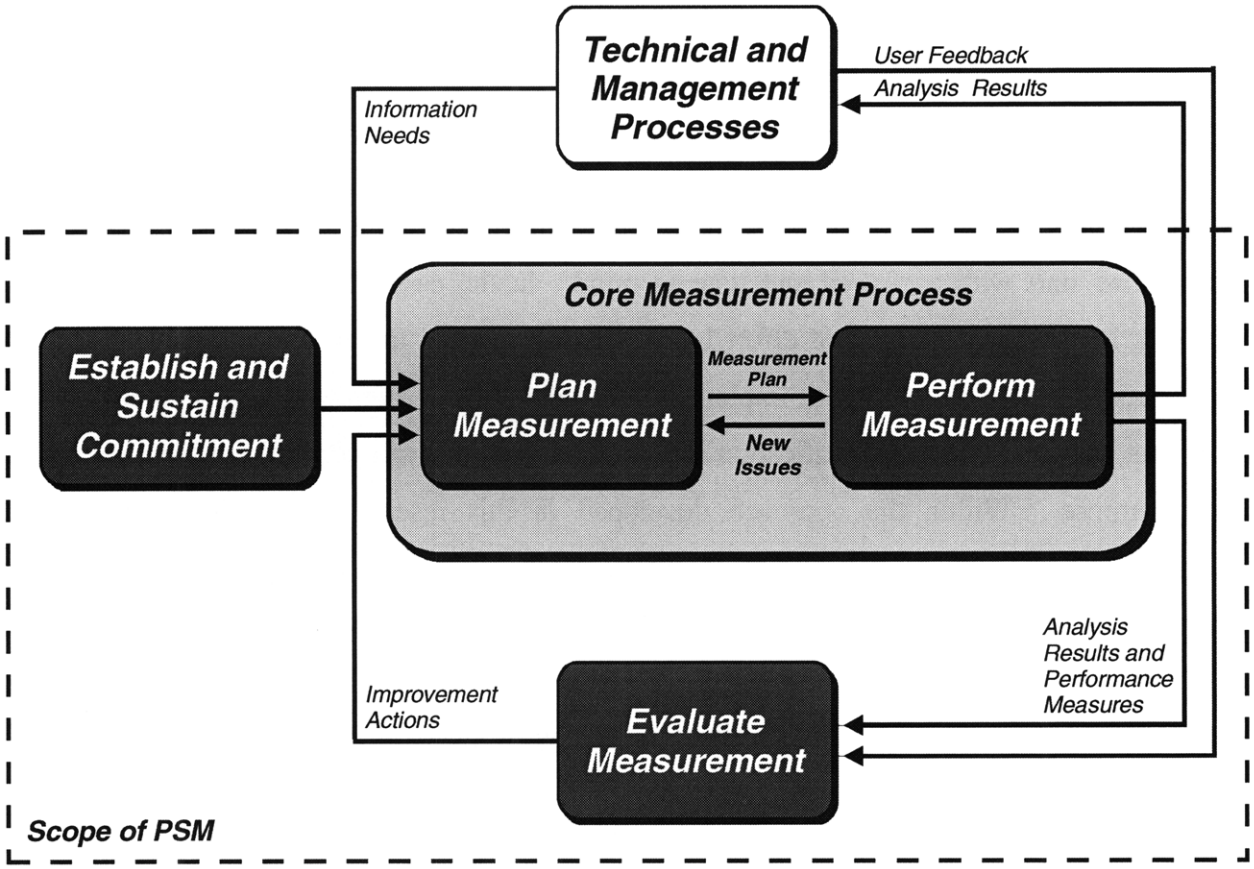


Figure 5-2. PSM Measurement Activity Framework.

In the above construct, the "Technical and Management Processes" loop represents the external framework in which the measurement is conducted and it provides the context for what the GQM approach called the "Goal". In the PSM framework, this gives rise to specific "Information Needs" that the "Measurement Process" elements are attempting to respond to. Within the "Scope of PSM" dashed line, the actual measurement process takes place. To be effective, leadership needs to understand the value and contributions a good measurement process can provide to the enterprise, hence the "Establish and Sustain Commitment" block as an input to the "Core Measurement Process". Within the "Core Measurement Process", an iterative loop is set up between the "Plan Measurement" activity and the "Perform Measurement" activity. This feedback is intended to communicate what needs to be measured and why in the forward direction, and what the problems or insights were in performing the measurement in the return direction. Once both of these activities are accomplished, the results of the effort need to be evaluated in light of their impact on the information needs driving the measurement process in the first place, and on the measurement plan to address any shortfalls the analysis of the

measures may indicate. The iterative nature of the process with regular feedback from the information need user provides an effective and targeted process for implementing a solid measurement approach.

The important take away from this general discussion on metrics and measurement processes is the need to start with a desired end-state in mind. In the case of both the GQM and PSM methods, a significant amount of effort is invested up front to understand the context and the desired result before attempting to implement a measurement system. In this methodology, the work that has gone into the identification and creation of the enterprise value structure serves the same purpose. Within the approach developed in this research, these goals (GQM) or information needs (PSM) are defined as the enterprise value definitions. The subsequent questions that are asked of these values are 1) How does the decision maker characterize the delivery of value? and 2) How does the decision maker know how much value is being delivered? These correspond to the attributes and metrics needed for a complete value structure to be built for the enterprise.

Chapter 5 Summary

Value flow through an organization is a direct function of how well the enterprise is aligned. Alignment is needed in terms of the actual attributes used by enterprise decision makers as well as the alignment between enterprise attributes and metrics used to assess value delivery. The X-matrix provides a useful tool for evaluating the existing state of alignment within an enterprise as well as a powerful mechanism for understanding how to restructure specific aspects of the enterprise objectives, values, attributes or metrics that do not align. Metrics themselves play an integral role in driving enterprise behavior and should be carefully constructed to ensure the desired enterprise behavior is inculcated into enterprise operations minimizing unintended consequences.

CHAPTER 6 – CREATING AND SELECTING ENTERPRISE VALUE PROPOSITIONS

"Ideas are like rabbits. You get a couple and learn how to handle them, and pretty soon you have a dozen."

—John Steinbeck

This chapter lays out the core elements for creating value propositions. As Steinbeck suggests in the above quote, once a couple of ideas are understood and some experience in applying them is obtained, the possibilities for how they might be adapted or modified for other uses begins to multiply rapidly. In a sense, this is the hope for the methodology that follows. A working level knowledge of frameworks and tools provides insight into applications beyond those in which the knowledge was gained or the framework was first used.

This chapter describes the use of enterprise architecting (EA), object process methodology (OPM), and the Architecture Tradeoff Analysis Method (ATAM) to rigorously define, develop and rate alternative enterprise architectures. The discussion begins with a description of the challenges associated with conducting full tradespace exploration activities and the impact this has on the value proposition phase. This is followed by a discussion of how value propositions explicitly and rigorously connect between the enterprise purpose statement, the desired attributes and the concrete mechanisms by which the desired attributes can be delivered. The chapter concludes by presenting a framework by which to evaluate alternatives using a value-focused methodology to select the options with the highest level of value delivery to the enterprise.

As a reference point in the discussion, recall that Chapters 4 and 5 cover the subject of value identification. Figure 6-1 reproduces the overarching framework employed in the methodology development. With the conclusion of Chapter 5, the Value Identification phase is fully developed, and the discussion moves into the value proposition phase.

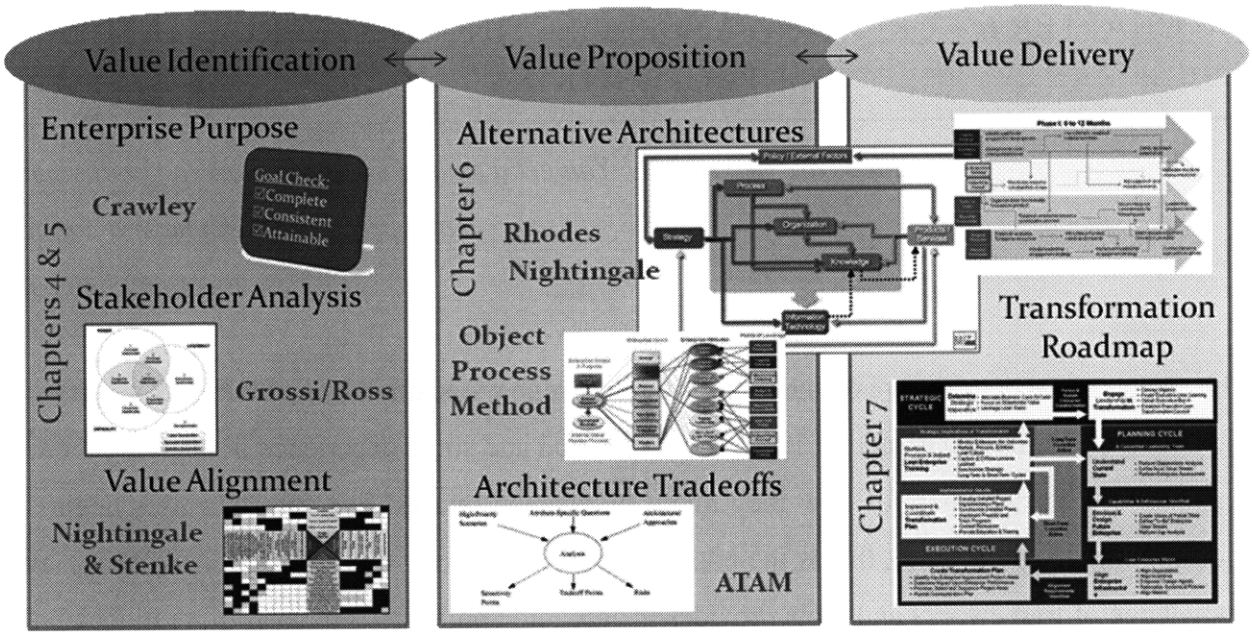


Figure 6-1. Methodology Roadmap.

The shift in phase between value identification and value proposition is an important one in the value-creation framework. The value identification work is oriented around largely known values (at least once the major enterprise decision makers have been identified), and the difficulty lies in scoping and aligning the enterprise value structure to flow value. This requires insight on the part of the architect. In the value proposition phase, the challenge is significantly different. In this phase, the task-at-hand is a methodical and structured approach to creating potential value propositions that could create more favorable value exchanges between the enterprise decision makers—and having some confidence that once the job is "finished" the approach didn't leave out better alternatives to the one that was selected. This requires creativity executed in a systematic fashion. It is this "systematic creativity" exercise that is captured in the idea of "tradespace exploration". This concept lies at the heart of this research approach by applying enterprise architecting techniques as a way of fully exploring the possible tradespace options and implementing it through OPM to explicitly capture and systematically structure the interactions between various components.

Understanding and Bounding the Tradespace Challenge

A major issue in the pursuit of alternative architectures is the ability to generate a wide variety of architectures that will span the full space of viable alternatives, ensuring that significant portions

of the tradespace are not left unexplored. At the same time, the sheer number of alternatives and complexity of managing them must be addressed to keep the architect from drowning in the volume of information that could result from a totally exhaustive search process.

To appreciate how quickly this type of analysis can blow up computationally, one has only to consider the growth in the possible number of combinations that would result if there were a jar of marbles and a jar of jacks. For the sake of the analogy, consider the various enterprise architecting views as the marbles. That puts eight different and unique marbles in the jar. Think of the jacks as the number of unique attributes the enterprise value is measured against. For the sake of argument, assume there are five unique attributes. For simplicity, assume that each enterprise architecting view connects an average of three different attributes. That means each individual view will have a potential number of different attribute combinations of 10 (See Equation 6-1) assuming that the order in which the attributes relate to the enterprise architecting view is not important.

$$binomial\ coefficient\ \binom{n}{m} = \frac{n!}{m!\,(n-m)!} = \frac{5!}{3!\,(5-3)!} = \frac{5!}{3!\,2!} = \frac{5 \times 4}{2 \times 1} = 10$$

where n = number of elements in the set

m = number of elements chosen

Equation 6-1. Binomial Coefficient Equation.

Summing this up over the entire eight views yields a potential number of 80 different combinations. While this is a fair number of alternatives to examine, it is not an unreasonable number. Unfortunately, there is a third jar to consider, the mechanisms by which the attributes are delivered. Again, for simplicity, assume that each attribute has an average of 5 different mechanisms used to arrive at the desired attribute, and again, an average of 3 mechanisms will be chosen to generate the desired attribute. This means that each attribute has a total number of potential combinations of 10 as well. Taking the number of views, the average number of attributes, and the average number of mechanisms into account to provide for a full architectural description of the possible value propositions results in a total number of unique architectures of $8 \times 10 \times 10$ or 800 architectures.

The above example assumes the enterprise architecture views themselves remain constant. In fact, this is an overly simplistic view, and the views themselves should also be considered in the mix, in which case the total number of alternatives quickly reaches into the 10's of thousands of potential combinations. The generalized equation for the total number of potential combinations is provided in Equation 6-2.

$$\#\ of\ Total\ Possible\ Architectures =$$

$$(\#\ of\ views) \times (\#\ of\ attributes) \times (\#\ of\ mechanisms) =$$

$$X_v \times \frac{n_a!}{m_a!\,(n_a - m_a)!} \times \frac{n_p!}{m_p!\,(n_p - m_p)!}$$

Where X_v = Number of Views
n_a = Total Number of Attributes
m_a = Average Number of Attributes per View
n_p = Total Number of Mechanisms (or Points of Leverage)
m_p = Average Number of Mechanisms (or Points of Leverage) per Attribute

Equation 6-2. Generalized Equation for Computing Number of Architectures.

In the case where there are 7 views, 9 attributes, and 9 potential mechanisms (as Section III enumerates, this is the condition for the UAS AI enterprise) in which no *a priori* judgments are made concerning the potential number of view-to-attribute and attribute-to-mechanism connections, the total number of possible combinations is 9.22×10^{11}. If the total number of average connections between views & attributes and attributes & mechanisms is restricted to three, the total number of possible combinations falls to 49,392.

Clearly an approach is required that will provide a method for ensuring the full scope of possible designs is considered without having to fully enumerate the entire population of possible combinations. The method developed for this analysis attempts to balance the competing demands of completeness versus time and resources by using a Quality Functional Deployment (QFD) approach for assessing the most important enterprise architecting views with respect to

the desired attributes, only expanding the tradespace in those views that have the highest degree of relevance to attribute delivery.

The QFD approach provides a convenient method for systematically applying subjective criteria to a ranking or ordering problem. In this case, the intent is to determine how important each enterprise architecture view is with respect to delivering the desired value attributes articulated by the enterprise decision makers. A template for this analysis is provided in Figure 6-2. The methodology for thinking through the QFD scoring is very similar to that already described for the X-matrix. In this case, the interaction between the enterprise view running down the left-hand column and the attribute running across the top column is scored a 9, 3, 1, or 0 to indicate the importance of that view's contributions to the delivery of the attribute. A strong interaction is scored a 9, and moderate interaction a 3, a weak interaction a 1, and no interaction a 0. Each attribute-view interaction is scored independently and the totals summed across the row for the views and the columns for the attributes. A comparison of the total scores for the views provides insight into which views are likely the most important to consider for the enterprise in question. The scores for the attributes provide insight into how well each attribute is represented.

Enterprise View	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	Attribute N	Total Impact
Strategy	1	3			3		7
Policy			9			1	10
Process	9	3		9			21
Organization			3		1	1	5
Knowledge				1		3	4
Information Technology		3	3				6
Product		9			9	9	27
Services	1						1
Total	11	18	15	10	13	14	

Figure 6-2. Attribute-to-Enterprise View Mapping (QFD) Matrix.

From the example in Figure 6-2, the QFD analysis suggests the most important views to consider in some depth are the Policy, Process and Product views. More insight from the value elicitation data is needed to conclusively treat the others as more or less constants for the enterprise architecting challenge, but the QFD analysis provides a solid point of departure for down-scoping the tradespace analysis to a manageable size.

Tying Architecture Development to Value Definition

The underlying premise in the methodology is to filter out alternative architectures that do not provide a value exchange proposition before they are even considered. The way this is accomplished is by using the value attributes themselves as the objectives the architecture must enable. For this to be effective in "weeding out" architectures that do not provide the necessary value exchange to the enterprise, a rigorous implementation approach is needed to connect the enterprise purpose, attributes, and structure to flow value from start-to-finish.

Combining the information derived from the X-matrix and the QFD analysis just discussed for the enterprise views, the structure for such an analysis begins to emerge. The X-matrix provides the means for ensuring alignment between the enterprise objectives, values and attributes. Presumably, a well-aligned X-matrix means that the ability to produce the desired attributes will result in the enterprise defining the activity as "value added" in the course of execution. The QFD analysis of the enterprise views against these same attributes provides the connection between the type of actions that can be taken (the views) with the desired attributes.

The merging of these two perspectives into a single, end-to-end, integrated model that rigorously preserves these interactions should result in an enterprise architecture that by definition produces a viable value proposition. The methodology employed in this research for combining and extending the information gleaned from the X-matrix and the QFD analysis is the Object Process Methodology (OPM) developed by Dori [12] and adapted by Crawley for the purpose of systems architecting [13]. This approach is detailed in the next section.

The geometrical growth in numbers underpins the entire remainder of the analysis that follows. The full combinatorial analysis would have to be undertaken if the assumption that the value proposition can be down scoped is rejected. The methodology described in the next section is certainly robust enough to handle this full expansion; however, without a way to automate the analysis with modeling or other automated tools, this level of analysis is impractical. This is where reality meets theory. The OPM development in the next section will be for the general case, but the scoping method employing the QFD approach is used in practice to reduce the problem set to something manageable.

Putting Rigor into Enterprise Architecture Development

With the foregoing discussion as preamble, the task of implementing the enterprise architecture framework to generate alternative value propositions can now be addressed directly. This starts with a simple extension to the enterprise architecture framework advanced by Nightingale and Rhodes [11], and then dives into the specifics of implementing OPM for the approach to generating alternative enterprise architectures (this research treats "alternative enterprise architectures" and "alternative value propositions" as synonymous based on the value-creation framework from LEV implemented at the outset of Section II).

Adapting the Enterprise Architecting Framework

The first element in alternative architecture generation is to make a relatively straightforward adaption to the enterprise architecting model developed by Nightingale and Rhodes that was presented in Figure 3-7. The original model is extended one layer down to capture the key role that context plays in the consideration of both the enterprise as a whole as well as the local environment in which each of the various "views" operate. This extended model is illustrated in Figure 6-3.

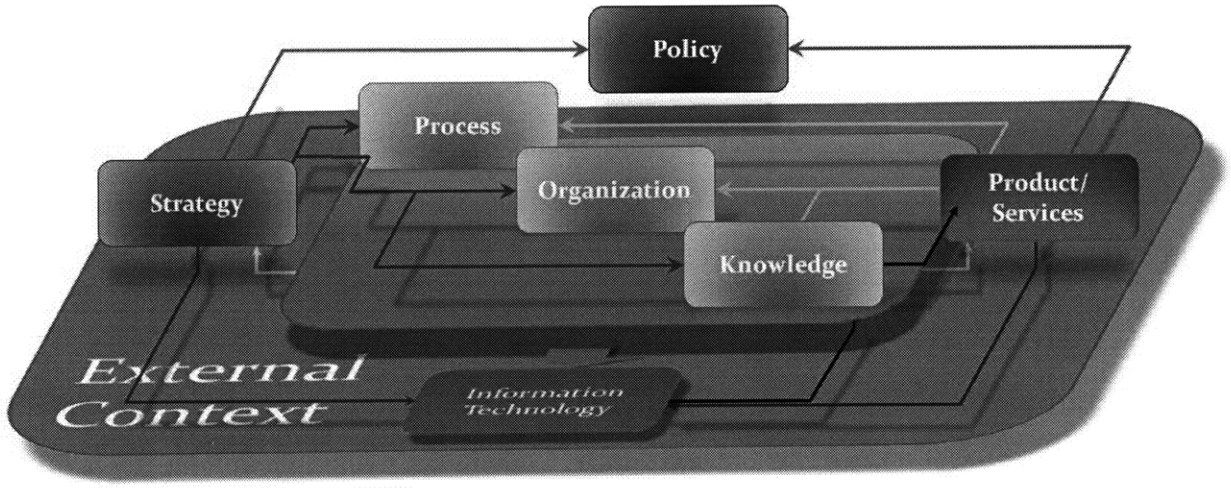


Figure 6-3. Adapted Enterprise Architecting Framework.

In this model, the "views" of strategy, policy, process, organization, knowledge, and product/services arise out of the specific, local context in which they operate. Information technology is shown "in-plane" with the context as a way of illustrating the critical role it tends to play as an interface mechanism between the internal enterprise environment and what goes on in the external context. Taken collectively, all the views together represent the sum total "footprint" of the enterprise in the broader environment (the entire "blue" backplane). The implication is that each view must be architected in such a way that it functions appropriately in its local environment (the box around each view) while at the same time contributing the necessary attributes needed for the proper functioning of the enterprise that it supports (the portion represented by the blue backplane).

The enterprise architecting framework is used in two principal ways. The first is to provide a systematic way of looking at alternative architectures to minimize the risk that important design

factors are missed or not considered as the architecture is created. The second is to help manage the complexity of the tradespace by providing a way of selecting the most critical elements of the architecture that are driving the delivery of the enterprise attributes without having to go through a full expansion of all of the views. This has already been fore shadowed with the discussion in the previous two sections and the use of the QFD method to correlate views to attributes. This second task is accomplished by taking the enterprise purpose statement and the X-matrix information and explicitly drawing the relationships between the enterprise purpose, the enterprise architecture views, and the desired enterprise attributes. This is accomplished using object process methodology (OPM).

Object Process Methodology Development

Object process methodology (OPM) [12] is a system development methodology that integrates many system attributes into a single model. It explicitly describes elements as objects, processes or the links that interconnect them. It is especially useful for the enterprise architecting arena because it provides a framework for rigorous *qualitative* system thinking, and possibly provides an avenue to quantitative modeling and analysis. [13] The application of this methodology to the alternative architecture development process provides a method for integrating the enterprise purpose, architecture framework, and X-Matrix information into a single, cohesive approach. The reader is referred to Dori's work as the definitive reference on describing the mechanics of the methodology. [12] The approach taken in the development of the architecture generation model is an adaptation of OPM articulated by Crawley as the fundamental language in which he espouses the system architecting discipline. [13]

Short of a complete tutorial on OPM, the simplest approach is to present the general model and then explain the principles used to construct it. Figure 6-4 illustrates the four-layer architecture generation model developed for this analysis. The model is labeled on the top with the equivalent terms used in this research. For comparison purposes, the OPM terminology is provided along the bottom of the figure. To avoid confusion, the terminology introduced in this research will continue to be used (vice that of Dori). The reader is encouraged to consult Dori [12] for full development of OPM and to compare and contrast the application made in this analysis with those presented by Dori.

The first layer, the far left "stack" labeled "Enterprise Scope and Purpose" encapsulates the overall enterprise purpose and scope by explicitly focusing the entire effort on the delivery of the enterprise purpose statement and value definition with the scope of the enterprise activities (recall, these were all developed under the "value identification" phase). The enterprise purpose is further characterized with any critical attributes or constraints. Stack 1 one can be described as the enterprise intent and scope communicated in OPM language.

The second layer, the "Enterprise Views" stack, is just that—the seven/eight "views" represented by the enterprise architecting framework. Each view is connected to the enterprise purpose through an interaction link. In the case of the example in Figure 6-4, these links are represented as simple effect links, but specific data collected on the enterprise may allow these to be specifically categorized to capture the context in which the enterprise purpose and enterprise view are interacting. Note that in the Figure 6-4, the "Strategy", "Organization", "Knowledge", and "Information Technology" boxes are grayed out. For illustration purposes, these correspond to the views in the QFD analysis presented in the previous section that all had low attribute score totals. "Policy", "Process", and "Product/Service" views were all scored highly on the QFD assessment, so these views will be considered in the most detail as part as the analysis moves forward. The other views will be set and recorded for the purpose of establishing a baseline should it be determined later that one or more of these views should be included as the problem is looped through subsequent iterations.

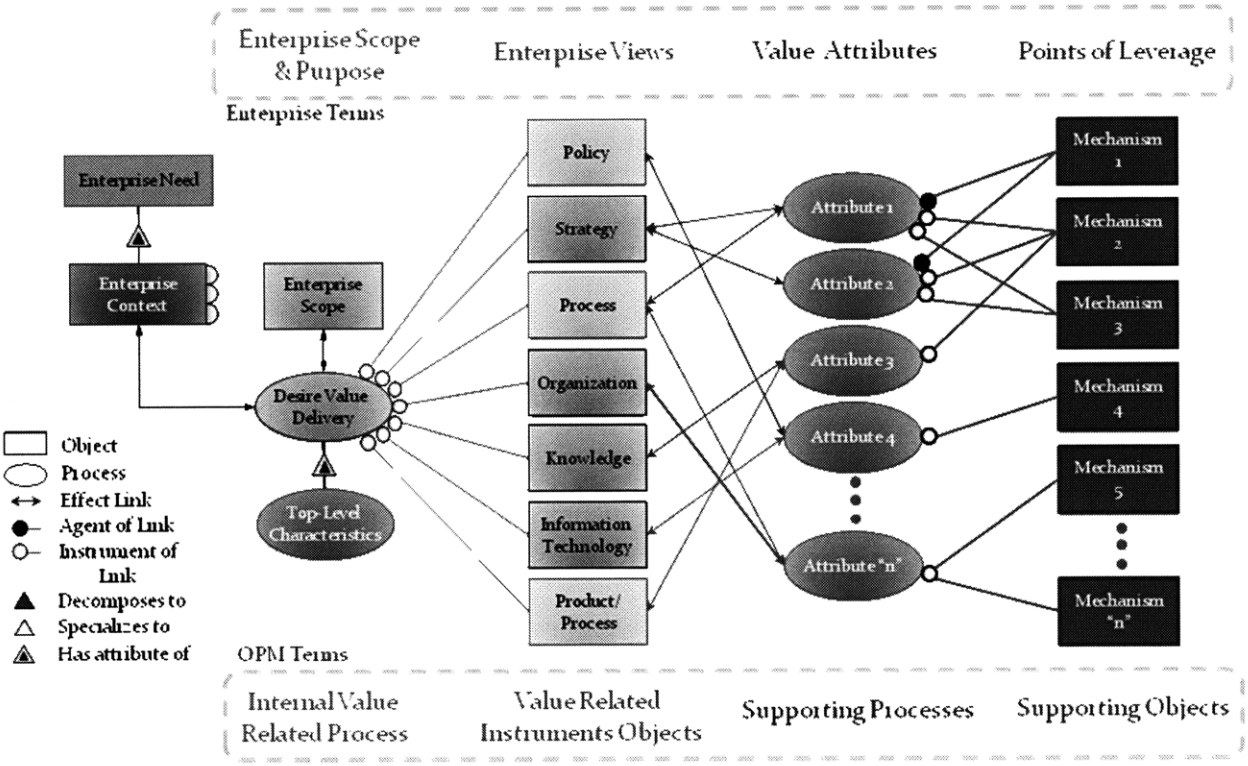


Figure 6-4. Architecture Generation Model using Object Process Methodology.

Stack 3, "Value Attributes," is taken from the X-Matrix key attributes column, and "put into action." In other words, the X-matrix describes "states" that characterize the enterprise. In the architecture generation model described here, these states are transformed into processes with verbs. The result of accomplishing these processes will be the desired state annotated in the X-Matrix and explicitly defined by the OPM in the "Enterprise Scope and Purpose" objects and processes.

Stack 4, "Points of Leverage", are the concrete mechanisms needed by the attribute processes in order to enable their processes. They are classified as either agent objects involving human interaction (connected with a filled black circle), or as instrument objects (connected with an open circle). It is at this layer that the architect's creative task begins in earnest since this represents the layer at which the previous work at the enterprise purpose and scope level, as well as the X-Matrix information, more or less ends. The enterprise architect must apply the needed domain expertise (or go out and solicit it) to begin to connect the means to the ends. How this is accomplished in practice will become clearer with the application that follows in Section III. To illustrate briefly, suppose the enterprise defined in our analysis is a car manufacturer trying to

design a next generation vehicle, and suppose that "Attribute 1" was a vehicle with high fuel economy. If the enterprise view is defined as the "Product" view, a possible set of "Mechanisms" that might enable the delivery of high fuel economy would be an efficient engine, lighter body frame, or alternative power generation. If the view is switched to "Policy" then a "Mechanism" might be regulations for higher average miles per gallon for the vehicle fleet.

As discussed previously, the number of different permutations goes up geometrically with each additional layer in the architecture, hence the motivation for implementing an approach that would help the architect scope the problem better on the front end. The "inactive" views can be retired from active consideration with explicit documentation concerning the assumptions under which they were moved out of the active design space so that if conditions change in the future, these decisions on the applicability of any single view can be revisited and another assessment done as to the relevance of the view under the new circumstances. This is what makes the use of the QFD analysis described earlier such a convenient tool. It concisely sums up the overall perspective of the architect with respect to the particular views dominating the tradespace, and with some additional documentation, serves as a way to capture thoughts and perspectives on the decisions about which views should be actively considered in the tradespace.

Two points should be made at this juncture. First, the decision as to which views play a driving role in the enterprise architecture value delivery is still a subjective assessment. The intent with coupling the QFD and OPM approaches is that it institutes a degree of structure and rigor into the qualitative nature of the decision by providing a way for the architect to consistently visualize and assess the importance of the interactions between the processes and the objects. Ultimately, the interactions themselves are what the architect should be attempting to drive through the design process. The OPM approach provides a rigorous approach for bringing these interactions into the foreground and then characterizing them in a consistent language and representation so the architect can do better than just go on his or her "gut" for what views are important or which can be removed from active consideration.

The second point to make is that while certain views may be set aside as less dominant design mechanisms within a given enterprise context, they still need to be architected with the other active views. In other words, just because they are "grayed out" on the model does not mean the

architect does not design them into the overall enterprise. It just means that a prescribed form will be used in their implementation, or that they depend so much on one or more of the other views for a particular case that there is really no point in independently trading that particular view on its own.

The result of this exercise is the production of any number of specific "Mechanisms" to enable the attribute processes. These "Mechanisms" become the building blocks of the enterprise architect for crafting the details for how the architecture concept will translate the function (attribute processes) into form (the supporting objects in Stack 4). This is at the heart of the architect's responsibility. The advantage OPM provides is a structured way in which to generate these alternative objects that puts the problem back into bounded rationality space. Without this layering in the OPM approach, the complexity in both numbers and interactions would quickly overwhelm even the most robust efforts at keeping everything straight.

The "Mechanisms" set of objects within the OPM structure also play a significant role in that they end up defining the interface between the enterprise and the external environment. According to Rechtin and Maier, "The greatest leverage in system[4] architecting is at the interfaces. The greatest dangers are also at the interfaces." [86] They go on to describe the impact when the components (or in this case, the "mechanisms") are highly interdependent:

> "When the components of a system are highly independent, operationally and managerially, the architecture of the system *is* the interfaces. The architect is trying to create emergent capability. The emergent capability is the whole point of the system; but, the architect may only be able to influence the interfaces among the nearly independent parts. The components are outside the scope and control of an architect of the whole."

This condition is a precise description of the enterprise architecting challenge and serves to highlight why the OPM approach is so important. It is through this rigorous framework for developing the architecture that the interactions mentioned in the above quote can be clearly, and consistently, identified and "architected" to achieve the desired emergent behavior in the system.

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[4] For the purposes of this research, the same heuristic Rechtin and Maier apply to the 'system' problem can also be applied to the 'enterprise' challenge.

In addition, the problem can also be "farmed-out" to local expertise in a given domain for additional insights, ideas, or brainstorming sessions to ensure the full space of alternative options is adequately explored. By segmenting the problem down the dual lines of both the enterprise architecture view and the attribute processes, others engaged in the process can be provided with a clear context in which to generate inputs. It also provides a way to organize and interface inputs back into the architecture from what could be largely disparate groups. The result of this end-to-end alternative architecture development method should be a clear sense that the tradespace of interest has been thoroughly saturated, and the architect can begin evaluating the alternatives with a high degree of confidence that no stone was left unturned in the quest for the best possible set of value propositions.

Once the "Point of Leverage" stack is declared "complete," the overall architecture can once again be assessed, and the "Mechanisms" ranked with respect to how critical they are to one or more attribute processes. The ATAM method described under the architecture selection approach (see the next section in this chapter) takes this next step. The ATAM identifies what it calls sensitivity and tradeoff points within an architecture [14]. The ATAM describes these as follows:

> "We term key architectural decisions *sensitivity points* and *tradeoff points*. A *sensitivity point* is a property of one or more components (and/or component relationships) that is critical for achieving a particular quality attribute response... Sensitivity points tell a designer or analyst where to focus attention when trying to understand the achievement of a quality goal. They serve as yellow flags: 'Use caution when changing this property of the architecture'. Particular values of sensitivity points may become risks when realized in an architecture... Sensitivity points use the language of the attribute characterizations."
>
> "A *tradeoff point* is a property that affects more than one attribute and is a sensitivity point for more than one attribute. For example, changing the level of encryption could have a significant impact on both security and performance. Increasing the level of encryption improves the predicted security but requires more processing time. If the processing of a confidential message has a hard real-time latency requirement then the level of encryption

could be a tradeoff point. Tradeoff points are the most critical decisions that one can make in an architecture, which is why we focus on them so carefully."

The alternative architecture generation model provides a convenient method for the architect to understand and identify which of the "Mechanisms" in a given alternative architecture are likely to be sensitivity or tradeoff points based on what they are connected to and their relative importance to an attribute process successfully delivering the desired characteristics. It is for this reason this last column in the model is labeled "Points of Leverage". By consciously mixing and matching enterprise views, attribute processes, and mechanisms together, the architect should have a considerably wider degree of latitude in designing out damaging sensitivity or tradeoff points and building on those that reinforce the desired enterprise performance or behavior. The sensitivity and tradeoff points within a given architecture provide the basis on which to begin building the transformation plan described in Chapter 7.

With the tools now in place, the enterprise architect is in a position to work with some confidence toward the goal of fully expanding the potential value propositions that will provide the required value delivery to the enterprise decision makers. The next issue addressed is the means by which these alternatives are assessed and a specific enterprise architecture selected as the best overall approach for value delivery.

Enterprise Architecture Selection Approach

The general approach applied to the development and implementation of an architecture evaluation method is a model taken from the Architecture Tradeoff Analysis Method (ATAM) developed by the Software Engineering Institute (SEI). [14] This framework provides a straightforward approach for combining all of the key enterprise attribute characteristics, architectural evaluation criteria, and risk assessments together in a single approach. The ATAM provides an explicit method for directly tying the enterprise attributes to the architectural evaluation criteria. This preserves the integrity of the value structure through the evaluation by keeping the attributes of the desired value delivery at the forefront of the evaluator's mind when scoring alternative architectures. In corresponding fashion, *risk is defined as the overall confidence of the evaluator in the ability of the architecture to deliver the level of attribute performance specified.*

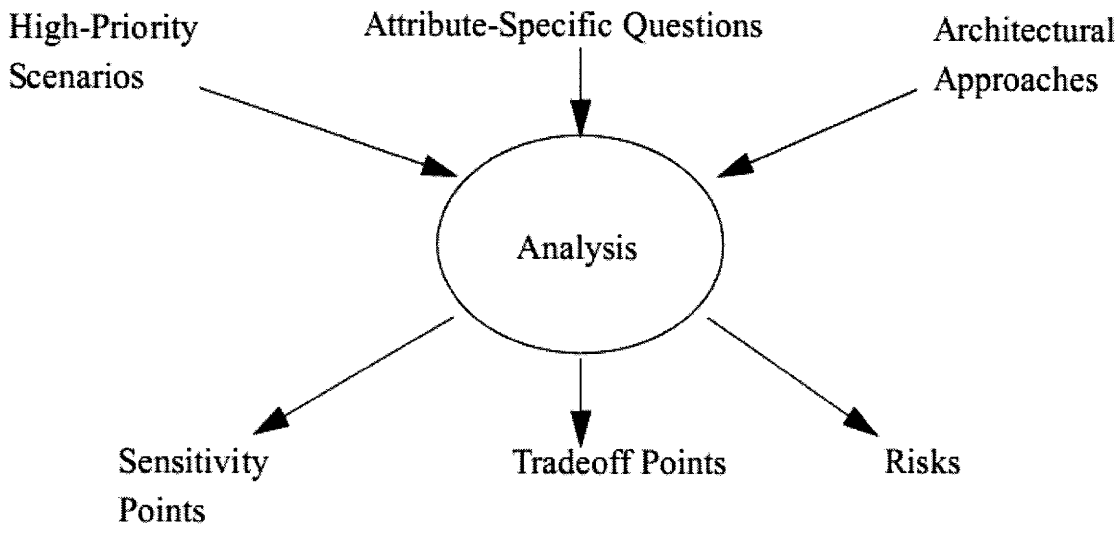


Figure 6-5. Architecture Tradeoff Analysis Method Framework.

The methodology already developed to this point provides the inputs to the "Attribute-Specific Questions" and "Architectural Approaches" with the corresponding outputs from the OPM structure for the "Sensitivity Points" and "Tradeoff Points". High-Priority Scenarios have not been explicitly developed or treated in the discussion up to this point. For the purposes of this research, these scenario dependent aspects of the problem are embedded in the utility space for a given context. If the scenario is changed, these utilities will need to be revisited, and the analysis will potentially have to be re-accomplished to accommodate major shifts in decision maker attribute value ranges. To be practical, this level of dynamic analysis needs computational modeling to be tractable. Risk is the remaining element that is undeveloped at this point, and it will be addressed as the third set of architecture evaluation metrics.

The following discussion is broken down into three specific sets of evaluation criteria. The first section discusses the enterprise value metrics (which the ATAM approach addresses explicitly). These are a direct measurement of the desired enterprise attributes the architecture should deliver. The second set of criteria concern themselves with an evaluation of the architecture itself. These metrics are intended to assess the logical relationships, coherence, and adherence to architecting principles of the architectural structure. The final set of criteria is for the evaluation of the enterprise architecture risk defined above.

A Brief Word on Selection Criteria and Frameworks

Before diving into the specifics of the evaluation method, a brief word on methods for accomplishing evaluations in the more general sense is in order. For the sake of space, the discussion that follows is based almost entirely from the MATE short course material developed by Rhodes, Ross, and McManus. [87] As part of this course, a summary of various multi-attribute ranking methods is presented. The following provides a summary of these various alternatives [87]:

- Lexicographic
  - Rank Attributes
  - Score alternatives with natural units; (normalize scores)
  - Alternative with highest score in most important attribute is selected; if tied, tie-break with second most important attribute score, etc.
- Pugh
  - Choose baseline alternative
  - Determine comparison of each alternatives' criteria to baseline: +/S/-
  - Sum +/S/- for each alternative; clear best alternative ranked first, etc.
- QFD
  - Rank attributes
  - Score alternatives with 1,3,9
  - Alternative with highest score summed across attributes is selected
- Modified decision matrix
  - Rank attributes
  - Score alternatives with natural units; normalize scores
  - Alternative with highest weighted sum across normalized attribute score is selected
- Multi-Attribute Utility
  - Elicit single attribute utility curves
  - Elicit multi-attribute weights
  - Score alternatives with single attribute utility curves
  - Alternative with highest multi-attribute utility is selected

A key point to remember in a discussion of alternative ranking methods is that each of the methods listed above can result in a different ranking. In these instances, the question that naturally comes to the forefront is "Which method is best?", and the answer is "It depends!" There is a direct correlation in the effort required to conduct an analysis with each of these methods and the resulting confidence typically achieved in the result. Figure 6-6 provides a purely qualitative assessment on the author's part for what the tradeoff in effort vs. confidence may look like and where each of the above methods falls in this space (the assessment is made having conducted ranking exercises implementing all five types of approaches).

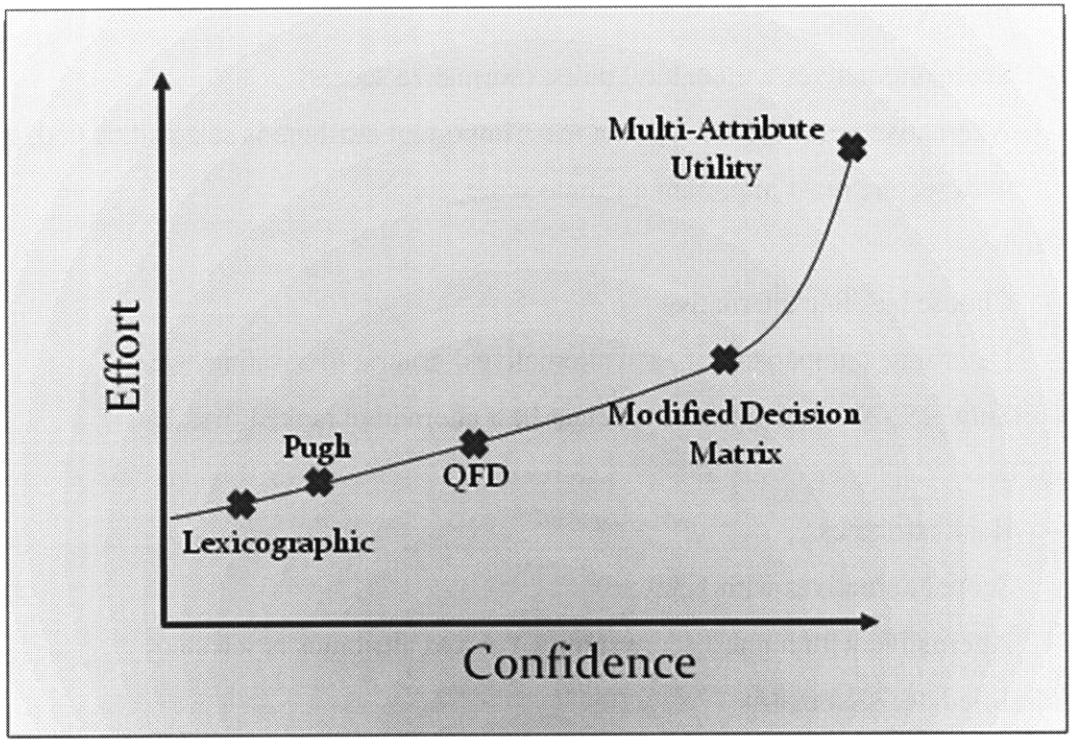


Figure 6-6. Notional Relationship between Ranking Method, Effort and Confidence.

It is worth noting that the "Multi-Attribute Utility" method collapses into the "Modified decision matrix" method when the utility curves for each attribute are neutral across the entire range of the attribute metric. Further analysis by Ross has found that when the shape of the utility function is not known or was incorrectly inferred, the use of a neutral utility curve actually provides a better overall mapping. This suggests that if time or resources are constrained, the best place to start may be to collapse the full "Multi-Attribute Utility" scoring into a "Modified

Decision Matrix" since this will likely result in the least impact to the overall confidence in the results while significantly reducing the total level of effort required to perform the analysis.

Enterprise Attribute Criteria

The first and principle mechanism by which alternative enterprise architectures are evaluated will be through the metrics developed as part of the X-matrix exercise. Recall that the X-matrix provides an explicit mapping between the enterprise attributes and the metrics used to measure their delivery (Figure 6-7 is provided for quick reference). In essence, the enterprise architecture ranking method will use the estimated total delivery of each metric as a means of estimating the relative extent to which each architecture delivers the desired enterprise value. This ranking is obviously the one of primary importance in any final determination of "architectural goodness" since this is ultimately what the enterprise architecture is intended to deliver—enterprise attributes defining value.

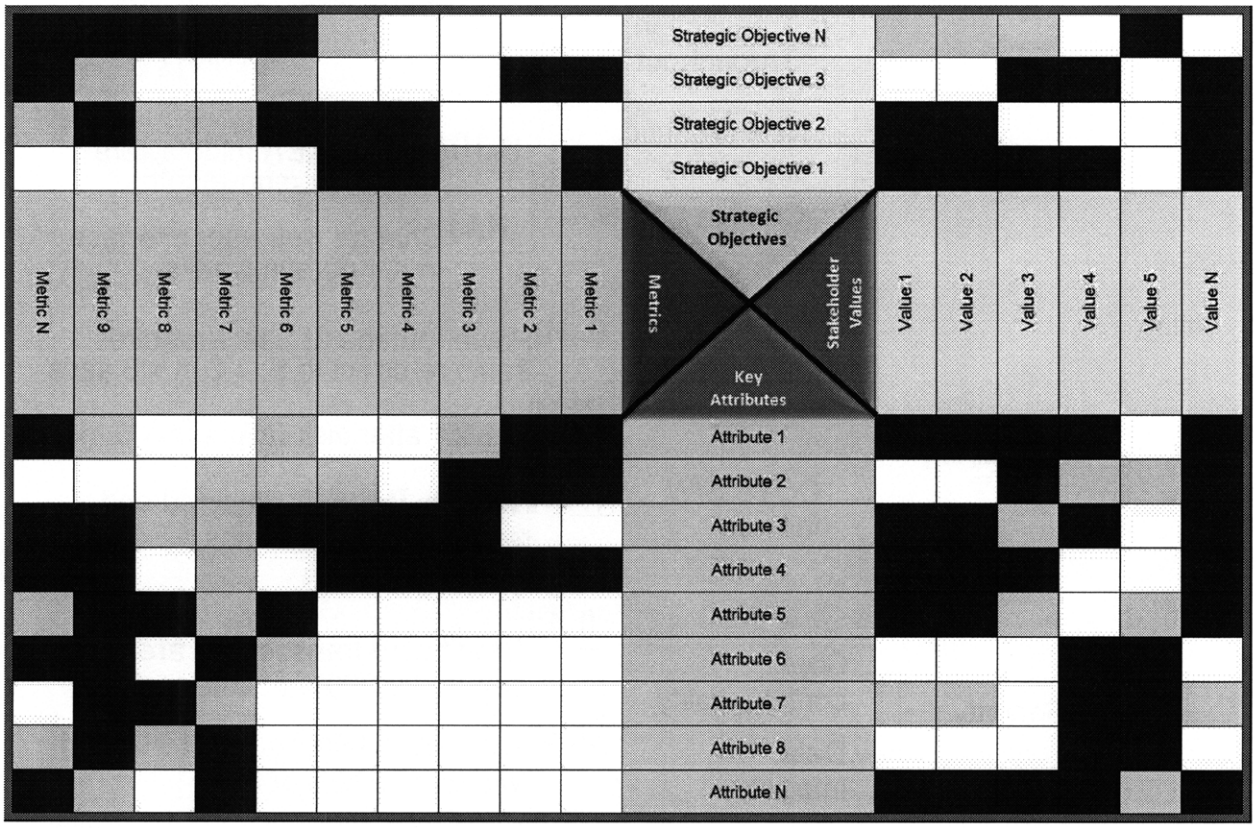


Figure 6-7. General X-matrix Template Revisited.

A note with respect to the ATAM approach is worth making. The ATAM framework builds a "utility" tree with the same kind of information captured in the X-matrix. When an architecture

is evaluated using the ATAM approach, each metric is assessed based on its importance to the delivery of the attribute (and the risk rating which will be discussed later in this section). Unfortunately, this evaluation method misses the important consideration that metrics may in fact be applicable to more than one attribute. For the sake of completeness, an example of the ATAM "utility" tree is provided in Figure 6-8. For comparative purposes, the stack after "Utility" correspond directly to the desired enterprise attributes, the second stack corresponds to the attribute metrics, and the last set of "descriptions" corresponds to the metric range or desired performance. The two letters in parentheses correspond to the importance of that metric in delivering the associated attribute and the overall confidence in the architecture delivering the associated level of performance respectively.

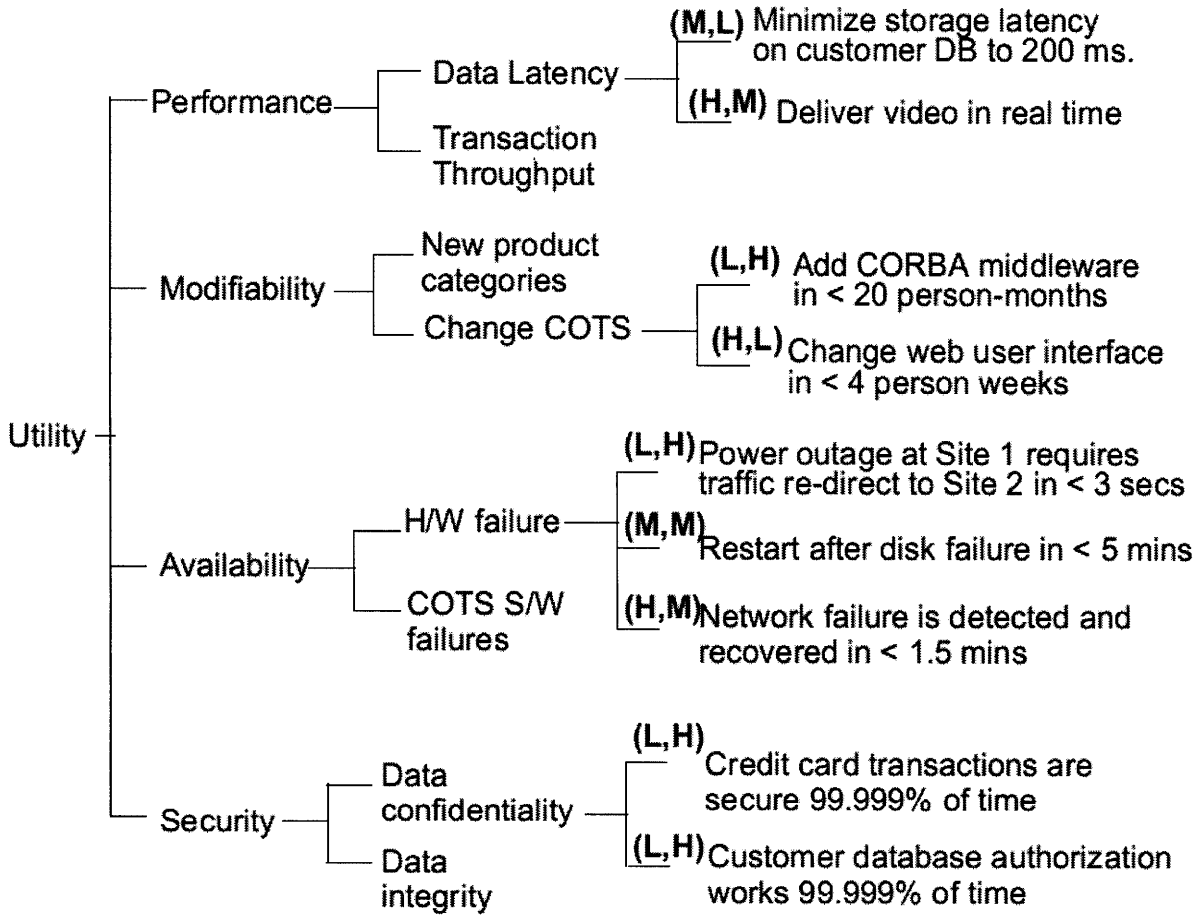


Figure 6-8. Example of an ATAM Utility Tree Analysis.

In those instances were a relatively large number of alternative architectures need to be evaluated, using the utility tree approach within an X-matrix evaluation may provide for a relatively fast way of filtering out the lower performing architectures and reserving the more detailed analysis for the "quarter finalists."

Architecture Evaluation Criteria

The second set of evaluation criteria used to assess alternative architectures are metrics on the overall quality of the architecture itself. Some consideration may need to be given as to whether the enterprise attribute evaluation criteria should be applied first, followed by the enterprise architecture evaluation criteria or vice versa depending on which will be the quicker of the two to assess. Failure to pass through either set of criteria should fail a potential architecture. If a large number of architectures need to be evaluated, using the ATAM method just described may provide the simplest and fastest way to quickly down select to the top set of highest performing architectures. Once these are filtered out, the next best thing may be to apply the architectural criteria described below before conducting the more detailed enterprise attribute assessment detailed in the previous section. Regardless of the approach taken, the general principle is to filter the alternative architectures through the set of criteria that will be the simplest and quickest to evaluate, moving to the progressively more time consuming and detailed assessments as the total number of alternatives shrinks.

The architectural evaluation metrics used in this assessment are a synthesis of criteria developed by Crawley and Wagenhals. Crawley specifically calls out criteria related to the relative "elegance" of the proposed architecture. [7] He describes this assessment by evaluating the following criteria:

1. Some subjective criteria re: whether solution is simple and pleasing
2. Decomposition of form matches function
3. Decomposition of form maps to team, stations and flow
4. Decomposition allows easy Integration and Verification
5. "Adherence to Architectural Principles"

Augmenting the criteria from Crawley is work done by Dr. Lee Wagenhals, Dr. Sajjad Haider, and Dr. Alexander Levis at George Mason University. [15] The primary architecture evaluation metrics proposed in their model are as follows:

1. Is the architecture logically correct?
2. Does the architecture exhibit the desired behavior?
3. Do instantiations of the architecture exhibit the desired performance characteristics?
4. Do systems built in conformance to this architecture provide the desired capability?
5. Can we analyze alternatives?

It is important to note that this second framework for architecture evaluation was developed as a broader effort, namely the desire to build executable object-based architectural models and using them to evaluate alternatives through modeling and simulation. The overall system proposed by Wagenhals et al., is depicted in Figure 6-9. Notice that the evaluation of the architecture is the last step in the creation of a verified, executable model used to evaluate alternatives. As previously mentioned, an executable model is currently out of reach in the current research, but any thoughtful consideration of desired future ends recommends an approach that can be extended into an executable framework with as little re-structuring as possible. With this as the underlying intent, the activity in this analysis will end at the point where the model would actually be created and exercised.

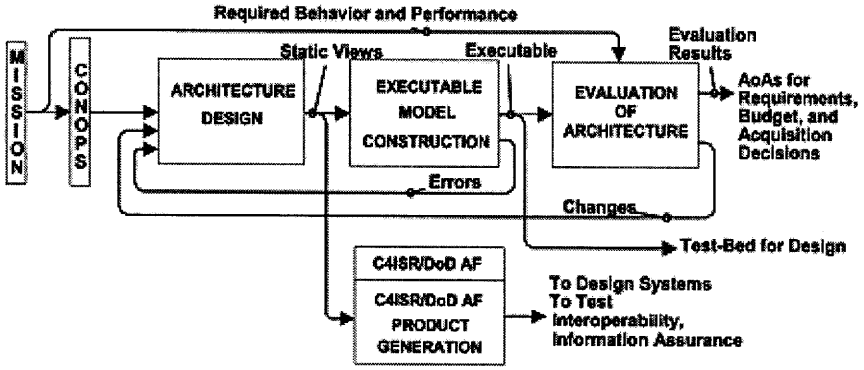


Figure 6-9. An Architecting Process from Wagenhals et al.

If the validation aspects of the above criteria are set aside, the result is a significantly shorter list of architecture evaluation metrics for verification purposes. The final synthesized set of criteria used in this evaluation are as follows:

1. Does the architecture exhibit the desired behavior?
2. Does decomposition of form map to team, stations and flow?
3. Does architecture adhere to Architectural Principles?

Risk Evaluation Criteria

The third category of evaluation criteria considered in this analysis is the ATAM risk factor introduced earlier in this section. This criteria is perhaps the most subjective of all, but the exercise is nonetheless an important one, especially as a means of closing the feedback loop with the enterprise architect and the enterprise decision makers. The ATAM approach is a general assessment of an architecture's risk in a "high, medium, low" approach where, once again, the factor being addressed is *the overall confidence in the architecture delivering the desired attributes*. This is a bit of an inverse of the way in which risk is normally considered. In other words, a high confidence would result in the risk for that particular architecture being scored "low".

Selection Approach Summary

The result of assessing each alternative architecture through the three sets of criteria described above should be a final architecture that provides a high-level of value delivery at an acceptable level of risk. This will ultimately be a qualitative decision, but it can be made in a rigorous fashion by implementing the methodology put forward in this chapter. Establishing a rigorous method of evaluation is the first step on the road to defining an analytical approach to this problem that can be implemented through executable models.

The enterprise architecture evaluation process should be tightly coupled and integrated with the enterprise decision makers. Ultimately, it will be the decision makers themselves who will provide the resources and motivation whereby the changes will take place. In this regards, the enterprise architect is well-served in extending the evaluation to the broader enterprise stakeholders at an appropriate juncture in the analysis. Fostering a sense of ownership on the part of the decision makers for the final value proposition selected to move forward is a significant advantage for implementing the needed transformation activities described in the next chapter.

Chapter 6 Summary

A rigorous method for developing alternative value propositions is needed for a thorough treatment of the value-creation framework implemented in this research. This method deals with the large number of potential architectures developed in the course of the assessment by creating a system that *a priori* filters out non-value added architectures. The method is instantiated through the OPM language to explicitly tie together the enterprise purpose statement, scope, architectural views, attributes and mechanisms in a rigorous, structured approach to ensure the full tradespace of alternatives is considered. The results are evaluated through three sets of criteria that ultimately result in a "best of breed" architecture selected for the enterprise value delivery mechanism.

CHAPTER 7 – DELIVERING ENTERPRISE VALUE

"Obstacles are what you see when you take your eyes off the goal."
—Vince Lombardi

Delivering value is the final phase in the value-creation framework implemented in this research. It is here that the theory of the proceeding four chapters is turned into concrete reality for there to be any enduring consideration of the ideas advanced to this point. The execution phase of any endeavor often proves the undoing of an idea, and in the case of an enterprise, there are a host of forces all conspiring against the successful implementation of the value proposition. The only sure way to see clear of the issues is to stay focused on the objective—or the obstacles will overwhelm you.

Much has been said in the literature concerning transformation in recent years. It is not the intent to rehash this information here, but it is worth pointing out that without a strong motivating factor to drive change, making a successful transformation from one state to another is all but impossible. [88] It is also clear that a structured approach to planning and implementing transformation is essential. This chapter lays out the methodology for accounting for these factors by combining the Enterprise Transformation Roadmap put forward by Nightingale with the insights on points of leverage from the ATAM model.

Getting from Here to There: The Enterprise Transformation Roadmap

At the heart of delivering value is the need to move the enterprise from its current architecture to the new one developed in the preceding discussion. The mechanism by which this is achieved is called an enterprise transformation plan that describes in concrete detail the actions and results to be achieved to move the enterprise from its current position to the one envisioned by the future enterprise architecture. This requires actions that are specific, actionable, and accountable to individuals to perform and report.

The framework for building the enterprise transformation plan is that described by Nightingale and Srinivasan called the "Enterprise Transformation Roadmap." [16] Through a consistent application of the process depicted in Figure 7-1, many of the activities and details needed to build a successful enterprise transformation plan are called out explicitly. A detailed explanation

of this roadmap process will not be undertaken here. For details on the execution of the Enterprise Transformation Roadmap, see [16].

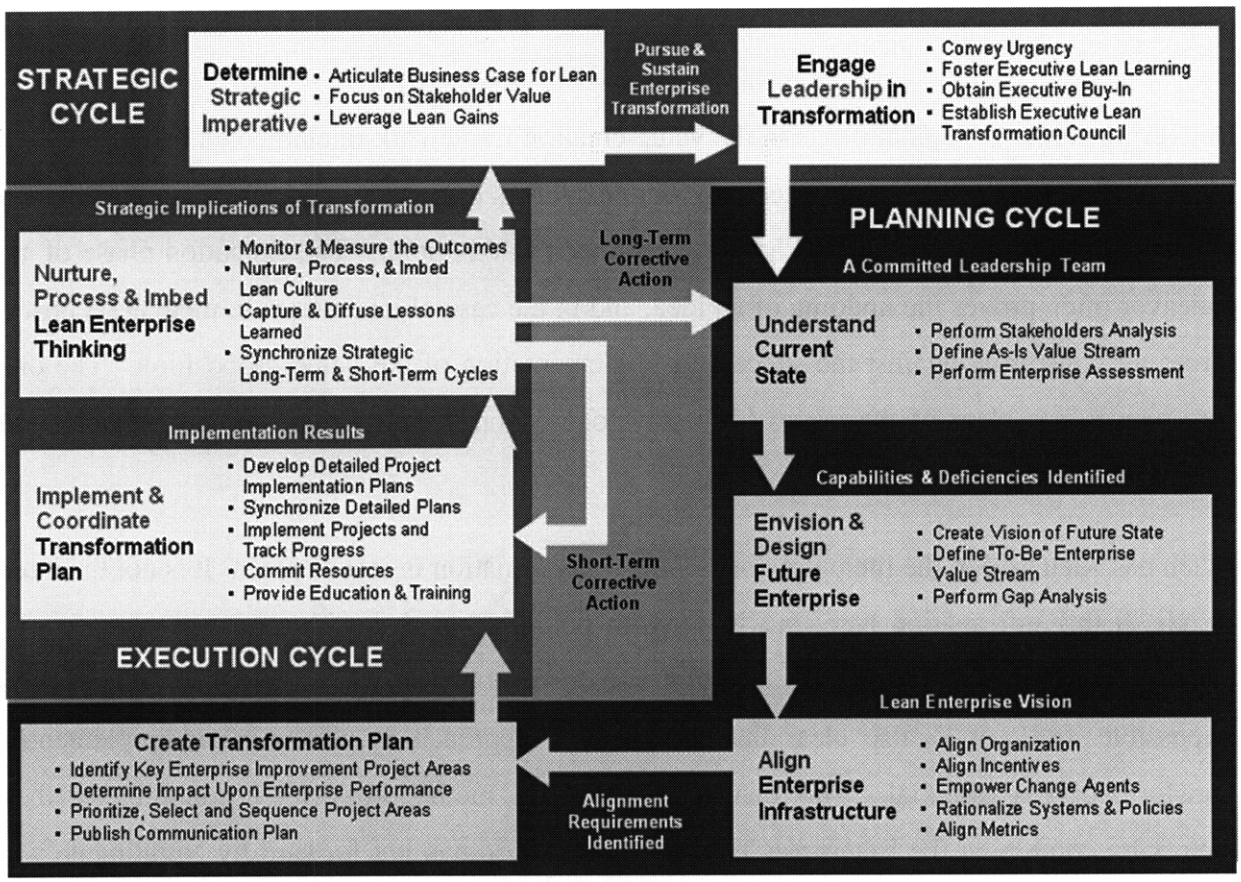


Figure 7-1. Enterprise Transformation Roadmap.

