STRATEGIC OUTSOURCING AND SUPPLIER INTEGRATION
IN THE HELICOPTER SECTOR

By

Rudy G. Prudente

B.S., Industrial Engineering
Columbia University, 1980
M.S., Industrial Engineering
Columbia University, 1986

Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of

Master of Science
in Engineering and Management

at the
Massachusetts Institute of Technology
February 1999

© 1998 Massachusetts Institute of Technology
All rights reserved

Signature of Author ................................................. System Design and Management Program
January 7, 1998

Certified by ............................................................ / Kirkor Bozdogan
Principal Research Associate
Center for Technology, Policy and Industrial Development
Thesis Supervisor

Accepted by ............................................................ Thomas Magnanti
Co-Director, System Design and Management Program
Strategic Outsourcing and Supplier Integration in the Helicopter Sector

By

Rudy G. Prudente

Submitted to the System Design and Management Program on January 10, 1998
in partial fulfillment of the requirements for the degree of
Master of Science System Design and Management

Abstract

Make-buy decisions, and their associated strategic sourcing activities, define the very identity of firms, shape their competitive advantage, and determine their long-term survival and success. Conceptually, make-buy decisions reflect a firm’s overarching strategic directions and are grounded in its clearly-articulated core competencies.

This thesis critically examines two analytical frameworks in the literature that have been advanced to explain or guide make-buy decisions by firms. The case study focuses on a commercial helicopter development program that has prompted the case study firm to undertake a fundamental rethinking of its long-standing make-buy policies, sourcing strategies, and supplier integration practices. The objective of the study is not only to assess the applicability and generalizability of these analytical frameworks but also to gain new insights into the dynamics of make-buy decisions. The thesis also examines the firm’s new sourcing strategy, linked to its make-buy decisions, resulting in long-term collaborative and partnering relationships with its significant subsystem suppliers, both domestically and internationally.

The ex post case study analysis, concentrating on the nose section of the development helicopter, generally confirmed at a fairly high level the usefulness of applying these analytical frameworks to key make-buy decisions before such decisions are made. However, at a more detailed level of analysis, focusing on specific subsystem components and the pacing technologies underlying them, the analysis also raised sufficiently important issues on whether their outsourcing (“buy” decision) may have been consistent with maintaining the firm’s core competencies and longer-term competitive advantage. The analysis also pointed out that higher-level strategic considerations may override make-buy and supply chain design strategies that may be suggested by a technical decomposition of the product system architecture.

Thesis Supervisor: Kirkor Bozdogan
Title: Principal Research Associate, Center for Technology, Policy and Industrial Development
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE OF CONTENTS</td>
<td>5</td>
</tr>
<tr>
<td>TABLE OF FIGURES</td>
<td>7</td>
</tr>
<tr>
<td>TABLE OF TABLES</td>
<td>8</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>9</td>
</tr>
<tr>
<td>1.1 MOTIVATION FOR RESEARCH</td>
<td>11</td>
</tr>
<tr>
<td>1.1.1 Defense Budget Reduction: Major Shifts in the General Market Environment</td>
<td>11</td>
</tr>
<tr>
<td>1.1.2 Industry Strategies to the Changing Market Environment</td>
<td>13</td>
</tr>
<tr>
<td>1.1.3 The Case Study Firm's (HFGI) Strategy</td>
<td>19</td>
</tr>
<tr>
<td>1.2 RESEARCH GOALS AND METHODOLOGY</td>
<td>22</td>
</tr>
<tr>
<td>1.2.1 Research Approach</td>
<td>22</td>
</tr>
<tr>
<td>1.2.2 Outline of Chapters</td>
<td>23</td>
</tr>
<tr>
<td>2. REVIEW OF LITERATURE</td>
<td>24</td>
</tr>
<tr>
<td>2.1 FIRM STRATEGY: CONTEXT FOR MAKE-BUY AND OUTSOURCING DECISIONS</td>
<td>25</td>
</tr>
<tr>
<td>2.1.1 The Strategic Perspective</td>
<td>25</td>
</tr>
<tr>
<td>2.1.1.1 Competitive Advantage: Conceptual Frameworks</td>
<td>26</td>
</tr>
<tr>
<td>2.1.1.2 Resource Based View</td>
<td>29</td>
</tr>
<tr>
<td>2.1.1.3 Strategy and Process</td>
<td>32</td>
</tr>
<tr>
<td>2.1.2 Strategy Formulation: Perspectives and Types</td>
<td>33</td>
</tr>
<tr>
<td>2.1.3 Applicability of Models</td>
<td>36</td>
</tr>
<tr>
<td>2.2 MAKE-BUY DECISIONS AND PRODUCT-PROCESS DEVELOPMENT</td>
<td>37</td>
</tr>
<tr>
<td>2.2.1 Transaction-Cost Approach</td>
<td>37</td>
</tr>
<tr>
<td>2.2.2 Resource-Based Approach</td>
<td>40</td>
</tr>
<tr>
<td>2.2.3 Product-Process-Supplier Chain Dependencies</td>
<td>43</td>
</tr>
<tr>
<td>2.3 REVIEW OF LITERATURE ON SUPPLIER RELATIONSHIPS</td>
<td>49</td>
</tr>
<tr>
<td>2.4 CHAPTER SUMMARY</td>
<td>53</td>
</tr>
<tr>
<td>3. MAKE BUY FRAMEWORKS</td>
<td>54</td>
</tr>
</tbody>
</table>
3.1 Historical Make-up and Asset Specificity .............................................. 55
  3.1.1 Prior Innovation and Part Specific Assets .................................. 56
3.2 Specific Frameworks Applied ............................................................. 58
  3.2.1 3-D Concurrent Engineering Make versus Buy Decision Matrix ............ 58
  3.2.2 Technology Maturity and Competitiveness Framework ...................... 61
3.3 Supplier Relations Improved through Interactions ................................ 64
3.4 Chapter Summary ................................................................................. 67

4.1 The Industry ......................................................................................... 69
  4.1.1 Helicopter Industry Setting ......................................................... 69
  4.1.2 Market Outlook ........................................................................... 73
  4.1.3 Partnerships .................................................................................. 75
4.2 The Firm ............................................................................................... 77
  4.2.1 Background ................................................................................... 77
  4.2.2 Opportunity - A New Medium Lift ............................................... 78
  4.2.3 The Development Helicopter ....................................................... 79
    4.2.3.1 Background ........................................................................... 79
    4.2.3.2 Aircraft Configuration and Partnership .................................. 82
4.3 Chapter Summary ................................................................................. 88

5. Case Study ............................................................................................. 90
5.1 Partnership Background - Cockpit ....................................................... 91
    5.1.1 Product and Partner Description ................................................. 93
    5.1.2 Cockpit Structure ...................................................................... 95
    5.1.3 Additional Subsystem Components ........................................... 99
5.2 Company Make-Buy Process ............................................................... 100
  5.2.1 Division Level Make-Buy Matrix ................................................. 101
  5.2.2 Program Specific Make-Buy Matrix ............................................ 102
  5.2.3 Current Sourcing - A Result of Prior Decisions ............................ 104
5.3 Frameworks Applied to the Cockpit Module ....................................... 106
  5.3.1 3-D Concurrent Engineering Make vs Buy Decision Analysis Matrix, Applied ........................................ 107
  5.3.2 Technological Maturity and Competitiveness Framework, Applied .... 111
5.4 Supplier Relationships ......................................................................... 117
  5.4.1 Partnering .................................................................................... 118
  5.4.2 Activities to help partnering ....................................................... 120
5.5 Chapter Summary ................................................................................. 124

6. Conclusions ......................................................................................... 127

Bibliography ......................................................................................... 130
TABLE OF FIGURES

Figure 2-1, Porter's Five Forces: Elements of Industry Structure ................................................. 27
Figure 2-2, Porter's Value Chain & Value Stream ........................................................................ 28
Figure 2-3, Iterative Sourcing Decision Process ........................................................................ 44
Figure 2-4, Overlapping responsibilities across Product, Process and Supply Chain development Activities .................................................................................................................. 45
Figure 2-5, The FAT 3-D Concurrent Engineering Decision Model .............................................. 46
Figure 3-1, Level and Type of Innovation ...................................................................................... 57
Figure 3-2, Matrix of Organizational Dependency and Product Decomposability ....................... 59
Figure 3-3, The Make vs. Buy Decision Analysis Matrix: Decomposability, Dependency, Clockspeed and Industry Competitiveness .................................................................................. 60
Figure 3-4, Technological Maturity and Competitiveness Framework ......................................... 62
Figure 4-1, Unit & Value Production Market Share ...................................................................... 72
Figure 4-2, World Helicopter Market - Total Military and Civil Units ......................................... 73
Figure 4-3, World Helicopter Market - Total Military and Civil Value of Production .................... 74
Figure 4-4, Major Modules for Development Helicopter .............................................................. 83
Figure 5-1, Cockpit Structural Components ............................................................................... 96
Figure 5-2, Current Utility Helicopter Cockpit Configuration ...................................................... 98
Figure 5-3, Program Level Make-Buy Process .......................................................................... 103
Figure 5-4, The Make vs. Buy Decision Analysis Matrix, Applied to the Cockpit Assembly .... 109
Figure 5-5, Technological Maturity and Competitiveness Framework, Applied to Cockpit Assembly ........................................................................................................................................................................................................... 112
Figure 5-6, Innovation Framework applied to Cockpit Assembly .............................................. 118
Figure 5-7, CSCI Impact - Cockpit Structure .............................................................................. 119
Figure 5-8, CSCI Impact - Subsystem Parts ............................................................................... 119
Figure 5-9, Program Activities that Help Partnering .................................................................. 121
TABLE OF TABLES

Table 1-1, Aircraft Industry Business Strategies : Source: SRI Consulting, Business Intelligence Program ................................................................. 14
Table 2-1, Types of Strategies on a continuum between Deliberate and Emergent .............. 35
Table 4-1, Major Helicopter Manufacturers ........................................................................ 72
Table 4-2, Helicopter Program Partnerships ...................................................................... 77
CHAPTER 1: INTRODUCTION

1. Introduction

Make-buy decisions, and strategic sourcing actions directly flowing from them, define the very identity of firms, shape their competitive advantage, and determine their long-term survival and success. Conceptually, make-buy decisions reflect a firm's overarching strategic directions and are grounded in its clearly-articulated core competencies.

Critical determinants of these decisions may be viewed as being "deterministic" based on a well-defined long-term plan of action, or "evolutionary", reflecting an implicit, evolving, adaptive process of decision-making not necessarily driven by a prior strategic "master plan". Whichever view is adopted, make-buy decisions reflect a complex set of considerations, factors, and tradeoffs. Once made, these decisions have long-term consequences. They cannot be changed often, or for temporary reasons, because of the very high switching costs that would typically be involved.

This thesis critically examines existing analytical frameworks in the literature that have been advanced to explain or guide make-buy decisions by firms through a focused case study in the helicopter industry. The identity of the firm is not revealed by design, to shield the firm from any inadvertent disclosure of specific details necessary for the analysis presented here but which may be found sensitive, for whatever reason, by the host company, even though every attempt is made
to safeguard any information that may even remotely be considered proprietary or sensitive. For the purposes of this thesis, this case study company is referred to as the Helicopter Flight Group, Inc. (HFGI).

The case study, more specifically, focuses on a commercial helicopter development program by the case study firm which was previously active mostly in the military sector. The new development program has required the company to undertake a fundamental rethinking of its long-standing make-buy policies and strategies previously associated with its military helicopters. This commercial program, therefore, affords a rich opportunity for examining the firm’s make-buy decisions as it strives to respond to significant new challenges in the wider, worldwide, marketplace.

The firm’s new make-buy calculus is examined by making use of two previously advanced analytical frameworks: (1) the three-dimensional (3-D) concurrent engineering framework, due to Fine and Whitney\(^1\), and Fine\(^2\), and (2) the technological maturity and competitiveness (TM&C) framework due to Perrons\(^3\).

The thesis thus tests these analytical frameworks by concentrating on a detailed examination of the nose section of the development helicopter. The objective is not only to assess the applicability and generalizability of these analytical frameworks but also to gain new insights into the dynamics of make-buy decisions. The thesis also examines the firm’s new sourcing strategy, linked to its make-buy decisions, resulting in the long-term collaborative and partnering relationships with its significant subsystem suppliers, both domestically and internationally.

\(^3\) R.K. Perrons, “Make-Buy Decisions in the U.S. Aircraft Industry” (M.S. Dissertation, MIT, 1997), introduces a framework for analyzing Make-Buy decisions with regards to a firms competency and a technology’s maturity.
1.1 Motivation for Research

The larger context for make-buy decisions and strategic sourcing which defines the motivation for the research reported here, has been characterized by Bozdogan as follows:

"In recent years, many aerospace companies have downsized and consolidated their operations, reassessed their core competencies, and began a process of outsourcing an increasing share of their design, tooling, testing and production activities to their key suppliers. A primary short-run reason has been to reduce costs. A more fundamental longer-term reason has been to enhance their competitiveness in an evolving new worldwide market environment driven by a combination of factors. These include the need to reduce product development cycle time, manage increasing product complexity, maintain technological superiority, and gain access to new markets. In this new market environment, what corporations make internally and what they buy externally from other firms may well determine their longer-term survival and success. However, the make-buy and strategic sourcing consideration has become increasingly more complex, particularly in the face of rapid technological advances, shifting corporate alliances, and temporary market advantages. Systematic research in this topical area is expected to provide an improved understanding of the key determinants and processes underlying corporate make-buy and strategic outsourcing decisions."

1.1.1 Defense Budget Reduction: Major Shifts in the General Market Environment

The conclusion of the Cold War and subsequent US military budget reductions compelled major defense contractors to restructure, consolidate and streamline their operations. Defense-related procurement and R&D expenditures fell from $116.6 billion in 1987 to $81.6 billion in 1997 (See Fig.1-1). This cutback in defense spending severely reduced the quantity and magnitude of military acquisition programs and resulted in a significant reduction in the defense-related workforce. The process of significant consolidation within the aerospace industry, along with the

---

exit of many defense-oriented firms deciding to pursue commercial market opportunities, led to a reduction in the number of contractors and subcontractors that supported the defense industry.\(^6\)

![U.S. Department of Defense Military Budget](image)

**Figure 1-1, U.S. Department of Defense Military Budget, Actuals & Projected 1987 - 2002**

In view of these significant shifts in the defense market, many companies have been struggling to find alternate means of ensuring and strengthening their economic viability. The process of adaptation has been particularly difficult for firms in the military aerospace industry, which have significant overhead infrastructure costs to support. It has been contended that over the years defense companies, especially those with existing contracts, have been "subsidized" with "follow-

---

\(^6\) John-Tepper Marlin, review of *Dismantling the Cold War Economy*, by Ann Markusen and Joel Yudken, in *Journal of Economic Literature*, 31(3), September 1993, pp.1464-66. The authors note that despite a massive buildup in federal military spending, the number of contractors and subcontractors shrank from nearly 140,000 in 1982 to fewer than 40,000 in 1987.
on contract awards by the Pentagon. However, such a practice, even if true, is highly unlikely to continue into the future, in view of the sharp cutbacks in defense spending.

This shrinking defense procurement environment characterizes the current market conditions facing the US military helicopter industry. The budget for the development of modern military helicopter platforms has paralleled the general downward spiral in defense spending. In 1989, total spending for Research & Development, services and vehicle hardware for US Department of Defense helicopters was $2.07 billion. In 1997, these helicopter-related defense expenditures were reduced to $614 million. The reduction in government funding for the acquisition of utility helicopters has had a particularly large impact on the case study helicopter firm, named the Helicopter Flight Group Inc. (HFGI), which has focused its energies on several strategic activities to adapt to the altered military acquisition environment.

1.1.2 Industry Strategies to the Changing Market Environment

Business Strategies

The aircraft industry has adopted various strategies in reaction to the shrinking and uncertain market environment. These strategies include actions addressing both external market conditions and restructuring internal operations. Of the ensuing strategies catalogued in Table 1-1, HFGI is implementing all eight strategies intended to preserve the firm's baseline operation. This context of change and adaptation defines the background conditions surrounding the case study examination of the make-buy decisions related to the new helicopter development program.

---

7 Ibid. The authors note that federal support of R&D since WW II has focused heavily on the aerospace, communications, and electronics industries (called "ACE" by the authors) because of their military importance. The authors trace the development of the ACE complex through "lobbying" for subsidies, a "closet industrial policy" and "follow-on" projects.
9 As noted earlier, HFGI is a pseudonym used in place of the case study company's real name for the reasons already indicated.
Table 1-1, Aircraft Industry Business Strategies: Source: SRI Consulting, Business Intelligence Program

Sourcing Strategy
Companies make sourcing decisions to support tasks performed in production, research and development, purchasing services, financial services and various administrative functions. In many cases, short term needs and transaction-cost calculations are the basis for these decisions. This short term outlook is generally consistent with the industry’s tactical treatment, historically, of make-buy decisions. There are, however, numerous examples of make-buy and sourcing decisions that have strategic, far reaching, effects on the firm, by predetermining the structure of its future activities. Whether a tactical or strategic view is espoused, a framework that provides consistent direction to a firm’s make-buy and sourcing decisions, would appear to be generally preferred.

In a 1994 study, North American and European purchasing executives representing over one hundred multinational companies identified strategic sourcing as one of the top five significant
trends in their industries. Several companies involved in the aerospace industry such as: Boeing, General Electric, Martin Marietta, Honeywell Inc. American Airlines, Lockheed, Allied Signal Inc. and United Technologies, were included. These companies are increasingly viewing make-buy strategies as a mechanism for building and gaining competitive advantage. It is noteworthy that top management now explicitly identifies and evaluates sourcing strategies as part of the strategic planning process. High level executives are currently placing considerable emphasis on the significant impact that supply management strategies can have on company performance. 11

Currently, many firms are using “core competency” frameworks to guide their strategic decisions aimed at strengthening their long term competitive advantage. A core competency represents the integration of a bundle of constituent skills and technologies which enable a firm to deliver a fundamental customer benefit. It is not an ‘asset’ in an accounting sense (e.g., a plant, a distribution channel, or a brand). Neither is it considered to be a product or a program. It is more “an activity, a messy accumulation of learning ... and .. will undoubtedly comprise both tacit and explicit knowledge.” To be ‘core’, a competency must be competitively unique, in that the company’s level of competence is substantially superior to all others. 12 To be successful, firm’s should concentrate their efforts at developing and protecting these core competencies. They should be constantly scanning the environment to identify and acquire the competencies necessary to be competitive. Given a company’s limited resources, source decisions that encompass a core competence based strategy will focus a firm on those activities that can add superior value to the market.

In a recent conference, organized by the Lean Aerospace Initiative at MIT, Rudy Bini of the Boeing Military Aircraft Missile Systems Group indicated that sourcing strategy in his corporation had extended past the arena of consolidating the supplier network based on specific products. He suggested that sourcing strategies are presently being seen from the viewpoint of ‘core competencies’. In reviewing a firm’s strategy, competencies including engineering and production

capabilities are being assessed and compared to the capabilities distributed over its supplier network. Bini further noted that these discussions could have serious implications for the future direction that the company might take with respect to the scope of make-buy decisions. 13

A firm’s overall competitive strategy requires informed sourcing strategies. The overall competitive strategy is dependent upon the contextual situation envisioned over the firm’s planning horizon. Management, through its assessment of the firm’s internal structure and the external environmental forces that surround the company, typically interprets this larger context. Different firms can be exposed to similar environmental pressures and yet may respond to them quite differently, within their own set of circumstances and preferences. This is consistent with the observation that organizations have their own character, personality and culture. From this we can understand that strategy development and management are truly complex corporate activities that deny easy and universal recipes that can be applied across the board. Thus, the essence of proper management is to combine a solid understanding of the external forces surrounding the firm and adapt the company’s responses to the specific characteristics and circumstances characterizing that company.

Focus on Product-Process-Technology
The case study in this thesis concerns itself with make-buy decisions involving the design, testing, tooling and manufacturing of components and complex assemblies. These decisions are associated with choosing where to source technologies and processes which were earlier considered “core” to the case study firm. These decisions can take on a critical strategic dimension. With any given technical requirement, a firm has to ask whether it should develop the necessary technology internally or to purchase it externally. Rapid technological developments have prompted firms to realize that it is not possible or affordable to develop all of the required technologies internally. This realization forces difficult choices on which technologies to develop in-house and which technologies to purchase in the form of services, component parts or assemblies. These choices have far-reaching consequences. As discussed before, the firm’s overall strategy should link its

13 Rudy Bini is a source Manager at Boeing Military Aircraft Missiles System Group and is in charge of the Preferred Supplier Certification Process for the military business of the corporation. His remarks were part of a question and answer session at the Supplier Relations Focus Team Meeting of the LAI held on Oct. 13, 1998.
more specific strategies for engineering, product development, system integration, manufacturing and supply chain management.

Over time, sourcing decisions on product, process and technology have a significant impact on the maintenance and development of a firm's capabilities. The choice of its product and/or process manifests itself in the design and manufacturing capabilities of the firm. Concurrently connected with these decisions are interfaces and dependencies that a company has to its supplier network. The specific choices a firm makes can limit or broaden its depth of knowledge, experience and capabilities. Welch and Nayak express the concern in this manner:

When sourcing decisions are examined, managers must ask themselves whether it will be detrimental to their firm's competitive position to outsource R&D, design, engineering, manufacturing, or assembly, both in the short term and in the long term. Managers must determine the importance of process technology in attaining and/or sustaining competitive advantage. Managers must also consider a forecast of those technologies that have the potential to provide significant competitive advantage in the future. 14

One would thus expect that decisions on technology and innovation are critical to a firm's overall strategic business plan. This business strategy, which reflects the general direction or purpose of a firm, must also encompass the implementation of a planning process that links strategic technology issues to the operational make-buy decisions being considered. Many firms have a formal technology planning process which attempts to identify, capture and document those technologies, innovations and enhancements that will drive the firm's future products. Given a firm's limited resources, many of these technical needs will most likely be provided by the supplier base. With these resource limitations in mind, it is important that firms actively consider their suppliers' technological capabilities as part of an integrated approach to gaining competitive advantage. However, with a firm's growing dependence on supplier generated technology, its capability in nurturing cooperative supplier interactions takes on a greater significance. Juxtaposed upon these considerations is the business urgency to deliver revenue and profitability, or in some cases to simply survive. Technology decisions, and the subsequent sourcing decisions, are complex and sensitive to the context of the firm's particular circumstances at any given time.

