SUPPLIER MANAGEMENT PRACTICES OF THE JOINT DIRECT ATTACK MUNITION PROGRAM

by

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Abstract

U.S. defense aerospace contractors have been in the process of reducing the supplier base and delegating greater responsibilities to key suppliers in order to remain competitive in the face of defense cutbacks. The trend towards greater outsourcing has meant that new products and modifications of existing systems are being designed, developed, and produced by first tier and lower tier suppliers. Supplier management becomes increasingly important as suppliers take on a greater role in product development.

The Joint Direct Attack Munition (JDAM) program reveals changes in the model for supplier relationships in the defense aerospace industry that have been accompanied by unprecedented results. The joint Air Force and Navy program was designated a Defense Acquisition Pilot Program by the Department of Defense to implement acquisition reform--particularly the reform measures of the Federal Acquisition Streamlining Act of 1994. Changes in decision-making, program structure, and organizational culture occurred as the result of reform measures and the product development administration of the program. The changes implemented by the Government as well as the innovative supplier management practices of the prime contractor showed progress in the general model for supplier relationships towards a more collaborative, team-oriented partnership.

The JDAM program not only reveals the use of a new model for supplier relationships and management but also reveals that the underlying corporate strategies of

subcontractor firms influenced the types of information exchanged within the program. Limitations in certain types of information exchanged, however, did not necessarily limit subcontractor contributions to product development and to program affordability goals. It was also revealed that the dynamics behind JDAM team formation influenced the type of innovation in development of the Guidance Control Unit. The linkages of the suppliers and the supplier designs resulted in innovations that changed the system architecture. In future programs, the Government, prime contractors, and suppliers may be able to manage the types of resulting designs and innovations by focusing on team dynamics and inter-relationships.

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BIOGRAPHICAL NOTE

For the past two years, the author has worked as a Research Assistant with the Lean Aircraft Initiative. Her technical interest is in systems engineering and product development. Previously, the author worked at *L'Institut von Kármán des Dynamiques des Fluides* in Rhode Saint Genèse, Belgium, where she developed methods of analyzing irregular aerodynamic heating effects of thermal protection tiles on the European Space Agency Shuttle upon reentry into the atmosphere. Ms. Lucas published "The Effect of an Elevated Tile on Heat Transfer and Transition in Hypersonic Flow" in 1993. She also worked at the Space Engineering Research Center and the Technology Laboratory for Advanced Composites at the Massachusetts Institute of Technology, where she received her Bachelor of Science degree in Aerospace Engineering in 1994. She is a member of the Sigma Xi Honor Society and has been a member of the American Institute of Aeronautics and Astronautics and the Society of Women Engineers.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACAT	Acquisition Category
ADM	Acquisition Decision Memorandum
ADR	Alternate Dispute Resolution
AMRAAM	Advanced Medium-Range Air-to-Air Missile
ANOVA	Analysis of Variance
APB	Acquisition Program Baseline
AQL	Acceptable Quality Level
ATD	Advanced Technology Demonstration
ATE	Airborne Test Equipment
ATE	Automatic Test Equipment
AUPP	Average Unit Procurement Price
AUPPR	Average Unit Procurement Price Requirement
CAE	Component Acquisition Executive
CAIV	Cost As an Independent Variable
CDA	Commercial Derivative Aircraft
CDE	Commercial Derivative Engine
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CE	Concept Exploration and Definition
CEP	Circular Error Probable
CICA	Competition In Contracting Act
CM	Configuration Management
COEA	Cost and Operational Effectiveness Analysis
CPFF	Cost-Plus-Fixed-Fee
CPIF	Cost-Plus-Incentive-Fee
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DAPP	Defense Acquisition Pilot Program
DEM/VAL	Demonstration and Validation
DFA	Design for Assembly
DFARS	Defense Federal Acquisition Regulation Supplement
DFM	Design for Manufacturing
DFMA	Design for Manufacturing and Assembly
DoD	Department of Defense

DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoDM	Department of Defense Manual
DOE	Design of Experiments
DPRO	Defense Plant Representative Office
DT&E	Development Test and Evaluation
DUSD(AR)	Deputy Under Secretary of Defense for Acquisition Reform
EAC	Estimate at Completion
E&MD	Engineering and Manufacturing Development
EC	Electronic Commerce
ECP	Engineering Change Proposal
EDI	Electronic Data Interchange
EMD	Engineering and Manufacturing Development
EMD-1	Engineering and Manufacturing Development-Phase 1 (Demonstration and Validation)
EMD-2	Engineering and Manufacturing Development-Phase 2
EMI	Electromagnetic Interference
FAR	Federal Acquisition Regulation
FASA	Federal Acquisition Streamlining Act (also FASTA)
FFP	Firm Fixed-Price
FOT&E	Follow-On Operational Test and Evaluation
FPI	Fixed-Price Incentive
FSCATT	Fire Support Combined Arms Tactical Trainer
FY	Fiscal Year
G&C	Guidance and Control
GCU	Guidance Control Unit
GPS	Global Positioning System
GPSRM	Global Positioning System Receiver Module
GSA	General Services Administration
IFB	Invitation for Bids
ILS	Integrated Logistics Support
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IMU	Inertial Measurement Unit
IMVP	International Motor Vehicle Program
INS	Inertial Navigation System
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
IPS	Integrated Program Summary
IOT&E	Initial Operational Test and Evaluation
IT	Information Technology
JCS	Joint Chiefs of Staff
JDAM	Joint Direct Attack Munition
JPATS	Joint Primary Aircraft Training Systems
JROC	Joint Requirements Oversight Council
JSOW	Joint Standoff Weapons Program
JSPO	Joint System Program Office
KC	Key Characteristic
KPC	Key Product [or Process] Characteristic
LAI	Lean Aircraft Initiative
LANTIRN	Low-Altitude Navigation and Targeting Infrared [System] for Night [Aviation]

LCC	Life Cycle Cost
LRIP	Low Rate Initial Production
MC	Mission Computer
MDA	McDonnell Douglas
MDAP	Major Defense Acquisition Program
MDI	Manufacturing Development Initiative
MIL-SPEC	Military Specification
MIL-STD	Military Standard
MNS	Mission Need Statement
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NDAA	Non-Developmental Airlift Aircraft
NPR	National Performance Review
O&S	Operation and Support
OFPP	Office of Federal Procurement Policy
OMB	Office of Management and Budget
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PAT	Process Action Team
PDR	Preliminary Design Review
PEO	Program Executive Officer
PM	Program Manager
PMD	Program Management Directive
PO	Program Office
PPCG	Pilot Program Consulting Group
PRR	Production Readiness Review
QOT&E	Qualifying Operational Test and Evaluation
QT&E	Qualification Test and Evaluation
R&D	Research and Development
RCM	Requirements Correlation Matrix
RDT&E	Research, Development, Test and Evaluation
RFP	Request for Proposal
RFQ	Request for Quotation
RLG	Ring Laser Gyro
SAF/AQ	Secretary of the Air Force for Acquisition
SEMP	Systems Engineering Management Plan
SEMS	System Engineering Master Schedule
SFW	Sensor Fuzed Weapon
SOO	Statement of Objective
SOW	Statement of Work
SPC	Statistical Process Control
SPO	Systems Program Office
SRD	System Requirements Document
SRR	System Requirements Review
SSET	Source Selection Evaluation Team
SSP	Source Selection Plan
SW	Software (also S/W)
TAS	Tail Actuator Subsystem
T&E	Test and Evaluation
TCP	Task Change Proposal
TDP	Technical Data Package

TPM	Technical Performance Measurement
TRR	Test Readiness Review
UAV	Unmanned Aerial [or Air] Vehicle
UPP	Unit Procurement Price
USAF	United States Air Force
USD(A)	Under Secretary of Defense for Acquisition
USN	United States Navy
VECP	Value Engineering Change Proposal
WBS	Work Breakdown Structure

CHAPTER 1

Introduction to the Research Topic: Supplier Relations and Management

In recent years, United States defense aerospace contractors have been in the process of reducing the supplier base and delegating greater responsibilities to key suppliers. To remain competitive in the face of defense cutbacks, firms have generally chosen to give first tier suppliers a larger role in the production of major components, inspection functions, and the management of lower tier suppliers.

Some firms use supplier certification programs to ensure quality in existing standard products. The trend towards greater outsourcing, however, has meant that even new products or systems and modification or upgrades of existing systems are being designed, developed, and produced by first tier and lower tier suppliers. Supplier management becomes increasingly important as suppliers take on a greater role in product development.

The first section of this chapter describes different types of supplier relationships and how those relationships are important to other aspects of supplier management. Different supplier management practices are described not only in terms of supplier relationships, but also in terms of management, organization, measurement, quality, cost, and cycle time. The types of supplier relationships practiced are critical to these areas of supplier management. The second section of this chapter describes the changing model for supplier relationships and the changing role of suppliers in product development. While the changing model for

supplier relationships has been well documented in the automobile industry, the changes taking place in the defense aerospace industry are not widespread and have generally met ongoing difficulties.

The Joint Direct Attack Munition (JDAM) program reveals changes in the general model for supplier relationships in the defense aerospace industry that have unprecedented results.[4] The JDAM program, a joint Air Force and Navy program, was designated a Defense Acquisition Pilot Program by the Department of Defense to implement acquisition reform, including the reform measures of the Federal Acquisition Streamlining Act of 1994. These Government-initiated reform measures had significant effects on the relationships among Government representatives, the prime contractor, and suppliers of the JDAM program. Changes in decision-making, program structure, and organizational culture occurred as a result of reform measures and of the product development administration of the program. In particular, the following measures had a strong impact on program relationships and management: the Average Unit Procurement Price (AUPP), which was used to measure life cycle costs; the emphasis on *competitive* acquisition; the use of a rolling evaluation and downselect process; the expectation of a stable, multi-year procurement; an accelerated time schedule; the limited role of the Government with reduced oversight; the implementation of Government Advocacy Teams and the encouragement of open communications; true total contractor configuration control; a limited project scope and the establishment of "live-or-die" requirements; the extended 20-year warranty provided by the prime contractor; the use of commercial practices; the concept of Cost As an Independent Variable (CAIV) and the ability to conduct cost-performance trades; the streamlining of standards, specifications, "how-to's," and requirements; contractor incentives and "pay for performance;" contractor training and the encouragement of Design for Manufacturing/Design for Assembly (DFM/DFA); and Alternate Dispute Resolution. The changes implemented by the Government as well as the innovative supplier management practices of the prime contractor have progressed the model for supplier relationships towards a more collaborative, team-oriented partnership.

[4] These results are discussed in Chapter 3, Appendix B, and Appendix C.

The dynamics that led up to supplier team formation in the JDAM program are significant not only because document the change in supplier relationships and management in the defense aerospace industry, but also because they were particularly shaped by the underlying corporate strategies of each of the supplier teammates. The supplier teammate strategies included the desire to: maintain trade secret information, maintain a commercial pricing strategy, overcome a situation of financial uncertainty, and enter the military market with the benefit of a long term relationship. These particular strategies changed the type and level of information exchanged with the prime contractor organization and the other suppliers. The limitation of certain types of information flow between the prime contractor and suppliers, however, did not always result in a less team-oriented relationship or create an adversarial barrier. The push to open communication barriers that had once impeded many past relationships in the defense aerospace industry may account for the general expectation of implementing total open communications. The benefits and intended benefits of sharing pricing data and design information should be carefully analyzed and distinguished to achieve program goals and to achieve desirable supplier relationships.

The dynamics underlying the formation of the JDAM team model for supplier relationships also had an impact on the types of design changes made in the JDAM program. The integration of the key suppliers, both black box and built-to-print suppliers, into a team to perform a relatively large-scale system re-design resulted in design innovations that were architectural in nature. The re-design of an established, dominant system--for the Guidance Control Unit of the JDAM product--along with the integration of the key suppliers, contributed to the resulting architectural innovations. The formation of new linkages between the key suppliers contributed to a change in the linkages of the components from each of the key suppliers--without significant changes in the individual components of the system. Several examples of innovations that resulted from the competition-driven re-design of the Guidance Control Unit exhibit this architectural nature. Contractors and suppliers, with the knowledge of how team formation affects the nature of innovation within a program, may be able to reconfigure the management of technological innovation depending on the types of innovation desired. The model for strategic supplier partnerships in the automobile industry embraces the integration of suppliers early into the product development process; early supplier

involvement may be a method of taking advantage of the full innovative capacity of supplier firms and of facilitating more radical innovation--which changes not only the components being designed or the linkages among the components involved, but a combination of the components and their inter-relationships.

The first chapter of this thesis analyzes supplier relations and management characteristics of various types of relationships and the changing supplier relationship models that developed in the automobile industry. The second chapter outlines the research methodology. The results of the research are given in Chapter 3, Dynamics of Supplier Team Formation in the JDAM program. The factors contributing to the formation of the JDAM supplier team model, the interaction between competitive strategies and information flow, and the affect of team formation dynamics on design innovation are presented in Chapter 3. Conclusions and recommendations for future research are given in Chapter 4.

The appendices cover a description of the Lean Aircraft Initiative as well as detailed descriptions of the JDAM program and the product development administration of the JDAM program. Appendix B describes the features of the JDAM product, schedule, and purpose of acquisition reform, along with some of the major benefits resulting from acquisition reform measures of the Federal Acquisition Streamlining Act of 1994 and other important legislation. Appendix C describes the major pieces of acquisition reform that were initiated by the Government in the JDAM program. The reform measures implemented in the program administration are described in Appendix C in the context of achieving an affordable system--that is, meeting or exceeding requirements in an accelerated time frame--as well as in the context of making radical changes in decision-making, program structure, and organizational culture. Key Government initiatives included: the Average Unit Procurement Price (AUPP), which was used to measure life cycle costs; the emphasis on *competitive* acquisition; the use of a rolling evaluation and downselect process; the expectation of a stable, multi-year procurement; an accelerated time schedule; the limited role of the Government with reduced oversight; the implementation of Government Advocacy Teams and the encouragement of open communications; true total contractor configuration control; a limited project scope and the establishment of "live-or-die" requirements; the extended 20-year warranty provided by the prime contractor; the use of

commercial practices; the concept of Cost As an Independent Variable (CAIV) and the ability to conduct cost-performance trades; the streamlining of standards, specifications, "how-to's," and requirements; contractor incentives and "pay for performance;" contractor training and the encouragement of Design for Manufacturing/Design for Assembly (DFM/DFA); and Alternate Dispute Resolution. These Government initiatives had a clear and significant impact on the dynamics of team formation and on program relationships.

1.1 Approaches to Supplier Management

Using a framework developed by Bhote[1], supplier management may be perceived as a four-stage process. The "stages" are those that a supplier and prime contractor would undergo to achieve strategic supplier management and to enter into a mutually beneficial relationship. These stages may also be conceived of as different types of supplier relationships:

- Stage 1: Confrontational
- Stage 2: Arm's Length
- Stage 3: Goal Congruence
- Stage 4: Full Partnership.

