

sdmpulse

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Integrating knowledge: An MIT story

By Luke Cropsey, SDM '08

Editor's note: This is the first in a series of articles addressing how SDM alumnus Luke Cropsey is integrating knowledge from various MIT resources and transferring it to his employer, the US Air Force (USAF). Cropsey represented the USAF as MIT's Lean Advancement Initiative (LAI) Fellow for the '07-'08 academic year, while completing his SDM degree. In this article, Cropsey outlines how he synthesized resources from four communities—LAI, the Systems Engineering Advancement Research Initiative, SDM, and the USAF—to come up with an overarching methodology for examining and addressing the complexities of integrating unmanned aircraft systems into the National Airspace System.

John Steinbeck once remarked that "Ideas are like rabbits. You get a couple and learn how to handle them, and pretty soon you have a dozen." This characterizes my experience in the SDM program and provides a convenient starting point for discussing integrating knowledge.

SDM is all about instilling "systems thinking" as a mental framework for evaluating the world, and this methodology is integrative in its very essence.

Combining systems thinking with the tools and rich course content of SDM's curriculum has produced an explosion of ideas from a whole host of different communities that I have had the privilege of working with while here at MIT.

I came to MIT with 12 years of experience as an Air Force officer working primarily in research and development or other early life-cycle development engineering roles. Ostensibly, the Air Force sent me to MIT as the 2007 Lean Advancement Initiative (LAI) Fellow so I could learn to improve processes. However, once my foot was in the door, the legendary opportunities afforded by MIT were too powerful to resist, and I found myself deeply engaged in several additional forums, including SDM.

SDM ultimately transformed my most basic mental models for understanding



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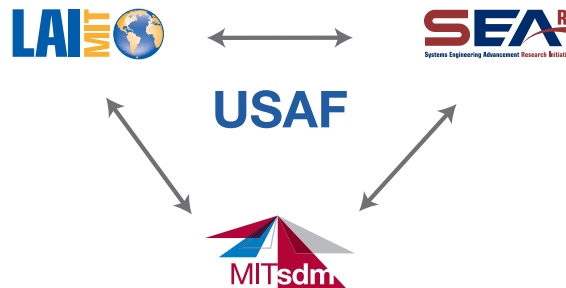


Figure 1. Cross Community Engagement



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complex systems. The common tie between the SDM and LAI communities was the Systems Engineering Advancement Research Initiative (SEArI) spearheaded by Director Donna Rhodes, who also served as my thesis advisor.

I began to address a problem of significant scope and complexity, namely how to integrate unmanned aircraft systems (UAS) into the National Airspace System (NAS), drawing knowledge from each of these MIT communities. As Figure 1 illustrates, there was a free-flowing dialogue between these four groups—the US Air Force (USAF), LAI, SEArI, and SDM—that helped me develop a methodology central to solving this challenge. The insights provided by each combined not only to provide a way to advance the specific Air Force problem, but also to produce a general methodology extensible to value-focused, enterprise architecting efforts beyond just the immediate problem of flying UAS in the NAS. What follows is a discussion of how knowledge from each of these communities was integrated to solve the problem at hand.

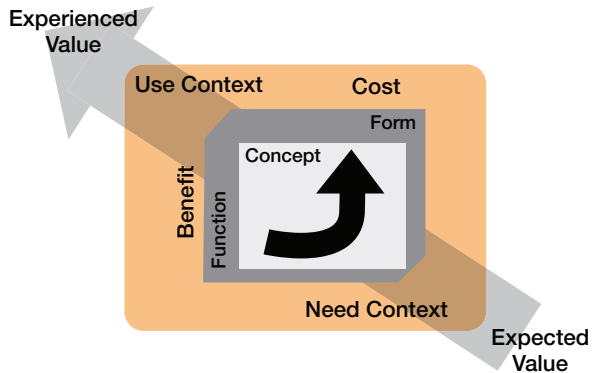


Figure 2. System Architecting Problem Abstraction.