Given their impact though, these technology sourcing decisions must be made thoughtfully and carefully.

Make-buy decisions for components already in production can also have a significant impact on the process capabilities of a firm. Venkatesan relates the issue as follows:

Many of today's manufacturers are making commodity-like components to preserve jobs. This single-minded focus can become a self-defeating objective as it often results in insuring parts that are easy to manufacture, while outsourcing those that are hard to make. Over time, fixed costs rise, product differentiation declines, and manufacturing performance remains stagnant as employees become complacent. Manufacturers must turn to a new strategy and learn how to not make the parts that divert a company from cultivating its repertoire of skills.\(^{15}\)

In this situation, a string of seemingly tactical decisions over time, cumulatively could manifest a detrimental long term impact, by degrading the manufacturing “skills” of the firm. What appear to be independent make-buy decisions over time without any explicit strategic framework guiding them, could implicitly weaken the long-term competitive strength of the firm.

**Operational Initiatives**

Sourcing decisions on product, process and technology are shaped within the context of a firm’s current programs to improve its operations. Ever increasing expectations of market growth and financial performance have guided firms to examine and improve their supplier management practices. In some cases, improvements in supplier management are considered critical to a firm's survival. For some defense oriented firms attempting to compete in the international commercial market, supplier performance plays an integral role to a firm’s competitiveness.

Companies continue to reduce the size of their supplier base in the expectation of further efficiency gains through reduced management and purchased parts cost. In conjunction with this effort, recent programs in supply chain management concentrate on specific operational improvements. These efforts include, for example, TQM (Total Quality Management), EDI

---

(Electronic Data Interchange), certified supplier programs, ISO 9000 certification, JIT (Just in Time) delivery. Metrics measuring supplier quality, delivery, lead times, financial stability, buyer support, price, and other performance factors are being used in the selection of suppliers. The technology and design capability of suppliers, is viewed as necessary but not sufficient criterion for supplier selection. In this context, the firm needs to locate and contract with world class suppliers that can support the varied cross-functional needs of the company. These needs cover a broad range of areas such as technology and product development, manufacturing and logistics support, and after market and customer service.

Given the recent trend toward supplier consolidation and the growing focus on core competencies, firms need to nurture their supplier relationships based on the realization of buyer and seller interdependence. Sourcing strategy expands the outlook of firms from simply considering their own self-interest to practices and outcomes that are beneficial to its supplier base as well. From a make-buy perspective, the capabilities that a firm can access from its supplier base in responding to the needs of its customers start to take on a greater significance. As such, firms need to take a systematic view of the elements of the value chain and reflect on how it has to be structured and managed.

1.1.3 The Case Study Firm's (HFGI) Strategy

Product Strategy

Consistent with the aircraft industry business strategies proposed in the previous section,, HFGI is aggressively pursuing non-defense related sales and internally-funded development programs. However, the firm has maintained supportive activities for several important Defense Department projects that are critical to sustaining the precarious revenue stream of the company.

Early in the decade, HFGI advanced a strategy utilizing three platforms intended to preserve consistent revenues and facilitate expansion into new markets. Its first initiative continued to
support the sales and product diversification of its primary utility helicopter product. A substantial application of the firm's resources remained in support of its most important and traditional customer, the US military. However, the projected decrease in overall Defense disbursement bounded the expectations for new hardware revenue from this formerly reliable market base. Department of Defense expenditures for helicopter purchases from the company exhibited a consequent declining trend over the past decade. Total US Defense Department procurement from the company in 1989 was valued at $899. By 1997 the level of procurement had dwindled to about $294 million.\(^{16}\) In response to this drastic reduction in the size of its historically primary market, the company initiated an aggressive effort at marketing various helicopter models overseas. In 1997, 40% of the company's $1.6 billion in revenue came from international sales.\(^{17}\) Most of these sales were for its popular utility helicopter. This three product strategy acknowledged that the firm's near term prosperity remained coupled to successfully marketing its prominent helicopter model and its derivatives.

The second product in this strategy required the development of an updated commercial medium lift helicopter. This vehicle would succeed an aging array of comparably sized aircraft that were approaching the end of their economically functional life cycles. This firm designed, developed, and manufactured a successfully popular medium lift helicopter in the 1960s that enabled diverse transport applications and missions. However, change in the regulatory requirements to this class helicopter in Europe and the US was limiting the aging model's mission capability. The firm expected to capitalize on the reputation it had created with its earlier fielded design in various commercial markets. The new development medium lift helicopter would provide these customers with a replacement vehicle that would satisfy the revised operational requirements as defined by the regulatory agencies. In addition to the commercial market, there was an equivalently substantial demand projected for utility and militarized versions of this vehicle in the international market. The company confidently expected this development helicopter program to provide expanded revenue streams by 2002.\(^{18}\)


\(^{17}\) HFGI Historical Archives Document (1998), p.87.

\(^{18}\) Ibid., p.88.
The third supporting leg of the strategy is accomplishing the final development, production and fielding of a reconnaissance helicopter for its primary military customer, the US Army. In this vehicle program, HFGI is teamed up with another helicopter manufacturer in a contract to design and build prototype aircraft. Although the procurement schedule for the production phase of this helicopter program has suffered several postponements, the company anticipates this product to deliver moderate revenues by 2006.\(^{19}\)

HFGI's sourcing approach has been product or 'core business' oriented. The firm has make-buy matrices for the division and by program that indicate the make-buy status of major subsystems. Technical issues of product performance advantage, firm proprietary interests and flight safety criticality are major considerations in determining the make-buy status of a subsystem. Operational issues such as: plant capacity utilization, whether an item is schedule pacing, workforce stability concerns, etc. are also considered. Given the similarity in design between HFGI's primary utility helicopter product and the development commercial vehicle, the make-buy matrices for both programs were also similar. Specific differences between program and company make-buy matrices were processed through a high level management committee.

It is not clear whether the core competency framework has been formally used by the firm in an analytical effort to determine its source strategies. There are, however, observed linkages between make-buy decisions and the firm's current manufacturing assets, as well as the firm's integration capabilities in design and assembly.

In the development program for a new commercial helicopter, HFGI partnered with five international companies to share development and program risk. The composition of aircraft components contributed by each firm was a result of partner negotiations that considered partner capability, product value, product modularity, partnership agreement and HFGI's willingness to give up various subsystems.

\(^{19}\) Ioid.
1.2 Research Goals and Methodology

Academic literature and case studies on strategy indicate that make-buy decisions should be made with an organization's core competencies or core products in mind. The supplier strategy of a US defense helicopter manufacturer in relation to the development of a new commercial medium lift helicopter is reviewed with these issues in mind.

Key Questions

Given several motivations and frameworks, the key questions addressed in this research are:

⇒ How do strategic decision-making approaches within a particular helicopter firm affect source selection as well as outsourcing decisions?
⇒ What was the process followed in reaching make-buy and strategic outsourcing decisions? Who was charged with make versus buy decisions?
⇒ What are the similarities, differences and relationships between supplier management practices in connection with existing production operations of the helicopter firm, on the one hand, and in support of development programs, on the other hand?
⇒ What short-term and long-term considerations affect specific make-buy, supplier selection and strategic outsourcing decisions of development programs?

1.2.1 Research Approach

Approach

In order to address the questions above, focused case-study analysis of a helicopter manufacturer is conducted through a review of the make-buy decision for a high level subsystem of a new development helicopter. Interviews are conducted with selected managers and engineers from program management, product development teams and functional organizations. The make-buy decision is reviewed using: the 3-D Concurrent Engineering Make versus Buy Decision Analysis Matrix; and the Technological Maturity and Competitiveness framework. Extensions to the models are suggested after examining the decision in light of short-term tactical as well as long-term strategic perspectives. Additionally, motivations behind supplier selection and outsourcing decisions are documented.
1.2.2 Outline of Chapters

Chapter 2 reviews aspects of the literature on business strategy, make-buy decisions, product-process innovation and the growing importance of inter-firm relationships. The chapter examines the complexity of strategy development. It considers the notion that developing the strategic content and process formulation of a firm’s strategic plan represents a complicated activity that incorporates a myriad of issues that sets the context for an analysis. Although general frameworks can serve as a starting place for the process of strategy formulation, the influence of the details of a firm’s specific context dominate and temper any ‘pure’ implementation of a given framework. In light of this, firms develop make-buy strategy within the context of an overall company strategy.

Chapter 3 examines the two specific make-buy frameworks that are used to analyze the case study in the thesis. The resource based view provides the academic underpinnings for these frameworks. As structured, they provide different ‘lenses’ by which to examine make-buy decisions. However, both consider the pace and/or maturity of a technology’s development important. The chapter includes a review of literature indicating that improved supplier relations result from increased interactions between firms.

Chapter 4 covers a brief discussion of the helicopter industry structure and information about the integrator firm leading the development project. A background discussion of the helicopter development program is included.

Chapter 5 presents the case study conducted as part of this research. It describes the subsystem studied and reviews issues surrounding its outsource using the two make-buy frameworks introduced in Chapter 3. Additionally, activities implemented by the program to facilitate problem solving and partnering are reviewed.

Chapter 6 discusses conclusions drawn from the use of the two frameworks in reviewing the case study subsystem. The chapter reviews issues and conclusions regarding changes in the approach towards supplier relations and its effect on the strategic outlook of the firm.
CHAPTER 2 - REVIEW OF LITERATURE

2. Review Of Literature

The chapter provides a review of the existing literature focusing on firm strategy development, strategic make-buy decisions, and building closely-knit relationships with key suppliers. A review of these three areas indicates the high degree of complexity surrounding the make-buy decisions by firms. Viewed from a system perspective, the issues involved are highly interrelated. Through strategy development, a firm determines the activities it will pursue to compete in the market. The longer term strategic directions adopted by the firm defines the broader context for its make-buy decisions. How the firm defines its core competencies in light of these strategic directions drives its make-buy decisions. However, how it defines its core competencies is not a trivial matter, a firm’s ability to define its core competencies is, by itself, a core competency. Moreover, make-buy decisions require a close understanding of the capabilities, or core competencies of the suppliers. Without such understanding, it would prove difficult for the firm to reach optimal make-buy decisions, as well as to evolve mutually-beneficial long-term relationships with key suppliers offering synergistic and complementary capabilities. Thus, defining the firm’s strategic directions, its core competencies, its make-buy strategy, and its outsourcing decisions are inextricably linked together.
2.1 Firm Strategy: Context for Make-Buy and Outsourcing Decisions

A firm’s approach to make-buy should be viewed in the larger context of the overall longer-term strategy of the enterprise. Both sets of decisions need to be consistent with the overarching strategic directions of the company. An understanding of these strategic directions by all key decision makers within the firm can result in consistent decisions across organizational functions, programs and products.

From this larger perspective, a brief review of the literature related to the concept of business strategy and the strategy formulation process is given below. The discussion is intended to convey primarily an overview of the central issues addressed and main analytical frameworks offered in the current academic literature. It should be noted that the conceptual frameworks that are summarized provide valuable analytical insights into real-world decision problems when supported by detailed contextual observations. The discussion below is also expected to provide useful conceptual “lenses” through which the case study presented later in the thesis can be viewed.

2.1.1 The Strategic Perspective

For business theorists, a goal has been to provide practical guidance to firms in determining and implementing the activities necessary for success. Theorists find, however, that accounting for competitive success is complex and highly situation specific. Companies often have unique identities, with their own history, capabilities, policies and culture. Individual industry sectors also have their own special market, structural and technological circumstances, as well as critical success factors. In order to ensure their longer term success, firms need to understand the dynamics of change in their external environment and devise effective responses through proactive strategies.

The scholarly literature on business strategy attempts to explain why certain firms are successful. Success is often considered the attainment of a competitive position or series of competitive
positions that lead to superior and sustainable financial performance. Early business literature
defines three essential conditions for success. First, strategy is as a means of integrating the
various individual actions and choices that transpire within a company’s ongoing activities. By
developing and implementing an internally consistent assemblage of goals and policies that
together characterize its position in the market, a firm can ensure that activities at all levels of the
organization will be consistent with senior management direction. Second, this internally
consistent set of goals and policies align the firm’s strength and weaknesses with the industry’s
external threats and opportunities. Strategy, in this case, is seen as the act of aligning a company
and its environment. With constant change both in its external environment and within the
company itself, this alignment would represent a dynamically ongoing process. Thirdly, a strategy
is concerned with the development and practice of a firm's ‘distinctive competencies’. The
applications of these unique competencies were central to a firm’s competitive success. 20

2.1.1.1 Competitive Advantage: Conceptual Frameworks

Porter proposed the most influential frameworks currently used in business strategy.21 Porter’s
approach centers on the review of the structure of the industry and a firm’s position within it. The
attractiveness of an industry, and a company's strengths and weaknesses, set the context for the
identification and development of a firm's competitive activities. A thorough appreciation of the
structural characteristics of an industry is necessary for assessing the long-term profitability
prospects of an industry. Additionally, Porter defines the strategic factors that a firm can
capitalize on to gain a sustainable competitive advantage. With a comprehensive understanding of
both the industry structure and firm strategies, Porter believes firms can develop actions that can
help strengthen their longer term competitive advantage.

Five Forces

The “five forces” model offered by Porter posits that there five forces that commonly shape
industry structure: the intensity of rivalry among competitors; the threat of new entrants; the

---

20 K. R. Andrews The Concept of Corporate Strategy (Homewood: Dow Jones Irwin, 1971)
threat of substitutes; the bargaining power of buyers; and the bargaining power of suppliers. These five forces help shape prices, costs and investment requirements that determine the long-term profitability opportunities within an industry. (See Fig. 2-1). The significance of each of these forces on industry structure varies from industry to industry. Using the framework, the company can analyze the elements of industry structure to identify those factors that are critical to competition. The final output of the industry analysis is the identification of key opportunities emerging from the favorable factors affecting the industry and the key threats resulting from the adverse impact to industry attractiveness. These opportunities and threats should be reflective of all the critical issues determined from the review of the industry. A thorough examination of these

**Figure 2-1, Porter’s Five Forces: Elements of Industry Structure**
issues can lead to strategic innovations, which can fundamentally change the structure of an industry.  

Value Chain and Competitive Advantage

The value chain, Porter's second framework, segments the firm into strategically relevant stages to account for all the value added tasks performed by the company. (See Fig. 2-2). The framework classifies these tasks into nine broad categories, of which five are the so-called primary activities and the other four are termed the support activities. The primary activities can be considered the traditional managerial functions of the firm, which involve the movement of raw materials and finished products, the production of goods and services and the marketing, sales and the subsequent servicing of the outputs of the firm. The support activities are more pervasive in that they cut across and support all of the primary functions and each other. They constitute the

![Figure 2-2, Porter's Value Chain & Value Stream](image)

---

22 Ibid., pp.4-8.
managerial infrastructure of the firm, encompassing all the processes and systems to assure proper coordination and accountability, human resource management, technology development and procurement. The activities defining the value chain constitute the foundation of the firm's controllable factors. The analysis of these activities in comparison to those of its major competitors will determine the basis for actions aimed at sustaining competitive advantage. Competitive advantages can be divided into two basic types: having lower cost than rivals, or the firm's ability to differentiate its products and command a premium price that exceeds the extra cost of doing so. Successful firms consistently achieve either one or both types of advantages. 24

2.1.1.2 Resource Based View 24

The resource-based view is based on the notion that the central sources of competitive advantage are dependent on the development of the resources and capabilities of the firm. This stands in contrast to the strategic direction just discussed, which establishes the market-driven forces of an industry as the primary source of creating opportunities for a firm's profitability. The resource based view posits four basic premises which are essential to achieve competitive advantage. These are unique competencies, sustainability, appropriability and timing.

Unique Competencies
This view presupposes that the resources and capabilities that underlie a firm's operations are heterogeneous across many companies. That is, each company commits to the development of a specific set of resource bundles and capabilities. These resources are different from firm to firm. Some firms develop bundles that are superior. Similarly, some firms are able to be more efficient than others. The firms endowed with the better or more efficient resources are able to achieve more efficient production and/or better satisfy their customers. It is a firm's unique and superior set of competencies which result from its management of its resources and capabilities that enable it to generate greater value.

23 Ibid., pp.35-37.
Sustainability

For firms to maintain a sustained competitive advantage, the superiority of its unique competencies must be preserved. Since strategy is concerned with longer-term success, the condition of heterogeneity (i.e., the distinct differences a firm enjoys in its resource utilization and bundling capabilities) must be lasting in order for the firm to create and add value. The resource-based view focuses on two factors for preserving uniqueness: imitability and substitutability. Substitutes are represented in alternate product forms that compete with and reduce the value a firm can collect for its products. Firms need to scrutinize the environment to be aware of such substitutes and subsequently evaluate its competencies in relation to these threats. Limiting imitation of its products and competencies is additionally important to firms. The factors preventing imitation include: producer learning, buyer switching costs, reputation, buyer search costs, property rights to scarce resources, and information asymmetries.

Dierickx and Cool suggest that “how imitable an asset is depends on the nature of the process by which it was accumulated.” They further note that characteristics that serve to impede imitation consistent with this idea include: time compression, diseconomies, asset mass efficiencies, interconnectedness of asset stocks, asset erosion, and causal ambiguity.25 The idea points to “non-tradable assets which develop and accumulate within the firm.” Peteraf suggests that these types of resources are central to the resource-based view:

Such (non-tradable) assets tend to defy imitation because they have a strong tacit dimension and are socially complex. They are born of organizational skill and corporate learning. Their development is ‘path dependent’ in the sense that it is contingent upon preceding levels of learning, investment, asset stocks and development activity. For such assets, history matters. Would-be-imitators are thwarted by the difficulty of discovering and repeating the developmental process and by the considerable lag involved. Importantly, assets of this nature are also immobile and thus bound to the firm.26

26 Peteraf, p.183.
Appropriability

Factor immobility or appropriability is another key requirement for sustainable advantage. This issue addresses the questions of who will collect the economic rent and whether full economic value is being generated. The benefit that can be collected depends on the ownership and control of the sum of the assets in the system that generate value. Sometimes companies are not able to appropriate the full value created because of a gap between ownership and control. Non-owners that diminish the value collected by the primary firms may control complementary and specialized factors. The other issue is the inability of the firm to realize full economic value. This situation result from inefficiencies or misplaced benefits that prevent a business from generating its full economic value. An example of this may be the lost value that results from the poor relations between a firm’s management and its labor unions. Appropriability of economic rent relates to the issues of the distribution of total value and the size of the value created. 27

Timing

This factor relates to the foresight or circumstances that lead a firm to acquiring a superior resource position prior to the arrival of competitors. It is less costly for a firm to accumulate these advantageous resources and capabilities if other firms are not competing for them. According to Peteraf:

... the economic performance of firms depends not only on the returns from their strategies but also on the cost of implementing those strategies. Without imperfections in strategic factor markets, where the resources necessary to implement strategies are acquired, firms can only hope for normal returns. 28

In other words, the value generated by a strategy should not be offset by the cost of its implementation. It is this condition that planned or opportunistic timing of resource and capability generation tries to achieve.

---

28 Peteraf, p.185.
2.1.1.3 Strategy and Process

Based on their review of the literature, Hax and Majluf suggest that strategy should be viewed by conceptually separating content and process. They believe that there are certain fundamental goals that companies try to achieve and these represent the content of strategy. There are, however, aspects of strategy that "not only depend on the nature of the firm but also on its constituencies, its structure, and its culture." In this way, strategic goals depend on the implementation process used to determine and achieve them. Strategies between firms differ as a result of this interplay between goal and implementation determination. Certainly, the context determined by its internal capabilities and its response to the external environment affects the firm’s approach to strategy formulation and application. Despite the conceptual separation of content and process for an intellectual understanding of strategy, the authors point out that both aspects are not separable in the effort of developing a firm’s strategy.

Hax and Majluf propose a definition of strategy, which covers these conceptual issues: 29

- Determines the organization purpose in terms of long term objectives, action programs and resource allocation priorities.
- Selects the businesses' the organization should be in.
- Achieve long term sustainable advantage
  - by responding to opportunities and threats from its environment.
  - by responding to strengths and weaknesses of the organization.
- Identifies distinct managerial tasks on various levels - corporate, business and functional.
- Is a coherent, unifying and integrated pattern of decisions.
- Defines the nature of economic and non-economic contributions that the firm intends to make to its stakeholders.
- Is an expression of the strategic intent of the organization.
- Is aimed at developing and nurturing the core competencies of the firm.
- Is a means of investing selectively in tangible and intangible resources to develop the capabilities that assure a sustainable competitive advantage.

The above definition combines a range of ideas presented by both Porter and the resource-based view. It is meant to provide a unified framework to the conceptual aspect of strategy generation. However, as mentioned above, the substance of strategy cannot be separated from the process of

strategy formulation. In this case, the authors review several typologies of process formation and highlight two main groupings that tend to dominate. These center on a deliberate, explicit, formal analytic approach, in contrast to an emergent, implicit, pattern-like development of strategy.

2.1.2 Strategy Formulation: Perspectives and Types

Perspectives – Deliberate, Explicit vs. Emergent, Implicit
This view of strategy emphasizes the degree to which strategy formulation is purely deliberate versus being purely emergent. Mintzberg saw either extreme a ‘pure’ formulation and highly unlikely in the realm of business. Most companies were thought to have a strategy formation process in the middle of the continuum between either approach. Additionally, it was thought that a firm would exhibit a propensity for one or the other.