Stage 1 represents a confrontational arrangement in which the prime contractor and supplier are opposed against one another, seeking individual gain at the expense of the other. Stage 2, an "arm's length" relationship, is a cautious and tentative one in which the parties may be adversarial but recognize the connection of their business interests. In stage 3, the prime contractor and supplier recognize the benefits of goal congruence, a coming together of their mutual goals. The parties work towards achieving overlapping goals. Stage 4 is a full partnership in which the prime contractor and supplier work together as a team. In a full partnership, the parties not only try to achieve their own goals with the help of the other party or parties, but work as a team. The goal of a strategic supplier relationship is achieved through this final stage.

[1] Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, pp. 14-21.

In the defense aerospace industry, many relationships have been characterized as confrontational or arm's length relationships. While goal congruence is emerging as a new paradigm in the defense industry, the idea of a full partnership has been met with significant resistance. A change in supplier relationships toward the full partnership stage requires changes in decision-making, organizational structure, and organizational culture. In many cases, the roots of traditional arm's length relationships in the defense aerospace industry have been difficult to overcome. Working toward a strategic supplier[a] partnership, however, could significantly benefit the Government, prime contractors, and the suppliers. The JDAM program demonstrates progress in the relationships among the Government, prime contractors, and suppliers towards a more strategic partnership.

In general, Table 1-1 highlights some of the advantages that could be experienced by the prime contractor and the supplier if a full partnership stage were instituted.

Table 1-1: Benefits of a Full Partnership[2a]

Contractor Company Benefits	Supplier Company Benefits
• Excellent quality	• Larger volumes
• Lower prices each year	• Longer-term agreements
• Shorter lead time	• Quality, cost, cycle time assistance
• Lower inventory and cycle time	• Training, coaching
• Early supplier involvement	• Stable forecasts
– Savings ideas	• Advance planning information
– Reduced design cycle time	• Security and growth
	• Increased profits and ROI

By working with the supplier, the prime contractor would have the opportunity to improve product quality, enjoy lower prices each year from

[a] Note: The use of the term, "supplier," in this thesis is used interchangeably with the term, "subcontractor." Sub-suppliers denote second tier suppliers and (second tier) subcontractors.
[2] Adapted from Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 30.
[a] Note: The JDAM program experienced some of these benefits but did not fully integrate their suppliers early in development.

suppliers, reduce lead time, and lower inventory and cycle time. By bringing the supplier early into the development of the product or subassembly, the prime contractor could be rewarded with savings ideas from the supplier and a reduced design cycle time. The supplier could also benefit from a more stable relationship by experiencing longer contracts and larger volumes. The supplier might benefit from assistance with quality, cost, and cycle time (which may impact other areas such as engineering or manufacturing) in training or coaching sessions with the prime contractor. The supplier might be able to benefit from more stable forecasts that the prime contractor would be able to give. The supplier could then, in turn, pass more stable forecasts on to sub-suppliers. The supplier would also be better able to plan and pass planning information on to its sub-suppliers. The additional security and growth that are associated with an advanced partnership would be likely to result in increased profits and return on investment (ROI) for the supplier and the prime contractor.

Strategic supplier relationships may be beneficial for both the prime contractor and supplier. Without a strategic relationship, prime contractors and suppliers may not only miss opportunities, but they may also deter one another from achieving mutually beneficial goals. The relationship between the prime contractor and supplier determines what "stage" the supplier management program is in and what supplier management practices are used. Supplier relationships also determine the extent of mutual benefit--or harm.

Supplier relationships have important implications in all areas of supplier management. Section 1.1.1 describes the effect of supplier relationships on supplier management in greater detail. It is recognized that, just as supplier relationships affect supplier management, supplier management practices have an impact on supplier relationships. Sections 1.1.1 through 1.1.7 discuss all aspects of supplier management: supplier relationships, management, organization, measurement, quality, cost, and cycle time.

1.1.1 Supplier Relationships

Table 1-2 shows how the stages of supplier management may be characterized in the area of supplier relationships. Table 1-2 describes supplier relationships among the stages of supplier management in terms of trust, number of suppliers, the economic relationship, the extent of information exchanged between the parties, the level of commitment to the partnership, and profit-sharing as a means of tapping supplier creativity.

These relationships are discussed here in the context of supplier management and are also highlighted in section 1.2, with a description of supplier relationship models in the automobile industry.

Table 1-2: Stages of Supplier Management in the Area of Supplier Relationships[3]

Stage 1 Confrontation	Stage 2 Arm's Length	Stage 3 Goal Congruence	Stage 4 Full Partnership
Distrust	Suspicion	Limited trust	Full trust
Supplier proliferation	Multiple suppliers	Reduced supplier base	Single sourcing
Economic dominance	Laissez-faire	Preferred suppliers	Partnership suppliers
Supplier kept in dark	Limited information	Mutual consultations	Frequent visits, training, and technical help
No commitment to partnership	Cautious overtures	Mutual sharing of plans	Early supplier involvement
No tapping of supplier creativity	Creativity neutrality	Supplier cost reductions with no sharing	Savings sharing

The relationship between a prime contractor and supplier is one of the most important aspects of a strategic supplier management program. The level of trust in a supplier relationship must be high to enable a true, full partnership. Because of the contractor's position, the contractor must

[3] Adapted from Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 14.

usually make the first move toward that commitment.[a] To reach a state of full trust, however, both the prime contractor and the supplier must be willing to share their strategies, plans, technologies, and costs with one another. For a full partnership, the prime contractor and supplier must also be willing to help each other--especially through competitive pressures and temporary setbacks in quality, cost, and delivery. In confrontational and arm's length relationships, when a supplier encounters a problem with quality, cost, or delivery, then the tendency of the prime contractor is generally to end the relationship rather than help the supplier. In the spirit of teamwork, the prime contractor should be willing to not only help the supplier, but encourage the supplier to enter into similar partnerships with the supplier's key sub-suppliers--thereby strengthening the entire supply chain. Furthermore, the prime contractor should be willing to share savings with the supplier in an equitable manner. In return, the supplier must also be ready to accept responsibility for setbacks in quality, delivery, and performance.

Another key component of a supplier relationship is the number of suppliers. In a confrontational relationship, for example, prime contractors maintain control over their suppliers by parceling out parts to a large and growing number of suppliers. As stated previously, if the prime contractor determined the quality, delivery, cost, or performance of a part to be unacceptable, then the prime contractor would simply switch suppliers. In an arm's length relationship, the prime contractor would continue to use multiple suppliers as a type of "safety net." In a goal-congruent relationship, the supplier base would be significantly reduced after recognizing the advantage of having key suppliers. The step from a reduced supplier base to a single sourcing arrangement in a full partnership, however, is typically met with considerable opposition. Single sourcing refers to an arrangement in which there is only one supplier per part number. Many purchasing professionals oppose single sourcing because they fear the loss of control over prices, quality, and performance of the part that would seemingly occur when the supplier is freed from

[a] In the case of the defense aerospace industry, the Government may be in a position to make the first move towards commitment. This is evidenced in the JDAM program and highlighted in Appendix C.

competition. Nevertheless, single sourcing requires that the full trust, loyalty, and commitment of a full partnership exist a priori. Single sourcing should also be distinguished from sole sourcing. While single sourcing is recommended, sole sourcing should be avoided. Sole sourcing refers to a situation in which there is only one source: the prime contractor is left with no choice, and the supplier is left with little incentive to trust the prime contractor. In single sourcing, there are several suppliers, from which the best is chosen. A single sourcing arrangement encourages loyalty and provides a medium for trust to grow.

By having a large supplier base, prime contractors in a confrontational relationship could establish a position of economic dominance over the suppliers. In an arm's length relationship, however, a laissez-faire attitude would be taken toward suppliers. In a goal-congruent relationship, the prime contractor would keep a preferred supplier list, recognizing the benefit of having a reduced supplier base. These preferred suppliers, or key suppliers, would have to build up the trust of the prime contractor over time by meeting or exceeding cost, quality, delivery, and performance expectations. In a full partnership, strategic supplier management takes the preferred supplier list one step further. Suppliers are already considered "best-in-class" and would therefore be pre-selected. Partnership suppliers are virtually an extension of the prime contractor's company.

With increasing trust and commitment between the parties, the level of information exchanged is generally expected to grow naturally. In a study of the role of information technology in the automobile industry, for example, the "climate of the relationship," or the character of the relationship--as determined by the level of trust and commitment, for instance--was the most consistent predictor of cooperation through information exchange when compared to other structural or technological

factors.[4] To have a full partnership, the prime contractor and supplier must be willing to share strategies, plans, technologies, and costs with one another. A partnership requires disclosure of information as well as a willingness to help one another. In a strategic supplier relationship, the prime contractor would provide training and technical assistance to the supplier. A high level of commitment would mean that the prime contractor and the supplier would be willing and able to work together for mutual benefit.

Formal displays of commitment include: full ownership, equity investments, long-term contracts, and exclusive contracts.[5] Informal displays of commitment may take many forms. Informal commitment may be the result of a strategic decision, a desire to uphold a fair reputation, or even pressure from a sole sourcing situation. Commitment by a prime contractor to its suppliers might be a strategic decision if, for example, it would be simpler to deal with a limited number of suppliers that have performed well in the past. A prime contractor would also be more likely to be committed to its suppliers if their relationship were expected to continue through current and future contracts. Both the supplier and prime contractor would be committed to the relationship if there were a mutual desire to maintain a fair business reputation. On the other hand, a prime contractor would be forced into a commitment if there were a lack of alternate suppliers.[6]

In strategic supplier management, the suppliers would be integral to the product design and development. Suppliers would become involved early in the process and work closely with the prime contractor's engineers. The ability of the suppliers to become involved in product design and development would require a commitment on the part of the prime contractor. Early supplier involvement could give the supplier a sense of accountability to the design.

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[4] Bensao, M., "Interorganizational Cooperation: The Role of Information Technology. An Empirical Comparison of US and Japanese Supplier Relations," Fontainebleau, France: INSEAD Working Paper, 1994.

[5] Stein, Kevin P. *Implementing Japanese-Style Supplier Relationships in the US Auto Industry*, MIT Sloan School of Management Master's Thesis, 1994, p. 10.

When early supplier involvement is teamed with profit-sharing arrangements with the supplier, the supplier may make a substantial contribution to the design. Savings sharing or profit-sharing could also have a significant impact on supplier employee morale, willingness to share cost reduction ideas, and the dedication of resources to design improvements.

1.1.2 Management

Table 1-3 describes supplier management in the area of general management.

Table 1-3: Stages of Supplier Management in the Area of Management[7]

Stage 1 Confrontation	Stage 2 Arm's Length	Stage 3 Goal Congruence	Stage 4 Full Partnership
Purchasing as an appendage	Cost preoccupation	Quality preoccupation	Emphasis on quality, cost, and cycle time
Crisis management	Nomadic management	Settled management	Team management

According to this framework, the movement toward a full partnership would require a shift from a singular preoccupation with cost or quality to a synergistic focus on quality, cost, and cycle time. The management would aiso need to progress from crisis control, or "fire fighting," to problem prevention. In a confrontational relationship, the problems that had been suppressed by the relationship or pushed down the product development line from design to production would finally surface. Rather than execute a planned, focused management program, crisis control would become the dominant management strategy. In an arm's length relationship, a nomadic management would dominate in which clear direction is not taken or not identified. The settled management approach would encourage

[6] Helper, Susan. "How Much Has Really Changed Between US Automakers and Their Suppliers?" *Sloan Management Review*, Summer, 1991, p. 16.
[7] Adapted from Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 14.

compromise, but the team management approach would encourage the supplier and prime contractor to work together toward a strategic goal.

1.1.3 Organization

To enable strategic supplier management, the organization of the companies would also need to change (see Table 1-4). Functional barriers between departments can often limit visibility. The evolution of the functional organization to a matrix organization, however, also has limitations. Suppliers may sometimes be disadvantaged by matrix organizations, which have both functional and program managers, particularly in the cases where sourcing and purchasing are divided. In these cases, sourcing would evaluate and select suppliers but purchasing would handle the day-to-day transactions once the supplier was selected.

Table 1-4: Stages of Supplier Management in the Area of Organization[8]

Stage 1 Confrontation	Stage 2 Arm's Length	Stage 3 Goal Congruence	Stage 4 Full Partnership
Functional barriers	Matrix	Centralized supply management	Integrated product teams
Purchasing decentralized	Sourcing-purchasing separation	Quality as part of supply management	Engineering, quality, purchasing, and supplier on one team

Strategic supplier management would encourage the use of integrated product teams, in which functions not previously included in supplier management--such as quality, purchasing, and the supplier--become part of the team. The supplier would become an extension of the contractor

[8] Adapted from Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 14.

company. Direct inclusion of the supplier would make a full partnership possible.

1.1.4 Measurement

For strategic supplier management, evolution of the supplier relationship in the areas of measurement, quality, cost, and cycle time would also need to occur (see Table 1-5). In a confrontational or arm's length supplier management practice, the focus on price would result in contractors squeezing price reductions out of suppliers at the cost of quality and delivery. The prime contractor could also focus on lead time reduction at the expense of missing shipments to customers. Suppliers may be left to bear the burden of lead time reduction as well: additional warehousing costs would either be absorbed by the supplier or passed on to the prime contractor through higher prices. In an advanced supplier management system, the total cost of procurement would be a guiding metric. The total cost of procurement would include not only price, but also the cost of poor quality and poor delivery. Finally, the concept of cycle time and its measurement would become important not only in manufacturing but to the entire organization.

Table 1-5: Stages of Supplier Management in the Areas of Measurement, Quality, Cost, and Cycle Time[9]

	Stage 1 Confrontation	Stage 2 Arm's Length	Stage 3 Goal Congruence	Stage 4 Full Partnership
Measure-ment	Price	Stock-outs	Inventory turns	Total cost
	Variation from budget	Line shutdowns	Lead time reduction	Total cycle time
Quality	Specs are vague and arbitrary	Specs: formula computer approach	Classification of characteristics	Specs through QFD
	Boiler-plate AQLs[a]	Reduced AQLs	Zero defects	Target values
	Heavy incoming inspection	Reduced incoming inspection	Skip lot	Certification
	Cpk[b] unknown	Cpk>1.33	Cpk>2.0	Cpk>5.0
	SPC[c] unknown	SPC control charts	DOE[d] to solve problems and precontrol for SPC	DOE at design stage of product/process
Cost	3-Quote syndrome	Negotiations through bluff and bluster	Value engineering	Cost targeting
	Part proliferation	Standardization	Reduced part number and model base	Business concentration
	Random part number system	Preferred parts list	Description data base	Group technology
Cycle time	Large safety stocks	MRP[e] and over-reliance on computer	Focused Factories	Schedule linearity
	Long lead time	Push system	Pull system	Indirect labor productivity
	Poor and yo-yo forecasts	Long production runs; long setup time; process flow	Small lot sizes; short setup times; product flow	Near-instant customer delivery

[9] Adapted from Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 15-16.
[a] See section 1.1.5 Quality, for a discussion of AQLs, Acceptable Quality Levels.
[b] See section 1.1.5, Quality, for a discussion of C_{pk}'s.
[c] See section 1.1.5, Quality, for a discussion of Statistical Process Control in supplier quality management.
[d] See section 1.1.5, Quality, for a discussion of Design of Experiments in supplier quality management.
[e] See section 1.1.7, Cycle time, for a discussion of MRP, manufacturing requirement planning, in supplier management.