Two important points should be emphasized in Figure 7-1. The first is the Enterprise Transformation Roadmap describes an iterative process in which the actions that are undertaken to change the enterprise are continuously reviewed and assessed against the desired outcomes, and the plan is updated to account for the actual extent to which the enterprise changes based on a given activity or event. The second is that the Enterprise Transformation Roadmap provides a convenient framework for operationalizing the enterprise architecture framework from Chapter 6 by providing a clear set of inputs within the "Planning Cycle" within which the enterprise architecting inputs and outputs can be collected up and transferred into the enterprise transformation plan. The Enterprise Transformation Roadmap is an implementation of the value-creation framework used in this research. The effort in this thesis is to create a rigorous method by which the "Strategic" and "Planning Cycle" tasks outline in Figure 7-1 are addressed

and integrated. The use of the Enterprise Transformation Roadmap methodology fills in the remaining gap in the current research by providing a structure for the "Execution Cycle" and the block that connects the "Execution" and "Planning" cycles—creation of the transformation plan itself.

The remaining task is to connect the output from the enterprise architecture analysis and selection activity described in Chapter 6 with the broader framework for enterprise transformation. Fortunately, the ATAM approach used as the backbone for the alternative architecture assessment methodology results in the identification of sensitivity and tradeoff points within each architecture. Taken collectively, these are labeled "Points of Leverage" in the OPM model. These points of leverage focus the transformation plan development onto the mechanisms with the highest potential for change.

Connecting the Dots: Using Points of Leverage to Focus Transformation Efforts

The point of interface between the OPM developed for the enterprise architecture description and the Enterprise Transformation Roadmap occurs between the "Points of Leverage" in the OPM and the "Align Enterprise Infrastructure" box in the Enterprise Transformation Roadmap. Figure 7-2 illustrates this point of connection explicitly. It is worth noting that although the "Points of Leverage" from the OPM correspond most directly to the "Rationalize Systems & Policies" action under "Align Enterprise Infrastructure", the precursor tasks in both the "Planning Cycle" and the "Strategy Cycle" of the Enterprise Transformation Plan are all accounted for in the methodology for constructing the OPM representation of the enterprise architecture. The Enterprise Transformation Roadmap provides a number of additional activities that provide additional insight into the current enterprise state and operations, but the overall information content is very similar, to include the "Align Metrics" activity that occurs immediately after the "Rationalize System & Policies" activity.

The advantage gained from completing the ATAM assessment is the focus it provides for building the transformation plan that follows as the next step in the Enterprise Transformation Roadmap process. By explicitly calling out the sensitivity, and in particular, the tradeoff points in the architecture, the highest leverage mechanisms within the enterprise will become the natural focus of the transformation plan.

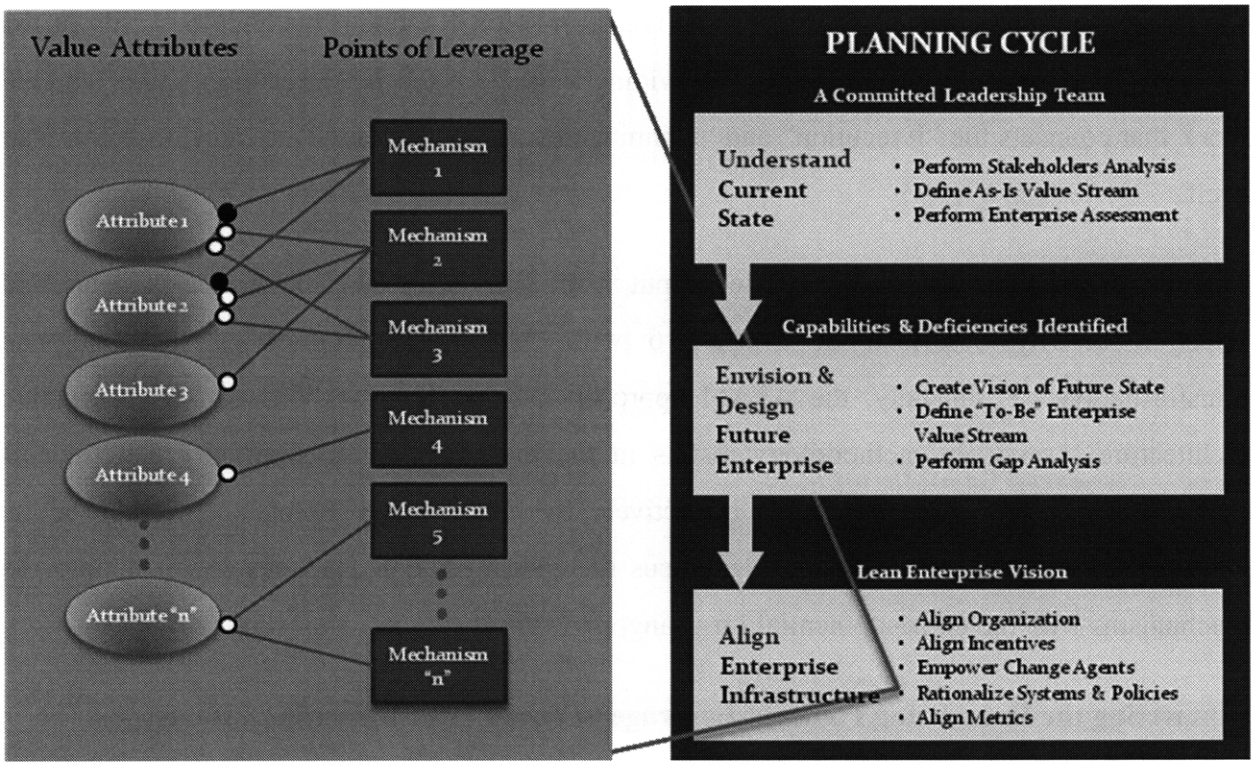


Figure 7-2. Interfacing the OPM Model with the Enterprise Transformation Roadmap.

To create the enterprise transformation plan, Nightingale and Rhodes specify the following considerations that should be addressed in the transformation planning stage [89]:

– Determine how the enterprise transformation story needs to be told
– Provide incentives for change that are aligned with stakeholder values
– Do you have the people and/or organizational capabilities needed to transform?
– Are the appropriate structure and governance processes in place?
– Communication should flow from the enterprise leadership
– Align performance metrics with architecture (also with vision strategy)[5]
– Plan for removal of obsolete/extraneous enterprise artifacts

By identifying the tradeoff points from the ATAM analysis, the above issues focus on developing a plan that will target the highest leverage mechanisms within the selected

[5] For the case of implementing the OPM model of the enterprise architecture as developed in this research, the alignment between performance metrics (called attribute metrics in this research) and the architecture will have already occurred through the use of the X-matrix analysis leading up to the OPM build.

architecture. In this manner, the two frameworks complement one another well. The OPM analysis narrows the transformation planning scope to the highest payoff factors, and the transformation planning provides the additional breadth needed to fully account for the wide-range of issues to be addressed for the transformation plan to be effective.

In addition to the specific planning items called out by Nightingale and Rhodes, the Enterprise Transformation Roadmap details the following actions that should also be accomplished:

- Identify Key Enterprise Improvement Project Areas
- Determine Impact Upon Enterprise Performance
- Prioritize, Select and Sequence Project Areas
- Publish Communication Plan

Taken collectively, these activities provide a solid basis on which to initiate an enterprise transformation plan to achieve the objective state characterized by the selected enterprise architecture. Once accomplished, the effort moves into the "Execution Cycle" within the Enterprise Transformation Roadmap, and feedback on the effectiveness of the transformation plan is incorporated to make the appropriate adjustments or changes to produce the desired outcomes. It is in the "Execution Cycle" that the enterprise architecture will be "validated" against the value delivery achieved to the enterprise decision makers. Without an executable model of the enterprise architecture, this is the first instance the architect has the opportunity to receive feedback on the enterprise design, but even so, this must be taken with a large measure of circumspection since by definition the future architecture is still in the making. Final judgment as to the validity of the objective enterprise architecture is only possible full implementation and the value delivery assessed by the enterprise decision makers.

Making Progress: Metrics and Stable Intermediate Forms

This brings us back to the issue of metrics and the importance they have in driving the enterprise in the desired direction. As mentioned previously, if these metrics are not aligned appropriately, both vertically and horizontally through the enterprise, achieving the desired changes to the enterprise architecture will be next to impossible. Achieving alignment through the transformation process is especially challenging as old mindsets and ways of conducting business are in transitory states. Often the direct business practices that need to be changed are

obvious enough, but many times the metrics that have been driving enterprise behavior are second order effects that do not come to light until the enterprise is put into a change state. It is only then the behavior induced by the previous metrics may actually be recognized as the source of behavior counter to the direction leadership is taking the enterprise.

This is one reason why it is important to design what Rechtin and Maier call "stable intermediate forms". [86] According to this collaborative systems heuristic, "Complex systems will develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not." Rechtin and Maier go on to elaborate by saying the following:

> "Stability means that intermediate forms should be technically, economically, and politically self-supporting. Technical stability means that the system operates to fulfill useful purposes. Economic stability means that the system generates and captures revenue streams adequate to maintain its operation. Moreover, it should be in the economic interests of each participant to continue to operate rather than disengage. Political stability can be stated as the system has a politically decisive constituency supporting its continued operation."

The implications for transformation planning are significant. The insight from Rechtin and Maier suggest that a transformation plan sequenced in stages that are stable, incremental improvements over the previous enterprise architecture will ultimately provide a faster path to full enterprise capability. Designing a transformation plan at this level of sophistication requires a tremendous level of insight into the interactions between every component of the enterprise architecture and a willingness to postulate possible future states in which the enterprise will have to successfully operate in these intermediate forms (perhaps indefinitely) before reaching the desired objective architecture.

Chapter 7 Summary

Do not be deceived by the relative brevity of this chapter. The importance of building a solid enterprise transformation plan cannot be over-emphasized. Fortunately, solid frameworks already exist in which to conduct this portion of the analysis. The Enterprise Transformation

Roadmap is the approach implemented in this research, and further details on executing this model are referenced appropriately. The primary task of this chapter is to draw the connection between the OPM construct of the enterprise architecture and where the outputs of this analysis provide inputs into the Enterprise Transformation Roadmap methodology. Further assessment of the transformation plan and the "Execution Cycle" of the Enterprise Transformation Roadmap highlighted the continuing importance metrics play in shaping and motivating enterprise behavior. This in turn led to a discussion of creating stable intermediate forms and the need to integrate these 'way points' into the transformation plan to speed the overall enterprise transformation process and boost the probability that the objective enterprise architecture will actually be realized.

This concludes the methodology development section of this thesis. An end-to-end framework for rigorous value-creation is now in place and available to apply to the UAS airspace integration challenge introduced in Chapters 1 and 2. Furthermore, the methodology development process implemented in this research has ensured the framework to be robust to the scope of the UAS airspace integration activity as well as compliant with the broader DoD CBA process. In theory, the tools are assembled for conducting the needed analysis of the UAS airspace integration challenge and emerge with a viable set of recommendations.

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SECTION III: APPLICATION

With a framework now in place to address the issues identified in Section I, the UAS airspace integration challenge is assessed using the methodology from Section II. A side note on the scope is warranted. Each enterprise architecting view is a thesis all by itself with very timely and appropriate insights into the UAS airspace integration issue. For the sake of time and space, these details are not developed as any number of different approaches could be implemented within each view for arriving at logical and implementable frameworks. Within the discussion in Section III, approaches developed by the author for each of the views are presented. The reader is encouraged to consider these as potential ways of tackling the practical assessment of the various enterprise views, but the methods presented are by no means the only (or perhaps even the best) means for addressing each view.

There is also the issue of data collection. Chapter 8 goes into some detail on both the method and results of the data collection effort undertaken as part of this analysis. This chapter was not included in the general methodology section primarily because the lessons or heuristics presented may not be fully extensible to a broader context. Additional research is required to make a broader statement as to the applicability of the insights gained from the data collection effort; however, as a descriptive assessment, the lessons learned and the approach to structuring the data collection should be both informative and helpful for future data collection efforts that attempt to implement the prescribed methodology.

Section III is organized into three chapters. Chapter 8 discusses the data collection and analysis results providing the specific context for implementing the value-creation framework in Chapter 9. Chapter 9 systematically goes through the three-phased value-creation framework outlined in Section II, up to the point of developing the transformation plan. In contrast to the methodology section, the application of the transformation plan is a significant element of the work involved in the analysis, and consequently, Chapter 10 will be devoted entirely to developing and recommending an approach to moving forward with the UAS airspace integration effort.

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CHAPTER 8 – DATA COLLECTION AND ANALYSIS

"You have more data than you think, and you need less data than you think."
—Douglas Hubbard[6]

At first blush, the prospect of trying to elicit a decision maker's value definition and exchange proposition may seem a daunting task. The subject is squishy, the questions are often open ended and ill-defined, and the decision maker will likely have to be redirected to a value-focused paradigm with active facilitation by the individual conducting the data collection interview. This is to be expected; however, once the task begins, it turns out to be much simpler in some ways than previously imagined.

Once the decision maker figures out they are not being asked for the answer, but instead being asked to describe the problem and the characteristics of a good solution, the dialogue opens up quickly. With some forethought on the part of the individual conducting the interview, a rich understanding of the decision maker's underlying values and attributes can be had for the asking – literally! Regardless of the specific outcomes from any one interview or data collection attempt, Hubbard's observation in the above quote is a good perspective to have during the data collection and analysis phase. It turns out there is more information in the data than anyone ever thought possible, and the task is trying to figure out how to make sense of it all. You almost never need all of the information you collect. In fact, the challenge it usually to sort through the volumes of data to find the two or three gems of insight that are buried and waiting to be dug out.

Chapter 8 is organized in roughly the sequence of how the data collection and analysis for the UAS AI effort occurred. There are often feedback loops and iterations that are necessary to converge on the right set of final enterprise decision makers and purpose statement (reference Chapter 4 and 9), but for the sake of needing to start somewhere in the process, the enterprise analysis and decision maker analysis results will be presented briefly to provide some sense for how an initial list of interviews was generated. The chapter then moves on to a discussion on

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[6] Quote is taken from Hubbard's book entitled How to Measure Anything: Finding the Value of "Intangibles" in Business. See reference [90] for full biographical listing.

how the interview was structured, and then an assessment of the data collected and knowing when enough data was available for a solid analysis. The chapter concludes with an analysis of the data and the implications for the enterprise value structure.

Knowing Who to Talk To: Iterating on Purpose and Stakeholder Identification

Without having to nail down the specifics discussed in the next chapter, a general sense for the UAS AI enterprise emerges from both the literature, the recent efforts in this domain, and first-hand knowledge of the players and organizations involved in these current or recently completed efforts. It is worth noting that this initial stage of iterating on the enterprise purpose and decision makers is considerably easier if the architect has domain knowledge of the area under investigation. Some care must be exercised to avoid unintentional grounding on the part of the architect, but overall, the data collection exercise suggested that extensive domain experience is a major advantage at this stage in the analysis.

Using the iterative approach detailed in Chapter 4, the enterprise purpose and stakeholders were iterated on for several cycles before a solid sense of convergence was reached. This 'sense' of convergence emerges as interviews were conducted and the individuals being interviewed begin to identify the same values, attributes, metrics, and ranges as previous interviewees. This can also be assessed by asking who the interviewee believes the critical decision makers are in developing the solution they described. When the answer to this question no longer results in additional organizations or individuals identified beyond those already elicited, the data set can be considered 'saturated' from the standpoint of revealing any new information, and the data collection effort is considered complete.

In the case of the UAS AI enterprise, this exercise in enterprise purpose and stakeholder analysis resulted in the identification of the organizations and individuals in Figure 8-1 being identified for value elicitation interviews.

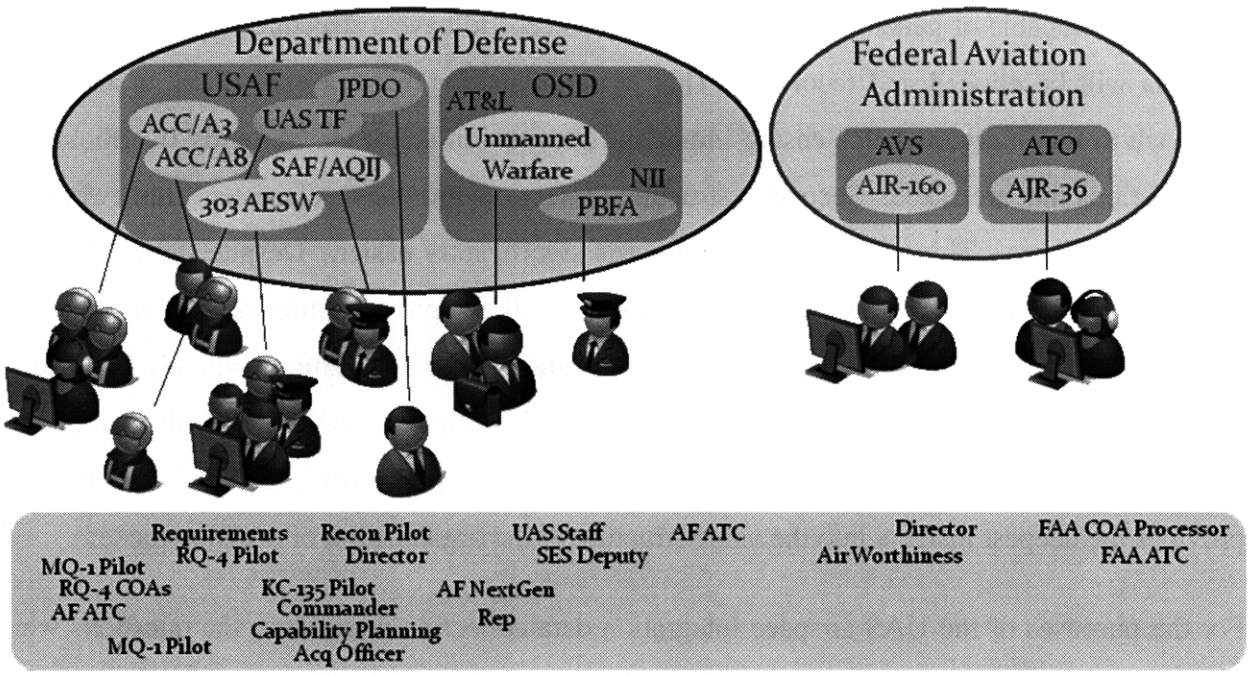


Figure 8-1. Organizations & Individuals Interviewed for Data Collection Effort.

Note the scope of the enterprise and the nature of the enterprise purpose both play a significant role in shaping the extent of the data collection effort and the number of different organizations and individuals to be interviewed. In addition, while other data elicitation methods could be used for collecting the value structure information (such as questionnaires, online surveys, teleconferences, etc), experience with the above process suggests that getting at the underlying value structure with an interviewee is a dynamic process with a high degree of communication on things that do not fit easily into a quantifiable framework. In these instances, research has shown the most effective communication occurs in face-to-face meetings, especially when it comes to picking up the non-verbal elements of communication that can be at least as important (and in some cases, more so) than what is actually said. [91] Other types of data collection may be effective once the initial interviews are conducted and the architect has a better understanding of the nature and language of the enterprise, but this level of refinement was not found to be necessary in the data collection effort conducted for the UAS AI effort.

Knowing What Questions to Ask: Structuring the Data Collection Interview

With the specific organizations and decision makers identified, the process of conducting the interviews needs to be addressed. Do not underestimate the volume of data that a single

interview is capable of generating. The interviewer needs to have a structured approach for how the data will be elicited and recorded. This is important for two reasons. First, a structured approach to the interview helps ensure important information is not inadvertently overlooked in the questions that are asked. Second, a structured interview provides a consistent framework for recording answers. This makes the data analysis significantly easier. Despite these efforts to cover the spectrum of issues, the interviewee will likely provide information, insights, or observations that do not fall into any pre-assigned category. If a structure is already in place to bin 85% of the other information, figuring out what to do with this "unsolicited" information is a much more tractable challenge. In addition, it is often the "unsolicited" information that provides the deepest insights into the value structure of the organization or decision maker.

For the purposes of the UAS airspace integration data collection interviews, the questions were structured around the template proposed by Ross (see Chapter 4). [9] The key distinction, however, is the interviewer needs to elicit the information described in the MATE approach using language that is native to the person being interviewed. This requires a considerable amount of insight and knowledge on the part of the interviewer, but the results warrant the additional work on the front end.

The interview questionnaire for the UAS airspace integration data collection effort is provided in Appendix E for reference. A comparison of the interview questions and the approach outlined by Ross demonstrates how the information requirements from MATE were translated into the context of the UAS AI enterprise. Leave plenty of room on the interview data collection sheet to write additional observations and inputs. In addition, the interviewer needs to realize that the interaction with the interviewee is only semi-structured. In other words, having the questions and knowing what information is needed is valuable going into the interview, but the flexibility for pursuing an angle the interviewee introduces that may not have been part of the original data collection set is important and the interviewer needs to adjust accordingly. Sticking rigidly to the interview questions will result in some of the most insightful information from the interviewee being missed altogether.

As a point of reference, the average interview using the set of questions in Appendix E took an average of 1 hour and 45 minutes. It is also important to note that the interviewee was not given

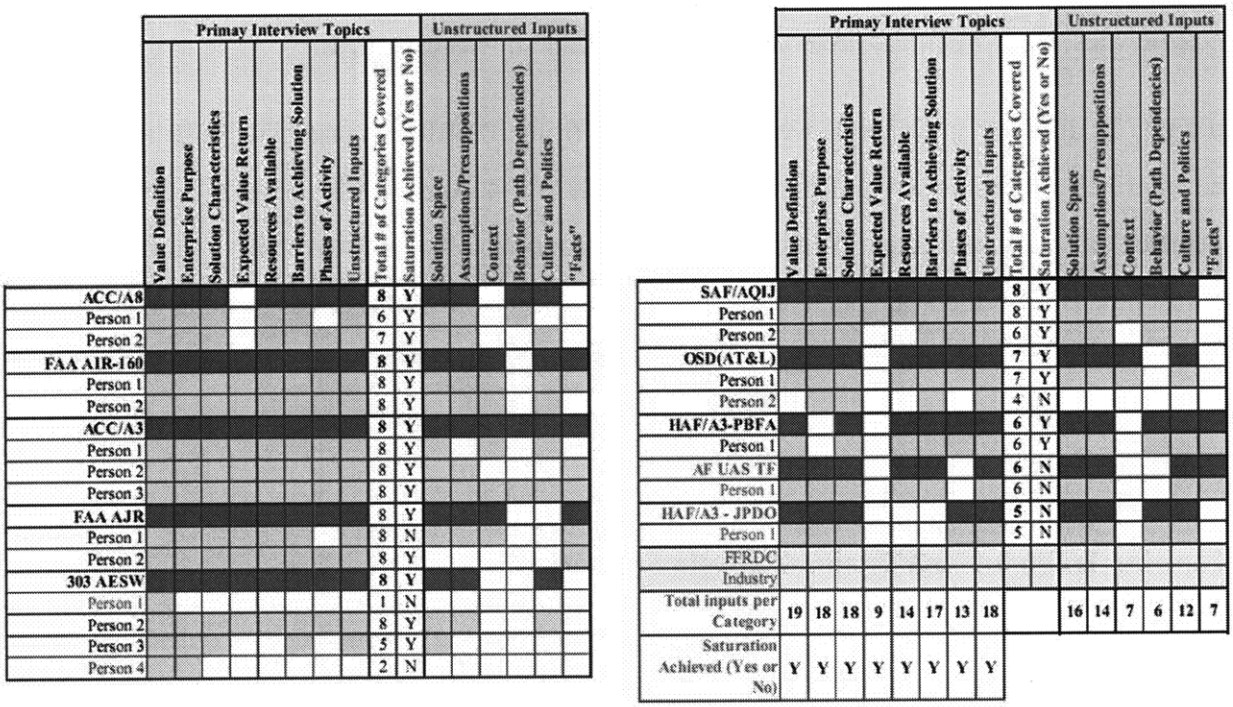
the list of questions. This was done deliberately to keep the conversation flexible and to allow the interviewer to tailor the "superset" of questions on the list to just those that would be most relevant to that particular interviewee. Having all of the questions together in a single document however, facilitated the analysis that followed by providing a consistent framework between interviewees, even when the area of expertise or concern was divergent.

In total, 20 different individuals were interviewed from 10 different organizations. Almost all of the interviews were conducted between 24 March and 4 April 2008. Figure 8-1 provides the specifics on the individual backgrounds and experience as well as the organizations they represented or provided perspective on the issues. All told, over 80 pages of notes resulted from the interview process and an additional two weeks of applied effort was required to reduce the data into a distilled set of information that could be analyzed and interrogated for value structure insights.

Knowing When to Stop: Evaluating Data Saturation

An important part of the data collection effort is knowing when there is sufficient data to accurately capture the enterprise value structure. The method employed in the UAS airspace integration effort is depicted in Table 8-1. In this analysis, the primary structure of the data collection interview is represented in the first seven columns of the table, labeled "Primary Interview Topics". The second set of data, labeled "Unstructured Inputs", captures the unsolicited inputs that did not fall cleanly into any of the predefined data categories. For the purposes of estimating completeness of the data collected, the information was examined from two different perspectives. First, did each organization collectively have good representation in the data from across the full range of structured interview topics depicted in the first seven columns? If so, that organization was considered to be "saturated", especially if the interview data revealed that multiple interviews within that organization produced significantly overlapping data sets. To help with interpretation, each individual with whom an interview was conducted was tabulated under their organizational affiliation and their inputs assessed relative to these first seven categories. If data was evident in a given category, that box was colored yellow and the organization row above that individual was turned green. In this way, a visual pattern could be established for how saturated a given individual's inputs were as well as the overall organization. On the initial pass through the data, the only additional information that was

recorded was whether or not the individual included unsolicited information in the interview. If so, the "Unstructured Inputs" box was also colored in yellow and flagged for further analysis at a later point in time.



	Primay Interview Topics										Unstructured Inputs					
	Value Definition	Enterprise Purpose	Solution Characteristics	Expected Value Return	Resources Available	Barriers to Achieving Solution	Phases of Activity	Unstructured Inputs	Total # of Categories Covered	Saturation Achieved (Yes or No)	Solution Space	Assumptions/Presuppositions	Context	Behavior (Path Dependencies)	Culture and Politics	"Facts"
ACC/A8									8	Y						
Person 1									6	Y						
Person 2									7	Y						
FAA AIR-160									8	Y						
Person 1									8	Y						
Person 2									8	Y						
ACC/A3									8	Y						
Person 1									8	Y						
Person 2									8	Y						
Person 3									8	Y						
FAA AJR									8	Y						
Person 1									8	N						
Person 2									8	Y						
303 AESW									8	Y						
Person 1									1	N						
Person 2									8	Y						
Person 3									5	Y						
Person 4									2	N						

	Primay Interview Topics										Unstructured Inputs					
	Value Definition	Enterprise Purpose	Solution Characteristics	Expected Value Return	Resources Available	Barriers to Achieving Solution	Phases of Activity	Unstructured Inputs	Total # of Categories Covered	Saturation Achieved (Yes or No)	Solution Space	Assumptions/Presuppositions	Context	Behavior (Path Dependencies)	Culture and Politics	"Facts"
SAF/AQIJ									8	Y						
Person 1									8	Y						
Person 2									6	Y						
OSD(AT&L)									7	Y						
Person 1									7	Y						
Person 2									4	N						
HAF/A3-PBFA									6	Y						
Person 1									6	Y						
AF UAS TF									6	N						
Person 1									6	N						
HAF/A3 - JPDO									5	N						
Person 1									5	N						
FFRDC																
Industry																
Total inputs per Category	19	18	18	9	14	17	13	18			16	14	7	6	12	7
Saturation Achieved (Yes or No)	Y	Y	Y	Y	Y	Y	Y	Y								

Table 8-1. Data Collection Saturation Analysis.

The second aspect of saturation evaluated was whether or not the full spectrum of enterprise decision makers was represented in the total pool of interviewed decision makers. In this case, the assessment was subjective, but the intent was to ensure that at least two different organizational layers in the management structured were interviewed to capture differences in the value structure induced by relative organizational position with respect to the UAS airspace integration effort. An assessment in this dimension revealed good saturation levels on the DoD side of the enterprise, but only moderate saturation on the FAA side. With the specific resource limitations of the current research, however, this moderate level of saturation was estimated as having provided at least an 85% data set at a high level of confidence.

Note there were several organizations that were interviewed that did not achieve full saturation, even at the individual organizational level. These organizations included the Air Force UAS Task Force and the Air Force lead for the JPDO. In both cases, this lack of data saturation was

determined to be acceptable because while both of these organizations are clearly stakeholders in the UAS AI enterprise, the saliency analysis (see the next chapter) indicated they were not stakeholders on par with the other organizations interviewed. In addition, the interview data collected from these two organizations proved to be almost totally overlapped with data previously collected from the other decision makers in the enterprise.

Once the collection was considered saturated from a primary data set standpoint, the unstructured topics that were provided as unsolicited inputs from the interviewees were re-assessed, and the additional analysis revealed a clear pattern to the type of information that was being communicated voluntarily. The information was binned according to the topic categories depicted in Table 8-1. The information that was provided in the "unsolicited" data can be generally categorized as "context" information and "behavioral" information. The implications of this observation will be addressed further in the next section.

Knowing What to Look For: Data Analysis

The reduced (but unfiltered) data collected during the interview process is provided in Appendix F for detailed reference or additional analysis. What follows in the remainder of this section is an analysis of the collected data that attempts to capture the relevant information for constructing the enterprise value structure. The high points will be summarized by questionnaire category to provide the contextual depth needed for the application of the methodology described in Chapters 9-11.

Certificate of Authorization Process – Strengths and Weaknesses

The intent of starting the questions with the Certification of Authorization (COA) process was to provide a concrete point of departure for the more conceptual questions that would follow. Using the COA (the current method by which the FAA approves flights of military UAS in the NAS) provided a known reference point for the interviewee to answer value questions about the existing process. This proved to be useful in helping the interviewee think in terms of value space rather than in alternatives. The data from this question suggested that DoD sees the extent to which the COA process delivers value in significantly different terms than the FAA. In effect, the COA process provides a proxy "As-Is" assessment to the current UAS airspace integration effort.

Discussions with ACC/A3 concerning the value delivery associated with the COA process revealed a number of important insights for architecting the future enterprise. Figure 8-2 illustrates the ACC/A3 value delivery assessment of the COA process.

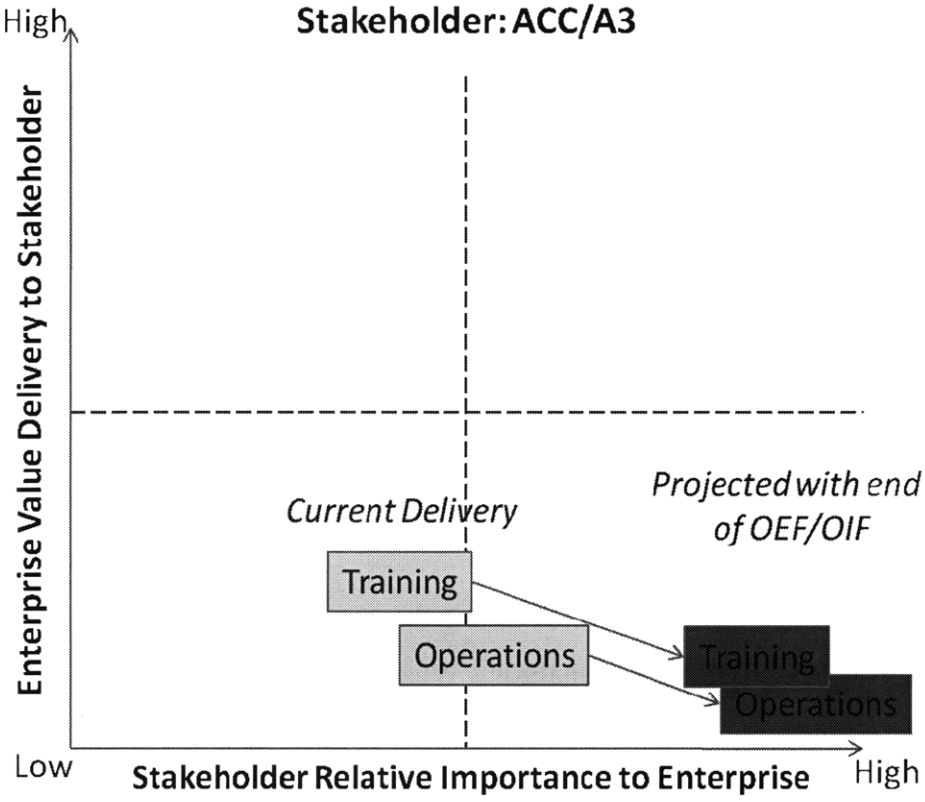


Figure 8-2. ACC/A3 Value Delivery Assessment of COA Process.

One very valuable outcome of this exchange with ACC/A3 was understanding the shift in the value delivery state should the conflict in Iraq end and all of the UAS assets ACC is currently operating in theater have to be sent back to U.S. basing locations. In essence, the ACC/A3 value shift indicates that if this were to occur, the ability of the COA mechanism to meet mission requirements would fall well short of the needed value delivery. The implication for current operations is that the war effort itself is being used as a way to keep pilots and crews proficient in their jobs. Without the war activity to provide this additional level of access to airspace for UAS assets, the current situation would not be sustainable.

Building off of the previous work conducted by Weibel [92]and Blackburn et al.[93], the AJR-36 value delivery assessment can be constructed. Notice that in Figure 8-3, there are a few more

aspects to the value delivery mechanism, but the safety aspect dominates the scene in terms of the value delivered as well as the importance placed on the delivery of that value. From an AJR-36 perspective, the COA process is working well.

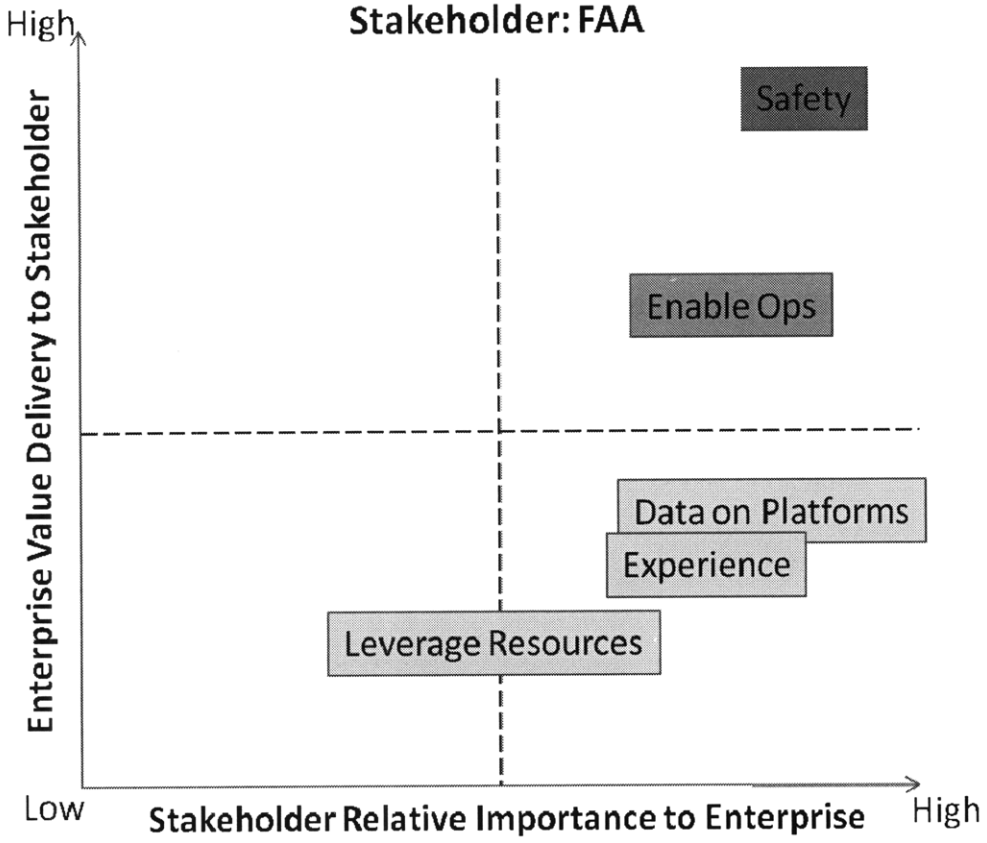


Figure 8-3. AJR-36 Value Delivery Assessment of the COA Process.

The challenge facing the enterprise architect is the creation of an architecture that preserves the FAA's value delivery level (especially with respect to safety) while significantly increasing the DoD value delivery level for operations and training.

Enterprise Scope and Purpose

The primary responses to questions regarding the nature of what the enterprise objective or purpose should be varied by organization. In effect, there were two primary sets of definitions, one from the Air Force and the other from the FAA, on what the UAS AI enterprise needed to accomplish. These are summarized as follows:

Air Force

- Purpose is driven by Air Combat Command (ACC)
  - Enable Training: 100% (4 of 4) of ACC/A3 interviewees said training missions for wartime ops was the primary purpose the UAS airspace integration effort should pursue
  - Conduct Operations: 100% (4 of 4) of ACC/A3 interviewees said conducting primary missions in or through the NAS when tasked was a second need for the UAS airspace integration effort
- Additional Perspectives taken from across the decision maker data
  - Need to access/transit airspace to accomplish above two activities
  - Shifting force structure puts more and more capability on UAS platforms increasing likelihood of usage
  - UAS airspace integration needed to preserve the principle of maneuver when using UAS assets

Federal Aviation Administration

- Safety
  - Ensure operations meet safety objectives
  - Underlying premise on which all other action is undertaken—AJR observation
- Enabler to DoD: Provide mechanism for mission accomplishment
- Maximize Resources
  - Leverage common objectives to get viable outcomes
  - Political and teamwork value
  - Dual-Use products

Resolving these two very different value definitions for the UAS AI effort will be at the heart of aligning and flowing the value each decision maker expects out of the activity pursued in the UAS airspace integration context. The following is a consolidated list of the different types of activities decision makers believe the enterprise needs to undertake in order to deliver the expected value:

- Fill the gaps in current UAS capabilities
- Provide the appropriate equipage to comply with the CFRs to fly in the NAS

– Enable airworthy UAS certifications
– Enable Situational Awareness data to ground station/pilot
– Address Policy issues impeding the progress of integrating UAS into the NAS
– Develop the appropriate procedures needed to integrate UAS into the NAS
– Develop the appropriate standards to integrate UAS into the NAS
– Still developing and evolving—don't know enough to say what the scope should be
– Define critical set of scalable activities and work on getting those laid out in more detail
– Comparative analysis with manned aircraft to demonstrate safety of UAS operations

Between the different perspectives on the value definition and the wide variety of views on the scope of the effort, the clearest message that emerged from the interview data on these two topics was the critical need for a well structured enterprise purpose statement with clearly defined goals and metrics associated with its delivery. This is addressed in detail in the next chapter.

Enterprise Stakeholders

As part of the interview process, the interviewee was asked to provide a list of organizations they felt were critical to the delivery of the value definition they provided. In other words, who needed to be involved and engaged in order for the enterprise purpose (as they defined it) to be successfully completed or realized?

Table 8-2 provides a consolidated tally of all of the stakeholders elicited during the course of the interviews. Of the 20 individuals interviewed, 17 provided an input to this question. Of these 17 individuals, the total number that mentioned the organization listed is annotated in the next column. Because this was a totally open-ended question based on the individual's definition of the enterprise purpose, those organizations that had a significant number of multiple interviewees identifying them as key organizations suggested a strong probability that these organizations would likely emerge from the saliency analysis as "definitive stakeholders", or using the model from Ross, decision makers.

Organization	Count out of 17 total*	Organization	Count out of 17 total*	Organization	Count out of 17 total*
ACC	2	303 AESW	5	Congress	4
ACC/A3	5	AFRL	3	NASA	1
ACC/A5	2	OSD(AT&L)	5	DHS	2
ACC/A8	4	PBFA	7	CBP	1
HAF	--	Joint Staff	1	Coast Guard	1
HAF/A2	1	DoD	5	NII	1
HAF/A3	5	FAA	10	NTSB	1
HAF/A5	3	FAA AIR-160	3	Feq Spctrm Off	1
HAF/A8	1	FAA AFS	1	Forest Service	1
AF UAS TF	2	FAA ATO	2	Standards Orgs	1
SAF/AQ	4	FAA ATO/E	1	Industry	1
SIMAF	1	FAA ATO/S	1	AOPA/ALPA/etc	2
ESC NextGen	1	FAA ATO/T	1	Senior Leaders	2
Acquisition Chain	3	FAA AVS	1	C2 Orgs	1

* Out of 20 interviews, 17 people provided inputs. The counts are a sum across all 17 inputs on how many people thought each organization should be considered a "key" stakeholder to enabling the enterprise value delivery.

Table 8-2. Consolidated Responses for "Key" Enterprise Stakeholders.

Without having conducted the saliency analysis for the stakeholders provided in Table 8-2, and simply going off of the relative frequency an organization was mentioned, the following general observations can be made. Total number of ACC references (specific offices being lumped into a total for the overall organization) amount to 23; total Acquisition references amount to 22; total FAA references amount to 20; total DoD and Congressional policy-level organizations amount to 15; and all other references combined amount to 16.

Two observations are worth noting. First, this is a much shorter list than the "full" stakeholder set provided at Appendix B. This suggests the enterprise architect should apply some domain insight as the Grossi method of enumerating enterprise stakeholders is executed. After eight or nine interviews, it became clear that the critical organizations consistently popped up regardless of the interviewee's particular view of the enterprise purpose statement. A number of other uniquely identified stakeholders would invariably surface, but just as predictably, these "one-off" stakeholders were only rarely mentioned by any of the other interviewees, and the specific stakeholders in these categories tended to be correlated very closely to the technical depth of the individual in his or her field.

Second, despite the fact that the enterprise purpose and scope appears to need additional work, there is a consistent picture for who needs to be engaged in the discussion. This provides an important area of consensus between both the Air Force and the FAA perspectives to help build the appropriate enterprise architecture.

Resources, Constraints, and Timeframes

As might be suspected with such variation in the responses for the scope of the UAS airspace integration activity, the inputs on the required resources needed for the enterprise to accomplish the purpose the individual interviewee articulated were all over the map. As Table 8-3 demonstrates, the range in funding was "already have enough" to $100s of millions per year.

Resources			Comments
Money	Manpower	Time	
$80M		4 yrs	Effort to put initial SAA capability on Global Hawk (303 AESW)
Minimum Possible			AF will only spend as much as needed to fix immediate ops (ACC)
$10/$100M	Grnd Radar	2 yrs/Life	Grnd based radar effort at Beale to eliminate TFRs (ACC)
	Req/Policy		Provide manpower /expertise to work ops policy and reg issues (ACC)
Millions			Will take significant investment to work this issue (ACC)
$80M		4 yrs	Effort to put initial SAA capability on Global Hawk (ACC)
Already have enough			Lot's of resources applied—just not coordinated/aligned (AF UAS TF)
Don't know			Current environment not well enough defined (FAA)
	2x current		Need unencumbered resources without bureaucracy constraints (FAA)
$20M	10 FTE/yr		Use this to baseline performance and failure mode characteristics (FAA)
$2/M yr	Small Team	5 yrs	Access 5 like effort from small, expert team focused on specific issues (FAA)
$50-100M			Per platform/location to resolve specific operational needs (OSD)
$10-15M/yr		5 yrs	Work to get larger scale plan put in place (OSD)
Need linkage			Connect UAS investment to equiv. needed for manned ops. (SAF/AQ)
$10M/yr		3 yrs	Per platform to get plan laid out, issues communicated, ldrshp on board (AQ)
$50M		Year 4	Pushes planning to real execution for tangible results (AQ)
$100sM/yr			Need real money to go out and procure assets to field capability (AQ)

Table 8-3. Consolidated Responses for Required Enterprise Resources.

The high variation in the timeframes over which various interviewees saw the UAS AI enterprise operating had a corresponding effect on an estimate of the time required to achieve the enterprise purpose as well. Estimates provided varied from completion dates of 2013, 2015, 2023, and many were simply indefinite. Nailing down the enterprise purpose and scope should provide for

a much improved understanding of the resources and timeframes that will be required to accomplish the value delivery articulated by each of the decision makers in the enterprise.

A discussion of constraints often led to significant entries in the "Remarks" categories (in other words, inputs that did not fall into any one of the structured interview categories). In general, the following list provides a good representative sample of the type of constraints interviewees identified as having the potential for the most impact on the effort. The organization providing the input is captured in parentheses at the end of the bullet.

- Need to convince senior AF/DoD leadership to take this issue on as a major interdepartmental effort (ACC)
- Funding has to be protected to make any progress on equipage/standards (ACC & OSD)
- Rulemaking process is the single most limiting aspect to making progress. Changes here could cut the time to reach standards by 50-70% (FAA)
- Arriving at a common purpose for the effort. A philosophical level of agreement is required on the vision (FAA)
- Data required to establish the needed regulatory requirements in the operational environment (i.e. wake turbulence categories, separation distances, etc) (FAA)
- Generating a higher level of leadership advocacy (OSD)
- Get the FAA to take more of a partnering role in the effort at senior leadership levels (OSD)

In the case of many of the constraints elicited in the above list, the architect will need to iterate closely with the relevant decision maker to determine if the constraint articulated can legitimately be moved as part of the analysis, or whether the issue is a true constraint and provides a hard boundary on the execution of the enterprise.

Barriers

Table 8-4 provides a summary of the results of the "barriers" question. Note that the question was entirely open ended, so the responses should be as nearly independent as possible barring any unintentional anchoring that occurred during the course of the interview. In a similar manner as the stakeholder analysis, the barrier assessment elicited responses from all 20 of the interviewees and the "Top Ten" list is provided in Table 8-4 based purely on the number of

instances in which the subject was mentioned as a major barrier to the UAS AI enterprise conducting a successful value delivery effort. The total number of responses with the identified issue is captured in the parentheses after the barrier name.

- Culture (9)
- Lack of leadership (8)
- Equipage shortfalls (5)
- Lack of funding (3)
- Lack of resources (3)
- No one person in charge (3)
- Politics (3)
- Lack of aviation heritage (2)

Table 8-4. Barriers to UAS Airspace Integration.

At the level of aggregation provided in Table 8-4, the preciseness of what is meant by each of these terms is conveniently left off. In fact, if the data is examined closely (See Appendix F for the complete data collection results) it will become apparent very quickly that a number of these terms meant significantly different things to the decision maker providing them. Once again, the architect must verify that the list is indeed an accurate one for what barriers must be overcome to successfully launch the enterprise.

There was a strong and pervasive theme that came to the forefront regularly, and that was the lack of strong leadership engagement on this topic. The sense was that leadership across all definitive stakeholder organizations lacked the ownership and will to see the airspace integration effort succeed. This will prove to be a major factor in both the current assessment and in future architecture considerations.

Without detailing all of the highlighted areas in Table 8-4, suffice it to say they each have similar detail and specific examples associated with them to provide a clear picture of the issues to be resolved by the future enterprise architecture. These barriers can be thought of as the hurdles to value delivery. What was even more enlightening was the emergence of fundamental cultural and organizational perspectives as the data was compiled and categorized. These will be

explicitly detailed in following sections because they represent very strong beliefs that will have to be taken into account with any future activity.

Solution Characteristics or Attributes

A sense for the diversity of decision maker perspectives on solution characteristics or attributes is conveyed in the following list. Note that these responses were provided in response to the question of what a good solution to the UAS airspace integration effort would "look like" from the interviewee's perspective.

- Conforms to existing structure
- Does no harm
- Man-like/equivalent access
- Integrated pilot SA
- Flexible to meet schedule requirements
- Safe
- Accepted as integral member of NAS
- Flexibility of operations
- New ops not significant emotional event
- Enables mission
- Consensus of approach
- Cost
- Impact on NAS structure
- Integrated equipage
- Sense-and-Avoid capable
- Pilot provided advisories
- ATC treats UAS the same
- Launching a recovering with United Airlines Flt
- Contingency responses understood
- Predictable behavior
- Fully cooperative
- Routine coordination
- My phone isn't ringing with a problem
- Responsive C2 system
- Airworthiness certified
- Reduced training/ops overhead
- Reduced operating cost
- Near-term feasibility of plan
- Capable technology
- Integrated procedures
- Comprehensive policies

The most apparent observation from the above data is the wide variety in the responses, and the implied challenge to the enterprise architect when it comes to creating a value proposition that is robust enough to deliver the wide range of characteristics described by the enterprise decision

makers. While not conducted as part of this research, a major issue that confronts the architect in this situation is a way to conduct this many utility interviews if a high confidence tradespace were desired as the outcome of the effort. This is especially true since attribute utilities cannot be aggregated across difference decision makers.

Remarks

The "Remarks" section of the data collection effort, along with the "Barriers" responses, was the single largest category of information collected during the interview process. The "Remarks" section represents all of the information provided during the interviews that did not fit into an already defined category on the interview questionnaire. Much of the data contained in this section of the results was unsolicited in the sense that it resulted from tangents or follow-ups from other questions. Because the volume of information in this section is so extensive, only a series of quotes will be reproduced here with the intent of conveying some of the more salient aspects of cultural differences, politics, and mindsets embedded within the various decision maker organizations involved in the UAS AI enterprise.

- The FAA perspective: "Interested in the anticipated case being good enough versus the best case being the norm." (FAA AIR-160)
- ACC's resource perspective: "Not going to launch a Manhattan Project or an ACAT 1 program." (ACC/A8)
- One AF UAS TF member's perspective: "Predator could fly today with its current complement of sensors and equipment and fully comply with the regulations associated with flying in the NAS—except for those conditions in which it goes lost link." (AF UAS TF)
- FAA description of legacy hurdles: "UAS are at the will of every other system that is already in operation in the NAS. We are trying to take a futuristically capable system and dumb it down so it will play nicely with a system that is 40-50 years old." (FAA AIR-160)
- SAF/AQ view on problem: "We've had the technology for decades to hit things. We can clearly use the same technology to avoid them. Technology is not the problem—it's the social element." (SAF/AQIJ)

- One blessed with much insight on AF culture: "I'm worried that if I solve the UAS problem, I'll be blamed."

If anything, these quotes bring to the forefront the fact that UAS airspace integration challenges are not fundamentally technical in nature. It is much more deeply rooted in the fundamental sociological differences between organizations and cultures. The implication for the architect is the need to craft an enterprise purpose statement that will be sufficiently strong to unite these diverse perspectives into a viable activity with all of the decision makers pulling in the same direction.

Summary of Data Collection Effort

The very act of going to each decision maker and eliciting the information contained in Appendix F was the single most important activity for gaining the needed insights into the values and perspectives of the various decision makers required to create the alternative architectures and transformation plan detailed in Chapters 9 and 10. The data set represented in Appendix F is rich in both the complexity of the decision maker value propositions and the breadth of the issues that it highlights as important to address in the analysis. The above discussion has only scratched the surface on the usefulness of this information for forging a path forward.

Knowing What to Do Next: Implications for the Value Structure

The last section of this chapter discusses the ramifications of the above observations and synthesizes a number of possible perspectives various decision makers are likely to have based on the responses to the interview. These observations in the data fall into two major categories, labeled "tensions" and "consensus" respectively. The areas that fall under the "tensions" moniker represent differing perspectives of the same topic. These are important because while the same word might be used, the differing perspectives on the subject result in often fundamental, philosophical disconnects on how activities should be pursued. For those falling in the "consensus" category, there is strong general agreement on the topics, and these represent areas where there appears to be good alignment already within the enterprise.

The issues held in tension are addressed first. The largest, and most significant of these, is the subject of safety. Figure 8-4 details the significant differences in how safety is viewed relative to the UAS platform itself between the DoD and the FAA. Any successful enterprise endeavor will

require, at a minimum that this tension be resolved to the satisfaction of all of the decision makers involved in the enterprise. Note that this tension does not imply that the Air Force, or DoD in general, is not safety conscious or does not take adequate measures to ensure the safety of their operations. To the contrary, safety is a critical enabler to mission effectiveness. It is this distinction, however, that drives the difference in perspectives. For the Air Force, safety is an important *mission enabler*, not an end in and of itself. On the other hand, the FAA's mission itself is safety, so the degree of emphasis between the two organizations and the relative amount of risk in the area of safety each are willing to take are significantly different, as the interview data points out.

This difference in perspective is captured well in the following excerpt from a recent Government Accountability Office (GAO) report on the subject of integrating UAS into the NAS [94]:

> "FAA and DOD officials acknowledge that military experience and operational data on UASs are not always directly transferable to operations in the national airspace system. The military's use of UASs is focused on mitigating the danger to troops. Safety and reliability risks that may be appropriate in a war zone to protect troops may not be acceptable in the national airspace system."

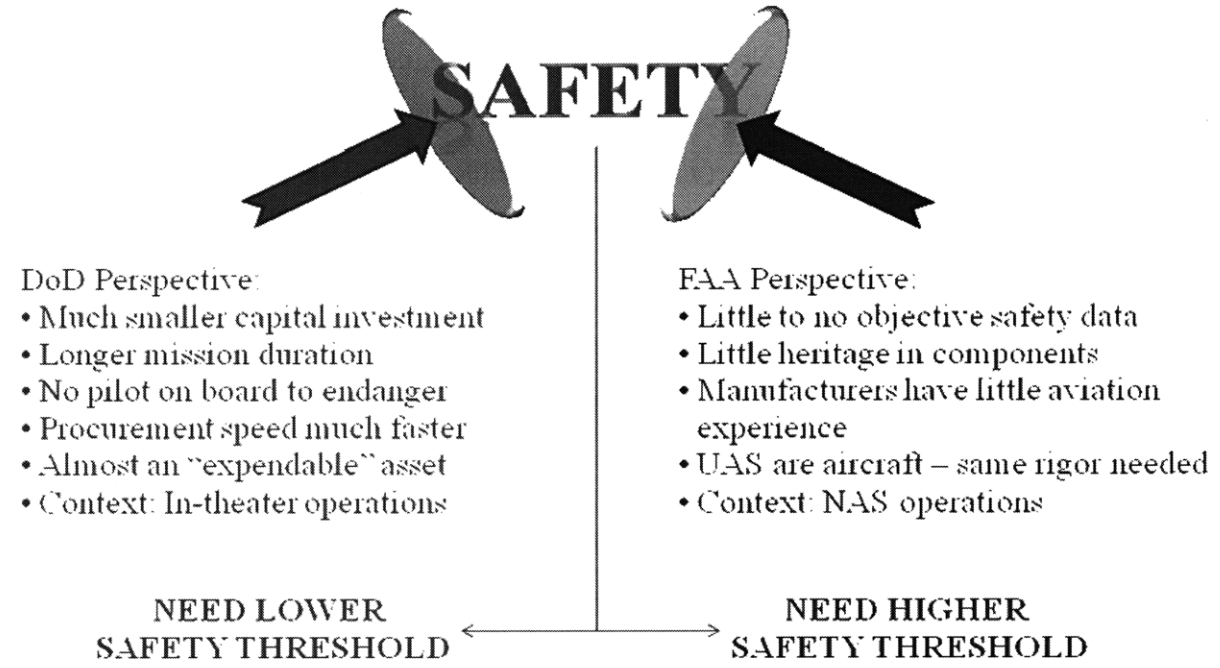


Figure 8-4. Differing Enterprise Perspectives on Safety.

The second issue in tension is the difference in perspectives on what is needed to move forward. This is labeled as differing perceptions on the hurdles that need to be overcome to generate positive movement forward on the airspace integration effort. This issue is one that falls largely down "professional" lines, as opposed to organizational lines. Figure 8-5 illustrates the difference between the ways the operational community sees the need to move forward versus the way the engineering or acquisition community sees the shortfalls that need to be addressed.

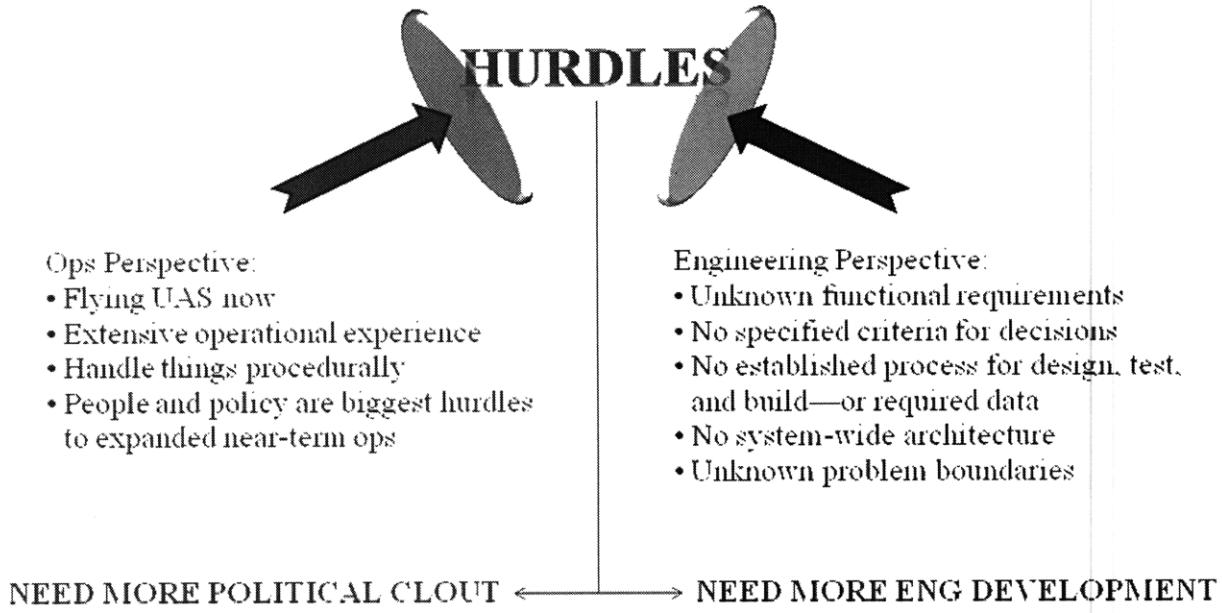


Figure 8-5. Differing Enterprise Perspectives on Hurdles.

The third and final tension addressed is the difference in the perceptions various stakeholders in the enterprise have of other organizations involved in the airspace integration effort. Figure 8-6 details these deeply rooted cultural perspectives ingrained in the day-to-day mental models of each of these decision makers. To further complicate the resolution of all three of these tensions, they do not all lie on the same "cleavage plane." That is, the resolution of one tension does not make either of the other two "go away." The enterprise architecting effort will have to arrive at a mechanism that provides for the resolution, or at least the containment, of all three of these factors simultaneously.

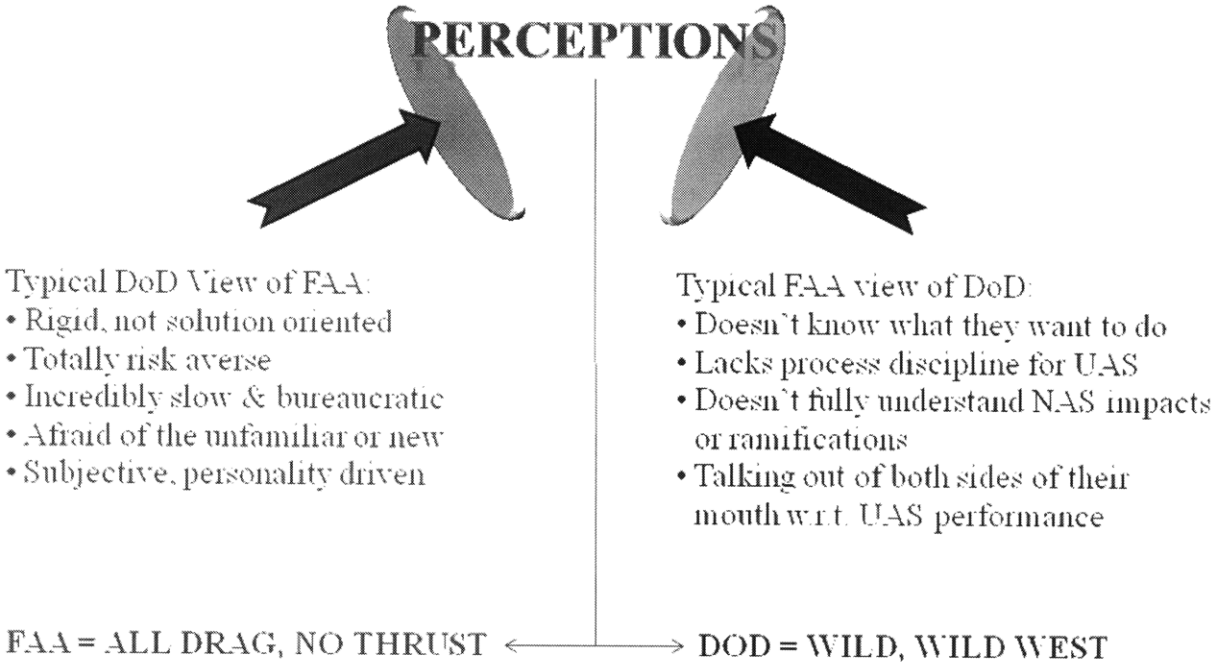


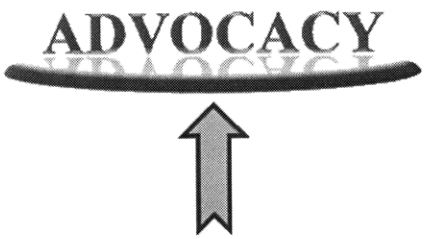
Figure 8-6. Differing Enterprise Perspectives on Other Stakeholders.

Fortunately, all is not doom and gloom with respect to the inter-relationships or the degree of alignment between stakeholders in the enterprise. There are a number of very important elements with general enterprise-wide consensus. The first of these is the issue of advocacy. All of the stakeholders unanimously agreed that senior leadership-level advocacy for the effort was both paramount though lacking, as was a single, coordinating office "in charge" of making the effort a success. Figure 8-7 details the additional perspectives voiced on this need for a collective "stepping up to the plate."

The biggest difficulty with this issue is how to generate an architecture that will facilitate the growth of this kind of support. Without a "burning platform" for change, accomplishing the major paradigm shifts needed for the appropriate policy and procedural changes, let alone the backing to resource the materiel development aspects of the problem, will be incredibly difficult if there is not significant senior leadership support for the effort across all of the stakeholder organizations in the enterprise.