Deliberate, Explicit
Proponents of the deliberate approach to strategy suggest that a structure and order to strategy development should be followed. Strategy is seen as planning for the future using an analytical process to establish long-range goals and action plans for an organization. It is a strategy that involves leaders at the center of authority who formulate their intentions as precisely as possible and then translate them into collective action.

One approach has strategists first choosing a mission - a long-term purpose for the organization. Short-term and mid-term objectives are subsequently defined that move the organization on a path toward the mission. Following this, a strategy is developed that achieves the objectives using short-term operating decisions or tactics. This deliberateness is characterized by formulation followed by implementation.

Mintzberg sees a purely deliberate strategy as one, which through a pattern in actions, is realized exactly as intended. For such deliberateness to occur he suggests three preconditions:
First, there must have existed precise intentions in the organization, articulated in a relatively concrete level of detail, so that there can be no doubt about what was desired before any actions were taken. Secondly, because organization means collective action, to dispel any possible doubt about whether or not the intentions were organizational, they must have been common to virtually all the actors; either shared as their own or else accepted from leaders, probably in response to some sort of controls. Thirdly, these collective intentions must have been realized exactly as intended, which means that no external force (market, technological, political, etc.) could have interfered with them. The environment in other words, must have been either perfectly predictable, totally benign, or else under the full control of the organization.  

The explicitness of the strategy refers to the openness of communication both internally to the organization and externally to constituents. It includes the degree to which different organizational levels participate in strategy formulation and the amount of consensus that is built around the intended courses of action.

**Emergent, Implicit**

There are, however, proponents of a less deliberate form of strategy development. They claim that due to the complexity of a firm’s environment, the process of developing a strategy is much more messy, experimental and iterative. Through a pattern of decisions by management in response to circumstances, an emergent strategy results. Some would agree that even in cases where a strategy’s intention is not fully articulated, a firm’s past actions by default represent a strategy.

In this regard, Mintzberg speaks of crafting strategy. Crafting a strategy, as opposed to planning one, centers not so much on thought and reason as on engagement, a feeling of “intimacy and harmony” with the factors that matter. Such a sense is developed through prolonged experience and commitment. Strategies can form as well as be formulated. Firms can gain from permitting their strategies to evolve gradually through actions and experiences. Emerging strategy cultivates learning as the strategy evolves, while purely deliberate strategy precludes learning due the exactness and rigidity it represents.

---

31 Hax and Majluf, p.18.
Hax and Majluf describe it this way: "Emergent strategy implies learning what works - taking one action at a time in search for that viable pattern or consistency. Emergent strategy means no chaos, but unintended order. Emergent strategy does not mean that management is out of control - only that it is open, flexible, and responsive - in other words, willing to learn."  

**Types**

The following table summarizes the various types of strategies in the continuum between the "deliberate" and "emergent extremes".  

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Major Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned</td>
<td>Strategies originate in formal plans: precise intentions exist, formulated and articulated by central leadership, backed up by formal controls to ensure surprise-free implementation in benign, controllable or predictable environment; strategies mostly deliberate.</td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Strategies originate in central vision: intentions exist as personal, unarticulated vision of single leader, and so adaptable to new opportunities; organization under personal control of leader and located in protected niche in environment; strategies relatively deliberate but can emerge.</td>
</tr>
<tr>
<td>Ideological</td>
<td>Strategies originate in shared beliefs: intentions exist as collective vision of all actors, in inspirational form and relatively immutable, controlled normatively through indoctrination and/or socialization; organization often proactive vis-à-vis environment; strategies rather deliberate.</td>
</tr>
<tr>
<td>Umbrella</td>
<td>Strategies originate in constraints: leadership, in partial control of organizational actions, defines strategic boundaries or targets within which other actors respond to own forces or to complex, perhaps also unpredictable environment; strategies partly deliberate, partly emergent and deliberately emergent.</td>
</tr>
<tr>
<td>Process</td>
<td>Strategies originate in process: leadership controls process aspects of strategy (hiring, structure, etc.), leaving content aspects to other actors; strategies partly deliberate, partly emergent (and, again, deliberately emergent).</td>
</tr>
<tr>
<td>Unconnected</td>
<td>Strategies originate in enclaves: actor(s) loosely coupled to rest of organization produce(s) patterns in own actions in absence of, or in direct contradiction to, central or common intentions; strategies organizationally emergent whether or not deliberate for actor(s).</td>
</tr>
<tr>
<td>Consensus</td>
<td>Strategies originate in consensus: through mutual adjustment, actors converge on patterns that become pervasive in absence of central or common intentions; strategies rather emergent.</td>
</tr>
<tr>
<td>Imposed</td>
<td>Strategies originate in environment: environment dictates patterns in actions either through direct imposition or through implicitly pre-empting or bounding organizational choice; strategies most emergent, although may be internalized by organization and made deliberate.</td>
</tr>
</tbody>
</table>

Table 2-1, Types of Strategies on a continuum between Deliberate and Emergent

33 Hax and Majluf, p.18.  
34 Mintzberg and Waters, p.270.
2.1.3 Applicability of Models

Business models need to be aligned with current managerial concerns. Corporate executives have indicated a gap between the academic definition of strategy and its actual application in industry. This may stem from the inability to describe a universal strategy model applicable to all business situations. The appropriateness of any one model for any particular business situation is unlikely, given the challenges imposed by a business environment characterized by ever increasing complexity, uncertainty and change.

Purpose and Constraints

Campbell and Alexander question the common approaches to strategy formulation and its implementation. They suggest that these approaches are at best confusing and at worse a crutch. It is their belief that organizations rely too heavily upon the planning process and the development of action plans as a substitute to understanding the objectives of strategy development. In this light, it is important for a firm to distinguish between purpose and constraints. Purpose is “what the organization exists to do”. Constraints are “what an organization must do in order to survive”. Developing a good strategy lay in a manager’s understanding of “the benefit of having a well-articulated, stable purpose; and the importance of discovering, understanding, documenting and exploiting insights about how to create more value than other companies do.” The weakness with high level stakeholder objectives as defined in many vision statements at a corporate level is that they merely restate the universal objective of all companies: to develop and sustain competitive advantage. 35

This criticism points to the need of a framework that can align the top level strategic posture of the firm with the operational moves that exploit the firm’s insights at creating value. Such a framework and process would need to be nimble enough to accommodate varying levels of

strategic analysis. The combination of the three analytic views outlined above are a possible series of frameworks to this end.

2.2 Make-Buy Decisions and Product-Process Development

This section reviews existing literature on the subject of make-buy decisions. Emphasis is placed on the transaction cost and resource-based approaches to make-buy decisions. The transaction cost approach is generally seen as being short term in emphasis. The resource-based approach by comparison, is generally viewed as taking a longer-term strategic perspective. This section also quickly reviews recent literature on the design of a firm’s supply chain as it relates to the development of the firm’s product architecture to highlight the importance of how make-buy and supply chain design issues are closely linked together.

2.2.1 Transaction-Cost Approach

The theory of make-buy can be traced to a paper authored by Ronald Coase in 1937 titled “The Nature of the Firm”. In it he offers an explanation to the existence of firms in an economic system that was based on competition and coordinated by the market price mechanism. He poses two basic questions about economic organizations: “Why is such organization necessary?”36, and “Why is not all production carried on by one big firm?”37. In essence, the issue raised was one of make-or-buy. Taken to an extreme, the first case represents the buying of all goods and the second the making of all goods.

Coase sees the firm and the market as alternative modes for organizing the same transactions.38 If the market price mechanism is so efficient, why do firms exist at all? Why wouldn’t consumers or firms just buy all the items they need from the marketplace? Consequently, if

37 Ibid., p.23.
38 Ibid., p.5.
firms exist due to some advantage over a market organized by the price mechanism, why wouldn’t a firm enlarge to the point that only one company existed? Why wouldn’t a firm elect to produce all the items it needs? The answer to both questions lay in the cost of transactions that are not represented by the price of the item being traded. Coase puts it this way:

All that was needed was to recognize that there were costs of carrying out market transactions and to incorporate them into the analysis, something which economists had failed to do. A firm had therefore a role to play in the economic system if it were possible for transactions to be organized within the firm at less cost than would be incurred if the same transactions were carried out through the market. The limit to the size of the firm would be set when the scope of its operations had expanded to the point at which the costs of organizing additional transactions within the firm exceeded the costs of carrying out the same transactions through the market or in another firm.39

Walker and Weber review two lines of thought that outline the transactional context in which firms would prefer to make rather than buy particular components. They consider “a transaction the transfer of goods or service between technologically separate units, and that the analysis of transactions focused on achieving efficiency in their administration.” 40

The first line of thought deals with transactions that occur with great or sufficient frequency to warrant concern over resource efficiency, given an imperfect world of market information for both the buyer and the supplier. Two dimensions govern these transactions: first, the buyer firm’s uncertainty associated with executing the transaction; and second, the uniqueness or specificity of the assets associated with the goods or service transacted. Both dimensions deal with the risk a firm faces with opportunistic supplier bargaining. Uncertainty in this case is the firm’s inability to assess supplier actions due to “limited information-processing capacity”. High asset specificity, where an asset has little use outside of the particular buyer-seller relationship, also makes opportunistic supplier decisions risky for the buyer. In the cases of

39 Ibid., p.48.
high uncertainty or high asset specificity, it is considered better judgment for the buyer to produce the component in-house. 41

The second line of thought is based on a model of efficient boundaries presented by Williamson. This model combines the differences in the transaction costs plus the production costs of a component, for make in-house versus buy, as a function of increasing asset specificity. The model indicates:

...that when asset specificity is low, suppliers enjoy a production cost advantage over buyers, since they are able to pool possibly uncorrelated or negatively correlated demand and thereby achieve smoother production schedules and greater economies of scale. The production cost differential decreases as roughly an inverse function of the increase in asset specificity and approaches zero, never favoring the buyer. Additionally, there was a point when the transaction costs of market contracting were unfavorable when compared to the administrative costs associated with in-house production.42

Using just the transaction cost difference, a firm would bring a component in-house relatively early with respect to the asset specificity variable due to greatly reduced administrative costs compared to contracting costs. However, when combined with the difference in production costs, which at this point favored the supplier, the model indicates that buyers should continue to purchase the component. Only when the sum of the production and transaction cost differentials, cross the asset specificity axis, should the firm make the item.

In light of Williamson’s efficient boundary model, Walker and Weber study a sample of make-or-buy decisions made in a division of a US automobile firm. The effect of transaction costs on make-buy decisions is evaluated through the impacts of supplier market competition and volume and technological uncertainties. Buyer production experience, comparative production costs between buyer and supplier, and transaction costs, are thought to influence the decision. In their study, comparative production costs is found the strongest indicator of make-or-buy

41 Ibid.
42 Ibid., p.374.
decisions overshadowing transaction costs. Volume uncertainty and supplier market competition are found to have secondary important effects.\textsuperscript{43}

One limitation with the transaction based model is its reliance on decision making through the analysis of a firm's cost to manage and manufacture a particular component in-house versus the firm's cost to manage the purchasing of a component and its price from a supplier. The ability of a firm to gather the full transaction costs associated with in-house management and market contracting is suspect. In addition, this framework is oriented specifically towards production costs to the neglect of related innovation, design, and development costs of the component. In the aerospace industry, these development costs have a great bearing on make-or-buy decisions.

2.2.2 Resource-Based Approach

The resource-based view emphasizes the need for companies to concentrate on activities, which represent core competencies to the firm. In this view, the design of the firm is centered on keeping those activities that draw upon its competencies, and buying or outsourcing all other activities.

Core Competency

A core competence is a unique, multidisciplinary blend of applied knowledge, skills, and technology. Achievement of a competitively superior mix of these components manifests itself in having developed decisive competitive advantage. Competitors cannot easily understand or replicate a core competence because of its complexity and reliance on "soft" factors such as know-how, organizational architecture and culture. Prahalad and Hamel write:

Core competence is communication, involvement, and deep commitment to working across organizational boundaries. It involves many levels of people and all functions. The skills that together constitute core competence must coalesce around individuals whose efforts are not so narrowly focused that they cannot recognize the opportunities for blending their functional expertise with those of others in new and interesting ways.\textsuperscript{44}

\textsuperscript{43} Ibid., p.387-388.
Prahalad and Hamel hence note that core competencies represent the collective learning in the organization. This especially includes the know-how to coordinate diverse production skills and to integrate multiple streams of technologies. It is supported by a reinforcing structure in the organization of work and a strategic organizational architecture that makes resource allocation priorities transparent to the firm. A core competency has three identifying elements. First, it can be used with a wide array of products that provide potential access to a variety of markets. Second, it makes an important addition to the value and benefit perceived by customers. And lastly, it is difficult for competitors to imitate. 45

**Strategic Outsourcing**

Quinn and Hilmer suggest two strategic approaches that allow firms to fully leverage their skills and resources. First, a firm should focus its own resources on a set of "core competencies" where it can attain definable preeminence and provide unique value for customers. Secondly, it ought to strategically outsource other activities - including many usually considered integral to any company - for which the firm has neither a critical strategic need nor special capabilities. 46 They indicate several advantages from such outsourcing:

The benefits of successfully combining the two approaches are significant. Managers leverage their company's resources in four ways. First, they maximize returns on internal resources by concentrating investments and energies on what the enterprise does best. Second, well-developed core competencies provide formidable barriers against present and future competitors that seek to expand into the company's areas of interest, thus facilitating and protecting the strategic advantages of market share. Third, perhaps the greatest leverage of all is the full utilization of external suppliers' investments, innovations, and specialized professional capabilities that would be prohibitively expensive or even impossible to duplicate internally. Fourth, in rapidly changing marketplaces and technological situations, this joint strategy decreases risks, shortens cycle times, lowers investments, and creates better responsiveness to customer needs. 47

Quinn and Hilmer also review the tactical and strategic risks to the firm due to outsourcing. Tactically, supplier markets are imperfect, and present risks to both buyer and seller with regards

---

47 Ibid.
price, quality, schedule, etc. In addition transaction costs for outsourcing - such as searching, contracting, termination, etc. - can overshadow the costs of manufacturing an item in-house. In light of such risks, a firm needs to account for: the likelihood of creating a competitive advantage from an activity; and its vulnerability should market failure occur in the provision of the item.

Is it possible to structure supplier agreements to provide “appropriate control” and still maintain flexibility to demand fluctuations? The authors point out a continuum of contract relationships in a mapping against flexibility needs versus need for control, which result from competitive edge and vulnerability issues due to outsourcing. “At each intervening point, the question was not just whether to make or buy, but how to implement a desired balance between independence and incentives for the supplier versus control and security for the buyer.” 48 The outsource condition needs to suit both parties and not predominantly benefit one party or the other.

With outsourcing activities, firms need to be wary of new types of strategic risks. Management's main strategic concerns are: the loss of critical skills or developing the wrong skills, the loss of cross-functional skills, and the loss of control over a supplier. 49

**Insourcing**

Just as important as assessing the reasons for an outsource, are considering reasons for an insource. Quinn and Hilmer write that:

> The key strategic issue in insourcing versus outsourcing is whether a company can achieve a maintainable competitive edge by performing an activity internally—usually cheaper, better, in a more timely fashion, or with some unique capability—on a continuing basis. If one or more of these dimensions is critical to the customer and if the company can perform that function uniquely well, the activity should be kept in-house. Many companies unfortunately assume that because they have performed an activity internally, or because it seems integral to their business, the activity should be insourced. However, on closer investigation and with careful benchmarking, its internal capabilities may turn out to be significantly below those of best-in-world suppliers. 50

48 Ibid., p.48.
49 Ibid., p.52.
50 Ibid., p.48.
This perspective is consistent with the core competence ideas presented by the resource based view.

2.2.3 Product-Process-Supplier Chain Dependencies

Despite its appeal, the resource based model does not specifically explain the evolution nor nature of the product-process and supplier dependencies that develop with its use. As firm’s focus on those activities that strengthen its core competencies, its reliance on the supplier network for goods or services and product knowledge increases. This interdependency extends to the product development effort of the firm. As suggested above, an advantage of outsourcing includes the innovations and capabilities brought to the relationship by the suppliers. Another advantage to outsourcing is the reduction in product development cycle time through efforts at concurrency and communication with the supply network. These advantages, however, need to be balanced against the inherent risks of the resulting dependencies of the firm on its suppliers.

Interdependency

Gutwald presents a framework of the make-buy decision that indicates the dependency of such decisions on the firms: engineering, integration, development, manufacturing and supply chain strategies (See Fig. 2-3). The framework maps out an iterative decision process, where the direction and capabilities in one area affect the nature of the decisions in other areas. These strategies and interdependencies are linked back to the over all firm strategy that identify the competitive advantages of the firm in the market. The framework is meant to “provide a practical road-map for determining the pattern and extent of firm specialization and coordination of decisions for competitive advantage.” It emphasizes the need to make simultaneous choices in product, process and supply-chain design in order to achieve global optimums.

Gutwald further documents a detailed sourcing decision flow chart that takes into account issues of: the items strategic importance; the sustainability of its competitive advantage; the vulnerability to the risks of using outside suppliers; the firms product capability in design, engineering, testing
and integration; the firm's aptitude at developing needed capability; and the firm's manufacturing, supplier and supply chain capabilities.

![Conceptual Overview of Decision Process](image)

**Figure 2-3, Iterative Sourcing Decision Process**

### Three Dimensional Concurrent Engineering (3-D CE)

Fine, in his book "Clockspeed", suggests that a broader view regarding the sources of competitive advantage is necessary. Porter's industry-firm framework is oriented at developing advantages through product cost and/or discrimination. The resource view of core competency focuses on developing internal capabilities that provide significant value to the customer. These views, however, do not represent the comprehensive contribution that a supply chain extends to a firm's success.

---

32 This sections draws from discussion in Fine (Chapter 8), pp.127-148.
Fine argues that competitive advantage comes from organizing the chunks of capabilities found within an organization and externally within its supply chain. He suggests that firms need to overcome the usual tendency of limiting its strategic analysis to its ‘natural’ boundaries, and develop a more inclusive strategy by expanding the domain of the problem: to include supply chain design issues.

Supply chain design consists of: choosing what work to outsource to suppliers (make versus buy); choosing which suppliers to use (supplier selection); and negotiating the contract (both the legalities and the culture of the relationship). Of these areas, the make-buy decision is considered the most important and is best accomplished in a concurrent engineering effort.

Figure 2-4, Overlapping responsibilities across Product, Process and Supply Chain development Activities\textsuperscript{53}

\textsuperscript{53} Ibid., p.146.
Successful application of Integrated Product Teams (IPT) in recent design efforts indicate the advantages provided by concurrency. Nonetheless, Fine considers recent IPT efforts as two dimensional, since their primary focus lay in coordinating product and process issues. He proposes the use of a three-dimensional (3-D) concurrent engineering approach that emphasizes the importance of simultaneous concurrent decisions with regards integrated product, process and supply chain functions.

Figure 2-4, conceptually denotes the 3-D Concurrent Engineering approach and the importance of coordination at the interfaces of – product architecture (make-buy), manufacturing system (make-buy), unit process manufacturing, and detail strategy. The figure points out that each development area consists of integration and ‘functional’ work. Integration decisions and coordination were most important for those activities where overlap exists between two or three functions.

![Diagram of 3-D CE decision model illustrating the imperative of concurrency](image)

Figure 2-5, The FAT 3-D Concurrent Engineering Decision Model\textsuperscript{44}

\textsuperscript{44} Ibid., p.147.
Figure 2-5 extends the conceptual decomposition of the areas of overlap into lower level activities. Each development area (product, process, supply chain) consists of two activities, which interact within each area and across to other areas in the development process. Fine describes the decomposition as follows:

Product development is subdivided into activities of architectural choices (for example, integrality versus modularity decisions) and detailed design choices (for instance, performance and functional specifications for the detailed product design).

Process development is divided into the development of unit processes (that is, the process technologies and equipment to be used) and manufacturing systems development—decisions about plant and operations systems design and layout (for instance, process or job shop focus versus product or cellular focus).

Supply chain development is divided into the supply chain architecture decisions and logistics and coordination system decisions. Supply chain architecture decisions include decisions on whether to make or buy a component, sourcing decisions (for example, choosing which companies to include in the supply chain), and contracting decisions (such as structuring the relationships among the supply chain members). Logistics and coordination decisions include the inventory, delivery, and information systems to support ongoing operations of the supply chain.55

The activities where concurrent engineering is considered most important is at the interfaces represented by the linkages between the three development processes located at the bottom of Figure 2-5 labeled: Technology, Architecture and Focus.

The interaction between product design and process capability is represented by the linkage connections at the bottom of the chart labeled -- Technology. This linkage is “the domain of traditional (two-dimensional) concurrent engineering.” It represents the coupling between detail design choices and decisions about process technologies and equipment used.

The Architectural linkage connects the issues of integrality and modularity of supply chain architecture to product architecture. Supply chain architecture, its integrality or modularity, is

55 Ibid., pp.145-146.
indicated by the proximity amongst its members. Proximity is measured across four dimensions: geographic (physical location); organizational (for instance- patterns of ownership, managerial control, inter-team dependencies); cultural (values captured through language, business mores, ethical standards, etc.); and electronic (connection through electronic technology). Integrity or modularity, in this case, is assessed by the proximity of the manufacturer to its supply chain members. Integrity may encompass firms with close facility locations that have a great deal of personnel interaction, and which share common business mores. Modularity can exhibit low levels of proximity across all four dimensions. 56

Product architecture, its integrality or modularity, is exhibited by the closeness in the coupling of the elements of the product. Integrality features components that: perform many functions; are spatially close; and are tightly synchronized. Modular product architecture, on the other hand, exhibits components that: are interchangeable; are individually upgradeable; have standardized interfaces; and can be localized for failure. 57

According to Fine, a strong dependency exists between a product’s architecture and its supply chain architecture. Integral product architectures usually result in integral type supply chains, just as product modularity is supported by a supply chain with modular characteristics. As a result, concurrent engineering should coordinate decisions about product architecture with the supply chain strategies of the firm.