1.1.5 Quality

In the area of quality, supplier management practices have generally experienced improvement. Progression toward advanced strategic supplier management practices would shift the focus on incoming inspection towards process control. In primitive systems, ineffective methods of exerting control over suppliers would be used. Acceptable quality levels (AQLs) would generally "boiler-plate" numbers based on tradition more than logic. The concept of C_{pk}'s and statistical process control (SPC) would be generally unknown in non-strategic relationships. Strategic supplier management would require a focus on process-oriented control rather than product-oriented control as well as a raised level of awareness of the techniques available to effectively maintain process control (and a willingness to implement them). In supplier partnerships, supplier quality training and the use of statistical design of experiments (DOE) would also be encouraged by the prime contractor. Furthermore, the use of design of experiments would be encouraged not only for solving chronic quality problems, but also for product and process design. "Precontrol" through DOE would replace the control charts of SPC. Contractor certification programs would eliminate incoming inspection and encourage early process control (precontrol) to achieve higher C_{pk}'s, zero defects, and 100 percent yields.

1.1.6 Cost

In the area of cost, the implementation of strategic supplier management would require changing methods used to determine cost and controlling the proliferation of suppliers and part numbers. The practice of getting "3 quotes" and selecting the lowest bidder, as characterized by Bhote, would be replaced by a system of "cost targeting" in which the estimated competitor costs would be targeted for reduction by a joint team of engineers from the prime contractor and supplier companies. Parts standardization would mitigate the problem of large numbers of part numbers. The problem might be better reduced, however, by shedding unprofitable product lines and by using group technology. Group technology refers to a method of defining parts with similar product

characteristics and manufacturing methods to limit parts proliferation and reduce setup and inventory costs.

1.1.7 Cycle Time

The strategies for reducing cycle time may also be expressed in terms of the four stages of supplier management. In stage 1, prime contractors and suppliers would resort to large safety stocks as insurance against bottlenecks. Large safety stocks would allow for on-time delivery despite problems along the path to production. In stage 2, manufacturing requirement planning (MRP) systems would be introduced. Stage 3 is characterized by the use of focused factories in which similar products are produced by dedicated, cross-functional teams. In a stage 4 relationship, schedule linearity would be practiced, in which the total output would be held constant over short periods of time, and the support functions would be added to the focused factory team. Long lead times would be reduced in strategic supplier management by extending the practice of cycle time management to all indirect labor operations. Finally, product delivery would become nearly instantaneous in an advanced supplier management system.

1.2 Changing Models of Supplier Relationships

The trend toward forming strategic supplier partnerships was strong in the automotive industry but has experienced difficulties and delays in creating widespread change in the defense aerospace industry. In this section, I will first describe changes in the model for supplier relationships in the auto industry. The partnership model for supplier relationships in the auto industry serves as a prescriptive model for supplier relationships in the aerospace defense industry. The differences between these two industries along the dimensions of supplier relationships as well as the nature of the products developed and produced, however, serve as additional barriers to the widespread implementation of a new supplier relationship model in the defense aerospace industry.

In the early 1980s, American auto makers began to change the structure of their supplier relationships because they were under competitive pressure from the Japanese auto makers. The Japanese had effective supplier relationships built on a large integrated manufacturing system. American auto makers who had been in confrontational or arm's length relationships began to adopt more collaborative and cooperative relationships. Traditional American approaches to supplier relationships were generally replaced by Japanese approaches. Both the traditional American model and the Japanese model for supplier relationships are virtually nonexistent in their original form, but the contrast between the "traditional" American and "new" Japanese approaches serves to illustrate the changes among supplier relationships in the auto industry. Features of the new (Japanese) model for supplier relationships in the auto industry are highlighted in Table 1-6.

The Japanese "keiretsu" alliances have been described as a critical source of Japanese competitive advantage.[10] Several advantages were discussed in the beginning of section 1.1. Partnerships have been described as a way to reduce product development time, share risks and resources, and acquire new skills or technologies in a commitment to learning.[11] The following section highlights the nature of Japanese partnerships, with the knowledge that these partnerships have been a valuable source of competitive advantage.[12]

[10] Gerlach, Michael, "Business Alliances and the Strategy of the Japanese Firm," *California Management Review*, 30, 1987, pp. 126-142.
Also: Nishiguchi, T., *Competitive Industrial Strategy*, New York: Oxford University Press, 1994.
Dyer, J.H. and W.G. Ouchi, "Japanese Style Business Partnerships: Giving Companies a Competitive Edge," *Soan Management Review*, Vol. 35, No. 1, Fall, 1993, pp. 51-63.
[11] Hamel, G., Doz, Y., and C.K. Prahalad, "Collaborate with Your Competitors--and Win," *Harvard Business Review*, January-February, 1989, pp. 133-139.
Also: Clark, K.B. and T. Fujimoto, *Product Development Performance*, Boston: Harvard Business School Press, 1991.
[12] Quinn, J.B. and F.G. Hilmer, "Strategic Outsourcing," *Sloan Management Review*, Summer 1994, pp. 43-55.

Table 1-6: Changing models of supplier relationships[13]

Category	Old Model	New Model
CHARACTER	• Distrust; dominance	• Trust; partnership
SUPPLIER NETWORK		
• Number of suppliers	• Large	• Small
• Supplier structure	• Flat	• Hierarchical
NATURE OF CONTRACTS		
• Contract length	• Short	• Long
• Stability	• Unstable	• Stable
SUPPLIER COMPETITION		
• Make vs. buy	• Bias for make	• Bias for buy
• Competitive pressure	• Competitive bidding	• Two-vendor policy
PRODUCT DEVELOPMENT		
• Role in product development	• Small role of suppliers	• Larger role of suppliers
• Timing of supplier involvement	• Late involvement of suppliers	• Early involvement of suppliers
• Forward integration of suppliers	• None: piece parts only	• Suppliers make kits, black boxes
• Reach-out to sub-suppliers	• Little or none	• Direct influence 2 to 3 levels down
QUALITY MANAGEMENT		
	• Detection rather than prevention	• Problem-solving
	• Quality control and inspection	• No incoming inspection
	• High defect rate	• Low defect rate
INFORMATION FLOW		
• Training	• Nonexistent	• Ongoing
• Technical help	• Very little	• Quality, cost, engineering help
• Responses to problems	• Exit system (finding a new supplier)	• Voice system (solving problems together)
	• Bargaining-oriented	• Problem-solving oriented

1.2.1 Character

The character of the traditional American model for supplier relationships differed dramatically from that of the Japanese model. The elements of suspicion in the traditional model typified the arm's length relationship

[13] Adapted from the following sources: Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 28, and Takeishi, Akira. *A Study of Supplier Relationships in the American and Japanese Automotive Industries*, Thesis in Management at the Massachusetts Institute of Technology, 1990, p. 19.

discussed in the first section of this chapter. In the traditional model, there was a low level of commitment between the supplier and the customer (the auto maker). The goal of the American auto maker was to maintain economic dominance over its suppliers and to reduce the risk of becoming dependent on any supplier. To maintain the strength of their bargaining position, American auto makers purchased parts at relatively low stages of assembly from a correspondingly larger number of suppliers. The suppliers were responsible for simply manufacturing parts that the auto maker designed. The suppliers were also aware that their relationship with the auto maker could be ended at any time in reaction to dissatisfaction related to any performance measure--including price. The low levels of commitment between the parties were also perpetuated by the (typically) short length of contracts.

The Japanese style of supplier relationships had the character of a full partnership. The level of commitment between the Japanese auto maker and its suppliers was high. The Japanese model of supplier relationships maximized the total benefit for the entire value chain of participants in the product development and production process. In the Japanese tiered supplier system, auto makers purchased component systems from the first-tier suppliers who, in turn, purchased parts from sub-suppliers in the second tier, and so on. The Japanese auto makers, thus, conducted direct business with a limited number of suppliers. Similar to the full partnership model of the first section of this chapter, the Japanese practiced single sourcing, with one supplier for a particular part. The Japanese also expanded the supplier role in the product development process to include detail design, sub-supplier management responsibilities, and some inspection functions.

1.2.2 Supplier Network

In the American model, the number of suppliers was vast and proliferating, and the supplier structure was flat. Auto makers maintained design control over the more complex component systems and maintained control over sub-assembly processes and the overall assembly process. The traditional American model of supplier relationships was designed to

ensure the auto maker against the risk of becoming dependent on any supplier by maintaining tight design and process control. American auto makers maintained a strong bargaining position by using a large pool of suppliers, switching suppliers, and maintaining a low level of commitment to the suppliers. American auto makers used several suppliers for the same part to minimize the risk of losing their dominant position. Furthermore, if the auto maker was not satisfied with the price or the quality of a part made by a particular supplier, the auto maker had several other suppliers to choose from. The auto maker might also inform suppliers that they could be dropped from their relationship without causing the customer any problems. With a vast supplier base, the auto maker could often make such a statement without much difficulty.

The American supplier model increased the supplier base by reducing barriers to entry into the component market.[14] Auto makers switched suppliers often, used several suppliers per part, brought most of the detail component design in-house, and carried out integration tasks. Thus, the suppliers' skills were reduced to a minimal level. As a result, most suppliers had no in-house design capability. The technology needed to enter the supplier market was minimized to part production. There was also an incentive to enter the market because the auto makers tended to switch suppliers and were primarily interested in price reductions that both new or old suppliers could offer.

The Japanese supplier system, on the other hand, was characterized as a tiered structure in which auto makers bought component systems from the first-tier suppliers who, in turn, bought parts from sub-suppliers. The hierarchy continued for the sub-suppliers of each tier in a similar manner. Thus, the Japanese auto makers conducted direct business with a distinct number of first-tier suppliers. The hierarchical pyramids of the Japanese supplier structure are shown in Figure 1-1. In the structure, lower-tier suppliers may overlap across and be part of several different pyramids of

[14] Helper, Susan. "Strategy and Irreversibility in Supplier Relations: The Case of the US Auto Industry." *Business History Review*, September 1991, p. 806.

first-tier supply chains. In other words, lower-tier suppliers may be suppliers to multiple higher-tier suppliers.

In the Japanese model, the auto makers relied on components and subassemblies from a small number of first tier suppliers. The first tier suppliers generated these component systems from a combination of parts produced in-house and parts from other lower-tier manufacturers. In the Japanese model, each tier of suppliers needed to manage its relationship with the tiers beneath it. Thus, while the lower tiers supplied progressively simpler components, higher tiers needed to be prepared to manage an integrated supply chain.

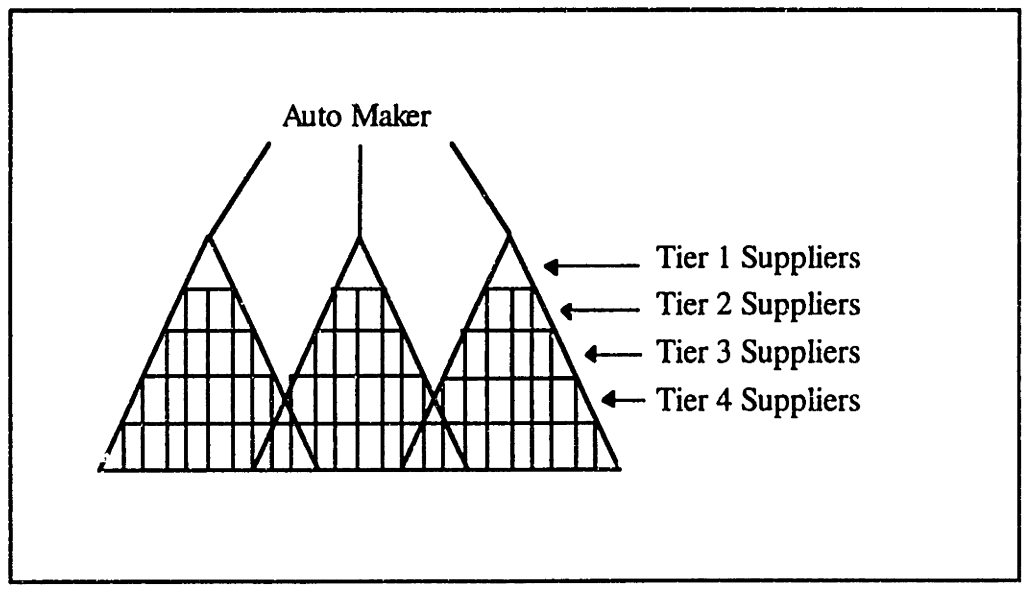


Figure 1-1: The ALPS Structure of Suppliers[15]

1.2.3 Nature of Contracts

The traditional American auto makers' contracts were short--typically for one year, after which competitive bids were reopened.[16] The short length and general instability of these contracts allowed American auto makers to

[15] Source: Nishiguchi, Toshihiro. "Competing Systems of Automotive Components Supply: An Examination of the Japanese 'Clustered Control' Model of the 'Alps' Structure." International Motor Vehicle Program (IMVP) Working Paper, May, 1987, p.7.
[16] Helper, Susan. "How Much Has Really Changed Between US Automakers and Their Suppliers?" *Sloan Management Review*, Summer 1991, p. 16.

maintain the economic dominance that characterized their arm's length supplier relationships.

Japanese auto makers, on the other hand, purchased parts from suppliers with whom they had long-term relations. Suppliers who achieved higher ratings from auto makers could obtain longer-term commitments. Thus, higher-performing suppliers enjoyed the benefits of long-standing relations with auto makers while weaker-performing suppliers were demoted to a lower tier. Suppliers also had a greater incentive to improve existing products and processes as well as to create innovative solutions because they could be rewarded with a longer-term contract and could enjoy more stable business.

Japanese auto makers also instituted practices to encourage continuous improvement and innovation without the threat of the customer leaving the relationship. The Japanese practiced single sourcing, an arrangement in which there is only one supplier per part number. With single sourcing, however, there existed the risk of losing control over prices, quality, and performance of the part as a result of freeing the supplier from competition. To minimize this risk, Japanese auto makers encouraged competition among its competent suppliers. The best supplier would be chosen among a small number of suppliers. This method of choosing among a small number of suppliers encouraged competition. The Japanese auto makers, however, not only encouraged competition, but also strategically helped the weaker suppliers. By providing technical help and training to its weaker suppliers, the Japanese auto makers fostered the ability of all their suppliers to remain competitive.