To illustrate the magnitude of this hurdle, consider the example of the Traffic Alert and Collision and Avoidance System (TCAS), used widely in manned aviation to help prevent collisions, which according to the GAO was developed "…over a 13-year period, at a cost of more than

$500 million…FAA officials believe that an acceptable detect, sense, and avoid system for UASs could cost up to $2 billion to complete and is still many years away." [94] In addition to the shear enormity of the financial investment required, there is the even larger issue of cultural and organizational lock-in that must also be addressed. The TCAS effort was not only a huge cost, but it required an act of Congress before the issue was taken up by the relevant parties. By all accounts, the UAS airspace integration effort is at least an order of magnitude more difficult problem to solve. All of the organizations involved in the current efforts agree that without strong advocacy across all of the key organizations, the degree of engagement will not be adequate for the task at hand.

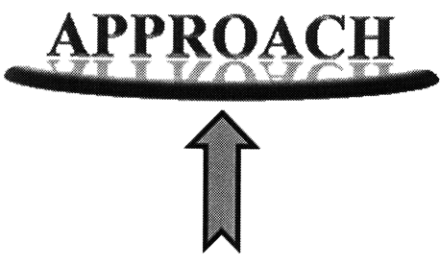


Consensus on:

- Need senior leadership to actively engage on the issue
- Need a single, consolidated focal point to lead effort
- Only need leadership to temporarily overcome obstacles and get solutions put in place
- Need a "stepping up to the plate," a collective will to find a solution, a desire to see UAS integration succeed as soon as possible

Figure 8-7. Enterprise Perspective on the Need for Advocacy.

The next issue with strong consensus is how the challenge should be approached. In this case, there is a positive consensus on the kinds of things that need to be worked and how they need to be approached. Figure 8-8 details these points of alignment within the enterprise.



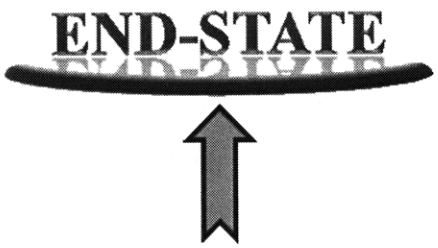
Consensus on:

- Bound the problem using a local case, collect data over time, and use data/experience to build a solid safety case
- Must accommodate limited resources to work the issue
- Policy, procedure, and materiel elements must be addressed concurrently and coherently
- Significant technology issues (e.g. SAA, spectrum, C2) need to be worked for appropriate equipage performance
- Must be done in a full DoD/FAA collaborative partnership

Figure 8-8. Enterprise Perspective on Approach.

The enterprise architecting effort should be able to use these points of agreement on what needs to be tackled at almost a product-level to build an initial core set of activities that will deliver these products while resolving the previously outlined tensions and filling the advocacy vacuum.

The final area of consensus for consideration is that of the enterprise "end-state." Besides the agreement on the approach to the problem, this area of agreement is perhaps the most critical to the prospect of arriving at a successful architecture since it suggests that despite the differences in many areas, there is at least a shared perspective on what a final future state might look like. Figure 8-9 provides characteristics that were typical across every decision maker interviewed. This convergence in perspective on the end-state provides the most concrete basis for building a broader level of consensus on the precise approach, goals, and objectives the enterprise will need to articulate before it will be possible to make good on the enterprise mission statement.



Looks like:
- UAS mission has full advantage of principle of maneuver
- Integrated operations with manned aircraft
- Transparent to Air Traffic Control
- Mirrors manned aircraft for flight planning and approvals
- Safety track record is equal to or better than manned
- UAS ops are routine, everyday and common occurrences

Figure 8-9. Enterprise Perspective on the End-State.

These points of tension and consensus provide the basis on which the enterprise architect will conduct the analysis described in Chapters 9-11 of this thesis. Note that the elicitation of the data, and the enterprise purpose and stakeholder analysis conducted as the first two steps in the value identification phase, are woven together tightly with this chapter. Both provided bounding elements on who needed to interviewed, what the scope of the questionnaire should be, and how the overall effort should be framed and presented.

The advantage of providing all of the data collection and analysis results upfront and together in a single chapter is the common basis the reader should now have for understanding the enterprise architecting decisions that are described in Chapter 9. It should also be apparent that the analysis in this chapter has only begun to unravel the myriad of issues surrounding the complex stakeholder and inter-organizational issues associated with this problem. Harkening back to Chapter 4 and the necessarily iterative nature of the methodology employed in the approach, this data collection and analysis effort should only be considered a "first pass" through the problem, not a final solution to the challenge.

Chapter 8 Summary

The data collection and analysis effort provides the basis on which to establish the enterprise value structure. An iterative process between identifying the enterprise purpose and decision

makers results in a list of organizations and individuals from which to solicit the appropriate value structure definitions. Understanding and assessing the degree of interview data saturation by the current interviewees provides the basis on which to judge the completeness of the data collected. Once the data collection effort is deemed complete, thorough analysis of the information should provide the depth of understanding needed to build an enterprise-wide value structure sufficiently robust to provide the tradespace for the building and evaluation of alternative value propositions using enterprise architecting tools.

CHAPTER 9 – UAS VALUE-CREATION ANALYSIS

"The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man."

— George Bernard Shaw

In the process of conducting the analysis that follows, the architect will find a certain degree of tension must be maintained between providing what each decision maker will likely see as their optimum "local" solution and what will actually create the overall best "global" result from a value flow standpoint in the enterprise. It is in this sense the architect may need to be "unreasonable" in persisting in their efforts to adapt the enterprise decision makers to a different way of looking at the problem.

Clearly in cases like the UAS AI effort a "business as usual" mentality for dealing with the complex issues identified in the previous chapter will not adequately resolve the value misalignments between the decision makers needed to flow value through the enterprise. Chapter 9 begins the process of translating the theory of Section II into practical application for addressing the UAS airspace integration challenge.

For the sake of clarity in presentation, the source of information for the remainder of the chapter is the interview data described in Chapter 8, unless specifically annotated otherwise. Citing the specific interview in which the data under discussion was collected will be done to the extent that it clarifies the issues, but specific citations will not be included. Refer to Appendix F should additional detail be desired beyond what is presented in the main body of this analysis.

UAS AI Enterprise Intent and Purpose Statement

In one sense, the argument could be made that the very act of calling out the enterprise activity as "airspace integration" presupposes a solution to a more fundamental problem identified in the interview data, namely the need to train and operate UAS to the satisfaction of the military services and combatant commander deploying the capability in the battlespace. The need to train and operate UAS is the underlying value the enterprise should be focused on delivering. Putting the context into the airspace integration arena brings in the additional need to satisfy the FAA's safety and capacity requirements in the pursuit of those training and operational needs.

Applying the enterprise purpose statement methodology, an analysis of the existing JIPT mission statement was conducted. The result is depicted in Figure 9-1. Notice that in this instance, the JIPT mission statement needs further clarification before it will pass tests of both completeness and attainability.

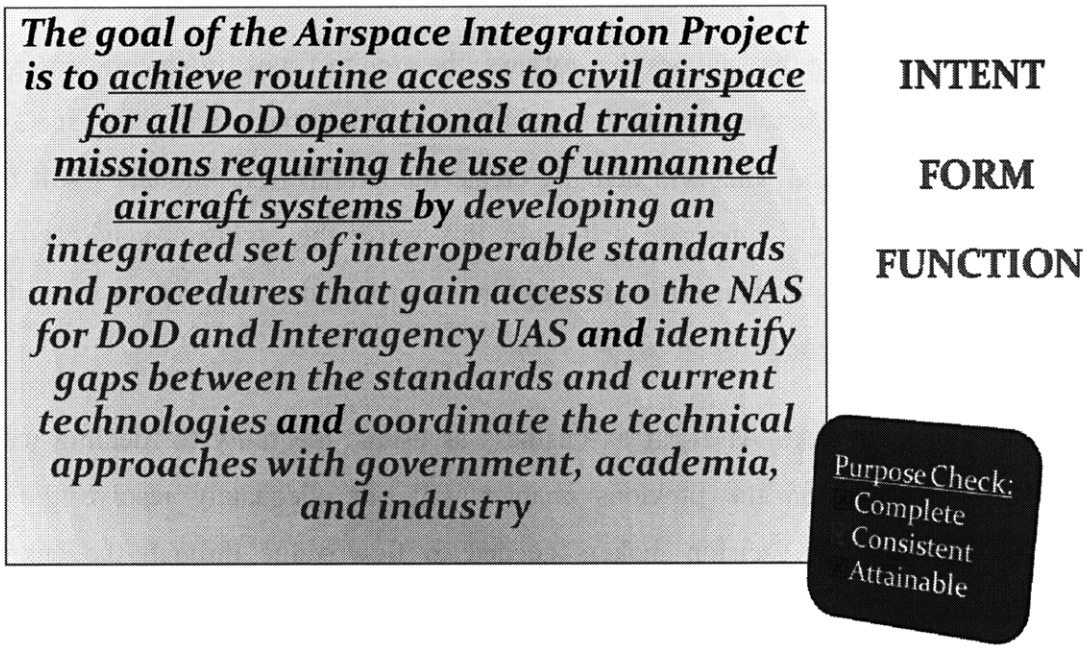


Figure 9-1. JIPT Mission Statement Analysis.

In particular, the JIPT mission statement needs to explicitly include the critical constraints on how the above intent is to be implemented. There is also a convolving of formal and functional elements together resulting in some ambiguity about what functions need to be performed as opposed to the form they will take in order to deliver that functionality.

The ambiguity in the current problem is apparent in a number of places in the interview data. The most telling was the observation from the FAA that they do not have any clear understanding of what DoD really wants to do in this area or how they want to move forward. There is also some uncertainty within the JIPT activity base on what is required within the functions of developing standards, identifying gaps and coordinating technical approaches. With no clear specifications of the constraints on the problem, these are open ended questions with no clear answers.

Perhaps more fundamental than even these disconnects is the sense from the interview data that not all of the enterprise stakeholders would even agree that the JIPT statement of intent is correct. In this case, the idea of routine access stems directly from the belief that this is required in order to achieve the desired training and operational missions. This is understandable. Unfortunately, as subtle as this distinction is, it has tremendous implications for the way the enterprise orients the structure and content of the activities it undertakes. In this case, transposing "routine operations" for "conduct training and operational missions" interjects a different value definition than the one elicited during the interview process conducted for this research. In fact, nowhere in the interview data from ACC does the idea of routine access come up in the underlying value delivery definition. Routine access does come up in the description of attributes some decision makers might use to assess value delivery, but this switch between the primary value definition (training and operational mission accomplishment) and an attribute describing the level of delivery (routine operations) is a distinction that must be preserved as the UAS AI enterprise purpose is further defined.

To address these shortfalls and ensure an UAS AI enterprise purpose statement that is appropriately defined and rigorous in its interpretation of decision maker value definitions, a clean sheet assessment was conducted using the interview data and the methodology developed in Chapter 4. Figure 9-2 illustrates the initial UAS AI enterprise purpose context analysis and how it fits in the broader military operational space, as well as the lower level of detail within the enterprise boundary (the 1 up, 1 down approach).

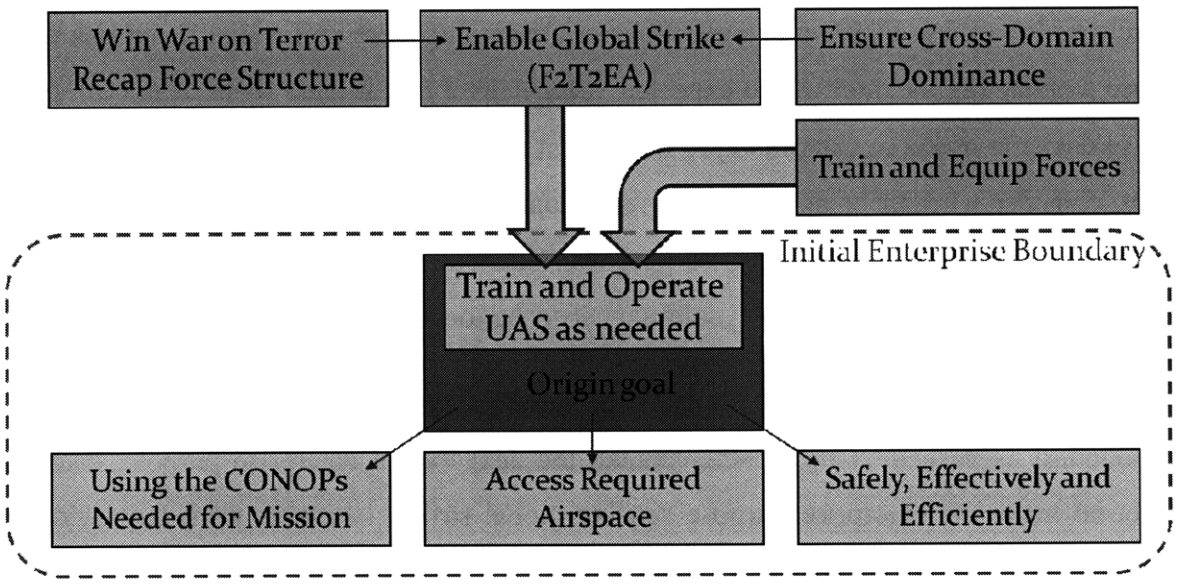


Figure 9-2. Initial UAS Enterprise Purpose Context Analysis.

Several observations are worth mentioning at this point. First, as expected, the value definition of train and operate occurs at the center (or origin) of the UAS AI enterprise. This need is the fundamental driver without which the activity would not occur. An analysis of the broader context reveals that the need to train and operate stems from the broader mission requirement the UAS supports which is to enable the Global Strike Concept of Operations, and in particular the Find, Fix, Track, Target, Execute, Assess (F2T2EA) mission thread. The initial "1 up" assessment in the context suggests good alignment between these two layers. This higher level context in which the UAS AI enterprise operates within will be referred to as the Global Strike Task Force (GSTF) extended enterprise.

The "1 down" assessment, however, reveals an important issue the architect must address before moving forward. The three primary internal functions for enabling the "train and operate as needed" origin goal are "using the CONOPs Needed for Mission", "Access Required Airspace", and "Safely, Effectively, and Efficiently" conduct the needed training and operational missions. An assessment of the completeness of this arrangement reveals a critical shortfall in the decomposition, principally the fact that "train and operate as needed" captures the first functional requirement quite well, but it doesn't speak to the second two functions in any direct sense.

This is an important element to get a hold of because these internal enterprise functions represent either constraints or additional value definition requirements on the enterprise "origin" purpose statement. The implication is that if the "origin" enterprise purpose statement does not adequately address these other value definitions or constraints there will a significant risk of the enterprise activity falling short of the expected value delivery to at least some, if not all, of the enterprise decision makers. Continuing to implement the methodology from Chapter 4, the next step is to consider whether or not the enterprise boundary should be expanded or contracted in order to assure a representative enterprise purpose statement. Given the above assessment, the current enterprise purpose statement would appear to be too narrowly stated, and the boundary should be expanded.

If the boundary is pushed "1 up" in the context, the next logical enterprise purpose statement would be to make the enterprise purpose "enable global strike" based on what is provided in

Figure 9-2. While this approach would be consistent with the practice of moving the boundary out, it misses the purpose which is to increase the available enterprise tradespace to include all of the necessary enterprise decision makers and their values or constraints. Unfortunately, a simple move "1 up" to "enable global strike" as the enterprise purpose statement does not resolve the representation issue. "Enable global strike" still suffers from the same lack of addressing both the "Access to Airspace" and the "Safely, Effectively, and Efficiently" functions.

To sort through how the dimensions of the enterprise purpose statement should be changed to accommodate all three of the lower level enterprise functions, the interview data was re-examined in a different light. One particular characterization of the problem from one decision maker suggested that there was in fact a more fundamental need beyond the desire to train and operate UAS. This more fundamental need is "restoring the principle of maneuver" to UAS platforms—independent of the context in which they are operating.

This observation seemed to be moving in the right direction with respect to what is needed for the enterprise purpose statement. Note that the word "seemed" is used. This is where the architect's job takes on a decidedly "art" flavor and creativity must be exercised to find ways of generating a resolution to the identified issue. In this case, the intuition behind "restoring the principle of maneuver" appeared to be a good place to start. This brings to the forefront the fact that there are aspects to the architecting business that are fundamentally creative, and while a framework can be implemented to assist in this endeavor, there are elements that are fundamentally tied to the architect's intuition, perception, and creativity. While there are a number of tools that may assist in some of these endeavors, it boils down in the end to the architect's underlying talents and abilities.

In the case of trying to understand how the idea of "maneuverability" might tie into both the DoD and FAA context, basic research was done to understand the meaning this term had in each culture. To be clear about what is meant by the principle of maneuver in the DoD context, Joint Publication 3-0, Joint Operations, provides a military context definition that will be used as the basis for understanding the principle as initially used by the interviewee. [95] Joint Pub 3-0 defines the principle of maneuver as follows:

a. The purpose of maneuver is to place the enemy in a position of disadvantage through the flexible application of combat power.

b. Maneuver is the movement of forces in relation to the enemy to secure or retain positional advantage, usually in order to deliver — or threaten delivery of — the direct and indirect fires of the maneuvering force. Effective maneuver keeps the enemy off balance and thus also protects the friendly force. It contributes materially in exploiting successes, preserving freedom of action, and reducing vulnerability by continually posing new problems for the enemy.

As one interviewee points out:

"Doctrine writers are operationally-focused and often take ISR for granted. Considering current roles for UAS, the grounds for a broader view are inherent. So the ability to publish orders for fires is based on intelligence for informed maneuver; therefore, freedom of maneuver for ISR platforms to inform the commander and make decisions for the maneuvering force presupposes the same need for maneuver by ISR forces as well. In short, it is not really just about 'fires.'"

This represents the fundamental linkage between maneuver for fires and freedom of navigation for ISR platforms such as UAS.

Further clarification is provided by Air Force Doctrine Document (AFDD) 1, in which the principle of maneuver is further refined to specifically address the aspect of maneuver with respect to air power operations, of which UAS are a contributing capability. [96] AFDD-1 expands on the principle of maneuver as follows:

"Maneuver **places the enemy in a position of disadvantage** through the flexible application of combat power in a multidimensional combat space. Air and space power's ability to conduct maneuver is not only a product of its speed and range, but also flows from its flexibility and versatility during the planning and execution of operations. Maneuver, like the principle of offensive, forces the enemy to react, allowing the exploitation of successful friendly operations and reducing friendly vulnerabilities. The ability to quickly integrate a force and to strike directly at an adversary's strategic or

> operational centers of gravity is a key theme of air and space power's maneuver advantage. Air maneuver allows engagement anywhere, from any direction, at any time, forcing the adversary to be on guard everywhere."

In the broader sense, the American Heritage Dictionary defines maneuver as "*A controlled change in movement or direction of a moving vehicle or vessel, as in the flight path of an aircraft.*" [97] In this sense, the use of maneuver in a civil airspace context is an exact analog to that of the military context. The sense of the word, the implication of the functional definition, and the intent in enabling maneuver for an UAS is consistent across both the military and civil sectors. The biggest difference is with respect to the object against which the UAS is being maneuvered. In the military context, the frame of reference is the "enemy." In the FAA context, the frame of reference is other aircraft in the airspace, or in the context of ground operations, physical obstructions in the path of the UAS.

The results from this investigation seemed positive in that using the idea of "maneuver" appears to provide a common perspective from which to view the enterprise. The question resulting from this approach is how this translates into a common metric for both sets of decision makers. To generate additional insight into this, Figure 9-3 provides a way to better visualize how maneuver looks in both the military and civil airspace contexts. Note that the common axis between the two contexts is "Safety" while the second axis for military context airspace is "Capability" and the secondary axis for civil airspace is "Capacity."

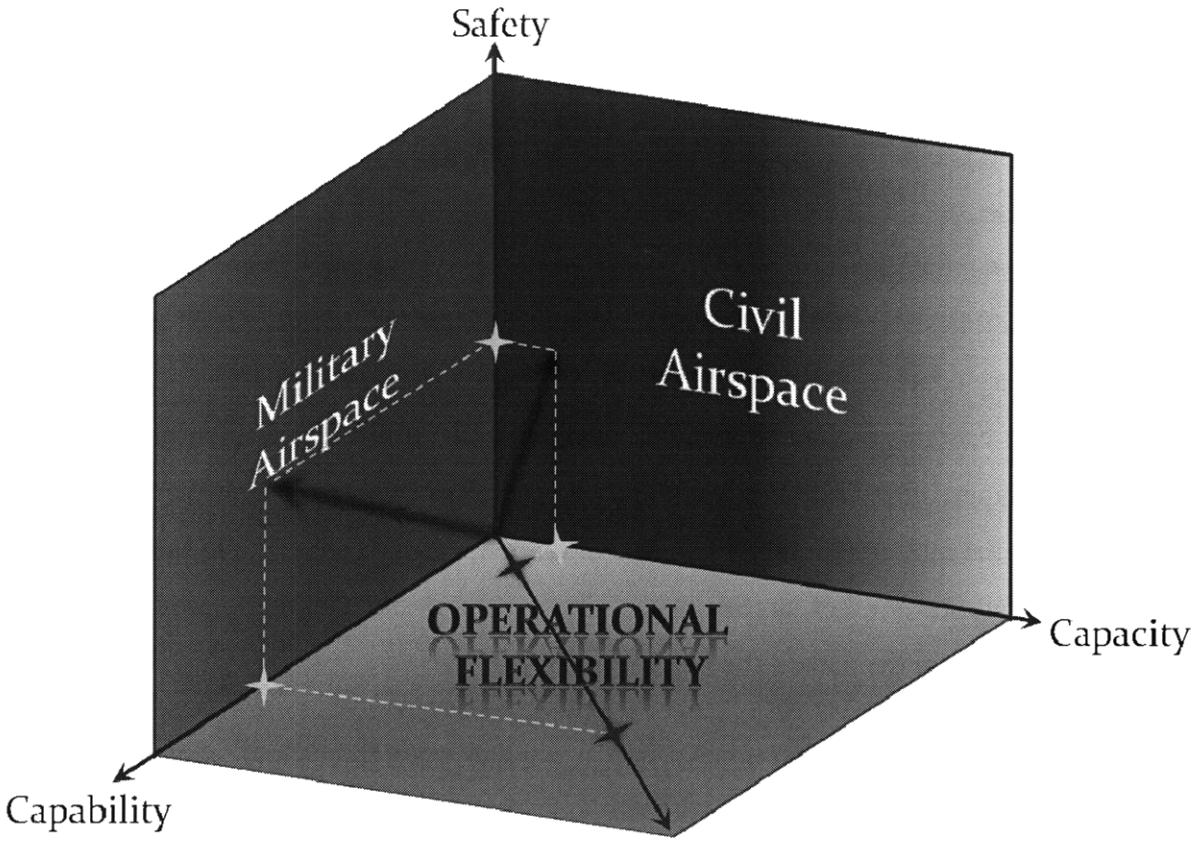


Figure 9-3. Understanding Impact of Maneuver on Enterprise Context.

The validity of the model should be judged by the extent to which it captures and explains the interview data. By using the "Safety – Capability" space to describe the military airspace context, nearly all of the cultural and organizational perspectives from the DoD decision makers can be addressed. The FAA interview data appears to fit equally well with the "Safety – Capacity" dimensions for the civil airspace. The question that remains is how to characterize the interaction of these two contexts if they are "swung" together to meet in the middle. This is, after all, the objective of the exercise. The enterprise purpose statement needs to result in some lower level attribute that both groups of decision makers can hold in common. The idea that both the military context and the civil context dimensions could be used to assess the operational flexibility of the UAS came to the forefront. This is represented in Figure 9-3 as the diagonal line running through the bottom plane labeled "Operational Flexibility."

The operational attribute of flexibility that is enabled by maneuver will be the common "ility" used to assess the degree of maneuver delivered to the enterprise (as Figure 9-3 illustrates). The

use of "flexibility" as a measure for maneuver has the advantage of having a robust theoretical and literature base against which to establish the appropriate metrics and architectural principles within the broader engineering and social sciences fields. It is also a basic tenet of air power theory. Air Force Doctrine Document 1 defines flexibility as follows:

> **Flexibility** allows air and space forces to exploit mass and maneuver simultaneously. Flexibility allows air and space operations to shift from one campaign objective to another, quickly and decisively; to "go downtown" on one sortie, then hit fielded enemy forces the next; to rerole assets quickly from a preplanned mission to support an unanticipated need for close air support of friendly troops in contact with enemy forces. [96]

The American Heritage Dictionary defines the word as follows:

> **flex·i·ble**
> 1.a. Capable of being bent or flexed; pliable.
> 1.b Capable of being bent repeatedly without injury or damage.
> 2. Susceptible to influence or persuasion; tractable.
> 3. Responsive to change; adaptable: a flexible schedule.

Note that in both cases, the same fundamental characteristics are inherent, primarily the concept of being able to adapt and being responsive to change. Thus, flexibility provides a basis across the enterprise for a common way to measure the extent to which the enterprise is delivering value that all stakeholders can hold in common.

The enterprise intent can now be described in more concrete terms as UAS operations that occur at the desired level of maneuverability as measured by the delivered flexibility (from both the DoD and the FAA perspective) to provide the needed mission capability (whether training or operational), with the appropriate level of safety and with acceptable capacity impacts to the NAS. Returning to the contextual analysis that started this line of investigation, the ability to "Restore the Principle of Maneuver" is now show in Figure 9-4 as the overarching basis upon which both the initial enterprise origin purpose of "train and operate UAS as needed" and "Enable Global Strike" are designed to enable.

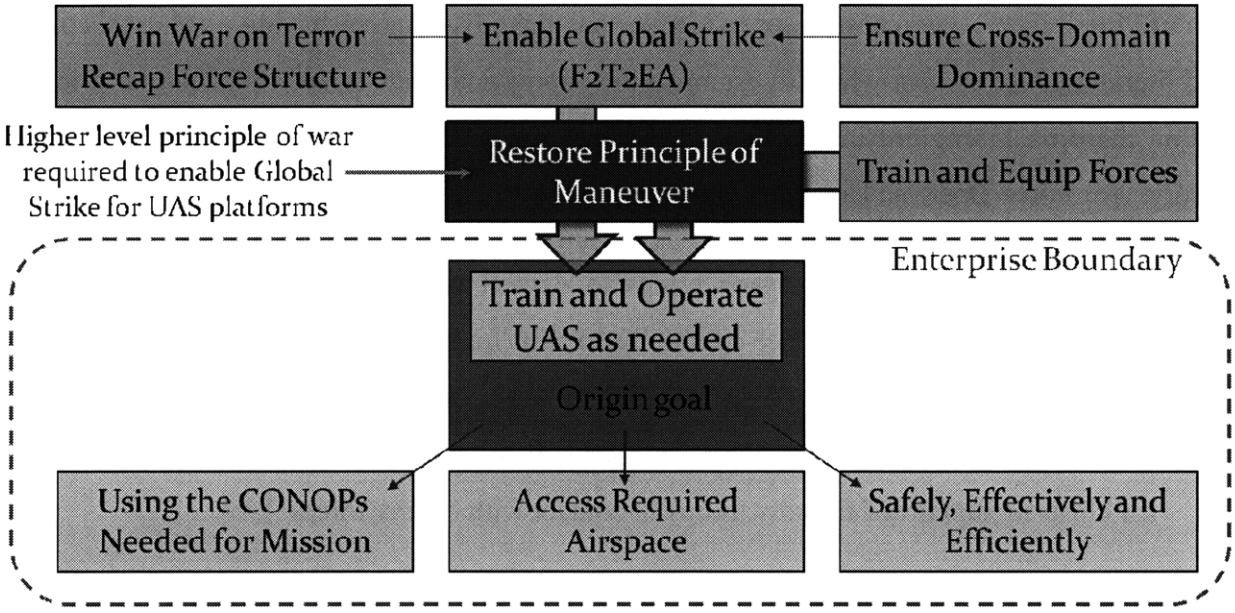


Figure 9-4. Iterated Enterprise Purpose Context Framework.

The analysis suggests that using "Restore Principle of Maneuver" works for the "1 up" context. What about the "1 down" situation since this is where the original "train and operate UAS as needed" fell apart in the initial analysis? In this case, "Restore Principle of Maneuver" works in all three of the needed sub-functions. It enables the CONOPs, provides the means of gaining access to the airspace, and it is the basis on which the UAS can avoid other aircraft or the ground and thus maintain safety in flight. The final enterprise context analysis is depicted in Figure 9-5. Notice that in this instance the decision is made to hang onto the primary value terms used by the interviewees by using them as a constraint on the extent to which the principle of maneuver would need to be delivered in order for the enterprise to find value in the approach.

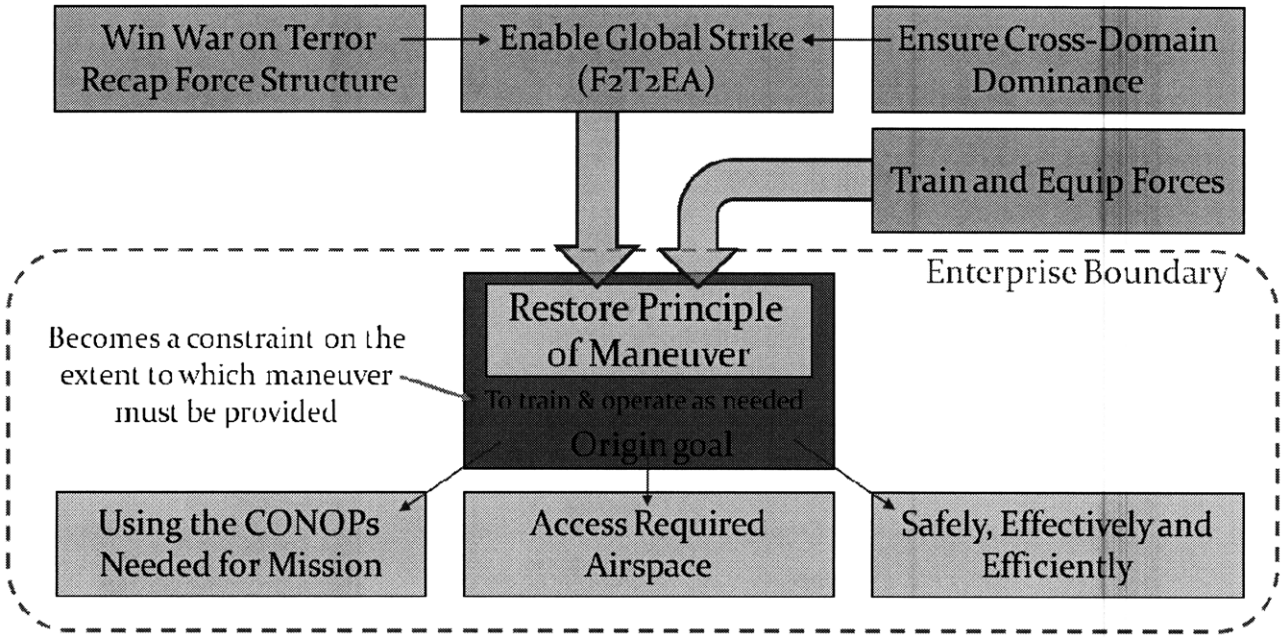


Figure 9-5. Final UAS Enterprise Purpose Context Framework.

The revised UAS AI enterprise purpose statement can now be provided, and it is shown with the checks for completeness, consistency, and attainability in Figure 9-6. Note that the new enterprise purpose statement has the entire set of intent, function, form, and constraints detailed. Technically, the function and form should be the result of a first pass at the enterprise architecture, but for simplicity in presenting the information in a logical progression, the entire enterprise purpose statement is provided. The development of specific components of the Enterprise Purpose Statement result as the enterprise architecting effort continues into the next phase.

Notice, however, what the impact is to the sense of the size of the tradespace that may be available for moving the effort forward under the new enterprise purpose statement vice the previous one that was targeted at "routine access". By pushing at the original enterprise purpose statement from different directions, the insights gleaned from looking at the data differently and discussing the research with other's in the field provided the additional depth in the scope of the analysis needed to attack the problem from a more fundamental level.

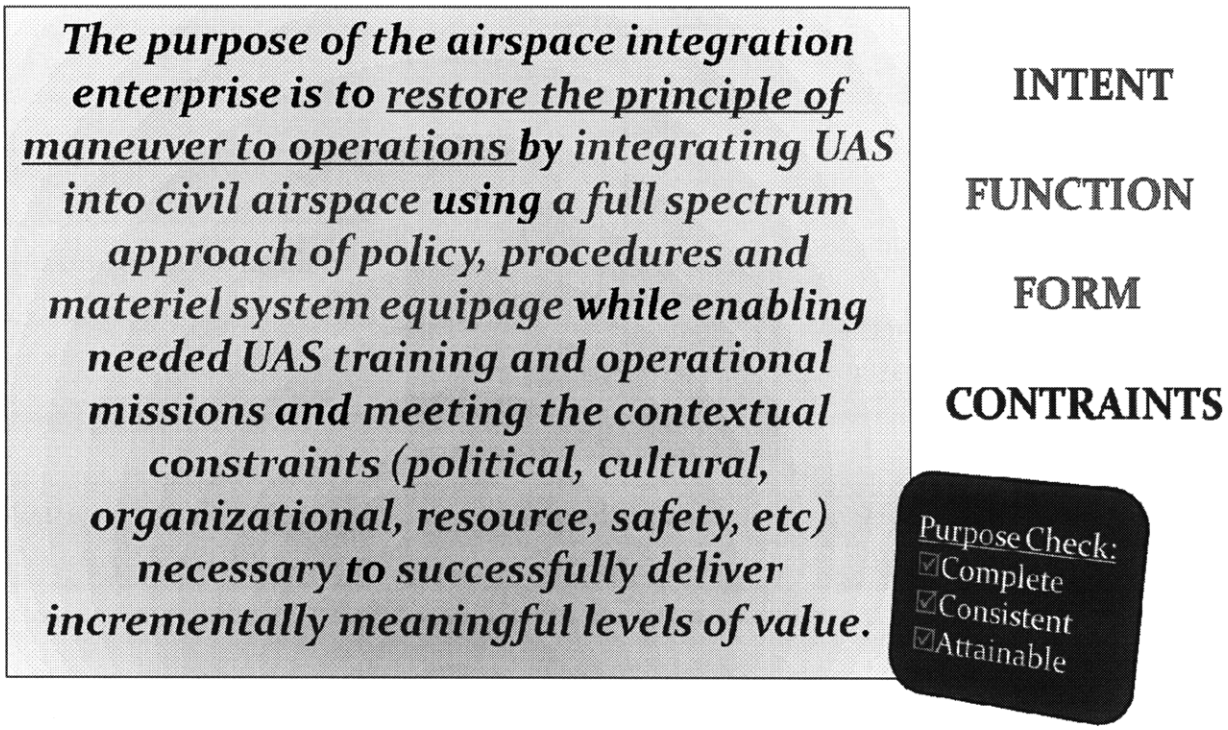


Figure 9-6. Final UAS Airspace Integration Enterprise Purpose Statement.

Also note the major enterprise constraints on how the value definition is to be delivered are included in this definition within the "constraints" aspect of the problem. This helps in resolving ambiguity and better defining the expectations of all concerned. Just this level of analysis and the ensuing results in the enterprise purpose statement will lead to a significant change in the focus and orientation of the UAS AI enterprise.

Again, it is worth pointing out that the entire enterprise purpose statement provided in Figure 9-6 is the result of several iterations between the enterprise purpose statement, the stakeholder analysis, the interview data, and ultimately the enterprise architecture selected as the best approach to delivering enterprise value. The iterations between the enterprise purpose statement, the stakeholder analysis, and the interview data provide the intent, function, and constraints in the final purpose statement. The form cannot legitimately be determined until after the enterprise architecting exercise is complete and the final architecture selected. As a preview, the final architecture selected for the value proposition set the policy requirements to be addressed explicitly, the process element centers the enterprise with the product view providing the basis for forward progress.

UAS AI Enterprise Stakeholder Analysis

With the UAS AI enterprise purpose taking form, an initial set of enterprise stakeholders can be established. The advantage of having extensive domain knowledge proved to be extremely beneficial at this stage of the investigation. Armed with previous experience and knowledge concerning which organizations were involved and the role they played in the airspace integration activity, it was possible to go through the stakeholder identification effort in a single pass rather than having to iterate as additional stakeholders were identified. This initial pass was then validated by a blind interview question posed to each stakeholder to ensure there were no additional stakeholders beyond the list. In fact, there were no additional stakeholders identified through the interview process, and the stakeholder identification activity was deemed complete. The effect was to significantly truncate the stakeholder identification process depicted in Figure 4-6 by only having to loop through the indicated process once.

The results of the stakeholder identification and saliency analysis are provided in Table 9-1. Notice that even the initial list of 34 organizations identified through the interview process is significantly smaller than the total number listed by the RTCA in Appendix B. The question that now presents itself is knowing where to draw the line for who will be considered as the key stakeholders, or as Ross puts it, the decision makers of the enterprise. [9] Recall from Chapter 4, the Grossi model provides an initial sorting and preliminary ranking for a large number of stakeholders. Once the initial list of stakeholders is assembled using the Grossi methodology, the model developed by Ross to characterize enterprise decision makers is used to further pair the list down to just those organizations that are central to the enterprise decision making cycle.

Stakeholder	Criticality Factor	Power Factor	Legitmacy Factor	Salience Index
ACC/A8	10	9	10	93
FAA AIR-160	10	9	10	93
ACC/A3	10	8	10	87
FAA AJR-36	10	8	10	87
303 AESW	8	6	10	63
SAF/AQI	8	6	10	63
OSD(AT&L)	8	4	8	43
PBFA	5	5	10	42
FAA AFS	6	6	6	36
AFRL	6	3	10	36
HAF/A2	4	6	8	35
HAF/A3	4	6	8	35
Joint Staff J-3/J-8	4	5	8	31
ESC NextGen Office	4	5	7	28
Coast Guard	5	3	8	26
AF UAS Task Force	5	3	8	26
FAA ATO/E	3	5	8	26
FAA ATO/S	3	5	8	26
FAA ATO/T	3	5	8	26
NASA	5	3	8	26
CBP	5	5	5	25
Congress	1	10	5	22
Frequency Spectrum Management Office	3	5	5	18
HAF/A8	2	5	6	17
ASC/XR	4	2	6	15
ICAO	8	2	2	12
ALPA	7	0	5	12
ACC/A5	4	2	2	7
AOPA	4	0	5	7
OSD(NII)	2	2	3	5
Forrest Service	5	0	3	5
NTSB	3	0	5	5
HAF/A5	2	2	2	4
ASTM	2	0	4	3

Table 9-1. UAS Enterprise Stakeholder's and Saliency Ratings.

Further assessment of the saliency index provides for a relatively straightforward way to categorize the relative importance of each stakeholder. The results demonstrate a distinctive grouping of the stakeholders with a clear demarcation of the definitive stakeholders for the enterprise being comprised of the following organizations: ACC/A8, FAA AIR-160, ACC/A3, FAA AJR-36, 303 AESW, SAF/AQIJ, USD(AT&L), and the PBFA. These in turn can be mapped to the Ross stakeholder taxonomy with the following assignments:

Level 0 Organization: USD(AT&L)

Level 1 Firm Organizations: SAF/AQIJ and PBFA

Level 1 Customer Organizations: ACC/A8 and AIR-160

Level 2 Design Organization: 303 AESW

Level 2 User Organization: ACC/A3 and AJR-36

Figure 9-7 illustrates the entire end-to-end stakeholder analysis methodology as applied to the UAS AI enterprise. For the purposes of this analysis, the above list of decision makers within the Ross framework will be used moving forward in the assessment. The fundamental assumption given the scope laid out in Chapter 2 (i.e. MQ-1, MQ-9, and RQ-4) is that if these eight organizations believe value is being provided to them by enterprise activity, a sustainable solution can be implemented for the UAS AI challenge.

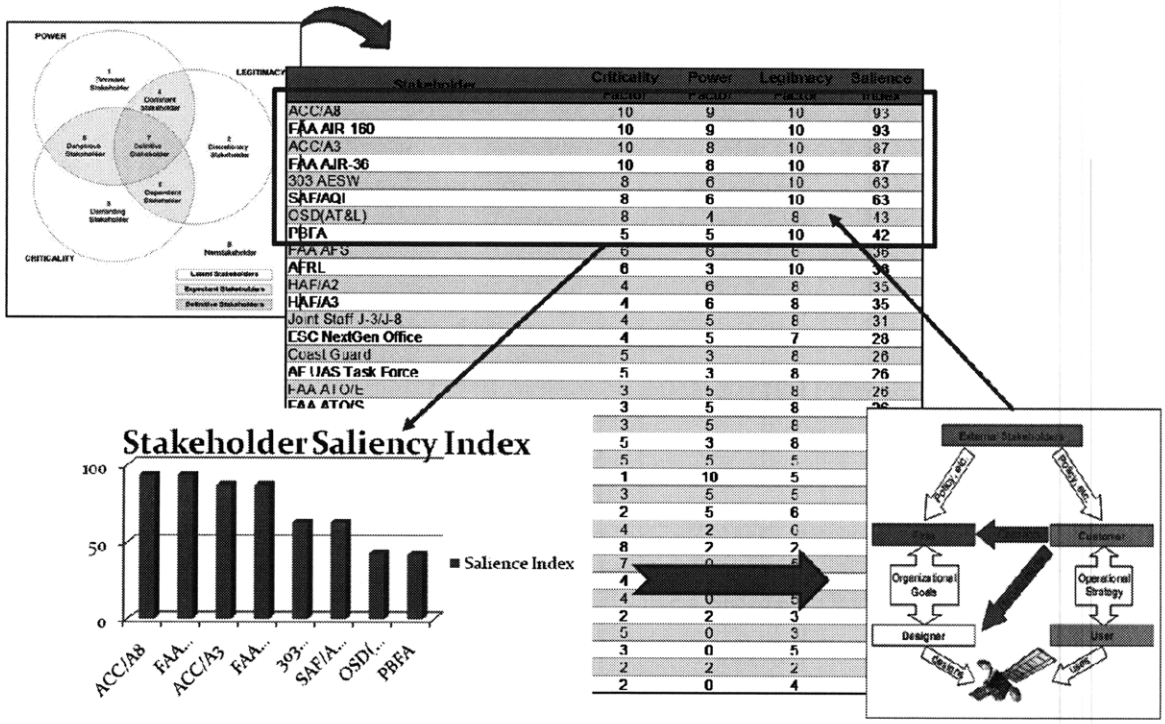


Figure 9-7. Stakeholder to Decision Maker Process.

The UAS AI enterprise decision maker set is now defined. In conjunction with the enterprise purpose statement and the wealth of information collected from the interviews, the basis for establishing the enterprise value structure is secured.

UAS AI JIPT Value Structure and Alignment

Initial Value Structure Assessment

Based on the information in the previous chapter and the analysis conducted to date on the UAS AI enterprise purpose statement and decision makers, an X-matrix was constructed depicting the value structure of the enterprise. Figure 9-8 represents a first pass through the value structure. Emphasis is on the fact that this is just a first pass. Until the results of the analysis are validated by the enterprise decision makers, the representativeness of the value structure depicted in Figure 9-8 cannot be stated with total confidence.

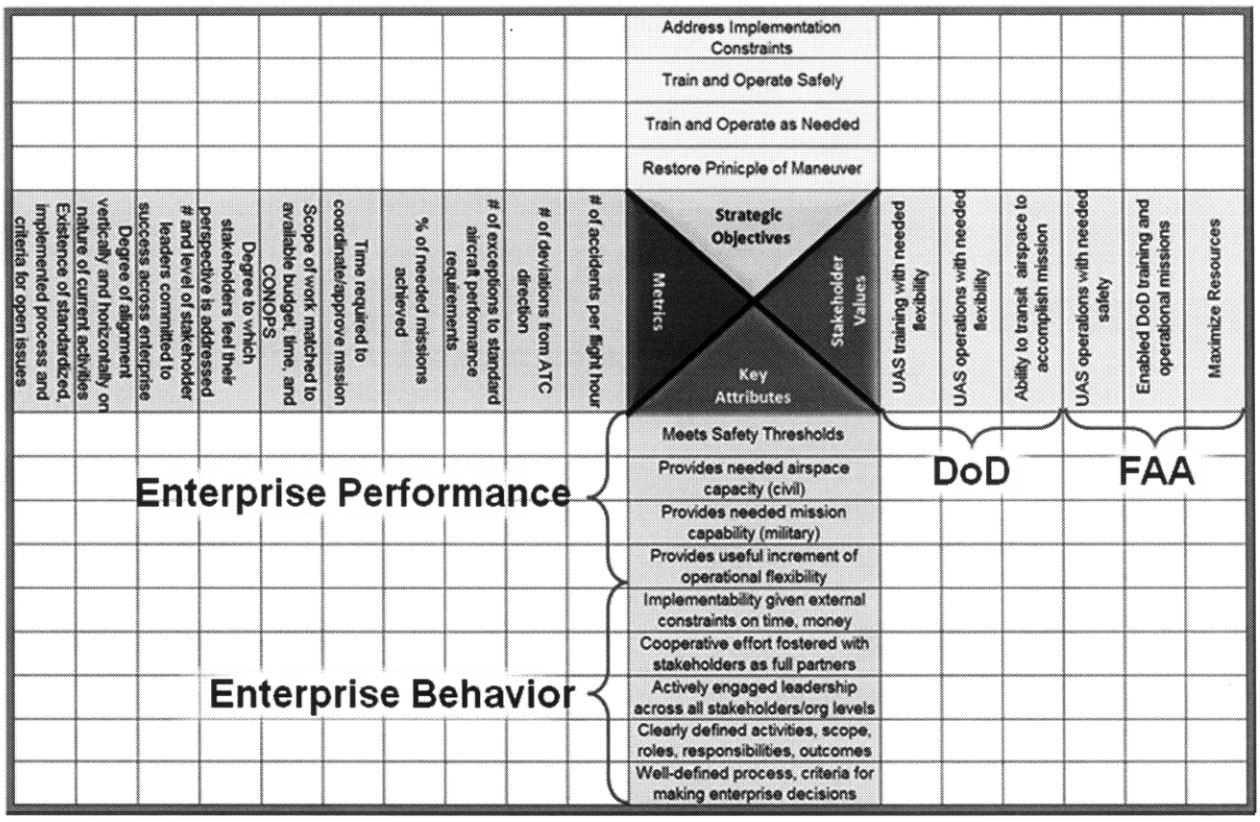


Figure 9-8. UAS Enterprise Value Structure Depicted in an X-matrix.

Before proceeding with the actual assessment, two points are worth making. First, the stakeholder value axis is comprised of two major groupings. The first three values represent

those that DoD organizations articulated over the course of the interviews. The second set are values derived from the FAA responses. Second, the key attributes also divide into two subcategories. The first set of attributes (4) represent those specific to the desired outcomes of enterprise activities, labeled as "Enterprise Performance" attributes. The other attributes (5) represent those attributes that specifically address the strong path dependent nature of arriving at the enterprise performance attributes. These attributes provide the insight on 'how' the enterprise performance attributes are delivered.

More on Enterprise Metrics

Given the importance metrics play in driving enterprise behavior, it is important to delve deeper into the rationale for why the above metrics were chosen the way they were. The first four key attributes are enterprise output specific as previously described: safety, capacity, capability, and flexibility. The key safety metrics include the number of accidents per flight hour (lagging indicator) and the number of deviations from ATC direction (leading indicator). Capacity is measured primarily in terms of the number of exceptions to standard aircraft performance requirements that have to be made in order for the UAS to fly through civil airspace, and capability is measured primarily by the percentage of needed missions that are actually flown. Flexibility gets aggregated into a measurement of the time required to coordinate or approve a mission, since this metric is of equal interest and valid to both the military context and the FAA context.

The enterprise behavior metrics, of which there are five, are intended to drive the enterprise behavior in very specific ways to address major shortfalls, barriers, or characteristics that came out of the data collection effort as consistent themes across the entire enterprise decision maker community. The intent is to ensure the enterprise executes on the delivery of the primary value mechanism of maneuver in a way that is implementable within the external constraints on budget and schedule, is cooperative amongst the enterprise stakeholders, actively engages leadership, clearly defines activities and roles, and establishes solid processes and criteria for arriving at consensus on enterprise decisions.

The corresponding metrics to these key enterprise behavior characteristics are, respectively, an assessment of the scope of the enterprise activity to the available budget, time, and CONOPs; the

degree to which stakeholders feel their perspective is being addressed by the enterprise; the number and level of stakeholder leaders committed to success across the enterprise activity; the degree of horizontal and vertical alignment in enterprise activities; and the existence of standardized, implemented processes and criteria to resolve open issues.

COA Value Structure Assessment

With the understanding that this analysis only attempts to make an initial first pass through the value-creation chain, and that the results require further iteration with the UAS AI decision makers, an assessment of the current JIPT effort is provided as a means of understanding how the emphasis and effort should be assessed. Figure 9-9 provides the results of this analysis.

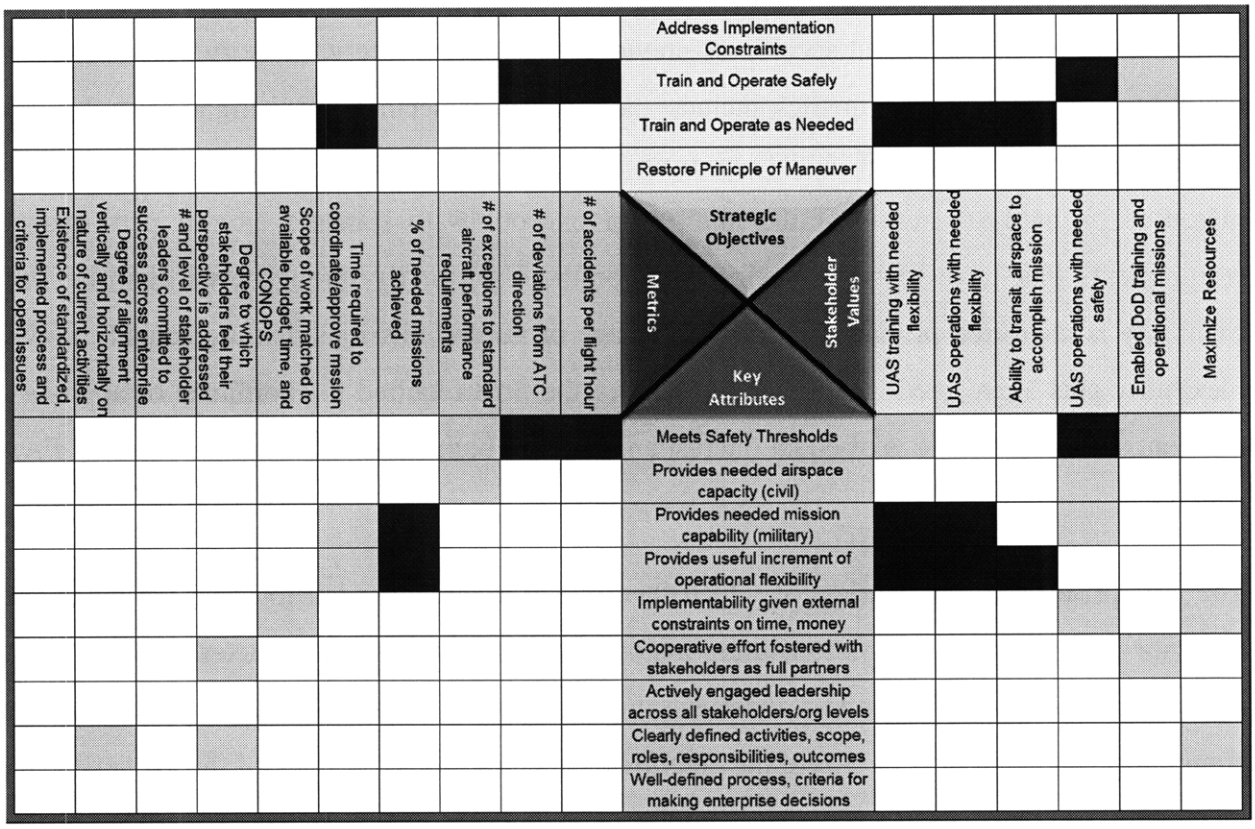


Figure 9-9. X-matrix Assessment of COAs using Redefined Purpose and Stakeholders.

Note that the existing COA activity only provides a strong degree of correlation across the enterprise value structure in the "Train and Operate Safely" strategic objective. The next best alignment is a weak correlation in the value structure with "Train and Operate as Needed." This assessment is based on the data from interviews with both ACC and the FAA, specifically, the

inputs received on the extent to which the existing COA process was delivering value. The supporting rationale follows.

COA Value Delivery Assessment from ACC/A3 and AJR-36

Recall from the previous chapter that discussions with ACC/A3 concerning the value delivery associated with the COA process revealed a number of important insights for architecting the future enterprise. [98] Figure 9-10 reproduces the value delivery assessment from ACC first provided in the data collection and analysis chapter.

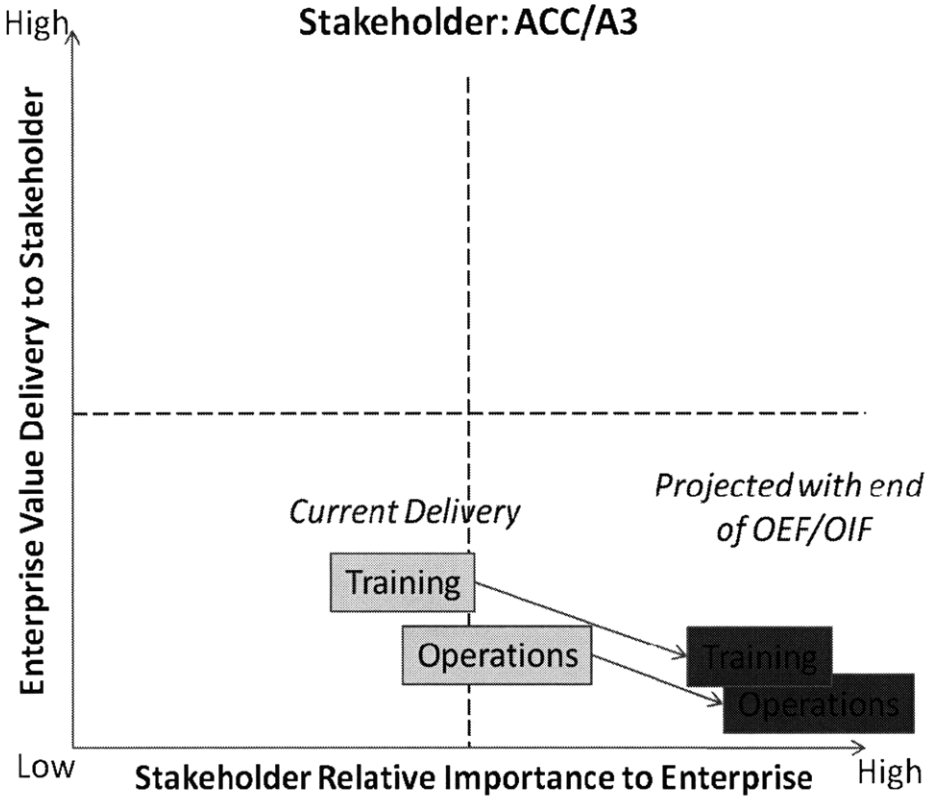


Figure 9-10. ACC/A3 Value Delivery Assessment of COA Process.

This provides the basis for the assessment of an overall weak correlation being recorded in the X-matrix for the "Train and Operate as Needed" strategic objective. Although the case is based on the current COA process as opposed to a specific JIPT process, the use of the COA for the current JIPT activity is appropriate since the JIPT Track 1 effort is still in work and no alternative to the COA exists currently.

Also recall from the previous discussion on COA value delivery that from an AJR-36 perspective, the COA process is working well. Again, the FAA value delivery assessment is provided in Figure 9-11 for convenient reference. In this case, the rationale for a strong correlation to safety through the enterprise value structure is easily understood and assessed.

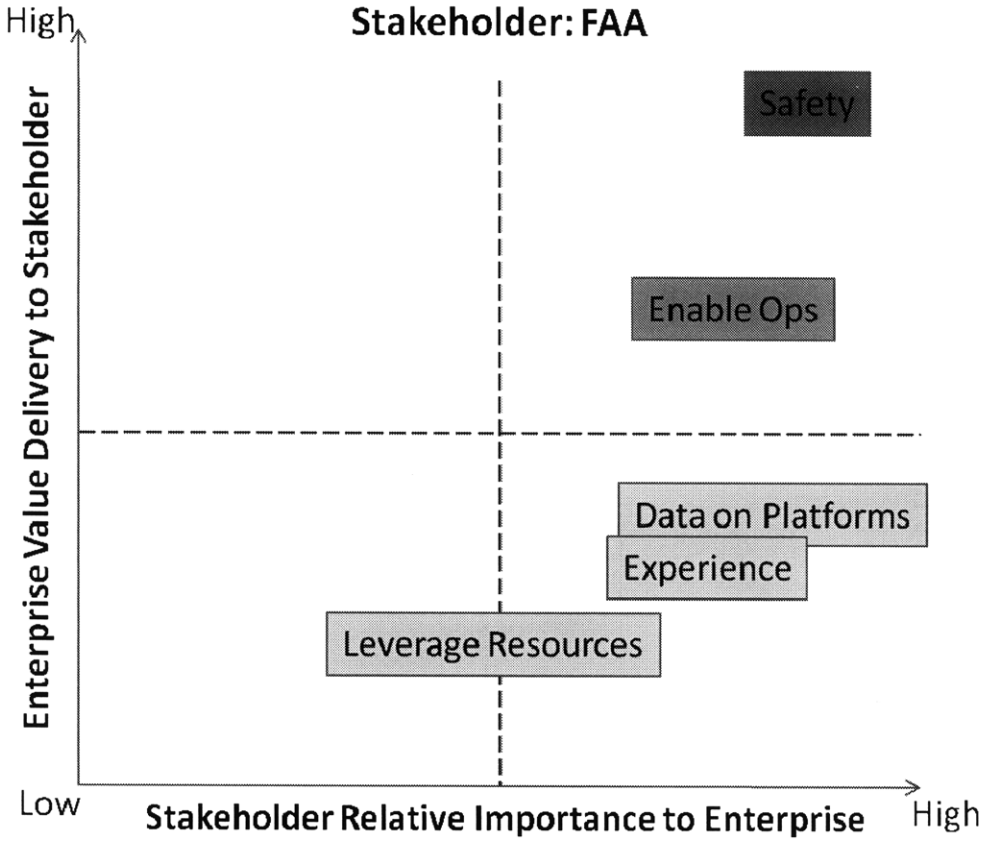


Figure 9-11. AJR-36 Value Delivery Assessment of the COA Process.

Using COAs going into the future, however, is something both ACC/A3 and AJR-36 said was of limited utility in the long-term. The expected growth of the number of COAs processed every year by AJR-36 (depicted in Figure 9-12) is a clear indication that significant restructuring or additional hiring will have to be accomplished to sustain even the current level of value delivery from an ACC perspective.

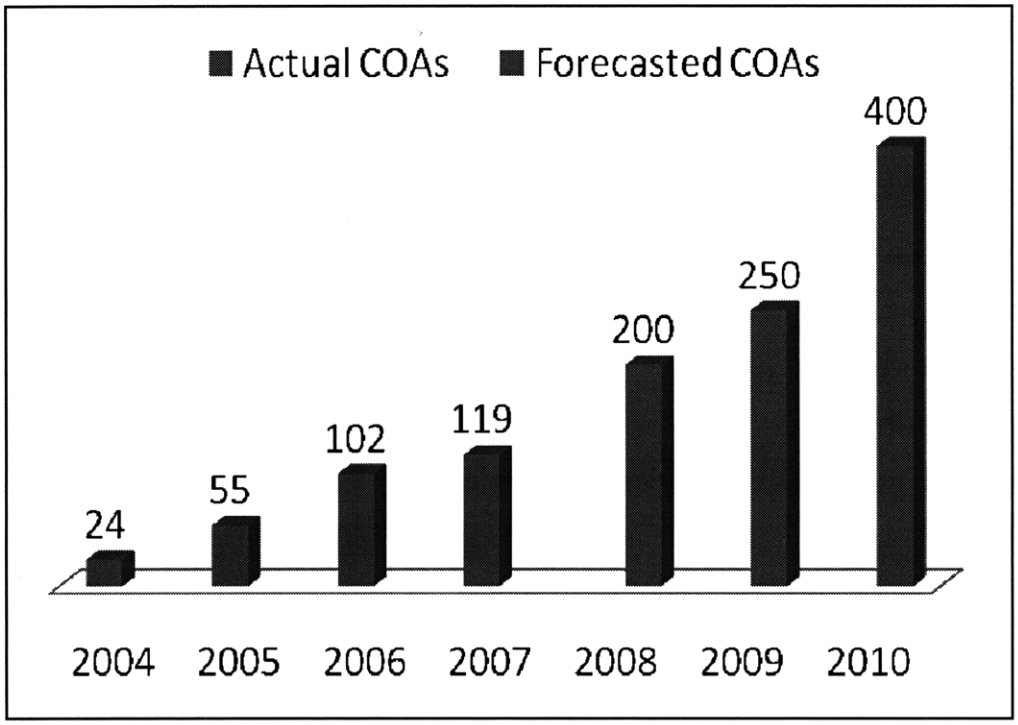


Figure 9-12. Actual and Forecasted Number of COAs.

Other ACC Factors

There is also an issue with shifting ACC expectations. The degree to which previously satisfactory levels of access continue to remain "adequate" as operations expand will very likely diminish with time. [99] What was acceptable several years ago for training and operations is meeting with increasing pressure to expand further. This shift in expectations results in an apparent decline in the level of value delivered by the existing COA process.

Further complicating this picture is the basing of a number of UAS units at various Air National Guard locations in portions of the country with no access to restricted airspace. This element was not explicitly addressed by ACC/A3 in the overall value delivery of the existing COA process, but it was an issue ACC/A8 brought up on several occasions as a growing area of concern to the Command. [100]

UAS AI Enterprise Value Structure Assessment

The UAS AI enterprise is necessarily broader in its scope and participation than the operational COA approval process. To provide the appropriate level of understanding for the value flow mechanisms between the airspace integration enterprise decision makers, their definitions of

value are provided below. Through the interview process, an attempt was made to construct the value exchange mechanisms from both an "in" (what inputs they expect to receive) and "out" (what outputs they expect to contribute) perspective for each organization. This proved to be complicated by the military culture of "doing what you're told" and varying definitions of the interfaces between the organizations engaged in the problem. For the purposes here, the value definitions centric to each organization provide a starting point from which to build the value propositions that create an actual flow of value through the enterprise. As an academic aside, it would appear from the anecdotal evidence that decision makers engaged in the airspace integration activity have a difficult time projecting value inputs they need from other stakeholders. That said, they all seemed to have a very well developed sense of the value they deliver from an internal perspective to the enterprise.