The Focus linkage relates manufacturing system design to the logistics and materials system design. This linkage points out the tight connection between in-house manufacturing and the supply chain. Manufacturing system design decisions about: job shop or process focus; cellular or product focus; affect decisions about the integrality or autonomy of the supply chain’s management.

56 Ibid., p.137.
57 Ibid., pp.134-135.
2.3 Review of Literature on Supplier Relationships

Two widely differing models of supplier management models have emerged in considering how to best manage supplier firms. The arm’s length model or traditional view, promotes minimizing dependence on suppliers and maximizing customer bargaining power. An operational activity to achieve this is to purposely keep suppliers at arm’s length and to avert any form of commitment. The traditional model was the predominantly accepted perspective of US firms, until the success of Japanese firms that was attributed to a supplier network managed with an alternate model. On the other extreme is the partner model of supplier management which has the attributes of close supplier relations. This model provides better performance by partnering firms due to: the sharing of information and the resulting better coordination of tasks; and the reliance on trust as a principle to build relationships. Several studies suggest that both customer and supplier firms benefit from a relationship characterized by partnering. Consistent with this, many American firm’s are adapting Japanese supplier management approaches to effectively compete in the global market. 58

Over time, Japanese automobile companies have capitalized on a partnering modeled supplier network to reduce cost, improve product development, and introduce innovative new products. It was once thought that partnering activities were applied to all firms in the supply chain. It appears however, that these supplier structures are complex, being composed of varying relationship types that have different operational characteristics.

Cooperative Relations

One study reviews Chrysler’s efforts to adapt the Japanese ‘keiretsu’ structure to its established hierarchical organization. The study lists several similarities and differences between the Japanese and American ‘keiretsu’ models, and indicates several ‘critical’ components of the Chrysler adaptation. One critical component was the operation of cross functional teams to facilitate

---

cooperation and trust between the manufacturer and the supplier. Another component was the use of presourcing or the selecting of suppliers early in the product development process and allowing them a high degree of responsibility for designing a particular item or assembly. In support of presourcing, the further adaptation of target costing —where an assembly’s cost was apportioned from the total projected price the market would bear for the final product— was implemented. These target costs were the basis for negotiations with the customers presourced suppliers, in place of the firm’s traditional multi supplier competitive bidding process. An additional component was total value chain improvement, where suppliers were encouraged to continuously improve processes for the value chain. Enhanced communication and coordination through increased interaction between firms, was a further component identified. A final critical component was the long term business commitment that the customer placed with the supplier. In implementing these ‘keiretsu’ type components, Chrysler effectively expanded into international markets and maintained or established a competitive advantage over its international competitors.  

A further study examines the relationship between supply chain management practices, supplier performance and company performance. The study surveyed the Directors and Vice Presidents of Quality for three hundred thirteen member companies of the American Society for Quality Control. These firms represent a wide range of industries, employee size, and revenue base. Empirical evidence is presented, which indicates that company practices that took advantage of supplier capabilities correlates positively and significantly with a company’s performance measures. “Using supplier knowledge and skills, requiring supplier certification of products and processes, visiting supplier facilities regularly, sharing confidential information, and using commodity teams to set supplier goals, all correlate positively with return on assets, and growth in market share, sales and return on assets. Additionally, in some cases, they correlate significantly with market share, customer service, product quality and competitive position.”

An investigation done in the early 1990s, indicates that there was significant inclination by suppliers in the automobile industry to engage in activities that supported cooperative relations between buyer-supplier firms. The study suggests that suppliers were considerably more willing than its customers: to furnish detailed information to their customers; to have long-term contracts; to take seriously customer requirements about product quality; and to have defect prevention systems in place. The study also indicates progress, from the early 1980s, towards a voice model of supplier relations. In this model, suppliers play an important role in solving joint problems and in generating fresh ideas about improvements in product and processes. However, despite active engagement in these activities, supplier firms felt that supplier-buyer relations were still lacking in trust. These firms also indicated that they did not receive much customer assistance in reducing costs or adopting new techniques. As of the early 1990s, the automobile industry still exhibited mixed directions towards buyer-supplier relations. 61

A work reviewing the history of Japanese industrial subcontracting indicates that over time, Japanese producers developed a distinctive sourcing strategy. In general, history indicates that the major firms focused their resources on strategically important products and processes while delegating other work to the subcontractors. This outsourcing relieved the primary firms from the responsibilities of overseeing complex operational and administrative tasks. In conjunction with this focus, many current Japanese subcontracting practices were developed. The modern form of Japanese subcontracting is based on distinct practices developed around the system of clustered control (tiered suppliers) and joint problem solving. These practices are: target costing (as discussed by Putnam and Chan, the use of ‘market price minus’ versus ‘cost plus’ principles); value analysis (joint activities at cost reduction inclusive of the sharing of detailed cost data); bilateral design (concurrent supplier design activities); subcontractor evaluation (grading suppliers to determine rank in the supply chain as well as point out areas of improvement); and purchasing agents' role (not just as downstream negotiators, but as subcontract evaluators, inter-firm coordinators and teachers). 62

Tiered Supply Chain Structure

A review of Japanese supplier management strategies dispels several commonly held views about the responsibilities played by the various tiers in an industrial Japanese supply chain. The most common notion has been that all Japanese first-tier suppliers are treated as exclusive partners and provided with early information regarding new products or product changeovers. This study discloses that Japanese auto makers reserve suppliers different roles. Various subcontractors, even first-tier suppliers, are provided different levels of responsibility for product development.

Several roles that suppliers could play include that of: partner, where the firms' relationships are nearly equal; mature, where suppliers have major responsibility but receive close customer guidance; child, wherein the customer determines in explicit detail the specification of the parts; and contractual, in which the supplier is used as an extension of the customer's manufacturing capability. These roles indicate the level of capability that the supplier is expected to provide the customer firm. For instance, only a few select first tier suppliers are accorded the role of partner and considered a full service provider (specification, design, manufacture and test). At the other extreme are the contractual suppliers who can be considered make-to-blueprint firms that do not contribute to the design effort at all. Commensurate with a supplier's role is a difference in the customer's dealings with and treatment of the supplier. 63

Another review of auto industry supplier relations covers US, Japanese, and Korean manufacturers. The study focuses on determining the type of supplier management model that is used by each geographic industry -arm's length or partnering. This study indicates that US auto makers manage most of their suppliers using an arm's-length model, Korean auto makers have managed their suppliers principally as partners, and Japanese auto makers have somewhat different relationships with suppliers depending on the nature of the component. The review concludes that only the Japanese auto makers have "strategically segmented suppliers in such a way as to realize many of the benefits of both the arm's length as well as the partner models". The

study further suggests that firms ought to think carefully about its supplier management and match its approach to specific firms according to the role they play in the customers supply chain.\textsuperscript{64}

2.4 Chapter Summary

This chapter provides a brief review of literature related to business strategy and the process of strategy formulation. The review is included to emphasize that the overall enterprise strategy sets the context for a firm’s make-buy decisions. This situation is evident with the case study reviewed later in the thesis.

Included in this chapter is a review of existing make-buy decision literature. It covers prevalent transactional cost and resource-based approaches. Transactional cost approaches appear to emphasize comparisons of short term costs of specific items. In contrast, resource-based decisions consider longer term and strategic perspectives which cover a broader range of issues than just the product. The chapter also covers recent literature regarding supply chain design and its linkage to product architecture.

The chapter includes a review of literature indicating that cooperative supply chain management practices can be beneficial to both customer and supplier firms. In addition, cooperative relations result from increased interactions between firms.

\textsuperscript{64} Dyer, Cho and Chu, pp.57-77.
3. **Make Buy Frameworks**

This chapter reviews specific make-buy frameworks that are used to analyze the thesis case study. An explanation of the firm's propensity to make parts due to an accumulation of specific capital assets is linked to product innovation literature. These indicate that a firm amasses more specific capital assets as innovation moves from a fluid to a specific pattern. The chapter further reviews two make-buy frameworks. The first framework, the 3-D Concurrent Engineering Make versus Buy Decision Matrix, was authored by Fine in his book "Clockspeed". The second framework, the Technological Maturity and Competitiveness model was developed by Perrons in his Masters thesis under the auspices of the Lean Aerospace Initiative. These frameworks suggest source decisions be based on strategic core-competency issues. In addition, the chapter includes a review of literature which indicate that cooperative supplier relations are beneficial to both the customer and the supplier. The literature further suggests that cooperative supplier relations can result from increased interaction between firms.
3.1 Historical Make-up and Asset specificity

A firm’s previous source decisions prescribe the context for current make-buy decisions. In some cases, a firm’s historic choice of make-buy decisions is based on a consciously planned strategy. For instance, many firms have identified their core competencies and maintain the activities that support these in-house. Other activities not affecting the firm’s core competencies are bought. After several iterations of make-buy decisions that reinforce the original core competency choices, a firm may begin to make decisions out of ‘habit’ instead of reasoning. Certainly the make-buy decision due to ‘habit’ can develop even without a strategic core competency framework. In either case, the firm’s historic make-buy decisions serve as a template for future decisions.

Note that a firm’s ‘habitual’ source decision is driven not only by items the firm wants to make, but also by the items the company is not interested in making. There are many examples that illustrate a company’s propensity to always buy certain components. In some cases, the items bought are beyond the design and manufacturing capabilities of the customer firm. In other cases, they are items that are somehow always less expensive to buy than to make. Here again, the tendency to buy certain parts is a result of the historical choices made by the firm.

From the discussion above, it is easy to see why components that have been sourced buy, are most likely to always remain bought. Depending on the component or technology, there may be difficult technical issues to address in vertically integrating within an industry. The firm can maintain a staff that is cognizant of the integration of these items into its product. However, it is unlikely that the detail knowledge that the firm can accrue regarding bought items will ever be as deep as the suppliers that provide the components.

It should be noted that in chapter two’s discussion on the transaction based approach to make-buy, Williamson indicates that as the specificity of the assets required to produce an item increased, it was better judgment for a buyer to manufacture the component in-house. The primary reason for this was the risk of opportunistic supplier actions given assets that had little use outside of a particular buyer-seller relationship.
3.1.1 Prior Innovation and Part Specific Assets

The innovation of new products has inherent make-buy decisions that need to be made. Teece and Abernathy and Utterback cover issues that relate make-buy decisions to the issue of innovation. Teece suggests a decision process that determines if a firm should contract out or keep in-house the manufacture of an innovation. This process takes into account various issues including: the firm's access to complementary assets; whether the asset was specialized; the firm's capacity at appropriating the innovation's rent (through the nature of the technology or protective mechanisms); the level of asset specialization required; the firm's cash position; and the competitions position with respect to the innovation. This process outlines a gated procedure flow chart that reviews each of the issues identified above to determine if the firm should 'make' the part by acquiring the necessary complementary assets. Note that three issues reviewed by the process, deal with the acquisition of a specialized asset. First is the need to determine if the 'complementary asset' in question is specialized. A later question reviews if the asset is critical. And finally, a firm's ability to pay for the asset is covered. Getting through all gates indicates that the firm ought to acquire the critical specialized assets and thereby 'make' the innovation.65

Abernathy and Utterback help explain the firm's propensity to acquire capital assets and in so doing, decide to the make parts. The authors provide a typology that describes changes in activities related to product and process topics as the firms innovation type changes. (See Fig.3-1). The emphasis of these activities vary as the innovation progresses with the product and/or process life cycle. As a product goes through its life cycle, the innovation pattern also changes. In this case, as the product matures, the innovation pattern changes from: fluid, to transitional, to specific pattern. As the figure indicates, innovation type progresses from: frequent major changes; to major process change; to incremental for product and process. Paralleling this, the production process also changes from: flexible and inefficient, to more rigid but changeable in major steps, and finally to efficient-capital intensive and rigid. As the product matures, capital assets became more product specific and entrench the organization into making the parts. 66

## Level and Type of Innovation

<table>
<thead>
<tr>
<th>Fluid Pattern</th>
<th>Transitional Pattern</th>
<th>Specific Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive emphasis on</td>
<td>Functional product performance</td>
<td>Product variation</td>
</tr>
<tr>
<td>Innovation stimulated by</td>
<td>Information on users' needs and users' technical input</td>
<td>Opportunities created by expanding internal technical capability</td>
</tr>
<tr>
<td>Predominant type of innovation</td>
<td>Frequent major changes in products</td>
<td>Major process changes required by rising volume</td>
</tr>
<tr>
<td>Product line</td>
<td>Diverse, often including custom designs</td>
<td>Includes at least one product design stable enough to have significant production volume</td>
</tr>
<tr>
<td>Production process</td>
<td>Flexible and inefficient; major changes easily accommodated</td>
<td>Becoming more rigid, with change occurring in major steps</td>
</tr>
<tr>
<td>Equipment</td>
<td>General purpose, requiring highly skilled labor</td>
<td>Some subprocesses automated, creating &quot;islands of automation&quot;</td>
</tr>
<tr>
<td>Materials</td>
<td>Inputs are limited to generally available materials</td>
<td>Specialized materials may be demanded from some suppliers</td>
</tr>
<tr>
<td>Plant</td>
<td>Small-scale, located near user or source of technology</td>
<td>General purpose with specialized sections</td>
</tr>
<tr>
<td>Organizational control</td>
<td>Informal and entrepreneurial</td>
<td>Through liaison relationships, project and task groups</td>
</tr>
</tbody>
</table>

Source: from Abernathy and Utterback, "Patterns of Industrial Innovation," p.40.

Figure 3-1, Level and Type of Innovation
3.2 Specific Frameworks Applied

This thesis applies two make-buy frameworks to review the ‘buy’ decision of an airframe subsystem for the development helicopter. The first framework, the 3-D Concurrent Engineering Make versus Buy Decision Matrix, is suggested by Fine in his book “Clockspeed”. The second framework, the Technological Maturity and Competitiveness model was developed by Perrons in his Masters thesis under the auspices of the Lean Aerospace Initiative. These frameworks suggest that source decisions be based on long term core-competency issues.

3.2.1 3-D Concurrent Engineering Make versus Buy Decision Matrix

The make-buy decision is instrumental in the development and maintenance of a firm’s core competencies. The decision influences the selection of new projects, new processes and new supply chain relationships that the firm engages in. The capabilities that are exercised in-house with the resulting work and activities from these choices, suggests an interdependence between the maintenance of a firm’s core capabilities and the make-buy decision. The 3-D concurrent engineering approach indicates that strategic make-buy decisions be structured to simultaneously manage the product, process and supply chain development activities of the firm.

The three dimensional concurrent engineering approach indicates that product architecture and supply chain architecture are closely linked. As discussed in chapter two, the two architectural approaches to product and supply chain design are modular and integral. The make-buy decision should be crafted to reflect this linkage between product and supply chain architectures. In addition, these decision must be consistent with the strategic core competency choices of the firm.

Fine relates three common reasons why a firm would outsource. First, is the firm’s inability to make or easily acquire the capability to make an item. Second, is that the supplier had lower

---

cost and is generally better at the manufacture of the item. And thirdly, that the supplier’s item is technologically superior to one that the firm had developed.

On the other hand, two important strategic reasons for a firm not to outsource are pointed out. The first reason being the need to reinforce the firm’s competitive knowledge. The sharpening of a firm’s knowledge base is necessary when “the item was crucial to the product’s performance, or the skill in producing it has been judged basic to the company’s technical memory.”

The second reason not to outsource is because of the items contribution to customer visibility or market differentiation. “A company should make what matters most to the customer or what differentiates the product in the marketplace; it should buy everything else.”

<table>
<thead>
<tr>
<th>Item is Modular (Decomposable)</th>
<th>Dependent for Knowledge and Capacity</th>
<th>Dependent for Capacity Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>A POTENTIAL OUTSOURCING TRAP</td>
<td>Your partners could supplant you. They have as much or more knowledge and can obtain the same elements you can.</td>
<td>BEST OUTSOURCING SITUATION You understand it, you can plug it into your process or product, and it probably can be obtained from several sources. It probably does not represent competitive advantage in and of itself. Buying it means you save attention to put into areas where you have competitive advantage such as integrating and other things.</td>
</tr>
<tr>
<td>WORSE OUTSOURCING SITUATION</td>
<td>You don’t understand what you are buying or how to integrate it. The result could be failure since you will spend so much time on rework and rethinking.</td>
<td>CAN LIVE WITH OUTSOURCING You know how to integrate the item so you may retain competitive advantage even if others have access to the same item.</td>
</tr>
</tbody>
</table>

Figure 3-2, Matrix of Organizational Dependency and Product Decomposability

---


69 Fine, Clockspeed p.165.

70 Ibid., p.166.
Combining the notions of product architecture and the reasons to outsource or maintain capability, the framework presented in Figure 3-2 is developed. This matrix reflects how outsourcing and product architecture affect each other. The author considers that the technological approach to product architecture (integral vs. modular) and the organizational reasons for outsourcing, whether for knowledge (design and development) and/or capacity (manufacturing), have varying strategic implications to the firm. These implications are outlined in the descriptions provided in the four quadrants of the figure. This matrix forms the basis for the make vs. buy framework suggested by the 3-D concurrent engineering approach.

Figure 3-3, The Make vs. Buy Decision Analysis Matrix: Decomposability, Dependency, Clockspeed and Industry Competitiveness 71

71 Fine, p.170.
The Make versus Buy Decision Analysis Matrix (Figure 3-3) extends the ideas developed in Figure 3-2. In addition to technological and organizational interdependencies, intertemporal (clockspeed) and competitive (density of supplier base) interdependencies are included. These issues were reviewed in chapter two. Fine suggests that analyzing make-buy decisions with this framework of four interdependencies, can provide strategic insight to the firm. The addition of the clockspeed and competitive factor sub-matrices of the supplier chain to the framework, provides additional analytical sensitivity regarding the strategic situation the firm would be in, given the technology / dependency quadrant.

In the slow clockspeed, limited supplier world of outsourced aircraft airframe structure, there is a moderate risk to an integrator firm from the suppliers. This risk, however, is reduced if the integrator firm maintains its knowledge about the outsourced item's integration into the product and the value that it contributes to the system. As indicated in Figure 3-2, a product with a modular architecture that is outsourced due to capacity reasons, is considered the best outsourcing situation for the firm buying the item. With the insight provided by this framework, it would be best for a firm with limited manufacturing capacity to drive the design process of a technology it understands towards a modular architecture to mitigate the risks of outsourcing.

A firm must also be cautious about outsourcing competencies to the extent that it loses its understanding about: what an item does; how to make it; and how it integrates into the final product. This scenario can occur to a firm that has lost sight of its competencies and was outsourcing indiscriminately for purely cost reasons. The framework indicates that such outsourcing would be disastrous for products with integral architectures in technologies with fast clockspeeds and few suppliers.

3.2.2 Technology Maturity and Competitiveness Framework

This particular make-buy framework is rooted in the observation that the aerospace industry does not explicitly account for the nature of a technology's maturity when making sourcing decisions.

---

72 R.K. Perrons, "Make-Buy Decisions in the US Aircraft Industry" (MS Dissertation, MIT, 1997), this section draws from discussion regarding this framework in Chapter 5 of Perrons' thesis.
This notion of technological maturity is combined with the idea of a firm's competitiveness in a technology to develop the basic matrix that constitutes this framework. An important consideration is whether the design or manufacturing technology associated with the source decision is a core competency of the firm. These three considerations make up the make-buy framework suggested by Perrons.

Figure 3-4, Technological Maturity and Competitiveness Framework

KEY:

technology directly pertains to core competencies

technology does not directly pertain to core competencies

73 Ibid., p.106.
Figure 3-4 shows the field of potential make-buy scenarios represented by the matrix. The matrix has four main categories: 74

1) the component or process involves a technology that is quickly evolving, and the company is substantially behind the leading firms with respect to its technological competitiveness (top left quadrant)

2) the component or process involves a technology that is quickly evolving, and the company is among the leading firms with respect to its technological competitiveness (top right quadrant)

3) the technology behind the component or process is relatively mature, and the company is substantially behind the leading firms with respect to its technological competitiveness (bottom left quadrant)

4) the technology behind the component or process is relatively mature, and the company is among the leading firms with respect to its technological competitiveness (bottom right quadrant)

As shown in Figure 3-4, each quadrant is further divided to indicate whether the design or manufacturing activity is considered one of the core competencies of the firm. The determination of whether an activity is a core competency is not a trivial matter. Perrons states that it is reasonable that a manager would consider an item that is made in-house a core competency simply because the firm manufactures it. However, it is suggested that the competency of an activity could also be inferred from the make-buy actions taken by the firm. Certainly managers of a firm will all have a viewpoint on the importance that certain capabilities have on the success of the firm.

Figure 3-4 further indicates the recommended make-buy action for each of the eight categories of the matrix. Several of these categories are worth reviewing as they have significance to the case study material.

74 Ibid., p.94.
For the category, a Core Competency in Mature Technologies where the firm is a Leader along the Competitiveness axis, the framework suggests a Make and Buy decision (lower right hand quadrant, core competency). In this case, the technology’s maturity indicates that it is probably easily imitated by competitors. Prahalad and Hamel would argue that such capabilities do not add to the firms distinguishable value to the customer with regards its competitors. With this in mind, a buy decision would be recommended. However, Perrons points out that it is important for managers to understand the underlying technologies related to the components being outsourced. One way to maintain this understanding is to make the item, even if only minimally. Additionally, some technologies, though peripheral, are directly related to the firm’s core capabilities. In order to maintain an understanding of this well established technology a semblance of it should remain in-house. These arguments support the recommendation to make and buy these items.

To the category, Non-Core Competency in Mature Technologies where the firm is Behind along the Competitiveness axis, the framework suggests a strict Buy decision (lower left hand quadrant, non-core competency). The reason for this was as discussed above.