To deal with the complexity surrounding UAS airspace integration, I borrowed a page from Professor Edward F. Crawley's system architecting playbook and chose to abstract the problem to a level of complexity that I could wrap my head around. Figure 2 represents my modification of Crawley's model to include key elements from LAI (value) and SEArI (context). As used in my research, "value" refers to what the individual stakeholder perceives as the problem to be solved or benefit to be delivered. "Context" is the exogenous environment in which the activities needed to deliver the desired value are taking place. For the UAS airspace integration (AI) problem, there were all kinds of traditional systems engineering going on inside the "gray box," but "architecting" (the translation of function to form through a specified concept) was largely absent, and neither the context nor the value state were ever explicitly considered in the ongoing UAS AI activities.

Drawing from LAI's rich history of lean development, I put an overarching model of value-creation in place to unify

the analysis. Figure 3 provides a graphical depiction of this framework from E. Murman et al. in *Lean Enterprise Value*. Not only was this an effective model for unifying the value analysis (depicted horizontally across the top of Figure 3), but it also speaks directly to a process for scoping out the size of the enterprise to be examined (depicted vertically on the left of Figure 3). This analysis clearly defined the scope of my work addressing value-creation for the three largest UAS platforms in the Air Force.

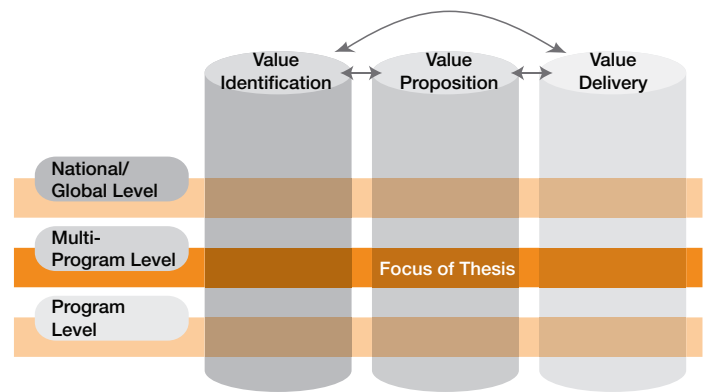


Figure 3. Overarching Value Framework.

Within each stage of the value-creation framework (i.e. value identification, value proposition, and value delivery), I developed a method to rigorously connect the methodology through each stage and link it to the activities in the adjacent space. For value identification, depicted in Figure 4, methodology was drawn from all three MIT communities. For the purposes of this discussion, the emphasis is on communicating the contributions of SDM, SEArI, and LAI. More details will be enumerated in future editions of the *SDM Pulse*.

The enterprise purpose statement construction was accomplished using Crawley's approach to building system problem statements. An enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices. The complex stakeholder analysis requirements of the UAS AI problem are addressed using a model developed by Ignacio Grossi out of LAI and adapted to a second construct from Adam Ross (of both LAI and SEArI).

Once the enterprise purpose is defined and stakeholders are identified, the value definitions of each stakeholder are aligned using an adapted X-matrix approach developed by Deborah Nightingale and Alexis Stanke in LAI.

Stage 2 of the value-creation framework, called value proposition, is where the analytical "heavy lifting" occurs. As Figure 5 shows, two significant models were used in creating value propositions.

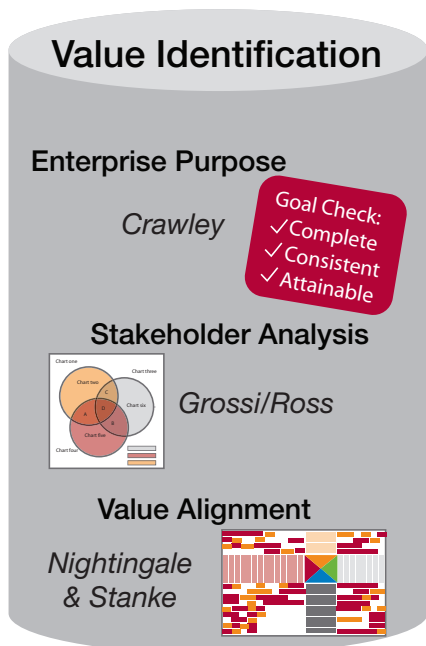


Figure 4. Value Identification Stage.