ACC/A8 and ACC/A3 Value Definition

Both of these organizations provided very consistent value definitions: train and operate with UAS to the extent required to fulfill service obligations to the joint warfighter. Discussion beyond this straightforward declaration of value focused on constraints associated with how this underlying outcome could, should, or would be accomplished. It was also clear from the interview data that both of these organizations define the ability to train and operate in very concrete, tangible terms. Their perception of the value delivery mechanism supporting this outcome was made in terms of specific platforms being able to operate at specific locations under specific conditions. There was very little abstraction involved in any of these conversations with either organization. The bottom line was routinely, "Can I do my mission?" followed closely by "Is it cost effective?"

AIR-160 and AJR-36

These two FAA organizations are paired based on the strong degree of correlation in their value definitions. Both of these organizations' value definition is driven in large measure by the ability to ensure safe operations in the NAS. Delivery of this value dominates all other considerations in the value delivery spectrum. This was, in fact, the single value definition provided by AJR-36 during interviews.

AIR-160, however, did articulate addition value constructs that contribute to their perception of delivered value. In addition to the need to ensure safe operations, AIR-160 also articulated several additional value delivery mechanisms that grow out of their engagement with the airspace integration activity. These include the value derived from enabling the operations required for another government agency to accomplish its mission, and the value derived from being able to leverage taxpayer dollars to work toward a common objective with the DoD. Additional insights gleaned from an analysis of the UAS experimental aircraft certification process suggests that AIR-160 also perceives value delivery in acquiring UAS data, experience, and leadership in the regulatory environment. [93] This broader value delivery definition, while in many ways tied to the safety proposition, is nonetheless significant in providing a richer understanding of how AIR-160 looks at potential situations and arrives at a value determination of outcomes.

SAF/AQIJ and the 303 AESW

The value commonality between these two organizations lies in the functional position they maintain with respect to ACC. These two organizations derive value in their ability to fill identified shortfalls in materiel capabilities the operational community has identified, or conversely, to develop a new materiel capability that provides a value to the operational community. To illustrate, consider the analogy provided during the course of an interview with SAF/AQIJ:

> "SAF/AQ is tasked to weaponize the warfighter. In a historical context, we'd contract with the blacksmith to make the sword. We'd leave the actual sword fighting to the knight. If he needed a different kind of sword, we'd go out and get it for him. Now there a few more rules to fighting, and SAF/AQ is being asked to procure capability in conformance with the rules for an integrated solution. We would like to be engaged in working the total solution to the airspace integration challenge--not just fix the 'truck' or make the 'black box', but be integral to the development of the materiel capability in conjunction with the policy and regulatory environment in which it will perform." [101]

The 303 AESW further characterized the assessment of value delivery by noting that there are the dimensions of cost and schedule in addition to performance that are also factored into a value

judgment determination concerning the activity. In other words, it is not just the delivery of a materiel asset that is graded. The cost and schedule associated with the development, design, fabrication, procurement and fielding of the materiel asset are also considered, in conjunction with how well it meets performance expectations. This is an important point to remember when organizational dynamics start to factor into the picture. In most military procurement activities, the 303 AESW would ostensibly own both the authority and resources required to definitize all three aspects of the effort – schedule, cost, and performance. In the case of the airspace integration activity, the performance specification lies outside of their direct control or influence.

USD(AT&L)

The value delivery definition for USD(AT&L) looks very similar to that of the 303 AESW and SAF/AQIJ. This is to be expected since the organization is also engaged in the acquisition of materiel capability. There is, however, an important difference between the value delivery definition of USD(AT&L) and that of the 303 AESW or SAF/AQIJ. USD(AT&L) defines value as the ability to exercise the required oversight needed to "Push the services for solutions that will in the end expand the solution space and provide better warfighting capability." [102] The distinction here may be a bit subtle, but it is an important one to drive home. The primary objective for the 303 AESW and SAF/AQIJ is the actual production of the materiel solution (e.g. aircraft, UAS, spacecraft, electronics, etc). The primary purpose of USD(AT&L) is to provide oversight, and where needed, redirect service efforts to meet materiel shortfalls. USD(AT&L) does not itself engage directly in the actual procurement or fielding of the materiel capabilities.

PBFA

The DoD Policy Board for Federal Aviation represents the official position of the DoD to the FAA on matters that are of common interest and applicability to all of the services. It provides a "one-stop" shop to deal with these cross-service issues. [99] The value definition articulated by the PBFA is the ability to work an issue across all of the services resulting in a common, interoperable solution with the FAA. Coordination and standardization, reducing time for staffing packages, and providing unity of voice from the DoD to the FAA are all key elements to accomplishing this value delivery.

Note that a prerequisite to accomplishing this task is consensus from the services on the existence of a common problem or issue that needs to be worked with the FAA, an agreed to or at least consensed position on the desired end-state for the PBFA interaction with the FAA, and a clear understanding of the costs and benefits for pursuing the specified course of action. Without meeting these basic pre-conditions, it is very difficult for the PBFA value proposition to be met.

X-matrix Summary of UAS AI Enterprise Alignment

To create the necessary alignment between all of the stakeholders described above, the X-matrix was re-coded to provide strong correlation throughout the entire enterprise value structure. The result of this analysis is shown in Figure 9-13.

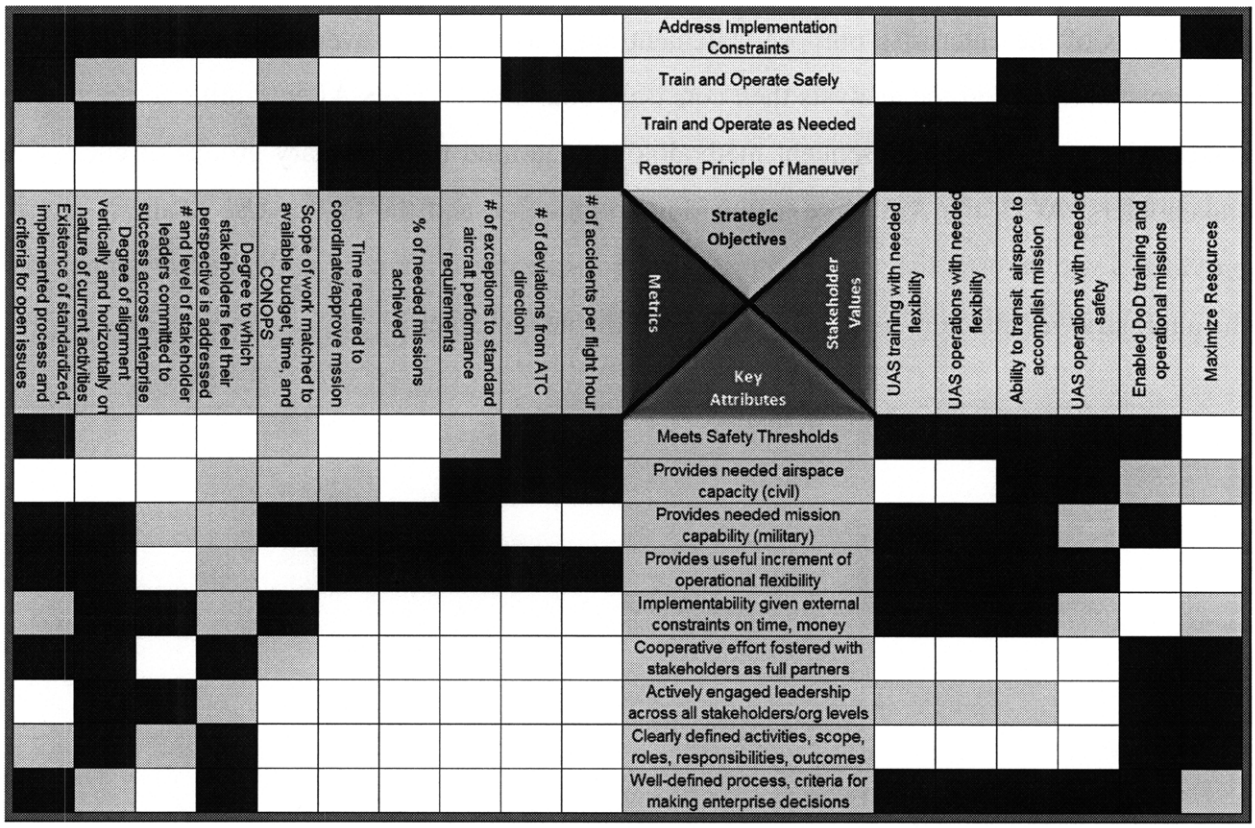


Figure 9-13. X-matrix Evaluation of UAS AI Enterprise.

Again, as an initial pass through the enterprise value structure, Figure 9-13 provides a good point of departure for going back to the enterprise decision makers for a vector check and to generate buy-in for the analysis that follows. In this case, there was enough confidence in the proposed value structure to warrant continuing with the analysis. If however, the architect did not feel confident the value structure would find widespread agreement amongst the decision makers in

the enterprise, an additional iteration with these decision makers at this juncture would be entirely appropriate before expending the needed effort to generate alternative architectures based on the value structure capture by the X-matrix.

The other question that comes up frequently in the case of assessing the value alignment of future enterprises is "How do you actually effect the changes put into the matrix?" This is in fact precisely the point of conducting the next series of activities within the enterprise architecting domain. The enterprise architecture is the means by which the value alignment proposed in Figure 9-13 is implemented.

Chapter 9 Summary

The results of the enterprise purpose statement analysis revealed several shortfalls in the JIPT mission statement and the analysis then concisely bounded the UAS AI enterprise activity. The stakeholder analysis and subsequent methodology identified three primary groups of enterprise stakeholders: ACC, the Air Force acquisition community, and the FAA. Use of the X-matrix provided a way to establish the appropriate enterprise value alignment as the primary input into the alternative architecture exercise described in the next chapter.

CHAPTER 10 – UAS VALUE PROPOSITION CREATION AND SELECTION

"Know your enemy and know yourself and in a hundred battles you will never lose."

— Sun Tzu

The key to creating solid value propositions is insight into each decision maker's value definition in addition to your own. To be as effective as possible in creating architectures that deliver enterprise-wide value, the architect must be capable of seeing the context through the eyes of each individual decision maker and understanding what the value scene looks like from that decision maker's perspective. This insight coupled with a clear sense for personal biases or tendencies is the basis for creating solid value delivering architectures. Applying the principle of war referenced in the above quote by Sun Tzu several millenniums ago to the current application, if the architect has a deep knowledge of the decision makers' value definitions and a clear understanding of his or her own predispositions, the result will be a value proposition that will "never lose."

The previous two chapters provide for understanding the decision maker value definitions. This chapter now takes that knowledge and applies it using the enterprise architecting methodology developed in Section II. Before beginning, however, the context is examined in light of each enterprise architecting view to provide a more robust basis for the QFD analysis. Then the QFD assessment is conducted to understand which enterprise architecting views play a dominant design role in the value proposition. Third, the OPM model for the enterprise is constructed using the results of the QFD model, the enterprise purpose statement, and the X-matrix. Fourth, the resulting architectures are assessed and the most desirable solution selected for implementation.

Contextual Assessment of Enterprise Architecting Views

Before conducting the QFD assessment of the enterprise architecting views and the value attributes from the X-matrix described in the previous chapter, an analysis of the existing situation from the perspective of each view should be conducted to provide the additional insight needed to know how important each view is to the various attributes that will be assessed. Once some understanding of the existing context issues are established with respect to each enterprise

architecting view, the QFD analysis can be conducted to narrow down the alternative architecture views that will be assessed as design variables in creating the alternative value propositions.

Policy/External Factors

The external factors surrounding the enterprise activity have been addressed leading into this section. The policy aspects, however, warrant some additional attention. The external policies are a major constraint to developing viable alternatives. Specifically, the USD(AT&L) guidance on the airspace integration problem stipulates three guiding principles in the generation of a solution: Do no harm, Conform rather than create, and Establish the precedent. [3] The guidance from the OSD Unmanned Roadmap is articulated as follows:

> **"Do no harm**. Avoid new initiatives, e.g. enacting regulations for the military user that would adversely impact the Military Departments' right to self-certify aircraft and aircrews, ATC practices or procedures, or manned aviation CONOPS or TTPs or that would unnecessarily restrict civil or commercial flights…"
>
> **"Conform rather than create**. Apply the existing Title 14 Code of Federal Regulations (CFR) (formerly known as the Federal Aviation Regulations, or FARs) to also cover unmanned aviation and avoid the creation of dedicated UAS regulations *as much as possible*. The goal is to achieve transparent flight operations in the NAS…"
>
> **"Establish the precedent**. Although focused on domestic use, any regulations enacted will likely lead, or certainly have to conform to, similar regulations governing UAS flight in International Civil Aviation Organization (ICAO) and foreign domestic (specific countries') airspace…"



Figure 10-1. Joint FAA/OSD Approach to Regulating UASs.

The approach to building an integrated UAS capability is shown in Figure 10-1. These policies formed the historical constraints within which the JIPT activities were conducted and with which the current enterprise must conform. In addition to this explicit OSD guidance on airspace integration, there are also the standing policies regarding DoD acquisition requirements, federal statutory and regulatory requirements, interoperability requirements, and host of others that are applicable almost exclusively to the product view. They will not be addressed in any greater degree of detail as they do not have substantial influence on the architecting design activity.

Strategy

The contextual drivers in this enterprise have been detailed previously (See Section I for additional background). Certain aspects of the resource constraints should also be considered in this view given the broad ranging implications associated with how funding and manpower are allocated within the DoD and the impact this has on efforts that are attempting to get off the ground. Existing resource limitations have placed the "As-Is" enterprise in a position where it must operate on a "shoe string" budget of $5-$10M per year over the next several years. This has significant implications for the other views as well as the strategy implemented for a way forward. The current discussion attempts to address the resource constraints in light of the more

fundamental question of the enterprise purpose itself. In other words, the level at which "restoring maneuver" will be funded will depend directly on the extent to which senior Air Force and DoD leadership see the effort contributing to the "1 up" purpose of "enable global strike."

Without completely rehashing the enterprise purpose statement analysis conducted in Chapter 9, recall the enterprise purpose statement that resulted was the need to restore the principle of maneuver to UAS platforms. Previous efforts at UAS airspace integration have failed not because they lacked talent or the ability to execute at the program level. Nothing could be further from the truth. These activities have had the benefit of some of the best minds in DoD, FAA, and industry working extremely challenging technical and procedural requirements to turn integrated operations for UAS into reality. Recall the enterprise purpose statement analysis indicated the primary shortfall for the JIPT was in the thrust of the purpose statement itself--standards were the means rather than the end, and instead restoring maneuver should be the focus.

This is all well and good at the level at which the current multi-program analysis is being conducted; however, a "1 up" analysis of this redefined purpose of "restoring maneuver" will reveal a major hurdle in realizing this value proposition. The primary issue, at a strategic level, to initiating an effort to "restore maneuver" to UAS platforms is the need to balance the extent of investment in restoring maneuver with the benefit that results in the delivery of the "1 up" purpose described in Chapter 9 as "Enable Global Strike." In other words, the value proposition at the next level up from the currently defined UAS airspace integration enterprise is not "maneuverable UAS" but rather "enabled global strike." The extent to which Air Force senior leadership will find value in an investment in the UAS AI enterprise is dictated by the increase such an investment makes in the Air Force's ability to conduct global strike missions.

From a strategic view, then, the enterprise architect's responsibility is to align the value structure between the "1 up" GSTF extended enterprise and the UAS AI enterprise purpose as defined in Chapter 9. This amounts to the enterprise architect ensuring that the analysis conducted in Chapter 9 on the enterprise purpose statement and value structure integrate directly into the efforts of the UAS AI enterprise architecture. This is accomplished by explicitly calling out the need to develop a strategic approach to the problem that actively seeks feedback from the "1 up"

level of the GSTF extended enterprise on how well the path pursued by the UAS AI enterprise satisfies the need for "enabling global strike."

To illustrate how this looks in practice for the UAS challenge, consider the perspective provided by Mr. Parker at SAF/AQIJ concerning the extent to which the UAS AI enterprise should be resourced to pursue putting additional maneuver on UAS:

> ". . . as the proportion of the force that goes unmanned increases, the ability of the overall force structure to maneuver incrementally declines. It is not, ultimately then, about scratching the itch of UAS advocates and their architectures.
>
> "When we think about the larger picture, some level of capability-challenged UAS is okay. When USAF flew then-called drones off of DC-130s in Vietnam times, nobody was, or would have been, concerned about the maneuver of the rest of the force structure being impaired. Failure to solve this is no big deal IF UAS are few and fill in small niche capabilities.
>
> "...maneuver for the strike package is what is key, for training, deployments and operations... We're certainly past a tipping point when we now start thinking about strike packages. From Gen Jumper [former Air Force Chief of Staff], 'Prior to any conflict, preparation is key. The team of GSTF [Global Strike Task Force] assets, aligned within an AEF [Air Expeditionary Force], will be on call and ready for immediate tasking to hot spots around the globe. As in any emerging crisis, the first requirements call for ISR platforms. [103]'
>
> "Platforms enable CONOPs... as we see in this quote, the CONOPs implicitly calls for the ISR platforms to be yet EVEN MORE responsive to get to an AOR [Area of Responsibility] to prepare for the strike force – for not just "targets" and "fires" as we may traditionally think, but for advance logistics, force protection, the whole deal. If you move your ISR force to unmanned platforms in a big way before they have freedom-of-navigation capabilities [equate with maneuver], the foundation of the house of cards is undermined ..."

The strategic task before the enterprise architect is to fundamentally understand and coordinate across the UAS AI enterprise boundary with senior Air Force, DoD, and FAA leadership on the extent to which these other organizations are willing to resource "restoring maneuver" given the "1 up" considerations just detailed. By articulating the purpose as "restore maneuver", the UAS AI enterprise has brought to the forefront the strategic importance of the effort to "enable global strike" and provided an effective handle for the UAS AI enterprise architect (and for that matter, the enterprise decision makers) to communicate the connection between the enterprise efforts and those of the extended enterprise at the Air Force, DoD , and FAA levels.

Practically, the impact on the enterprise architecting effort is a clear articulation of the constraints the "1 up" value structure imposes on the enterprise architecture effort. In other words, the results of the strategic level alignment in value structures across the enterprise boundary will be a clear articulation by the GSTF extended enterprise on the constraints under which the principle of maneuver will have to be restored to UAS platforms in order to deliver the "1 up" value definition of "enable global strike."

Process

The above discussion on the broader strategic issues that need to be resolved notwithstanding, the analysis returns to the specifics of what will be required for a successful enterprise effort at the multi-program level. The activity model implemented by the JIPT to accomplish the airspace integration activity was fundamentally sound; however, the JIPT effort is still attempting to deliver the single most important process required for value delivery—a joint safety analysis framework for proposed UAS operations that would be conducted collaboratively between the DoD and the FAA. As JIPT Track 2 Activity Center efforts ramped up, and major planning efforts were started for better defining the scope of activities for the longer-term solution, the immediate need for a common safety assessment process fell by the wayside, despite several attempts to propel it along. It lacked the sustained level of resources and attention needed to turn it into an implementable approach to make a tangible difference to the approval of near-term operations.

At a more fundamental level, the JIPT effort also needed a clear process and criteria for making important scope, budget, manpower, and technical decisions. In "Managing the Human-Side of

Technological Innovation," Katz makes a convincing case from the literature and empirically collected evidence that in the absence of a well-defined, agreed upon goal or objective, a team must create criteria for how decisions will be made or chaos will surely follow. [19] This shortfall in the JIPT process model resulted in a struggle to generate an overall coherence to the activity that people could see, understand, and follow. Instead, individuals were often unclear about what needed to be done, what objectives they were attempting to meet, or what success looked like for their part of the initiative. It also led to suboptimal allocation of resources since budget allocation was not accomplished in a manner consistent with a well-articulated, published set of criteria.

There was also a distinct need for processes that enabled cross-functional sharing of information between efforts engaged on different parts of the problem. This was especially true as the effort started to mature on the equipage issues that needed to be resolved. The ad hoc nature of meetings, the distributed nature of the organizations involved in the effort, and the lack of focus on creating meaningful interaction at the technical level created significant hurdles to effective and efficient transfer of information. Much of this communication gap was the result of the distributed nature of the enterprise, and a web-based application was put in place to better facilitate the exchange of information. Unfortunately, this venue never really proved to be effective for the transmittal of technical information. Allen describes the phenomenon associated with how different types of information are communicated in organizations with associated studies that show technically rich information content almost always requires a face-to-face meeting to be effective. [104] This fact has significant implications for the organizational view considered next.

Organization

The organizational issues associated with the previous UAS AI efforts were substantial, and they represent a significant design challenge for the enterprise architect to establish a meaningful organizational paradigm in a highly-distributed entity with a dispersed authority structure. An organizational analysis conducted using Allen's framework found the fundamental JIPT organizational structure sound given the nature of the problem. In this analysis, a major consideration in the organizational structure is the determination of whether to go with a project-centric structure, a functional-centric structure or a matrixed structure. As Figure 10-2

illustrates, a number of different parameters feed into the decision on which type of organizational structure to implement. In the case of the JIPT effort, the organization was suitably positioned in the organizational design space to accommodate the rate at which knowledge is advancing (dK/dt), the degree of subsystem interdependencies (I_{ss}), and the overall length of the project (T_i). [105]

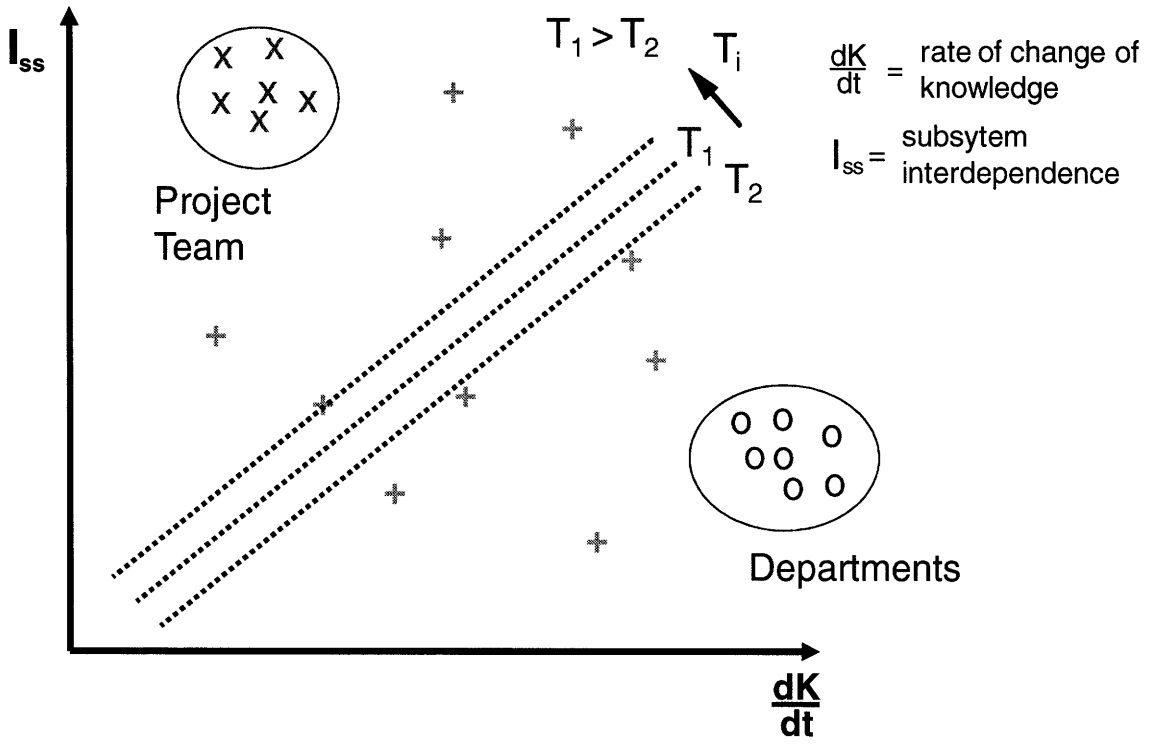


Figure 10-2. Variables Impacting Choice between Project vs. Functional Structure.

The three primary roadblocks in the JIPT context are the number of organizational boundaries present within the JIPT membership, the geographically distributed nature of the team, and the lack of any consistent, fundamental innovation occurring within the SIPTs or ACs. The major issues to be addressed included the following:

> To help bridge the organizational boundaries, the recommendation is to **create a common model of the end-to-end problem** that will allow all of the SIPTs and ACs to understand where they fit in the broader picture, and to get everyone discussing the same problem in the same language.

The JIPT should **institute better management of the meetings it is conducting** in order to realize the full benefit of the opportunities these forums represent for communicating complex technical information in a face-to-face venue.

Increase the number of face-to-face communication opportunities. This is especially true with respect to the amount of **unstructured, informal time** in which people could discuss the issues they felt were important to them or their particular SIPT.

The quality of innovation within the JIPT is the third challenge in need of some additional insights. In this case, **decreasing the total number of personnel working on the problem and increasing the percentage of time for each remaining individual** would likely pay significant dividends.

Gains in the overall effectiveness and efficiency of the UAS integration effort could be realized if the team were at least **co-located and if the total number of organizations represented could be whittled down to around seven total, but certainly no more than 10**.

The organizational design aspects of the enterprise architecting effort must address the above issues if the inefficiencies associated with the previous efforts are to be minimized or eliminated.

Knowledge

The need to manage information and data in the JIPT airspace integration enterprise was just beginning to take shape at the current level of activity. In this case, the knowledge management activity needs to be able to deal with a future quantity of data that will be extremely large and will need to be accessed from differing motivations and needs. As a consequence, the enterprise architecture will need a robust metadata standard, a process for accepting, verifying, and validating data submitted for inclusion in the data repository, and methods for extracting the desired information quickly to meet varied demands. The IT view will need to tie into this aspect of the Knowledge view very closely.

The JIPT effort had just started defining the elements that needed to be considered in this view. As such, it represents a relatively nascent view, and it is likely that the requirements for what the Knowledge architectural requirements look like will need to be developed as the enterprise

becomes better informed about what kind of information and data is important to collect and analyze. It will also be important that the information associated with the effort be seamlessly available to all of the enterprise stakeholders.

Information Technology

A number of important aspects of the enterprise will need to be enabled through the IT view. Knowledge capture will depend heavily on an IT system that is capable of extending to meet the growing data storage, security, and data type requirements. It must also provide a mechanism to the Organizational view that will help breach some of the organizational inefficiencies associated with the distances at which the various enterprise stakeholders interact and share information and data. Providing a platform on which to launch a common enterprise model is paramount to solid progress being made on this issue.

From a Product perspective, the IT architecture becomes one of several dominant features. The issue of command and control (C^2), data links, bandwidth, security, automation schemes, etc. drives much of the physical design space around the implementation of the needed equipage. The IT view is highly coupled with the Product view, and there are likely aspects to this that are not even apparent with the current level of understanding on the problem. Additional constraints in this arena include how spectrum management and radio frequency allocations will occur; what communication protocols will be used; the general issue of how and which standards will be applied and enforced; what the impacts are to flight critical software and on-board processing requirements with the addition of a man-on-the-loop, autonomous collision avoidance system; and host of others.

While some of these issues are yet distant in the future, others have already overtaken the effort. Protected frequency for UAS use in communicating with ATC and maintaining C^2 links is already a growing concern with a number of enterprise stakeholders. The extent to which the enterprise architecture needs to proactively deal with some of these issues remains an open question at this point, but clearly there is a need for an explicit treatment of these issues within the broader effort.

Product

The product issues are substantial. The one that drives many of the other aspects of the technological challenge is the modular versus integral architecture debate. Nowhere is this more apparent than in the Sense-and-Avoid equipage requirements. In this case, there is a fundamental disconnect between where the technology performance puts the preferred type of architecture (integral) versus what various stakeholders (specifically the FAA) would prefer to see implemented for the purposes of testing, evaluation, and the ability to provide a broader base of manufacturing capability to the problem. [106] The current airspace integration product development state is clearly in the early ferment stage of Figure 10-3. Every penny is going into figuring out how to get the needed performance out of sensors, processors, algorithms, communication pipes, human factors, etc.

	Early ferment	Dominant design emerges	Incremental innovation	Maturity	Eclipse or renewal
Demand Opportunity	Lead users, early adopters - high payoff, low switching costs	Early mainstream - usability, cost more important	Mainstream customers - soft factors, aesthetics	Saturation, segmentation, customization	Find ***new needs*** or ***new customers***
Business Ecosystem	Many entrants - diverse business models	Decisive battles for leadership	Intensifying competition, early consolidation	Fierce competition, consolidation around majors and minors	
Technological Infrastructure	Make it work - innovate on ***performance***, diverse integrative designs	Select optimal architecture, drive down ***costs***, focus on ***ease of use***	Provide broader offer, rationalize **portfolio**, build complementary ***assets***	Develop ***broad portfolio***, build ***platforms***	Search for ***new options***

Figure 10-3. Characteristic Product/Industry Life Cycle Phenomena.

In this early ferment stage, the natural technological infrastructure needed to support these high performance demands is an integrative design. The natural progression is for a large, diverse number of entrants into the market at this stage. Recall, for the JIPT activity, the product is focused on the equipage requirements needed for sense-and-avoid, reliable C^2, situational awareness for pilots in ground stations, etc. None of these "products" are at any significant level

of maturity at this point (at least from a technology trajectory standpoint depicted in Figure 10-3).

Unfortunately, the highly regulated nature of the NAS environment precludes a "natural" evolution of technology in this sphere, at least from the perspective of several key components, one of them being the sense-and-avoid solution. The nature of the FAA's safety assessment process, the testing regime, and the unknown performance requirements all drive design decisions that look much more like spirally developed, modular architectures. This is clearly an additional element of tension at the product level that the enterprise architecture will need to account for and accommodate. The lack of broader engagement from DoD prime contractors on this issue might be in part due to this conflict.

As an aside, it should also be pointed out that the above discussion is not intended to imply that the FAA is responsible for conducting all of the safety testing required to enable broader UAS integration into the NAS. In fact, the safety assessment process itself is pretty generic and very similar between both the DoD and the Department of Transportation (DoT). More to the point, the Air Force and DoD will establish and run their own safety assessment programs and provide the data to the FAA for further assessment. The FAA is not funded or manned to take on the level of effort required to accomplish the amount of work required. A major task of the enterprise architect is to arrive at a structure that recognizes this distinction in roles while also minimizing the possibility that the DoD and the FAA might arrive at different conclusions while assessing the same data set.

Another way to look at the product architecture requirement for the existing state is to consider where the typical UAS flight in the NAS winds up in the space defined in Figure 10-4. [107] From a military in-theater usage standpoint, the UAS is in the "smash hit" quadrant because there isn't much change required to the way the Air Tasking Order gets done, and the perceived payoff is significant (although, as the discussion in "Strategy" points out, the lack of maneuver on UAS platforms is setting up significant issues for how UAS capability will move forward into the future). When the context is shifted to the NAS, however, UAS airspace integration flips down into the lower right corner, the "Long Haul" quadrant, because the behavior change that is required on the part of the existing infrastructure is high with the current UAS performance

capabilities. There is actually a degradation in the overall performance of the system when it does accommodate the UAS. The enterprise architecture needs to address this aspect of the problem by developing a full spectrum of options in the product design that provide a way for the UAS to migrate out of the lower right quadrant and into the upper right segment. Just as importantly, the enterprise stakeholder community needs to see and understand this dynamic to facilitate better alignment at the philosophical level for what needs to be done moving forward in the design space. This is a view that fundamentally supports the need to address the other axis of the "civil airspace" context presented in Chapter 9--the "capacity" axis in Figure 9-3.

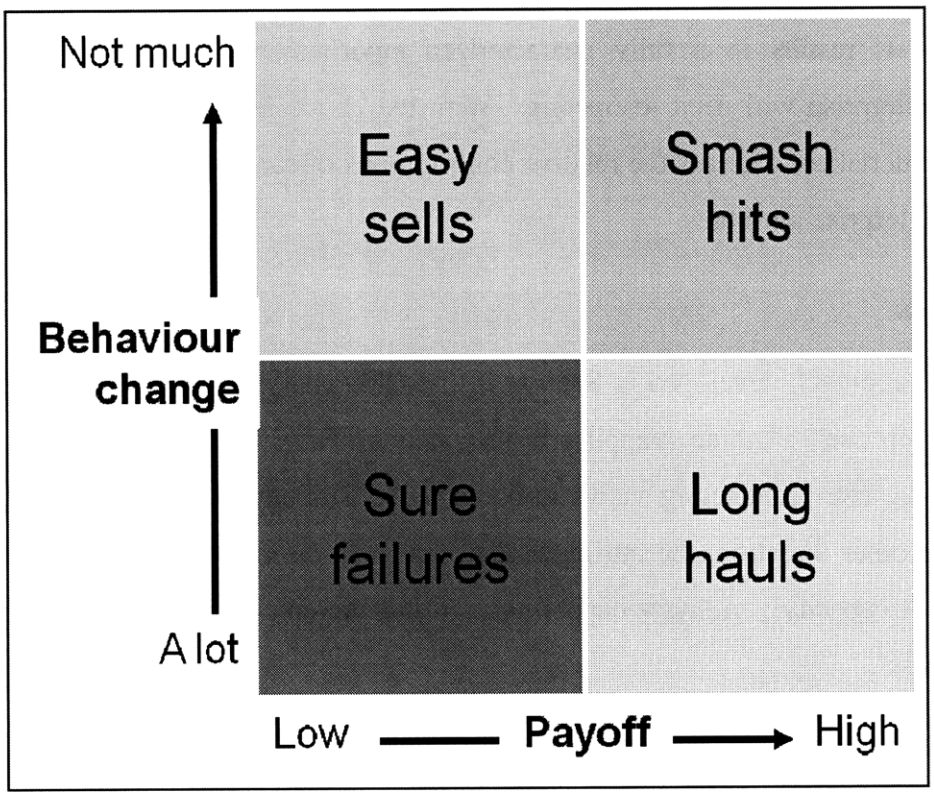


Figure 10-4. Capturing Value from Innovations.

Services

For the UAS AI enterprise, and likewise for the existing JIPT effort, the Services view is not considered as one of the active views. The UAS AI effort is oriented around the delivery of additional maneuver as it relates to the UAS platform. This makes the assessment an inherently

Product-focused effort as opposed to one characterized as a "Service" oriented industry or case study. As a result, the Service element will be dropped from further consideration.

Summary of Enterprise View Context Analysis

A number of recent and on-going efforts to integrate UAS into the national airspace provide the context for the current enterprise activity. These efforts yield a significant degree of insight into the difficulties associated with creating a sustained effort for solving this issue (due in large part to the overarching problem of unifying senior leadership on the need to "restore maneuver" as discussed in the "Strategy" view). The NASA Access 5 effort, the RTCA SC-203, the JIPT, and the USD(AT&L) UAS Task Force activities provide key insights for the current effort. Augmenting this information with the specifics of the data collection effort undertaken for the current analysis results in a fully characterized environment in which the UAS airspace integration enterprise will need to operate. With the above information for insight, the QFD analysis is undertaken to assess the relative contributions of each enterprise architecting view to each of the enterprise attributes.

QFD Analysis

Applying the approach developed in Section II, the QFD analysis for the enterprise architecture "views-to-enterprise" attribute mapping is provided in Table 10-1. For this assessment, the dominant enterprise architecting views turn out to be Strategy, Policy, Process, and Product. Going in the other direction, the attributes that appear to be influenced by the most views are 'safety', 'civil capacity', 'military capability', 'useful increment of ops flexibility', and 'well-defined process'.

Enterprise View \ Attribute	Meets Safety Thresholds	Provides needed airspace capacity (civil)	Provides needed mission capability (military)	Provides useful increment of operational flexibility	Implementability given external constraints on time, money	Cooperative effort fostered with stakeholders as full partners	Actively engaged leadership across all stakeholders/org levels	Clearly defined activities, scope, roles, responsibilities, outcomes	Well-defined process, criteria for making enterprise decisions	Total Impact
Strategy				9	9	9	9			36
Policy	9			3	9		3	9	9	42
Process	9	9	9	9					9	45
Organization					1	3	3	3	3	13
Knowledge	3	3	3	3	3			1	1	17
Information Technology	9	3	3			3				18
Product	9	9	9	9	3					39
Services										0
Total	39	24	24	33	25	15	15	13	22	

Table 10-1. QFD Assessment of Views-to-Attributes Mapping.

The implications from the QFD analysis suggests that 'Organization', 'Knowledge', and 'Information Technology' related issues should be resolved through the use of a common approach that satisfactorily addresses the issues presented in the previous section, but will not be varied as actively traded design variables in the alternative architecture tradespace. The remainder of the views are assessed further to understand what the interactions are and how they should be treated in the alternative architecture design space.

All of the interview data, with one exception, treated policy as a constraint on the problem as opposed to something the decision makers felt they had any ability to influence directly. Even in the one case where a policy constraint was brought up as a major issue that needed to be worked, the interviewee had little hope that it could be changed in any substantial way, at least within realistic timeframes on which this analysis is being conducted. As a result of the interview data, the 'Policy' view, while clearly an important influence on the enterprise, will be treated as a

constraint. The net result of this decision will be to treat it as a constant much as the 'Organization', 'Knowledge', and 'Information Technology' views are static in the analysis.

Also recall that the previous discussion on 'Strategy' highlighted the higher-level "1-up" issues associated with coalescing senior Air Force, DoD, and FAA leadership around the need to "restore maneuver" to UAS platforms based on "enabling global strike." Regardless of the final enterprise architecture selected for moving the UAS AI effort forward, the need to create this unified perspective on the level of investment in the principle of maneuver as the underlying raison d'être of the UAS AI enterprise is an *a priori* requirement for moving any activity forward.

Further analysis within the 'Strategy' view at the multi-program level reveals another set of dependencies, primarily the coupling that should take place between the 'Strategy' view and those of 'Process' and 'Product'. Recall from the previous discussion on the product view that the overall approach should be tailored to account for where the product is within the technical evolutionary trajectory in addition to the interactions in "customer" behavior. The evolutionary trajectory path is an assessment that falls directly out of the 'Product' view, and in the case of the impacts to "customer" behavior, the 'Process' view speaks to this dynamic. The implication of these observations (coupled with the previous paragraph on the principle of maneuver) is that 'Strategy' is in fact a derived quantity for the UAS AI enterprise depending on the choices that are made for 'Process' and 'Product'. Thus it is no longer considered a true design variable since it can be determined based on the design decisions made in the other two views. In addition, the strategic imperative to bring a unified perspective to the level of resourcing that should be applied to the effort to restore maneuver based on the contribution to enabling global strike is a common requirement across all possible alternative architectures regardless of the specifics that come out of the combination of the 'Process' and 'Product' views.

Figure 10-5 provides a summary of the QFD results and analysis for the purposes of moving forward with the alternative architecture development.

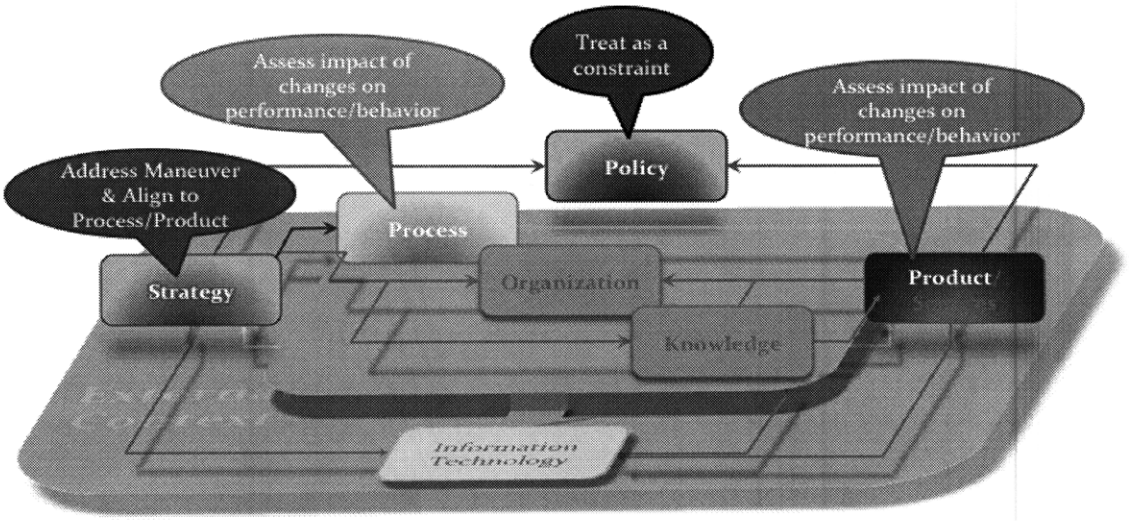


Figure 10-5. "Active" UAS Airspace Integration Enterprise Views.

In summary, the QFD assessment revealed that there were four primary views that influenced attribute delivery for the enterprise. These were 'Strategy', 'Policy', 'Process', and 'Product.' Of these views, additional analysis found that 'Policy' could not be changed with any degree of confidence in the outcome and is treated as a constraint. The 'Strategy' view was determined to be both an *a priori* requirement for all architectures (i.e. a unified perspective on the need for restoring maneuver) and a derived value from 'Process' and 'Product'. It was likewise removed from the active design space. This leaves 'Process' and 'Product' as the two dominant decision variables explored with alternative architectures in the next several sections.

UAS Enterprise Alternative Architectures

UAS Airspace Integration Enterprise Object Process Model

Using the methodology described in Section II and the information collected and assessed from the X-matrix and QFD, an OPM for the UAS AI enterprise was constructed. The result of this effort is depicted in Figure 10-6.

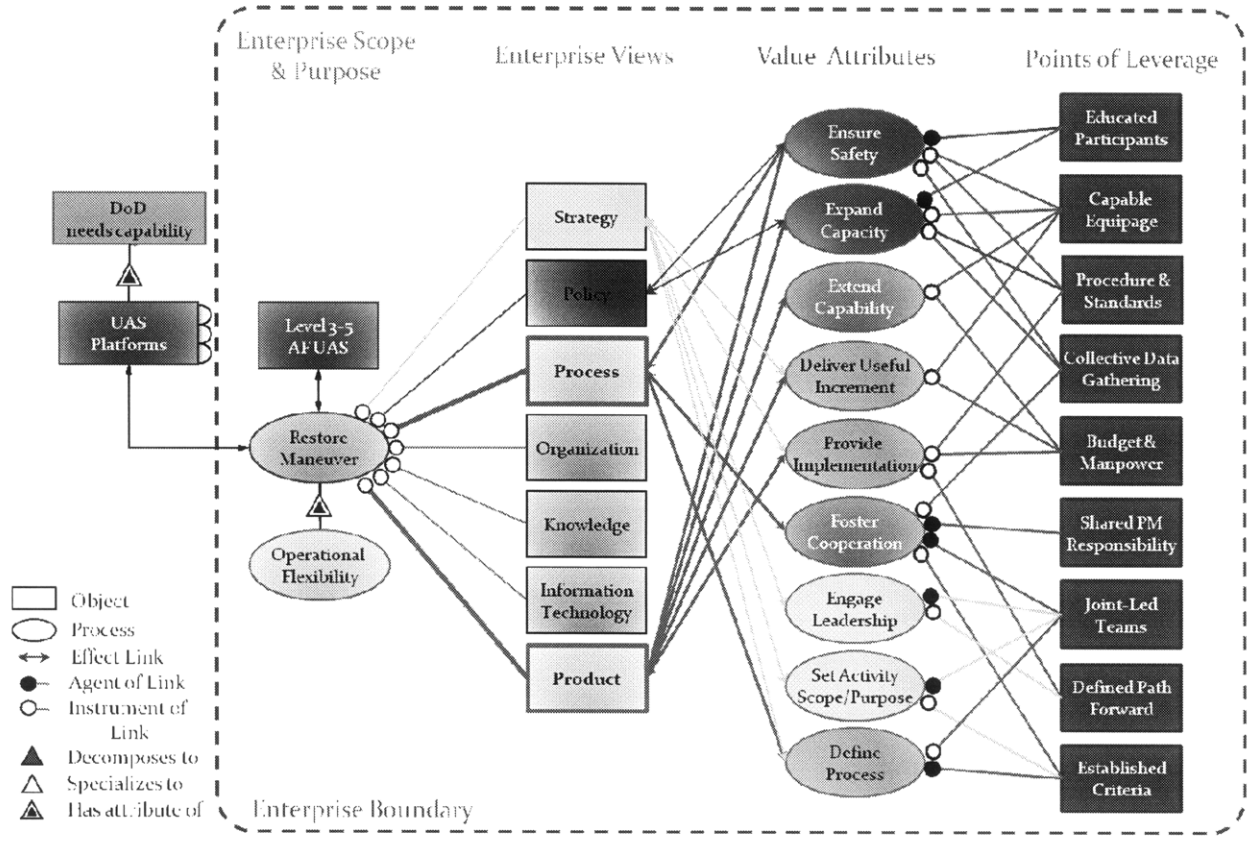


Figure 10-6. UAS Enterprise Architecture OPM.

The first layer, the far left "stack" labeled "Enterprise Scope and Purpose" encapsulates the overall enterprise purpose and scope by explicitly enumerating the value focus ("Restore Maneuver") to the object of that focus ("Level 3-5 AF UAS"). The process of "Restoring Maneuver" is further characterized by the attribute of "Operational Flexibility." Stack 1 one can be described as simply the enterprise intent and scope communicated in OPM language.

The second layer, the "Enterprise Views" stack, is just that—the seven "views" represented by the enterprise architecting framework. The color-coding is relatively straight forward, but technically should not be done until after the entire model is constructed. The grey boxes represent those views that do not significantly contribute as major drivers within the internal enterprise context (as determined by the QFD analysis). The red box, 'Policy', is a significant architectural constraint in the design that must be satisfied, as previously explained. The green boxes represent the views that have active, independent designs and trades connected with their content—for this analysis, 'Process' and 'Product'. The yellow box, 'Strategy', is an actively

designed view, but it must address the underlying value consensus for restoring maneuver and it is dependent on the 'Process' and 'Product' views per the previous analysis.

Stack 3, "Enterprise Attributes," is taken directly from the X-Matrix key attributes column, and "put into action." In other words, the X-matrix describes "states" that characterize the enterprise. In the architecture generation model described here, these states are transformed into processes with verbs per the methodology described in Section II. The result of accomplishing these processes will be the desired value delivery annotated in the X-Matrix. Each of these attribute processes is color-coded based on the number of active enterprise views that an attribute process interacts with.

Stack 4, the stack furthest to the left, the "points of leverage", are the mechanisms needed by the attribute processes in order to actualize the result of their processes. They are classified as either agent mechanisms involving human interaction (connected with a filled black circle), or as instrument mechanisms (connected with an open circle). As an example, consider the path trace from "Restore Maneuver" to "Process" to "Foster Cooperation." The job of the architect is to come up with as many different possible types of mechanisms as possible attached to the end of this sequence that facilitates the delivery of better enterprise cooperation within the 'Process' domain. For the OPM in Figure 10-6, the possible mechanisms that might contribute to the successful "fostering of cooperation" include "collective data gathering", "shared PM responsibilities", "joint-led teams", and "established criteria."

Candidate Architectures: Views Held in Common

Implementing the full QFD and OPM models just described for the UAS AI enterprise results in the determination that of the seven different views, only four played a significant role in driving the enterprise performance and behavior. Recall, however, that in the QFD analysis the 'Policy' view is treated as a design constraint or constant. In addition, recall that there is also one element of the 'Strategy' view that is also consistent across architectures—the need to create a unified senior leadership perspective on restoring maneuver to UAS platforms based on the contribution to enabling global strike.

These "four and half" views (policy, organization, knowledge, information technology, and the first element of strategy) were not actively traded between candidate architectures. As a consequence, they are all described up front before the specific candidate architectures are enumerated since they draw upon largely the same structure in each of these views. Note that just because these views are not actively included as design variables in the alternative architecture development process does not mean the architect ignores them. It simply means each of these views only needs to be designed once to deal with the specific value attributes to which the view contributes. The specifics for the "design" of each of these four and half views follows.

Policy View

As described previously earlier in this chapter, the current policy from USD(AT&L) dictates three axioms that will be observed as a solution to the airspace integration effort: Do no harm, conform rather than create, and set the precedent. These policies drive the consideration of airspace integration as the principle means by which to restore the principle of maneuver. The astute observer will have no doubt looked at the architecture development segment in Figure 10-6 and wondered what necessitated the integration of UAS into the airspace in order to restore the needed degree of maneuverability. After all, there are likely a number of different ways in which the Air Force could restore maneuver to these platforms that do not require their integration into the National Airspace System (although this perspective would do violence to the belief that freedom of navigation and the principle of maneuver are tightly interwoven in the UAS context).

Air Combat Command continues to look into other venues for doing just this in fact. One of these mechanisms involves the implementation of Part 93, Special Air Traffic Rule, for custom designed airspace. By ACC's own admission, however, the likelihood of this approach gaining any traction is extremely remote, and the clear consensus was that the only viable, long-term option is to pursue a capability that provides for routinely integrated UAS operations in the NAS. Other suggestions such as different basing locations (both within and without the U.S.), changes to the airspace structure itself to provide for dedicated UAS airspace, and others as far out as "Buying Albania" have been floated at various points in the past. All of them suffer from the same fundamental shortcoming in that they do not materially improve the intrinsic ability of the

UAS platform to maneuver. As a result, integrating them into the civil airspace structure continues to remain foremost on the "desired" list as the way to restore maneuver to these platforms.

Since the 'Policy' view remains relatively unchanged from that described previously in the context assessment earlier in the chapter, the discussion will not be reproduced here. The only additional aspect that is worth mentioning is the potential evolution of the NAS structure as the Next Generation Air Transportation System becomes better defined and funding begins to flow into modernization. This would fundamentally change the external context of the enterprise and would trigger a re-evaluation of the decision to treat policy as a constraint.

Organizational View

Recall from the context assessment that several recommendations came out of the analysis of the JIPT organizational structure. Most of the issues identified within the organizational view find their way into the mechanisms of "Joint Led Teams" and "Establish Criteria." As pointed out previously, many of the organizational issues faced by the JIPT can be mitigated by a simple down scoping of the number of different organizations involved in the activity. Recall, the analysis indicated the JIPT effort had the appropriate organizational structure in place, but it needed additional help on several important implementation considerations.

To overcome many of the organizational interface barriers, the current organizations should implement several changes that would dramatically increase the degree of communication and information flow. First, a regular 18-24 month personnel rotation should be established between the active organizations in the enterprise. This would pay significant dividends in the quantity and quality of the communication occurring between geographically dispersed offices.

Second, a common model for discussion reference and investigation is an absolute must if substantive dialogue is going to occur as things move into the future. Interview data shows very clearly that different organizations are still talking past one another, even after working the issue together in the same rooms for over two years. A common reference model would provide a much needed grounding point for discussions and evaluations. It provides a mechanism for bridging the geographical and cultural divides between enterprise decision makers.

Resolution on the third organizational issue, lack of consistent innovation, will be addressed through the interaction of some of the other views, principally the 'Process' and 'Knowledge' views. The tie back to the organizational element is important to bring out, however, because the best source of high quality innovations occurs within an individual's own organization. [108] This means the 'Knowledge' management and 'Process' views need to provide a mechanism that reinforces this type of collaboration. This impacts the "Foster Cooperation" attribute process, and suggests an additional supporting object may need to be included that enables this process to establish the appropriate interactions between the 'Organizational', 'Process', and 'Knowledge' views.

Knowledge View

In the 'Knowledge' view, the architecture needs to enable several key enterprise performance and behavioral attributes, primarily "Ensure Safety" and "Foster Cooperation." To enable the "Ensure Safety" attribute process, the 'Knowledge' view needs the mechanisms of "Educated Participants", and "Collective Data Gathering". Education will need to be a systematic effort that starts with the participants closest to the current UAS activities, and then grows outward from there to inform and educate other airspace users and controllers until the level of understanding concerning UAS platforms is as ubiquitous as knowledge and expectations concerning manned aircraft.

The "Collective Data Gathering" mechanism provides a strong linkage between the 'Knowledge' view and the 'Information Technology' view. Essential for the appropriate collection of data is an understanding of what information is needed to collect the appropriate data to inform the decisions or change the appropriate criteria. While the 'Information Technology' view plays a key role in the infrastructure needed to capture and retrieve the needed information, it is the 'Knowledge' view that ultimately describes why the data in the 'IT' view is important and how it will be used to inform other decisions.

Under "Foster Cooperation" the primary mechanisms are "Collective Data Gathering", "Shared PM Responsibility", "Joint Led Teams", and "Establish Criteria." Note that "Collective Data Gathering" is already emerging as a potential tradeoff point in the architecture as it has now shown up in several different attribute processes as a mechanism. By "Establishing Criteria" for

what data needs to be collected under the auspices of fostering cooperation, a key path dependency in the enterprise is addressed, namely the quality and integrity of the data provided for safety assessments. It also provides a method for the enterprise stakeholders to discuss and get smart on the differing assumptions and criteria they are bringing to the table with respect to their safety considerations. The principle forum that enables this is the "Joint Led Teams" mechanism. By systematically going through and connecting these various mechanisms back through the attribute processes and views, a clear picture of the interactions between views, processes, and mechanisms begins to come into focus.

Information Technology View

The 'IT' view provides many of the critical interfaces needed between the other views. As previously mentioned, the 'Organizational' view needs to stay connected to the 'Product' and 'Knowledge' views, and 'Knowledge' needs 'IT' internally in order to carry out its own requirements for data collection, storage, and retrieval.

Fortunately, bandwidth for shipping data between organizations is not typically an issue, at least within the FAA and the DoD. There are a few issues to be resolved with respect to domain permissions, and a dedicated shared resource may need to be established and maintained in order to address some of these file sharing and collaboration issues between IT systems, but these are all within the grasp of the enterprise to make happen with existing tools and technologies.

Further definition of the 'IT' view may not be possible in any level of explicit detail until things progress further in the evolution of some of the other views. This is especially true with respect to trying to define the command and control IT requirements for portions of the 'Product' view. Of some interest, the ATAM approach actually recognizes this uncertainty in the construction of architectures. [14] It specifically calls out this fact by saying the following:

> "...it is not uncommon for an architect to answer an elicitation question by saying: 'we haven't made that decision yet'. In this case you cannot point to a component or property in the architecture and call it out as a sensitivity point because the component or property might not exist yet."

Given the level of maturity in the effort, the 'IT' view is an area that does not lend itself to the identification of more concrete, specific design decisions. The "wait-and-see" decision to not decide must be documented and then revisited as other things fall into place later in the effort.

Strategy View

Aside from the 'Policy' view, unifying senior leadership on a clear articulation of the constraints for restoring the principle of maneuver to UAS platforms is the single most important element the architect must design into the UAS AI architecture. This is the first element addressed under the 'Strategy' view described previously. The rationale for this reasoning is relatively straight-forward. Recall that under the enterprise purpose statement analysis, the conclusion was the enterprise should focus on "restoring the principle of maneuver" to UAS platforms. This addresses the identified shortfalls and constraints elucidated under the enterprise purpose statement framework nicely, but it gives rise to a practical consideration from the strategic perspective, namely the premise that "restoring the principle of maneuver" is an underpinning construct that those "1 up" from the current enterprise will see as a valid value definition from the standpoint of "enabling global strike."

This underlying premise is captured beautifully at the OSD-level by one interviewee who said, "Leadership is the firewall to identifying value. If leadership doesn't believe there is value to UAS airspace integration, nothing else matters—money, manpower, etc." The implication in both the quote and the consideration driving the current strategy view is the need to carefully consider the extended enterprise impact when declaring the enterprise purpose statement or intent. In this case, the data from the interviews suggests that a simple declaration of "restore the principle of maneuver" as the underlying value definition needs to be reconciled with a higher-level group of decision makers that fall outside the current scope of the decision makers considered for this analysis, and who's value definition centers around "enable global strike" not "restore the principle of maneuver."

The consequence of this "1 up" assessment of the GSTF extended enterprise decision makers means the system architect must implement a strategy that accounts for the constraints from the "1 up" level to build a unified perspective on the UAS AI enterprise value definition—restore the principle of maneuver. As the quote points out, unless senior leadership sees the value in

restoring maneuver to UAS platforms (the contribution it makes to "enabling global strike") in the manner articulated by the UAS AI enterprise, none of the rest of the analysis and recommendations will result in any lasting value delivery. If the UAS AI enterprise value structure around "restore maneuver" is not well-articulated with respect to the GSTF extended enterprise value structure centered around "enable global strike", the perceived value exchange with respect to "restore maneuver" will only be secondary at best.

It should be apparent that this continually expanding boundary of the enterprise scope could go on ad infinitum as each successive layer of decision maker is considered in the process. Recall, the purpose of this research is to address the problem at the multi-program level, effectively placing the senior leadership of the Air Force, the DoD, and the FAA outside the immediate enterprise boundary and into the "GSTF extended enterprise" or "1 up" level in the enterprise purpose framework from the perspective of the current analysis. The practical result of this scoping decision is that the issue of creating a unified senior leadership position on the value of "restoring the principle of maneuver" lies outside the scope of the current analysis, but the need to bring the extended enterprise together for a consensus on the constraints becomes a strategic factor in the success of the enterprise. If this cannot be achieved, the enterprise will have virtually no ability to deliver long-term value.

The immediate task of the enterprise architect is to arrive at an enterprise strategy that enables the required convergence of senior leadership on the current UAS AI enterprise constraints. Practically speaking, the most effective path is to tie the principle of maneuver (and the associated military doctrine with techniques, tactics, and procedures), freedom of navigation, and the shifting of capability from manned aircraft to unmanned platforms with an objective analysis of projected capability the Air Force will be equipped to provide the combatant commander in the future. This should be done specifically as it relates to "enable global strike" CONOPS as detailed earlier in this chapter. This approach is complicated by the realization that current force structure decisions have resulted in an actual perceived increase in the level of combat capability the Air Force is providing to the combatant commander with UAS assets. The analysis must clearly draw out the underlying basis for current operations and demonstrate the extremely limited set of conditions under which current operations are extensible to the broader environment in which these platforms must ultimately operate to be compatible with Air Force

and DoD doctrine and principles of war (commensurate with the perspective articulated by Gen Jumper on the role ISR platforms will play moving into the future [103]). There should also be a clear picture of the compromises made to the basic tenets of airpower in order to put UAS into wartime operation along side of manned aircraft.

Clearly this aspect of the analysis is both highly nuanced and on the fringe of the enterprise scope defined in this analysis; however, the architect is beholden to the enterprise decision makers to create an enterprise architecture that will successfully deliver the needed value under the constraints imposed by the "1 up" GSTF extended enterprise. In this instance, the architect needs to address the very definition of value and the lack of clear constraints within the senior Air Force, DoD, and FAA leadership on this topic. Significant iteration with the UAS AI enterprise decision makers will be required to refine and implement an effective strategy for achieving the desired ends, but the effort is paramount to a successful enterprise architecture.

Service View

The 'Service' component of the enterprise architecture framework does not really play to any significant degree in the current enterprise (as alluded to previously). An argument could be advanced that the FAA's role in the enterprise is primarily one of a service provider, but this perspective misses the fundamental distinction that arises as a result of the FAA's regulator role. A significant degree of insight was shed on this aspect of the FAA's approach to UAS airspace integration by Blackburn et al. looking at the issue of UAS experimental aircraft certification (EAC) procedures conducted by the FAA's airworthy certification office (including AIR-160 as a major element in the EAC approval process). [93] The upshot of the UAS EAC process evaluation was that while it was possible to develop a value proposition in both directions (i.e. on the part of both the industry applicant and the FAA), the relationship could not be characterized as anything close to what would normally be considered a "service" type of activity.

Candidate Architectures: Differing Views

The 'Process', 'Product' and second half of the 'Strategy' view will now be described for the two primary architectures resulting from the architecture generation effort. These are labeled as "Architecture 1 – Process Focused", and "Architecture 2 – Product Focused." In each instance, the pro's and con's associated with each view will be assessed.

Architecture 1: Process Focused

The first architecture for consideration is the Process Focused architecture depicted in Figure 10-7.

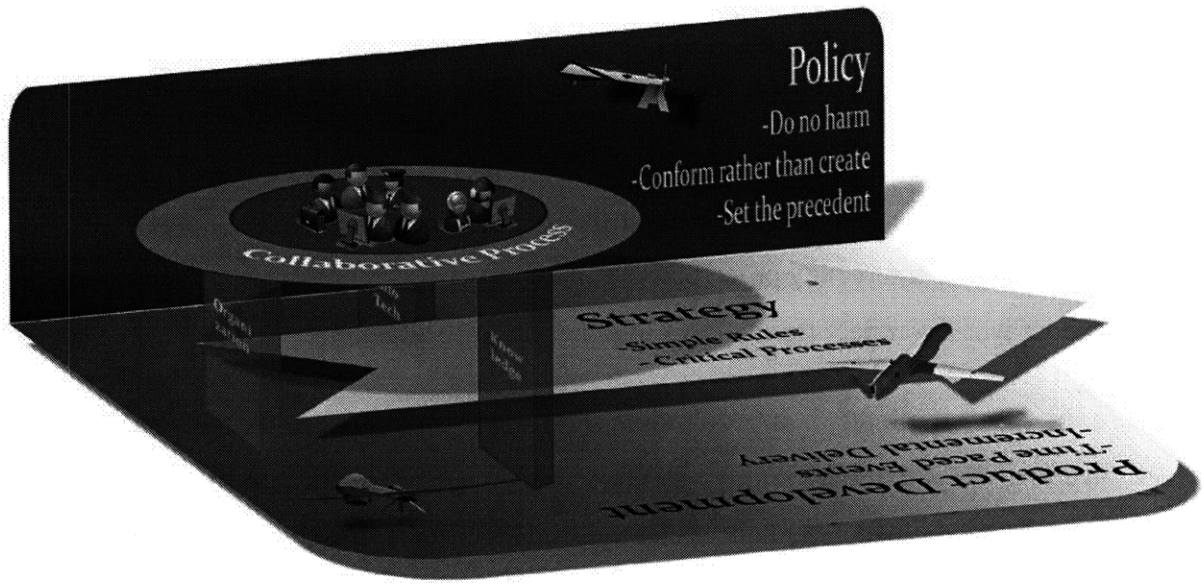


Figure 10-7. Process Focused Enterprise Architecture.