For, a Core Competency in Quickly Evolving Technologies where the firm is a Leader along the Competitiveness axis, the TM&C suggests the item be Make (upper right hand quadrant, core competency). In this case, the technology is likely important to the firm in order to remain ahead of its competitors. Due to this, it is best for the firm to retain the item in order for the company’s personnel to gain knowledge from this activity.

### 3.3 Supplier Relations Improved through Interactions

One can imagine, that a firm’s dependence on the supplier chain will grow as a result of the ever increasing pressure by the market place for firms to improve the value provided to the customer. In a firm’s constant effort to isolate those competencies that it can best generate value with, companies are relegating the source of many non-core components to its suppliers. Given this
scenario, it seems appropriate that the relations between the buying firm and its suppliers take on a character that is different from industry's prevalent arm's length model to supplier relations.

Several studies have indicated that supplier partnerships are beneficial to both parties in the short and long-term. These relationships are shown to improve with considerable interaction, information sharing and joint problem solving, to name a few activities.

Landeros and Monczka indicate that cooperative buyer-seller relationships are beneficial to the parties involved. It identifies five attributes that are usually present in a cooperative relationship. These attributes are: a supply pool consisting of one or a few preferred suppliers; an alliance incorporating a credible commitment between the buying and selling firms; joint problem-solving activities; an exchange of information between the firms; and joint adjustments to marketplace conditions. These attributes stand in contrast to traditional buyer-supplier interactions like 'open market bargaining and vertical integration'. This cooperative buyer-seller relationship provides the manufacturing firm with additional avenues to achieve success.\(^{75}\)

Stuart's 1993 study on supplier partnership is consistent with the above observations. This study indicates that the characteristics that promote partnerships are very much different than the traditional arm's length approach. Traditional approaches emphasize: choice due to price, short term contracts, evaluation by bid, many suppliers, supplier responsibility for problems, proprietary information, and a clear delineation of business responsibility. On the other hand, partnerships are characterized by: choice due to multiple criteria including management philosophy, longer term contracts, intensive and extensive evaluation, fewer select suppliers, joint problem solving, sharing information, and 'quasi-vertical integration'. Partnerships are also seen to provide short term benefits such as - speedier throughput time, reduced downtime and rework, inventory reductions, etc. Long term benefits such as - reduced cost structure, product sales gains, and improved

product quality, are also manifested. In summary, partnering relationships are shown to improve through considerable interaction, information sharing and joint problem solving.  

An even more enlightening example of a change in approach towards suppliers, is a study done by Dyer on Chrysler. This company, enabled by its approach to its supplier base, was able to excel in the market competition against even the Japanese automobile companies. Chrysler Corp. was able to successfully adapt a ‘keiretsu’ type model in its supply chain management. This model was characterized by mutually supportive relationships between manufacturers and suppliers. Critical components of Chrysler’s model include: cross-functional teams, target costing, choice of suppliers early in the vehicle’s concept-development stage, and having Chrysler’s and its suppliers’ engineers work side by side to develop components. In addition to this emphasis on the product development aspect of the process, Chrysler instituted a system that solicited cost reduction suggestions from its supplier base. Each suggestion was an opportunity for the companies to work jointly in improving the competitive cost of the vehicle. This system called SCORE, helped Chrysler involve suppliers deeply in its efforts to lower costs and make processes more efficient. In many ways, Chrysler’s SCORE program was considered the heart of its ‘keiretsu’ type model.  

The issue of trust is starting to be seen as an important requirement for proper partnering to succeed. A recent article by Kumar indicates major drawbacks from the exploitation of trust. Studies of manufacturer-retailer relationships in a variety of industries reveals that exploiting power has major drawbacks. Such exploitation can come back to plague a company if the balance of power changes. Victim companies will invariably discover ways to resist such exploitation. Working as partners allows retailers and manufacturers to provide customers with greater value than they could have when trying to exploit one another. In order to facilitate cooperative supplier relations, it is important for powerful companies to build systems that strive to

---

compensate partners fairly for their contributions and resolve differences in a manner that partners perceive as fair.  

3.4 Chapter Summary

The chapter reviews specific frameworks that are used to analyze the thesis case study.

An explanation of the firm’s propensity to make parts that it has capital assets for, is linked to product innovation literature. These indicate that a firm accumulates specific types of capital assets as innovation moves from a fluid to a fixed pattern of innovation. The tendency of a firm to maintain manufacturing capabilities sets a precedence for current make-buy decisions. The accumulation of specific assets appears to influence the make-buy character of the firm.

The 3-D Concurrent Engineering Make versus Buy Decision Analysis Matrix is based on the interaction of four interdependencies that affect the supply chain. These interdependencies are: technological (reflected by integral vs. modular product architecture); organizational (knowledge for design and development; and capacity for manufacturing); intertemporal (clockspeed); and competitive (density of supplier base). The analysis of make-buy decisions with this framework is meant to provide strategic insight to a firm.

The Technological Maturity and Competitive framework combines the notions of: technological maturity, the firms competitiveness in a technology, and the core competency aspect of the technology to the firm. This framework can support the make-buy decision making of the firm.

The chapter reviewed several studies, which indicate that supplier partnerships provide both short-term and long-term benefits to participating firms. These relationships were shown to improve through considerable interaction, information sharing and joint problem solving.

CHAPTER 4 - THE INDUSTRY AND THE FIRM


A review of the global demand for new helicopter vehicles suggests that it is desirable for manufacturers to have a mix of both military and commercial markets. Both markets exhibit slow growth in terms of total sales. However, the commercial market exhibits a somewhat higher growth rate in terms of unit production. In addition, some specialists believe that civil market demand can be stimulated if the industry develops products that are affordable in terms of both acquisition and operating costs. Maintaining a presence in the military segment is essential, as 72% of world production value between 1997 to 2006 is expected to come from this market segment.

New product launches in the helicopter industry involve a high degree of risk, as well as considerable development cost. Consequently, manufacturers in the industry have increasingly found it necessary to establish partnerships with other firms in order to roll out new product. Thus, new product launches have been typified by partnerships. For the Helicopter Flight Group Inc. (HFGI), this has meant approaching the introduction of a new commercial helicopter through the avenue of partnering. In so doing, it has had to start buying a ‘core’ product of the firm, airframe design and manufacture, which it had earlier designed and built itself.
4.1 The Industry

4.1.1 Helicopter Industry Setting

U.S. Background

The helicopter industry started its growth after the vehicle demonstrated its potential use during World War II. It has developed into an international industry with worldwide sales for new equipment valued at $5.26 billion in 1997.\(^7\) It is an industry that consists of two major sectors, military and civil, with major manufacturers located in the US and Europe. Helicopters are designed to meet particular customer needs and mission requirements. The variety of such missions and requirements makes it difficult to classify helicopters into discrete market segments. Nevertheless, an accepted criterion for vehicle classification is the vehicle gross weight. Hence, the industry has traditionally been segmented into four categories based on vehicle gross weight. These segments are: light, with gross weight below 7,000 pounds (further subdivided into light single engine and light twin engine); intermediate, with gross weight between 7,000 and 15,000 pounds; medium, with gross weight between 15,000 and 35,000 pounds; and heavy, with gross weight greater than 35,000 pounds. For the most part helicopters classified in the intermediate, medium and heavy categories are multi-engine air vehicles.

The helicopter is an aircraft that has the unique ability to both hover and achieve modest speeds of flight. Missions that require access to locations not reachable by conventional means became logical applications for helicopter transport. In 1939, Igor Sikorsky’s VS-300 set the dominant design for modern helicopters with a large rotor blade atop the machine for lift and propulsion and a smaller tail rotor to counteract torque and help control the aircraft.

Early helicopter designs were developed for a "low-level" air environment scenario in support of US military tactical requirements. After WW II, Sikorsky (then United Aircraft), developed medium helicopters such as the S-51 in 1946 and the S-55 in 1950 for the US military.\textsuperscript{80} Meanwhile, Bell Aircraft developed a small light helicopter, the Bell Model 47, that received commercial use certification from the Civil Aeronautics Administration in 1946. Vertol (later acquired by Boeing) developed the H-21, a helicopter capable of airlifting heavy loads and as many as 20 combat troops. During the Korean War, Bell's Model 47 and Sikorsky's S-55 were used extensively as air ambulances, rescue vehicles and troop transport.\textsuperscript{81}

In the 1960s, helicopters were designed and manufactured in response to the requirements of the military during the Vietnam War. In this period, Bell developed the UH-1 series of intermediate helicopters, Sikorsky the S-61 and S-64 "Skycrane" medium lift, and Boeing the CH-47 "Chinook". During this period both US and international manufacturers invested heavily into technology and infrastructure which develop products that could also be used in civil applications. The UH-1 vehicle was used as a basis for the design of the Bell 205 and the Bell 206 "Jet Ranger". Sikorsky capitalized on an amphibian version of the S61N which was used by the petroleum industry to ferry cargo and personnel to offshore oil rigs and remote construction sites.\textsuperscript{82}

In the 1960s and the early 1970s industry manufacturers concentrated on their own domestic markets. The Vietnam War, regional conflicts, and the Cold War defense buildup created sufficient and steadily growing demand facing the manufacturers in the Unites States and allied countries. This situation limited any need for manufacturers to focus on the development of international sales. However, with the end of the Vietnam War, military purchases for equipment declined. Competition among U.S. producers for a shrinking domestic market intensified. Meanwhile, European manufacturers focused and gained an advantage in the international arena.

\textsuperscript{80} Harry Pember, \textit{Seventy Five Years of Aviation Firsts} (Stratford: Sikorsky Historical Archives, Inc., 1998), pp.37-39.
\textsuperscript{82} Ibid., p.158.
An additional development by the 1970s, was the rise of unique commercial mission requirements that were not easily met by the adaptation of military products. Military helicopters had become increasingly sophisticated, more costly, and less suitable for civil applications. This situation made it less possible for helicopter manufacturers with a dominant military product line to gain a competitive advantage from its involvement in the military sector. At this time the industry became more discretely segmented into military and civil markets, a segmentation that continues today.\(^3\)

During the 1980s and into the 1990s, the industry had extended its marketing efforts to the Third World countries which represented a large untapped area for growth. To enter these new markets, however, manufacturers had to comply with local government demands for cooperation and participation. Many of these nations made contract award conditional on joint technology and production programs, offset procurements, government-to-government grants, and/or licensing agreements with a local manufacturer.

**International Competitors**

Today, the helicopter industry comprises several major competitors in both the United States and Europe. The larger companies have products covering both the military and civil markets. These companies usually limit their product lines to vehicles in the same weight classification. For instance, Bell helicopter has focused on light and intermediate gross weight aircraft, drawing on its development experience with the Bell 206 and UH-1 vehicles. Sikorsky, on the other hand, has concentrated on medium and heavy gross weight helicopters. It should be noted that two US manufacturers of small single piston engine helicopters, Robinson Helicopter and Schweizer Aircraft, are projected to produce up to 16% of the unit production worldwide during the period 1997 to 2001. However, due to the comparatively inexpensive configuration of single piston engine helicopters, these companies could not be separately shown on the value production chart in Fig. 4-1. Eurocopter enjoys a much broader product line compared with the American

---

companies. It has successfully marketed aircraft models spanning the light single, light twin, and medium gross weight categories.

European helicopter companies have enjoyed several advantages over American manufacturers. The development of the European Community (EC) provides formidable economic barriers as US firms try to compete in Europe. EC community members have reciprocal purchasing agreements among the member countries, which provide EC companies with an advantage over non-European producers. Additionally, most non US helicopter producers receive some type of direct subsidy from their respective governments. This type of government support helps strengthen the European firms' competitive capabilities in the international arena as well. For some American

---

Table 4-1, Major Helicopter Manufacturers

<table>
<thead>
<tr>
<th>UNITED STATES</th>
<th>EUROPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell Helicopter</td>
<td>Augusta</td>
</tr>
<tr>
<td>Boeing / McDonnell Douglas</td>
<td>Eurocopter</td>
</tr>
<tr>
<td>Sikorsky</td>
<td>Westland</td>
</tr>
</tbody>
</table>

---

84 Jaworowski and Dane, pp.16-17.
firms, US government purchases provide the base quantity of helicopters needed to keep a competitively priced vehicles on the international market. Without these government purchases, international customers would have had to support a much larger portion of the manufacturers' overhead costs. Despite such government purchases, US firms have had to reduce profit margins to remain price competitive and gain market share internationally.

4.1.2 Market Outlook

Projected growth in delivered vehicles for the worldwide helicopter market to 2006 will be driven by the higher expected expansion of the commercial market. Over the 1997-2006 period, the total commercial helicopter market is projected at over 8,070 units, valued at roughly $19.6 billion (in FY97 dollars). In contrast, over the same period, the total military rotorcraft forecast is estimated at 4,640 units, worth roughly $49.8 billion in FY97 (U.S. dollars).

![Graph of World Helicopter Market - Total Military and Civil Units]

Figure 4-2, World Helicopter Market - Total Military and Civil Units

In 1997, the commercial sector comprised over 60% (714) of the 1,163 new units projected for delivery by the industry (See Fig. 4-2). Roughly 436 of these 714 commercial helicopters (60%),

---

85 Ibid., pp.12-18. This section is based on data and discussion derived from this source.
were of the single piston or single turbine engine variety. Due to this, new civil aircraft represented only $1.3 billion (25%) of the $5.26 billion rotorcraft market in 1997. Military helicopters, on the other hand, were dominated by the multi-engine configuration and so contributed a larger portion to the total market value of $3.96 billion in 1997, with fewer aircraft of 449 units.

Meanwhile, The commercial segment is projected to grow to 818 units (65% of the market) representing $2.1 billion (32% of the value), by 2002. This trend is expected to taper down slightly to 863 helicopters (63%) or $2.21 billion (26.2%) by 2006. The annual growth rate in the commercial sector in terms of both number of units and sales revenue is expected to be only slightly greater than for the military sector. Due to the predominance of single piston and single

![World Helicopter Market - Total Military and Civil Value of Production](image)

Figure 4-3, World Helicopter Market - Total Military and Civil Value of Production

turbine configurations in the commercial projections, the civil segment is expected to dominate total industry-wide delivered units (See Fig. 4-2). However, with almost all units composed of the multi-engine configuration, the military helicopter sector will continue to dominate the dollar value market of the industry (See Fig. 4-3).
The future optimism facing the commercial sector is largely due to the new helicopter development activities in the industry. Bell has introduced the light single 407 and is developing a twin engine 427. Bell and Boeing have launched a twin engine, six to nine passenger, civil tilt rotor aircraft, the 609. Augusta has offered an uprated twin engine A109 Power and is going to introduce a single engine variant, the A119. McDonnell Douglas (prior to the merger with Boeing) continues its effort at reworking an eight seat MD-600N. Additionally it has launched an advanced version of the MD 900 Explorer, the MD 902. Eurocopter introduced its EC135, and plans to follow through with the EC120. Sikorsky launched its S92 at the Paris Air Show in 1995, with plans for aircraft certification by the year 2000.

Industry analysts expect demand for intermediate twin-engine helicopters to increase because of low fleet inventories, aging fleet models, and regulatory pressure. In addition, some manufacturers believe that introducing new and improved rotorcraft will stimulate and increase the demand and level of sales within the commercial sector. Many of the new products are responsive to the market’s emphasis on cost-effectiveness and reliability. The importance of reducing fleet owner operating costs is evident in the design approach of several new configurations. Manufacturers are hoping that their new products will offer better value for the customer’s investment when compared with earlier products.

4.1.3 Partnerships

International cooperation in new product development has increased significantly in the aircraft industry since the late 1960s. In 1969, for fixed wing, engine and helicopter products, there were 11 primary level joint ventures or partnerships. By 1979, there were 17 such cooperative ventures and by 1990, the industry had 36 primary ventures. Overall, there was greater participation by
European firms in such arrangements. In 1990, only 9 U.S. companies were involved in these ventures compared with 33 European companies.  

One factor that inhibited the participation of US aerospace companies in international cooperative ventures has been the general worry about the degradation of the country’s defense industrial and technology base. Concerns existed over the use of foreign sourcing for defense system components, foreign investment in the US, offset sales arrangements, and technology export through international defense cooperation. Due to the politically problematic nature of equipment sales to certain countries, the US aerospace industry has had difficulty participating in some markets. The US aerospace industry has had difficulty participating in some markets. This has no doubt been a prevailing issue in the sourcing process of US aircraft companies attempting to forge commercial ventures with overseas partners.  

The primary reason for these joint ventures is the prohibitive cost that new product development places on a company. These partnerships allow firms (and nations) to share in the total R&D costs and temper the risks of market uncertainty. European collaboration has resulted in governments’ participation through commitments to purchase a certain number of a project’s vehicles. This is true for the European EH-101, NH90 and Tiger helicopter programs. The stability and volume of ‘guaranteed’ purchases reduce unit cost and make the final product more competitive in the market place.  

Joint ventures and partnerships were common in the helicopter industry. It is no wonder that HFGI engaged partners in its effort to launch a new commercial helicopter. The following are helicopter programs that were joint ventures or partnerships through 1990:

---

86 Virginia C. Lopez, The U.S. Aerospace Industry in the 1990’s, A Global Perspective (Washington DC: Aerospace Industries Association of America, Inc., 1991), p.45. The data include only ventures at the primary partnership level and exclude ventures in the avionics, materials or launch vehicle areas. The data, however, are representative of the overall industry trend.
87 Ibid. Summary and Highlights Insert, p.1.
88 Ibid., p.46.
<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>PARTNERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>P120 L Helicopter</td>
<td>Aerospatiale, France; SA, Singapore; CATIC, China</td>
</tr>
<tr>
<td>EH-101 Military Helicopter</td>
<td>Agusta, Italy; Westland, UK</td>
</tr>
<tr>
<td>Eurocopter PAH-2 HAC Military Helicopter</td>
<td>Aerospatiale, France; MBB, Germany</td>
</tr>
<tr>
<td>Eurofar Civil Helicopter</td>
<td>Aerospatiale, France; MBB, Germany; Agusta, Italy; Alenia, Italy; CASA, Spain; Westland, UK</td>
</tr>
<tr>
<td>JEH A1229 Military Helicopter</td>
<td>Agusta, Italy; CASA, Spain; Fokker, Netherlands; Westland, UK</td>
</tr>
<tr>
<td>BK-117 Civil Helicopter</td>
<td>MBB, Germany; Kawasaki, Japan</td>
</tr>
<tr>
<td>NH-90 Military Helicopter</td>
<td>Aerospatiale, France; MBB, Germany; Agusta, Italy; Fokker, Netherlands</td>
</tr>
<tr>
<td>N-442 Civil Helicopter</td>
<td>MBB, Germany; IPTN, Pakistan</td>
</tr>
</tbody>
</table>

Table 4-2, Helicopter Program Partnerships

4.2 The Firm

4.2.1 Background

HFGI is a US helicopter manufacturer with a long history in the industry. Its product line spans across intermediate, medium and heavy gross weight vehicles. Its major product is a military helicopter that has several derivatives designed around its basic architecture. Its models are widely deployed by all branches of the US military. The company also markets helicopters to the commercial segment, which are used for executive, aeromedical, search and rescue, and transport purposes. As part of a strategy to reduce its dependency on US military sales, the firm has marketed its medium and intermediate sized aircraft to international customers. As a measure of its success, its helicopters are used in nearly fifty nations. For an alternate source of revenue, the company has licensed the manufacture of several helicopter models to companies in Europe and Asia. Over its history, HFGI has produced more than 8,400 helicopters through 1997.
As indicated in the introduction and in the above industry description, HFGI had to improve its overall financial structure dealing with both the revenue and cost side of the business. Marketing its utility helicopter internationally and the development of a commercial medium lift helicopter were avenues to improve revenues. The firm's three product strategy indicated that these activities were necessary to the company's success. On the cost side, the company concentrated on the improvement of: the internal processes that drove the operational environment of the firm; and its supplier management practices. Process improvement events called 'kaizens' were instituted company wide and held by every department. These events emphasized process improvement activities that reduced the amount of flow time it took for product and information to get through the company. In addition, the firm was actively engaged in shrinking its supplier base to fewer, but selected, quality companies. These issues - supplier consolidation; improved product and information flow; reduced inventory, storage, inspection; etc.- influenced the context in which the make-buy decisions of the development program were made.

4.2.2 Opportunity - A New Medium Lift

HFGI embarked on the development of a commercial medium lift helicopter as part of a three product strategy defined in the early 1990's. In part it reflected HFGI's response to the reduction in U.S. Defense budget expenditures during that period. International partnering was consistent with the global business perspective the firm had adopted. Additionally, international risk-sharing partners reduced corporate financial exposure and would increase regional market penetration. The search for appropriate partners was cited as one of the reasons for a three-year wait to launch the program. Successful partnering was an essential part to the viability of the program.

Market studies had indicated a demand of over 5,300 medium lift helicopters of this type from the year 2000 to 2019. The vice president of the program estimated a $20 billion market, which included civil replacements and demand from international operators, as well as emerging
markets. Forecasts had found that China would require 2,000 aircraft, the Commonwealth of Independent States 600, and Europe 340 helicopters. More than 1,600 aircraft would be needed to satisfy the needs of traditional civil and international military markets. Program representatives indicated a potential market for its helicopter of at least 700. The vice president of the program was quoted as having said: "The helicopter market is going up worldwide, and the medium segment has the biggest potential." 89

The development helicopter was designed to serve a variety of commercial and international utility needs. It would be used to transport passengers (19-22 capacity) and cargo, as well as provide aeromedical, search and rescue, and resource development support. It was also designed for offshore oil and executive transport use. Other potential uses included international military/paramilitary missions such as anti-submarine warfare and law enforcement.