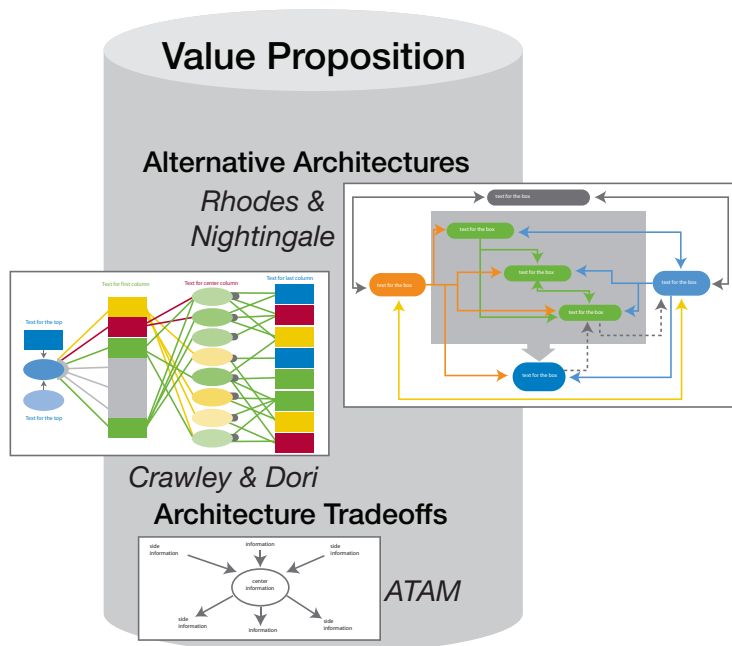


Figure 5. Value Proposition Stage.

The approach is centered around the enterprise architecting models proposed by Nightingale and Rhodes (LAI and SEARi respectively) and implemented through a rigorous Object Process Methodology (OPM) adapted from Dov Dori by Crawley (SDM).

Once the alternative enterprise architectures are created using these two tools, a preferred architecture is selected using an approach developed by the Software Engineering Institute called the Architecture Tradeoff Analysis Method (ATAM), which I discovered through discussion with an LAI researcher.

The final step in value-creation is the value delivery stage. The primary methods used in this portion of the analysis leverage the ATAM method results highlighting key architectural leverage points with the LAI Enterprise Transformation Roadmap. The result is a concrete, actionable plan for moving the enterprise forward in delivering the specified value.

Where does the impact of integrating these methodologies show up? Fundamentally, the result of combining these constructs is a rigorous, methodical approach to achieving value flow in complex stakeholder enterprises operating in a context that is dynamic and highly fluid. Using a well-established value foundation grounds the method. Implementing both the system and enterprise architecting approaches allows the strengths of each perspective to inform the other. The system architecting perspective is significantly expanded through use of the enterprise architecting lens, but the enterprise

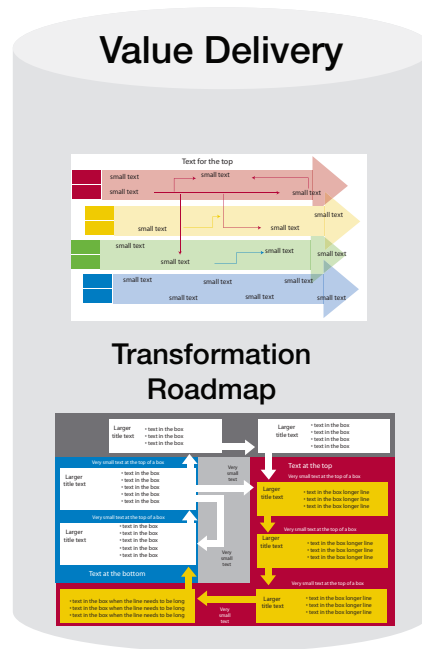


Figure 6. Value Delivery Stage.

architecting practice is significantly bolstered by the application of rigorous OPM approaches from system architecting.

The resulting methodology is a robust approach to tying value directly to an enterprise architecture that provides a

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seamless transition to detailed product design later in the development cycle. This approach is especially useful in situations that involve a large number of stakeholders and/or government agencies and regulators where arriving at a common definition of value can be extremely challenging.

In the next article, tools used in the methodology just described will be examined in more detail. Practical

examples will yield insights that a trip down theory lane will not provide. The third and final article in this series will provide a glimpse of the potential impact and value delivery the analysis may have on the UAS airspace integration challenge. This last article will include a summary discussion concerning the extensibility of the approach to other venues and will round out the methodology development.