In this architecture, the enterprise is dominated by the collaborative process depicted in the center of the picture. All of the enterprise decision makers work in a collaborative environment with a common sight picture established through well-defined criteria and processes. The process is supported by the 'Organization', 'Knowledge', and 'Information Technology' views described previously. All of it is grounded on the backplane of product development—fielding capable equipage and thus enabling additional maneuver on the UAS platforms under consideration for specific CONOPs. The strategy of implementing critical processes and simple rules [18] stems from the factors introduced as a result of the process and product decisions. The entire activity takes place against a policy backdrop that mandates the three-plank platform of doing no harm, conforming, and setting the precedent.

Process View

The 'Process' view cuts a wide swath across the various attribute processes from Figure 10-6, engaging "Ensure Safety", "Foster Cooperation", and "Define Process." The "Ensure Safety" attribute process was discussed previously under the 'Knowledge' view, but the nature of the actions required in each of the mechanisms takes on a significantly different flavor when looked

at under the process lens. Key elements related to "Educate Participants" include processes for educating industry partners who may seek a UAS experimental aircraft certification to conduct testing and data collection, processes for educating other government agencies about the issues and protocols associated with flying UAS in the NAS, and processes in place to better educate other DoD and FAA offices about the current state of affairs and the points of contact for addressing UAS issues. These all fall into the general category of "educate the masses" on the existence of UAS and how they are being flown. In a more concrete way, processes need to be established to explicitly train and familiarize air traffic controllers with UAS unique issues (i.e. lost link procedures and emergency procedures) so there is a clear understanding within the ATC community about what to expect from a UAS in either of those situations.

In the case of "Ensure Safety" and "Capable Equipage", the process related architectural elements have to address the methodology by which the equipage will be researched, developed, fabricated, tested, and fielded. Without a clearly articulated performance specification against which to design hardware and software, a well-defined process for activities that will result in the needed specifications is what is ultimately required. It is this trace through the alternative architecture OPM that provides this view with its strongest position relative to the other views. This will also have direct implications for the 'Strategy' view. Notice that while this particular architecture explicitly calls out the need for this equipage process, it does not specify the object to which the process should be applied. This in turn becomes the largest shortfall of this architecture, but these points will be demonstrated once the evaluation criteria are applied.

For the "Ensure Safety" and "Procedure and Standards" fragment, the existing work by the JIPT stands as a model for continuing down this path. Enough has been detailed on this aspect of the JIPT's work to forego further details on this fragment. There is an open question in assessing Architecture 1, however, concerning the degree to which this element is emphasized. Relegating the procedural and standards development mechanism to the same overall level of emphasis as the other mechanisms described in this section may deemphasize this aspect of the work that is much needed.

For the "Ensure Safety" and "Collective Data Gathering" fragment, the 'Process' view must supply the necessary approach to defining and implementing a data management approach and

knowledge sharing mechanism across organizational boundaries. This is especially true with respect to the data for safety critical decisions. Once again, in the absence of *a priori* standards on what constitutes an acceptable level of performance, the process in which this consensus is reached becomes the driving mechanism in the architecture.

In the "Foster Cooperation" and "Share PM Responsibility" fragment, there is a need to work out the process under which programmatic decisions are reached and how they are implemented. Clear definition to this process provides an effective and efficient method for executing the day-to-day program management decisions needed on a whole host of topics that would otherwise bring the enterprise to its knees if there were not clearly established guidance and processes in place.

The last fragment in the 'Process' view that will be considered is the "Define Process" and "Establish Criteria" mechanism. As previously mentioned, the lack of established performance specifications creates any number of difficulties, especially for the engineering community who rely on these specifications to understand the functional requirements of the part and to design a system capable of delivering the needed performance. Because these specifications do not exist for the UAS category of aircraft, the conversation should focus on the problem space before it is turned on the solution space. [19] One effective way to accomplish this objective is to implement a set of decision criteria that all of the stakeholders agree is binding on how decisions should be documented, discussed, and decided. Short of this, it is unlikely the enterprise will ever have any significant success in aligning the multitude of different organizations and efforts into a single vector of intent. This has been a chronic problem with past and current efforts in this domain.

Product View

The 'Product' view is one that is similarly cross-cutting in the number and range of attribute processes that are impacted by what goes on in this view. The full architectural description for this view will not be provided here, just the high points to provide enough definition to bring out the salient characteristics for the purpose of evaluating the architecture. The two most significant attribute processes attached to the 'Product' view are the "Ensure Safety" and "Provide Implementation" views. With respect to the "Ensure Safety" attribute process, the

critical supporting object is the "Capable Equipage," and in the case of "Provide Implementation", the key supporting object is the available budget and manpower. Each of these will be considered in turn.

For the "Capable Equipage" object within the product context, the most significant issue is the question of what has to be built and to what performance specifications. As was pointed out under the process view, these are unanswered questions and are not likely to have well-defined responses anytime within the next five to ten years. This is what makes the 'Process' view so central to this particular enterprise architecture. As a result, the architect will have to pay particular attention to the threat of unfocused, diluted materiel development efforts within this enterprise if the risk is not mitigated in some other way. In addition, the explicit lack of a concrete platform within this architecture also opens up the potential for adverse consequences when it comes to fighting for budget and manpower, discussed next.

Within the DoD context, the programs that end up with the money more often than not are those efforts that are tied clearly and unequivocally to a specific, high-profile mission or objective. This makes communicating the impact of a budget cut to Congress very straightforward and provides a clear description of the potential impact loss of resources may have to the warfighter's ability to accomplish the desired mission or create the intended effect. The more abstract the rationale becomes from this very tangible and concrete point, the more difficult it becomes to convey the impact of funding and manpower decisions. There is nothing explicit within the Architecture 1 framework that requires this kind of direct tie between the platforms and the budget/resources drill.

The 'Product' view, while absolutely essential to the enterprise moving forward, is hindered by not having a dedicated program to marshal support, address the constraints and attempt to fight for more resources. It takes a direct hit in the "Implementable Program" attribute process as a result of the combination of these factors.

Strategy View

The 'Strategy' view grows out of the need to accomplish the things previously articulated in the 'Product' and 'Process' views. Like the 'Product' view, not all of the attribute process and

supporting object combinations will be presented here. The most important attribute processes are "Engage Leadership" and "Set Activity Scope/Purpose."

To provide a framework for thinking about different types of strategies and where they are important, the model developed by Eisenhardt is presented. [18] This model describes three basic strategy approaches that companies can typically take when faced with complex business contexts: position, resource, and simple rules. The situations and factors that bear on the decision about which approach to use are provided in Table 10-2.

Description	Three Approaches to Strategy		
	Position	Resources	Simple Rules
Strategic Logic	Establish position	Leverage resources	Pursue opportunities
Strategic Steps	Indentify an attractive market Locate a defensible position Fortify and defend	Establish a vision Build resources Leverage across markets	Jump into the confusion Keep Moving Seize opportunities Finish strong
Strategic Question	Where should we be?	What should we be?	How should we proceed?
Source of Advantage	Unique, valuable position with tightly integrated activity system	Unique, valuable inimitable resources	Key processes and unique simple rules
Works Best In	Slowly changing, well-structured markets	Moderately changing, well-structured markets	Rapidly changing, ambiguous markets
Duration of Advantage	Sustained	Sustained	Unpredictable
Risk	It will be too difficult to alter position as conditions change	Company will be too slow to build new resources as conditions change	Managers will be too tentative in executing on promising opportunities
Performance Goal	Profitability	Long-term dominance	Growth

Table 10-2. Three Approaches to Strategy.

An examination of the criteria in Table 10-2, further augmented by additional information in the cited source, will quickly lead the reader to the conclusion that the most appropriate choice for an overarching strategy is the "Simple Rules" approach outlined above in the far right hand column. The "Simple Rules" strategy also ties in very cleanly with the first half of the strategy view discussion related to unifying senior Air Force, DoD, and FAA leadership on the value of "restoring the principle of maneuver." The Air Force in particular is looking at UAS platforms as a significant growth area (as is DoD writ large), and tying the implementation plan back to basic doctrine and warfighting principles with several key processes significantly reduces the

complexity. This in turn provides senior leadership with the ability to get and keep their heads wrapped around the issues and to advocate for the needed changes effectively.

The impact on engaging leadership and setting the scope/purpose is significant. Rather than pursing a classic DoD event-driven sequence of events, the effort should be put on a flexible 18-24 month, time-certain development path. Kicking things out the door in this kind of an incremental fashion helps the enterprise from several standpoints. [109] First, it smoothes out the inevitable transitions that will come up in this work as things progress by putting in a structured mechanism for forcing those transitions, and thereby a process in which to ensure their effective and timely transitions.

Second, this approach to fielding capability into operational use sooner will provide a significant opportunity for more data collection, operational testing and evaluation, and "what-if" drills needed to convince the FAA the safety case has been met. Use of this kind of incremental, spiral delivery or evolutionary framework is also the most consistent with what DoD acquisition policy guidance recommends for programs just getting off the ground.

Third, it provides a basis for planning that has heretofore been lacking. By creating a time driven calendar, there should be significantly fewer unknowns within the rolling two-year window ahead of the program. It also matches up to the overall DoD budget clock speed quite nicely while still providing enough time for significant advancements to be made in the delivery of restored maneuver (and thus meeting one of the enterprise purpose statement constraints of providing incrementally valuable deliveries).

Perhaps most significantly, this strategy fits hand-in-glove with the emphasis on process-driven criteria and decision making. In one sense, you could say this strategy is itself a recursive process. In an environment with as few concrete specifications as the current UAS airspace integration effort, the need for a strategy that can effectively deal with large degrees of uncertainty in both inputs and outputs is clearly the strategy to call upon. Notice that even the objective of the simple rules strategy, growth, is well-aligned with the enterprise intent of restoring ("growing") the principle of maneuver back onto UAS platforms.

Architecture 1 Evaluation

The above information is used as a basis for scoring Architecture 1 against the previously described architecture evaluation metrics. It is worth pointing out that each Architecture is scored against the established criteria, not against one another. While this scoring methodology has strengths and weaknesses, one of the biggest reasons for proceeding down these lines is the consistency it shares with already conducted source selection evaluations accomplished by the DoD. It also forces a higher level of rigor into the justification of why a certain Architecture received a given score for a specific set of conditions. As described further in Section II of this research, other value ranking methods may also be employed (i.e. the Pugh, QFD, Single Attribute, etc).

Table 10-3 captures the results of the Architecture 1 scoring exercise. Note that the overall Architecture placed in the bottom of the green zone with an overall risk rating squarely in the upper middle of the yellow zone. The biggest shortcomings were in the areas pointed out in the above discussion. For this analysis, the QFD results for each enterprise attribute were used as relative weights between each of the Enterprise Performance and Behavior metrics. To account for the addition of architectural evaluation metrics, both the enterprise performance and behavior categories each gave up a total of 0.05 points off their totals to contribute a weighting of 0.1 to the architectural evaluation metrics. The confidence (risk) rating stands independent from the other enterprise weighting criteria and is not weighted relative to the other factors.

Airspace Integration Architecture #1										
Process Focused Architecture										
Overall Architecture 1 Rating:									0.834	
Overall Architecture Risk:									0.72	
Node	Cap.	Attributes	Wt.	Measures of Performance	Threshold				Initiative Eval	Score
1										
Enterprise Performance			0.52		0.2	0.8	1			
0.841					LMV	GE	MDM	BL		
1		**Enterprise Performance Metrics**	1							
	1	Safety 1	0.16	# of Accidents per Flight Hour	1E-05	1E-07	1E-09	0.00001		4.88E-07
		Safety 2	0.16	# of ATC deviations per Flight Hour	0.1	0.01	0.001	0.1		0.00180328
		Capacity	0.2	# of exceptions per approval	20	10	0	20		2
		Capability	0.2	% missions achieved vs requested	80	95	99	80		95
		Ops Flexibility	0.28	Time to coord/approv mission (days)	60	1	0.05	60		7
Enterprise Behavior			0.38							
0.829					LMV	GE	MDM	BL		
1		**Enterprise Behavior Metrics**	1							
	1	Implementability	0.28	Scope matched to budget, resource (% match)	20	80	100	10		86
		Cooperation	0.17	Extent people feel their perspective is addressed (% addressed)	50	80	100	25		98
		Engaged Leadership	0.17	% enterprise leaders committed to UAS success	20	80	100	25		65
		Clearly Defined Activities, Scope	0.14	Extent of enterprise alignment (%)	20	80	100	20		70
		Well-defined processes & criteria	0.24	% work done by standard processes,	20	80	100	35		89
Architecture Assessment			0.1							
0.814					LMV	GE	MDM	BL		
1		**Architectural Checks**	1							
	1	Logically Correct	0.2	OPM completeness for architecture description	20	80	100	20		82
		Provides Desired Capability	0.3	Degree to which architecture satisfies decision makers	50	80	100	10		82
		Decomposition maps to team, stations, and flows	0.3	Degree to which supporting process and objects "fit" at interface	20	80	100	45		80
		Adheres to "Architectural Principles"	0.2	Extent to which complexity, ambiguity and uncertainty are managed	20	80	100	10		82
Confidence Rating										
0.720			1		Low	Med	High	BL		PoPs
1		**Risk: Confidence in achieving the desired enterprise attributes**	1							
	1	Safety 1	0.1	Effort required to achieve attribute	60	80	100	100		70
		Safety 2	0.1	Effort required to achieve attribute	60	80	100	100		63
		Capacity	0.1	Effort required to achieve attribute	60	80	100	100		75
		Capability	0.1	Effort required to achieve attribute	60	80	100	100		91
		Ops Flexibility	0.1	Effort required to achieve attribute	60	80	100	100		77
		Implementability	0.1	Effort required to achieve attribute	60	80	100	100		82
		Cooperation	0.1	Effort required to achieve attribute	60	80	100	100		96
		Engaged Leadership	0.1	Effort required to achieve attribute	60	80	100	100		75
		Clearly Defined Activities, Scope	0.1	Effort required to achieve attribute	60	80	100	100		77
		Well-defined processes & criteria	0.1	Effort required to achieve attribute	60	80	100	100		100

Table 10-3. Architecture 1 Scoring Results.

Architecture 2: Product Focused

As you may expect, the other primary architecture developed for consideration is the product-focused enterprise. Much like the previous architecture built the core activity set around a collaborative process, the product-focused architecture builds the core set of activities around specific UAS platforms, in this case the MQ-1, MQ-9, and RQ-4, as depicted in Figure 10-8.

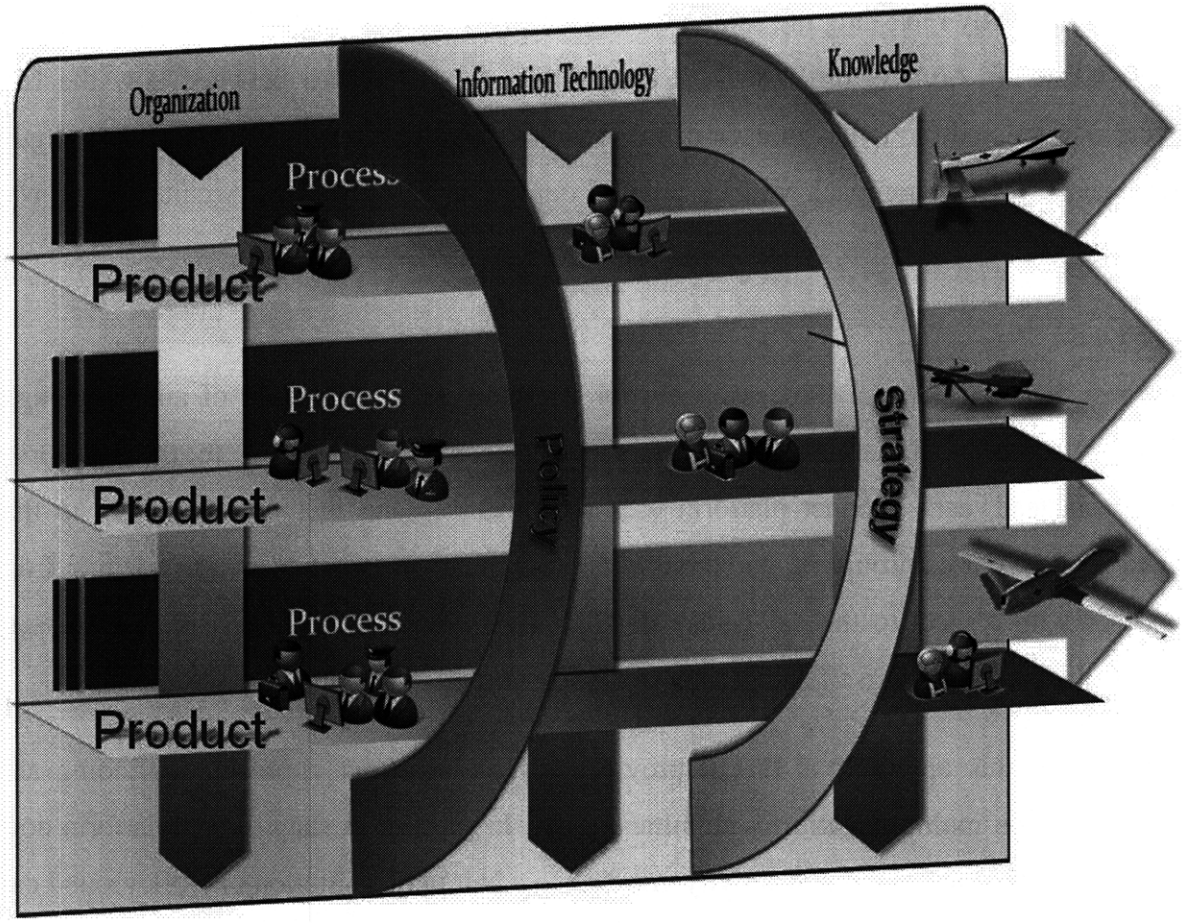


Figure 10-8. Product Focused Enterprise Architecture.

In this architecture, the individual UAS platforms become the primary avenues down which the enterprise's efforts move forward on restoring maneuver to these aircraft. They are unified in their otherwise independent efforts through a single set of policies and strategies that provide the overall direction to the effort. Each product development line is supported by the needed processes to resolve any outstanding issues or actions and foster the required cooperation among the players. The organization, information technology and knowledge components of the enterprise run through all three of the product platforms in a "cross-cutting" direction to provide

the needed support, infrastructure, and data management required for all three efforts. Different products may also find themselves at different points in the product development process, and consequently, there may be different manpower, budget, and expertise required and/or available to continue pushing the restoration of maneuver back onto these aircraft. Each can be tailored to respond to the specifics of the situation and environment confronting that specific platform.

Rather than explicitly rehashing the same information presented out of the first architecture, the approach taken for Architecture 2 will be to describe the differences between how the first architecture addressed the issues in each of these views vice the second architecture. Strengths and weaknesses of the approach will be pointed out in the same way as Architecture 1 was described.

Process View

The biggest difference in the 'Process' view for Architecture 2 is the lack of any one single collaborative process providing the overarching perspective and control to the enterprise activities. Instead, each product platform uses the processes and methods that work in that particular situation or environment, and the efforts proceed at somewhat of an arm's length from one another with respect to the day-to-day details. Everyone working the issues is intensely focused on the product line itself and getting capability pushed out as quickly as possible.

The strength in this approach is that it provides for a concurrent approach to finding and resolving issues on multiple platforms simultaneously. In addition, a snag in one platform does not necessitate the entire enterprise activity grinding to a halt until a solution or work around can be implemented on that product line. Depending on the nature of the issue, the other platforms may be able to continue unabated in their activities. This layering of multiple concurrent processes provides a degree of robustness to changing environmental factors that Architecture 1 lacked. For instance, resources can be shifted between product development efforts to help resolve issues and fix problems to keep the overall enterprise on track.

The downside to this structure is the loss of integration across the enterprise. The Architecture 2 arrangement is structurally prone to stove piping effects, and significant effort and attention would have to be devoted to making sure the cross-cutting elements in the organization, knowledge, and information technology domains provided sufficient presence to mitigate against

this tendency. It could also have the potential to work at cross-purposes with the enterprise attribute associated with fostering cooperation, especially if so many different activities are being done concurrently that one or more of the enterprise decision makers no longer has the ability to cover all of the bases simultaneously. This is a very real consideration for the FAA decision maker groups as they struggle to get additional manpower applied to an already rapidly accelerating workload.

Product View

The 'Product' view is obviously where Architecture 2 comes into its own. By focusing so narrowly on restoring useful increments of maneuver to an individual UAS, the enterprise has the opportunity to make harder hitting inroads and to consolidate gains as they are implemented. Because DoD and Congress typically program and budget down largely platform lines, this approach aligns better with a significant set of budget, manpower, and schedule interfaces the enterprise needs to maintain close connections with to remain effective.

The Architecture 2 arrangement also provides a more scalable arrangement should additional resources be available to apply to the challenge. The product-centric approach provides for better mapping to existing organizational forms within the enterprise, and it will likely provide for better leveraging of existing manpower allocations at several of the decision maker organizations, particularly the 303 AESW and SAF/AQIJ. Whether this level of scalability is something that is even needed is still in question. The current level of resourcing against the airspace integration issue in general is significantly less than what is likely required to conduct even a single product development effort with any degree of alacrity.

Strategy View

This is actually a point in common between both Architecture 1 and 2. By implementing the same simple rules strategy, Architecture 2 may be able to mitigate some of the fragmenting potential pursuing relatively independent product development efforts may introduce into the enterprise. This is especially true if the enterprise governance structure is instituted in a way that would help ensure consistent criteria and metrics are being applied across each of the development efforts. A fuller discussion of governance alternatives is likely something that should be included in this discussion, but time and space preclude a more developed assessment

and recommendation. At a minimum, governance should be added to the alternative enterprise architecture generation model as an additional supporting element. This way the architect can ensure the subject is at least considered and a decision documented so a deliberate direction with respect to the overall enterprise operational strategy can be determined.

Architecture 2 Evaluation

The results of the Architecture 2 evaluation are provided in Table 10-4. Notice that while the overall score for Architecture 2 is essentially identical to that of Architecture 1, the risk assessment is not nearly as good. This is primarily a result of the fragmenting potential described in the above discussion. The actual Enterprise Performance and Behavior metrics are assessed to have relatively strong returns with this Architecture. The risk rating captures the impact of the path dependencies. In other words, the lower risk rating says that generally there is less confidence Architecture 2 will actually be able to make good on this level of attribute delivery as a result of the more fragmented approach. This shows up predominantly in the Enterprise Behavior category of "Well-defined processes & criteria."

Airspace Integration Architecture #2										
Product Focused Architecture										
Overall Architecture 2 Rating:									0.830	
Overall Architecture Risk:									0.641	
Node	Cap.	Attributes	Wt.	Measures of Performance	Threshold				Initiative Eval	Score
1										
Enterprise Performance			0.52		0.2	0.8	1			
0.849					LMV	GE	MDM	BL		
1	Enterprise Performance Metrics		1							
	1	Safety 1	0.16	# of Accidents per Flight Hour	1E-05	1E-07	1E-09	0.00001		1.44E-07
		Safety 2	0.16	# of ATC deviations per Flight Hour	0.1	0.01	0.001	0.1		0.00282051
		Capacity	0.2	# of exceptions per approval	20	10	0	20		5
		Capability	0.2	% missions achieved vs requested	80	95	99	80		98
		Ops Flexibility	0.28	Time to coord/approv mission (days)	60	1	0.05	60		10.6
Enterprise Behavior			0.38							
0.808					LMV	GE	MDM	BL		
1	Enterprise Behavior Metrics		1							
	1	Implementability	0.28	Scope matched to budget, resource (% match)	20	80	100	10		94
		Cooperation	0.17	Extent people feel their perspective is addressed (% addressed)	50	80	100	25		91
		Engaged Leadership	0.17	% enterprise leaders committed to UAS success	20	80	100	25		80
		Clearly Defined Activities, Scope	0.14	Extent of enterprise alignment (%)	20	80	100	20		80
		Well-defined processes & criteria	0.24	% work done by standard processes,	20	80	100	35		60
Architecture Assessment			0.1							
0.810					LMV	GE	MDM	BL		
1	Architectural Checks		1							
	1	Logically Correct	0.2	OPM completeness for architecture description	20	80	100	20		82
		Provides Desired Capability	0.3	Degree to which architecture satisfies decision makers	50	80	100	10		82
		Decomposition maps to team, stations, and flows	0.3	Degree to which supporting process and objects "fit" at interface	20	80	100	45		84
		Adheres to "Architectural Principles"	0.2	Extent to which complexity, ambiguity and uncertainty are managed	20	80	100	10		74
Confidence Rating										
0.641			1		Low	Med	High	BL		PoPs
1	Risk: Confidence in achieving the desired enterprise attributes		1							
	1	Safety 1	0.1	Effort required to achieve attribute	60	80	100	100		70
		Safety 2	0.1	Effort required to achieve attribute	60	80	100	100		63
		Capacity	0.1	Effort required to achieve attribute	60	80	100	100		60
		Capability	0.1	Effort required to achieve attribute	60	80	100	100		98
		Ops Flexibility	0.1	Effort required to achieve attribute	60	80	100	100		68
		Implementability	0.1	Effort required to achieve attribute	60	80	100	100		96
		Cooperation	0.1	Effort required to achieve attribute	60	80	100	100		70
		Engaged Leadership	0.1	Effort required to achieve attribute	60	80	100	100		96
		Clearly Defined Activities, Scope	0.1	Effort required to achieve attribute	60	80	100	100		93
		Well-defined processes & criteria	0.1	Effort required to achieve attribute	60	80	100	100		75

Table 10-4. Architecture 2 Scoring Results.

Insights from Architecture 1 and 2 Evaluations

As a result of the initial effort with the first two architectures, several design considerations come to light. First, the process-focused architecture could benefit significantly in the implementability attribute if some additional structure were to be imposed that would provide for a better product structure in the interface between the enterprise and the external environment. This is true for all of the reasons cited as strengths under the product-focused architecture description.

On the other hand, the product-focused architecture clearly suffers from the lack of a unifying process construct that would facilitate the enterprise behavior characteristics desired by a large majority of the decision makers. The benefits derived from this scenario are those extolled by the process-focused architecture. An obvious solution would be to merge the two architectures together.

The question is how to proceed down this line of reasoning. Is it best to try to modify the process-focused architecture with Architecture 2 inputs or the other way around? To answer this, the basic functions of the architect are revisited: manage complexity, reduce uncertainty, and drive out ambiguity. With these goals set clearly before the alternatives, the decision to stick with a process-focused architecture is the obvious choice.

By integrating the enterprise efforts under a single process, the potential for confusion between enterprise organizations and activities is significantly reduced and minimized. A single process also provides for a clear path toward continuous process improvement activities that would be significantly more difficult to achieve if the processes were fragmented down product lines. In a sense, you would give up the advantage of what would hopefully turn into standardized work, eventually reaching the point where the FAA could codify it into regulation because it produced such excellent results.

Uncertainty becomes an interesting parameter because in this case, the local uncertainty for each product platform will actually be increased by going to the process-focused architecture; however, the overall enterprise uncertainty should go down. How does this work? If each UAS platform had the flexibility of pursuing its own means and methods in pushing maneuver back onto its aircraft, the case can certainly be made that the local uncertainty will get less. Consider,

however, the impact on the broader enterprise. As each UAS platform pursues this policy, the lack of a strong top-down driven process means that each platform could elect to take different approaches and equipage paths for reaching the next desired increment in operational flexibility. At the enterprise level, this proliferation in the approaches actually causes the overall uncertainty to go up since it is no longer clear that consistent implementations of algorithms, sensor technologies, redundancies, or procedures are rigorously transferred between UAS systems. This is a significant driver of uncertainty, especially for the FAA decision makers engaged in the enterprise. Architecture 1 is much more conducive to accommodating an approach to resolving these types of issues than the product-focused architecture will be.

The issue of driving out ambiguity is actually a wash between the two architectures. On the one hand, a single collaborative process drives out ambiguity by denying the opportunity for multiple forums to exist that could work at cross-purposes to one another. Alternatively, the clear focus on a specific UAS platform and the issues dominating the delivery of additional operational flexibility also has the potential to drive down ambiguity since the objective and outcome are so tangible and immediate.

In light of these considerations, the process-focused architecture was considered the better candidate for providing the overall enterprise structure. The platform-focus from the second architecture must then be interjected to strengthen the external interfaces and meet the implementation constraints. The approach ultimately arrived at for this convolving of the two architectures was to specify the individual UAS platforms under consideration, and explicitly call one of them out to serve as the pathfinder for the others. To mitigate against potential bottlenecks in this approach, off-ramps onto one or more of the other UAS platforms will be planned into the enterprise strategy to keep the activity flexible and moving forward.

With the issue of combining the strengths of the first two architectures resolved, the only other question remaining is whether or not they both collectively missed anything important that needs to be filled in. This is where the benefits of having to roll up the sleeves and actually plumb the depths of each supporting object within the various views and attribute processes pay dividends. The insights into the interactions between supporting objects, attribute processes, and views

provides a much richer understanding of the dynamics in the system than would otherwise be possible.

As a result of the previous two architecture builds, and alluded to in the discussion of Architecture 1 shortfalls, it is apparent that a key object is under-emphasized from the "points of leverage" stack—standards. Upon further reflection at the mechanisms level, however, and the continual questioning of whether there were other possible concept fragments that could be interjected to either enhance, replace, or provide a substitute for an existing mechanism, standards emerged as a dominant mechanism. In fact, on further reflection, the standards object was actually removed from the mechanisms tradespace and turned into a constraint.

The rationale for doing this is straightforward. Recall, the purpose or intent of the enterprise is to restore the principle of maneuver to the specific UAS platforms under discussion. Previous efforts, such as those undertaken by the JIPT, actually pursued the development of standards as the primary objective of the effort. Ultimately, this confuses the means with the ends. To drive out ambiguity and provide a clear delineation in roles and responsibilities, the development of standards is placed cleanly within the FAA's historical regulatory role, and is removed from active pursuit by the airspace integration activity. Doing this helps keep the enterprise effort well-focused, and it re-establishes some of the organizational discipline needed for the activity to be successful. While the enterprise efforts will most certainly contribute in an extensive way to the development of standards, the pursuit of them should not be an objective of the enterprise. This is likely another point within the current JIPT structure that is frustrating efforts at building better cooperation and collaboration between the various organizations engaged in the activity. Figure 10-9 illustrates the end-to-end result of this integrated architecture.

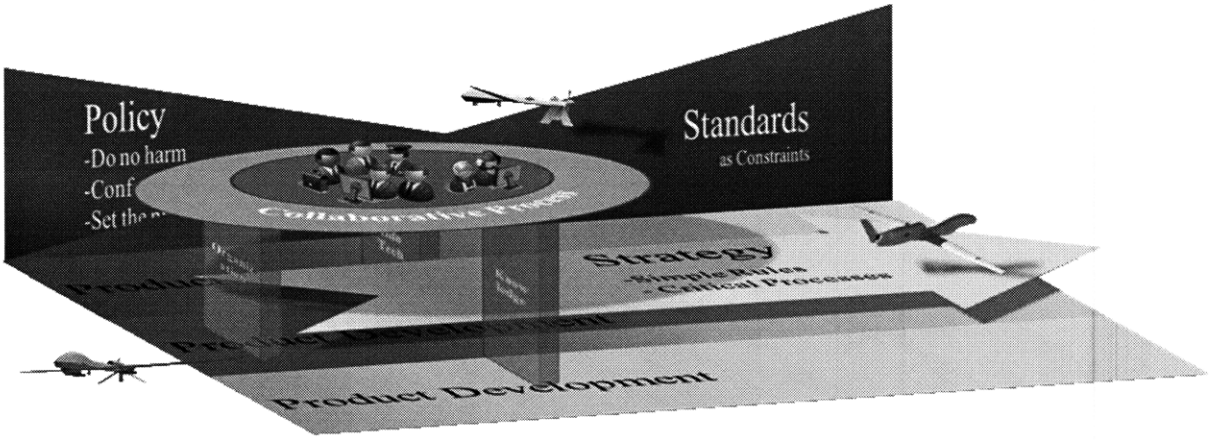


Figure 10-9. Product-Informed Process Enterprise Architecture.

Architecture 3: Product-Informed Process

The results of the Architecture 3 evaluation scoring are shown in Table 10-5. As would be expected, the integration of the previous two architectures' strengths and the inclusion of the standards as additional constraints resulted in appreciably higher Enterprise Performance and Behavior scores and a better overall confidence rating for achieving them. For comparative purposes, the primary sub-category scores for all three architectures are presented in Figure 10-10. The baseline data is an assessment of the previous JIPT effort. Note that this comparison is not a true apples-to-apples comparison. In the case of the JIPT baseline, the effort was actually attempted with historical results. Furthermore, it was never architected in the sense the other three alternatives have been. This results in "double jeopardy" for the JIPT baseline performance evaluation scores.

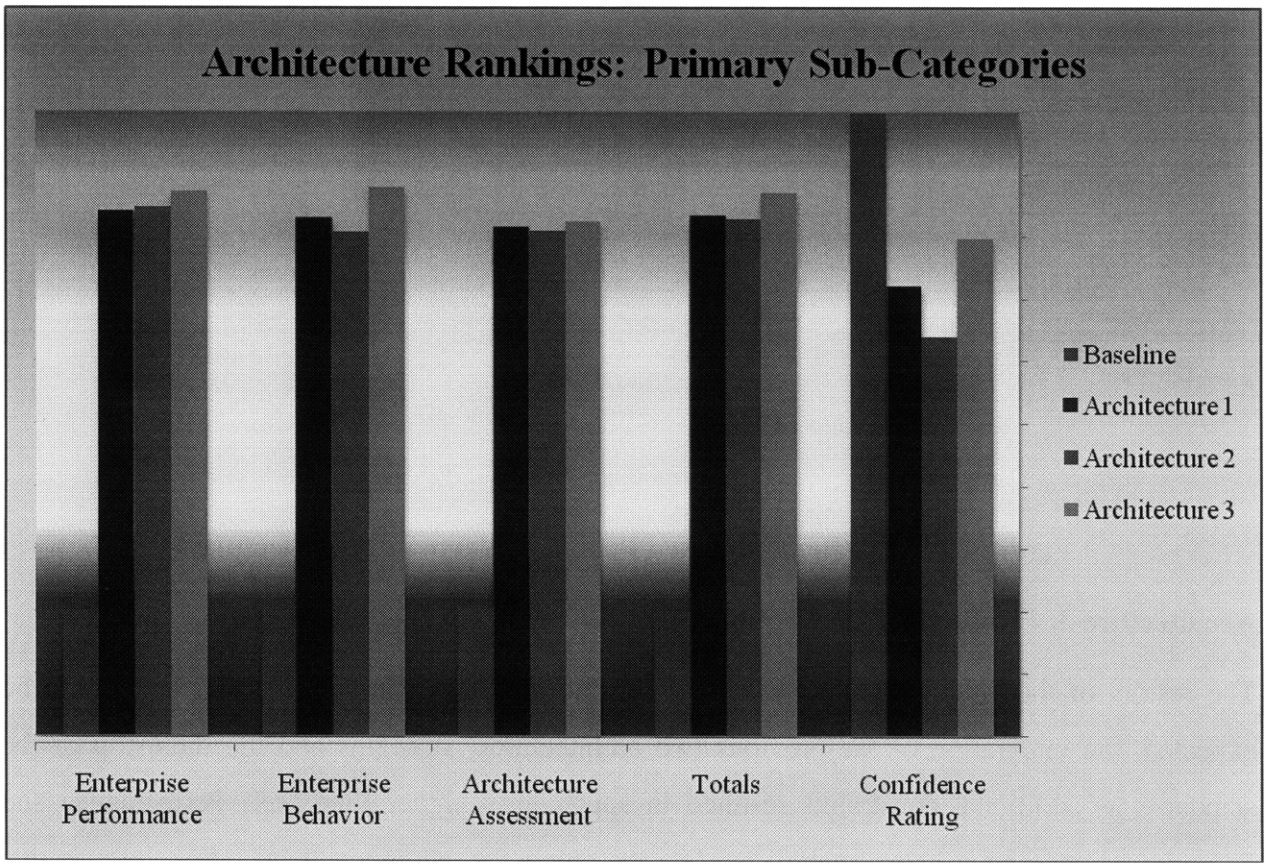


Figure 10-10. Comparisons of Alternative Architectures Scoring Results.

Airspace Integration Architecture #3										
Product-Informed Process Architecture										
Overall Architecture 3 Rating:									0.871	
Overall Architecture Risk:									0.798	
Node	Cap.	Attributes	Wt.	Measures of Performance	Threshold				Initiative Eval	Score
1										
Enterprise Performance			0.52		0.2	0.8	1			
0.874					LMV	GE	MDM	BL		
1	Enterprise Performance Metrics		1							
	1	Safety 1	0.16	# of Accidents per Flight Hour	1E-05	1E-07	1E-09	0.00001		1.44E-07
		Safety 2	0.16	# of ATC deviations per Flight Hour	0.1	0.01	0.001	0.1		0.00183333
		Capacity	0.2	# of exceptions per approval	20	10	0	20		2
		Capability	0.2	% missions achieved vs requested	80	95	99	80		98
		Ops Flexibility	0.28	Time to coord/approv mission (days)	60	1	0.05	60		7
Enterprise Behavior			0.38							
0.879					LMV	GE	MDM	BL		
1	Enterprise Behavior Metrics		1							
	1	Implementability	0.28	Scope matched to budget, resource (% match)	20	80	100	10		94
		Cooperation	0.17	Extent people feel their perspective is addressed (% addressed)	50	80	100	25		91
		Engaged Leadership	0.17	% enterprise leaders committed to UAS success	20	80	100	25		80
		Clearly Defined Activities, Scope	0.14	Extent of enterprise alignment (%)	20	80	100	20		80
		Well-defined processes & criteria	0.24	% work done by standard processes,	20	80	100	35		89
Architecture Assessment			0.1							
0.826					LMV	GE	MDM	BL		
1	Architectural Checks		1							
	1	Logically Correct	0.2	OPM completeness for architecture description	20	80	100	20		82
		Provides Desired Capability	0.3	Degree to which architecture satisfies decision makers	50	80	100	10		82
		Decomposition maps to team, stations, and flows	0.3	Degree to which supporting process and objects "fit" at interface	20	80	100	45		84
		Adheres to "Architectural Principles"	0.2	Extent to which complexity, ambiguity and uncertainty are managed	20	80	100	10		82
Confidence Rating										
0.798			1		Low	Med	High	BL		PoPs
1	Risk: Confidence in achieving the desired enterprise attributes		1							
	1	Safety 1	0.1	Effort required to achieve attribute	60	80	100	100		70
		Safety 2	0.1	Effort required to achieve attribute	60	80	100	100		63
		Capacity	0.1	Effort required to achieve attribute	60	80	100	100		86
		Capability	0.1	Effort required to achieve attribute	60	80	100	100		91
		Ops Flexibility	0.1	Effort required to achieve attribute	60	80	100	100		84
		Implementability	0.1	Effort required to achieve attribute	60	80	100	100		96
		Cooperation	0.1	Effort required to achieve attribute	60	80	100	100		96
		Engaged Leadership	0.1	Effort required to achieve attribute	60	80	100	100		80
		Clearly Defined Activities, Scope	0.1	Effort required to achieve attribute	60	80	100	100		86
		Well-defined processes & criteria	0.1	Effort required to achieve attribute	60	80	100	100		100

Table 10-5. Architecture 3 Scoring Results.

Final Architecture Description

Implementing the third architecture will result in all of the previously described characteristics, both for those elements combined out of Architectures 1 and 2, and the additional payoff associated with including standards as a major constraint in the activity base. For the purpose of bringing the final architectural description to some semblance of a conclusion, however, a brief summary of the critical elements are presented below.

Policy

Policy is a major constraint that must be satisfied by the architecture in this design effort. Policy mandates that solutions conform rather than create, do no harm, and set the precedent for other nations. In addition, standards are considered the purview of the FAA, and will enter the enterprise sphere only from the standpoint of how they enable or limit the ability to provide another increment of useful operational flexibility to the enterprise. Data and knowledge generated in the pursuit of restoring maneuver to the UAS platforms under consideration should provide a basis for the FAA to move forward in the standards arena, but this will not be an objective of the enterprise.

Strategy

A simple rules strategy should be employed to guide the overall direction and pace of enterprise activities (in conjunction with the previously described strategy for unifying senior leadership value perception of restoring the principle of maneuver). Implementing a simple rules strategy that is anchored in a couple of critical processes will provide the needed flexibility to adapt to a highly dynamic external context; a context with changing budget, manpower, and operational priorities. It is also a context in which there are very few discrete known's against which to plan. The rapid pace of changing priorities, the evolution in technology and CONOPs, and unknown performance standards make this a highly uncertain environment in which the enterprise must consistently make headway.

Process

Path dependencies dominate the internal enterprise landscape. The surest path through these potential landmines is with the implementation of a single, integrated process that results in a highly collaborative environment that is open and transparent across the entire enterprise. The

'Process' view is the primary driver in many of the Enterprise Behavior attributes, and the extent to which the enterprise makes establishing collective, agreed upon criteria for resolving issues and plotting a way forward a priority will determine the long-term effectiveness and efficiency of the enterprise activities.

Product

Putting the technological poweress behind building a UAS platform with the kind of materiel equipage needed for useful gains in operational flexibility is the foundation on which the enterprise as a whole will move forward. In the end, no matter how good the strategy or collaborative the process, if the materiel capability is not up to the task, the objective of increasing the operational flexibility of these assets within the NAS environment will ultimately fail. The important point to remember is that this product development activity must be accomplished in a fundamentally different way, employing a time-pacing schedule that consistently pumps out incremental improvements for further testing and data collection. The extent and frequency of these releases can be directly regulated by the constraints imposed by current budget and manpower limitations. Focus on a single platform initially and build out from there.

Organization

The basic organizational structure of the current JIPT effort is fundamentally sound, but should be reoriented off of a standards focus and onto an operational flexibility approach. Active steps should be taken to reduce the total number of organizations involved in the effort (resolved by down scoping the enterprise to that recommended in this analysis). Additional effort should be expended to create a common model that can be shared across organizational boundaries to clarify language and information that is communicated over both geographical and cultural divides.

Knowledge

Information and data must be deliberately structured and then routed through the enterprise in a way that fosters transparency and collaboration. It should become the ultimate "currency of the realm," but for this to happen, the previously described 'Process' and 'Strategy' views must be instituted so these critical decisions can be made and implemented.

Information Technology

Information technology is the highway over which the information and data in the 'Knowledge' view will travel. It is also through this mechanism that many of the important external interfaces with budget, manpower, and political sources are made. In many cases, the effectiveness of IT is not measured by what is happening as much as by what is not happening (i.e. losing budget, manpower, political capital because information can't flow where and when it needs to.)

This summarizes the overall "look and feel" of the enterprise when Architecture 3 is implemented in the way envisioned by the architect. The only remaining consideration is how best to move from our current position to the one described by the future vision state embodied in this architecture, the subject of the final chapter in this section.

Chapter 10 Summary

The QFD analysis of the enterprise architecting views mapped to the enterprise attributes revealed the importance of four views in particular to the UAS airspace integration challenge: 'Strategy', 'Policy', 'Process', and 'Product'. Further analysis suggested that 'Policy' be treated as a constraint and held constant while 'Strategy' emerges as a result of choices in the 'Process' and 'Product' views. The result is an active trading of 'Process' and 'Product' design alternatives that give rise to a specific strategy needed to implement them. Two alternative architectures resulting from this exercise provided the additional insights needed to generate a third optimal design with good performance and behavior delivery and a reasonable confidence level in achieving the results.

CHAPTER 11 – UAS ENTERPRISE TRANSFORMATION PLAN

"Principles become modified in practice by fact."

—James Fenimore Cooper

Up to this point, the discussion has centered around the theoretical and conceptual development of a process for rigorously driving value into alternative enterprise architectures. This final chapter in the application section describes the specific issues that need to be considered and the actions required to take the enterprise from its current state to the realization of the enterprise architecture selected in the previous chapter. This is ultimately where theory must contend with what happens in the real world. The chapter will start with a detailed discussion of the actual recommendations, and then conclude with the broader enterprise transformation roadmap considerations. The approach taken is consistent with the methodology described in Chapter 7.

Connecting the UAS OPM with the Enterprise Transformation Roadmap

The OPM model is provided again in Figure 11-1. Note, however, that the "Points of Leverage" stack is now color-coded. The previous discussion on sensitivity and tradeoff points can be used to help formulate the transformation plan by identifying which mechanisms provide the greatest degree of leverage on enterprise value delivery. The red-filled supporting objects represent those that are critical tradeoff points within the architecture and the lack of which will almost certainly lead to enterprise failure. The yellow-filled supporting objects are those objects that are important to the successful realization of the architecture. They may represent less critical tradeoff points or they may be sensitivity points with fewer connection points to other attribute processes. Without the successful implementation of these important objects, it will be very difficult for the enterprise to achieve the desired end-state. The green-filled supporting objects are those things that should be relatively straightforward to implement, and at the same time, will not make or break the transformation plan. The blue supporting objects are largely secondary in nature, but without them, the delivery of the desired enterprise attributes will be difficult. In other words, in and of themselves, these objects do not necessarily contribute to the advancement of primary enterprise attributes, but without them, key attributes cannot be secured.

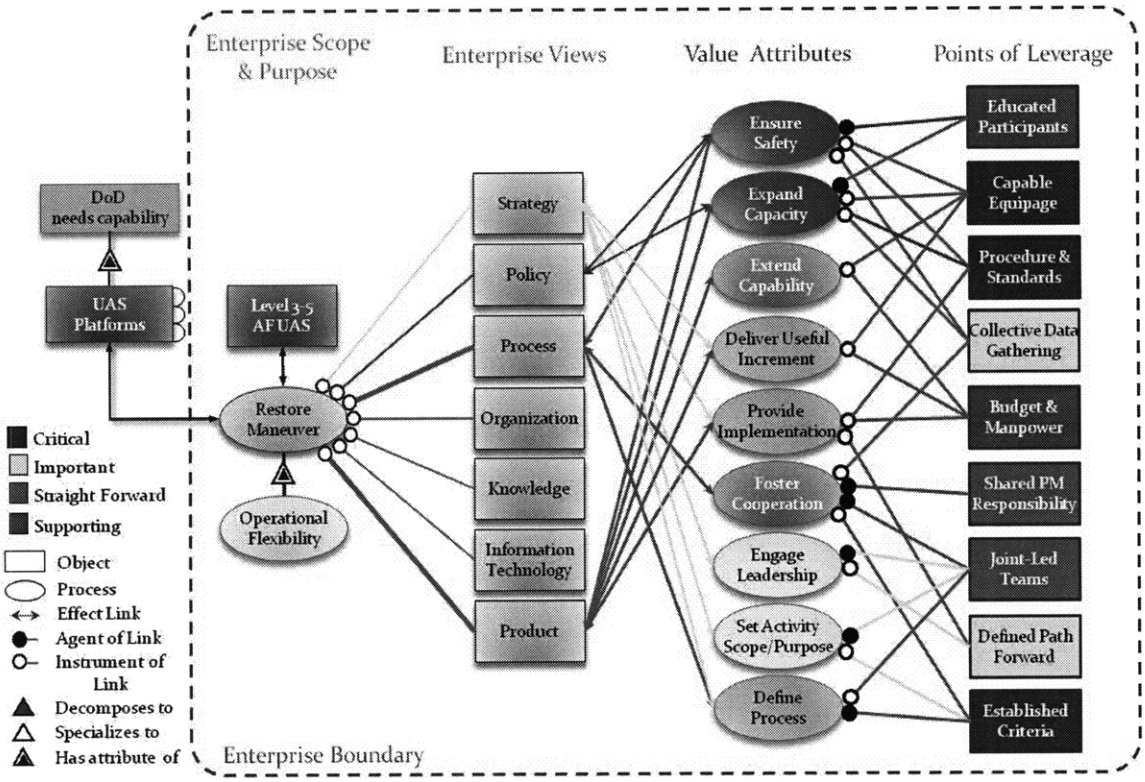


Figure 11-1. Using the OPM View to Identify Sensitivity and Tradeoff Points.

Harkening back to the discussion in Section II of this research in reference to the analytical methodology used to conduct architecture evaluations, the transformation plan is a scenario under which certain actions and priorities will be assigned in order to achieve a specified outcome. [14] Just as these scenarios were combined with the various architectural alternatives to identify sensitivity and tradeoff points, these same tradeoff and sensitivity points can now be reused to generate the "transformation plan" scenario, essentially running the methodology in reverse. The interactions between the various components of the analysis from Section II are depicted below in Figure 11-2 for quick reference. [14] Notice that when the assessment is conducted for creating and evaluating alternative architectures, the result of the analysis produces insights into the sensitivity and tradeoff points as well as the risks. For the purpose of the transformation plan, reverse the arrows and conduct the analysis in the other direction, using the sensitivity points, tradeoff points, and risks in conjunction with the selected architecture to create the transformation plan scenario (or scenarios if the degree of uncertainty warrants multiple decision paths). This is the underlying motivation and basis for how the supporting objects are categorized in the above architecture description.

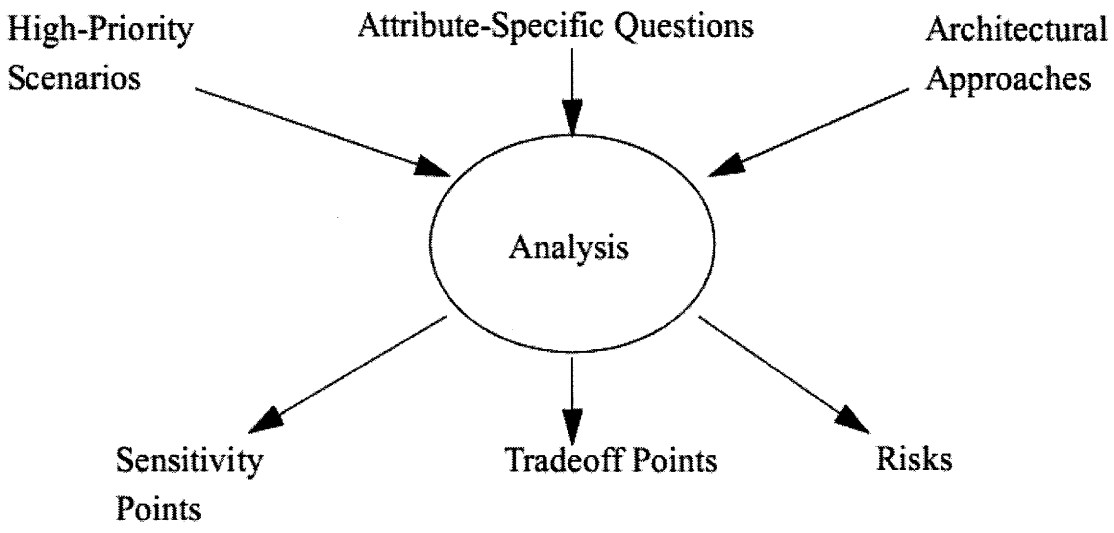


Figure 11-2. ATAM Concept Interactions.

The final element needed to implement a transformation plan is to connect the results from using the sensitivity points, tradeoff points, risk assessment, and enterprise architecture to the Enterprise Transformation Plan first introduced in Chapter 3 and reproduced below in Figure 11-3. The broader Enterprise Transformation Plan provides the bigger picture considerations that need to be integrated into the transformation plan while the specifics that arise out of the above architectural analysis provide the details that need to be addressed explicitly by the transformation plan. Recall, the enterprise architecting activities primarily fall within the "Planning Cycle" steps of "Understand Current State" and especially "Envision & Design Future Enterprise." The remainder of the Enterprise Transformation Roadmap provides the broader elements needed to implement a full-bodied plan.

This completes the linking of the Enterprise OPM and architecture selection results with Enterprise Transformation Roadmap plan methodology. To recap, the ATAM approach using the specific information out of the architecture generation OPM is used to assess and pinpoint the high-leverage sensitivity and tradeoff points in the architecture. These in turn are combined with the identified risks and architecture to layout the scenario-specific elements that need to be explicitly addressed in the transformation plan. These enterprise specific call outs are then integrated into the broader Enterprise Transformation Roadmap framework to ensure any remaining considerations are addressed and included in the transformation plan.

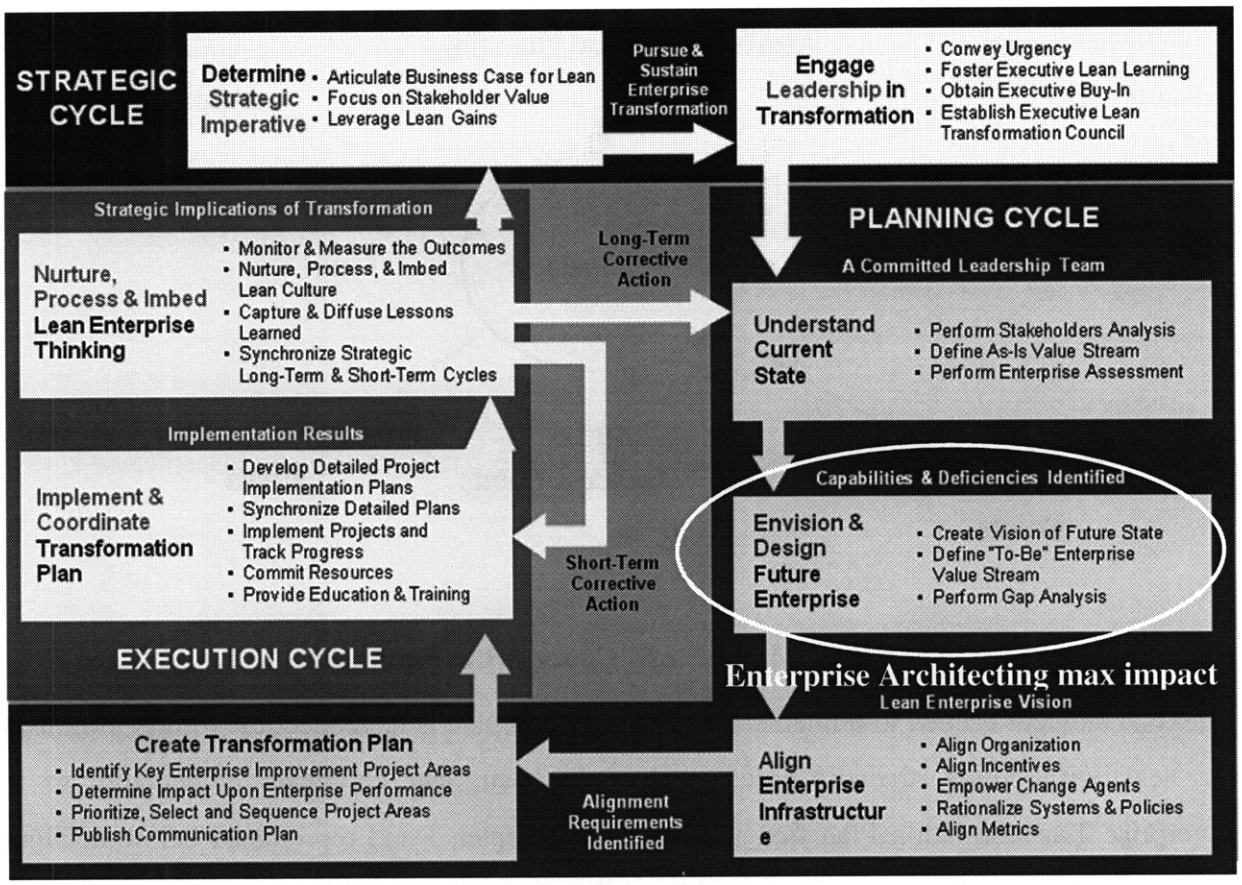


Figure 11-3. Enterprise Transformation Roadmap.

Enterprise Transformation Plan

The above discussion on linking the OPM and enterprise transformation roadmap might suggest a cleaner process than is actually the case. Both the Enterprise Transformation Roadmap as well as the Enterprise Architecting endeavors are inherently iterative in nature, and will overlap in terms of the material and content covered under each. Recall from Chapter 7 and the broader framework for enterprise transformation, the discussion of the transformation plan will start with the Enterprise Transformation Roadmap, and then dive into the details of the Enterprise Architecture and OPM to feed in the needed information in the "Planning Cycle" phase of the Roadmap. In reality, there is significant interaction between these two frameworks, and in the end, it isn't nearly as important to maintain the distinction between which framework supplied what information as it is to ensure a fully integrated transformation plan results from their use. Details for each of the Enterprise Transformation Roadmap steps will now be detailed to provide the level of details needed for an effective plan to be created.

Planning Cycle

The transformation plan for the airspace integration enterprise actually starts with the "Planning Cycle" instead of the "Strategy Cycle." The reasons for this are twofold. First, the effort has a major shortfall in the "Strategy Cycle" portion of the Roadmap as identified by the interview data citing the lack of leadership commitment and engagement as a major barrier to enterprise success. Second, since the previous 100 pages in this report have been devoted to primarily the front-end of the "Planning Cycle" for the UAS AI enterprise, it makes sense to pick up from the Enterprise Architecting discussion at this point, especially since the Roadmap itself is intended to represent a repeating cycle and the point of entry is less of an issue anyway.

The Enterprise Architecting effort has effectively addressed all of the issues presented under the "Understand Current State" and "Envision & Design Future Enterprise" subtasks. The next step requires the enterprise infrastructure to be aligned. Each of these tasks is discussed in turn.

Align Enterprise Infrastructure

To align the organizations involved in the enterprise, several of the key architectural considerations highlighted under the value structure and contextual assessments in Chapters 9 and 10 come to bear. First, the overall scope and number of active participants in the activity should be cut down to less than ten total, and preferably something closer to six or seven. The recommendation out of this analysis is obvious. Down scope the activity to looking at a single platform and then engage just those organizations needed to directly address that particular platform. Given the nature of the current funding situation and the available size, weight, and power (SWaP) margins, the RQ-4 Global Hawk provides the easiest platform on which to begin building capability. It is also the one with the greatest training and operational needs associated with existing mission requirements. Once these decisions are made, and the enterprise is re-scoped according to the purpose statement provided in this report, there should be good alignment in the organizations involved in the enterprise.

Aligning incentives is somewhat more problematic since the usual tangible kinds of incentives are not necessarily transferable to the government sphere. The best that can be done without broader leadership engagement in this area is to once again re-scope the enterprise purpose statement in a way that provides for positive value delivery to each organization in the enterprise.

Organizations should then be incentivized by the fundamental value proposition. Outside of the value delivery mechanism, it is difficult to see how the various stakeholders in the enterprise might be provided with additional incentives.

Empowering change agents will need to occur in several different forums and with various spans of influence. Initially, change agents will likely have to be content with focusing on those things that do not require significant capital investments or expenditures. In this regard, the collaborative, process-focused architecture chosen for the enterprise architecture provides a natural venue in which to establish many of these kinds of changes. The structure of the enterprise itself is an accommodating environment for process and operational innovations in the way the effort is pursued, and the collegial nature of the enterprise should provide a receptive forum for presenting, discussing, and implementing changes when and where they make sense. As the scope of the activity increases, and additional resources become available, the magnitude of the changes that are realistic should also grow. This may start to influence infrastructure and even organizational placement into more geographically central locations to further facilitate the work. Initially, the enterprise should identify at least one individual from each organization that will serve as a change agent champion to the enterprise leadership. Once the governance issues have been resolved, a consistent process for floating up proposed changes and having them acted on will provide the needed implementation for these change activities.

Rationalizing systems and policies as well as aligning metrics are resolved inherently within both the architecture and the X-Matrix. The architecture provides for the establishment of decision criteria and processes by which to resolve enterprise decisions. The X-Matrix provides the alignment between the values, key attributes, and metrics needed to drive enterprise behavior consistently toward the strategic objectives. These will not be reproduced here given their fuller development in Chapter 9.

The take away from the discussion on alignment is that the architecture itself should provide the fundamental structure under which the organizations, incentives, and metrics fall into place. If the architecture is not providing that level of concrete guidance, the architect should revisit the architecture and consider if there are not important supporting objects or attribute processes that may be missing from the architecture. This should have been caught when the architect

evaluated the architecture against the appropriate key attributes, but this higher-level perspective may bring out operational aspects of attempting to implement the architecture that may not have come to the forefront when the architecture was evaluated simply with respect to the key attributes specified by the enterprise.

Create Transformation Plan

The backbone of the transformation plan grows out of the methodology described in the first part of this chapter. Using the OPM and the ATAM methodology to identify the sensitivity and tradeoff points in the architecture, and then categorize them appropriately, the important supporting objects can be captured and addressed in the transformation plan. Figure 11-4 and Figure 11-5 capture the details of supporting element dependencies and time phasing.

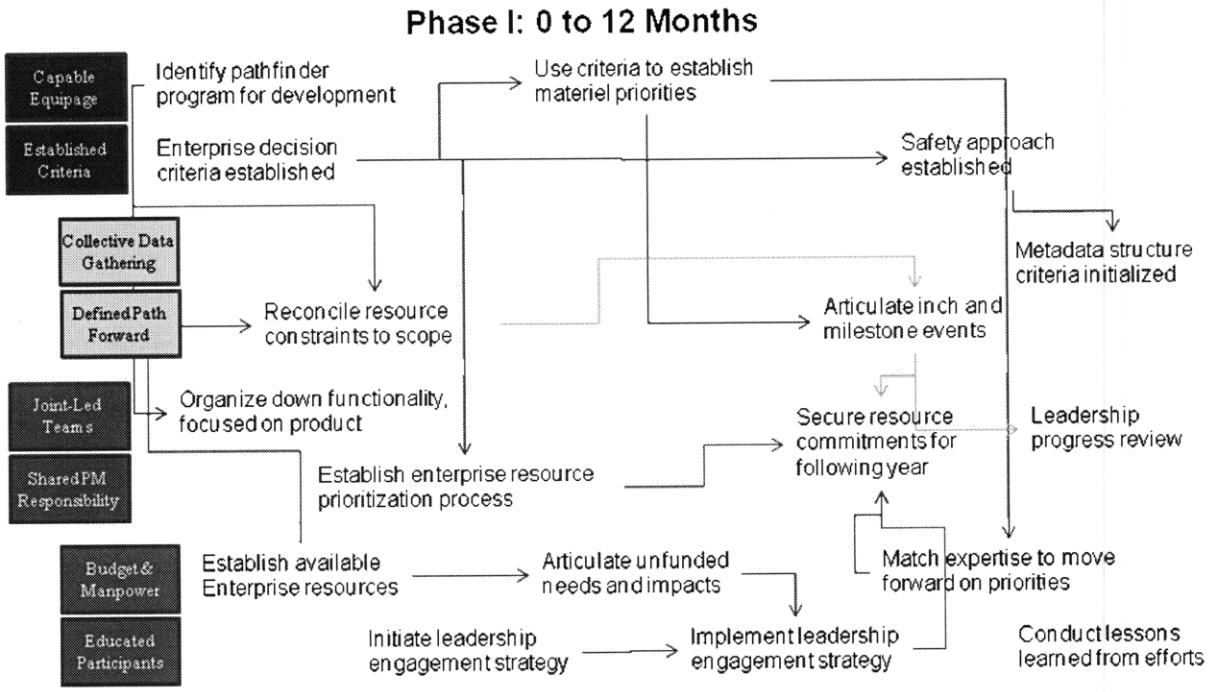


Figure 11-4. Phase I of the Transformation Plan.