1.2.4 Supplier Competition

Under the traditional model, American auto makers tended to make their own sub-assemblies and components. Some of the factors in a make-buy decision are given in Table 1-7.[17]

Table 1-7: Factors included in an accurate make-versus-buy analysis[18]

Make	Buy
• Direct labor and materials • Cost of incoming inspection of piece parts • Costs of poor quality: scrap, analyzing, repair, line inspection, and test • Direct labor and administrative overhead • Technical/managerial capability and plant capacity tied up • Inventory costs: piece parts • Purchase transaction and handling costs: piece parts • Quality assurance and engineering costs: piece parts	• Supplier price • Cost of incoming inspection of product • Purchasing, supplier quality assurance, engineering costs: product • Inventory costs: product

The basis for American auto makers' decisions to make their sub-assemblies was the desire to keep design control within the firm. There was also a desire to maintain supplier competition by encouraging a proliferation of suppliers and by maintaining low barriers to entry. American auto makers also maintained competitive pressures among its supplier base by using a process of competitive bidding for the component systems that it purchased. The dominant pattern was an annual inquiry of suppliers. The suppliers with the lowest bids were chosen regardless of prior relations with the auto makers. The process of competitive bidding ensured that auto makers would achieve the lowest price, while the bias for making

[17] Also see: Fine, C.F. and D.E. Whitney, "Is the Make-Buy Decision Process a Core Competence?," MIT Center for Technology, Policy, and Industrial Development, January, 1996.

component systems ensured that the most complex, detailed design work was carried out in-house.

The Japanese model encouraged a full partnership with suppliers. Under this model, outsourcing any non-core component or sub-assembly technology was the dominant pattern. The Japanese auto makers thereby allowed suppliers to have a greater role in product development. The Japanese auto makers also used a "two-vendor policy" for the competition among its suppliers. The policy encouraged competition between suppliers with long-standing relations to foster a continued commitment to improving product and process performance, lowering costs, and making innovative breakthroughs.

1.2.5 Product Development

The role of suppliers in product development may be classified into three types, suppliers of: (1) "supplier-proprietary" parts, (2) "black box" parts, and (3) "detail-controlled" parts.

Supplier-Proprietary Parts Suppliers

Supplier-proprietary parts suppliers developed the parts entirely as standard products. These suppliers typically had full in-house research and development facilities. Rather than designing to customer's specifications, these suppliers provided off-the-shelf proprietary components.

[18] Adapted from Bhote, Keki R. *Strategic Supply Management: A Blueprint for Revitalizing the Manufacturer-Supplier Partnership*, New York: American Management Association, 1989, p. 72.

Black Box Parts Suppliers

The terminology, "black box parts," referred to an auto makers' drawings of the part. The parts were simply drawn as empty boxes, indicating the type of parts that would be installed in those spaces rather than indicating the detailed design of the parts.[19]. These suppliers typically had in-house R&D facilities and were able to conduct detailed engineering based on the functional specifications provided by the auto makers.

Detail-Controlled Parts Suppliers

"Detail-controlled" parts are those parts entirely designed by auto makers. These suppliers typically did not have in-house design capabilities. They received the detailed designs from customers and merely manufactured the parts. ("Piece part" suppliers may fall into this category when the parts produced by the supplier are relatively small or simple.)

Table 1-8 summarizes the nature of the design work performed by Japanese and American auto suppliers in 1989. Black box suppliers accounted for 62% of Japanese suppliers while American auto makers used detail-controlled parts for 81%.

Table 1-8: Nature of Design Work Performed - % of Total Parts Costs (1989)[20]

	Japanese	US
Supplier-Proprietary	8%	3%
Black Box	62%	16%
Detail-Controlled	30%	81%

Each supplier model therefore matched the nature of the actual design work performed. In other words, American auto suppliers had a small role in product development and manufactured piece parts designed by the auto maker. On the other hand, the role of suppliers in product development

[19] Stein, Kevin P. *Implementing Japanese-Style Supplier Relationships in the US Auto Industry*, MIT Sloan School of Management Master's Thesis, May 1994, p. 8.
[20] Takeishi, Akira. *A Study of Supplier Relationships in the American and Japanese Automotive Industries.* MIT Sloan School of Management Master's Thesis, May 1990, p. 13.

was larger in the Japanese model, encouraging a larger percentage of suppliers to make "kits" or black boxes according to the functional specifications provided by auto makers.

Table 1-6, Changing Models of Supplier Relationships, captures other dimensions of the differing roles of suppliers in product development. Particularly, the traditional American model indicates that suppliers were brought into the development process later than their Japanese counterparts. The American auto suppliers were involved once the designs had been completed, at a late stage in product development. In the case of detail-controlled parts, suppliers were brought in only for their manufacture after the development of the product.

The Japanese partnership model encouraged early involvement of suppliers. Suppliers were part of the design team and were encouraged to make technological improvements to the design of the product or the process of its manufacture as well as improvements over the product cost.

1.2.6 Quality Management

Traditional American quality management relied on detection of errors rather than a process of prevention of those errors (see Table 1-6). Quality control and inspection were the central focus of typical American quality management programs. Using this after-the-fact method, American auto makers did not try to learn from their experience with defective parts by determining the root of the problem. American makers therefore tolerated variance by its suppliers. Furthermore, their quality control and inspection methods centralized responsibility for defects in certain staff rather than diffusing the responsibility to all employees. Finally, ad hoc adjustments were made to minimize defects.

The Japanese quality management program was focused on problem-solving with the suppliers. Japanese auto makers assumed a zero defect rate, effectively eliminating the inspection of incoming parts. The basis of assuming a zero defect rate was to eliminate defects at their origin. Auto makers urged suppliers to solve problems at their origin whenever problems

would arise. Employees at the auto maker and the supplier firms were responsible for solving quality problems and became accountable for their products.

1.2.7 Information Flow

The American arm's length relationship placed information exchange between the customer and supplier at a minimal level. Auto makers provided a set of delivery expectations, including part print, packaging, delivery frequency, and quality requirements, in a request for quotation (RFQ), and suppliers responded with their bids.[21] Because the large majority of American auto suppliers provided detail-controlled parts, the level of information exchange was low. Training for suppliers by the auto makers was virtually nonexistent. Little technical help was provided. A bargain-oriented approach was used by the auto maker in response to problems. If the supplier problem was significant, the auto maker would simply find a new supplier.

The arm's length approach to supplier relationships also had elements of suspicion. Auto makers wanted to minimize the risk of dependence on any supplier by, among other things, minimizing the extent of joint activity with suppliers. Suppliers also wanted to protect competitive information, including their cost structure, to avoid placing a cap on their price premiums. There was a fear that sharing information would expose suppliers to the risk of losing their competitive advantage. If, for example, a supplier offered a proprietary technology, the technology would be protected to avoid dissemination of the technology to other suppliers who might accept lower margins to produce it.

Table 1-6 highlights differences in information flow between the American and Japanese models for supplier relationships. Japanese auto makers and suppliers worked at a high level of information exchange. Information exchange in the Japanese model was both vertical and horizontal across the tiered structure. Vertical information exchange occurred up and down the

[21] Stein, Kevin P. *Implementing Japanese-Style Supplier Relationships in the US Auto Industry*, MIT Sloan School of Management Master's Thesis, May 1994, p. 8.

pyramids of suppliers (see Figure 1-1) as well as between the customer and supplier. Some of the data exchanged might have included product design, volume plans, long range strategic plans, proprietary technologies, manufacturing processes, cost structures, and research and development efforts.

With a full partnership, based on working together in product and process design and manufacturing for mutual benefit, the Japanese system encouraged open relations. Auto makers provided ongoing training and technical help and adopted an approach of solving problems together. Because risks of opportunistic behavior (on the part of their suppliers) existed in the Japanese model, Japanese auto makers needed to work hard to maintain the trust, loyalty, and commitment of their suppliers.

Certain measures have been taken in the defense aerospace industry to work towards the supplier partnership model for improved relations and their associated benefits. Government acquisition reform initiatives have had a significant impact on supplier relationships in certain programs, but the tendency toward strategic partnerships has not been widespread. The Defense Acquisition Pilot Programs, including the Joint Direct Attack Munition (JDAM) program, represent a significant step toward supplier partnerships in the defense aerospace industry.

The next chapter briefly outlines the research methodology. The results of Chapter 3 are primarily drawn from interviews with members of the JDAM program. The findings from the program illustrate not only the emergence of supplier partnerships but also the importance of business strategies of the subcontractors involved in the program as well as the implications of managing the types of innovation on the subcontractor level through managing integration of the subcontractor into the contractor team. These findings are expressed in detail in Chapters 3 and 4. Appendices B and C also present information regarding the JDAM program in detail.

CHAPTER 2

Research Methodology

Information regarding supplier involvement in product development for the JDAM program was collected through two main methods: field interviews and survey research. The survey encompassed a broad range of topics and targeted several defense aerospace programs including the JDAM program. In contrast, the JDAM program was the focal point of the field interviews.

2.1 Field Interviews

The field interviews, and not the survey research, were the primary source of information for the thesis. The field interviews were conducted in early 1996. The determination of potential contacts and arrangements for the company visits began in the fall of 1995. Managers and engineers were interviewed at McDonnell Douglas Aerospace, the selected prime contractor for the JDAM program. In addition, subcontractors for the program were interviewed. The primary subcontractor for the thermal battery source and the three primary subcontractors for the Guidance Control Unit provided details regarding supplier management operations for the program. These interviews provided information which not only distinguished JDAM's supplier management practices from the norm but also showed significant differences between the supplier management practices of each of the subcontractors.

2.2 Survey Research

With the help of Product Development Focus Group Members in the Lean Aircraft Initiative Consortium, a Survey of Contractor and Customer Relationships in the Defense Aerospace Industry (formally entitled the "Lean Aircraft Initiative Survey on Product Development Practices in the Defense Aerospace Industry: Contractor and Customer Relations Survey") was developed in early 1995. Several drafts of the survey were reviewed and asked to be pre-tested by members of the Lean Aircraft Initiative Consortium (within the Product Development Focus Group) prior to the first mailing.

The survey was limited to 18 aerospace defense projects: AIM9X, AM^3, Apache Longbow, C-17, Comanche, F-14, F-16 Block 50, F/A-18 E/F, F-22, F-110 Engine, JAST, JDAM, JSOW, Kiowa Warrior, LANTIRN, SFW, Tier 2 UAV, and V-22.

2.2.1 Contents of the Survey

The survey was composed of six sections, for a total of 100 pages, although each respondent was only asked to complete two of the six sections. After the initial set of survey mailings, only the sections of the survey that were relevant to each respondent were sent out.

The first section of the survey, Respondent Information, was a general section for all respondents. Information requested in Section 1 included background information about the respondent's involvement with a project, the various information flows within a particular project, and customer and prime contractor interactions.

Respondents were asked to complete one of the next five sections of the survey depending upon their project's current stage of product development. The sections were divided according to various stages of product development: Concept Exploration, Demonstration and Validation (ATD), Engineering and Manufacturing Development (E&MD), and Production, as well as Operations & Support.

Section 2, Concept Development, included questions concerning requirements analysis, contract structure, and information flows. Section 3, Demonstration and Validation (ATD), included similar questions to the previous section, with additional questions concerning Contract Data Requirements Lists, Life Cycle Cost, Risk Assessment, and Producibility Analyses. Section 4, Engineering and Manufacturing Development (E&MD), contained similar questions to the previous section. Section 5, Production, focused on information flows as well as changes that affect those involved in production.

2.2.2 Identification of Potential Respondents

Lists of potential respondents from the Focus Group Members were acquired and combined beginning in early 1995. The intent of the survey was to target respondents across: the entire product development cycle, several projects, Government and industry (prime contractors and subcontractors), and job functions to gain a broad perspective of the relationships that exist in the aerospace defense industry. The job functions that were targeted are included in the following table:

Table 2-1: Targeted Job Functions

Government	Industry
PEO	Program management
Program management	Engineering
Technical management	Manufacturing and Production
Financial management	Logistics
Engineering	Contracts
Manufacturing and Production	T&E and Reliability
User	Marketing
DPRO	
Logistics	
T&E and Reliability	
Marketing	

With a broad range of job functions desired from both the industry and Government for several projects, a full sample of respondents was difficult to attain. The list of potential respondents also proved difficult to attain

and thereby limited the significance of the total sample. In the next section, the processes used to obtain responses for the survey are described.

2.2.3 Survey Mailing

In June 1995, the first set of approximately 120 surveys was mailed to the names received from the Focus Group Members. Subsequent sets of surveys were added as additional names and addresses of potential respondents were received. A total of approximately 220 surveys were mailed to potential respondents throughout the summer and fall of 1995.

With a low response rate, two follow-up letters were sent to those who had not responded. The first follow-up letter was mailed in the beginning of August, and the second one two weeks later. Because there was still a low response rate, the help of Consortium Members was requested. A total of approximately 120 surveys were returned.

2.3 Barriers and Limitations

Several factors contributed to the difficulties that were experienced in the collection of the survey responses. The incomplete sample could be attributed not only to the low return rate of the surveys that were mailed out but also to the incomplete list of potential respondents. The survey targeted a large number of people in several programs, which would require distinctive cooperation and assistance from members of each program and company (whose priorities naturally were elsewhere). Because the survey also targeted programs across the product development cycle, the likelihood of receiving significant numbers of responses from programs within the same product development stage was diminished. Although this was partially intentional so as to determine important relationships across the product development cycle, the incomplete sample size restricted the usefulness of the results. The length of the survey also must have deterred several potential respondents from answering the survey. The limitations and complexity of some of the survey questions probably added to the low response rate.

The preliminary analysis of the survey data, however, pointed the research in the direction of program analysis rather than industry-wide or company-wide research. In particular, analysis of survey data showed that programs handled the importance of program relationships differently. The following two tables illustrate this result. Table 2-1 shows the results of an Analysis of Variance performed for the single factor, importance of information. Questions 1.11 through 1.14 are included in Appendix D. Question 1.14 asks the respondent to rank the importance of the program to a given set of stakeholders, including the PEO, SPO, technical support lab, test and evaluation, logistics, training, DPRO, a user representative, a user in the field, the prime contractor, a first tier subcontractor, and a supplier. The statistical mean of the member responses for each program were compared through an Analysis of Variance (ANOVA). Table 2-2 shows that the program means are not significantly related (1.6%) to the overall (grand) mean of all the programs.

Table 2-2: Statistical Analysis of Survey Question 1.14, Importance of Information

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10.27	15	0.68	2.14	**0.016**	1.80
Within Groups	24.27	76	0.32			
Total	34.54	91				

While the importance of the information provided to members of the program varied greatly among the programs surveyed, the detail level of the information provided to these same program members was significantly (84%) related among programs (see Table 2-3).