4.2.3 The Development Helicopter

4.2.3.1 Background

This helicopter program was a self-funded commercial venture for the firm. Due to the cost and complexity of the program, the company sought out development partners. This program sourced the design, development and manufacture of large sections of the airframe system to five international partners. In prior aircraft fielded by the company, the airframe system was considered a 'core product'. As such, it was a system designed, tooled, and built by the company for prototype and production aircraft. In this new program however, partnering reduced financial and other development risks to the company. Additionally, a large market potential was identified in the regions represented by these international partners.

Another goal of the program was the dual use of the designed dynamic component system. Based on the similarity to the firm’s existing medium lift helicopter model, the development dynamic component system was designed to be used as an upgrade to older designed models.

As mentioned above, the firm emphasized operational process improvements to reduce its costs of doing business. This environment of process improvement led to a program rule of thumb where subassemblies were delivered straight from the suppliers to final assembly staging. Back shop subassembly work, normally done by the firm, was to be reduced as much as possible. This policy was meant to reduce product flow time and minimize in-house inventory. To accomplish this goal, the company had suppliers bundle together a larger set of subassembly components. As an example the firewall, the hydraulic start motor and hoses, the pneumatic check valve, the inlet and exhaust ducts and associated hardware of the Auxiliary Power Unit (APU) subassembly, were bundled together by the supplier. With other models, the firm married these APU components in a back shop subassembly operation. In so doing, the firm was responsible for requirements management of the assembly details from their manufacture or purchase to inventory to assembly. The alternate operational practice that consolidated components into larger chunks was consistent with the final assembly ‘integrator’ view that the company had adopted.

Model Attributes 90

The development model is a medium weight helicopter with a weight empty of 14,866 lb. and a gross takeoff weight of 24,100 lb. With external loads, the gross weight increases to 26,500 lb. The vehicle has a maximum cruise speed of 155 knots and a range of 480 nautical miles at a speed of 140 knots.

The helicopter is powered by two CT7-8 turboshaft engines that meet customer demand for hot temperature, high altitude takeoff and climb performance. Each engine is rated at 2,000 shp. (takeoff and maximum continuous power), with a one engine inoperative rating of 2,350 shp. for 30 sec., 2,200 shp. for 2 min. and 2,000 shp. for 30 min. The power plants are to be equipped with a dual channel, full authority digital engine control system.

The aircraft is designed with a 733 cubic-foot interior cabin area that can carry 19 passengers seated forward in a civil configuration and twenty two passengers seated sideways in a utility configuration. The cabin can accept up to three airline-style LD-3 cargo containers. Added stowage space is available in the large 90 cubic-foot area located in the aft ramp compartment. Additionally, the civil configuration is to be fitted with crash worthy seats, a flotation system capable of Sea State 5 conditions, and large push-out type emergency windows.

The helicopter avionics system is of an open architecture and can accommodate Arinc 429 and MS 1553 interfaces. The cockpit has four liquid crystal displays. These have an engine indication and crew alert system (EICAS), a caution advisory annunciation system, navigation page, electrical system page, and built in test (BIT) functions. Primary flight displays provide attitude, navigation, altitude, airspeed, as well as engine performance data.

The vehicle has an automatic flight control system (AFCS), which features a fully coupled, dual digital autopilot with an automatic approach to hover option, and includes six solid state rate gyros. The unit includes an independent, three-axis stability augmentation system. The computer also performs flight director functions as well as provided a comprehensive preflight procedure and BIT for maintenance personnel. The flight control system includes three dual redundant hydraulic servos vertically mounted onto the main gearbox housing.

The helicopter features a four bladed, fully articulated main rotor head with elastomeric bearings. The titanium yoke type main rotor head will meet FAA/JAA damage tolerant criteria and is designed for 'infinite life'. The all-composite wide chord rotor blades have a swept, tapered anhedral tip to improve control loads, hover performance and noise characteristics. Additionally, the transmission/drive system features a compound planetary gearbox rated for up to 4,170 shp.

A key performance and marketing element is the vehicle's ability to meet FAA/JAA requirements for two-segment, Category A vertical takeoff and departure criteria. In the first segment, with the loss of one engine, the helicopter is capable of both rejecting the takeoff and landing safely, or
continuing the takeoff. A continued takeoff requires the aircraft to climb to 200 feet at a rate of 100 fps at takeoff safety speed with the landing gear deployed. The second segment requires the helicopter to achieve a 150 fps rate of climb at best climb airspeed with gear retracted to an altitude of 1000 feet, with maximum continuous power on the operative engine. This requirement specifically addressed conditions that exist when transporting passengers and equipment to oil rigs located out at sea.  

Cost Advantages

Another important selling point in addition to the features described above is that the development helicopter is designed to be less expensive to operate and maintain than other helicopters in its class. Reduced costs mean increased profits for passenger services, package express and other commercial operations. The vehicle is to be certified to FAA FAR 29 / JAA JAR 29 regulations. This, combined with its usefulness, versatility, low purchase price and attractive operating costs made the consortium confident of the success of the program.

4.2.3.2 Aircraft Configuration and Partnership

Parceling out the helicopter’s airframe structure to a set of international partners was a technical, organizational and managerial challenge to the program. In prior aircraft programs, HFGI was the sole provider of all airframe structure and subsystem components for the helicopter. As such, the partner approach was very much different from the usual company procedure. The module descriptions that follow are meant to convey the complexity of the task that the international consortium had taken on. Naturally, the integrator firm did its best to modularize the parcels to minimize the interface problems at final assembly. See Fig 4-4 for major aircraft modules.

---

91 “Article on Progress of Program,” Aviation Week, 1996.
92 Based on HFGI, Program Brochure, 1997.
The company engaged itself in a lengthy process that identified and finalized business arrangements with five partners. Partners were chosen on the following criteria: technical and manufacturing capability, quality expertise, financial stability and strategic market alignment. The company gave additional consideration to the business relationships developed with these firms on other projects. For instance, HFGI had licensed one of its helicopter models to one of the Asian partners in a prior business arrangement. The South American partner had supplied similar equipment to other helicopter models that the firm manufactured. The European partner had prior dealings with the company through one other European firm a decade earlier. Due to the complexity involved in coordinating the activities of this international consortium, prior familiarity with some of the partners improved the possibility of its success.

93 Ibid.
Major modules were defined to facilitate remote site subassembly with final assembly and integration accomplished at HFGI's manufacturing facility. These modules defined the content contributed by each partner in the manufacture of the aircraft. They included not only the airframe structure, but also a large number of components for various subsystems of the aircraft that were physically located in the modules when the aircraft was finally assembled.

From a structures viewpoint, the major modules had to define body structure groups that would meet FAA Category A and B helicopter transport and JAA Class I and II rotorcraft for public safety regulations. These modules were designed to achieve particular aerodynamic handling and stability qualities across a range of various flight conditions. Structural design criteria included: aircraft weight, flight loads, maneuver rates and landing speed. These body groups were also designed to survive certain crash load factors. The modular structures were designed to achieve an aircraft life that supported the life cycle cost requirements of the vehicle.

Integrator
HFGI was the lead firm in this helicopter development program that included an international team of aircraft design and manufacturing companies from four continents. The international team was composed of three Asian firms, one European firm and one South American firm. All of these companies had extensive experience in the aerospace industry.

Cockpit
The cockpit of the development helicopter, the subsystem case study of this thesis, supported the requirements for two pilots. It included flight controls, braking mechanisms, and electrical, avionics, and power plant controls that allowed either pilot to maneuver the aircraft. Its structure was composed of frames, beams, stringers, skins and support sub-assemblies manufactured from aluminum and composites.
The cockpit was to be manufactured by the Cockpit Supplier Company, Inc. (CSCI)\textsuperscript{94}, an aerospace firm based in Asia. It was a military oriented firm that had strong ties with its local defense forces. It was a relatively large firm for the country and employed 6,000 people. It had a history of manufacturing aircraft through licenses from U.S. firms and had designed and built its own indigenous fighter aircraft. CSCI was reported to have a 6.5% stake in the development program.

**Cabin**

The cabin of the helicopter was the section of the aircraft that interfaced with most of the major modules. The cockpit, aft transition, sponsons and main rotor pylon had surfaces, which had to mate up correctly at joining for final assembly. The cabin was an important structural element to the airframe subsystem. Its top deck supported the main dynamics subsystem, which provided lift to the helicopter. The engines, rotor head and transmission, hydraulics and flight control systems had numerous components that were mounted onto this airframe structure. Providing correctly located mounting provisions for these apparatus was a challenging task. Additionally, the cabin was the shell where passengers and material would be transported by the vehicle.

The cabin of the helicopter was the responsibility of another Asian firm that was a subsidiary of a well-diversified multinational company. The firm was established in 1920 as a subdivision of its parent company and manufactured a wide variety of commercial and military aircraft. This aircraft division employed 3,800 people. It manufactured the following aircraft under license; SH-60J anti-submarine helicopter, UH-60J search-and-rescue helicopter, F-15J/DJ strike fighter, and the F-4EJ fighter. It also produced major fuselage panels and structures for Boeing 777, 767 and 747 commercial jetliners. This partner was noted to have a 7.5% share of the development program.

**Main Rotor Pylon, Aft Transition and Interiors**

The main rotor pylon was a construction of various composite fairings, which were designed to overall aircraft FAA/JAA aerodynamic and structural criteria. Some of these fairings acted as doors and access points for top deck maintenance activities. The engine cowlings mated up with

\textsuperscript{94} CSCI is a pseudonym used in place of case study company's real name for reasons noted earlier.
the aircraft's main firewalls and as such were designed to meet fireproof requirements. Main pylon fairing assemblies had interfaces along the cockpit, cabin, aft transition and firewalls. These fairings were difficult to install while maintaining assembly profile and gap requirements.

The aft transition and tail cone was a structure composed of frames, beams, longerons, access panels, ribs, fittings and fairings. These were manufactured from aluminum and composite material and sub-assembled together to mate with the cabin and tail rotor pylon. This section included a hydraulically powered ramp and a baggage area. It had mounting provisions for the tail drive system, several antennas, gyros, sensors, emergency lights, ramp control, and electrical harnesses. Hydraulic tubing, control cables and mounts that were part of the tail rotor control system were also included in this installation.

The aircraft provided an optional utility or civil interior. The utility interior was of a soft blanket type and needed to satisfy internal noise levels given certain flight conditions. The civil interior was composed of easily removable interior hard panels that acted as the cabin sidewalls, ceiling and forward and aft bulkheads. It also used acoustic treatment in order to satisfy a stricter set of noise level requirements. Overhead units for environmental control ducting and electrical wiring, as well as cabin, emergency and passenger reading lighting were also part of the interior.

The main rotor pylon, aft transition and interiors of the aircraft were designed and delivered by a subdivision of a large industrial European outfit. This company had product that spanned the fields of aeronautics, automotive, energy, and industrial services. The aerospace division was originally founded as an independent company. Two levels of holding companies, which are involved in the banking and the electric utility generation industries of its base country held a majority of its equity. The company employs 2,500 people, of which approximately 850 work for the aerospace division. The company manufactured wing structures for the Embraer RJ-145 commuter aircraft, fuel cells and control surfaces for the Airbus A-300 and 310 jets, fuselage for the Astra SP and SPX mid-sized commuter jets and boat hulls for racing yachts. The European partner reportedly had a 7% portion of the program.
Sponsons and Fuel System

The sponsons were constructed of composite and aluminum and housed the aircraft’s fuel cells and main landing gear. The fuel system consisted of fuel tanks, a fuel quantity gauging system, a gravity fill system, a pressure fill system and a suction fuel feed. The sponson and fuel systems were designed to meet FAR/JAR crash resistant requirements.

A South American partner that had extensive experience in the fixed wing part of the industry delivered the sponsons and fuel system. It was formed in 1969 and privatized in 1974. It employed over 3,900 personnel. It was a leading aerospace company in the region and produced turboprop and jet aircraft that were exported worldwide. It possessed up-to-date plant and equipment, such as a sophisticated machine shop and facilities for composite component fabrication. The company had delivered over 5,000 aircraft since its founding. Among its most successful models were a 19 passenger, twin-turboprop regional/commuter and military transport; and a 30-passenger, twin-turboprop commuter. Its newest product was a 50-seat regional twin jet, considered to be the most advanced and profitable regional jet in the commuter market. It was also developing a 37 passenger derivative of this model. This firm had a 4% share of the program.

Tail Rotor Pylon and Horizontal Stabilizer

The tail rotor pylon was a sheet metal aluminum structure with several Kevlar fairings. It included a primary airframe structure made up of aft and forward aluminum spar build-ups. The assembly had mounting accommodations for dynamic component gearboxes and the stabilizer. Hydraulic tubing, pulleys, brackets and cables for tail rotor control were included. In addition, anti-collision and tail position lighting and their corresponding wiring harnesses were also provided. The horizontal stabilizer was of aluminum and composite construction. It was mounted on the left side of the tail rotor pylon and supported by a composite strut.

The tail rotor pylon and horizontal stabilizer were delivered by a third Asian company that was a consortium of three entities. The base company was specifically formed to conduct activities related to the helicopter development program. The first of the consortium companies was responsible for the manufacturing work and had 7,000 employees. A second company would
provide the engineering support and the third company was responsible for export administration. The consortiums manufacturing arm was formed in 1969, and manufactured an indigenously designed helicopter. It was also engaged in the high-volume production of mini-vans and passenger buses. The design firm of the group was the nations foremost research institute in helicopter dynamics. This partner reportedly held 2% of the project.

**Major Suppliers**

A change in business approach was also necessary for suppliers of major components. Suppliers of items such as: main rotor servos, the aircraft cockpit and cabin heating system, cooling fans, etc., were approached to share in the development risk. Many large suppliers participated by supporting the design, manufacture and test of their components for the development program without up front payment by HFGI. The supplier’s development costs were amortized across the production requirements for future aircraft. In some cases where an international partner would install hardware that was part of a larger subsystem procured from a supplier, HFGI negotiated terms and pricing that were applied to the partner purchase requirements of these items.

**4.3 Chapter Summary**

A review of the helicopter industry and the firm indicated that HFGI, a manufacturer of medium multi-engine turbine helicopters, would have to be in both the military and commercial segments of the market. The military segment represented the larger market segment in terms of dollar value. HFGI maintained two products that were directed to military type customers, and specifically the US military. The commercial segment represented an area with slightly greater market growth and specific opportunities for HFGI to introduce a new commercial medium lift helicopter.

HFGI’s product strategy appeared consistent with industry opportunities. It’s need for partners to reduce development program risk and it’s move towards penetrating the global market, led HFGI to lead a six firm international consortium in developing a new medium lift helicopter. The
selection criteria of international partners included: technical and manufacturing capability, quality expertise, financial stability, strategic market alignment, and historical dealings with the firm.

As a group, the partners were reported to have contributed at least 27% to the development cost of the aircraft. Not only did partnering reduce the program funding requirement for HFGI, it also alleviated the integrator firm from having to manage the numerous manufacturing and procurement tasks associated with the airframe subsystems that were outsourced.

HFGI decided to buy airframe subsystems for this development helicopter program. It capitalized on the modularized structure of the model’s airframe and parceled out its design and manufacture to the international partners. Traditionally, airframe was considered a ‘core product’ sourced make on other helicopter models manufactured by the firm. Components for aircraft subsystems that were located within these modules were included in this outsource effort. The management of the organizational and technical complexities that resulted from this effort was substantial.

Programs directed at improving the operational activities of the firm influenced the work content assigned to the partners and the higher tiered suppliers. An emphasis on reductions in product flow time and inventory increased the outsourcing of subassembly work.

---

CHAPTER 5 - CASE STUDY

5. Case Study

This chapter reviews the decision to outsource the cockpit of the development helicopter. When viewed from the level of the industry and the firm, the partnership arrangement used to develop a new helicopter model was consistent with the firm's global low cost strategy to compete. The firm's make-buy decision process for new products was reviewed in relation to program implementation. In addition, two frameworks based on the core competency point of view are used to review the cockpit decision. The Make vs. Buy Decision Matrix of the 3-D Concurrent Engineering framework was used to review the consistency of this decision with the knowledge and capacity needs of the firm. The Technological Maturity and Competitiveness (TM&C) framework was applied at a more granular level, with a decomposition of the cockpit into major sub-components.
5.1 Partnership Background - Cockpit

Outsourced airframe modules, a result of industry precedence

The outsource of the cockpit was part of a firm level strategic decision that used international partnering as an arrangement to develop a new model helicopter. As described in prior sections of this thesis, the engineering, design, and manufacture of modular airframe sections was sourced to five international partners. This approach was different from other development projects by the firm which were funded by its primary customer, the U.S. military.

The development program, being commercial, was self-funded and required corporate approval for it to proceed. With its large development cost, corporate approval was not achievable without alternate sources of capital. Partnering, as exemplified in chapter four, was common practice in the aerospace industry. Consistent with industry examples, partnering in this program would reduce schedule, financial and other development risk. Additionally, partnering provided an entry point to the perceived market potential of the regions represented by the international partners. This aspect was important as industry competition continued to center around the developing markets that were not dominated by either European or American manufacturers. The international partnering arrangement facilitated program approval at the corporate level. As discussed in prior sections, this commercial helicopter program was integral to a product strategy that diversified the firm’s sources of revenue. Strategic considerations at the industry and firm level were instrumental in the company’s make-buy decision towards partnering on an international scale.

Matching product and firm capabilities

With a partnering arrangement necessary, HFGI had to determine what portion of the aircraft would be sourced to the partners. In the company’s make-buy matrix, the airframe structure, as well as numerous other subsystem assemblies, was earlier designed and built within the firm. The entire dynamics system, inclusive of blades, rotors, and transmissions, was considered a core product that significantly contributed to the firms revenue through spares orders, and would be kept in-house. Avionics and automatic flight control systems (AFCS) were high-value subsystems.
whose technology needed to be kept within the firm. Major propulsion items, such as engines and the APU, needed to be specified and controlled by the company. When compared to these items, airframe was considered the likely subsystem to outsource. In addition to airframe, the main rotor pylon, interiors and the fuel system were also outsourced to the partners.

Another consideration in this decision were the capabilities and preferences of the partners. For instance, one of the Asian firms was a major supplier of airframe structure to Boeing. Manufacturing the cabin for this helicopter program fit well with this companies goal to be a world provider of airframe subassemblies to the international aerospace industry. As mentioned above, the South American partner had prior experience with providing fuel components to the company. Sourcing the sponson and fuel system to this firm was believed to be a good match. The European partner had worked with the firm on composite structures several years earlier. The main rotor pylon and aft transition represented a good fit to this firms capabilities. The tail rotor pylon and horizontal stabilizer structure provided a good match to the capabilities of its partner firm. Finally, with the cockpit, CSCI's experience with a co-production program on the UH-1 indicated a capability of dealing with the complexity of helicopter cockpits.

Review of Design and Manufacturing
As the integrator firm, HFGI expended a great deal of effort at reviewing the design and manufacturing approaches taken by the partners. With constant communication and in-country representatives, HFGI maintained an understanding of the many issues involved in the design and development of these modules despite the distant location of the partners. An advantage in this situation was the understanding on the part of the firm's engineers of the baseline design that was the basis of the work being done by the partners.

In the initial stages of the program, HFGI had spent a great deal of preliminary design effort in defining the form and function of the helicopter. As a starting baseline, HFGI provided the partners with initial design concepts derived from this preliminary design effort. Initial concepts documented through interface control drawings, identified and controlled critical interface points and defined component locations. The program used an "International Wide Area Network" via
satellite to share 2D and 3D electronic information with the partners. Subsystems were appropriately divided up to fit within the interface areas consistent with partner airframe modules. The international partners were tasked with the completion of various analytical and design work that dealt with the design and manufacturing issues associated with their respective modules. These analyses were reviewed by HFGI’s functional specialists as a part of the design acceptance process. Such checks were considered part of the integrator’s responsibility at maintaining the design integrity of the aircraft.

From the integrator standpoint, the modular airframe design had to accommodate HFGI’s manufacturing needs at final assembly. A program goal was to develop a “bolt together” final assembly process. In order to meet this goal, precision aircraft sections and components were essential. Additionally, interchangeable and repeatable manufactured parts and processes were necessary. Partners had to maintain precise control of interfaces between aircraft sections, as well as, component location for system installations. In order to achieve this program goal, the consortium committed to the use of production-capable tooling during the development phase. The companies used the 3D electronic design data to design and develop its tooling. Where necessary, partners were provided the manufacturing technologies and training to support this manufacturing plan. The use of state-of-the-art tooling and manufacturing processes at the partner sites was integral to the success of this manufacturing strategy.

5.1.1 Product and Partner Description

Cockpit Description
The cockpit was to support the physical requirement to seat two pilots engaged in the operation of the helicopter. This structure included flight controls, braking mechanisms, and electrical, avionics, and power plant controls that allowed either pilot to maneuver the aircraft. The airframe was made of frames, beams, stringers, skins and support sub-assemblies manufactured from aluminum and composites. It also included hydraulic tubing and electrical harnesses required to
support baseline and optional equipment. Attached to this structure were the windshields, overhead windows and emergency exit side windows. The assembled structure mated up with the cabin and the main rotor pylon.

The cockpit included components that interfaced with several subsystems on the aircraft. There were provisions for a retractable nose landing gear assembly inclusive of hydraulic tubes and harness connections. Mechanical flight control components that connect to cyclic and collective sticks in the interior and the mixer control rods on the top deck were to be supplied. The instrument, circuit breaker and avionics panels with their corresponding support mount structures were also included. The cockpit electrical harnesses, which were the conduit for power and signal connections to various sub-systems in the aircraft, were to be installed at the partner's facility. A number of these harnesses were routed to several large connectors located at the aircraft's interface station line to facilitate easy hook-up with the mating harnesses from the cabin.