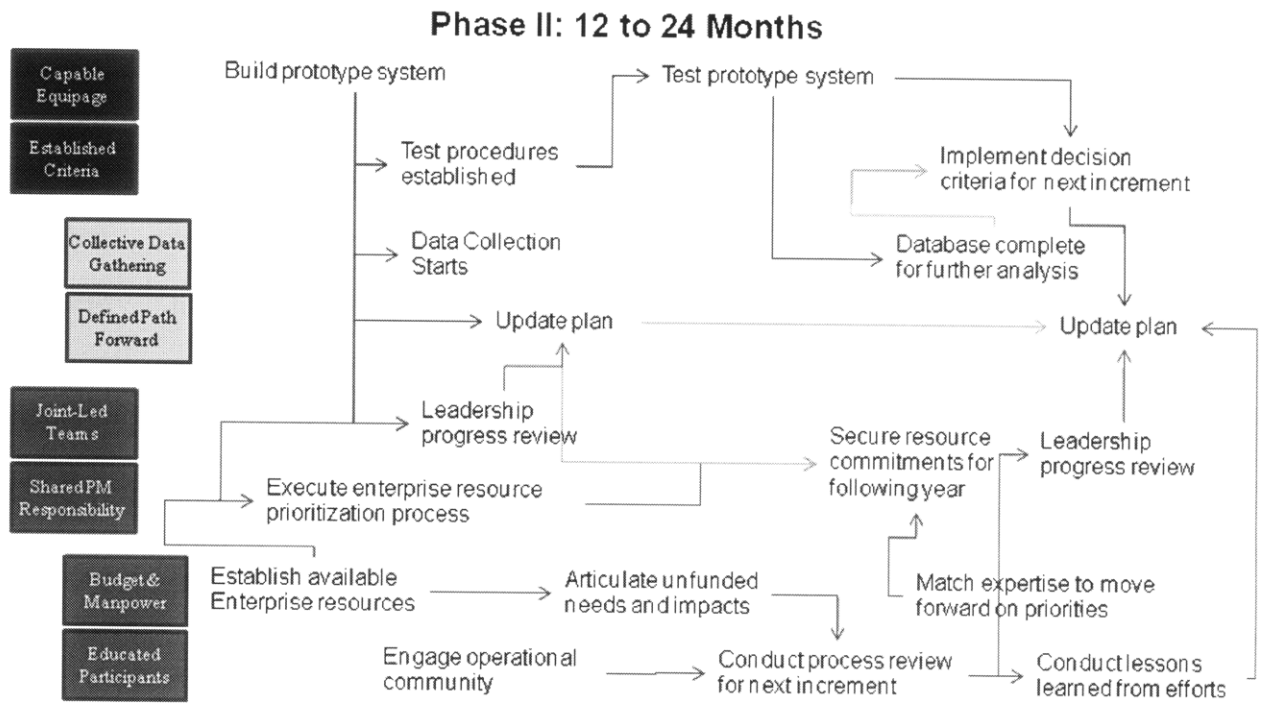


Figure 11-5. Phase II of the Transformation Plan.

Several general points are in order prior to delving into the details of the transformation plan. First, in keeping with the process-centric enterprise architecture, the 24-month plan depicted in Figure 11-4 and Figure 11-5 is a repeated cycle. The 24-month clock speed is designed to interface with the primary DoD budget cycle that occurs on every even year, the issuing of the Program Objective Memorandum, or the POM. This provides the primary mechanism for new budget requests to be vetted through the DoD budgeting process and included in the budget request sent to Congress.

In addition, putting the enterprise on a 24-month time-paced calendar will provide a greater sense of urgency in pushing gains in equipage and procedures implemented and tested. This incremental release philosophy is essential to the long-term success of the enterprise based on the interview data and information collected on the nature of how the FAA builds the experience and information base needed to expand the operational flexibility of aircraft flying in the NAS.

The other obvious reason for implementing a transformation plan that is a recursive process is because in the current context, it is not at all clear what the ultimate product requirements or use

context will ultimately be. Under these kinds of uncertainties, it is impossible to specify what the final details will look like, but the method employed to arrive at them may be.

A description for how each of the supporting elements in the transformation plan will be implemented can now be undertaken. Capable equipage is secured through the targeted application of technology on the RQ-4 Global Hawk to begin the first 24-month cycle. The specific objectives of this initial two-year cycle will be to conduct the appropriate technology survey, and select the most promising candidates for further development. The approach that should be taken for this effort should be one of "incremental commitment." The Incremental Commitment Model (ICM) is an approach detailed in a recent National Academies commissioned study conducted by the Committee on Human-System Design Support for Changing Technology. [110] The overall approach is further developed and a decision method presented using the ICM by Dr. Boehm at the University of Southern California Center for Systems and Software Engineering. [111] The ICM is based on five fundamental principles deemed critical to success for human-system integration efforts such as the UAS airspace integration effort. These are enumerated by the Committee on Human-System Design Support for Changing Technology and detailed below:

1. Satisficing of system stakeholders (e.g., users, acquirers, developers);
2. Incremental growth of system definition and stakeholder commitment;
3. Concurrent system definition and development;
4. Iterative system definition and development; and
5. Risk management.

A full implementation of the ICM with the associate decision method described above is beyond the scope of the existing transformation plan, but the details are well-aligned with the needs of this effort and should be examined in detail for further actions to take beyond those called out in the Phase I and II diagrams provided in Figure 11-4 and Figure 11-5.

"Establish Criteria" is the next critical supporting object. The collaborative process at the center of the enterprise architecture should provide the venue in which to secure early and continuous enterprise stakeholder buy-in and implementation of these criteria. This should be the first priority within the transformation plan. Without clearly established criteria, the enterprise will

be crippled in its decision-making abilities. The collaborative process instituted by the enterprise should make the review and validation of decision criteria a part of the regular review cycle. Furthermore, these criteria need to be clearly documented and communicated to the entire enterprise activity to allow for the effective use of the prescribed "simple rules strategy" articulated in Chapter 10. The mechanics of creating these criteria require the enterprise leadership to meet and spend intensive time collectively discussing and agreeing to these criteria. This should be accomplished through one or more off-site meetings without the distractions of other work or issues diluting the effort.

"Collective Data Gathering" was detailed earlier as an element within several attribute processes. From an implementation standpoint, the process for how safety will be assessed, the questions that will need to be answered, and the allowable data collection and validation procedures all have to be defined before the specifics of which data needs to be collected can be determined. Reference to the Phase I and II plan will demonstrate the dependencies associated with this activity.

"Defined Path Forward" is the second priority the enterprise must undertake. This is essential for two reasons. First, generating broader leadership engagement and advocacy for the effort will be impossible without a clearly articulated plan for how the desired operational flexibility will be achieved. Interviews with several of the enterprise decision makers brought this point out with considerable force and clarity. Second, securing the needed budget and manpower cannot proceed without a clearly defined set of objectives and deliverables against which money and manpower can be committed. This dovetails back into the "Capable Equipage" block and the need to implement the ICM to create a tractable problem that can be appropriately scoped and implemented for the available resources. Once this proverbial "chicken-and-egg" problem can be dealt with, positive reinforcing loops can grow and expand the effort.

"Joint Led Teams" and "Shared PM Responsibility" are both supporting objects that already have some legacy with the previous and current efforts in this domain. The recommendation in this transformation plan is to push the degree of shared responsibility and cooperation to an entirely new level of transparency and trust within the enterprise. Both of these actions can be implemented concurrently with the other supporting objects previously discussed and detailed.

In some instances, such as for "Established Criteria" and "Defined Path Forward," the existence of these relationships will provide a better foundation in which to accomplish other tasks. Once again, the nature of how the enterprise establishes these joint teams and shared program management duties should be the subject of early decision criteria and processes.

"Budget and Manpower" largely follow the dictates of the external POM process mentioned previously. The important aspect to this supporting object is to align it as quickly as possible with these external interfaces to ensure the highest probability of securing the needed resources. If this alignment is not achieved quickly, the entire effort may very well be sidelined for another POM cycle (2 years). It is particularly important that the Air Force, OSD, and the FAA all submit mutually reinforcing budget requests through the funding process. On the Air Force side, this should be the budget function attached to the RQ-4 program and ACC/A8. On the FAA side, this should be primarily the AIR-160 office.

"Educated Participants" was discussed at some length in Chapter 10. The basic transformation plan for this element is to begin to engage the assistance of training and educational centers of excellence to pull together the necessary programs and materials to get the word out to as broad a constituency as possible. Some of this is already underway with efforts by both AIR-160 and AJR-36. The UAS experimental aircraft certification report reference earlier also provides a number of excellent recommendations on specific steps the FAA could take in regards to this particular item. [93]

Collectively, the timing and dependencies annotated in Figure 11-4 and Figure 11-5, along with the above recommendations, provides the core to the transformation plan activities that need to occur to initiate a successful enterprise activity. The additional details from Chapters 9 and 10 that further enumerate the specifics within each supporting element provide a comprehensive description of the types of activities that need to be undertaken for significant progress to be made in this arena.

Execution Cycle

The execution cycle provides the first opportunity for feedback on the effectiveness and efficiency of the activities outlined in the transformation plan. As the old military adage says, "No plan of battle ever survives contact with the enemy." [112]

Implement & Coordinate Transformation Plan

The development of detailed project implementation plans, budgeting, and resource commitment will need to be accomplished as the details for the first two-year cycle comes into focus. Specific call outs are made in the Phase I and II diagrams for enterprise-wide reviews and updates in order to secure the needed synchronization and phasing between organizations and activities. Detailed program plans such as the one shown in Figure 11-6 will have to be developed and coordinated to provide a master schedule against which planning and execution can be tracked and measured. Education and training will need to be provided internally to the enterprise to help reduce the inefficiencies that result from the different cultures and perspectives each organization brings to the table.

It is important to point out that the detailed program planning that must be carried out should still be done in conformance with the broader enterprise strategy of implementing simple rules and a few critical processes. The more complex an undertaking becomes the more simple the rules should be for how it is managed. [18] For the enterprise to remain agile and flexible in the dynamic environment of changing budget, priorities and performance objectives, a deliberate effort to guard against "solution lock-in" must be ingrained into the architecture itself. By forcing an incremental delivery every two years, a recalibration of the program can occur on regularly scheduled intervals, providing the opportunity to not only refresh the potential technology applied to the problem, but to re-evaluate the processes and approaches as well.

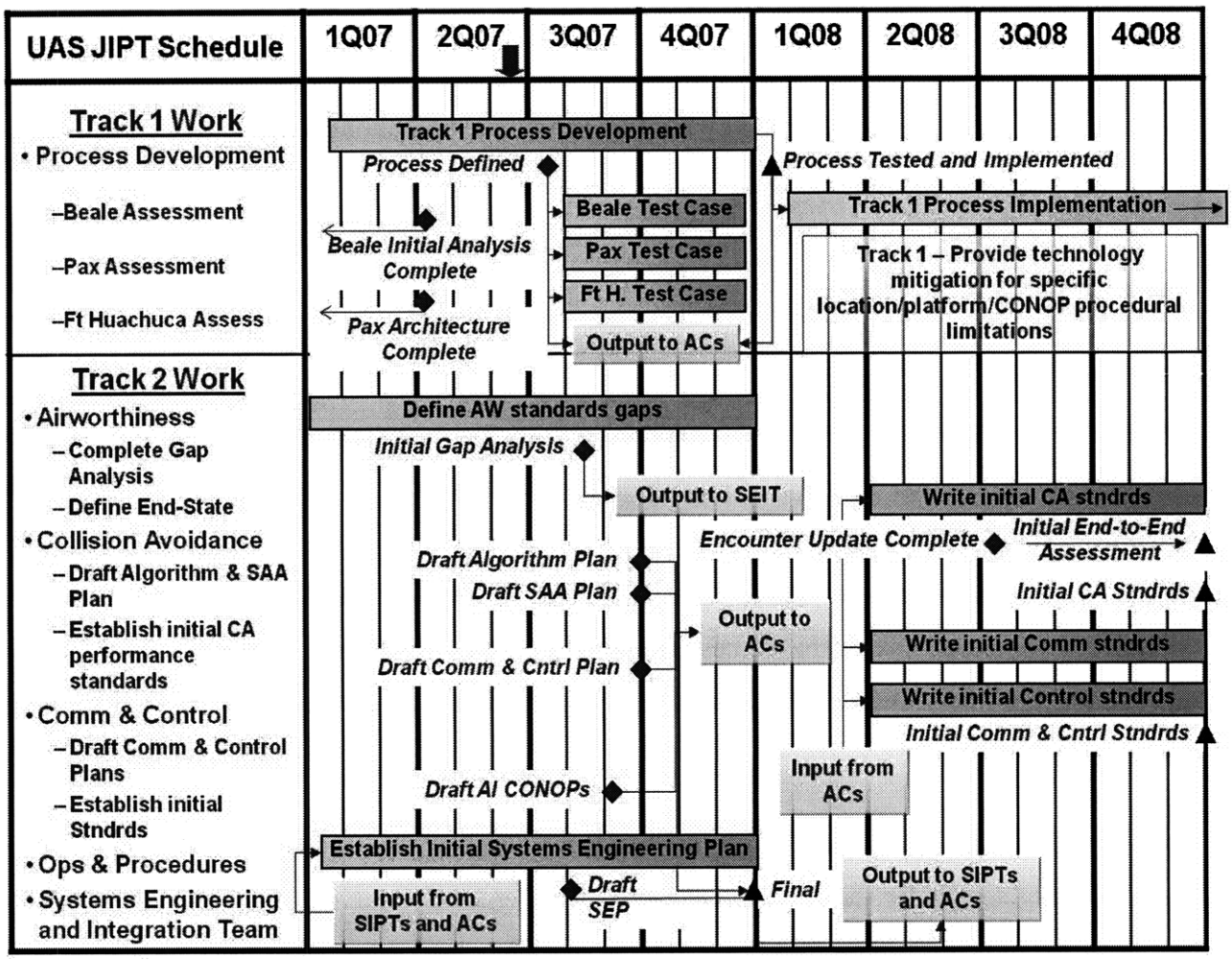


Figure 11-6. Example of Detailed Program Plan from JIPT Effort.

Nurture, Process & Imbed Lean Enterprise Thinking

Once again, because the chosen architecture is an inherently process-based structure, the implementation of lean practices for continuous process improvement and the elimination of waste in the execution of the enterprise activities can be embedded into the enterprise from the ground up. The challenge is to create the culture. The hooks are there and the tools are available, but it is not at all clear that the organizations involved have either the knowledge or the motivation to institute solid lean enterprise practices.

The best hope for successfully integrating lean practices into the enterprise is to conduct value stream mapping for the critical processes that are instituted at the initiation of the effort. If tangible savings and value can be exhibited early and often as the enterprise matures, there is a reasonable expectation that lean practices will take hold. With the appropriate leadership, these

practices can be formalized and the appropriate culture and perspectives cultivated throughout the entire enterprise. Results from these exercises should also be used to close the feedback loops into the strategic and planning cycles to leverage the operational experiences gained on the execution side of the transformation cycle. This will help create the "macro" level process improvement needed through the entire enterprise transformation process, not just within the planning or execution cycles.

Strategic Cycle

The third and final stage in the transformation roadmap is the Strategic Cycle. This aspect of the roadmap details the activity required to determine the strategic imperatives of the enterprise and undertakes to actively engage the enterprise leadership in the transformation process itself. This portion of the transformation plan is a critical element in the UAS AI enterprise and represents a significant source of risk to the successful execution of the enterprise activities. Nearly every decision maker interviewed cited the lack of engaged, committed leadership as a major barrier to the success of the effort.

In this regard, the Enterprise Transformation Roadmap provides a clean way to integrate the issues highlighted under the "Strategic" view of the enterprise architecting effort, specifically, the need to unify the senior Air Force, DoD, and FAA leadership perception of the value of restoring the principle of maneuver to UAS assets based on the contribution made to "enabling global strike." The creation of this strategic level support and active endorsement goes to the heart of the issues previously discussed in Chapter 10.

There are two approaches to building enterprise success in the face of endogenous factors . The first would be to pursue a "bottoms-up" approach by operating entirely within the existing resource constraints and building an initial portfolio of successes. Success breeds success, and if the enterprise can begin to build the reputation of being able to deal with the highly dynamic nature of the problem in a way that provides for meaningful improvements in operational flexibility, all the while adhering to the resource and political constraints surrounding the problem, then the needed leadership advocacy will begin to materialize.

While this "bottoms-up" approach is likely necessary, it probably will not be sufficient in and of itself. The additional "top-down" approach will almost certainly be required to build a durable

effort that will deliver the required value. This "top-down" approach was discussed extensively under the "Strategy" view in Chapter 10, and will not be revisited here. The point is that ultimately, the senior leadership at the "1 up" level from the current enterprise needs to be of one mind on the value proposition proposed by the intent behind "restoring the principle of maneuver" and the contribution it makes to "enabling global strike." They need to subsequently get behind the effort and provide the required advocacy and resource support needed to make incrementally useful value deliveries.

The other key element to this facet of the transformation plan is the need for a communication strategy that is both simple and inclusive. This need was a key observation from the interview data, and it provides some insight into the lack of more energetic leadership engagement on the subject to date. One interviewee surmised that one of the reasons there was not more leadership involvement on the topic of airspace integration was due to the complexity of the problem and a lack of a clear, actionable plan that leadership could understand, articulate, and push further up the command structure. The enterprise architecting effort conducted here should provide the needed clarity on the issues and what needs to be done to address them. By providing the information in this analysis in a format that enables senior DoD and FAA leadership to fundamentally understand and articulate the issues, the degree of leadership advocacy and buy-in should expand considerably, even in the short-term.

Once this has been accomplished, hit "repeat" and start over again at the planning cycle stage to reassess the current state and see what adjustments need to be made in order to keep the enterprise moving forward toward the objective of restoring maneuver to UAS operations. In addition, also recall that the transformation plan should be structured in such a way as to provide stable intermediate forms along the change path. These stable intermediate forms should be the starting point from which each two-year cycle begins the planning phase of the process. Because the context is in such a dynamic state, calling out the specifics of each of these states would not only be impossible, but it would also defeat the purpose of having an iterative process in which to work out the details of what these should look like as the system and enterprise evolves.

In conclusion, it should be pointed out that in reality, the Enterprise Transformation Roadmap can be started in either the Strategic Cycle or the Planning Cycle, at least in terms of the analysis

conducted for the UAS AI problem. There are advantages and disadvantages to each. In reality, both stages would likely need to be implemented concurrently so that the senior leadership value perspective on the UAS AI problem could be aligned even as small, incremental successes are claimed as proof the enterprise architecture is both valid and executable.

Barriers

Before concluding, a brief note on barriers to the transformation plan is in order. Recall that an extensive discussion of enterprise barriers was presented in the discussion of the data analysis collected from the interviews conducted with enterprise decision makers. All of these barriers are relevant to the discussion here, and the previous recommendations largely addressed the most significant of these barriers. More to the point is the existence of transformation specific barriers not addressed by the previous discussion.

The largest transformation related barrier that will need to be overcome is the perception among many that the time and effort focused on "process" is wasted energy that would be better spent actually getting things pushed out the door. This was touched on previously under the "Execution Cycle" discussion. It will be imperative that this mindset and attitude be countered with effective and tangible examples of lean enterprise practices at work.

Consolidated List of Research Findings and Near-Term Recommendations

A list of the "Top 5" research findings and near-term recommended actions resulting from this effort summarizes the hardest hitting results of this research. The research findings provide the context for implementing the near-term "tactical" recommendations that follow.

Research Findings

This summary of the research findings provides a succinct statement of the insights the methodology developed in this thesis provided in the analysis of the UAS AI effort. No ubiquitous claims to validation or extensibility result from this research; however, the methodology did prove useful in the following ways:

1. **The deployed methodology provides a clean interface to the existing DoD Capability-Based Assessment (CBA) process.** The results and implementation recommendations appear to align well with Air Force and DoD organizational structures

and responsibilities. In addition, the recognition of CBA as a value-based approach resulted in significant insights and extensions to the current CBA processes based on the broader value-focused literature and theory.

2. **The enterprise purpose framework and the X-matrix analysis yield well-aligned value structures both vertically and horizontally across the Global Strike Task Force (GSTF) extended enterprise and the UAS AI enterprise, respectively.** Disconnects between the UAS AI enterprise and the broader GSTF extended enterprise were highlighted. Using the X-matrix to assess the internal UAS AI enterprise provided key insights into needed development of specific attributes and metrics to align disparate decision maker perspectives within the enterprise. The coherency established by the value alignment in both dimensions provided a basis for accomplishing the more detailed analysis for the enterprise architecting effort.
3. **Unarticulated assumptions come to the forefront of the analysis, and several doctrine-to-activity disconnects were highlighted.** The combined insights resulting from the value alignment activities described above, coupled with the more detailed and rigorous analysis using the Object Process Methodology (OPM), served to highlight the interactions that were present (or lacking) between various elements of the enterprise. By requiring a clear articulation of what these interactions actually look like, as opposed to what people often mistakenly took for granted, disconnects between the doctrinal elements related to flying UAS (what was said) could be contrasted with the activities that were actually implemented (what was done). These insights provided a rich source of information for where barriers might exist to moving the UAS AI effort forward.
4. **The need for a consolidated position at the GSTF extended enterprise level on the constraints under which the UAS AI activity should operate surfaced as a major hurdle to creating value.** This insight resulted from the enterprise purpose statement analysis and an assessment of the vertical alignment in the value structure. This information, coupled with the explicit interactions described by the architecture OPM, highlighted the following: the current move to push additional capability onto UAS platforms is occurring without a clear trade having been conducted on the impact those platforms' capabilities bring (or don't) to the global strike capability of the larger Air Force force structure. The research methodology provided clear insights into the need for

this discussion at the GSTF extended enterprise level to specify the resource expenditures for restoring maneuver to UAS.

5. **Rigorous implementation of the methodology provides strong and clear linkage between the delivery of the GSTF extended enterprise value definition (i.e. global strike) and the specific, concrete actions the UAS AI enterprise must accomplish to realize the desired level of maneuverability.** The Enterprise Transformation Roadmap provided a robust approach for translating the GSTF Extended enterprise values driving the UAS AI enterprise into a concrete, time-phased roadmap grounded in details and practical implementation considerations. It is through the Enterprise Transformation Roadmap the transition is made from subjective (but needed) expressions of value definitions (i.e. restore maneuver) to concrete, specific, and actionable plans that can be implemented, assessed, and modified to take into account the relative success of a set of activities (i.e. implement joint-led teams).

In summary, the methodology as implemented in this research provides a natural interface to the existing DoD CBA process, yields vertically and horizontally aligned activities, pushes assumptions and interactions to the forefront of the discussion, establishes the strategic issue(s) that must be addressed to flow value, and connects subjective values directly to specific, actionable effort needed to deliver the desired value.

Near-Term Recommendations

With the previous research findings as context, the following "Top 5" describes the near-term, "tactical" activities needed to move the UAS AI activity in the right direction for realizing the desired value of both the UAS AI enterprise (restore maneuver) and the GSTF extended enterprise (enable global strike). The list is in roughly the order of highest-to-lowest priority.

1. **The UAS airspace integration purpose statement must clearly link military capabilities (i.e. global strike), where the principal shortfall is maneuver, and the need to integrate UAS into the airspace.** Solutions will be more difficult to resource if there is a perception that UAS airspace integration is the end goal as opposed to enabling the relevant mission area. Unmanned aircraft are national security programs tied directly to projected military capability, and framing the airspace integration issue in the same light is important to elevating the discussion to the appropriate level. A proposed UAS

AI purpose statement connecting the desired military capability with airspace integration is provided as follows:

> *The purpose of the airspace integration enterprise is to restore the principle of maneuver to operations by integrating UAS into civil airspace using a full spectrum approach of policy, procedures and materiel system equipage while enabling needed UAS training and operational missions and meeting the contextual constraints (political, cultural, organizational, resource, etc) necessary to successfully deliver incrementally meaningful levels of value.*

2. **Implement a senior leadership engagement plan to specify the constraints** the Air Force and DoD have on the effort to restore the principle of maneuver to UAS platforms (i.e. Non-Recurring Engineering costs, production numbers, limited or niche mission areas assigned to UAS, the maneuver of the overall force, etc). Elucidating these constraints within the broader context of "enabling global strike" puts a handle on the strategic issues for senior leadership to engage on. Communicating the value of restoring the principle of maneuver will be most effective through an analysis of Air Force capability delivery and the ramifications of current UAS policy and practices on the Air Force's ability to deliver "global strike" to the Combatant Commander. Once the constraints are clearly established, they should be implemented in concert with a "Simple Rules" strategy of a few key processes and a couple of critical criteria (i.e. decision rules or processes—see Recommendation #4) to govern the overall enterprise effort across Air Force, DoD, and FAA decision makers.
3. **The enterprise must produce a resource-constrained approach** providing an incremental product delivery the decision makers within the UAS AI enterprise, and the GSTF extended enterprise will consider worthy of investment, while also meeting the intent of the limitations brought out in Recommendation #2. This means active engagement with all of the enterprise decision makers to ensure the development of a properly scoped, "revolving" two-year plan, providing an increase in value from the end user's perspective (i.e. how has global strike capability increased because of these expenditures of resource?).
4. **The absence of clear end-state, performance objectives requires the establishment of decision criteria and processes to effectively direct UAS AI enterprise activities.**

Recommendation #4 expands on the need for enterprise governance decision criteria in the face of unspecified, final objectives or outcomes (the current condition in which UAS AI efforts are operating). Day-to-day activities needed for UAS AI enterprise unity of effort depend on clearly established governance criteria for teams or activities facing unspecified performance objectives or requirements [17]. More complex systems or activities require simpler (and fewer) rules for effective decision-making (see reference [18] for further expansion of this topic). As decisions arise, the only meaningful way to make consistent progress is to have a consensed set of priorities or criteria against which the enterprise has agreed to make resource and materiel related decisions. While seemingly straight forward, this approach is largely absent from past and present efforts.

5. **Limit the number of active decision makers on any one given enterprise effort** to less than 10, and preferably no more than six or seven, by segmenting the scope of activities into specific subsets of the problem the enterprise can work in parallel. Additional analysis shows the rapid decrease in activity effectiveness with an increase in the number of decision makers beyond the prescribed six or seven recommended for this effort [19]. One approach to implementing this recommendation would be to have the Air Force work all of the early operational aspects for the Level 3-5 UAS, have the Army work all of the early operational aspects for the Level 0-2 UAS, and have the Navy work all of the broader systems engineering aspects to the problem. These would be accomplished as largely independent efforts (and consequently involve fewer decision makers), but lessons learned and process related information would be communicated back out at the full UAS AI enterprise level. This would also allow each service to conduct activities within the constraints established by their respective services while still contributing to the UAS AI enterprise effort.

In summary, implementation of near-term actions include redefining the UAS AI enterprise purpose, engaging senior leadership to clearly specify constraints, initiating a cyclical, 2-year plan to operate under these constraints, establishing the appropriate governance decision criteria, and limiting the total number of decision makers on any one given effort.

Chapter 11 Summary

The Enterprise OPM provides the insight into the key points of leverage in an enterprise to focus the transformation planning stage of the Enterprise Transformation Roadmap. Using the Enterprise Transformation Roadmap provides a broader set of implementation issues to consider in the advancement of the current enterprise state towards the desired objective articulated by the selected enterprise architecture, in this case the product-informed, process focused architecture. Using the approach outlined in the Enterprise Transformation Roadmap, specific details concerning the planning and execution stages of the UAS airspace integration activities are called out by referencing the specific mechanisms that have been determined to provide the highest degree of leverage over the enterprise performance and behavior characteristics. The top five research findings and near-term recommendations the UAS airspace integration enterprise effort should address provide concrete, tangible action items to move forward.

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SECTION IV: WRAP-UP AND FUTURE WORK

This final section and chapter conclude by examining potential extensions to the methodology developed in Section II. Specifically, the use of the framework developed in this research for use in DoD Capability-Based Assessment (CBA) processes is examined along with an investigation into the additional effort required to create an executable model of the enterprise architecting portion of this analysis. The chapter concludes with thoughts on the need for further iteration with the UAS AI enterprise to reach a truly implementable plan and the need to think at least a level above the point where the current challenge resides in order to secure a lasting solution.

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CHAPTER 12 – FURTHER RESEARCH AND FINAL THOUGHTS

"He can compress the most words into the smallest ideas of any man I ever met."
—Abraham Lincoln

Hopefully, you have not arrived at this point in the research discussion only to find yourself in violent agreement with Abraham Lincoln, at least with respect to this thesis. Certainly the methodology and application described in this research leaves much to be desired from an implementation standpoint, and this is in fact a good piece of the discussion that follows. Turning the three enterprise architecture point designs explored under the application section of this research into a true tradespace exploration methodology will require the implementation of executable models to deal with the sheer number of potential alternatives.

Before tackling that issue, however, a brief excursion is made into an extension of the methodology presented in this research back to the CBA framework that provided an initial constraint to the path selected. Inadvertently through the selection of the methodology and framework employed in this analysis, an approach to resolving several CBA execution problems presents itself. This methodology extension will be addressed briefly, followed by the executable model discussion. The research concludes with a couple of final thoughts on the current research and the need for continued work in this area of value-focused thinking and enterprise architecting.

Methodology Extensions

Recall that for the research and methodology developed in this thesis, the decision was made to implement an enterprise architecting framework developed by Nightingale and Rhodes. [11] This enterprise architecting framework can be switched in the OPM construct for a different set of enterprise views that more closely aligns with the existing CBA process, namely the DOTMLPF framework already in place through the JCIDS process. Figure 12-1 provides the general architecture development OPM for the CBA context.

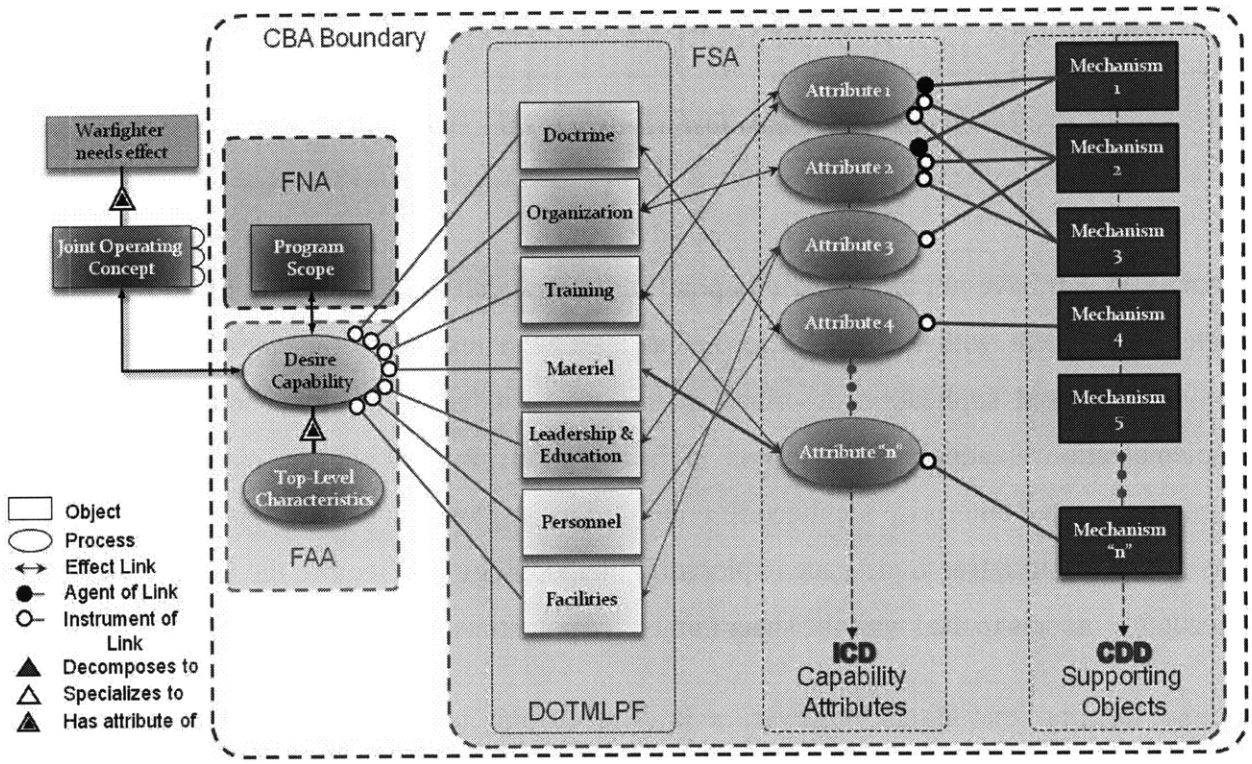


Figure 12-1. Methodology Extension to CBA using DOTMLPF for "Views".

In addition to the architecture OPM elements described previously in Section II of this research, the CBA context in Figure 12-1 also has a number of additional items included to provide a reference back to the current CBA and JCIDS processes (Reference Chapter 2 for more detail on the CBA process itself). With the simple substitution of the JCIDS DOTMLPF framework for the enterprise architecting framework used in this research, all of the methodology developed in Section II can be applied directly to the CBA assessment.

The power of using the approach outlined in Section II for the CBA process is the ability to resolve at least one observed shortfall in the implementation of the current CBA process within the DoD, and it paves the way for a resolution of a second issue. The immediate implementation problem the current methodology resolves is the lack of a consistent instantiation of a single, value-focused approach across the entire DOTMLPF assessment that is rigorous enough to span the full scope of organizations and needs typically associated with a CBA activity.

This addresses a significant shortfall in the current CBA process as it relates to the depth of analysis for which a true value-focused approach is maintained. This is most apparent when the analysis calls for a Materiel solution to be included as part of the tradespace. The observation of

the current CBA process is that the value-focused content of the FAA and FNA appears to be lost as the analysis enters into the more detailed programmatic and engineering realm of the FSA. By instantiating a rigorous methodology for keeping track of the interactions and relationships between the DOTMLPF components, maintaining the appropriate value-focused approach to the Materiel design aspects of the problem are preserved. This also forces the Materiel community to articulate the results of the analysis back into the attribute space rather than in technical performance or engineering terms. This provides a way to understand the contribution of the Materiel component on the same terms as the other factors in the DOTMLPF framework ensuring a good "apples-to-apples" comparison between alternative methods of delivering value.

The second shortfall this approach at least sets up is the ability to start thinking about the use of an executable model for detailed Materiel tradespace exploration using the value-focused approach developed here and tied in with the Multi-Attribute Tradespace Exploration (MATE) methodology. This addition is depicted in Figure 12-2 as the red rectangle labeled "Multi-Attribute Tradespace Exploration".

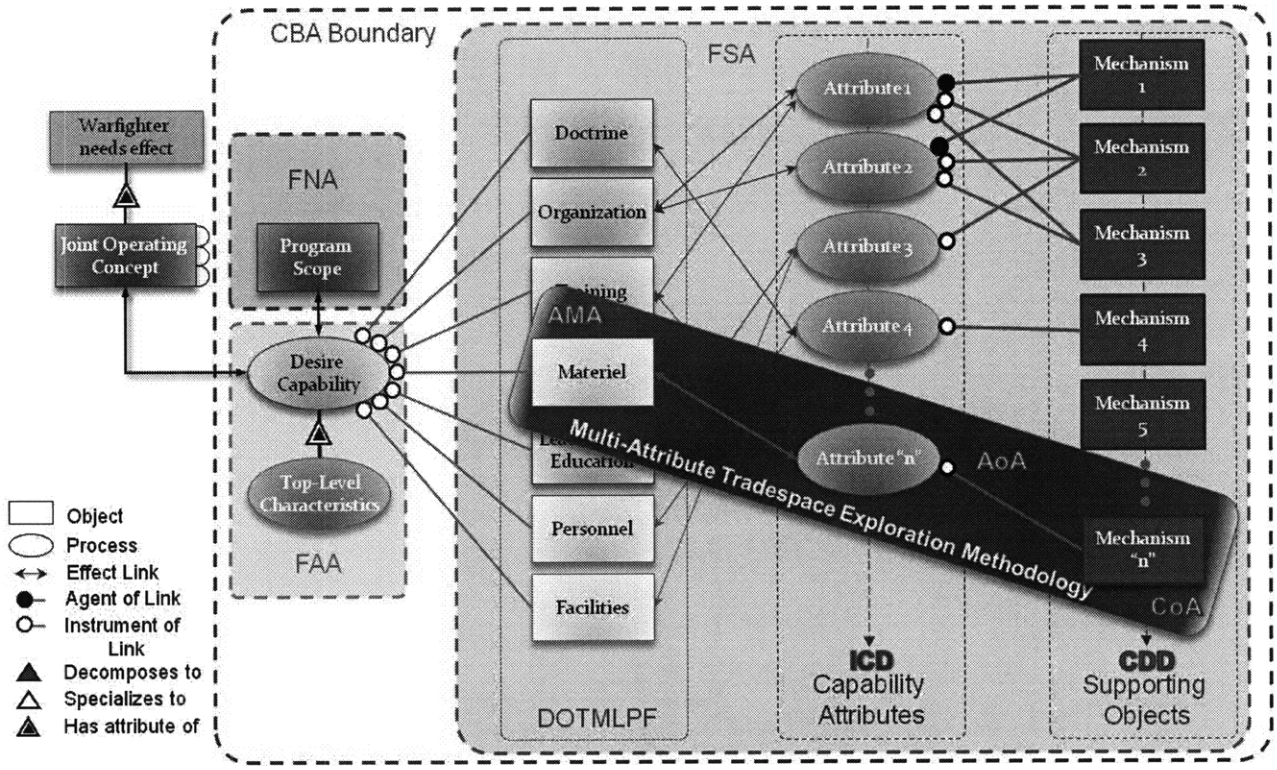


Figure 12-2. OPM Connection between Architecture and Materiel Design using MATE.

The use of an executable model in the CBA framework has all of the same benefits mentioned previously in Section II. In the case of the existing analysis framework operated by the DoD, the added advantage is the ability to seamlessly flow capability-focused information from the beginning of the process at the Joint Staff J-8 level, down through the relevant Functional Control Boards, out to the appropriate executive agent or lead service, and in the case of the Air Force, tasked to the appropriate MAJCOM for additional analysis before finally arriving at the Materiel provider for an assessment of potential solutions. Once the tradespace has been explored, the information can be returned in the same direction using the same language and metrics to communicate the utility of any given point design as compared with any of the other DOTMLPF factors.

Before continuing, a brief comparative assessment between the enterprise architecting construct put forward by Nightingale and Rhodes and the DoD DOTMLPF framework is warranted to provide the reader with some sense for the relative degree of completeness these two frameworks bring to the analysis. A first-order mapping is depicted in Figure 12-3.

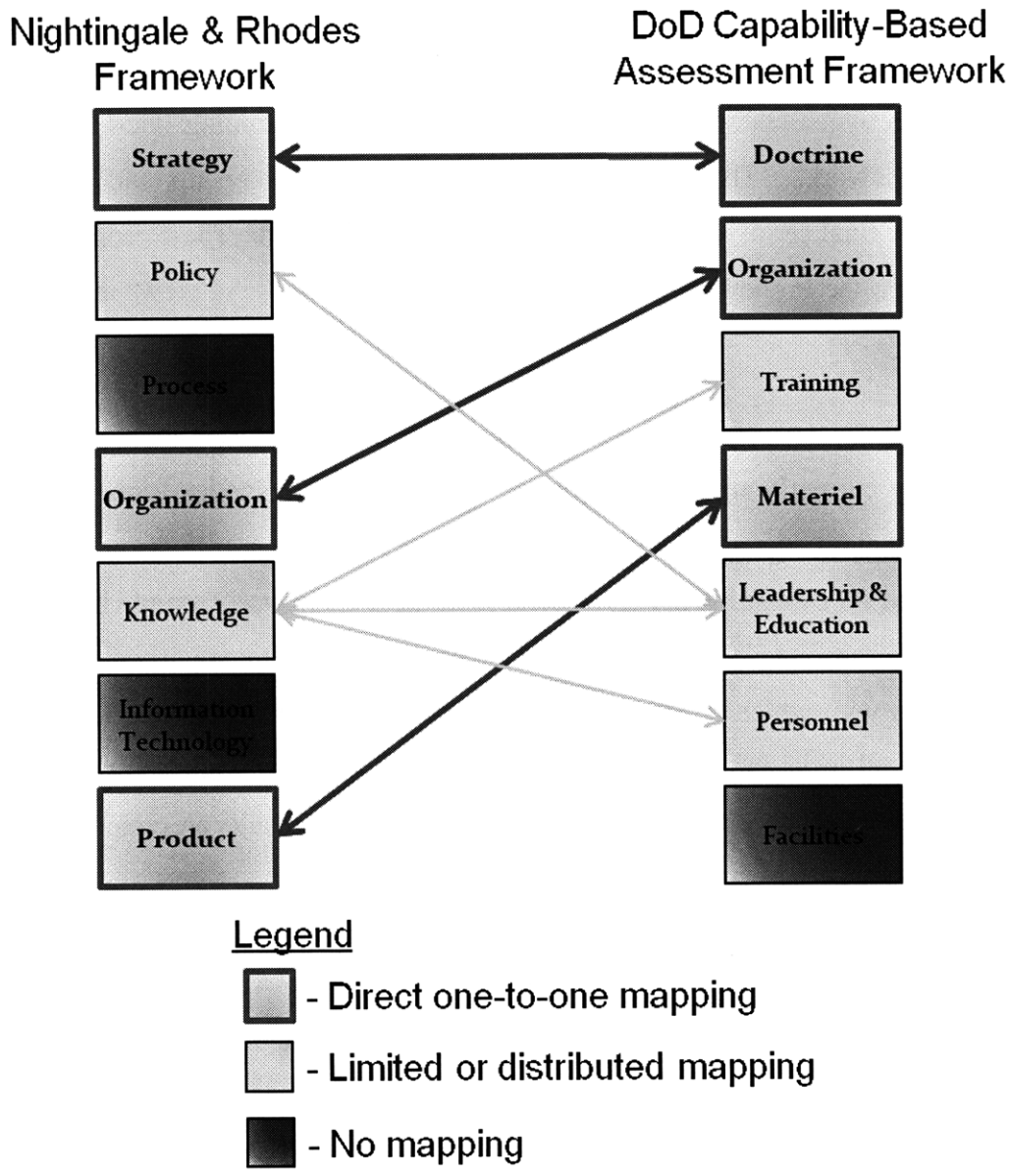


Figure 12-3. Enterprise Architecting-to-DOTMLPF Framework Mapping.

The most obvious differences are highlighted red. In the case of the DOTMLPF construct, the framework lacks any explicit treatment of either 'Process' or 'Information Technology' in the "views" through which the enterprise is architected. For its part, the Nightingale and Rhodes framework does not explicitly address the 'Facilities' perspective from the DOTMLPF framework. In both instances, each framework could benefit from the additional perspectives the other could provide. In the case of those views that are colored as yellow, there is either some limited (or incomplete) mapping between the frameworks, or the information is split into different segments in the other framework. In the case of the 'Policy' view from Nightingale and

Rhodes, there is an incomplete mapping of the perspective to that of 'Leadership and Education'. This is likely an area that the DOTMLPF framework could make more explicit. For its part, the enterprise architecting framework only partially deals with the 'Training' view advanced by the DOTMLPF framework. The same holds true for both 'Leadership and Education' and 'Personnel'. The final set of views are those color-coded as green. These represent one-to-one mappings between the frameworks where each framework treats these views in nearly identical fashion.

A superficial assessment of these differences suggests that both frameworks may not be complete as they currently stand, although the Nightingale and Rhodes framework appears to address a somewhat broader spectrum of issues than does the DOTMLPF framework. In reality, a rigorous method for evaluating the completeness of these frameworks should be developed that would provide an "absolute" sense for how robust any particular framework is when it comes to the completeness with which it addresses the enterprise architecting effort. This is an area of research that is still in its infancy, and future research in this area would be needed before the analysis could progress beyond the relatively simple descriptive results presented here.

Tradespace and Executable Model Extensions

With all of the potential advantages highlighted throughout this research on getting the methodology to the point of an executable model, the natural question is what would be involved in making this happen. Glazer makes the following observations concerning what is needed from a simulation capability to be useful to enterprise architects [113]:

- Representative of the actual enterprise, its structure, dynamics, and environment;
- Able to capture behavioral complexity as it arises from the architecture itself;
- Able to address specific problems the enterprise faces in a timely manner; and
- Capable of evolving and adapting to reflect the changing nature of the enterprise.

Glazer goes on to qualify the use of the modeling techniques he has developed with the following observations:

> "This [hybrid] approach is not a *predictive* approach to simulation modeling intended to improve operational efficiency (as most are); instead, this approach seeks to yield *insight*

into the behavior of a complex enterprise arising from its *architecture*. This *insight*, in turn, helps to accelerate the learning curve for enterprise managers seeking to shape and guide their enterprise from a system-level perspective. This approach allows the modeler to capture key attributes of the enterprise from multiple perspectives (*e.g.*, strategy, process, organization, products, etc.) and examine how the interactions between these perspectives drive the high-level behaviors of the enterprise. Such an approach takes a strategic view of the enterprise to guide enterprise architects and managers in understanding how the system, as a whole, delivers value to its stakeholders."

Glazner's approach implements the notional modeling framework depicted in Figure 12-4. The work Glazner has conducted is the culmination of over six years worth of research effort, and it represents a significant step forward in the enterprise architecting domain.

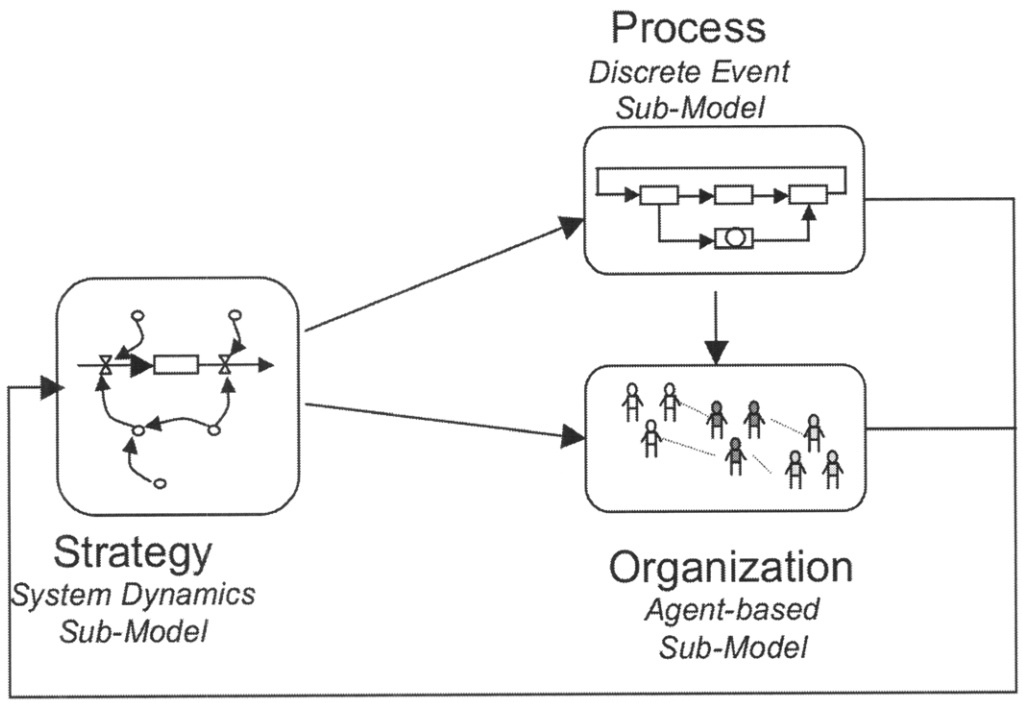


Figure 12-4. Notional Hybrid Enterprise Architecture Modeling Framework.

The big question that remains open as a result of the research in this thesis is whether the MATE framework could be adapted directly to the enterprise architecting challenge as an extension to the methodology. To go one step further, if the MATE methodology could be implemented successfully, would it be robust enough in the enterprise architecting domain to remain

prescriptive (it is in the technical product arena where it was initially developed)? This would effectively represent the next logical extension to Glazner's work where the models developed by Glazner may provide for a way of connecting attribute delivery to cost and performance characteristics of the enterprise.

To help flesh out some of these issues, a simple set of models was constructed to try to uncover some of the additional issues to be resolved before a MATE implementation would be possible in the enterprise architecting effort. Using the work already accomplished on the UAS AI enterprise, a very course Excel model of the MATE framework is used to explore some of these underlying issues that require further work. [87] Recall, the interview questionnaire and the stakeholder analysis were specifically oriented around the MATE approach to gathering and collecting the needed data for the methodology in Section II. This translates into a 100% match between the methodology in this thesis and the MATE construct for attribute and utility elicitation. Although the utility functions were not elicited during the data collection interviews, reasonable approximations can be estimated from the data (See Figure 12-5). These utility curves were developed for five out of the nine attributes for the enterprise as a subset to simplify the analysis.

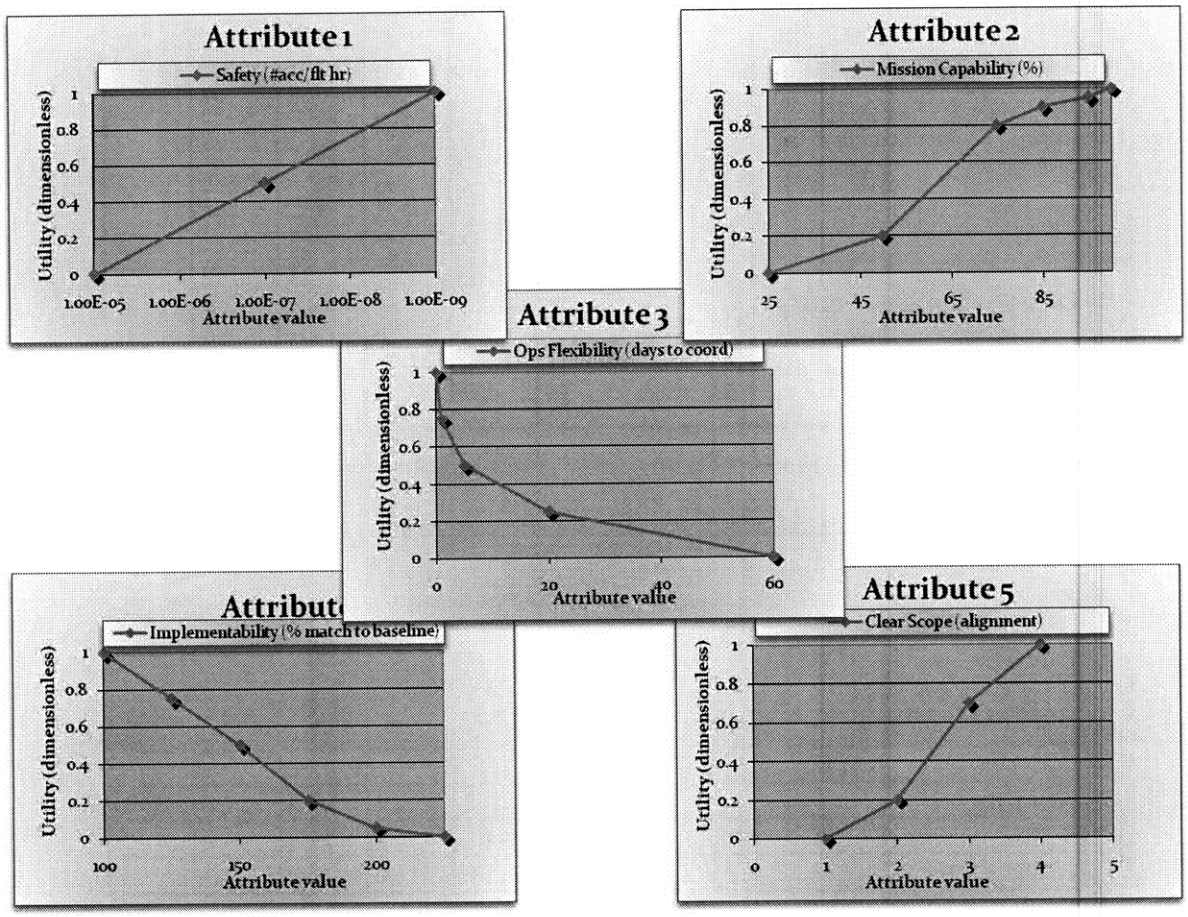


Figure 12-5. Estimated Utility Curves for UAS Airspace Integration Attributes.

At this level of analysis, there are no disconnects with the existing MATE methodology and the requirements for the enterprise architecting effort. An analysis of the three architectures developed in Section III against the five attributes selected for the MATE assessment provide some insights into where the complexities of the problem will begin to emerge.

Design Choices - enter names below, and Attribtes in natural units	Select Baseline with "x"	Safety (#acc/flt hr)	Mission Capability (%)	Ops Flexibility (days to coord)	Implementability (% match to	Clear Scope (alignment)	Cost (millions)
Process Focus		1.44E-07	75	5	115	3	$6
Product Focus		1.44E-07	70	10.6	150	1	$5
Prod-Process	x	1.00E-08	80	7	125	2	$7
Weights		0.16	0.1	0.14	0.12	0.08	
Best		1.44E-07	80	5	115	3	5
Worst		1E-08	70	10.6	150	1	7

Table 12-1. UAS Airspace Integration Architecture Design Choices.

In the case of each alternative architecture developed in Section III, the challenge is how to assess the performance of the architecture against each of the five enterprise attributes. A true understanding of the safety performance will likely require at a minimum some parametric assessments coupled with higher fidelity models of specific components, such as the sense-and-avoid sensor, the detection algorithms, and the command and control systems. Mission capability is an even more difficult value to estimate, and if conducted in reality, would likely require some kind of relationships to be established between the specific choices in the enterprise architecture for the degree of collaboration & safety and the willingness of the FAA to approve an operation. Ops flexibility as it is defined is a bit easier to get a handle on since it is a tangible construct describing the length of time that is expected in order to receive an approval to fly. Implementability would require additional models for the expected costs and scope growth for each architecture examined. The cost category itself is an extremely difficult quantity to assess and a clear set of standards for establishing the cost relationships to the architecture design

variables (in this case the "views" in the enterprise architecture framework) would have to be developed. Notice for the example in Table 12-1 that safety and mission are essentially removed from consideration by setting all three alternatives equal to one another. This may imply that these attributes would be better categorized as constraints if this is in fact how they are handled in reality. On the other hand, if the decision results from simply not knowing how to model these attributes for each of the alternative architectures, the lack of information or framework for an approach can be addressed.

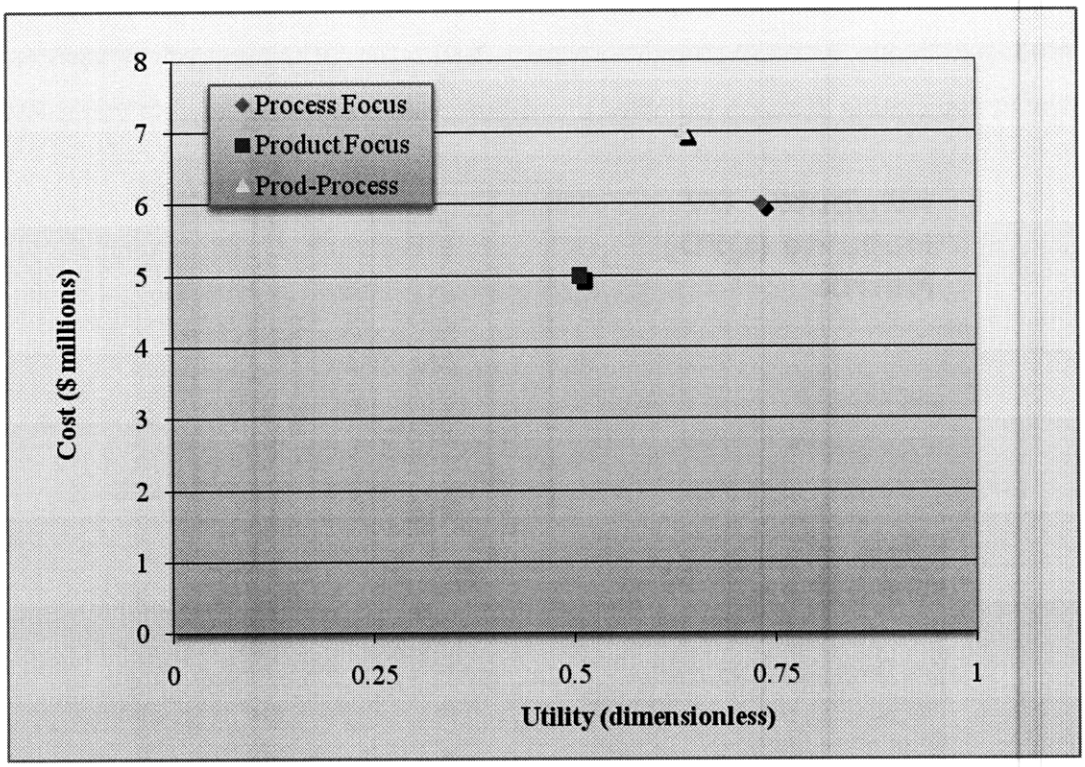


Figure 12-6. Utility vs. Cost for UAS Airspace Integration Architectures.

The results for the three architectures examined in Section III are plotted in Figure 12-6 for the sake of completeness. Notice that as cost is incorporated explicitly into the model for each architecture, some of the relative rankings begin to shift between the three alternatives. This may also be due in some measure to the less than complete consideration of all the enterprise attributes.

Other than the need to deal with cost in an explicit manner, the extension to this point does not appear to provide much in terms of additional insights into the architecture design and the associated utility. This is after all roughly the same utility quantities arrived at in the Section II

analysis. The real power of MATE as applied in the current methodology comes from parameterizing the decision variables that comprise the overall architecture selections. In the method used in this research, this translates into the "Mechanisms" used to produce the desired enterprise attributes. This has a significant advantage over the design-choice method just described. Instead of attempting to arrive at some overall "cost factor" for each architecture (and the associated difficulties just described), each mechanism used in the creation of the architecture can be costed independently, and because each mechanism is a much more concrete object than the architecture as a whole, estimating the cost relationships for each mechanism relative to the utility produced should be more straightforward. Again, the QFD approach is used as a very rough way of associating decision variables to attributes and cost, as depicted in Table 12-2.

Attribute - DV Mapping (QFD) Matrix

Attributes	Design Vars	Capable Equipage (SAA Range)	Established Criteria (Articulated Processes)	Collective Data Gathering (Quality)	Defined Path Forward (Deliverables)	Joint-Led Teams (# of Co-led Teams)	Total Impact
Safety (#acc/flt hr)		-9	-9	-3	-3	-1	25
Mission Capability (%)		9	9	1	3	3	25
Ops Flexibility (days to coord)		9	9	9	3	1	31
Implementability (% match to baseline)		1	1	3	9	9	23
Clear Scope (alignment)		3	3	3	9	3	21
Total		31	31	19	27	17	
Cost		9	3	9	1	3	
Total w/Cost		40	34	28	28	20	

Table 12-2. Relationship Between Attributes and Design Variables (Mechanisms).

The quantification of the relationship between the attributes and the mechanisms in the above table brings out additional issues that have to be resolved. The quantification of mechanisms such as "Established Criteria" to each of the attributes suggested relationships that were not initially captured in the OPM description of the enterprise architecture. This suggests that a QFD approach to relating mechanisms to attributes would be a worthwhile endeavor as part of the primary methodology sequence articulated in Section II. In other words, beyond just the

existence of the connection between an attribute and a mechanism, the QFD forces an evaluation of the strength of that connection and the underlying basis. This underlying basis is the most important aspect to uncover since it will drive the interaction behavior as well as the cost function for that mechanism and attribute pair. Arriving at a consistent method for accomplishing these evaluations and cost estimates is a shortfall in the current body of literature and would require additional research, although some initial work has been attempted in this area. See reference [114] for a treatment of policy and budget related methodologies and an approach for connecting these factors to architectures (although the reference was an assessment against space systems, the considerations are germane to the current topic in this research).

If the mechanism-to-attribute relationship can be adequately described or otherwise quantified, the range over which the mechanisms vary can be associated with a particular level of utility delivery for each attribute. If the cost relationship between the level of performance for each mechanism is included in the model, an avenue for exploring the full architectural tradespace now becomes possible. Up until this point, the evaluation was limited to a handful of point designs. Employing the MATE methodology, even in this very low fidelity approach using the QFD to associate mechanisms with attributes and costs results in an alternative architecture tradespace depicted in Figure 12-7.