Table 2-3: Statistical Analysis of Survey Question 1.11, Detail Level of Information

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.74	15	0.38	0.63	0.84	1.80
Within Groups	45.86	76	0.60			
Total	51.6	91				

Thus, while the (mean) level of detail among programs is significantly related, the (mean) importance of information flows among the various program members differs substantially for each program. This result illustrates the need to focus on individual programs to examine more closely the dynamics of the information flows in order to substantiate the differences among programs regarding the importance of these information flows.

CHAPTER 3

Dynamics of Supplier Team Formation In the JDAM Program[a]

The Joint Direct Attack Munition (JDAM) program was designated as a Defense Acquisition Pilot Program (DAPP) to implement the reform initiatives of the Federal Acquisition Streamlining Act of 1994. The actions taken to implement acquisition reform and to improve system affordability changed the dynamics of the relationships among the various parties: the Government, prime contractor, and suppliers. The JDAM program dynamics revealed a change in the overall supplier model from a traditionally hierarchical approach to a collaborative, team-based one. Research also showed that the information exchange patterns of the suppliers was heavily dependent upon the competitive strategies underlying each firm. Finally, the dynamics of the JDAM team model formation resulted in specific types of innovation. In the future, the parties may be able to manage program innovation by focusing on the team dynamics and inter-relationships.

3.1 Introduction to the JDAM Program

The Joint Direct Attack Munition (JDAM) tail kits (Figure 3-1) are INS/GPS guidance kits which attach to 1000- and 2000-pound, unguided bombs,

[a] Factual information regarding the JDAM program was provided by interviews by the author with members of the McDonnell Douglas Corporation, Rockwell Collins, Honeywell, Loral, and Lockheed Martin Specialty Components who were directly involved with the JDAM program. Material was also provided in the form of briefings and other documentation. The interviews were conducted in the early part of 1996. Some material was masked for proprietary reasons. All presentations and materials included in this thesis were unclassified.

thereby converting them into "smart" munitions. The tail kits include external covers, a tail fairing/structure, a tail actuator subsystem, a combined system battery, control fins, a GPS antenna, a wire harness assembly, and a Guidance Control Unit. The JDAM tail kits are also accompanied by storage containers and strakes which are strapped onto the body of the bombs for added maneuverability. Airborne test equipment is also included in the system.

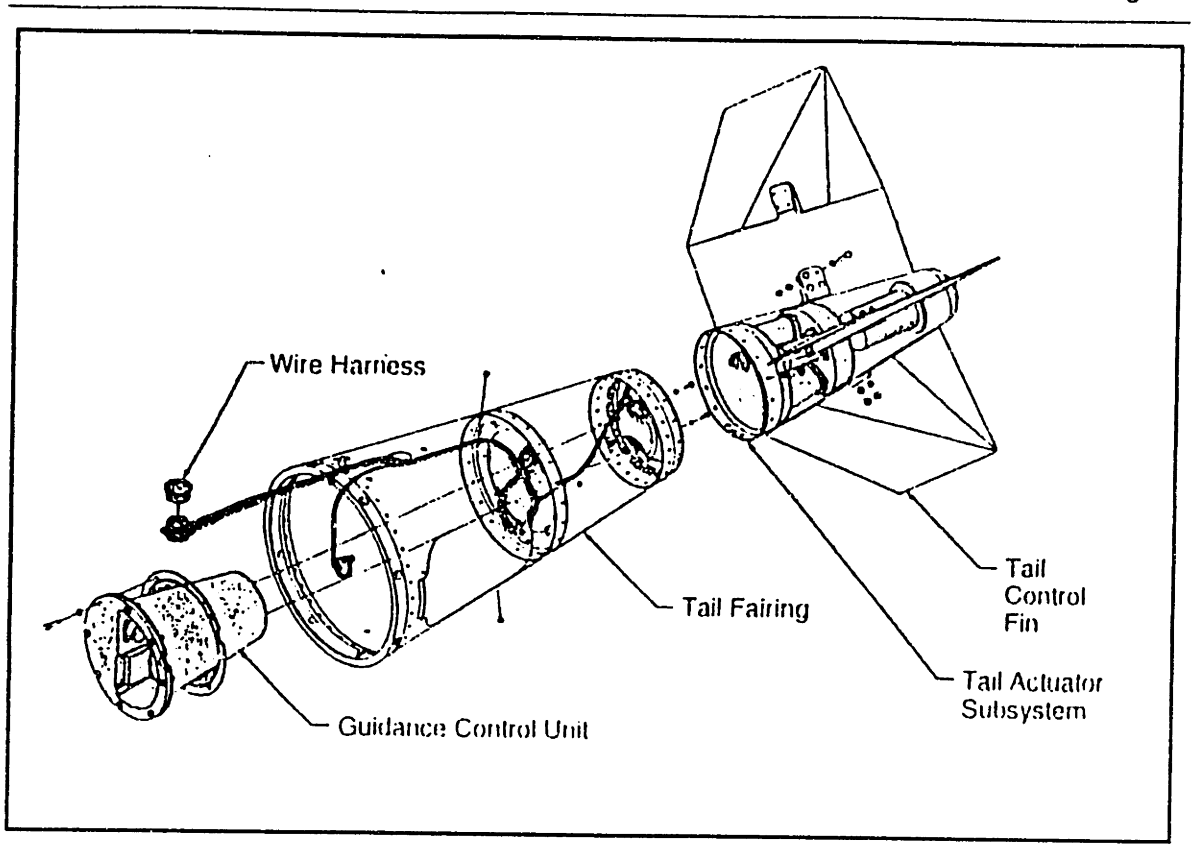


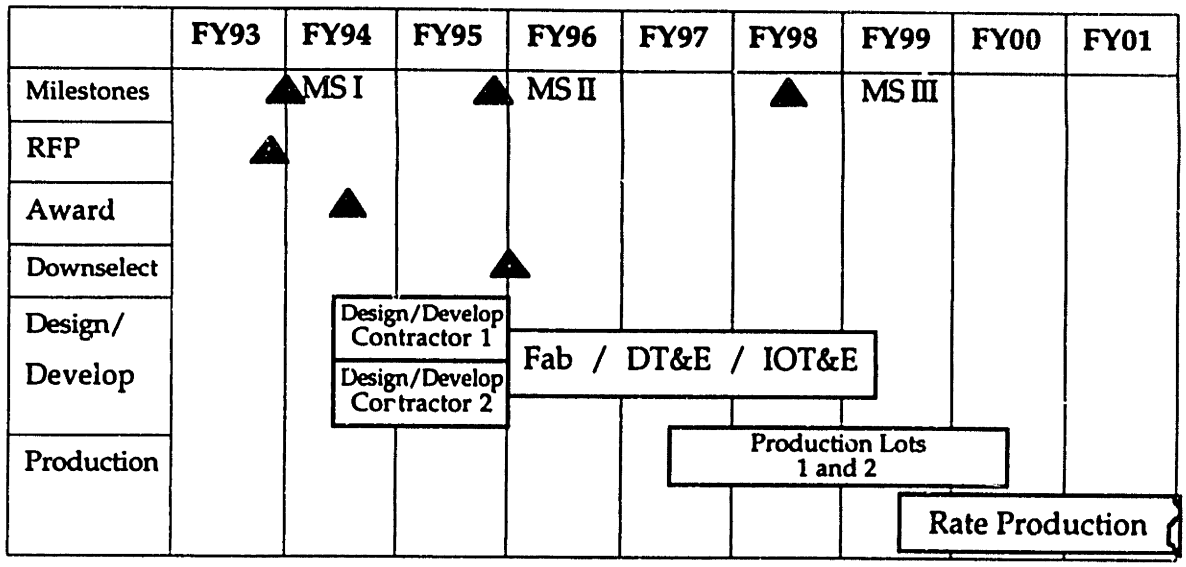
Figure 3-1: The JDAM Tail Kit[22]

[22] Source: "JDAM Tail Kit," McDonnell Douglas Presentation, January 10, 1996.

3.1.1 Program Schedule

The joint Air Force and Navy Defense Acquisition Pilot Program (DAPP) involved an initial contract award to two prime contractors, Lockheed Martin and McDonnell Douglas, for EMD-1, in 1994. The first phase of development, EMD-1, could be compared to the Demonstration and Validation phase of traditional acquisition processes (with design and development), while EMD-2 includes fabrication, Development Test and Evaluation (DT&E), and Initial Operational Test and Evaluation (IOT&E). Table 3-1 is a schedule of the accelerated JDAM program development. After an 18-month rolling evaluation period with two prime contractors during the first phase of development, EMD-1, the downselect to one prime contractor, McDonnell Douglas, occurred. The downselect occurred at the end of 1995, marking the beginning of the second phase of development, EMD-2. Production lots 1 and 2 are scheduled to be completed by the middle of the year 2000. Roughly 600 tail kits are expected to be produced in Lots 1 and 2. Rate production for the following three lots, Lot numbers 3 through 5, are anticipated to begin in 1999. It has also been agreed that future contract prices and terms may be re-negotiated after the first five production lots.

Table 3-1: Accelerated JDAM Program Development[23]



3.1.2 Price and Number of Units

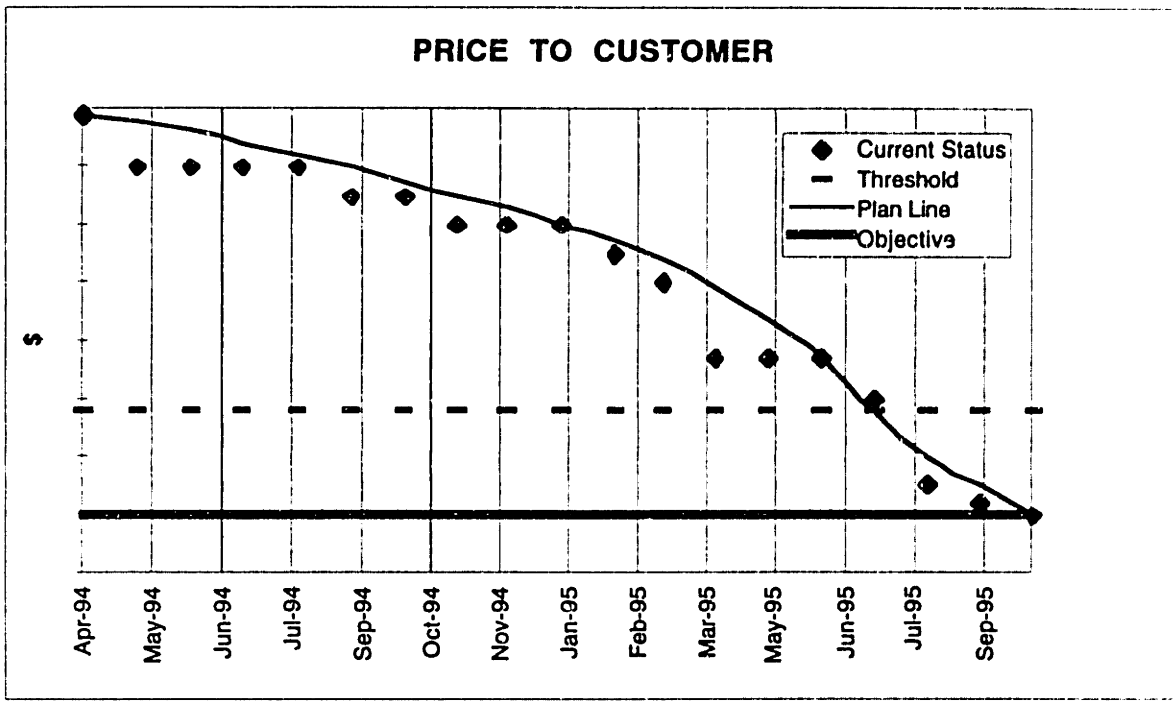
The total order for JDAM tail kits by the Services for the first 5 production lots was 74,000 units (at the end of EMD-1). Initial independent Government cost estimates from the Pentagon were approximately $68K per bomb. The Government requested a kit price requirement of $40K in the Request for Proposal (RFP). The original order was for 40,000 units, but, when the price of the JDAM units dropped dramatically over the course of EMD-1 and once the Government recognized that the kit could be produced for less than the requested $40K per bomb, the order for JDAM kits was raised to 74,000.

McDonnell Douglas won the downselect at the end of EMD-1 with a unit price of approximately $14K. An estimated 60% of the cost of the units involved the Guidance Control Unit. The price of the kit was tracked using an Average Unit Procurement Price tracking data sheet developed by the prime contractor. The data sheet is shown in Figure 3-2. The graph of the price to the customer is represented on a linear scale (along the vertical axis) versus the time in months (along the horizontal axis) for EMD-1. The objective line represented the final objective for the prime contractor (which

[23] Source: "JDAM Development: Accelerated Program," McDonnell Douglas Presentation, June 28, 1995.

the prime contractor met). The threshold value was determined by the prime contractor as the value that needed to be achieved to remain competitive with the other contractor team. The status points on the graph show that the prime contractor met the objective through a series of changes in the Average Unit Procurement Price.

JDAM AUPP Status - IPTs



Near Term AUPP Reduction Initiatives

Item	Description and Status	Delta ($)
1	G&C Initiatives	
2	Airframe Initiatives	
3	Support Equipment	
4	Procurement Initiative	
5		
6		
	Future AUPP Reduction Ideas	
A		
B		
C		
D		
E		
F		

Figure 3-2: AUPP Tracking Data Sheet for the Customer[24a]

[24] Source: "JDAM AUPP Status--IPTs," McDonnell Douglas Corporation, December 1995.

[a] Note: AUPP dollars represented on linear scale. Objective line represents final objective.

3.1.3 Program Results

The efforts of the Government, prime contractors, and suppliers of the JDAM program resulted in significant achievements in increased affordability and schedule reduction, while meeting or exceeding requirements. Some effects of acquisition reform are shown in Table 3-2. The AUPP, as previously mentioned, was reduced from an original R&D startup estimate of $68K to approximately $15K (or $14K) at the time of the contract award for production in October of 1995. The sum of R&D startup costs was reduced from $380 million to $310 million. The development program length was reduced from 46 months to 30 months. Total procurement cycle length was reduced from 15 years to 10 years. The warranty provided by the prime contractor was increased from a 5-year shelf life to a 20-year shelf life. The military performance was increased from the original accuracy requirements. Finally, the streamlining of standards, specification, "how-to's," and requirements had significant effects. Government-mandated military specifications and standards were eliminated (and had originally started at a total of 87 required). Government-mandated Statement of Work pages were reduced from 137 pages to 2 pages. The contractor proposal length was significantly reduced from 1000 to 15 pages.