Company Description 96

The Cockpit was provided by CSCI, an Asian based aerospace company that was established in 1969. It was considered a leading regional manufacturer of aircraft, aircraft engines and avionics. It employed 6,000 people and had strong ties to its national defense structure. The firm developed its own Indigenous Defense Fighter (IDF), the AT-3. It was also involved in a number of coproduction projects: the F-5 E/F jet fighter, the T-53 turbofan engine (Allied), and the UH-1H helicopter (Bell). It had manufacturing capabilities in sheet metal, machining, composites and assembly. The firm was qualified to ISO 9000 and ISO 9002. In addition, HFGI had done business with the national government of CSCI. Early in the 1990s, HFGI sold medium lift helicopters to several branches of this country's defense forces. Given its design and manufacturing capabilities; its experience with the UH-1H helicopter co-production; and the prior sales to its government, CSCI met the criteria that were needed in a partner.

Partner Deliverables

The structural and subsystem assemblies required from CSCI were jointly reviewed and were generally kept within the firm's technical and manufacturing capabilities. In specific cases, manufacturing capabilities were transferred to the firm in order for it to deliver airframe structure. As part of its statement of work, a major portion of the cockpit design was to be completed by CSCI. Part of this work was subject to conceptual constraints as laid out by the preliminary design work done earlier in the program. In addition, there was a set of detail designs controlled and specified by HFGI, of which CSCI was responsible to supply hardware. This set included subsystem components installed across the aircraft structure that needed tight specification control for proper system integration. Some examples of integrator controlled sub-systems were the - heat and ventilation system, avionics cooling, pedal adjust assemblies for mechanical flight control, aircraft environmental sensors, exterior and interior lighting, cockpit instrumentation, and various avionics box mounts.

The partner was also responsible for manufacturing consistent and interchangeable tight tolerance assemblies. It had to maintain critical interfaces for: seat tracks, avionics racks, landing gear support, windows, and control rod fittings. Most importantly, mounting locations at the cockpits major manufacturing break to the cabin had to be held to tight tolerances.

5.1.2 Cockpit Structure

Structural Approach ⁷⁷

The conceptual approach to the cockpit airframe structure was developed by HFGI during the programs' preliminary design phase. This approach was made a requirement for the partner to implement. In this way, the cockpit structural design was more a result of HFGI's own efforts

⁷⁷ Based on unpublished Manufacturing Engineering correspondence (HFGI, 1994).
Figure 5-1, Cockpit Structural Components

and not of the partners. The design was a ‘four piece’ cockpit consisting of - (1) an all graphite canopy; (2) & (3) two built up sheet metal structures that provided the modules lower support, and (4) an aft structure assembly composed of monolithic machined station frames assembled to sheet metal components and skins. See Fig. 5-1 for a view of this structure.

The partner responsible for this structure did not have the complete array of manufacturing capabilities necessary to produce this design. HFGI transferred manufacturing technology to the partner firm to address this gap in capability. The canopy construction used 3D ply data design
and manufacturing techniques developed in another helicopter program by HFGI. The technique used a single mold for graphite skin and skeleton composite manufacturing. Although familiar with composite structure, CSCI was not acquainted with this particular manufacturing process.

The monolithic machined frames at the aft structure replaced the traditional sheet metal station frames of a skin and stringer construction. This design approach was meant to capitalize on the high speed machining of blocks of aluminum into airframe structure. High speed machining was not, as yet, a fully developed method of manufacturing. Several large fixed wing companies were reportedly experimenting with this technology. HFGI's main source of information was the corporate research and development group that was investigating and experimenting with this technology. Even with conventional machining, however, both partners agreed that the cost and weight benefits of this approach outweighed the sheet metal build up method. The design criteria for these machined frames were worked out by HFGI and transferred to the partner.

Alternate Structural Approach

An alternate cockpit design that would not have required a transfer of manufacturing technology was the concept used in the firm's existing utility helicopters. This approach would have capitalized on a proven design, and allowed the partner firm to use its existing set of design and manufacturing capabilities.

The cockpit design for several utility helicopter models manufactured by the firm shared the same approach (see Fig. 5-2). In this design, a three-piece canopy was mated to a lower assembly structure. The canopy sub-assembly was composed of a sheet metal assembly, a machined structure and a composite nose. These items were bonded and riveted together into a single subassembly unit, which was then assembled onto the lower structure. The lower structure was composed of sheet metal stringers, angles, doublers, skins, and machined fittings that were

---

98 Ibid.
separately manufactured in a back shop or purchased from a supplier. These items were used to put together a series of small subassemblies. These subassemblies where then assembled, held together, and riveted in a large assembly fixture. The final subassembly fixture mated the lower and aft build up structures. This common design approach facilitated a manufacturing process that capitalized on the same or very similar tooling and manufacturing methods used by the derivative helicopter models. The development helicopter’s cockpit, although very similar in outward appearance to prior models, represented a departure from this design.
5.1.3 Additional Subsystem Components

Installation
Another difference in the manufacturing approach of the cockpit, was the timing of the installation of subassembly details that would be mounted into the structure. A helicopter model’s mission requirements may call out avionics, environmental control, and mission equipment which need specific mounting racks, control panels and harnesses. These different subcomponents can make the cockpit layouts different between models. Usually, the differences in model configuration were accommodated in the subassembly and final assembly build-up of the aircraft. The current manufacturing process ‘stuffed’ the aircraft with subsystem components at final assembly, after the major structural components of the vehicle were joined. For the development helicopter, the ‘modular’ approach had subsystem components installed earlier in the manufacturing flow, prior to final assembly build-up. Partner parts which needed to be installed later in the final assembly stage due to installation interference problems were placed in kits and shipped with the larger assembly.

Operational Considerations
This modular approach reduced HFGI’s operational activities, since responsibilities for the management of the detail design and manufacture of the Cockpit was transferred to the partner. Despite the large amount of information that had been developed by HFGI in preliminary design, a great deal of effort remained for the partner to complete.

From a manufacturing and purchasing viewpoint, there was a significant reduction in HFGI’s responsibilities. Numerous purchase requests, purchase orders, and manufacturing work orders did not need to be placed. Inventory, inspection and storage requirements at HFGI’s facility were reduced. There was, however, an increase in the coordination provided by the support functions to monitor partner deliverables.

The above situation had positive implications on product flow and the inventory levels for HFGI in a production environment. As discussed in Chapter four, operational process improvement
activities had become commonplace at the firm. The partners represented manufacturing resources that could supply major components of the helicopter in a parallel flow. Additionally, the inventory cost of these major assemblies was held by the partner firms until their module was delivered to the final assembly facility. This situation would reduce the overall inventory levels of HFGI, and eventually, would improve its inventory turn rate. The more subassembly work that could be provided by the partners, the better the flow and inventory picture became for the integrator firm.

As described above, the partner was also responsible for the procurement and installation of several components whose sources were determined by the integrator firm. Technical control over the component specifications and supplier choices in these cases was necessary for the successful integration of these sub-systems across the aircraft. Some examples of integrator-controlled sub-systems were: the heat and ventilation system; avionics cooling; pedal adjust assemblies; aircraft environmental sensors; exterior and interior lighting; cockpit instrumentation; and various avionics box mounts.

5.2 Company Make-Buy Process

The documented make-buy decision process of the firm was a procedure implemented by the Manufacturing Engineering Department (ME). The ME business process indicated that the department was to “control and coordinate all manufacturing source selection and source change activity as well as all make-buy decisions and changes, .. in response to New Business initiatives”.

The firm intended that the make-buy decision process reflect existing and future business objectives. Consistency between make-buy decisions and the strategic posture of the firm would be reflected by the senior management body that was charged with these decisions.

---

5.2.1 Division Level Make-Buy Matrix

HFGI’s approach towards make-buy decisions was product or ‘core business’ oriented. The firm had a policy to maintain a division level make-buy matrix, which documented the source guidelines for major aircraft subsystems and their corresponding components. In addition, make-buy matrices at the program level reflected any exceptional circumstances specific to the program.

A Management Make-Buy Committee (MMBC) developed the division wide and program specific source guidelines. The MMBC was a senior level management team that included the: Director of ME (Chair), Program Manager, Division Controller, Small Business Liaison Officer, Director of Industrial Engineering, and the Vice Presidents of Engineering, Material and Programs.

The MMBC reviewed several key factors to determine the source guidelines for subsystems and components. It examined how highly leveraged an item was across several products and also considered the availability of in-house capabilities in making these guideline determinations. Other key review factors included: the component’s effect on product performance advantage; the item’s dollar value and future spares potential; and if the item was schedule pacing to product delivery. In addition, it considered whether an item was an existing core business of the firm and if it was a high technology proprietary item. Secondary factors considered in this make-buy planning were: effective capital resource utilization; the maintenance of a stable work force; and the maintenance of a strong and flexible subcontractor structure.

The Division Level make-buy matrix included nearly 250 items that covered all the major subsystem components of the helicopter. Each item was reviewed against the criteria described above. In addition each item was assessed regarding the firm’s capability in: engineering design, manufacturing engineering, testing facilities and the production of details and/or subsystem assemblies. These assessments were indicated on the matrix and supported the individual make-buy decisions.
5.2.2 Program Specific Make-Buy Matrix

Description of Program Make-Buy Process
A program make-buy matrix was required to be generated when a new business opportunity arose. It was the responsibility of the Program Manager to initiate a program make-buy plan during the proposal stage of a project. The make-buy structure for the program was determined by the Program Make-Buy Team (PMBT), headed by the Program Manufacturing Engineering Manager (PMEM).

The PMBT was a mid-level management team headed by the PMEM and composed of the: Program Engineering Manager, Operations Center Manager(s), Purchasing Manager, Manager of Financial Operations, Product Integrity, Industrial Engineering Manager, and others necessary to assist in the make-buy decision. The PMBT’s composition was representative of the MMBC except at a lower level in the management hierarchy. These representatives were closer to the specifics of a given program, and were in a position to articulate particular make-buy needs not immediately apparent to higher levels of management.

Using the division product matrix and criteria defined by the firm’s business policy procedure, the PMBT recommended a program make-buy plan. If the plan was consistent with the existing Division matrix, the program matrix was implemented into the system. If the recommended plan was different than the Division matrix, it was presented to the MMBC for approval. If the plan was not approved, the PMBT was reconvened to further evaluate its recommendations.

In the unlikely event that the Program and the MMBC were not able to come to closure, the Program recommendation was elevated to a senior level Arbitration Board consisting of the: Vice President(s) of Manufacturing, the Vice President of Material, the Vice President of Finance and the Director of Manufacturing Engineering. This arbitration board would review the rejected plan and decide the best course of action for the firm.
Figure 5-3, Program Level Make-Buy Process

Development Helicopter Program Make-Buy Decision

As discussed earlier in the chapter, an international partnering arrangement was necessary for corporate approval of the program. This corporate interface necessarily involved the Chief Executive Officer of the company. The funding required by the program elevated the make-buy discussion to the most senior levels of the firm. The senior executives, realized the impact that this program had internally and were in the Arbitration Committee mode even prior to the official make-buy procedure. This senior level sensitivity provided early review of the strategic issues at the company level. The approval process described above was implemented as a formality, but only after the salient discussions and decisions were made at the Management Council level of the firm. It was at this higher level that the appropriate VP’s of Manufacturing, Material and Engineering could develop a partnering strategy that fit within the capabilities of the organization.
With the exception of airframe structure, the similarity in product architecture between HFGI's primary utility helicopter and the development commercial vehicle, resulted in a make-buy plan that was very similar for both programs. Even for the development program, airframe structures were classified as 'core products' and were sourced make-or-buy at the detail and subassembly levels.

5.2.3 Current Sourcing - A Result of Prior Decisions

Effect of aerospace industry on the helicopter industry
Another structural element for source decisions was the historical development of make/buy decisions in the fixed wing segment of the aerospace industry. Source decisions for subsystems and components were determined by the number and capabilities of the companies represented in the supplier base. Historically, the helicopter industry had benefited from the technical developments in the fixed wing sector. For instance improvements in: engines, landing gear, auxiliary power units, hydraulic systems, avionics etc., were driven by the needs of the fixed wing community. Over time, the supplier base for many subsystem components were defined and developed. The helicopter industry used this established base for product variants to existing dominant designs, modified to address helicopter requirements. Just as the fixed wing community found it beneficial to out source the design and manufacturing of these components to its supplier base, so did the helicopter industry.

Prior decisions determine present choices

Capital Investment
The make-buy structure for this program was an historical result of make-buy choices by the company for prior programs. This structure was greatly influenced by the manufacturing and assembly capabilities in which the firm had decided to invest. For instance, capital investments in gear cutting, gear grinding, heat treat and carburizing equipment supported the manufacture of transmission gears. The firm's machine shop was updated with state-of-the-art machining centers
that were tooled to manufacture rotor head and transmission details. The blade shop had product-specific machinery that supported the manufacture of the metal and composite parts of the blade. As detailed above, there was a propensity to invest in asset-specific equipment for dynamic components. As a result, gears, transmission details, rotor head parts and blades were all made internally (although, in some capacity-related instances, the end result was both make-and-buy).

Machined airframe structure was originally manufactured in the firm’s machining shop. Its source designation however, was make-and-buy. As demand for the dominant utility model increased in the late 1980s and early 1990s, these frames were gradually bought from suppliers. This trend of buying machined frames reflected the firm’s changing machining focus on making dynamic components at the expense of airframe parts.

Given that machined airframe parts were basically buy items, outsourcing airframe modules to the partners had less of an impact on the firm. The shops that encountered a reduction in work due to the partnering arrangement were the sheet metal and subassembly shops. Both of these areas had less capital equipment overhead. Additionally, given the configuration differences in vehicles, fixtures and tooling for existing product would not be easily transferable in these areas. Major and final assembly had less work due to the “bolt together” approach and the “stuffing” of modules prior to joining them.

Note that the specific assets, which can drive make-buy decisions, were not necessarily manufacturing assets. HFGI had a great deal invested in the testing capability of various aspects of the aircraft. Due to the critical role that safety plays in this industry, comprehensive-testing capabilities were considered important. Keeping manufactured and purchased parts within the control of the firm instead of offloading such responsibilities to the partner, helped maintain the firm’s testing capability.

Supplier Base

The current supplier network of the firm also resulted from prior make-buy decisions on other programs. Many of the major suppliers solicited for subsystem components on the development
program were on the approved supplier list of the firm. As discussed in chapter four, the company’s efforts at shrinking its supplier base led to a pool of quality firms to do business with. In some cases, negotiations with suppliers regarding the development program were coupled with negotiations for components of current production programs. So, the context of source supplier selection had to be reviewed from an overall company level and not just the specific program level.

**Structure and Frequency of Updates**

Due to the infrequency of new product introduction, subsystem make-buy decisions were just as sporadic. Many of the helicopter design programs during the 1980s and 1990s were derivative models based on the product architecture of the firm’s dominant medium lift utility helicopter. As such, the make-buy choices on these programs were generally in line with division make-buy guidelines.

The production phase of this successful medium lift helicopter in the early 1980s set the structure of the Division Make-Buy Matrix for helicopter models of this type. In production, the company had invested in capital equipment, tooling, and fixtures which defined much of the make-buy structure in manufacturing derivatives of this model. Changes in the matrix normally reflected a change of make parts to a make-and-buy designation. These revisions were made to address short-term capacity limitations. It should be noted that on this development program most of the make-buy choices, other than the partner choice for airframe structure, were well aligned with the firm’s existing make-buy structure.

### 5.3 Frameworks Applied to the Cockpit Module

Two make-buy frameworks were used to explore issues related to the ‘buy’ decision of the cockpit. The Make vs. Buy Decision Matrix of the 3-D Concurrent Engineering framework was used to review the consistency of this decision with the knowledge and capacity needs of the firm. The Technological Maturity and Competitiveness (TM&C) framework was applied at a more
granular level. For this review the cockpit assembly was decomposed into major sub-components and then examined using the TM&E framework. This examination suggests important implications for the firm's core competencies, which result from the 'buy' nature of the cockpit assembly.

5.3.1 3-D Concurrent Engineering Make vs Buy Decision Analysis Matrix, Applied

The 3-D CE Make versus Buy Decision Analysis Matrix was used to review the 'buy' decision of the cockpit assembly. For HFGI, the cockpit assembly, as well as the other airframe modules, were outsourced due to development funding constraints, risk mitigation, and marketing considerations. Industry characteristics and firm specific strategic issues drove such motivation. The 3-D CE framework does not accommodate the specific assessment of such reasons.

The modularity presented in this discussion is specific to the architecture implemented on the development helicopter. This example was not a good parallel to industries where modular components are used across different products. For example, unlike a Pentium II chip, the cockpit for this development helicopter could not be used on the NH 90 nor on the EH 101. Neither could this cockpit be used on any of HFGI's other helicopter models.

Product and Supply Chain Architecture
The examination looked at the aggregate cockpit module that was outsourced. As discussed in chapter four, cockpit modularity resulted from a company and program strategy where five international partners supplied the helicopter airframe subsystem. The development of product system architecture with clean modular interfaces was a goal of the development process.

HFGI's preference to split aircraft content into airframe and dynamics was exhibited in prior experiences with international co-production programs. Here, the overseas co-producer firm supplied the airframe structure and managed aircraft integration, while HFGI supplied the dynamic components. The same airframe / dynamic component split was used for this program.
The new model's design was patterned after HFGI's successful utility helicopter, which had a modular airframe architecture. This architecture supported the firm's manufacturing sequence at the final assembly area. The development program capitalized on this modularity and defined airframe subsystems that were parceled out to the international partners. Team reviews of the new design facilitated even cleaner interface breaks than on prior models.

This example mapped nicely with Fine's FAT 3-D CE framework presented in Chapter Three. This framework suggested that product and supply chain architectures be aligned according to the integral or modular nature of the product design. In this case, the modular airframe architecture of the development helicopter matched the supply chain architecture represented by the international partners.

It must be noted, however, that not all components included in the partner deliverables were modular. Several of these were parts of larger subsystems that needed adjustment to other components during the integration effort at final assembly. An example of this was mechanical flight control apparatus related to pedals and control sticks. The partners also shipped some components as kits. These parts were included in the airframe module, but were better installed later in the aircraft's assembly to minimize interference. From a high level perspective, the complexity of system integration may appear deceptively simple. Decomposing the module deliverables into its components gives a better indication of system integration complexity.

**Assignment on the Matrix**

The outsourcing of the cockpit assembly was consistent with the upper right-hand corner of the Make vs. Buy matrix. As discussed in chapter three, this corner represented the best situation for a firm to outsource. In the cockpit assembly case, HFGI understood the product from a design and process point of view. It had specified the basic design approach which the partner firm implemented. Its "bolt together" assembly approach required it to understand how the cockpit assembly would integrate with the rest of the airframe modules. In addition, subsystem
integration was facilitated by HFGI's control of relevant sub-component specifications. In this cockpit assembly case, the partner was more reliant on the integrator company for knowledge. See Figure 5-4 for the classification of the Cockpit Assembly on the Make versus Buy matrix.

![Figure 5-4, The Make vs. Buy Decision Analysis Matrix, Applied to the Cockpit Assembly](image)

The clock speed and industry competitiveness of the suppliers indicated a moderate strategic risk. Only a few suppliers capable of delivering such modules in this slow moving airframe industry. In addition, its control over specific tools, fixtures and manufacturing processes made CSCI the only
supplier of the cockpit module. This situation was true for all the modules provided by the international partners. Although the necessary capital assets and knowledge were reproducible at other sites (certainly by HFGI), extensive cost and schedule repercussions would result from a partner decision to stop participation in the program. The risk and revenue sharing approach implemented by the program was meant to mitigate the risk of such non-participation. All parties were meant to have a stake in the risks and rewards of producing a low cost, affordable helicopter for the commercial marketplace.

**Issue of Knowledge Retention**

The outsourcing of airframe modules raised the issue of whether HFGI had started down a path of dependency for knowledge in airframe design, manufacturing, and supplier sourcing. What prevented the firm from losing important information regarding airframe structure competencies?

HFGI’s personnel had extensive experience and knowledge of airframe design and manufacturing. Much of the conceptual design and basic data for the development helicopter originated from its activities. The partners were tasked with accomplishing detail design and analytical work within the constraints defined by HFGI. As mentioned before, personnel at the integrator firm constantly reviewed partner designs and kept abreast of the specific issues faced by the partners. Much of this interface was facilitated through the exchange of electronic data, and video and telephone conferences. For this project constant communication with the partners helped maintain the firm’s specific knowledge about this airframe design.

In addition, the company was involved in other programs that applied its capabilities at airframe design and manufacture. For instance, the skills necessary in the design and manufacture of composite structure was exercised in the reconnaissance helicopter development program for the Army. Production of derivative utility helicopters helped maintain the firm’s expertise with sheet metal structural assemblies. The company’s three-product strategy allowed for the maintenance of knowledge in a variety of areas.
5.3.2 Technological Maturity and Competitiveness Framework, Applied

The Technological Maturity and Competitiveness (TM&C) framework was used to review the sub-components of the cockpit assembly. The item’s position on the matrix was determined from the core competence viewpoint of HFG1. The make-buy decision indicated by the item’s position in the matrix was compared for consistency to the overall ‘buy’ nature of the cockpit assembly. As described above, the cockpit’s major components were: airframe structural components, mechanical flight control fittings, various avionics mounting supports, electrical panel assemblies, control panel assemblies, circuit breaker panel assemblies, specification controlled components, hydraulic tubing and electrical harnesses.

Framework Inputs

Figure 5-5 indicates the make-buy position of the various cockpit components using the TM&C framework. Note that primary structural airframe components were decomposed into the: composite canopy; high speed machined frames at the aft structure; and the subassembly build up of structure. Several items were combined together for easier representation on the matrix. This was the case for several types of panel assemblies and the aggregated category of specification controlled parts.