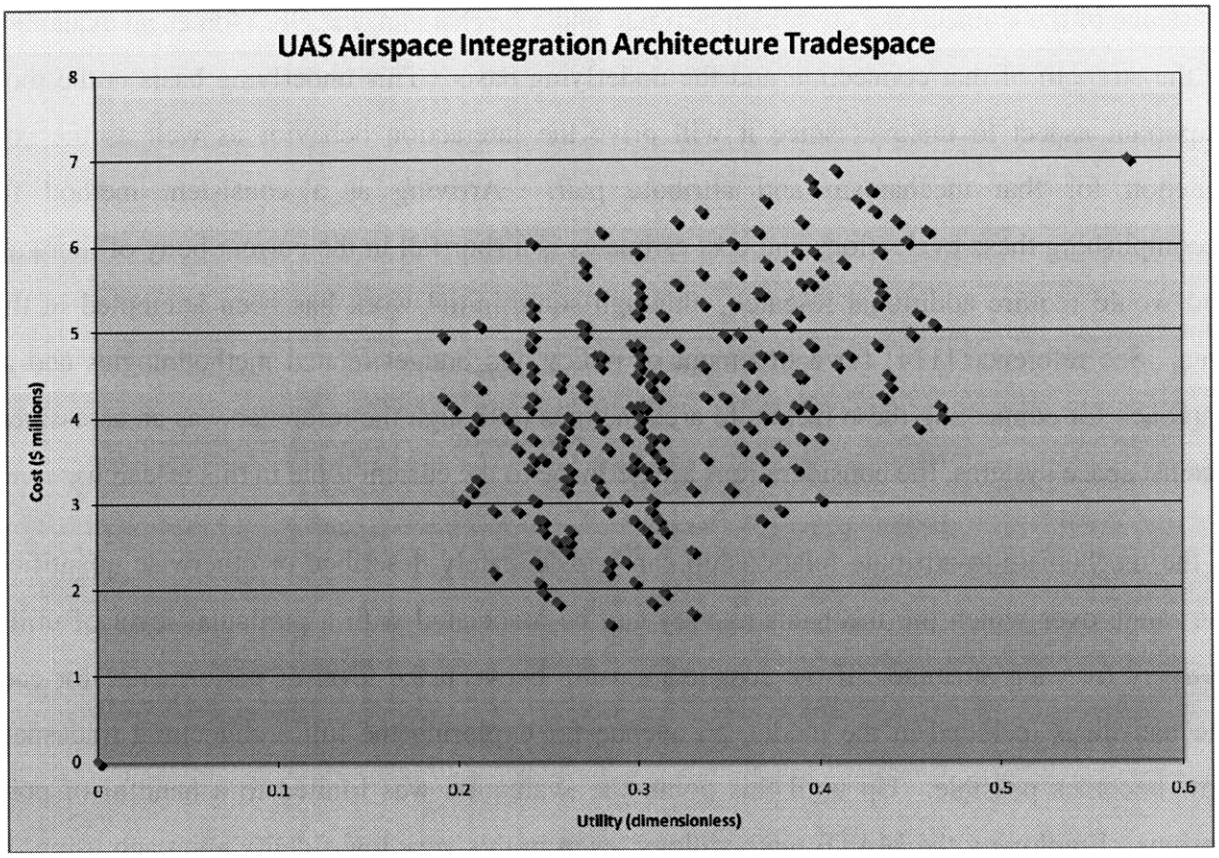


Figure 12-7. UAS Airspace Integration Architecture Tradespace Plot.

To provide more insight, the above information is sorted by each contributing mechanism to understand the impact each mechanism may play on the relative cost/utility location of a given design. These additional plots are provided in Figure 12-8. General trends can be observed and considered with these views. For instance, in the case of "Capable Equipage" the decision variable or mechanism that was varied was the range at which the UAS sense-and-avoid system could detect another aircraft. The further out the range, the better the utility return, but the more expensive the UAS becomes. This train of thought is consistent with the tradespace depiction by noting the yellow triangles in the plot represent a sense-and-avoid system with a "long" range, resulting in a trend that puts the yellow architectures along the leading edge of the utility "front" but also typically costing more than architectures using less capable sense-and-avoid systems. By employing a tradespace analysis perspective, the architect has a much better understanding of where various architecture point designs fall within the broader tradespace.

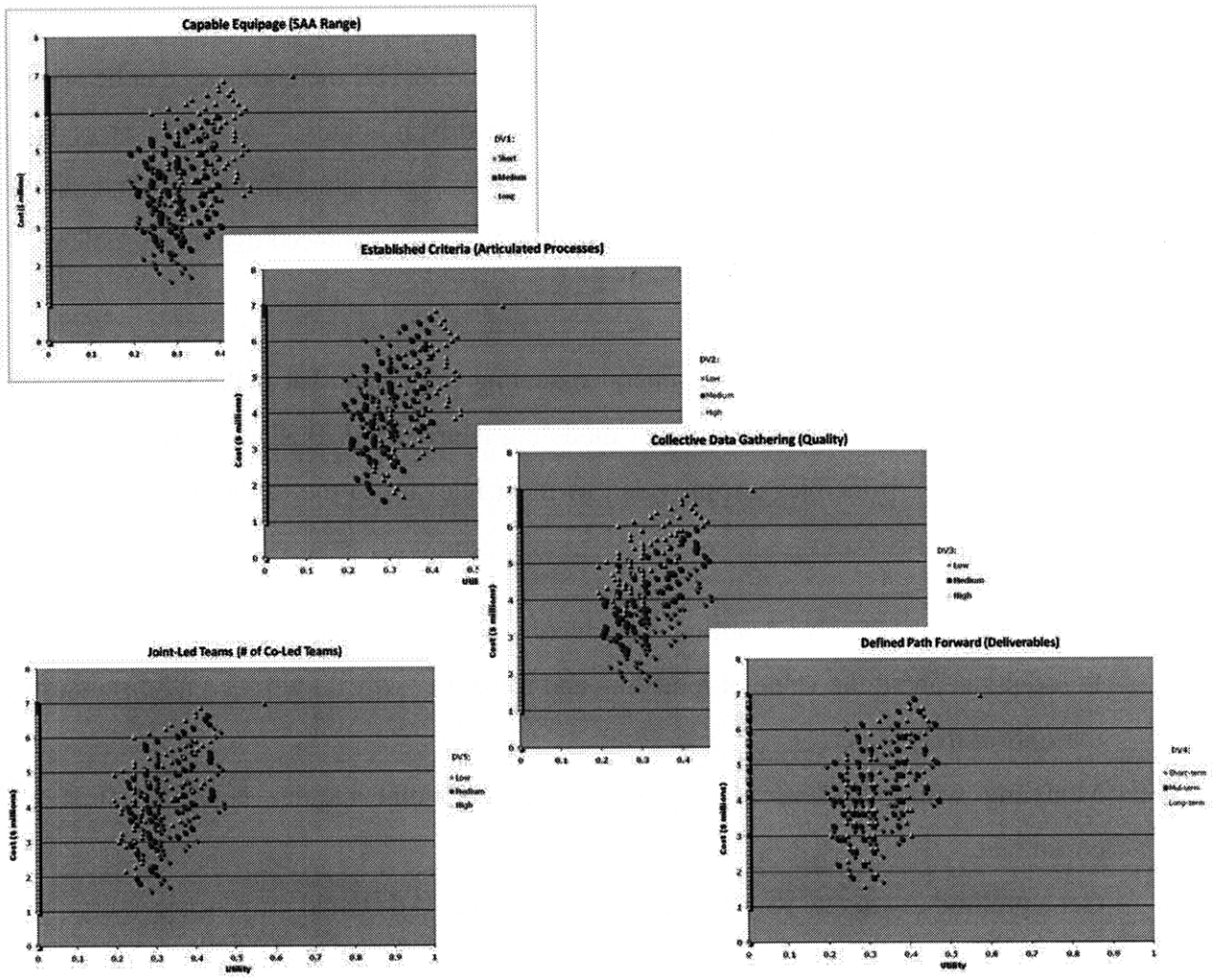


Figure 12-8. UAS Airspace Integration Tradespace Plots for Specific Mechanisms.

Each individual mechanism can be explored in a similar manner so that a clear sense for the relative impact on the utility and cost functions can be determined. This also serves to highlight why it is so important to get the relationships between the mechanism and the attributes and costs identified as rigorously as possible. The validity of the tradespace is only as good as these relationships and the fidelity to which they are modeled. To reiterate the point made earlier, arriving at a consistent, repeatable method for quantifying the kinds of relationships and dynamics for what are typically very "soft" relationships between enterprise attributes, mechanisms, and costs is the single largest hurdle for implementing the above described approach.

In closing this discussion of executable models for enterprise architecting endeavors, several observations are warranted. First, the issues described above only begin to scratch the surface of

the capabilities the MATE method could bring to the table. The reader is referred to the work by Ross at reference [64] for an in-depth discussion of how the MATE methodology can be applied to uncertain and changing contexts in a dynamic, time driven context. A treatment of these issues is both outside the scope of the current research and premature from the standpoint of needing the previously identified issues resolved before the more advanced dynamic problem can be successfully tackled.

The other thing to keep in mind is the general modeling principles that make for a successful effort. Sterman provides an excellent set of modeling heuristics in Business Dynamics. [115] The following 5 of 12 principles are provided as most relevant to the discussion of modeling issues:

- Develop a model to solve a particular problem, not to model a system.
- Be skeptical about the value of modeling and force the "why do we need it" discussion at the start of the project.
- Modeling works best as an iterative process of joint inquiry between client and consultant.
- Get a preliminary model working as soon as possible. Add detail only as necessary.
- A broad model boundary is more important than a great deal of detail.

Keeping these overarching principles at the forefront in the pursuit of the above challenges will keep the results targeted on the enterprise value definition. The extent to which a model like MATE, or even the approach developed in this research, is useful is the degree to which it provides insight and understanding to the enterprise architect in designing an enterprise concept that effectively creates and delivers the value each enterprise decision maker expects as a result of their contributions and interactions with the enterprise (recall the earlier reference and discussion from Glazner).

Final Thoughts

In keeping with Sterman's observation that "Modeling works best as an iterative process of joint inquiry between client and consultant," the analysis and results presented in this research represent no more than a "first pass" at a solution to the UAS airspace integration challenge. The results captured in the initial architecture and transformation plan in Section III will require at

least another couple of iterations with the UAS AI enterprise decision makers before all of the appropriate constraints and nuances have been adequately addressed to attempt some form of implementation of the initial results presented in this thesis.

This iterative nature of the methodology is of course at the heart of any successful method attempting to deal with the complexities of these types of issues. Recall from Chapter 2 that the method will likely require at least three passes through the framework presented in Section II, bouncing results and implications off of the enterprise decision makers for feedback and adjustments before the more detailed transformation planning effort should be undertaken. This feedback loop should occur early and often in the enterprise architecting effort and cannot be overemphasized.

As stated at the outset of this research, the intent is to provide a rigorous methodology that is consistent with the DoD CBA process and robust enough to treat the full spectrum of issues associated with the UAS airspace integration effort. The methodology is clearly consistent with the DoD CBA process. The extent to which the UAS airspace integration issues have been successfully articulated and resolved is a question that only time and additional effort will fully reveal.

The organization of the material into a methodology and application section is designed to facilitate the extension and refinement of the approach in future theoretical work while still providing a concrete "real world" deliverable by addressing a current and growing concern of the Department of Defense and the Federal Aviation Administration. The breadth of issues that are integral to the enterprise architecting endeavor resulted in obvious omissions of further detail in a number of sections, most notably the development of tools that could be applied within each enterprise architecting view to provide further insight and guidance on alternatives the architect could apply to the challenge at hand. Each of these warrants development commensurate with this thesis. In addition, the treatment of executable models, the above discussion notwithstanding, was at best a sketch of the challenges associated with this kind of effort. This is an area of significant research, and the body of knowledge on modeling enterprise architectures will continue to expand at ever increasing rates over the next several years. The results of these

efforts should certainly be leveraged for the additional insights they may bring to the value creation endeavor.

Perhaps Albert Einstein provides the best summation of this research effort in the following observation [116]:

> *The significant problems we face in life cannot be solved at the same level of thinking we were at when we created them.*

If this thesis provides even a small basis for elevating the level of thinking on restoring maneuver to UAS platforms, then the time will have been well spent. Clearly, the challenge presented in this analysis will require significant contemplation and a considered course of action to realize the fullest potential UAS platforms have to offer to the DoD.

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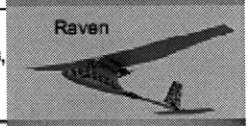
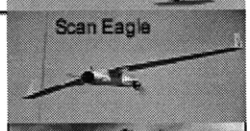
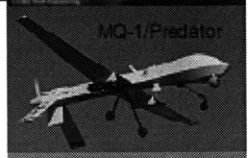
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APPENDIX A – CURRENT MILITARY UAS CATEGORIES

Domestic Use UAS Levels	Current System Attributes					
	Airspeed (kts)	Weight (lbs)	Operating Altitude (ft)	Current Systems (Projected by 2014)	Description	UAS Examples
Level 0	≤ 250	≤ 2	≤ 1,200	Hornet, BATCAM, Wasp	Systems under 2 lbs, within LOS control, operating in unregulated airspace	
Level 1		2 - 20	≤ 3,000	Raven, Dragon Eye, FPASS, Pointer, BUSTER, MAV	Systems under 20 lbs, operating below VFR airspace	
Level 2		21 – 1,320	< 18,000	Silver Fox, FINDER, Aerosonde, MARTS ScanEagle, Neptune, **OAV-II**, Tern, Mako, Shadow, Pioneer, REAP, RAID, TARS, **JLENS**, Killer Bee	Systems under 1,320 lbs fall under light sport aircraft standards	 
Level 3		1,321 – 12,500		Maverick, Snow Goose, **Dragonfly**, Hunter A, Hunter B, Onyx, I-Gnat-ER, **Eagle Eye**, ER/MP, Firescout, BAMS, Hummingbird, Predator	Systems over 1,320 lbs, operating below Class A airspace	 
Level 4	> 250	≤ 12,500		Currently no DOD UAS fall in this category. Example system is Killer Bee concept UAS	Systems operating below 10,000 ft MSL with max airspeeds that exceed the limit of 250 kts	
Level 5	Any	> 12,500	≥ 18,000	Reaper, Global Hawk **N-UCAS, HAA, NSMV**	Systems operating at or above 18,000 ft MSL fall under Class A airspace standards	

Note: This chart is meant to be evolutionary in nature. It reflects current capability/technology and is likely to evolve. As an example, although not a separate JUAS category, airships are recognized as having capabilities and attributes similar to other UAS. As their utility becomes more operational, they will be included in appropriate JUAS categories. The data presented represents typical parameters for the systems that fall in each category; there are several exceptions.

- Operational Altitude: The normal altitude range for systems based on payload capabilities, airspace management requirements, & aircraft capabilities
- Endurance: Includes the time from launch to recovery, based on single aircraft capability without refueling
- Radius: The radial distance from a launch site to the operating area, limited by C2 linkage and/or endurance and desired time on station
- Exceptions: Aerosonde endurance - 30 hrs; radius - 1,000 nm; Silver Fox airspeed - 105 kts; Predator airspeed - 118 kts; N-UCAS weight - 46,000 lbs
- UA operating within an operational theater must comply with existing ACO / SPINS
- Airspeed: 250 kts is the upper airspeed limit for operations below 10,000 ft MSL
- Weight: 1,320 lbs is the upper MGTOW limit for FAA light sport aircraft, 12,500 is the upper limit for normal, utility, and acrobatic aircraft
- Altitude: -- 1,200 ft AGL is upper altitude limit for Class G uncontrolled airspace
  -- 3,000 ft AGL is the lower limit for VFR en-route altitudes
  -- 18,000 ft MSL is the lower altitude limit of Class A airspace, (Predator is an exception as it operates above 18,000 ft.)
- Design: FAA standards also vary for winged aircraft, rotorcraft, and airships

Military Domestic Use UAS Categorization. [3]

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APPENDIX B – UAS AIRSPACE INTEGRATION STAKEHOLDERS

The following list provides a sense for the size of the UAS airspace integration total stakeholder community. The information contained in this list was provided courtesy of the RTCA Special Committee 203 leadership, and the organizations listed have attended or otherwise expressed a desire to be actively engaged in the effort to create or influence the development of FAA standards governing the flight of UAS in the National Airspace System. No other criteria was provided to the RTCA SC-203 leadership beyond a request for a list of the organizations involved in their effort. The only modification made by the author to the information provided was to remove instances of duplicate organizational entries. The RTCA SC-203 database is by individual, and for this research, only organizational distinctions are considered. To preserve the anonymity of the SC-203 participants, all individually identifiable information has been removed.

Organization:	**Country:**
Australian Research Centre for Aerospace Automation (ARCAA)	AUSTRALIA
Civil Aviation Safety Authority (CASA) Australia	AUSTRALIA
V-TOL Aerospace Pty Limited	AUSTRALIA
Wackett Aerospace Centre	AUSTRALIA
EUROCONTROL	BELGIUM
Executive Board Member Technical Affairs	Belgium
Canadian Air Force	CANADA
Foreign Affairs and International Trade Canada	CANADA
Jane's	CANADA
MDA - Airborne Systems	CANADA
Transport Canada	CANADA
Unmanned Vehicle Systems Canada Inc.	CANADA
UVS Canada	CANADA
ICAO Air Navigation Bureau	Canada
CS Communication & Systems	FRANCE
Dassault Aviation	FRANCE
DSNA/DTI	FRANCE
SAGEM Defense Security	FRANCE
Thales Alenia Space	FRANCE
UVS International	FRANCE
DFS Deutsche Flugsicherung GmbH	Germany

Organization:	**Country:**
EADS Deutschland GmbH, Willy Messerschmitt Straíe	Germany
German Air Navigation Services Headquarters	Germany
Industrieanlagen Betriebsgesellschaft mbH	GERMANY
Northrop Grumman Electronic Systems	Germany
Israel Aircraft Industries, Ltd	Israel
Alenia Aeronautica S.p.A.	ITALY
Nara Institute of Science & Technology	JAPAN
National Aerospace Laboratory NLR	NETHERLANDS
TGR Helicorp Ltd.	NEW ZEALAND
Boeing	SPAIN
BOEING RESEARCH & TECHNOLOGY EUROPE, S.L	SPAIN
BAE Systems	UNITED KINGDOM
BAE SYSTEMS - Regional Aircraft	UNITED KINGDOM
Barnard Microsystems Limited	UNITED KINGDOM
CAA	UNITED KINGDOM
Eurocae WG73 UAV	UNITED KINGDOM
ISRAirline Pilots Association President	UNITED KINGDOM
QinetiQ	UNITED KINGDOM
Thales	UNITED KINGDOM
Thales UK	UNITED KINGDOM
UK Civil Aviation Authority	UNITED KINGDOM

Organization:	**Country:**
University of Birmingham	UNITED KINGDOM
AUVSI	UNITED STATES
US Army AMRDEC/SED Aviation Division	UNITED STATES
AAI Corp	UNITED STATES
AAI Corporation	UNITED STATES
Academy of Model Aviation	UNITED STATES
ACSS - Aviation Communication Surveillance Systems, LLC	UNITED STATES
Adsystech	UNITED STATES
Advanced Ceramics Research	UNITED STATES
AERO&SPACE USA INC	UNITED STATES
Aerodyne	UNITED STATES
Aerosonde	UNITED STATES
Aerospace Daily	UNITED STATES
Aerotonomy, Inc.	UNITED STATES
AeroVironment	UNITED STATES
AFRL	UNITED STATES
AFRL/HEAS	UNITED STATES
AFRL/UAC	UNITED STATES
AFRL/VACC - Control Systems Dev	UNITED STATES
AIA	UNITED STATES
Air Force	UNITED STATES

Organization:	Country:
Air Force, 452 FLTS/DO	UNITED STATES
Air Force, AFRL/VACC	UNITED STATES
Air Force, RSW/XRX	UNITED STATES
Air Line Pilots Association	UNITED STATES
Air War College	UNITED STATES
Aircraft Owners and Pilots Association	UNITED STATES
Aircraft Owners and Pilots Association	UNITED STATES
Airline Pilots Association	UNITED STATES
Alias Science	UNITED STATES
AmTech Center for Collaboration	UNITED STATES
Analytical Graphics Inc.	UNITED STATES
ANSER	UNITED STATES
AOPA	UNITED STATES
ARINC Engineering Services, LLC	UNITED STATES
ARINC Incorporated	UNITED STATES
ARINC, LLC	UNITED STATES
Army	UNITED STATES
Arthur Feinberg Assoc.	UNITED STATES
ASTM International Technical Committee Operations	UNITED STATES
Atlantic Test Ranges	UNITED STATES
AUVSI	UNITED STATES

Organization:	Country:
Aviation Management Associates, Inc	UNITED STATES
Aviation Management Associates, Inc.	UNITED STATES
Aviation Support Associates	UNITED STATES
AvioniCon	UNITED STATES
BAE Systems-Communications, Navigation, Identification and Reconnaissance	UNITED STATES
Ballistic Recovery Systems, Inc.	UNITED STATES
BattleSpace, Inc.	UNITED STATES
BELL HELICOPTER	UNITED STATES
BLR Group of America, Inc.	UNITED STATES
Booz Allen Hamilton	UNITED STATES
Brigham Young University	UNITED STATES
BTC Inc.	UNITED STATES
CAS, Inc.	UNITED STATES
Center of Excellence/JUAS COE/NDGI	UNITED STATES
Certification Services, Inc.	UNITED STATES
Cessna Aircraft Company	UNITED STATES
Cloud Cap Technology	UNITED STATES
Coast Guard	UNITED STATES
Computer Networks & Software, Inc.	UNITED STATES
Consultant	UNITED STATES
Continental Airlines Inc.	UNITED STATES

Organization:	Country:
CSSI, Inc.	UNITED STATES
DCS Corporation	UNITED STATES
Defense Research Associates, Inc	UNITED STATES
Department of the Interior	UNITED STATES
Department of Defense	UNITED STATES
Department of Homeland Security, US Customs and Border Protection	UNITED STATES
Department of Industrial and Systems Engineering Rutgers University	UNITED STATES
DHS, CBP Air & Marine	UNITED STATES
DHS/ CBP Air & Marine	UNITED STATES
DRA, Inc.	UNITED STATES
Drexel University Autonomous Systems Lab	UNITED STATES
DRS Technologies EWNS	UNITED STATES
DSC Corporation	UNITED STATES
DuaneMorris	UNITED STATES
Dynamic Aerospace, Inc.	UNITED STATES
Eagan, McAllister Associates Inc.	UNITED STATES
Embry-Riddle Aeronautical University	UNITED STATES
Embry-Riddle Aeronautical University - Daytona Beach Campus	UNITED STATES
Essex Industries, Inc.	UNITED STATES
Evergreen	UNITED STATES

Organization:	Country:
Evergreen Unmanned Systems	UNITED STATES
F.J. Leonelli Group, Inc.	UNITED STATES
Federal Aviation Administration	UNITED STATES
Federal Aviation Administration - Air Traffic Organization	UNITED STATES
Federal Aviation Administration R&D Field Office, AAR-210	UNITED STATES
Federal Aviation Administration Technical Center	UNITED STATES
Federal Aviation Administration, ATO Operations Planning (ATO-P)	UNITED STATES
Federal Aviation Administration, Rotorcraft Directorate	UNITED STATES
Federal Communications Commission	UNITED STATES
FEDEX	UNITED STATES
FJ Leonelli Group Inc.	UNITED STATES
Flight Safety Technologies	UNITED STATES
Foliage Software Systems, Inc	UNITED STATES
Frequentis Defense, Inc.	UNITED STATES
Garmin International, Inc.	UNITED STATES
GE Aviation	UNITED STATES
General Atomics	UNITED STATES
General Atomics Aeronautical Systems	UNITED STATES
General Atomics Aeronautical Systems Inc	UNITED STATES
General Atomics Aeronautical Systems, Inc	UNITED STATES

Organization:	Country:
General Atomics, Aeronautical Systems, Inc.	UNITED STATES
General Atomics-ASI	UNITED STATES
General Dynamics Robotics Systems	UNITED STATES
Geneva Aerospace	UNITED STATES
GKN & Associates	UNITED STATES
GSA - OGP - MT - MTC	UNITED STATES
GT Aeronautics, LLC	UNITED STATES
GulfStream Aerospace Corp	UNITED STATES
Hanchuck Consulting Services	UNITED STATES
Harris Corporation	UNITED STATES
Harris Technologies LLC	UNITED STATES
Hi-Tec Systems	UNITED STATES
Honeywell	UNITED STATES
Honeywell Inc., Aerospace Electronic Systems	UNITED STATES
Honeywell International, Inc.	UNITED STATES
HQ AF Flight Standards	UNITED STATES
HQ AF/A2ZC	UNITED STATES
ICF International	UNITED STATES
Idaho National Laboratory	UNITED STATES
Innovative Solutions International, Inc.	UNITED STATES
ITT Industries	UNITED STATES
Japan International Transport Institute	UNITED STATES

Organization:	Country:
JIL Information Systems	UNITED STATES
John D. Odegard School of Aerospace Sciences University and Tulane	UNITED STATES
John D. Odegard School of Aerospace Sciences, University of North Dakota	UNITED STATES
John Hopkins University/ APL	UNITED STATES
Johns Hopkins University Applied Physics Laboratory	UNITED STATES
Joint UAS Center of Excellence	UNITED STATES
Joint UAS Center of Excellence, JFCOM	UNITED STATES
Joint Unmanned Aircraft Systems, Center of Excellence (JUAS COE)	UNITED STATES
JSWalker Group/Aviation Solutions, Inc.	UNITED STATES
JUS-ISAC, LLC	UNITED STATES
Kansas UAV Consortium	UNITED STATES
Kutta, Inc.	UNITED STATES
L-3 Communications Corp.	UNITED STATES
Lockheed Martin	UNITED STATES
Lockheed Martin Aeronautics Co	UNITED STATES
Lockheed Martin Aeronautics Company	UNITED STATES
Lockheed Martin Corporation	UNITED STATES
Lockheed Martin Information Technology Services	UNITED STATES
Lockheed Martin Missiles and Fire Control	UNITED STATES
Lockheed Martin Systems Integration	UNITED STATES

Organization:	Country:
LuftKing Aerosolutions	UNITED STATES
Lycoming Engines	UNITED STATES
Metron Aviation	UNITED STATES
Milsys Technologies	UNITED STATES
MIT Lincoln Laboratory	UNITED STATES
MITRE	UNITED STATES
MITRE	UNITED STATES
MITRE CAASD	UNITED STATES
MITRE Corporation	UNITED STATES
MITRE Corporation/CAASD	UNITED STATES
MITRE Corporation/CAASD	UNITED STATES
MITRE/CAASD	UNITED STATES
MITRE-CAASD	UNITED STATES
MITRE-CAASD	UNITED STATES
Modern Technology Solutions, Inc	UNITED STATES
Modern Technology Solutions, Inc.	UNITED STATES
Mosaic ATM	UNITED STATES
MTSI	UNITED STATES
Mulkerin Associates Inc.	UNITED STATES
NASA	UNITED STATES
NASA Ames Research Center	UNITED STATES
NASA Dryden Flight Research Center	UNITED STATES

Organization:	Country:
NASA Langley	UNITED STATES
NASA Langley Research Center	UNITED STATES
NATCA	UNITED STATES
National Air Traffic Controllers Association	UNITED STATES
National Defense Magazine	UNITED STATES
National Science and Technology Council	UNITED STATES
National Transportation Safety Board	UNITED STATES
NAV AIR	UNITED STATES
NAVAIR	UNITED STATES
NAVAIR/4.5	UNITED STATES
Naval Air Systems Command	UNITED STATES
Naval Air Warfare Center	UNITED STATES
Navy	UNITED STATES
NBAA	UNITED STATES
New Mexico State University/Physical Science Laboratory	UNITED STATES
New Vistas International	UNITED STATES
NOAA	UNITED STATES
NOAA Marine and Aviation Operations Centers	UNITED STATES
NOAA/Dryden Flight Research Center	UNITED STATES
North Carolina State University	UNITED STATES
Northrop Grumman	UNITED STATES

Organization:	Country:
Northrop Grumman Corporation	UNITED STATES
Northrop Grumman Corporation	UNITED STATES
Northrop Grumman Corporation- ES	UNITED STATES
Northrop Grumman Integrated Systems	UNITED STATES
NTSB	UNITED STATES
NTSB, Office of Aviation Safety (AS-50)	UNITED STATES
Office of Naval Research	UNITED STATES
Office of Secretary of Defense, Department of Defense	UNITED STATES
Ohio University Airport	UNITED STATES
Penn State Electro-Optics Center	UNITED STATES
Predesa	UNITED STATES
Prioria Inc.	UNITED STATES
Procerus Technologies	UNITED STATES
Purdue University	UNITED STATES
QSS Group, Inc	UNITED STATES
R3 Consulting	UNITED STATES
Raytheon IIS	UNITED STATES
Raytheon Systems Company	UNITED STATES
RCAPA	UNITED STATES
Research Integrations	UNITED STATES
Rockwell Collins, Inc.	UNITED STATES

Organization:	Country:
RTCA, Inc.	UNITED STATES
Russell Systems	UNITED STATES
Saab International USA	UNITED STATES
SAE International	UNITED STATES
SAF/AQIJ	UNITED STATES
Sagem Morpho, Inc.	UNITED STATES
SAIC	UNITED STATES
Satcon Applied Technology	UNITED STATES
Scientific Applications & Research Associates	UNITED STATES
See Aero	UNITED STATES
Sensis	UNITED STATES
SETA II/Federal Aviation Administration	UNITED STATES
Sikorsky Aircraft Corporation	UNITED STATES
SITA	UNITED STATES
Sky Tech Aerial Imagery Copter Wrights, LLC	UNITED STATES
Smiths Aerospace Electronic Systems	UNITED STATES
Solers, Inc.	UNITED STATES
Sparrow-Tech Inc.	UNITED STATES
SRA	UNITED STATES
SRA International, Inc.	UNITED STATES
Student	UNITED STATES
Swift Engineering Inc	UNITED STATES

Organization:	Country:
Systems Engineering & Consulting, Inc.	UNITED STATES
TAAC Airspace Operations	UNITED STATES
TAAC UAS Program Manager	UNITED STATES
Telenergy	UNITED STATES
Telephonics Corp	UNITED STATES
Textron, Inc.	UNITED STATES
The Beacon Group	UNITED STATES
The Boeing Company	UNITED STATES
The Drake Group	UNITED STATES
The Insitu Group, Inc	UNITED STATES
The Insitu Group, Inc	UNITED STATES
Transportation Security Administration	UNITED STATES
Tucson Embedded Systems, Inc.	UNITED STATES
TUV America, Inc.	UNITED STATES
U. S. Army	UNITED STATES
U. S. Navy	UNITED STATES
U.S. Navy	UNITED STATES
UAS FIT	UNITED STATES
UAV Communications, Inc.	UNITED STATES
UAV Flight Systems, Inc.	UNITED STATES
UAV Marketspace, Inc.	UNITED STATES
UAV National Industry Team (UNITE)	UNITED STATES

Organization:	Country:
UNITE	UNITED STATES
United Airline Pilots Master Executive Council	UNITED STATES
United Airlines, Inc.	UNITED STATES
US Airways	UNITED STATES
US Army	UNITED STATES
US Army AMRDEC	UNITED STATES
US Army TSM-UAS	UNITED STATES
US Coast Guard	UNITED STATES
US Department of the Interior, National Business Center Aviation Management Directorate	UNITED STATES
US DOT Volpe Center	UNITED STATES
US Navy	UNITED STATES
ViaSat, Inc.	UNITED STATES
Volpe National Transportation Systems Center	UNITED STATES
Washington Consulting Group	UNITED STATES
William Mitchell College of Law	UNITED STATES
WinTec Arrowmaker	UNITED STATES

APPENDIX C – STAKEHOLDER SALIENCY DETERMINATION

Criticality Factor	Level Description	Level range
Urgency	The stakeholder is time insensible or has very low demands for a timely response to its claims at risk in the enterprise	0-2
	The stakeholder asks for its stakes or values with enough anticipation allowing the enterprise to attend them in a timely manner	2-4
	The stakeholder requires attention to its stakes in plausible or reasonable times	4-6
	The stakeholder calls for a prompt attention to the stakes at risk in the enterprise	6-8
	The stakeholder demands immediate attention to the stakes it compromise in the enterprise and their associated payoffs	8-10
	Urgency Level	
Importance	The stakeholder has null or very low dependency on the stakes it puts at risk in the enterprise	0-2
	The stakeholder shows low dependency on the values obtained from the enterprise	2-4
	The stakeholder relies on the values obtained from the enterprise for its future actions or operations	4-6
	The stakeholder shows high dependency on the stakes it contributes at risk in the enterprise	6-8
	The stakeholder demonstrates very high dependency on the stakes it puts at risk in the enterprise and on the values obtained from it	8-10
	Importance Level	
	Criticality Attribute (Weighted) Average	

Criticality Factor Saliency Determination

Power Factor	Level Description	Level Range
Coercive	The stakeholder threatening position to obtain the outcomes desired from the integrated enterprise is null or very low	0-2
	The stakeholder uses threatening arguments to obtain the outcomes it desires from the enterprise	2-4
	The stakeholder is able to pose real threats regarding his claims on the enterprise	4-6
	The stakeholder is capable of using some elements of force, violence, or restraint to obtain benefits from the enterprise	6-8
	The stakeholder is determined and totally capable of using force, violence, or any other restrain resource to obtain desired outcomes from the enterprise	8-10
	Coercive Power Level	
Utilitarian	The stakeholder has null or very low control over the resources (material, financial, services, or information) used by the enterprise	0-2
	The stakeholder has some control over some of the resources used by the enterprise	2-4
	The stakeholder controls the use of some of the resources used by the integrated enterprise	4-6
	The stakeholder heavily administers significant number of the resources used by the enterprise	6-8
	The stakeholder extensively administers most of the resources used by the enterprise	8-10
	Utilitarian Power Level	
Symbolic	The stakeholder does not use or barely uses normative symbols (prestige, esteem) or social symbols (love, friendship, acceptance) to influence on the enterprise system	0-2
	The stakeholder uses some level of normative symbols or social symbols to influence on the enterprise system	2-4
	The stakeholder uses moderate levels of normative symbols or social symbols to influence on the enterprise system	4-6
	The stakeholder relies on normative symbols and/or social symbols to claim his stakes from the enterprise system	6-8
	The stakeholder extensively uses normative symbols and social symbols in order to obtain value from the enterprise system	8-10
	Symbolic Power Level	
	Power Attribute (Weighted) Average	

Power Factor Saliency Determination

Legitimacy Factor	Subtypes	Level Description	Level
Broad definition		Generalized perception or assumption that the actions of a stakeholder are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions.	0-10
Pragmatic	Exchange Legitimacy	Extent to which the stakeholder maintains a materialistic (based on goods, services, or any other type of exchange) relationship with the enterprise, and the importance of those exchanges to the welfare of the enterprise system	0-10
	Influence Legitimacy	Extent to which the stakeholder helps in defining the strategic or long-term interests of the whole enterprise and its submission to those interests before its own welfare.	0-10
	Dispositional Legitimacy	Degree to which the stakeholder is predisposed to share or adopt the enterprise values demonstrating honesty, decency, and trustworthiness in the relationship	0-10
		Pragmatic Legitimacy Average Level	
Moral	Consequential Legitimacy	Degree to which the accomplishments of the stakeholder are perceived by the whole enterprise system as "the right thing to do"	0-10
	Procedural Legitimacy	Extent by which the stakeholder's value creation *processes* are perceived as sound and good efforts to achieve some, albeit invisible, ends as valued by the enterprise system	0-10
	Structural Legitimacy	The degree by which the stakeholder is perceived as having the right internal organizational structure to perform its assigned role in the enterprise system	0-10
	Personal Legitimacy	Extent by which the leaders of the stakeholder organization are perceived as having the adequate charismas, personalities, and authority to perform the job the stakeholder is supposed to do for the enterprise system	0-10
		Moral Legitimacy Average Level	
Cognitive	Comprehensibility Legitimacy	Degree of existence of cultural models that provide plausible explanations for the stakeholder participation in an enterprise and its related endeavors	0-10
	Taken-for-grantedness Legitimacy	Degree to which the legitimacy of the stakeholder is taken for granted without an explicit evaluative support	0-10
		Cognitive Legitimacy Average Level	
		Legitimacy Attribute (Weighted) Average	

Legitimacy Factor Saliency Determination

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APPENDIX D – COUHES APPROVAL

MIT Committee On the Use of Humans as Experimental Subjects

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 Massachusetts Avenue
Cambridge, Massachusetts 02139
Building E 25-143B
(617) 253-6787

To:	Luke Cropsey
From:	Leigh Firn, Chair COUHES
Date:	03/06/2008
Committee Action:	**Exemption Granted**
Committee Action Date:	03/06/2008
COUHES Protocol #:	0803002634
Study Title:	Intergrating Unmanned Aircraft Ststems in the National Airspace Systems: An Application of Value-Focused and Enterprise Architecting

The above-referenced protocol is considered exempt after review by the Committee on the Use of Humans as Experimental Subjects pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

If the research involves collaboration with another institution then the research cannot commence until COUHES receives written notification of approval from the collaborating institution's IRB.

If there are any changes to the protocol that significantly or substantially impact the rights of human subjects you must notify the Committee before those changes are initiated.

You should retain a copy of this letter for your records.



CONSENT TO PARTICIPATE IN INTERVIEW

Integrating Unmanned Aircraft Systems into the National Airspace System: An Application of Value-Focused Thinking and Enterprise Architecting

You have been asked to participate in a research study conducted by Maj Luke Cropsey from the System Design and Management Program at the Massachusetts Institute of Technology (M.I.T.). The purpose of the study is to identify and map the relevant stakeholders in the Air Force Unmanned Aircraft System (UAS) airspace integration enterprise; understand decision maker value definitions and attributes; employ enterprise architecting theory to construct appropriate value propositions for the enterprise; select the most appropriate architecture for delivering enterprise value; and assess the robustness of the enterprise architecture to changing environments. The results of this study will be included in Maj Cropsey's Masters thesis. You were selected as a possible participant in this study because you represent a key airspace integration stakeholder or decision maker; you have firsthand knowledge of specific aspects of the airspace integration effort; or you can provide important insights to the value definition and constraints your organization may have with respect to the airspace integration issue. You should read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

• This interview is voluntary. You have the right not to answer any question, and to stop the interview at any time or for any reason. We expect that the interview will take about one hour, but it may be somewhat shorter or longer depending on your position and engagement with the airspace integration effort and the organizational level you represent.

• You will not be compensated for this interview.

• Unless you give us permission to use your name, title, and / or quote you in any publications that may result from this research, the information you tell us will be confidential.

• We would like to record this interview on audio cassette so that we can use it for reference while proceeding with this study. We will not record this interview without your permission. If you do grant permission for this conversation to be recorded on cassette, you have the right to revoke recording permission and/or end the interview at any time.

This project will be completed by 15 August 2008. All interview recordings will be stored in a secure work space until 1 year after that date. The tapes will then be destroyed.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

(*Please check all that apply*)

[] I give permission for this interview to be recorded on audio cassette.

[] I give permission for the following information to be included in publications resulting from this study:

[] my name [] my title [] direct quotes from this interview

Name of Subject

Signature of Subject _____ Date _____

Signature of Investigator _____ Date _____

Please contact Maj Luke Cropsey at 617-259-0689, or email lcropsey@mit.edu, with any questions or concerns.

If you feel you have been treated unfairly, or you have questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143b, 77 Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253-6787.

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APPENDIX E – UAS INTERVIEW QUESTIONNAIRE

What is (are) the primary need(s) the Certificate of Authorization/Waiver process satisfies for your organization?

What are the strengths of the COA process?

What are the weaknesses of the COA process?

How well does the existing COA process meet your needs?

If you projected your needs into the future over the next 5-10 years, how are they likely to change?

How extensible do you feel the COA process will be for meeting your future needs?

Why will the existing COA process work/not work for meeting your future needs?

What marching orders would you give a UAS airspace integration effort to better meet the needs described above (i.e. describe a mission statement for the effort)?

In what environments and timeframes must this mission be accomplished (i.e. describe the need(s) that must be met in terms of mission and scheduled delivery of value)?

Who do you believe the critical decision makers are for satisfying the above stated need(s)?

What benefit do you expect the other decision makers to provide you in exchange for the resources you contribute?

What do you perceive as the other decision makers' contributions in this activity?

What scope of activities would the airspace integration effort need to undertake in order to meet the need(s) specified?

What conditions do you have on how the activity should proceed (if any)?

What characteristics would a good airspace integration solution have (i.e. how would you know if the effort is successfully accomplishing the mission previously articulated)?

What measures do you use to evaluate how well the characteristics described above are provided?

How would you prioritize these characteristics with respect to one another?

Measure: something tangible or intangible that you use to evaluate or judge the "goodness" of a desired characteristic.

For each of the measures described above, what is the minimal amount of each measure that would be needed before the need begins to be met?

For each of the measures described above, what is the maximum amount of each measure beyond which there is no further value in meeting the need?

Context: The political, regulatory, operational, and policy environment in which UAS airspace integration approval process occurs

Describe the near-term (within the next 5 years) environment and conditions in which you need a solution to the needs identified above.

Describe the mid-term (within the next 5-10 years) environment and conditions in which you need a solution to the needs identified above.

Describe the far-term (the next 10-15 years) environment and conditions in which you need a solution to the needs identified above.

Is there a set of scenarios that would better capture the current, intermediate and future desired delivery of value or need satisfaction? If so, what are they?

What do you believe are the major barriers to achieving authorization to operate UAS in different contexts?

How does your definition of the need, the characterization, or the measurement quantities change with each scenario if at all?

At what point in the degree of access would you say "good enough?" Why?

Constraints: boundaries limiting the extent of activities that can be pursued in the UAS airspace integration effort.

What constraints must be satisfied in meeting these needs (i.e. cost incurred, time required, organizational prerogatives, etc.)?

What is it about these constraints (if any) that are important to you?

Which of these constraints do you feel you have the ability to control?

Which constraints do you feel you can influence but don't directly control?

Do any of the decision makers identified previously directly control any of these constraints? If so, which ones and how would you attempt to influence them?

Which constraints do you consider to be outside of your ability to change and that you must conform with? Do any of the decision makers identified previously directly control any of these constraints? If so, which ones?

If any of the current constraints you just described could be changed, which ones do you think would have the greatest impact on the extent to which your needs could be satisfied? What would the impact be?

What resources to you have available to provide to the airspace integration activity in order to satisfy the needs you articulated? Specifically, what manpower, funding, or influence do you bring to the table?

For each of the three scenarios presented, in what timeframes would you like to be able to operate in the described fashion?

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APPENDIX F – DATA COLLECTION RESULTS

Appendix F contains the full data collection set for all of the interviews conducted to build the UAS airspace integration enterprise value structure. Several points should be made prior to presenting the data. First, every interview was conducted in compliance with Massachusetts Institute of Technology policy and in conformance with the standards established by the Committee on the Use of Humans as Experimental Subjects (COUHES). Appendix D provides the approval from COUHES for conducting the interviews.

Second, all personally identifiable information has been removed from the data collected. For the purpose of clarity in the data, an "ID Number" has been retained that was randomly assigned to an individual. This is important in order to understand the differences within as well as between organizational value structures and how divergence within a single organization may influence how the organization's value structure is created.

Third, the information was transcribed from the interview sheets to an Access database to help with interrogating the data and sorting it across different dimensions. The data reduction was very much an analysis that evolved over time. As a consequence, the information is binned more along the interview questionnaire topic lines than it is on the primary inputs categories depicted in Table 8-1. The advantage of using Access in the data analysis was the ability to create reports looking at the data across different dimensions. For simplicity, however, the following data sets are organized at the top level by the questionnaire topic, then by the organization from which the inputs were solicited, and finally per the individual providing the interview data.

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COA Strengths by Organization

Organization	COA Strengths	COA Strength Comments
ACC/A3		
ID: 1		
	None	Doesn't believe COAs should be required to begin with. Should be able to operate in "routine" capacity using an exemption to VMC requirement for operations under specific conditions--AF/A3 should interpret AFI-11202, vol 3 themselves with a determination that UAS are exempt from VMC requirements based on using charted UAS routes to display ingress/egress routes to Class A airspace while flying on an IFR flight plan (contends FAA already tacitly recognizes IFR in class A airspace as complying with Part 91 requirements. Pipe in additional radar feeds to ground station to further enhance SA if required. Ditch COA and pull the trigger.
ID: 2		
	Provides only current method for allowing us to train with UAS	Only mechanism in place currently for allowing us to deviate from current requirements for performance. Once the COA is approved, it generally works well enough.
ID: 3		
	Only avenue for operating UAS outside of building a platform that can comply with the regulations	
FAA AJR		
ID: 13		
	Brings all of the needed parties together	Process is well vetted, oversight is established, and there is a broad line of communication between ATO, AVS, and regional facilities. It also serves as a mechanism to educate air traffic controllers and others in regions that may not be familiar with UAS operations (Global Hawk going into Grand Forks is a good example). The process is tailored to mesh with Flight Standards policy and directives.
	Educates people on UAS	
	Well-vetted process within the FAA	
ID: 20		

Organization	COA Strengths	COA Strength Comments
	Presents safety case	Presents a safety case to detail how the operator will establish an equivalent level of safety. This is the biggest strength. It ensures the public's trust.
	Process reviewed monthly	The COA process is reviewed monthly by the FAA to evaluate user feedback and further improve the process

COA Weaknesses by Organization

Organization	COA Weaknesses	COA Weaknesses Comments
ACC/A3		
ID: 1		
	Doesn't Improve Safety	Used example of the Reveille MOA approval as an example. Had been conducting operations in this area for several years before this past year's renewal, at which point the FAA decided they needed further "proof" of the safety of the operations, and required the AF to conduct a safety assessment of the operations in the MOA. Did the analysis, and are conducting operations in the exactly the same way they always have. No value added, process doesn't quantitatively measure the safety of the operation or quantify the impacts of changes. Totally personality driven.
	Doesn't Meet Needs	Airspace access is at a standstill. FAA is so risk averse we have to submit a new COA request to go to a new location even with a national COA for RQ-4.
	Is not Extensible	Airspace access is starting to drive basing decisions. Lack of available airspace may drive formal training to Base X, existing Base Y may become LRE for anything not in the formal training pipeline and Ops may go to the bases with comm nodes for basing.
	Only Serves to Deflect Blame (i.e. pure CYA)	
	Time Consuming Process	
	Very Bureaucratic	
ID: 2		
	Hard to complete	Current instantiation of the process is much harder to complete than the early version. Also made it a "one-size fits all" form which further complicates the picture. A result of over-reacting on the FAA's part.
	Long, tedious process	Form is nearly impossible to fill out and you cannot put an "N/A" in a data requirement box even if it doesn't fit for that particular COA application
	Requirements are too stringent	Latest checklist and internal FAA memo on COA requirements tacked on additional requirements that are not needed
ID: 3		

Organization	COA Weaknesses	COA Weaknesses Comments
	Too much detail	This is especially true with respect to the flight standards requirements. Originally, when COAs where only being requested and granted to AF operations, FAA HQ was not even engaged in the discussion. It was all done through the local FISDO office. It was highly dependent on individual idiosyncrasies, but once the folks were educated on the operation and the platform, the COA process was pretty straight forward. No longer. The COA process is way too much into the minutia. We need to get to a "file-and-fly" like level of access. The current COA process hampers effective mission execution.
AF UAS TF		
ID: 19		
	Can be cumbersome/detailed	Is cumbersome and detailed, although if you didn't have this, most organizations would do many of these requirements anyway. Online application helped considerably with the workload.
	Is not Extensible	Takes 60 days to essentially do the equivalent of filing a flight plan on the manned operations side of the house.
	Risk Averse	Let me fly a Predator and I will prove to you that I can match and even beat manned equivalent performance. Don't lump individual platform capabilities (or lack thereof) into a single UAS category.
FAA AJR		
ID: 13		
	Education	Having to have extensive meetings to educated new segments of the FAA air traffic controller community, regional offices, flight standards, and proponents on the requirements and limitations takes a huge amount of time (again, reference the extensive meetings already taking place to get people up to speed on Global Hawk operations preparatory to going into Grand Forks). This includes both the air traffic controllers as well as the Air National Guard with respect to what is doable and what is not.
	Manpower Intensive	Even with the movement of the COA application to an online platform, the process still requires a significant investment in time and effort. As an example, in '06, ATO only had one individual working COA applications. In '08 that has expanded to 3 full-time people supported with administrative assistant
	Staffing through the FAA	The process, while ensuring the appropriate expertise is engaged on the approval process, is itself a time and resource intensive effort. The staffing process itself becomes a significant bottleneck to the throughput of the COA process.

Organization	COA Weaknesses	COA Weaknesses Comments
ID: 20		
	Education	Have to educate agencies that are not historical airspace users. Hopefully education is ongoing through interaction with AJR, policy and regulatory updates and best practices.
	Extensibility Difficult	Office would need to grow in the number of people processing COAs just to keep pace; new technologies need to be developed to provide for better compliance. File and Fly is both a technology problem and an acceptance problem.

Scope by Organization

Organization	Scope	Scope Comments
303 AESW		
ID: 5		
	Gaps filled	
	Equipped	
	Airworthy	Anything required to meet our own airworthiness standards and needed for equipage to fly in the desired airspace. 1) Must be airworthy, 2) Must have the equipage to fly in the airspace you want to operate in, 3) Some on-board solution to fill in the gaps between the UAS and the manned standard.
ACC/A3		
ID: 1		
	Enable the data needed for the ground station feeds	
ID: 2		
	Policy, procedures, standards, equipage	
ID: 3		
	Policy, procedures, standards and equipage	
FAA AIR-160		
ID: 8		
	Still Developing	The scope of activities required for the airspace integration effort are still developing, and will likely continue to evolve over the next 5 years as we get smarter about what needs to be done. DoD is still doing R&D, and this provides an additional mechanism for future emerging requirements that may not currently be on the books. COAs are still being issued at a rate of ~100/year.
ID: 9		
	Define a critical scaling of activities	Need to define a critical set of activities that are scalable from the need to meet immediate requirements to the broader far-term objectives. Figure out how to leverage activities now to meet future requirements (Track 1 approach to the problem).

OrganizationScope	Scope Comments
FAA AJR	
ID: 20	
Manned Operations	Compare how manned aircraft changes were incorporated, and you will likely be in the same ball park. VLJ example would be down the same lines.

Airspace Integration Purpose by Organization

Organization	AI Purpose	Purpose Comments
ACC/A3		
ID: 1		
	Provide mechanism to feed ADS-B, radar, etc into UAS ground station for pilot SA	The first effort will solve the situational awareness picture between the UAS and manned aircraft operating in the airspace. This effort will provide the pilot with the SA needed in the NAS to account for the non-cooperative air traffic portion of the problem.
	Integrate UAS capability with combat aircraft in the battlespace	If we solve the combat airspace integration challenge so we can fly UAS and manned combat air operations seamlessly, we will solve the CONUS airspace integration problem in tandem--with a couple of add-ons for NAS specific operations (see next purpose)
ID: 2		
	Break down all CFRs/FARs and where possible include UAS requirements explicitly.	Need to incorporate UAS as a full-fledged member of the family. Get rid of discussing them as "exceptions" to the manned regulations. They need to be integrated as a standard part of the rules. Lost link procedures would be an example of a UAS specific requirement that would need to be added to the regulatory requirements.
ID: 3		
	Put the appropriate equipage on the airframes.	We won't get anywhere until the airframes are equipped and capable of following the procedural and operational rules for aircraft flying in the NAS. In the Global Hawk case, need navigation database to enable RNAV operations, CNS/ATM equipage, and SAA certified system. Likely 2015 at the earliest.
ACC/A8		
ID: 23		
	Targeted Integration	Find a way to integrate UAS by examining all of the options. Have to use the context to determine where to integrate. Need to fully integrate in some environments. Example: Due regard requirement for international airspace access.
	Bring capability up to requirements	Address the materiel shortfalls in UAS so they will have the ability to operate as specified by the airspace access requirements denoted in the appropriate regulations.
	Change the rule set	For UAS specific issues, regulations need to be changed to recognize fundamental differences. Example: Do right of way rules need to be modified for UAS with less capability?

Organization AI Purpose		Purpose Comments
ID: 24		
	Drive the materiel solution.	Should lead the effort to drive towards a primarily materiel solution that provides for the necessary equipage needed to fly in the NAS. Should provide the mechanism for someone to file an 1801 to say how you are equipped to access the requested airspace.
	Provide certification path	Should provide framework in which certifications can be approved for maneuvers, pilot's situational awareness, data collection and ultimate flight.
AF UAS TF		
ID: 19		
	Initiate a combine DoD/FAA dialogue to figure out what will meet needs	Grab whoever is needed out of the DoD and the FAA, get all the materiel solutions together, and then figure out what will be required to meet the needs.
FAA AIR-160		
ID: 8		
	Integrate UAS	This needs to be done within the existing infrastructure
	Identify further gaps	As progress is made, additional expertise will need to be applied to the problem to uncover heretofore unknown gaps with expertise that may not be currently applied to the topic.
	Baseline performance characteristics and functionality	This needs to be done in several representative sets or configurations
	Assess current automation systems	Need to understand and assess the impact of current automation systems and their anticipated ramifications due to aircraft performance envelopes
	Establish CONOPs	Need solid concepts of operation/employment in the airspace to assess avionics performance and handling
ID: 9		
	Difficult to answer	The question is difficult to nail down because it must be answered against the broader backdrop. It is only a piece of the puzzle.
	Define the structure	Define the structure of the overall problem in which the AI participants contribute to the problem.
	Understand failure modes and characteristics	FAA focus--"Interested in the anticipated case being good enough versus the best case being the norm."
	Develop CONEMPs for standard/contingency operations	Need the CONEMPs for standard operations and contingency responses.

Organization	AI Purpose	Purpose Comments
	Identify each participant's role	Each participant's role should be clearly identified and tied back to the broader objectives framework so they understand the value of their contributions and how it contributes to the whole.
	Assess intended use environment	Look at the safe operation of the UAS in their intended use environments.
FAA AJR ID: 13		
	Develop regulatory guidance	Need integrated and specific UAS regulatory guidance
	Integrate UAS into Air Traffic Controller Handbook	UAS operations need to be integrated into air traffic controller procedures and activities so they know how to address and deal with UAS specific issues
	Provide a safety basis	A significant limitation of existing UAS operations is the lack of concrete safety analysis, data, and experience. Activities are needed to put UAS safety analysis and understanding on the same footing as manned aircraft. Need data on the type and number of UAS operations, lost link events, emergency procedures, etc. This kind of data makes us all smarter about operations and how they are performing. Starting from scratch is difficult in this context. We are straddling the fence with one foot in the manned aircraft community with a well established safety history, and one foot in the UAS community that is on a very shaky safety ground. Designs need to be done in the future that specifically prevent safety incidents from occurring, rather than engineers designing these systems in isolation for other engineers. Need an operational perspective incorporated into the design of these systems.
	Establish UAS categories	Need appropriate UAS categories established before UAS separation categories can be created and integrated into air traffic control procedures. This deals specifically with UAS sizes, wake vortex, etc.
	Do the needed human interface design	UAS design and ground stations need a lot of human factors research. Need to understand how the UAS context is different. What are the human factors associated with flying an aircraft 6,000 miles away from the pilot? Need to understand the bounds on this element

Organization	AI Purpose	Purpose Comments
	Create a predictable system	Define what predictability means when things go wrong. Identify how the air traffic controller can help in these situations. There is a gap in the knowledge in time and space. How do you fill these? What is done for lost link procedures? Need to develop prior knowledge of these things, not something that is gained by trial and error on the operational fly.
	Well-characterized systems	The effort should produce a system that has been wrung-out thoroughly. Don't want to look at a smoking hole in the ground and then say "We didn't think of that!" We need a priori knowledge of how the system is going to behave across its full spectrum of operations and contingencies. We need to explore situations and understand them before they happen in the airspace, not as a result of them happening in the airspace.
	Measure performance differences	How do we measure the difference between manned and unmanned aircraft? What do these differences look like from an ATC perspective? Are the existing manned standards safe enough? All of these questions need answers.
ID: 20		
	Address Collateral Issues	Additional aspects will likely come to light as the effort proceeds. These must also be addressed.
	Policy Updates	Updated policy on how UAS will be integrated into the NAS needs to be written
	Rule Making	FAA needs to accomplish the required updates to the regulatory environment to explicitly address UAS requirements
	Work technology to eliminate SAA issue	This is the number 1 thing holding things up.
	Work technology for other compliance concerns	Other equipage requirements need to be addressed to enable full compliance
HAF/A3 - JPDO		
ID: 16		
	Address the performance gaps	Address the performance gaps on a UAS to the point where it looks, feels, tastes, and smells the same as a manned aircraft.
USD(AT&L)		
ID: 21		

Organization	AI Purpose	Purpose Comments
	Develop autonomous SAA	
	Conduct MS&A	Modeling and simulation is required to evaluate needed performance goals
	Secure data links	
	Define flight phases	
	Specify contingency procedures	
	Develop standards	Need performance standards to figure out what you need to do
ID: 22		
	Get to File-and-Fly Access	Achieve the same level of access as manned aircraft.
	Keep long-term perspective	JIPT Track 2 effort is making progress in terms of defining the problems, what needs to be done to solve them, and focusing technology development efforts on those pieces we can't fix.
	Work local ops challenges	The TFR at Beale is a procedural fix, but it is extremely limiting to operations that can be flown out of that location. If we had a technology solution to solve the 0-18,000 ft problem, it would help tremendously. Work immediate operational issues on a platform by platform, location by location basis for a while to gain further insights and build experience. ID the functional problem and then find the technology to support it.
SAF/AQIJ		
ID: 11		
	Preserve principle of Maneuver	The goal should be to preserve the capability of maneuver that aircraft bring to the fight. It is this principle that has been the distinguishing hallmark of history's great generals that consistently won on the battlefield. If the AF is going to shift capability to UAS platforms, it must do so without compromising this fundamental principle of warfare.
ID: 12		
	Keep critical mass on the effort.	As an AF, we need to keep the critical mass of expertise we've built up with the JIPT and others working this problem.

Organization AI Purpose	Purpose Comments
Develop game plan	Need game plan on what needs to be solved and an effective method of communicating it to senior leadership. Has to include the full spectrum of issues including hardware, policy, integration, modeling & simulation, what-if scenario developments, etc. Need to establish the way ahead with enough specificity so leadership can understand the issues, pick up the flag and run with it. Leadership doesn't know enough yet about what is needed.

Decision Makers by Organization

Organization	Critical DMs	Decision Maker Comments
303 AESW		
ID: 5		
	ACC/A3	Informs COMACC who provides requirements, scope, and resources in terms of dollars/manpower.
	ACC/A5	Informs COMACC who provides requirements, scope, and resources in terms of dollars/manpower.
	ACC/A8	Informs COMACC who provides requirements, scope, and resources in terms of dollars/manpower.
	AF UAS TF	
	ASC/XR	SIMAF to work with the FAA on MS&A to make sure the modeling reflects FAA concerns and assumptions otherwise the data won't be worth anything, and we won't have enough flight hours on the actual system to validate anything.
	ESC NextGen Office	
	FAA	Approval authority to turn UAS on. FAA needs to provide acceptance of flight in the NAS by looking at the data and a concept of employment by platform and assessing the adequacy of the materiel component to provide a safe enough operation.
	HAF/A2	COMACC-HAF/A3-PBFA chain all have a vote and they have to be value added in terms of scrutiny of the proposal from different points of view and perspectives.
	HAF/A3	COMACC-HAF/A3-PBFA chain all have a vote and they have to be value added in terms of scrutiny of the proposal from different points of view and perspectives.
	HAF/A5	COMACC-HAF/A3-PBFA chain all have a vote and they have to be value added in terms of scrutiny of the proposal from different points of view and perspectives.
	HAF/A8	COMACC-HAF/A3-PBFA chain all have a vote and they have to be value added in terms of scrutiny of the proposal from different points of view and perspectives.
	USD(AT&L)	
	PBFA	Official conduit through with COMACC voices needs to the FAA. COMACC-HAF/A3-PBFA chain all have a vote and they have to be value added in terms of scrutiny of the proposal from different points of view and perspectives.

Organization	Critical DMs	Decision Maker Comments
	SAF/AQ	
ID: 6		
	303 AESW	GH needs to integrate the solution on the bird.
	AFRL	AFRL needs to provide a way forward on the technical solution for SAA.
ACC/A3		
ID: 1		
	ACC/A3	Lead for determining feed requirements for command and control and working battlespace integration along with ACC/A5.
	DoD Leadership (JS or AT&L)	Would need their support to convince them this was a reasonable move to make given the context and mitigations in place.
	HAF/A3	Interprets AFI 11202 v3. Would have to determine that UAS are exempt from VMC requirements based on details provided under COA Strengths Comments.
	PBFA	Interface with FAA on AF position. Need to ditch the "play nice" tact and just tell the FAA how we are going to operate--take same approach as we use with manned aircraft operations.
ID: 2		
	303 AESW	Works with ACC/A8/A3 to develop the appropriate capability for aircraft equipage and capability
	ACC/A3	Has to work the training and operational need requirements for the UAS platform usage. Also responsible for articulating AF airspace integration needs/requirements up the chain of command
	Congress	Without a direct and specific interest on the part of the Congress to get this issue fixed, and the consequential pressure that follows on the FAA, this issue will not get the level of attention it needs from the FAA.
	FAA Administrator	This issue needs to get elevated beyond the layer of middle management that is currently calling all of the shots on the FAA side, and taken to the FAA Administrator level by Senior DoD leadership.
	HAF/A3	Works issues forwarded by COMACC and puts together an AF position to send over to the PBFA
	HAF/A5	Works in conjunction with HAF/A3 and SAF/AQ to put together AF position to send over to the PBFA

Organization	Critical DMs	Decision Maker Comments
	USD(AT&L)	This office needs to be convinced in order to pull along the JCOE and the Joint Staff to get DoD to engage with the FAA at the appropriate level.
	PBFA	This office needs to work the official comm channel between DoD and senior FAA leadership to advocate for the DoD training and operational needs.
	SAF/AQ	Works in conjunction with HAF/A3/A5 to put together AF position to send over to the PBFA
ID: 3		
	303 AESW	Works with ACC/A8/A3 to develop the appropriate capability for aircraft equipage and capability
	ACC/A3	Has to work the training and operational need requirements for the UAS platform usage. Also responsible for articulating AF airspace integration needs/requirements up the chain of command
	Congress	Without a direct and specific interest on the part of the Congress to get this issue fixed, and the consequential pressure that follows on the FAA, this issue will not get the level of attention it needs from the FAA.
	FAA Administrator	This issue needs to get elevated beyond the layer of middle management that is currently calling all of the shots on the FAA side, and taken to the FAA Administrator level by Senior DoD leadership.
	HAF/A3	Works issues forwarded by COMACC and puts together an AF position to send over to the PBFA
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	USD(AT&L)	This office needs to be convinced in order to pull along the JCOE and the Joint Staff to get DoD to engage with the FAA at the appropriate level.
	PBFA	This office needs to work the official comm channel between DoD and senior FAA leadership to advocate for the DoD training and operational needs.
	SAF/AQ	Works in conjunction with HAF/A3/A5 to put together AF position to send over to the PBFA
ACC/A8		
ID: 23		

Organization Critical DMs	Decision Maker Comments
FAA	Owns the rule set. DoD operates in the airspace, but the public is represented by the FAA. A lot of heat on the FAA to bend. Not sure they should on this. Need to work within the existing rule set.
Senior Leaders	Critical to have the senior leaders of each organization involved in the dialogue engaged across the spectrum.