Table 3-2: JDAM Measurements of Effectiveness: The Results[25]

	Program Milestone Events and Dates		
Measurement	R&D Startup RFPs (10/19/93)	R&D Contract Award (6/94)	Contract Award-Production (10/95)
AUPP (FY 93$)	68,000	48,000	15,000
R&D Costs (FY 93$)	380M	380M	310M
R&D Program Length	46	46	30
Procurement Cycle Length (years)	15	15	10
Warranty Length (years)	5	5	20
Military Performance: CEP[a]	13M/30M	13M/30M	<13M/<30M
Government-Mandated MIL-SPECs and STDs (number required)	87	80	0
Government-mandated SOW[b] specifying contract scope (pages)	137	100	2[c]
Contractor Proposal Length (page count)	1000+	--	15
Government-mandated contract delivery terms (number of reports)	243	250	15 EMD 2
Government program office staffing (manning level)	70	70	59 (1/96) 40 (4/96) 10 (12/97)

SIGNIFICANT ACCOMPLISHMENTS

- $2.1B was saved by the AUPP reduction from $68,000 to $15,000 (76%) for 40,000 production units.
- Reductions in contractual paperwork are unprecedented.
- Military requirements of the operational user were not compromised.
- This is the historic first application of a fix-or-replace warranty to a major weapons system.[d]

[25] Source: "JDAM Program: Current Status, Lessons Learned, and Future Direction as a FASA Designated Pilot Program (4/11/94) through MS II Down Select (11/11/95)," JDAM Program Office, January 19, 1996.

[a] Circular Error Probability: miss distance from aim point, measured in meters with/without GPS aided guidance.

[b] Statement of Work

[c] Statement of Objective

[d] See Appendix C, Product Development Administration of the JDAM Program.

The Government program office manning level was decreased from 70 to 59 by January of 1996 (and then to 40 by April of 1996). The contractor manning levels fluctuated at points of EMD-1, but were approximately 60 for Lockheed Martin and 100 for McDonnell Douglas. The key suppliers each had very few full-time members involved with the program, ranging from 2 to approximately 15, for each of the major subcontractors (discussed in the next section more fully).

For the JDAM program, the Government acquisition reform measures resulted in benefits to the Government in terms of reduced price, reduced development time, and reduced procurement length while meeting performance criteria. Acquisition reform measures (discussed more fully in Appendix C) also resulted in benefits to the prime contractor in terms of greater design flexibility and configuration control. The JDAM program also demonstrated the effect of reform measures on the dynamics of supplier team formation. These supplier dynamics were affected by the underlying corporate strategies of the supplier organizations. The dynamics of team formation in the program were also significant because they changed the system architecture and created architectural links among the original supplier designs which did not previously exist (or existed at a low level of assembly).

3.2 Supplier Team Formation

The Joint Direct Attack Munition (JDAM) program model for supplier relationships differed substantially from the typical hierarchical model that existed historically in defense aerospace programs. In the historical model for defense aerospace program relationships, the relationships between the Government and prime contractor and between the prime contractor and subcontractors (or suppliers) were often arm's length in nature.

The JDAM supplier model, however, was far from arm's length in nature. The Government, prime contractor, and key suppliers formed a central team, eradicating some of the barriers of arm's length relationships. Instead, the relationships more closely resembled goal-congruent

relationships and, at times, even partnerships. The process of forming this JDAM team model was an evolving process that took place over the course of the first development phase (EMD-1)--a period of 18 months. The barriers that each of the parties faced were broken down by actions taken by the Government in instituting acquisition reform and by the prime contractor, McDonnell Douglas, in creating an atmosphere of trust, commitment, and open communications. The actions taken by the Government to initiate acquisition reform are described in depth in Appendix C (preceded by a description of the JDAM program in Appendix B). In Section 3.1.1, the formation of the JDAM team model is described, as the consequence of competition of a rolling downselect process, active involvement by the Government, the changing role of the Government, organizational changes made by McDonnell Douglas, identification of the critical suppliers, and incorporation of these critical suppliers.

3.2.1 The JDAM Team Model For Supplier Relationships

The formation of JDAM team model for supplier relationships was largely competition-driven. The Government invoked competition between McDonnell Douglas and Lockheed Martin, the two prime contractors, through the use of a "rolling downselect" process during the first phase of development, EMD-1. The initial bid proposal narrowed the field of competition down to two prime contractors. The prime contractors were both given contracts for the entirety of EMD-1, with the knowledge that the downselect to one prime contractor would be made at the end of EMD-1. Throughout EMD-1, the prime contractors were continuously evaluated and provided with feedback, but little indication was given of which team was leading or lagging in the process. The rolling downselect, therefore, divided the two contractor proposals and established two contractor teams (Contractor A and Contractor B in Figure 3-3).

The "contractor" teams actually consisted of representatives from the Government and key suppliers as well as from the prime contractor organization. Government involvement, cooperation, and collaboration in the contractor team was significantly reinforced by the use of Government Advocacy Teams (Team A IPT and Team B IPT in Figure 3-3).

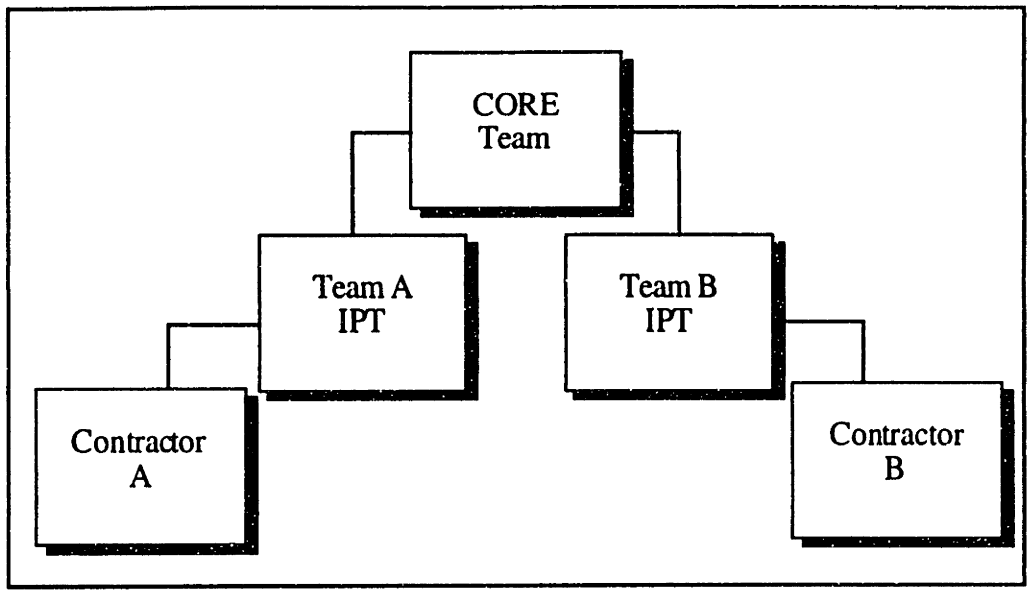


Figure 3-3: JDAM Government Advocacy Structure

The Advocacy Teams were Government teams designed to help the prime contractor achieve its affordability and acquisition reform goals. These Advocacy Teams were the primary interface between the prime contractor and the Government for the JDAM program, providing a direct link to the Joint System Program Office (JSPO). In the majority of defense aerospace programs, the "Core" Team is the main interface between the prime contractor and the Government, involving the functions of contracts, program control, integration and test, projects, and logistics from the JSPO. By changing the main lines of communication, the Government became heavily involved in the program, working together with the prime contractors. In the JDAM Weapon System Organization Chart for McDonnell Douglas, Figure 3-3, the MDA Government (Advocacy) Team has a direct link with the JDAM program manager.

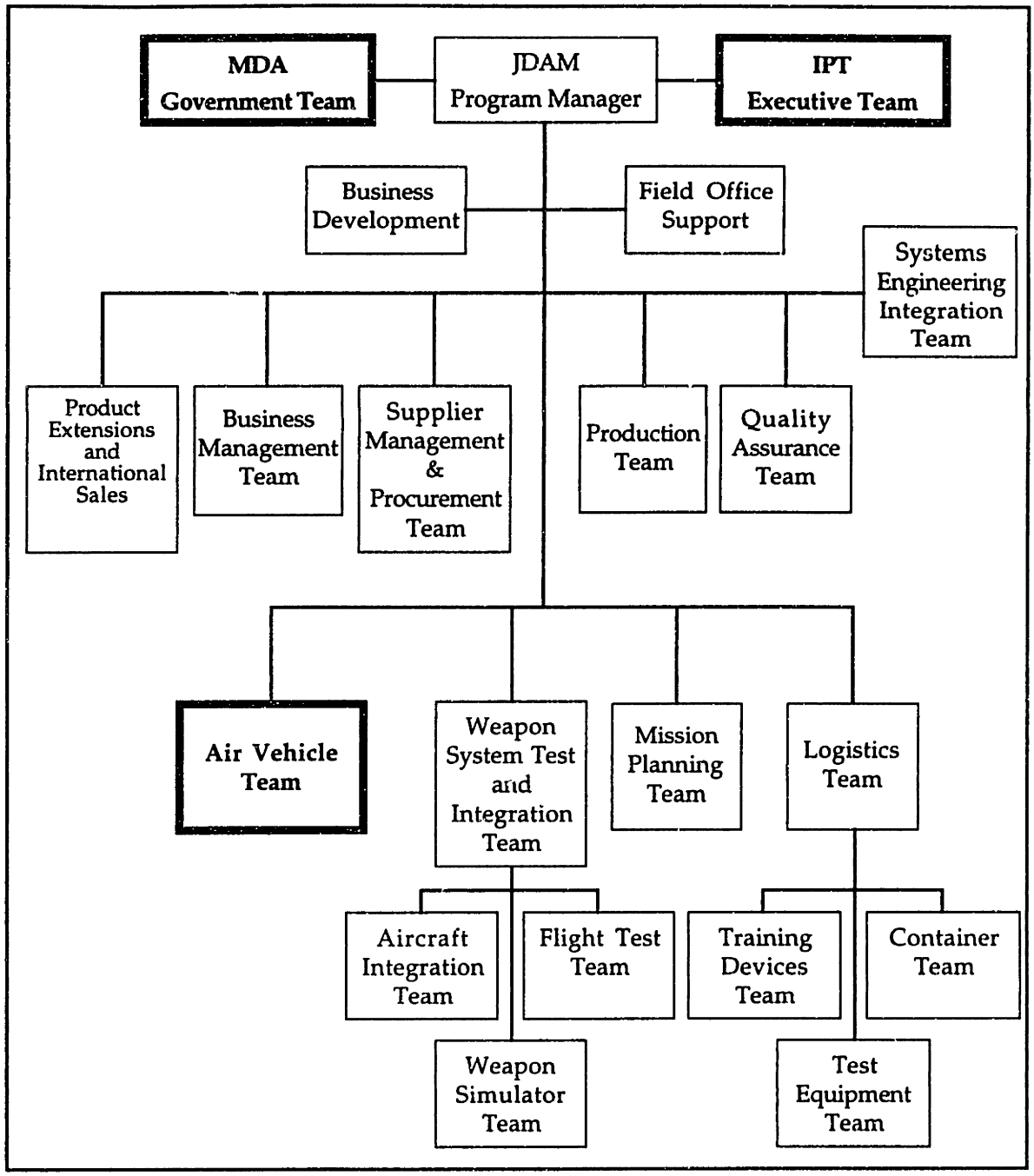


Figure 3-4: McDonnell Douglas JDAM Weapon System Organization[26]

[26] Source: "JDAM Weapon System Organization," McDonnell Douglas, St. Louis, MO, 1996.

The McDonnell Douglas (MDA) team had a unique organizational structure not only because of the levels of Government involvement but also because of the levels of supplier involvement. McDonnell Douglas first identified its major, critical suppliers, and then, over time, these suppliers became teammates. The McDonnell Douglas team consisted of McDonnell, as the weapon system integrator, and the Government as well as the following subcontractors: Honeywell, Loral, Rockwell International (Collins Avionics & Communications Division), HR Textron, and Lockley. These suppliers were an integral part of the JDAM Air Vehicle Team, part of the program structure for McDonnell Douglas, as shown in Figure 3-4. The Air Vehicle Team is decomposed in Figure 3-5, the Air Vehicle Team Organization. The largest portion of the Air Vehicle Organization was composed of the Guidance and Control and Airborne Test Equipment (G&C and ATE) Team. This team was divided into the major subassemblies of the product (excluding the container) and included: the Guidance Control Unit (GCU) Team, the Tail Actuator Subsystem (TAS) Team, the Airframe Team, the Mission Computer Software Team, and the Airborne Test Equipment Team. The Air Vehicle Program Organization was based on the Air Vehicle Product Structure, shown in Figure 3-6.

The JDAM product is essentially a guidance kit providing Inertial Navigation System and Global Positioning System (INS/GPS) guidance to existing free-falling bombs. Because a majority of the product (output) and product cost are contained in the guidance and control function, three of McDonnell Douglas' major subcontractors were part of the GCU Team. Honeywell provided the Inertial Measurement Unit (IMU); Rockwell provided the GPS Receiver; and Loral provided the Mission Computer. HR Textron supplied the Tail Actuator Subsystem, also part of the Guidance and Control function of the JDAM tail kit but external to the GCU Team (see Figure 3-5 and Figure 3-6). The last key supplier, Lockley, was responsible for the Tail Fairing/Structure (part of the Airframe structure) which would attach to the warhead.