The assessment of whether an item represented a company core competency was not a clear exercise. With one exception, the assessment was based on the identification of the component as a ‘core or key product’ on the Division and Program Make-Buy Matrices of the firm. The difficulty with this approach was the predominant classification of items as ‘core’ on the matrix, given that the firm had the capital assets to manufacture them. The underlying logic - if we had been making it, then it must be core - was apparent from the assignments on the matrices. This perspective was not surprising. As mentioned earlier in the chapter, the basic structure of the
division make-buy matrix was set by decisions made twelve to fifteen years ago in support of the production phase of the firm's primary utility helicopter product. From discussions with several Manufacturing Engineering managers, the Division Product Make-Buy matrix had probably remained the same over the past decade.
Leaders in Use, Development

Assessing the competitive position of the firm for the listed items was also problematic. Some of the items were clear-cut. For instance, the design and manufacturing approach for the composite canopy was based on Invar and semi rigid fluoroelastomeric tooling combined with electronic ply development and NC trim and drill methodologies. This process was developed on another development program of the company and considered on the leading edge of production composite technology. Although an airframe type of technology, its pace of advance was relatively rapid when compared to sheet metal technologies.

HFGI's sheet metal detail fabrication capabilities had been brought to the leading edge with investments in capital equipment such as: advanced rubber forming presses; improved heat treat and laser marking facilities; and a high speed NC machining center for extrusions. The manufacturing load for sheet metal work, however, was being reduced. As described in prior sections, the demand for sheet metal work in the utility helicopter market was low. The joint development helicopter for the Army was based on composite airframe technology, not sheet metal. Further, the decision to outsource airframe modules to the partners on the commercial development program leads to the inference that sheet metal was not regarded a core competency of the firm. Unless other new development programs would require sheet metal type technology, the future of retaining this manufacturing capability in-house was questionable.

The other items classified as make-and-buy in the mature, slowly evolving, "leader-in-use" category were: subassembly buildup, machined fittings, electrical harnesses, electrical panels, and hydraulic lines. Three of these had leading edge-manufacturing technologies that had been adopted by the company. Small-machined fittings with airframe or flight control applications were produced on a Flexible Machining System (FMS) in the machining center. Automatic wire cutting and bundling machinery that used design engineering electronic data as a source supported harness manufacturing. Hydraulic line manufacturing was supported by an NC tube bending system and an automated orbital welding system.
Subassembly build-up capabilities were reliant on specific fixtures and tooling that were designed for particular models. The various electrical type panel assemblies were also specific to helicopter models. A great deal of knowledge was resident in the experience of the assemblers that supported these areas. From the highly integral nature of this work, the firm could be considered as leading the field.

For all items in the “leaders-in-use” category, HFGI was well-staffed with capable design and manufacturing engineers. As indicated earlier, a considerable amount of design and manufacturing process planning work had been done on the cockpit prior to turning responsibilities over to the partner. The company’s engineering staff was instrumental in defining the cockpit configuration. Thus, HFGI was well versed in the design and manufacturing nuances of the cockpit. From a design and process point of view, HFGI was a leader in use and development. Airframe design, in this case, was supported by a core competence within the company.

**Behind Leader in Use, Development**

Specification-controlled components were sourced to companies that were much more capable at their design and manufacture than HFGI. Although the firm’s engineering staff defined the requirements for these components, their functional capabilities were restricted to what was being marketed by the supplier base. In these cases, HFGI was dependent on the component suppliers for both knowledge and parts. It should be noted that the specification-controlled items to be delivered with the cockpit module were of the slow moving, mature type. This would be true for heat ejectors, ventilation ducts, avionics cooling fans, pedal adjust assemblies, and interior / exterior lights. The quickly evolving specification type parts that were eventually mounted into the cockpit were the avionics components. These items, due to their high technology and high contribution to aircraft performance, were specified and bought by HFGI. Also, integration testing of the avionics components were done at the integrator firm. It was thought that keeping direct communication with the first tier supplier of these items maintained better technical understanding of the component instead of going through an intermediary such as a partner.
The other item categorized as “behind-leader-in-use” was the high speed machining of monolithic station frames. As noted earlier, this manufacturing technology was not yet fully developed. However, such technology could become a contributor to the airframe design competency of the firm. This manufacturing technology supported a different approach at designing station frame assemblies. Instead of a multiple part sheet metal build up, these stations could be made with fewer machined parts. Designing with this alternate construction needed an understanding of what product form could be achieved by this approach to machining and how these affected the mechanical properties of the design.

Issues
The TM&C framework classifications of the cockpit module subsystem components were generally consistent with the ‘buy’ nature of the module. This was true for — subassembly build up, sheet metal details, electrical panels and harnesses, hydraulic lines, and specification controlled parts. The application of this framework, however, raised concern about two items: the composite canopy and the monolithic machined frames.

Canopy
The composite canopy’s TM&C framework classification was ‘make’ since the firm was considered a leader in its use and the technology was evolving relatively quickly. Furthermore, this composite manufacturing technology was considered a core competence of the firm. The statements above led to two arguments consistent with keeping the structure in-house. The first argument considered the knowledge the firm could have gained in making both the tooling and the component. By outsourcing these activities, HFGI lost an opportunity to continue learning from this configuration. The second argument brought into question the sharing of this leading edge technology. Does sharing this technology possibly lead to developing another competitor in the helicopter industry? Does sharing this technology reduce HFGI’s competitive advantage over its competitors?
By outsourcing the activity off-site, HFGI lost the opportunity to learn by doing. Due to this outsource, HFGI’s manufacturing personnel were not able to sharpen their technology skills with this project. However, the on-site in-country assignment of HFGI’s design and manufacturing engineering personnel facilitated their involvement as the canopy was designed, developed and manufactured. In this particular case, HFGI engineers’ assigned to the partner site were able to learn from their engagement in supporting detail design and manufacturing activities.

The sharing of this technology can be viewed as being detrimental to the competitive advantage of HFGI. It was not immediately apparent, however, that this firm was interested in entering the helicopter industry. Further, significant barriers existed for new entrants into the industry: there were high capital requirements; experience within the industry was necessary for success; switching costs to current customers were high; brand identification played an important role; access to technology was extremely restricted; and government protection of local markets was relatively high. In light of these potential barriers to entry, it seemed a remote possibility that the transfer of this particular technology would result in the emergence of a new competitor in the industry.

An alternate to sharing technology may have been the use of an older canopy design from the existing utility helicopter model. This older configuration was reviewed earlier in the chapter. The configuration used mature sheet metal, machining and composite manufacturing technologies. The disadvantages of this configuration were weight and historical interface problems at subassembly and final assembly. Despite the issue of technology transfer, the all-composite graphite canopy provided technical and manufacturing benefits to the aircraft.

Technology sharing with the partner could be viewed as an avenue for building better partner relationships. The more opportunity that both firms had in solving problems together in a positive environment, the stronger the relationship could get. The partner firm benefited from learning a new technology. HFGI benefited from an improved relationship that developed a supportive risk-sharing partner for the long term.
Machined Frames

High speed machining technology applied to large airframe structure was still an evolving technology. As of several years ago, fixed wing manufacturers and machine tool companies were still experimenting with various spindles and bearing configurations appropriate for this application. Other issues related to control design, sensor capability, tool-balancing systems, cutter wear detection, etc., were still to be fully developed. Recall that both partners agreed to use large machined frames at the aft structure. CSCI was confident that it could economically produce this configuration even with a conventional machining approach. Given this situation, high speed machining as an avenue for a different airframe design was postponed until the technology matured further.

5.4 Supplier Relationships

The traditional arms-length approach used by HFGI in dealing with its suppliers was inconsistent with the partnering effort required for the development program’s success. Cooperative partnering activities were necessary. Technological innovation, as represented by the components of the cockpit assembly, were disruptive to the partners design and production practices. In response, constant communication and efficient methods of data transfer were important problem solving methods facilitating system integration and partnering. Successful problem solving activities paved the way to better partnering.

In this section, several analytical frameworks are used to identify the difficulty in implementing both technical and organizational activities related to this cockpit design effort. The ‘difficulty’ indicated by the frameworks provide a sensitivity to the type and amount of effort necessary to manage these design and partnering activities.
5.4.1 Partnering

For HFGI and CSCI, partnering was new and unfamiliar territory. Although both firms had worked on joint ventures before, neither had been involved in an international commercial endeavor of this magnitude. Frameworks based on technology innovation literature were used to review the entrenching and disruptive nature of the design and development of cockpit subsystem components to the firms.

The newness of the business relationship and the technical complexity of the cockpit module represented a spectrum of organizationally entrenching and disruptive processes and technologies that both firms had to incorporate. To address this 'hard' problem, methods and approaches were instituted to manage both technical and human interfaces. As examples, both firms used in-country representatives and daily electronic mock up updates to manage interfaces.

Fig 5-6 presents a Henderson and Clark\textsuperscript{100} framework that is applied to the decomposition of cockpit details. The activities used in implementing these innovations varied. The 'radical' innovations of the graphite canopy and machined frames required extensive technology transfer and training for both firms. The 'incremental' innovation of joining a modular aircraft relied on an accurate exchange of manufacturing information. Managing the 'architectural' innovation of subsystem component installation in partner modules instead of at

final assembly, depended on daily electronic data exchanges that quickly identified conflict areas to both firms.

A review of the development program’s effect on CSCI’s production and design capabilities with respect to product familiarity is shown in Figure 5-7. This framework classifies a decomposition of the cockpit’s major structural components. It indicates that the graphite canopy and aft structure design were disruptive to the partner’s product familiarity and operational capabilities. As detailed above, HFGI transferred design and manufacturing know-how to aid CSCI in understanding these ‘radical’ innovations. In contrast, the sheet metal and subassembly processes were familiar and entrenching to the partner’s capabilities.

Figure 5-8 classifies non-airframe subsystem components and their effects on CSCI’s product familiarity and operational capabilities. Items such as harnesses, panels and tubing were

---

101 William J. Abernathy and Kim B. Clark, “Mapping the Winds of Change,” Research Policy 14 (1985) : 8. These frameworks are variants of the transilience map as introduced in the referenced article.
considered well within the product and process experience of the company. However, for other items, the partner’s ‘buying’ capabilities could be entrenched or disrupted by the need to supply program subsystem components. Engineering’s ability to develop source control specifications; purchasing, quality, and test’s ability to support the process; and the supplier network’s ability to supply components were all part of this operational capability. The specification of the parts for various console assemblies needed to be consistent with the apparatus to be installed at final assembly. As such these specific parts were disruptive to the CSCI’s product familiarity. However, once the component requirements were defined, the firm’s existing supplier network was capable of delivering these items. The manufacture and purchase of flight control components such as supports, bell cranks, fittings, rod ends, etc. were similar enough in manufacturing process to existing components that these were thought to be entrenching.

In Figure 5-8, the items disruptive to CSCI on both axis’ were subsystem components specified by HFGI. For some, these parts were supplier specific. In these cases, HFGI provided both specification and source information to the partner. As mentioned earlier, on some components, HFGI had negotiated terms and pricing for partner requirements with their subsystem suppliers. As examples, ejector heater ducts and avionics cooling fans were purchased and delivered by CSCI for installation in the cockpit based on negotiation efforts by the integrator firm.

The management of the various components that comprise the cockpit assembly represented various challenges to the partners. Aspects of the program’s innovations were both entrenching and disruptive to both partners. The frameworks above point to the need for methods to communicate coordinate and exchange, both design and operational information between partners.

5.4.2 Activities to help partnering

A number of program activities employed to manage technical and organizational interfaces are classified and represented in Figure 5-9. These activities were thought to help the partnering
efforts between companies. Some of these efforts were operationally entrenching to HFGI, as with the use of Product Development Teams. While other efforts were considered operationally disruptive since their implementation countered prior organizational beliefs in the firm’s functional organizations.

![Diagram of HFGI View: Activities Supporting Partnering]

Figure 5-9, Program Activities that Help Partnering

**Product Development Teams**

Teaming was an organizational process integral to relationship building with the partner and within the firm. HFGI had recently been involved in a large concurrent engineering development effort. Thus, the incorporation of multi-functional Product Development Teams (PDT) for the development program was entrenching to HFGI as an organization. Many of the personnel assigned to the development program had PDT experience from prior assignments. Team membership included design and manufacturing engineering, test, materials, shop floor representatives, quality, purchasing, production control, etc. A dominant number of these
individuals were assigned full time to the program. Teams were co-located in a separate area from the rest of the facility. Weekly team and Program Management meetings were held. The PDT structure served as a base for the relationship building with the partners. It arranged for the support personnel needed to field technical or business questions. It provided a stable and core group of HFGI contacts that the partners could interface with.

On-Site Teams
HFGI also provided small teams that were resident at the international partner sites. Their presence facilitated communication and resolution of issues. These personnel were coordinated by a program leader who played the role of a designated point of contact. Team representatives were familiar enough with technical and program details to provide quick responses. If there were issues that the in-country personnel could not field, these representatives knew the appropriate PDT members at HFGI to interface with. The partners also sent representatives to live on site at HFGI to serve as communication interfaces. Partner effort at this was not as extensive. There were however, numerous visits by partner teams to support milestone discussions and to review and resolve technical conflicts.

Emphasis on Manufacturing Approach
Partner manufacturing plans were critical for achieving consistency across the partner base. Along with the engineering specification for design, a manufacturing statement of work was provided to the partners. CSCI was required to describe their manufacturing approach, just as it was required to respond to the design requirements of the part. The documentation received from CSCI provided the integrator firm with their approach for fabricating the complete assembly. This response provided HFGI with an opportunity to evaluate the partner’s understanding of the work package requirements. Upon review, suggestions to partner manufacturing plans were made by HFGI’s manufacturing engineering group.

Transfer of Technology
Technology transfer was another avenue used to build partner relationships. The development program’s manufacturing requirements dictated that all partners use tool and processes which
yielded high quality precision parts. To successfully produce these kind of parts, HFGI and partner manufacturing processes needed coordination. HFGI, with its integration experience, identified the tooling and fabrication technologies that could meet design requirements. Technologies and training in both composite and metallic part fabrications were identified and flowed down to the partners. HFGI in-country team members provided on-site hands on instruction of these processes.

Sharing Sub-tier Supplier Information
As mentioned in prior sections, the sharing of specification and supplier information for several components was part of HFGI’s support for the partners. This information flow, coupled with HFGI efforts at negotiating with suppliers, helped develop partner relationships as well as maintain successful subsystem integration.

Interface Control
Interface control drawings were used to coordinate partner and supplier components. These drawings controlled critical interface points and defined component locations that required tight tolerance machining. As systems integrator, HFGI was responsible for overall space management of the aircraft. The firm used an electronic mockup to manage this aspect of the program. HFGI’s PDTs, partners, and suppliers provided electronic models of their components to a central integration group at HFGI. This group merged the electronic model of the aircraft and the component files that were supplied. From this effort, interference was identified and resolved.

Change Notices
Two issues that hampering the building of relationships were change notices and discontinuity of personnel assignments over time. Despite all efforts, the design process of a development program results in configuration changes. These are a natural consequence of the compromise resulting from solving complicated system problems. Some changes have minimal impact, like moving a clearance hole a quarter of an inch. Other changes are of a greater magnitude, like a redesign of structural members due to updated structural test results. The number and extent of such changes affects the development cost shouldered by each of the participants of the program. At program
start, each partner had allocated a pool of funds thought to cover these change efforts. Early in the program, engineering, tooling, planning, and component costs due to changes were absorbed with minor documentation. However, as the program moved further towards completion, tighter budgets dictated less propensity to respond to changes without deep investigation.

Continue Contact
As the program progressed towards completion of major milestones, there was a tendency to shift personnel within the program to support varying workforce requirements. In other cases, budgetary constraints necessitated the transfer of personnel out of the program. This reduction in staff degraded the amount and quality of interface with the partners. Additionally, as they accomplished their statement of work, on-site team members returned to their home companies. This reduction in presence at partner sites necessarily reduces partner interaction. At such a stage, information updates to the partners was sporadic. In this situation, it is easy to overlook the international partners as the firm focuses its efforts on completing major integrator program milestones. This situation exemplifies the need to allocate appropriate and specific resources to the continued nurturing of partner interfaces.

5.5 Chapter Summary

This chapter described the complexity of the structural and subsystem components that made up the cockpit module assembly. In addition, it introduced the partner firm responsible for the cockpits design and delivery.

The chapter reiterated HFGI’s need for an international partnership to facilitate the development program’s feasibility. The situation was driven by industry pattern and firm specific issues, which related the partnering activity to the company’s product strategy. This need for partners was HFGI’s primary reason for ‘buying’ major airframe modules. Subsequent subsystem and component make-buy strategies were set by this decision.
The chapter briefly documented a summary of the make-buy procedure of the company. Furthermore, it described the process employed to update the Division and Program level Make-Buy Matrices with the institution of a new business development program. The most senior level of company management settled the make-buy decision to partner. Only the appropriate VP’s of Manufacturing, Material and Engineering could develop a partnering strategy that fit the organization’s capabilities.

The chapter examined the decision to ‘buy’ the cockpit module assembly using two analytical strategic frameworks grounded on the core competence viewpoint. It is to be noted that the primary industry and firm constraints discussed were not accommodated by the two frameworks used for analysis.

The analysis exercised the 3-D CE Make versus Buy Decision Matrix in an examination of the cockpit module outsource. The framework classified the outsourced activity in the -- modular and dependent-for-capacity niche of the matrix, which was a category best suited for outsourcing. The agreement on revenue sharing arrangements addressed the risk of partner non-participation. The firm’s multi-product strategy mitigated issues of knowledge degradation due to the cockpit module's outsource.

The chapter used the Technological Maturity and Competitiveness framework to review the consistency between ‘buying’ the cockpit and maintaining HFGI’s core competencies. It utilized the framework on a decomposition of the complex structural and subsystem components of the cockpit assembly. The framework categorized a majority of the module’s sub-components as either buy or ‘make and buy’. Sourcing components with these classifications to the partner was interpreted as consistent for the integrator firm. The chapter also examined core competency issues associated with the composite canopy and monolithic machined station frames.

Implementing detail design and analysis of the cockpit assembly in a partnership mode represented challenging opportunities to overcome for both firms. Despite giving the appearance of simple
modularity, the cockpit assembly outsource was a complex marriage of airframe structure and subsystem componentry. The review used frameworks that characterized the disruptive nature of the ‘innovations’ being introduced to CSCI’s product familiarity and product-design capabilities.

Similar frameworks characterized the partnership reinforcing activities implemented by the partners. Concurrent problem solving of technical issues that supported the integration aspects of the cockpit assembly improved the partnering relationship between firms. Other reinforcing activities included off-site personnel exchanges and the sharing of technical and supplier information. The firms implemented this set of activities to accomplish a different perspective from the traditional arm's length actions employed by HFGI.
6. Conclusions

Foremost, note that prior decisions considering the broad context of issues related to industry and firm opportunities determined the structure of the strategic framework implemented for the make-buy decisions of the development helicopter program.

The two frameworks employed to examine the module's outsourcing were beneficial mechanisms for reviewing this decision after the fact. They also appear valuable as methods to organize thought about design approach to supply chain and core competence issues usually neglected in a product development scenario.

The 3D CE Make versus Buy Decision Matrix investigated the decision to outsource the cockpit assembly as if it were a single modularized item delivered from the partner. This situation mapped reasonably well to the complementary architectural approach to product and supply chain design advocated by its author. Driven by manufacturing requirements at final assembly integration, the modular design approach to the airframe structure subsystem made it the logical outsourcing choice to facilitate the partnering arrangement.

Despite giving the appearance of simple modularity, the cockpit assembly outsource was a complex marriage of airframe structure and subsystem componentry. The Technological Maturity and Competitiveness framework examined a granular look at the decomposition of subsystem components included in this outsource. Although primarily supportive of the outsource decision, this framework raised some interesting questions about core competence issues related to the
detail items being outsourced. Arguments that alleviated the concerns raised by the framework indicated that some peripheral thought regarding core competency issues may have transpired.

Regardless of the postmortem applicability of these frameworks, they clearly do not accommodate the broader business issues that determined the partnering decision of the development program studied. Issues of risk sharing, near term market opportunities, future international market penetration, existing asset specificity, funding constraints, etc., do not easily fit into these frameworks. The complicated contextual environment addressed by the firm’s strategic goals and accommodated by the firms strategic process, are at an intellectual level not easily covered by simplistic frameworks. The firm’s ability to make rational high level decisions under unclear, poorly defined and ever changing circumstances may be a core competency in itself.

The decision to enter into partnering arrangement brought another set of complicated issues that tested the firms’ capabilities at managing the technical and organizational complexity inherent in the supply chain and product development problem. Prior experience with integrated product development and international co-production programs served as a base for an implementation of rich activities that supported the partnering direction.

Implementing detail design and analysis of the cockpit assembly in a partnership mode represented challenging opportunities to overcome for both firms. The review used frameworks that characterized the disruptive nature of the ‘innovations’ being introduced to CSCI’s product familiarity and product-design capabilities.

Similar frameworks characterized the partnership reinforcing activities implemented by the partners. Concurrent problem solving of technical issues that supported the integration aspects of the cockpit assembly improved the partnering relationship between firms. Other reinforcing activities included off-site personnel exchanges and the sharing of technical and supplier information. The firms implemented this set of activities to accomplish a different perspective from the traditional arm’s length actions employed by the integrator company.


"HFGI Article on Progress of Program." *Aviation Week*, 1996.


Quinn, James B., and Hilmer, Frederick G. “Strategic Outsourcing.”

Raffi Mario.; Esposito, Emilio.; and Zollo, Guiseppe. “Strategies of Technological Co-operation: Evidence from the Aircraft Industry.”
In Innovations in Procurement Management, pp.33-62.

Rajagopal, Shan, and Bernard, Kenneth N. “Strategic Procurement and Competitive Advantage.”

Sobek II, Durward K.; Liker, Jeffrey K.; and Ward, Allen C.
“Another Look at How Toyota Integrates Product Development.”

Stuart, Ian. “Supplier Partnerships: Influencing Factors and Strategic Benefits.”


Teece, D.J. “Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy.”


Venkatesan, Ravi. “Strategic Sourcing: To Make or Not to Make.”