ID: 24

303 AESW

ACC/A8U

AF UAS TF

AFRL

FAA

USD(AT&L) UAS TF

SAF/AQI

AF UAS TF

ID: 19

DoD	Needs to come to the table with a clear articulation of what they need
FAA	Needs to have in their mind what must be demonstrated that is realistic, and they can't lump everything together.

FAA AIR-160

ID: 8

AOPA	Existing NAS user advocacy groups including AOPA, ALPA, etc. Provides acceptance from the broader NAS user community.
ASTM	Standards bodies of all types to include ASTM, SAE, RTCA, etc
DoD	Defines operations that need to be conducted in the NAS for mission accomplishment and homeland defense.
FAA AFS	Provides pilot quals, ops approvals, separation standards, wake vortex classes, OPR for 6 FARS that have to rewritten, and own 5-6,000 civil safety inspections that have to be completed.
FAA AIR-160	Provides aircraft design, TSO'd standards, advanced avionics requirements, etc.

Organization	Critical DMs	Decision Maker Comments
	FAA ATO	Provides inputs for air traffic management issues, procedures, policies; Interprets CFR Part 91.
ID: 9		
	End Users	End users that have identified specific needs. They need to assess the viability of a UAS in meeting their needs given the current operational restrictions. They need to consider what contributions they would be willing to make to meet their objectives. Then they need to make the appropriate resource allocation using the full cost of ownership as the basis for their decision. In this context, the FAA responds to pull from the end users. There is no push, only pull. Congress might provide some push.
	Providers	Have the responsibility of providing the ability to enable the operations of the end user in a safe manner. Have to understand how the system will operate and interact with the rest of the airspace structure to ensure safety.
FAA AJR		
ID: 13		
	ATO	Critical player with AVS. Pretty much in synch with AVS.
	AVS	Critical player with ATO. Pretty much in synch with ATO.
	DoD	
ID: 20		
	DHS	Other public agency player
	DoD	Major public agency player. Primary focus is on accomplishing their missions. Some involve research that creates new products and enhancements. FAA provides greater access to support their missions.
	FAA AIR-160	Needs to write the regs and policy updates. Would oversee the overall safety look (SRM) process as the lead for the FAA.
	FAA ATO/E	En Route Air Traffic. Expertise in their areas to assess impact to the system.
	FAA ATO/S	Safety. Expertise in their areas to assess impact to the system.
	FAA ATO/T	Terminal Air Traffic. Expertise in their areas to assess impact to the system.

Organization	Critical DMs	Decision Maker Comments
	Industry	Other NAS users. Through RTCA involvement. Provide anything and everything to the effort. Whatever they are asked to provide, they in all likelihood would.
HAF/A3 - JPDO		
ID: 16		
	AOPA/ALPA	Need to be involved because you will be operating and impacting the airspace they use
	DEA/DHS	Need an interdepartmental structure because the success or failure of their operations impacts everyone else (ref Predator crash last year)
	DoD	Lead the collective effort forward
	FAA	Need to be totally linked up and synched with airspace integration activities
	NTSB/Safety Groups	Need to engage with the collective safety community to ensure safe operations
USD(AT&L)		
ID: 21		
	Acquisition	
	Command and Control	
	Congress	Guard issues are becoming increasingly important in the political arena
	FAA AIR-160	
	FAA ATO	
	Frequency Spectrum Management Office	
	ICAO	
	NII	
	Ops Community	Has to provide the motivation for a solution
	Requirements (J8)	
ID: 22		
	ACC/A8	

Organization	Critical DMs	Decision Maker Comments
	Acquisition Community	
	PBFA	Says the FAA are good guys trying to help
SAF/AQIJ		
ID: 11		
	303 AESW	Keep doing what they are doing. Build it and they will come. Need to get the primes engaged. Hold an industry day for the "big kids."
	ACC/A3	Needs to provide the will to move the airspace integration effort forward and embrace/comprehend what UAS success means and looks like. Need to realize they have created a force structure shift with procurement decisions regarding UAS capabilities. They need to either fully embrace it and do what is needed to enable the capability, or they need to stop it
	AFRL	Need them to have near-term responsiveness to Global Hawk technology needs. Need to figure out what needs to happen long-term. You can't solve a world-class problem without including world-class engineering firms. The solution can't be proprietary. It must be government owned--buy it and own it like we did with TCAS. Bad Example: Proprietary software in voting machines--bad news.
	FAA	Need complete and total embracing of UAS as a community requiring their services. Currently treat UAS with a degree of condescension that we have in some cases brought on ourselves.
	USD(AT&L)	A zealot, and we need one. Their function is one of oversight. They should be focusing on making the services do what needs to be done, not trying to do it themselves. They need to work the PPBS process, and they need to drive overall OSD behavior into some degree of coherency--reference the lack of an integrated OSD position on GH OIPT reviews.
	PBFA	Need complete and total embracing of UAS as a community requiring their services. Currently treat UAS with a degree of condescension that we have in some cases brought on ourselves.
ID: 12		
	ACC	Own and operate the UAS assets
	Acquisition Chain	Need them to build the materiel solutions
	CBP	
	Coast Guard	
	Congress	

Organization	Critical DMs	Decision Maker Comments
	FAA	Approval authority for operational use of UAS in the NAS
	Forrest Service	
	HAF/A3	Should be leading the effort, but currently no leadership. They are impaired by HAF/A2 mission growth who is busy fighting the war. Pease should be pushing this issue hard wearing his A3 hat.
	Joint Staff J-3/J-8	DoD level leadership for operational usage and planning
	NASA	
	PBFA	Super conservative and doesn't want to push the UAS airspace integration issue. Pease doesn't feel behind in this area in either of his roles as A3 or PBFA executive director.

Need Definitions by Organization

Organization		Primary Need COA Satisfies	Need Comments
ACC/A3			
ID: 1			
	Training Missions for Wartime Operational Missions	Wartime use of UAS are attractive for missions that would otherwise be limited from a human factors standpoint such as duration or G-limits, or are extremely hazardous and would otherwise not be feasible to attempt with a manned platform.	
	Operational Missions in CONUS	CONUS use of UAS the result of force structure decisions the AF has made concerning replacement capabilities for existing manned platforms; this will only likely continue to get further complicated in the future as additional manned assets are displaced with UAS platforms, making CONUS-based operations more and more dependent on UAS platforms. A possible relief to this scenario would be the potential for the AF to get back into the Counter-Insurgency business with manned platforms; however, this is currently unlikely and assets will be limited in their availability to support CONUS operations.	
ID: 2			
	Training Missions for Wartime Operational Missions	Safety of our pilots; not limited by human factors; need to be able to train like you fight; have to use a COA because of 7610.4 requirement to operate outside of restricted airspace with a UAS.	
ID: 3			
	Training Missions for Wartime Operational Missions	Dull, Dirty, or Dangerous missions	
AF UAS TF			
ID: 19			
	Training Missions for Wartime Operational Missions	Once the COA is approved and in place, it works for the purposes it was approved for.	
FAA AJR			
ID: 13			
	Puts the brake on UAS growth.	Until critical shortfalls in the data, knowledge, and experience with UAS can be filled in, the growth of UAS operations in the NAS needs to be tightly controlled and regulated to ensure the safety of operations. The COA process does that.	
	One of two ways for UAS to fly in the NAS safely (other is EAC)	COAs will be with us for a long time to come. Much is tied to the lack of SAA technology, lack of UAS specific regulatory guidance. Short of these issues being addressed, the COA is the mechanism by which we mitigate the safety risk. Safety is the bottom line	

Organization	Primary Need COA Satisfies	Need Comments
ID: 20		
	Provides risk mitigation	Application is accomplished through online site. Applicant is asked for mitigation strategy including lost link procedures, emergency procedures, airworthiness statement, detailed flight operations area (defining "the box" the aircraft will fly in), avionics suite, any sensors, how 91.113 will be mitigated through AIR-160 approved strategies, etc.
	Means for UAS to fly safely	UAS could not otherwise operate given their lack of compliance with various regulations, especially CFR Part 91.113

AI Characteristics by Organization

Organization	Characteristic of Good Solutions	Metric
303 AESW		
ID: 5		
	Conforms rather than creates	Number of new regs generated
	Does no harm	Currently undefined
	Man-like access	access equivalent to manned aircraft operational flexibility. Transparent to ATC that the UAS took off without a pilot on board.
	Equivalent level of safety	Acceptable operational risk
ACC/A3		
ID: 1		
	Simple for the pilot to use (data feeds are well-integrated into the ground station making SA easy)	# of Displays
	Mirrors manned aircraft implementation (uses same system for flight plan, NOTAMS, weather, etc)	Does or Doesn't Use Same System
	Flexible to meet schedule requirements (i.e. file flight plan for approval)	Time in hours
ID: 2		
	UAS as an accepted, integral member of the NAS	Normal operations
	Safe operations	Deviations from ATC direction
ID: 3		
	Flexibility of operations	Time to launch mission
	New ops location isn't significant emotional event	No longer raises an eyebrow
	Safety	Accidents/flt hr
ACC/A8		
ID: 23		
	Safety	Mid-airs/deaths

Organization	Characteristic of Good Solutions	Metric
	Mission enabled	Can I do my mission?
	Consensus on approach	Community on board with approach
	Cost	$$
	Impact on NAS Structure	Change required in infrastructure/procedures
ID: 24		
	Integrated equipage	Internal subsystem
	Sense-and-Avoid	Situational Awareness
	Provides pilot advisories	Provides heading, altitude, speed, range
AF UAS TF		
ID: 19		
	Know one will know or care there is any difference b/w manned/unmanned	Transparent with manned ops, no one blinks, very usual, common occurrence -- Integrated
	Launching and recovering with UA Flt 99.	Follows expected behavior/rules of the road (like NORDO procedures)--Predictable
	C-130, Huey, Predator all lined up waiting to take off.	Can follow ATC direction--Dynamic
FAA AIR-160		
ID: 8		
	ATC treats UAS just like any other aircraft with similar expectation on performance in response.	Performance vs. Procedural
ID: 9		
	UAS has enough capability to perform like a manned aircraft doing the same kind of operations.	Normal performance characteristics
	Contingency responses	Failure modes
	Technology, System Integration, Environment	Safety Threshold
FAA AJR		
ID: 13		
	Predictable	Prescribed behavior and interactions
	Safety	Manned baseline

Organization	Characteristic of Good Solutions	Metric
ID: 20		
	Everything is cooperating with everyone else, the way it was intended & approved, is safe	Integrated Ops using Technology Advances
	Don't know--too much on the table for next 30 years	
HAF/A3 - JPDO		
ID: 16		
	Manned equivalent ops	Same Airspace
	Manned equivalent ops	
	Manned equivalent ops	Act Like Manned
	Manned equivalent ops	Same Separation
HAF/A3-PBFA		
ID: 25		
	Routine coordination	Working efficiently
	Action item list is being worked	Overdue suspenses
	My phone isn't ringing	Number of complaints from field
USD(AT&L)		
ID: 21		
	Sense and Avoid Equipage	Complies with 91.113
	Responsive C2 system	Maintains connectivity
	Airworthiness Certified	Standardized training, logistics, maintenance
	Handles contingencies	Predictability
ID: 22		
	Level of improved safety	# of accidents
	Reduced training/ops overhead	training time
	Reduced operations cost	$$
SAF/AQIJ		
ID: 11		
	Manned equivalent ops	Arrangements to do a static display at Andrews should be the same as manned

Organization	Characteristic of Good Solutions	Metric
	Long-term access--supports principle of maneuver	Consistent with military expectations of military aviation
	Near-term feasibility of plan	Implementable
ID: 12		
	Capable Technology	Clear and declare EPs
	Integrated procedures	FAA comfortable with reliability of ops/procedures
	Comprehensive policies	Policies in place that specifically describe what we'll allow them to do

Resources by Organization

Organization	Resources Contributed	Resource Comments
303 AESW		
ID: 5		
	$80M for Global Hawk	
ACC/A3		
ID: 1		
	$10M and people to work ground radar capability ($100M LCCE)	Use ground-based radar as an interim work around until the longer-term SA feeds are available and ADS-B comes online. Radar becomes part of the system level analysis for the safety case.
	Manpower to work the requirements and policy changes	Primarily provide the manpower and expertise to work the operation policy and regulatory issues associated with conducting operations using UAS
ID: 2		
	Minimum possible	The AF will only spend as much resources in dollars and manpower as the leadership believes is necessary to fix an immediate operational problem.
ACC/A8		
ID: 23		
	Millions	Need to put millions of dollars on this problem for people who are willing to work the issue.
ID: 24		
	$80M from 2008 to 2015	
AF UAS TF		
ID: 19		
	Already have enough	Think we already have tons of resources applied to this. It just isn't coordinated and aligned.
FAA AIR-160		
ID: 8		
	Don't know!	Can't even build a program plan in the current environment.

Organization	Resources Contributed	Resource Comments
	Need unencumbered resources.	Need twice the number of people that are currently working the issue without the constraints of a government bureaucracy. Something along the lines of a mini skunkworks. Let me move to some place like Atlanta, and come back in a few years with the problem licked.
ID: 9		
	$20M/10 people per year	Use this to baseline performance and failure mode characteristics and contingency operations.
FAA AJR		
ID: 13		
	$2M/yr next 5 years	Access 5 like effort in terms of the organization and expertise involved in the activity, but should be smaller and more focused on the specifics that are needed.
ID: 20		
	Resources are involved.	There are a lot of people who have their fingers in this trying to move it forward. RTCA is a good example. Could use additional manpower and funding to accelerate the effort.
USD(AT&L)		
ID: 22		
	$50-$100M per location/platform	Put these resources on the Track 1 efforts to resolve specific operational needs in specific locations
	$10-$15M/yr for Track 2 work	Put these resources on the Track 2 development track for the first 3-5 years of work to get the larger scale plan put in place.
SAF/AQIJ		
ID: 11		
	Need linkage	We need a linkage between the size of the investment that would have been made for a manned aircraft like Global Hawk versus the amount needed to enable using them to get the advantage of maneuver back for the UAS. You don't get the UAS advantages for nothing.
ID: 12		
	$10M/per yr/per platform	Put this kind of money on the problem for the first three years to get the plan laid out, the issues communicated, and leadership on board

Organization	Resources Contributed	Resource Comments
	$50M in year 4/per platform	Pushes the planning into real execution for tangible results
	$100Ms/per yr	After year four, need real money to go out and procure the assets needed to put the capability in the field

Returns by Organization

Organization	Return Expected	Return Comments
ACC/A3		
ID: 1		
	Political Capital	
	Advocacy for AF position	
	Effort to move issue forward	
	Involvement	
ID: 2		
	Top-Level Leverage	Nothing is moving on this issue at the middle-management layer, especially over at the FAA. Need the appropriate stakeholders to engage on the issue so that the line FAA organizations start approaching the problem proactively with a solution oriented perspective.
	Policy Changes	Goes hand-in-hand with proactive engagement as well as the need for integrated regulatory environment for UAS.
	Proactive Engagement	Push to make things happen proactively, in a standardized way
ID: 3		
	Political Backing	Have to have the political backing to keep the effort funded and working towards a solution. Too often the airspace integration effort gets tossed below the cut line, or raided for other priorities.
FAA AIR-160		
ID: 9		
	Appropriate UAS type and quality to achieve objective	The end user should provide a UAS of the appropriate quality and type to achieve the operational objectives for which they intend the UAS. The problem is that while there maybe a general understanding of the requirement, management has to decide it is worth the resource investment to provide a UAS capable of meeting the objectives.

Constraints by Organization

Organization Constraints		Constraint Comments	Max Impact to Constraint Change
ACC/A3			
ID: 1			
	ACC/A3 Airspace and Ranges need to get better acquainted with CONUS requirements	This is needed to set the appropriate requirements for the advanced cockpit activity and to get a leg up on a proactive approach to integrating the ADS-B and other future requirements before they are required to demonstrate good-faith effort on our part.	
	Political Clout	Articulated approach only works if senior AF and DoD executives are willing to get engaged on the subject and spin the issue in a positive direction for all concerned, including the FAA. Should be cast in terms of increased security for U.S. by flying these missions, a proactive reaching out to the GA community by providing them with better awareness of UAS operations and safety considerations, providing for unique frequencies for ingress/egress routes and awareness of in-progress UAS operations, and getting ahead of ADS-B/NextGen requirements showing good faith effort to comply with airspace access requirements	Need to convince senior AF/DoD leadership to take this issue on as a major interdepartmental issue.
	Prioritized Funding	Needed for the CAF to ensure the systems are funded for acquisition.	
ID: 2			
	Equipage issues have to be fixed	Equipage is our biggest constraint in moving forward. Under this category, the single largest factor is a lack of SAA capability.	

Organization Constraints	Constraint Comments	Max Impact to Constraint Change
Senior leader engagement	in the end, ACC leadership has to take the airspace integration issue on as a command interest item. Currently have two SSS packages on the way out the door signed by the ACC/CV to the Air Staff for Coordination. One is a CORONA-like set of taskings to work actions at the HAF-level. The second is a way ahead for Ops, procedures, and policy.	
ID: 3		
		Funding has to be protected to make any progress on the equipage/standards. It will require money to be spent, and we have to have it on hand to put together a cogent program.
"Fix the truck" issues not funded	These issues are not fundamentally increasing the combat capability on the aircraft. They provide a mechanism for delivering the capability to the fight. Because of this indirect linkage, leadership continues to cut the effort in favor of more direct combat capabilities. Leadership does not truly understand how difficult working the operational approval for flights with the FAA really is. They just expect it to happen with no real insight into the true cost to the organization.	
Can put package together for COMACC	Send signed COMACC package up to HAF/A3 and PBFA for action	
Funding	Major constraint on what can be accomplished and keeping AFRL working the SAA equipage R&D piece is critical	
Organizational Biases	Both AF and FAA organizational biases pose a major constraint to moving the issues forward. Both operate under different assumptions and value different end-state objectives.	

Organization Constraints		Constraint Comments	Max Impact to Constraint Change
	Time	Time itself is a constraint. The modeling and testing can't necessarily be accelerated even if the budget where available to do so. Need the time to fly the missions, collect the data, and build the experience and comfort factor with respect to the safety of the capability	
ACC/A8			
ID: 23			
	Tailorable Approach	Solution should be variable based on the area of flight and the needs of the mission.	
ID: 24			
	Enable/Disable function	Need to have the capability to enable or disable an equipage component depending on the operational context of the flight.	
	Equipage issues	SAA needs to be designed for a man-on-the-loop capability vice a man-in-the-loop system	
	Equipage issues	SAA and other equipage requirements should be designed internal to the aircraft as an integrated subsystem--not as a 'strap' on to the existing system, or one that has to be bolted on before flight. Should co-exist with any other subsystem without having to turn something else off. Not something you have to externally configure for flight. Don't treat like tradable SWAP.	
	Equipage issues	Need a radar to do due regard. Need to understand and address unofficial concerns i.e. the need for multi-sensors for seeing and avoiding gliders.	
AF UAS TF			
ID: 19			

Organization Constraints	Constraint Comments	Max Impact to Constraint Change
Determination of Training and qualification requirements	DoD needs to determine collaterally what the appropriate training and qualification requirements are for operating UAS.	
Equipage issues	SAA isn't going to get here ahead of the need. We are going to have to accept some risk and put up with some more restricted airspace for national defense . The FAA has had the luxury of ignoring the need up to this point. The political pressure will continue to grow and then they will have to cave.	

FAA AIR-160

ID: 8

Has to be a community approach with recognized effectiveness for generating provable results.	A positive example for how to proceed would be the analysis that is being considered for putting in ground based, fused radar at Grand Forks for Global Hawk operations. This is a solid, root cause analysis that is being done from the ground up. A negative example would be the way in which TCAS was initially pursued for integration onto Global Hawk by Northrop Grumman. The equipment was not installed by certified technicians, the equipment itself was not from a TSO'd parts supplier, etc.	
Rulemaking Process	The current rulemaking process is a 600 plus day process, and that's for a relatively straight forward, easy change or addition. This can easily take 5 years to complete.	This is the single most limiting aspect to making progress on this issue. Changes here could cut the time to reach standards by 1/2 to 2/3s!
Standards have to be developed	The standards that go into the rulemaking process have to be developed, tested, and verified.	

ID: 9

Organization Constraints		Constraint Comments	Max Impact to Constraint Change
	Don't know yet	The bounding is based on validating a concept or approach. Not doing this results in a premium being placed on a subjective assessment when it comes time for submitting an operational approval request. As an example consider the 1 pilot/1 aircraft issue. FAA opinion currently says it is incomprehensible that something more than 1 pilot/1 aircraft could be safe. If the response is a subjective argument--we've already done it--you will get a subjective analysis of the safety. Goes back to the middle-out approach. If you want it bad, you'll get it bad. Demonstrates a lack of appropriate coordination/collaboration.	
	Elicit, Decompose, Align, Assess, Propose	This is a basic process that needs to be used to identify the various objectives and needs the UAS stakeholder community has that can be met through a combined, common effort. By explicitly outlining what requirements are aligned and the proposal for meeting them, confusion can be avoided or eliminated, and the stakeholders can make informed decisions about what they want to be involved with from a solution standpoint.	Arriving at a common purpose for the effort. Balance across the activity is needed. A recognition of the needs and approaches to meeting those needs must be articulated. Fundamentally, a philosophical level of agreement is required on the vision
FAA AJR			
ID: 13			
	Need robust T&E	Effort needs a very robust test and evaluation effort. The current approach is haphazard, hit and miss. Aware of some efforts underway such as TAAC out at New Mexico State University. Important thing is to build knowledge of platform limitations.	

Organization Constraints		Constraint Comments	Max Impact to Constraint Change
	Visible checks and balances	The assessment of what this looks like tends to be instinctive, cultivated over a career of doing air traffic management, versus something you can nail down as skill based. Need more time in the research and development stage along with experimental efforts to begin to fully understand how we build these kinds of checks-and-balances into the UAS.	
ID: 20			
			Who is going to provide us with the information needed to establish the regulatory requirements for things like wake turbulence categories for UAS?
	Follow rule for playing fair.	Need to ensure the effort maintained its integrity by full and open disclosure of information to the entire community. Transparency is important.	
USD(AT&L)			
ID: 21			
	Consensus	The approach needs to provide an avenue for the diverse stakeholders involved to come to agreement and consensus on how the airspace integration issue will be tackled.	
	Leadership	The activity needs strong leadership at several levels to be successful. Significant progress will be limited without this.	Generating a higher level of leadership advocacy for this issue is the number one issue that needs to be addressed.
	Organizational	Activity needs to the appropriate organizations engaged in the effort to be successful. Expertise is central to this problem, and the right expertise needs to be engaged on this problem to get it solved.	
ID: 22			

Organization	Constraints	Constraint Comments	Max Impact to Constraint Change
	Application specific technology	Technical constraints require solutions that can be tailorable to the platforms on which they are intended to fly.	
	Cost	Ties into the need to reduce operations cost--from both an operating and total ownership perspective. Have a lot of room to improve on this particular metric, but part of the problem is that nobody wants to fully load the total ownership cost of the system when considering the purchase of these assets. Airspace integration needs to be explicitly included.	
	Culture		Second largest impact would be to get the FAA to be more of a partner a the senior level
	Has to fit current airspace structure	Cannot propose radically different approach. Needs to conform rather than create. FAA controls this. DoD has very little influence on this.	
	Move technology to lower ATC workload	Needs to address the tools and technologies that will assist ATC in managing the airspace	
	Must take an incremental approach	Resource constraints prohibit a massive launching of resources to solve this problem all at once. Need an incremental plan to accommodate the fiscal realities	
	Resources		Single largest limiting factor to making progress
SAF/AQIJ			
ID: 11			
	Addresses budget realities	Fits in current program allocation	
	Addresses program realities	Meets current requirements	
	Addresses schedule realities	Fits in current program schedule	
ID: 12			

Organization Constraints	Constraint Comments	Max Impact to Constraint Change
Collaborative	Our efforts have to arm-in-arm with the FAA. This effort must be a full partnership.	

Epoch by Organization

Organization	Epoch Descriptions	Epoch Scenario Descriptions	Start Time
303 AESW			
ID: 5			
	Current COA Scenario	Continue to use existing COAs until a validated SAA capability can be fielded.	1/1/2008
	TBD	Schedule: iffy, anywhere from 2011 to 2015, with a start on SDD of 2010-2013. Don't really know what the schedule is because we aren't sure where the future priority will be placed on this particular issue. Timeframes have not been formally established, environment has not been formally established (i.e. what does global access mean). CDD language is too vague to build a program against with any certainty. Need better definition of the need.	1/1/2015
ACC/A3			
ID: 1			
	Current COA Scenario	Proceed with existing COA construct until advanced cockpit solution is at IOC for appropriate platforms to integrate feeds.	1/1/2008
	Restricted Routine Scenario	Leave COA altogether for situations in which there is a defined operating location, assets on published routes for ingress/egress, flying IFR with rated pilots, using integrated SA feeds. Use this period as a data collection timeframe to validate ability to operate safely in a limited, but integrated environment.	1/1/2011
	NextGen Scenario	ADS-B mandated on all aircraft; all aircraft become cooperative air traffic; all flights in the NAS require transponder and pilot to be squawking.	1/1/2020
ID: 3			
	Current COA Scenario	Will in all likelihood continue to operate on COAs for the next 8 to 10 years at least. Navigation Database, RNAV, RNP, route changes on the fly, TCAS issues resolved, local letters of agreement with published routes, 7610.4 excepted or amended all accomplished to allow for ops beyond COA.	1/1/2008
	Equipage Testing	Data collection with new SAA equipage on the aircraft, modeled performance, and on-going testing occurring while still operating on COAs to build up confidence.	1/1/2015

Organization	Epoch Descriptions	Epoch Scenario Descriptions	Start Time
	Routine Scenario	Operations would proceed from restricted routine operations as described above once the appropriate equipage and standards are in place. As experience continues to grow, operations should continue to expand as the safety of the operation continues to be demonstrated in less and less restrictive operations.	1/1/2018
ACC/A8			
ID: 23			
	TFRs	Maximize the number and use of TFRs available for the near-term (Beale context).	1/1/2008
	Reclassification of airspace	Reclassify the airspace under CFR Part 93 to extend "talk and squawk" requirements to 18,000 (Beale context)	1/1/2010
	SAA	Implement and operate with fully capable SAA capability on board to provide needed equipage to meet airspace requirements without the procedural limitations currently imposed.	1/1/2015
ID: 24			
	Current COA Scenario	Operations continue in the same vein until the acquisition community can field a viable SAA capability on a Global Hawk.	1/1/2008
	Gradual Phase in	COA's become progressively less and less restrictive as additional information and safety data is collected and validated against SAA systems and operations.	1/1/2012
	File-and-Fly	COA's fade out altogether as system becomes capable of meeting regulatory requirements.	1/1/2015
FAA AJR			
ID: 13			
	Current COA Scenario	Next 5 years will see the start of regulatory guidance emerging	1/1/2008
	Technology emergence	Next 5 to 10 years will see SAA technology and components maturing and coming into the mainstream.	1/1/2013
ID: 20			
	Current COA Scenario	RTCA is saying 2019 before standards will be available for FAA rulemaking process.	1/1/2008

Organization	Epoch Descriptions	Epoch Scenario Descriptions	Start Time
	Routine Scenario	Updated standards, policies, and regs will be available to measure compliance and access requirements. Very event dependent timeline from RTCA. Probably still not full file-and-fly capability. Likely much further	1/1/2019
	NextGen Scenario	NextGen would be the next thing to look at after current operations mature. Implementation of that may create further evolutions.	1/1/2020
USD(AT&L)			
ID: 22			
	Ramp up Phase	For next 3-5 years, get all of the Track 2 planning stuff done with long-term plan, major milestones, functional requirements, testing and evaluation, etc. all laid out in a coherent manner. Solve near-term problems for specific locations such as Global Hawk at Beale.	1/1/2008

Barriers By Organization

Organization	Barriers to AI	Barrier Comments
303 AESW		
ID:5		
	Lack of Leadership	# one problem with this issue. Nobody is at the top of the pile leading the way forward. Generate the way forward, plans, send them around, but get nothing back. Then stuck waiting for someone to come along and say "let's do this." people are ducking the decisions they need to make at every organizational level in the bureaucracy. That means the guys at ACC/A3/A8 could do a lot to help us if they would take a stand. Same with the 303 AESW. You end up with decisions through inaction. Just need someone high enough up in the leadership chain to temporarily overcome in the institutional biases and get a solution in place.
	Lack of Definition by the User on what is really needed	The solution needs to be resourced commensurate with the definition of the activity scope.
	Lack of Commitment by User	don't think the user fully appreciates the magnitude and complexity of the problem they are facing.
	Resources	if the User thinks they have defined the problem (a.k.a. global access) they have not resourced the ability to generate a materiel solution.
	Bureaucracy	failure to use existing chain of command/organizational relationships, responsibilities and authorities. Too many cooks in the kitchen. Ipso facto.
ID:6		
	FAA Culture	The FAA's perceived adverse attitude toward change is a lim fac. Perceived difference in urgency. Not doing their job to create the needed regulatory environment. Need to help write the test, not grade the test.

Organization	Barriers to AI	Barrier Comments
	Lack of Organizational Discipline	Have organizations that are not sticking to their knitting. AQ are a money provider, not a solution provider. They are getting into solutions. Their job is to provide money and validate the plan, not write the plan. People are talking instead of organizations talking. There is all kinds of misinformation, and misperceptions based on personal views instead of vetting them through organizational positions. The brainstorming phase is over. The good idea cut off date has come and gone. People are not being forced to operate within the disciplined positions and authorities of their organizations. We don't need more stakeholders. We need more people stepping up to fulfill their organizational responsibilities commensurate with their responsibilities.
ID:7		
	Lack of Money	
ACC/A3		
ID:1		
	Lack of Leadership Involvement	Someone has to be willing to stand up and say, "We are going to fly and give this a try because we think it is safe enough."
ID:2		
	Lack of Leadership Involvement	Need leadership to put senior level pressure on the FAA to be more sensible with operational approvals and approaches to expanding access
	Organizational Paradigms	FAA culture has become totally risk averse, and their approach for assessing risk is highly subjective and personality dependent. It doesn't even make logical sense sometimes
	Equipage Shortfalls	Missing the pair of eyes in the aircraft. This is an emotional issue and it must be resolved for there to be any chance of UAS being accepted as equal players in the NAS.
ID:3		
	Organizational Paradigms	The AF has yet to truly treat these assets as aircraft. Until that mindset is changed, there will always be an issue with UAS being accepted into the routine functioning of the NAS as equal partners.

Organization	Barriers to AI	Barrier Comments
	Airworthiness Questions	This issue goes directly to the need the AF has to make sure its own Airworthiness house is in order and that we have the ability to convince ourselves that the equipage we put on the aircraft is sufficiently robust and capable to find the aircraft in compliance with requirements--primarily our own AF stipulations first, and then in suite FAA standards.
	Equipage Shortfalls	Missing the ability to see-and-avoid with the emphasis on the avoid part. You need to see so that you can avoid. In this case, we are not capable of doing that to the extent necessary to be considered in compliance with the performance requirements for flight in the NAS.
	Lack of Leadership Involvement	This issue is stuck until the AF/FAA senior leadership decides to make it a priority to fix. Solid working level relationships provide basis for continuing to move forward, but fundamentally, this needs to be pushed from the top to break through some of the cultural and paradigm issues previously pointed out.
ACC/A8		
ID:23		
	Equipage Shortfalls	Reliable C2 is a major issue. Lost link issues require pre-planned contingencies to be worked out which is a tremendous burden on the infrastructure.
	Lack of clear guidance	Have to have a deterministic decision on where we will or won't fly--unless you have the appropriate equipage.
ID:24		
	Inflated perspective of manned performance	The FAA believes manned performance is actually better than it really is. Example: crummy clearing by pilots.
	FAA Culture	Has them trapped in a risk adverse perspective that makes them late to need. Slow to adopt needs of any kind into the NAS and the rules governing it
	Burden of Safety Proof	The burden of safety proof is going to require a major fiscal investment with a long-term payback before results are seen (i.e. ROI is long).
	Belief that UAS are fundamentally different	The FAA believes that UAS are fundamentally different from manned aircraft. UAS are not as big of a deal as the FAA thinks they are.
AF UAS TF		
ID:19		
	FAA's lack of willingness to quantify risk	The FAA lumps all UAS together when assessing the risk to the airspace. They should quantify the risk based on the individual subsystems rather than a single lumped category

Organization	Barriers to AI	Barrier Comments
	FAA won't look at alternative options	FAA isn't open minded enough to go look at options and assess the realities of the operational picture. They are totally close minded on this.
	Safety case bar set too high	The FAA's safety case requirements draws such a high requirement there isn't a system out there that can make the cut--including manned aircraft if they were to be held to the same standard.
	Lost link procedures/capabilities	Lost link procedures need work to keep the aircraft flying the way it should
	FAA is risk intolerant	DoD has ways that work, the FAA just won't consider them. Thinks the FAA's issue with noncooperative air traffic is over stated.
FAA AIR-160 ID:8		
	Lack of technical expertise across the community	There is an incredibly small pool of technical expertise available in the UAS community for moving the state of engineering forward. The very small pool of talent has no counterpart on the manned aircraft analogy.
	Program not a priority	Within the FAA, the UAS issue is not a priority in the broader scheme of things the FAA has on its plate. The result is a struggle to get resources to commit to the problem.
	Funding	This is a result of the relatively little priority the program has in the broader FAA program plan.
	Politics	A lot of companies think they can get Congress to dictate the path the FAA must take. A lot of program office time is absorbed having to respond to these Congressional inquiries.
	Culture	Acceptance from the manned aviation community is no where close to being at hand. In addition, the manned community is not willing to recognize the nuances the UAS technology base brings to the operational environment. It needs to be addressed in the broader policy, procedures, technology arena.
	Lack of equipment heritage	All of the UAS designs on the books are starting from scratch without the 2-3 years that typically go into development prior to going operational. There is no heritage on components. Part of the reason the DoD memo on sharing safety data with the FAA is so important.

Organization	Barriers to AI	Barrier Comments
	Lack of aviation heritage	90% of the manufacturers in the UAS business have never built an airplane before. Significant disconnect in aviation culture, both in terms of the manufacturing base as well as the UAS customer base. For example, there are over 19,000 law enforcement units in the U.S. and only 300 of them have aviation units. All of them think they will be utilizing small UAS in the future for law enforcement purposes.
ID:9		
	Lack of Leadership	Both on the FAA and the DoD fronts, need better engagement especially with respect to developing an agreed to common objective that can be managed effectively at whatever organizational level is required.
	Lack of appropriate resourcing	Don't have enough manpower or funding to pursue the problem in its entirety. Problem is further complicated by the observation that those that have the most control over the resources typically know the least about what needs to be done to solve the problem, or even what the magnitude of the challenges are that need to be addressed. Those that have a fundamental grasp of the domain knowledge typically have the least amount of control over the needed resources to solve the issues.
FAA AJR		
ID:13		
	Limited airframe/pilot capability	The inability to meet existing manned aircraft performance and reaction rates from an ATC perspective is a major limitation. They are nowhere close to the manned equivalent yet.
	Lack of system characterization	UAS have yet to be fully characterized across the operational domain. What happens when the aircraft can fly for 24 hours but your crews wear out? You still have all of the same traditional aircraft components--aircraft, pilot, environment--but you have complicated the problem by taking the pilot out of the aircraft/environment

Organization	Barriers to AI	Barrier Comments
	Culture	The cultural differences between the FAA and the DoD drives a fundamental difference in perspective. The DoD designs and fields many of its UAS platforms as "expendable" assets with very much of a "disposal mindset" underpinning their development and procurement. As a result, the DoD will default to a position that makes UAS risk acceptability considerably higher than for equivalent manned missions. The FAA sees the same platform and defaults to a more conservative risk position due to the unknown "X" factor associated with UAS platforms--lack of data, knowledge, experience, heritage, etc. results in a more conservative risk approach since the boundaries are not clearly understood or defined. Example: Army lost a Raven and they didn't go look for it. The rationale is that it would have costed more to have gone out and found it rather than just buying another one. This mindset is completely counter to the way the FAA sees the same issue. Why wouldn't you go out and find it to make sure you understand the failure mode, environment, and requirements needed to make sure it didn't happen again? At the heart of this issue is the belief that DoD is not treating UAS as aircraft. They are deploying them to meet specific operational requirements, not for integration into the NAS. DoD is still trying to make a platform designed for a specific combat need work in a much more rigorous airspace integration environment.
	Perceived cheaper	The view point that I can do this cheaper than with a manned aircraft. I still have pilot, aircraft and mission to control, only know they are all at geographically separate locations. How is this easier?
ID:20		
	Regulatory Updates	Along with the technology advancements required, this would be the second biggest issue that needs to be resolved.
	Equipage Shortfalls	Need SAA capability and the ability to meet compliance requirements in other areas as well
HAF/A3 - JPDO		
ID:16		
	Lack of "Marketing"	Need a track record of performance, and then continue to demonstrate UAS operational safety.
	No Central Belly Button	All of this activity is currently personality driven. Have a lot "IPTs" going on right now. Need one central belly button. Need an office for strictly UAS. Probably needs to be a joint organization being run by a 3-star--especially to have the horse power to get DSCA ops pushed through

Organization	Barriers to AI	Barrier Comments
	Politics	Rice bowls are and will be an issue (i.e. lost jobs in the commercial sector to culture in the AF)
	Equipage Shortfalls	UAS are not operating like you expect a manned aircraft to operate. Until they do, you won't get to integrated operations.
HAF/A3-PBFA		
ID:25		
	Moving target	The problem is that the situation is evolving, so it hard to know what requirements will exist in the future. Hard to know what access will be required as platforms are changed, as UAS evolve and become more sophisticated (i.e. 500 feet and below may expand significantly). Not a defined process of that gives us a good sense for this. If you did know what the requirements where, one measure would be whether or not your phone was ringing asking why they weren't getting the support they needed.
USD(AT&L)		
ID:21		
	Lack of standards	Can't measure progress without a performance objective. Need something against which to measure effort
	Politics	The PBFA funnel from the working level groups (like the JIPT) to the FAA doesn't work.
	Process	Need a better way to coordinate with the FAA. AT&L is filling this role because nobody else is doing it. Need the Joint Staff/Services to drive this train. Goes back to lack of advocacy.
	Resources	no one sees this as a high enough priority to fund it.
	No Advocate	People still don't see airspace integration as an issue that needs to be worked.
	No single organization with responsibility/authority	Still don't have one organization that is motivated to work the problem for a day job. Right now the task is still considered "extra work". This needs to translate into someone's primary mission or reason for existing if it is going to be solved in a timely fashion. The organization itself can be temporary, but the work itself won't get done with part time committees.
ID:22		

Organization	Barriers to AI	Barrier Comments
	Ad Hoc process	Still a very ad hoc process to get issues resolved. Can't have Fred Pease engaged for every single issue. All of the middle-management says "no" forcing a dialogue all the way at the top-level of the FAA. This is incredibly inefficient. PBFA is not transmitting the DoD position on
	Nobody is really in charge yet.	Ultimately, the problem needs to be transferred and vested in the guys who own and operate the assets. This has yet to happen at an organizational level within the Services.
	Lack of Leadership and Interest	DoD leadership has not invested the political capital to articulate the need to the FAA. Example: "No Go" letter to the FAA saying we have to have 5 flights a week at Beale. Hasn't happened.
	Cultural perspective	the operational components of the services dominate decision making. Financial component is relegated to having to react to the operational decisions. That has to change. There is an attitude that I will pay any price, that manpower is "free", and just give me the capability and I'll find a way to use it. We build capability first, and the we figure out how to use it.
	Short Sighted	DoD doesn't throw resources at a problem until it is a screaming issue. Until it is a current, major issue, we'll do nothing to solve it.
SAF/AQIJ ID:11		
	Lack of will	A major shortcoming that has be resolved for progress to be made is the collective will to find a solution. The enterprise as a whole needs to have the desire/will to see this UAS activity be as successful as it can as soon as possible. It needs to start with the AF. In the absence of will, we have an overwhelming propensity to blame shift to the FAA.
	Organizational G-lock	We are a product of our history (reference Icarus Syndrome). In this context it may require direct intervention on the part of Congress for this issue to be effectively resolved, much as they had to do with TCAS and the FAA.
	Leadership	Current approach to implementing UAS results in an illegitimate shifting of risk. The taxpayer is writing checks for UAS capability. If they can't be used to maximum effect, the taxpayer is being short changed on their investment. The only way a solution will be forthcoming is if leadership is positively motivated to find one, or negatively motivated through embarrassment to do something.

Organization	Barriers to AI	Barrier Comments
	Magnitude of effort unrecognized	Recognition of the magnitude of the effort required to provide the needed capability for UAS is due to either straight ignorance for the issues or woeful disregard for them.
ID: 12		
	Leadership	Need the leadership vacuum filled to provide center of mass on the issue. Need leadership in several functions and at all levels of the organization within DoD, FAA, and DHS. Also need leadership from industry and the private sector to move forward. There needs to be a collective "stepping up to the plate" on this issue.
	Culture	The belief the UAS fix will be a long-time in coming, that a very methodical approach requires a long time. The belief that UAS flying in the NAS is just too scary.
	Funding	A major limiting factor on making progress.
	Technology	We don't have a radar/EO package that can do what we need it to do from a performance perspective.

Remarks by Organization

Organization	Remark Type	Remarks
303 AESW		
ID: 5		
	Assumption	Assumption: 80% of the global access requirement will be addressed through the fielding of a GH SAA capability in the above timeframe and dollar cost. You won't know what you are building meets the requirement for performance until you define what you mean for global access. What does this mean? Current context implies that the performance needs to include national airspace access, and this in turn involves the FAA. Therefore, ultimate success with respect to the performance aspect of this issue is tied in with the FAA's approval of the operation, which in turn depends on the safety case for the operation.
	General Approach	Taking an incremental approach to this issue. First increment is classes 3-5, autonomous (man-on-the-loop) in-flight operations, in A,D,E,G airspace (SDD in FY2010). Increment 2 depends on the success of Increment 1. Next increment will depend on what ACC/FAA think the next most important thing is to fix as defined by the user and the regulator. Trying to take an approach that avoids goring each other's sacred cows. Build on success-as defined by the FAA accepting what we put on the aircraft.
	USAF	Acquisition leadership is extremely risk averse. Do the best job you can with the current resources. Don't have the resources to solve world hunger issue. Airspace integration is the pawn in the executive agency issue. Have to believe that HAF would act consistently with existing organizational responsibilities and use the PBFA as it was intended. COMACC goes to the AF/A3 as a staff agency to get what he needs done.
ID: 6		
	General Approach	Joint Force commander decides in theater, FAA decides in the NAS, ICAO decides internationally, host countries in their own airspace.
ACC/A3		
ID: 1		

Organization	Remark Type	Remarks
	GA Issues	There is growing perspective that general aviation air traffic is not being responsible enough to train and operate the way they need to in the airspace. Examples include TFR and Exclusion Zone violations by GA traffic. This gives rise to a perception that GA traffic is not flying as safely as it should be, and increasing regulation on their operation is occurring. Loss of noncooperative air traffic status is only a matter of time. Germany just banned it within the past year. Our time will come.
	General Approach	UAS operations should be divided into just two categories, those conducted on line-of-sight and those conducted on beyond-line-of-sight. For those conducted on line-of-sight, the aircraft should stay within visual range of the controller, wouldn't need to be a pilot, would have more stringent operating altitude limitations, but wouldn't need approval or COA to operate them. BLOS operations would require rated pilot and aircraft capable of being integrated into the airspace picture. Example is the current AF/Army issue with Restricted Operating Zones (ROZs) for organic Army assets. These aircraft are not integrated into the ATO, and they create exclusion zones for the rest of the airspace users. They should be limited below the coordination altitude and everything else should be on the ATO.
	General Approach	Don't create a whole new way of doing business. These are aircraft, we are going to treat them as such, and we'll fly them with rated
	General Approach	We should fly UAS just like manned aircraft. Rather than treating them as special "categories" we should treat them based on their functionality or mission capabilities.
	General Approach	We need to get the FAA away from the mindset of employing more restrictive regulatory policies to increase airspace safety and into better education of the airspace users to increase safety in the airspace.
	Manned Precedents	FAA won't agree to exempt UAS from VMC rules like it does with manned aircraft and airspeed restrictions(other examples include turbine engines, pressurized cockpits, TACANS, RNAV, INS, etc) because they believe this to " be a bridge too far" from a safety perspective.
	Work Around Solution	Remote Split Operations (RSO) is a possible work around for the lack of restricted airspace at guard locations. Launch using the LRE from Base X while the MCE is located at the local Guard base to fly the mission after launching. Politics are an issue since the maintenance would end up being done at Base X instead of the ANG base, limiting the number of available jobs, making the politics of this option problematic
	Work Around Solution	Proposed establishing addition restricted airspace in N. Dakota to deal with the issue up there. Initial FAA look was no, and the long-term prognosis is this will be denied as a viable work around by the FAA.

Organization	Remark Type	Remarks
ID: 2		
	Equipage Issues	Not sure SAA is an airworthiness issue in the classic sense given the constraints to moving forward. We should convince ourselves that we have the SAA problem solved, but do it with the FAA in-tow. Should be sharing data, safety information, design criteria, etc in keeping with a good faith relationship with the FAA.
	Equipage Issues	Even if Global Hawk were fully equipped with the appropriate capabilities to fly in the NAS, we'd still be on a COA until 7610.4 is updated.
	FAA	Everything is handled reactively. There is very little activity to work any issues proactively. There is also a problem with the FAA setting a "moving target" for performance requirements.
	General Approach	Need to generate a spirit of cooperation between the AF and FAA in solving this issue
	Operational Issues	Operations in the NAS account for less than 5% of all UAS flights currently being conducted.
ID: 3		
	COA Issues	Original COA coordination between ACC and the SPO was a bear. The bulk of the effort on the FAA side was geared toward educating and briefing all of the affected parties to the UAS operation, and much less on the COA approval process itself
	Equipage Issues	FAA has been, and continues to be, engaged with AFRL on the SAA development effort. This has been a positive thing.
	Equipage Issues	ACC ops is also now heavily engaged on the AFRL effort. Their involvement was the driving force behind AFRL finally picking up the radar as a viable sensor to use for the SAA problem.
	FAA	Air traffic concerns are relatively straight forward: can you talk, squawk, and respond--and what are you going to do in the event of a lost link event?
	FAA	Large air gap between working-level and the top-level FAA executives. Somebody above XXX needs to be making the calls on what is required for these national level issues--especially since FAA HQ seems to be the only organization with any issue about using or running TFRs for UAS ops.
	General Approach	Funding choices in our current context are hard choices. We are in the middle of a shooting war with no clear end in sight, we have an aging fleet of aircraft, etc. Everything that is needed is important. Making the resource priority call is difficult.

Organization	Remark Type	Remarks
	History	May 99: First GH flight in the NAS to participate in Roving Sands exercise. 02: FAA suggested putting in a RAC-D in the LRE at Beale to enhance safety of GH operations. AF agreed to do so. 05: FAA pulled the approval for using Radar at Beale as a sufficient risk mitigator for flights in and out of Beale when COA approval was moved from the local Regional offices to the FAA HQs. 07: The FAA suggested an additional radar as an alternative at Beale
	History	Doesn't trust the FAA on the COA approvals w.r.t. changing the TFR requirements at Beale given the track history to date. Need some assurances that if a radar goes in at Beale that it will be good enough to dispense with the TFRs. Positive the FAA won't be that forthcoming
	Work Around Solution	Part 93, Special Air Traffic Rules, could be used to create custom designed airspace to meet our operational requirements for flight in the NAS.
	Work Around Solution	AF leadership needs to strap on a testosterone patch and tell the FAA we have to have more than three TFRs a week to fly on. We are going to let those guys at Beale bleed out there because some mid-level manager doesn't think we need more access. National level decisions should not be made at that level. They should be made further up the leadership chain, but we have consistently failed to elevate these issues to the appropriate FAA offices. Upper middle-management at the FAA is not engaged on this problem.
	Work Around Solution	It took a year to coordinate the approvals needed for Global Hawk to fly to Australia, Germany, and Portugal. There are huge coordination issues with flying Global Hawk across the Atlantic (trans-oceanic routes are a concern if the UAS goes lost link or craps out and descends through the middle of these routes).
ACC/A8		
ID: 23		
	General Approach	What good is a car if you can't drive it on the road? Flying is dynamic in nature, and war is chaos. In segregated airspace, DoD gives UAS priority handling and right of way. Train analogy--has priority over road traffic at a railroad crossing. Put appropriate safety mechanisms in place like road signs, lights, train horns and bells, road barriers, etc. In the NAS, UAS don't get priority status which means they are trying to compete on an equal footing with manned. It is really hard to take the God-given mind out of the picture. IFR is essentially the way we have achieved the needed "safety systems" for UAS flight in the NAS, at least to date.

Organization	Remark Type	Remarks
	General Approach	At what level do you need to file-and-fly? Integration should be done in a targeted manner. In other words, we should pursue integration in only those instances where it will be of direct benefit to the mission being accomplished. We shouldn't be chasing world hunger. Need is location specific i.e. combat airspace vs. NAS. The solution should be tunable across need and location to make the cost/benefit equation work. Otherwise, we either need to go with a different asset, or pick a different location.
	General Approach	This is all about compromise. Technology is a great tool, but the problem needs to be addressed pragmatically, starting with the procedural element. Rule sets need to be evolved to keep things safe, but still accommodating without compromising. Example: We have traffic rules that we all obey when operating our cars, but there are instances in which vehicles are provided exceptions from complying--like fire trucks, ambulances, police cruisers, etc.
ID: 24		
	General Approach	UAS a "new phenomenon" in the airspace, and with no equipage standards, can't just go to file-and-fly. Things are accelerating much more rapidly than airspace management can deal with.
	General Approach	Success is a moving target. Things can always be improved. There will always be opportunities and limitations. Once you get there, things will need to modernize over time.
	General Approach	For a standard to emerge, you have to have developed materiel solutions. To the extent they fall short, they point you to the solution, and it becomes baseline data for the next iteration. SAA is important in this regard and it requires a fusion of different technologies.
	General Approach	There shouldn't be any issues with FAA engagement or interaction at the working level. In fact, this kind of engagement is needed to move forward on the problem. This is especially true with respect to the design requirements.
	General Approach	Not going to launch a Manhattan Project or an ACAT I program. Need a pragmatic approach fully funding a single vanguard program to chart the path. Global Hawk is the appropriate test case because it has the needed SWAP. Once that is working, scale the solution to other platforms. Current fiscal and political limitations are forcing this kind of approach. Just need to continue making forward progress
	OSD	Not sure OSD has caught up to the reality that a JPO approach isn't going to work from a resource standpoint. It isn't the lack of a requirement driving this issue, it's the lack of resources.
AF UAS TF		
ID: 19		

Organization	Remark Type	Remarks
	General Approach	DoD needs to get the job done. Should be OSD bringing the activity together, but OSD doesn't appear to have the ability to keep its kids in order. It also doesn't have the required expertise or resources.
	General Approach	FAA treats every UAS in the same way by lumping them altogether under one single process. FAA needs to distinguish between UAS capabilities and provide a measured response to aircraft capabilities rather than being so risk averse.
	General Approach	Predator could fly today with its current complement of sensors and equipment and fully comply with the regulations associated with flying in the NAS except for those conditions in which it goes lost link.
FAA AIR-160		
ID: 8		
	FAA	There will be significant issues with labor unions in the transition from current air traffic controllers to the future vision of air traffic managers who manage by exception in highly automated systems as opposed to the current practice of actively directing each aircraft in flight.
	General Approach	Should engage JPDO and OEP efforts as two primary futuristic stakeholders and as sources of future funding for UAS development activity. The FAA and the EU through EUROCONTROL/EUROCAE/EASA should create a high-level steering committee to open communication, eliminate redundancies, feed data, and drive standards. Elevate UAS as an enabling cross over between OEP--SES and JPDO--SESAR activities between FAA and EU.
	General Approach	The difference between technological capability vs. procedural fixes can be thought of as the difference between true collision avoidance capability vs. separation assurance procedures. The minimum performance requirements are still evolving. Guidance to SC-203 was to design the highway first and as we start to build it, things will start to drop off the "to-do" list.
	General Approach	The U.S. Government is going to remain the largest UAS customer for at least the next 10 years while the rest of these issues get sorted out for civil.
	General Approach	Using SFARS on the small UAS to move forward. Probably need to look at Part 23/25 changes that can then be run at a specific size, weight, and speed for a year to evaluate the changes, and then make another incremental step forward.
	History	UAS are at the will of every other system that is already in operation in the NAS. We are trying to take a futuristically capable system and dumb it down so it will play nicely with a system that is 40-50 years old.

Organization	Remark Type	Remarks
	Infrastructure Issues	Very saddled with 100 years worth of legacy. Can't think more than just past our nose for out of the box approaches. For example, we have over 11,000 aircraft airborne at any one time in the NAS, but we are still using the old 4,086 beacon codes.
ID: 9		
	Equipage Issues	There is some truth to the complaint that the FAA is "grading the test instead of helping write the test." We don't actually write the test, but we do have a responsibility to provide insight and clarity into positions that have been taken on issues, which we don't do a good job of all the time. We can't dictate a system design because it really limits the possibilities. We have to assess what is brought to us, not determine before hand what can be brought to us.
	General Approach	Bound the problem using a Track 1 style approach. Collect data over time, build experience with the system, and use this data and experience to build a solid safety assessment case with appropriate risk management system rigor. Without this kind of approach, the assessment by the FAA will be necessarily conservative in nature.
	General Approach	Are you a consumer/user or a provider/enabler? As a consumer/user, you will be primarily interested in the business case problem. As a provider/enabler you will be primarily focused on difficult questions of safely integrating UAS capability into the airspace structure. Further complicating this picture is the fact that we haven't clearly defined the problem set that has to be addressed. We can begin to draw some boundaries, but we don't have all of the details yet. Bounding the problem set becomes the critical issue that needs to be
	General Approach	UAS operations should be assessed based on the technology, system integration, and operational environment in which a safety threshold is established using specific criteria. Can't lump UAS into a single number. Need a set of parameters to establish appropriate safety levels, and these haven't been established yet.
	General Approach	Sexy and easy to point to SAA, but there are a number of issues. Concern that this is AF centric, and calling GH as "starting from a known" is an overstatement. We don't actually know that much. There are a lot of unknowns based on where GH came from, and the activities that are taking place with it that would provide data. It is being used in an operational mode, not a research mode. General philosophy is an incremental approach using baseline data to build safety case.
		Concern that this is AF centric, and calling GH as "starting from a known" is an overstatement. We don't actually know that much. There are a lot of unknowns based on where GH came from, and the activities that are taking place with it that would provide data. It is being used in an operational mode, not a research mode. General philosophy is an incremental approach using baseline data to build safety case.

Organization	Remark Type	Remarks
	General Approach	"Can do" doesn't represent a sufficient safety case for "Should do."
	Operational Issues	MQ-1, MQ-9, RQ-4 come into the picture in the middle of the problem. They have not provided a true safety assessment from the ground up. They typically want to base an operational approval on some paired down subset of issues that don't address the broader underlying concerns.
	Operational Issues	Those that want to use UAS have not fully assessed the cost with their use. Because this wasn't done up front, there is an inability to meet the need due to performance shortfalls. The end user has to consider these points before they buy these systems, and they have to budget and plan for their remediation if they do.
FAA AJR		
ID: 13		
	FAA	A major effort on the part of ATO with the COA process, and in a broader context, with the UAS issue in general, is the need for broader education on the nature of UAS activities and capabilities. Populating UAS terminology into regulations and handbooks, especially for air traffic controllers, flight standards, and proponents, is a major ATO effort. Developed a UAS 101 course that runs between 2-4 days long depending on the level of knowledge of the audience.
	General Approach	in the future, the airspace structure will change, technologies like ADS-B will drive different procedures, modernizing through NextGen effort will create further evolutions. Need to look forward into this environment for understanding where UAS performance needs to go in the future.
	Operational Issues	UAS operational pressures will continue to grow, especially once the war effort start to ramp down and DoD brings assets back to the States at the end of OIF. In addition, their uses are continuing to expand with applications that are now reaching into law enforcement, fire fighting, border patrol, etc. The memo that was signed last year between the DoD and FAA for Class D airspace and for defining operations of Small UAS provides some relief on this growing pressure, but it isn't the final answer for addressing the need.
	Work Around Solutions	COAs will not be extensible much further into the future. COA growth: 04-24, 05-55, 06-102, 07-119, 08-200, 09-250, 10-400
ID: 20		
	FAA	Already convened and closed a safety panel to address safety issues with UAS flight in Class D airspace.
	FAA	FAA has a safety panel convened to address safety issues with UAS flight in Class A airspace. Results will likely be released by the end of the year.

Organization	Remark Type	Remarks
HAF/A3 - JPDO		
ID: 16		
	Equipage Issues	Talking out of both sides of our mouth on our performance. We say that we want to integrate into the airspace just like a manned aircraft, but then we turn around and say we want/need special handling because we can't perform like a manned aircraft.
	General Approach	Doesn't mind the fact that there are rules that we have to comply with. You need them to provide order and structure. Doesn't know what they need to be for UAS, but you clearly need them for future operations.
	General Approach	Have to ask the hard questions about how we are going to operate, and there are going to be folks who aren't going to like it.
	General Approach	Every new technology that has been introduced faced resistance from the status quo.
	General Approach	If UAS can't get to the same general level of performance as manned aircraft, they will never be fully accepted or integrated into the manned environment.
	General Approach	Integration activities should occur in a smart, gradual manner. JPDO's marching orders are to develop the NextGen plan, not to do the actual program. The FAA is the implementation mechanism. Right now on the JPDO activity, there is growing interest in the UAS topic, but there is currently no study group or team dedicated to the topic. Industry is currently engaging through the RTCA. There is an R&D wedge in the plan for UAS. JPDO does the big picture, broad brush
HAF/A3-PBFA		
ID: 25		

Organization	Remark Type	Remarks
	General Approach	Attributes: through space congestion, proximity to busy airfields, proximity to ranges and restricted airspace, political constraints (talk with XXX on this angle). Each flying wing has a number of flying requirements: sorties to be flown, pilots with training objectives to be met. If these are not being met, there will be issues with achieving operational competencies. Training syllabus identifies a number of requirements that you have, but the student is always getting weathered out or his access is being stretched out, then the training effectiveness goes down as well. You can't train them in a reasonable amount of time. The whole process is delayed (A3OT can provide additional insights). Maintain currency for combat. For operational missions, they would be somewhat the same. If you have missions that have to be flown in support of an activity, you need to be able to fly them when you need to, for however long it takes to get it done. In this regard, it is pretty cut and dried. Where you able to actually execute the mission? Or did you have to use some other less desirable asset to do the mission because the UAS was unavailable to fly the mission for whatever reason. If available to fly the mission, how effective was the UAS in actually accomplishing the required tasking?
	USAF	Future UAS Access motivation: There is also the culture of the Air Froce/DoD to always (to the best of our abilities) to maximize weapon system utilization and effectiveness. Current manned fleets will at some point be replaced with unmanned. As a result, we have a need to get to integrated operations as UAS take over more and more of the mission space. Establishing an equivalent mission space to enable consistent freedom of maneuver. Our present day access is not meeting current requirement in some ways in some locations. This will only continue to get worse over time. Expectations are continuing to shift with the access (Ex. Nov 06 everyone was happy with being to fly on a TFR with 5 flights a week. The pressure is already growing to expand this). Our increasing requirements will eat into the expectation of how well these are satisfied. Rate of growth in UAS missions is exceeding the rate at which we can expand operations into non-segregated airspace.
	USAF	Internal fight as where the UAS thing belongs. Right now A2/A3 are battling the issue out. A2 has such a strong grip on the issue as a result of spinning up the Intel function. Decided the UAS Task Force would integrate into a lot of these existing IPTs.
USD(AT&L)		
ID: 22		
	General Approach	Training is a current issue. It should be worked next after we have a handle on the safety aspects. Everything else can be worked in parallel.
	General Approach	7610.4 should be specific to military operations. The argument shouldn't be that we have to make it work for everyone else.

Organization	Remark Type	Remarks
	Media	Starting to take a lot more interest in this issue.
	USAF	Could take a lesson from the Army. They are spending a lot of money to get Warrior a full airworthiness certification.
	USAF	Not happy with the lack of leadership the AF is displaying on this issue. AF leadership doesn't get it. Cultural inertia is a problem. Seems to be more interest in building bureaucratic empires than in solving the problems.
SAF/AQIJ		
ID: 11		
	Congress	The only way Congress is going to get engaged on the airspace integration issue is from the bottom up. National Guard units across the country are not going to be able to operate, and the issue will bubble up from the collective pressure that builds from these "independent" issues
	General Approach	The NextGen thing is significant. DoD needs to reassess its airspace needs in our current context with UAS. We need to be pushing for more access, not more TFRs. Our bill will be huge if we don't get out in front of NextGen and drive. We'll be displaced otherwise.
	General Approach	We've had the technology for decades to hit things. We can clearly use the same technology to avoid them. Technology is not the problem--it's the social element.
	General Approach	Have to deal with the entire scope of the problem in an integrated fashion. You cannot take a piecemeal approach to this issue and hope to get it solved.
	General Approach	Have to deal with the concrete realities of budget, schedules, and programs. In this environment it is important just to keep the ball moving down the field. If Global Hawk will put a due regard system on board, this is progress. Progress needs to be measured in concrete program terms. What is enabled that wasn't before?
	USAF	Underlying culture and presupposition about the UAS airspace integration effort: "I'm worried that if I solve the UAS problem, I'll be blamed." Touchstone issue at work in solving this from an AF perspective.
ID: 12		

Organization	Remark Type	Remarks
	General Approach	A good solution will occur gradually, in steps, phases, and by platform. File-and-Fly is the objective and is composed of three specific pieces: technology, procedures, and policy. The measure of success will be UAS doing ops "all by themselves, routinely." Example: pilot training progresses from the instructor doing it and you watching, to you doing it and the instructor watching, to you soloing. Use analogy for progressing on UAS front. The technology, policy, and procedures all have to happen together.
	General Approach	The JIPT benefit was in putting real leadership on the problem. This is the importance of keeping the JIPT effort together. They've thought through the problem, understand the magnitude, and have answers to the questions leadership will have on this topic.
	USAF	Hoping we would have taken this on at the institutional level. It is slipping away from us with the way we are dealing with the subject right now, and we could loss the effort to someone else