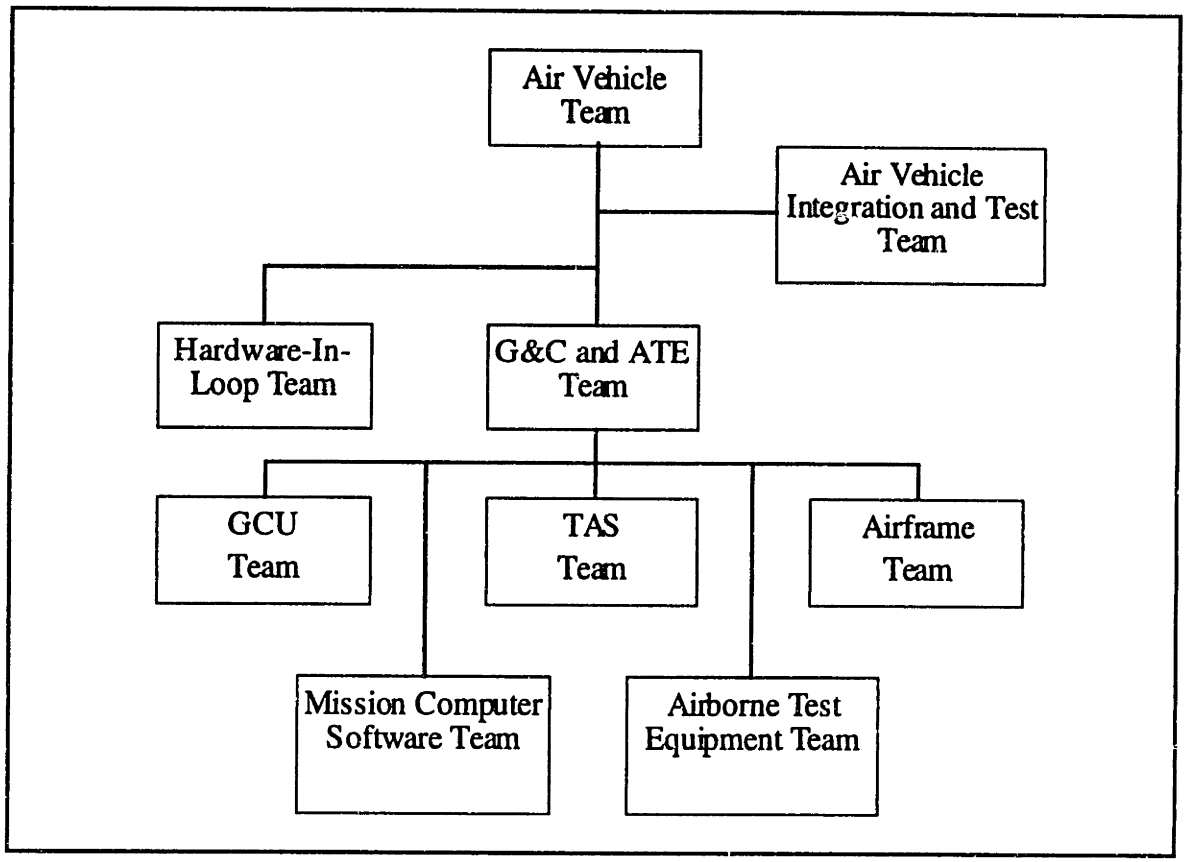


Figure 3-5: Air Vehicle Team Organization

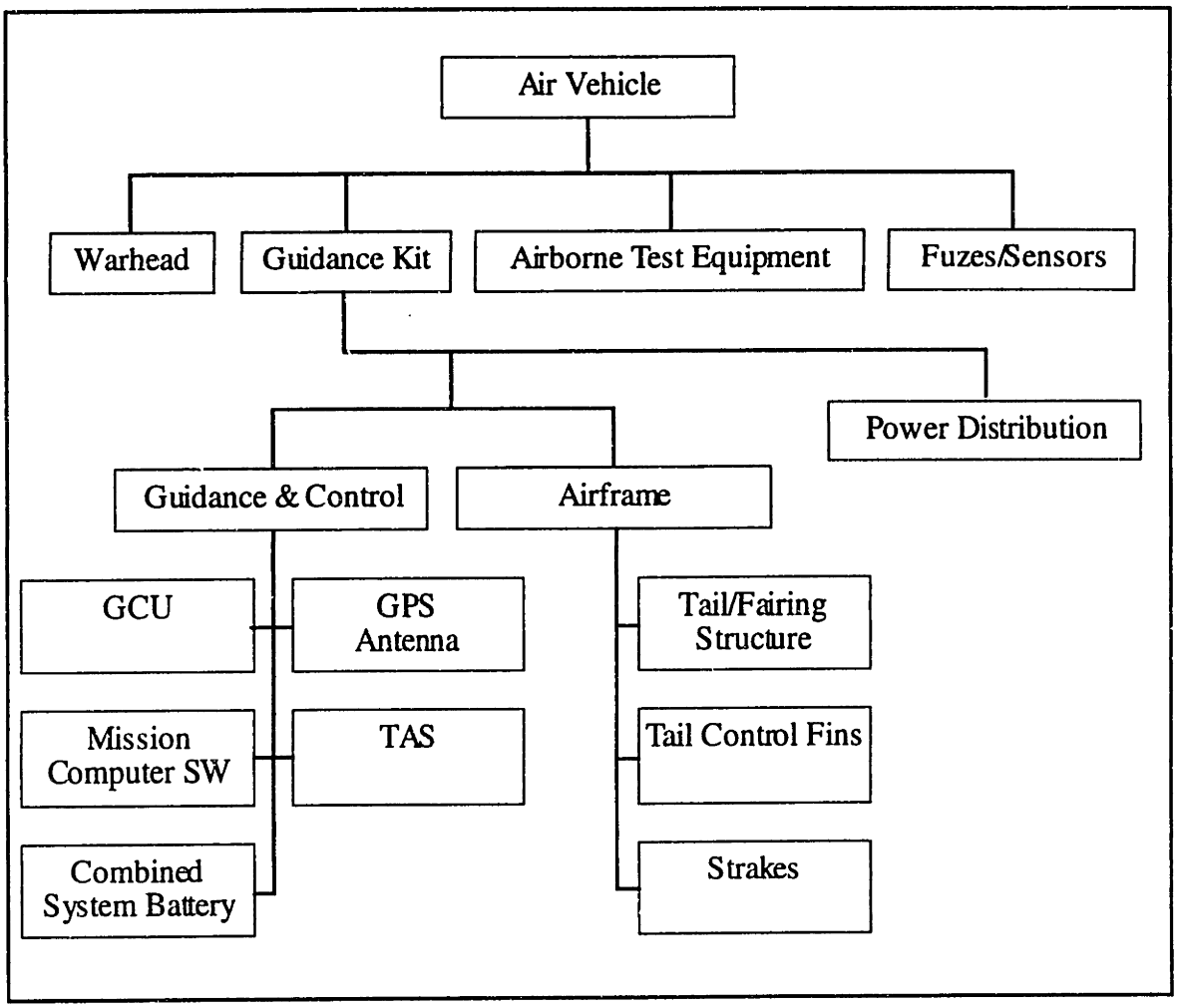


Figure 3-6: Air Vehicle Product Structure

McDonnell Douglas used innovative management practices to bring their subcontractors up to the team level. McDonnell Douglas formed an Executive IPT council (depicted in Figure 3-4) composed of Vice Presidents from each of the major suppliers participating. The formation of the Executive IPT established a formal arena for sustained top management commitment to the program. The Executive IPT discussed high-level program approaches and pricing strategies. Major subcontractors were therefore involved not only in developing a product but in creating and agreeing to a (winning) program strategy. The major subcontractors had a stake in the program and could also express their desire to win the contract. Furthermore, program level decisions were facilitated by the formation of the Executive IPT. With the involvement of top management,

program decisions were generally approved more smoothly because the key issues had been previously discussed.

McDonnell Douglas also created an Affordability Team to support all of its product IPTs and management decisions. McDonnell Douglas' product IPTs spanned across more than its major suppliers, but the level of supplier involvement varied among product IPTs. The level of supplier involvement was highest among McDonnell Douglas' designated key suppliers because of the executive-level teams that McDonnell Douglas created and because of McDonnell Douglas' commitment to making those teams part of an integrated team.

Another link McDonnell Douglas established between itself and its suppliers was the formation of "win strategy" steering committees (and subcommittees). These steering committees were developed to address critical program issues, including: competition strategies, affordability, commercial practices, commercial facilities, technology insertion, and design integration. The steering committees met to discuss ways to win the contract award and ways to improve system affordability. The use of commercial practices and facilities was introduced by the acquisition reform initiatives as well as the Department of Defense's commercial benchmarking results. The basic tenet of using commercial practices in the defense aerospace industry was that it would reduce costs in some cases to use commercial components, materials, practices, and facilities without sacrificing performance and safety. Technology insertion became a critical issue because of the rapid pace of technology advancement and growth. Technology insertion refers to the facilitation of "inserting" new technology advancements into later production lots to avoid or mitigate the problem of technological obsolescence. The benefits of technology insertion could extend to reduced operations, support, and maintenance costs as well. Emphasis on the use of commercial practices and products and the market-driven pace of technology advancement in industry have made technology insertion a viable and potentially lucrative option. Finally, design integration and re-design became necessary parts of the team's strategy to win the contract as the first phase of development came to a close. The key

suppliers became vital to design integration of the system subassemblies and to winning the contract award.

McDonnell Douglas also established "working level" IPTs with the key suppliers to determine program approach alternatives and strategies. These working level IPTs considered material buying approaches, testing and assembly approaches at various levels, pricing strategies, and specification streamlining. Many of the considerations of the working level IPTs were based on acquisition reform initiatives which, for example, encouraged commercial material buying approaches and specification streamlining. The working level IPTs were organized to avoid any overlaps or gaps and were given their own budgets and resource allocation responsibilities. The teams were therefore granted greater autonomy than traditional product teams. The teams were supported by integration and affordability teams, as well as the Executive council and steering committees.

The formal and ...ormal teams formed by the Government and the prime contractor evolved into a program organization that was characterized by trust and commitment. The key suppliers were heavily integrated into the prime contractor organization for the program. The customer perceived the suppliers simply as an extension of the prime contractor organization. Government representatives on the prime contractor team were also accountable for the contractor design. Finally, the Advocacy Teams generally brought the "voice of the customer" closer to the contractor organization. These team dynamics broke down some of the traditional barriers of the Government, prime contractor, and supplier organizations, combining program members into one team (the McDonnell Douglas Team). New lines of communication brought the customer closer to the prime contractor. The formation of a partnership between the prime contractor and key suppliers also introduced lines of communication between the Government and suppliers which did not previously exist in most programs. The JDAM team model was therefore one which brought the customer closer to the prime contractor and confounded the key supplier organizations with the contractor organization. The factors contributing to

this collaborative model for program relationships are described in more detail in the following section.

3.2.2 Factors Contributing to Team Formation

Several factors contributed to the formation of the JDAM team model. The competition between the two prime contractors during the rolling downselect helped drive the team members together. The formal and informal teams created by the Government and the prime contractor also helped to integrate the various team members. Other factors contributing to team formation and to the character of the JDAM team were: a common goal, "total open communications;" the formation of long-term relationships; the implementation of configuration control, design integration, and "workshare;" and supplier training.

A Common Goal

The competition between the two prime contractors in the rolling downselect established a common goal among the members of the McDonnell Douglas team. The rolling downselect was a continuous evaluation process during the first phase of development, EMD-1 (Engineering and Manufacturing Development 1, or Demonstration and Validation in traditional acquisition programs). Competition was induced by the knowledge that the other team would use all of its resources to win the final source selection at the end of EMD-1 as well as the importance of winning the contract. The 18-month competition helped to motivate McDonnell Douglas to capture the "voice of the customer" by working closely with the Advocacy Team. McDonnell Douglas also recognized that the suppliers were critical to the competition.

In the development phase of EMD-1, the McDonnell Douglas team was informed of their need to increase system affordability. McDonnell Douglas enlisted the help of their critical suppliers to increase affordability while meeting (or exceeding) system requirements and accelerated schedule restrictions. The suppliers were vital to system affordability. While McDonnell Douglas recognized the necessity of their key suppliers, the suppliers recognized their own responsibility--that their designs or

subassemblies could have "cost" McDonnell Douglas the contract award. Furthermore, if McDonnell Douglas had not acquired the award, then the suppliers would also have lost a stable, multi-year procurement contract.

Affordability therefore became a central goal of the team. In general, McDonnell Douglas worked closely with key suppliers to implement innovative solutions to affordability issues and to document their affordability progress. The MDA team provided the Government with requested (and required) Affordability Reports which detailed their progress on reducing cost along with the MDA rationale behind the design, manufacturing, and management evolution for affordability. For these Affordability Reports, McDonnell Douglas used Average Unit Procurement Price (AUPP) tracking charts to monitor and report their affordability progress. The tracking charts served to demonstrate progress, to itemize improvements through near-term initiatives, and to create solutions for the future.

Total Open Communications

"Total open communications" were important to the development of the JDAM team model. Non-disclosure agreements enabled communications between the prime contractor and the key suppliers (as well as between the Government and the prime contractor), permitting the "open" sharing of design information and cost data among the team. These corporate agreements allowed communications within, but not outside, the team. Any problems that needed resolution were directed to the Executive IPT. Design and pricing data exchange among many of the suppliers and McDonnell Douglas removed some of the barriers of defense aerospace supplier relationships, but was also not equally practiced among suppliers and across all working level IPTs. The open communications forum, in combination with the shared goal of winning the downselect and driving costs down, was, however, important to the formation of the JDAM team because it increased the level of team integration and also increased the cross-fertilization of ideas among suppliers.

McDonnell Douglas raised the level of team member integration by creating formal and informal lines of communication. The Executive IPT set a framework for teaming relationships which flowed down to the product IPTs. The Vice Presidents of the prime contractor and supplier organizations met each month. Any difficulties on the program working level could gain the attention of the Executive IPT. The Vice Presidents of the supplier organizations were therefore accountable for their involvement in the product design and represented their corporate involvement before meetings of the Executive IPT. Certainly, none of the Vice Presidents wanted to hold back the contract award or be responsible for holding back the contract award. The Executive IPT, however, did not improve the team relationship solely through focusing on solving the problems that arose. Rather, the Executive IPT also improved team relationships by keeping top management aware of program progress, the important issues, and the competition. The changes that were proposed at the working level could be implemented much more smoothly and quickly as a result of management awareness and agreement among the executives.

To focus on affordability, McDonnell Douglas implemented a number of managerial changes that demonstrated an awareness of the competitive spirit of the JDAM rolling downselect process as well as a corporate dedication to the program. By implementing changes that affected every one in the organization from the top management to the subcontracting organizations, McDonnell Douglas chose to implement changes that changed the culture of the organization.

McDonnell Douglas maintained that every program decision considered the impact on affordability. McDonnell worked closely with its suppliers at the "working level" as well as at the executive level. The program managers of McDonnell's product teams, including program managers of key supplier companies, met face-to-face during monthly status reviews at the supplier sites to focus on affordability. The program managers also spoke to each other on the phone several times a week. McDonnell Douglas and its suppliers formed a "win strategy" steering committee to focus on affordability and to focus on beating the competition team during the

EMD-1 downselect. McDonnell Douglas also created an Affordability Team to support all of its product IPTs and management decisions. McDonnell Douglas' strategy for focusing on affordability extended to all the employees of the program as well. McDonnell Douglas provided its own employees with the JDAM Performance Incentive Program to motivate employees further to focus on affordability.

McDonnell Douglas' affordability and win strategy steering committees also served to focus on the key issues, seek integrative solutions to problems, and formulate strategies to win the competition as a team. Communications between the prime contractor and key suppliers was not only amplified by the multiple paths of communication, but the high frequency of interaction. Monthly program reviews were held at the supplier sites, alternating among suppliers, for the GCU Team. The suppliers were invited to all the customer (Government) meetings, including award fee briefings before the Source Selection Evaluation Team (SSET). The suppliers were given the opportunity to witness how the prime contractor was graded and the problems that the customer cited. The customer could also discuss problems directly with the suppliers. The suppliers were privy to the status of McDonnell Douglas, including budgetary data: how McDonnell Douglas was spending funds as opposed to the actual budget, the amount of management reserve used to implement affordability and design changes, and how much McDonnell Douglas was under budget. Similarly, the prime contractor and suppliers could learn the status of the suppliers regarding their schedule, staffing, drawings, critical issues, and progress through the affordability tracking charts. The prime contractor would also work closely with the supplier through major reviews, including the: Preliminary Design Review (PDR), Critical Design Review (CDR), and Production Readiness Review (PRR). The prime contractor helped the supplier to develop the answers to questions that would (probably) be asked during the reviews, and then the IPT would ensure that desirable results were achieved. For the GCU Team, each of these reviews involved interactions with the team leaders for a day and a half, meetings with the product IPT for two weeks, another set of

presentations to the team leaders (dry run presentations), and then three to four days with the Source Selection Evaluation Team (SSET).

Additional committees that were formed also met regularly. The win strategy steering committees would meet every other month, and included people who were not directly involved in the program for alternative perspectives. Affordability committees, composed of members of the working level IPTs, would also meet face-to-face monthly. Affordability sub-teams were also formed as necessary. For example, sub-teams were formed for procurement initiatives, to eliminate multiple types of connectors, and to eliminate circuitry. For the GCU Team, a working level IPT, members held weekly telephone conferences (telecons). Three sets of topics were discussed at these meetings: (1) communication (including events, the focus on affordability, and the flow-down of streamlining and reform initiatives from the prime contractor and customer), (2) the "issues list," and (3) a roundtable discussion with an open format. The GCU program manager spoke with the managers at the key supplier organizations two to three times per day.

Commitment and the Formation of Long Term Relationships

The supplier relationships of the JDAM program were aided tremendously by the expectation of that the program would be stable and extend over several years. Historically, however, this was not prevalent. Typical procurement programs were generally about a year to two years in length. Suppliers also worked with the awareness that they could be demoted to a second source or dropped from the program altogether at any time. The JDAM program established clear downselect criteria that were passed on to the suppliers from the prime contractor. With a clear idea of what they were being evaluated on and in what time frame, the contractor team (together with the suppliers) would have some control over their stability and contractor status. Moreover, with the ability to not only control their designs (through total contractor configuration control granted by the Government) but also know the exact requirements and evaluation criteria, the contractor who lost the competition would be less likely to protest the contract award.

The suppliers also acknowledged ownership and accountability for their designs. By passing the same standards, criteria, and control on to the suppliers, the prime contractors demonstrated their willingness to empower the suppliers and extend their accountability. The prime contractor also demonstrated a commitment to the key suppliers that were part of the contractor team. The suppliers were aware of the evaluation criteria and were sufficiently assured that the prime contractor would not designate a second source or drop them from the team unless they clearly fell below set standards.

The key suppliers had not only the expectation of a stable, multi-year program, but also an anticipation that the JDAM program would build the relationship between the prime contractor and suppliers. There existed the potential for a long term relationship if the supplier performed well within the established criteria for the program. McDonnell Douglas extended their commitment to the suppliers and offered the potential for long term supplier relationships by including the suppliers in the contractor team, flowing down all requirements and reforms initiated by the Government, and giving them clear criteria for program stability (in so far as McDonnell Douglas had control). McDonnell Douglas also showed their commitment by flowing down configuration control (which was passed to them from the Government) and actively training and certifying key suppliers.

Configuration Control, Design Integration, and Workshare

Total contractor configuration control was granted to the prime contractor by the Government. Total contractor configuration control referred to the ability of the prime contractor to control the design of the JDAM guidance kit as long as the product met all of the "live-or-die" requirements, the fundamental Class I requirements, of which there were seven: (1) a low unit cost (with a target of $40K per weapon), (2) adverse weather accuracy, (3) aircraft compatibility, (4) Naval aircraft carrier suitability, (5) in-flight captive carriage re-targeting, (6) and warhead compatibility. The prime contractor was given greater control over the design to meet and exceed the affordability goals. In addition, the prime contractor experienced greater

accountability. McDonnell Douglas flowed this configuration control to the suppliers as well. In some cases, the suppliers did not accept control of the design. The JDAM product as a whole, however, experienced great reductions in the Average Unit Procurement Price (AUPP) as a result of supplier innovations--innovations which may not have been possible without the extension of configuration control. Configuration control, along with open communications and the expectation of a stable and long term relationship, helped to integrate the suppliers into the prime contractor team.

The risks associated with granting the prime contractor full configuration control were mitigated, however, by the requirement of an extended 20-year warranty by the prime contractor. The prime contractor was required by the Government to fix or replace any defective part or subassembly for a 20-year shelf life and 5-year active life (out of the container). The warranty was an alternative method (rather than the use of heavy oversight) for the Government to ensure a high quality product would be delivered. The prime contractor also flowed this requirement on to the suppliers as a way to reduce the risk the prime contractor had incurred by accepting the warranty provision. The prime contractor and suppliers were, in this way, dependent upon each other to ensure the quality of the design. The responsibility of the warranty was shared by the prime contractor, as the weapon systems integrator, and the suppliers.

By flowing down the design authority and responsibility (from the Government) to its suppliers, McDonnell Douglas reinforced their supplier partnership and improved the system design through increased affordability. McDonnell Douglas flowed down all the acquisition reform initiatives from the Government to its suppliers. The relief from military standards and specifications opened the "design space" and resulted in a cost savings. The following table shows the extent of the relief that extended to suppliers.

Table 3-3: MDA is Streamlining Subcontracts to Reduce AUPP, Progress to Date[27]

Specification MIL STDs/MIL SPECs	Number of references	Number deleted	Percent reduction (%)
Inertial Measurement Unit	66	62	94
Mission Computer	47	42	89
GPS Receiver	45	29	64
Wire Harness	67	61	91
Battery	73	62	85
Tail Actuator Subsystem	87	64	74

Changes allowed the prime contractor and suppliers to work side by side in winning the competition, in achieving affordability goals, and in making design changes. The focus on affordability, putting cost on the same level of importance as system performance, allowed the prime contractor team to make design trades and cost-performance trades. Striving to achieve a common goal--with clear criteria for evaluation--helped the prime contractor and suppliers work together as a team to implement design changes and increase affordability. The team focused on a highly integrated design which would incorporate design ideas from the prime contractor and the key suppliers. The effect of design integration on the team dynamics (and the team dynamics on the design integration) was magnified by the threat of competition in the late stages of EMD-1. The desire to integrate the design and to reduce AUPP drove the prime contractor and suppliers to work more closely together as a team.

"Workshare" was an effect which highlighted the integrated team effort. Some suppliers made concessions--reducing their responsibility and portion of the final product--if it would increase system affordability. Workshare dramatically illustrated the fact that the suppliers were involved in the contractor competition and not simply *their own* competition. Some of the boundaries between the prime contractor and suppliers and among the suppliers were broken down in this way.

[27] Source: Presentation by McDonnell Douglas Aircraft on the JDAM program dated September 8, 1995.

Supplier Training

The relationships between the prime contractor and the suppliers, as part of the JDAM program, had the potential to be long term relationships. The high levels of design integration and knowledge-sharing that occurred suggested that the program was the beginning of a (potential) long term relationship. McDonnell Douglas and its suppliers also invested time and resources in developing skills to compete in the defense aerospace market. The Government Advocacy Teams heavily emphasized the use of Design for Manufacturing and Assembly, as part of the Manufacturing Development Initiative, and provided the prime contractors with technical training. McDonnell Douglas also offered its key suppliers the opportunity to be part of their Preferred Supplier Program, a certification program that was part of McDonnell Douglas' supplier management plan. This certification would validate for the prime contractor: (1) that the suppliers were using advanced manufacturing and development processes and (2) that the suppliers were committed to becoming long term partners with the prime contractor. The certification would also save the prime contractor money by reducing oversight responsibility. The Preferred Supplier Program was an incentive to suppliers to gain a better chance of entering into future contracts with McDonnell Douglas. The members of the program would receive "extra points" in a contract bid. The program at McDonnell has gold, silver, and bronze levels, depending on levels of performance in various areas, including: delivery schedule, quality, management practices, and statistical process control (SPC). McDonnell Douglas had an active plan to get all of its suppliers on JDAM to at least a Bronze level. They sent an assessment team out to the suppliers. If the evaluation criteria were not met, then a training program would be offered to the supplier at the supplier site. The training offered by McDonnell Douglas was also extended to third tier suppliers. The relationships that McDonnell Douglas shared with the first tier suppliers were encouraged to be shared with suppliers down the vertical supplier chain. Additionally, some suppliers already had supplier certification programs in place for their own suppliers (the sub-suppliers).

3.3 Competitive Strategies and Information Flow

While the contractor-supplier team formation in the JDAM program described above highlights the full integration of the suppliers, the team formation was not met without difficulty. The change from a traditionally hierarchical system of relationships in a defense aerospace procurement program to the team organization of the JDAM program required a cultural shift. Despite a seemingly inordinate amount of effort spent on cultural change management by all parties involved, there are still important business implications which affect the information exchange between the prime contractor and certain suppliers. The underlying business strategies of suppliers certainly affect the information flow. Perhaps the parties could better understand conflicts and limitations to information flow that are caused by corporate strategies of suppliers by first analyzing the positions of suppliers and how they derive their competitive advantage in the marketplace. The following section illustrates how the strategies of supplier corporations had an impact on the types and levels of information passed from the supplier to the prime contractor (despite high levels of team integration).

3.3.1 Strategy 1: To Maintain Trade Secret

For the JDAM program, the primary competitive corporate strategy of the thermal battery supplier, Lockheed Martin Specialty Components, was to maintain its trade secret technology. The company was originally attracted to the stability and high volume that the JDAM program offered. The competition for the bid and the focus on affordability led the supplier to take initiative in designing a custom combined system battery for the program.

The JDAM tail kit required voltage sources for two functions: (1) a 100 Volt battery for the Control Actuation System of the tail fins and (2) a 28 Volt battery for the electronics system. The supplier combined these functions into one battery source to implement cost savings in production. The only primary concern--that the activation of the motor for the tail fin would affect the use of the 28 Volt source--was eliminated by conducting a

small, internally funded demonstration project. The supplier "piggybacked" the demonstration project onto other ongoing tests for other customers.

The facilities of the supplier included extensive dry room space for production, ceramics processing and precision machining tooling, battery analysis (chemistry and materials analysis) facilities, and an on-site environmental test (mechanical, temperature, shock, vibration, humidity) laboratory. With extensive facilities and experience, the supplier was capable of fully performing all of the core processes required for thermal battery production: the blending of the powders, pressing of the pellets, final assembly, non-destructive in-process testing and destructive testing, and development. The only items that the supplier normally purchases include the raw material powders, the case, and the headers or igniters. The key technology of the chemical content of the batteries was proprietary and, thus, the limiting factor regarding the level of information exchange.

The supplier's trade secret technology was protected by the low levels of outside interaction and outsourcing. Most items purchased from outside the company were commercial off-the-shelf technology, or stock items. The core technology was also protected by careful and prohibitive outsourcing. The raw material powders, for example, might be purchased from an outside source and then purified by the company. The company might also ask for headers (mechanical actuators) "built-to-print" from an external second tier supplier, receive the part, modify it for proprietary reasons, and then sell the entire battery product without leaking any information out to the header source. The nature of the battery, the fact that thermal batteries (once fully assembled and packaged) may only be tested by being ignited, also maintains the trade secret technology.

The battery supplier certainly is a case in which the expectations of quality performance and reliability may only be requested and demonstrated. Moreover, the ability of the prime contractor or Government to intervene or participate in the development of the product is strictly limited by the technology and the thermal battery business. It is not clear that the integration of the battery supplier with other suppliers in the JDAM

program would have been beneficial. The prime contractor and supplier worked at the level of expected performance and reliability, defining the interfaces between the battery and the JDAM system. The customary design approach of the supplier was used in the JDAM program, working together with the contractor on cost drivers through various integrative methods: combining batteries, changing the header type, altering the use of brackets, and adjusting the battery size. In the case of the JDAM program, the battery supplier offered to lower the overall production cost by using a combined system battery. The limited interface between the supplier and prime contractor in this case was therefore managed by the supplier as much as the prime contractor. The nature of the technology and supplier expertise in that technology made the battery supplier a necessary black box supplier to the prime contractor.

3.3.2 Strategy 2: To Maintain Commercial Pricing Strategy

Rockwell Collins provided the MDA team with the Global Positioning System Receiver Module (GPSRM). With experience from a previous, smaller program (that emphasized affordability), and with more commercial experience than members of McDonnell Douglas, Collins pushed for more requirements relief and sought more part control than McDonnell was ready to agree to at first. Members of Rockwell Collins described their organization as "a catalyst for cutting costs."[28] The supplier recognized the benefits of affordability before they entered into involvement with the JDAM program and pushed for implementation of commercial practices and greater part control. The supplier was the only supplier of the GCU Team who did not provide proprietary pricing backup detail despite non-disclosure agreements. The possibility of jeopardizing future pricing negotiations was viewed as too great a risk for Collins to take. Collins also asserted its unique, advanced commercial hardware pricing strategies. Collins pushed the cultural barriers to implementing the commercial practice initiatives of acquisition reform in the program and maintained its commercial pricing strategy throughout the development phase. This driven commercial approach to the program pushed

[28] Interview with the author, Rockwell Collins, March 27, 1996.

McDonnell Douglas to consider and accept the commercial practices of Collins. The Collins approach was reflected in the types of information exchange that occurred between the supplier and prime contractor. While the pricing strategies of Collins were restricted from the view of McDonnell Douglas, the level of engineering data exchange was high.

The original contract between Collins and McDonnell Douglas required a master list in which every part would be approved by McDonnell. After having experience with another defense aerospace program that heavily incorporated commercial practices, members of Collins were ready to launch into the commercial practices that acquisition reform proposed and that the JDAM program was to incorporate as a designated Defense Acquisition Pilot Program. Collins faced barriers from the initial contract; Collins pushed for the use of plastic rather than ceramic parts, wanting to choose their own parts. Eventually, McDonnell adopted what Collins submitted, making the part selection process more flexible for the entire team.

Aside from past experience with a "commercial" program, Collins supported giving its own suppliers greater freedom than McDonnell was able to give to its suppliers. Moreover, Collins already had an established set of long term, strategic supplier relationships with its five key suppliers. The commodity team of Collins had performed an evaluation on the team (of Collins' key suppliers) in the past and pre-qualified and pre-certified the suppliers. Collins had teaming relationships with established quality assurance standards, policies, procedures, and corrective actions and provided training to its suppliers.

The past experiences of Collins led to aggressive cost reductions and wide-spread use of commercial practices. The fact that Collins limited its information exchange was part of its business strategy. Collins refused to show McDonnell Douglas its material costs and rate structures. In line with its commercial strategy, Collins used a hardware pricing strategy that incorporated technology insertion--a strategy unique compared to other suppliers. The pricing strategy of Collins was therefore based on material

costs and advancements in technology rather than a learning curve theory (which was used by the other suppliers). The strategy incorporates an initial loss which is recovered in "out years."

In contrast to the level of backup pricing data exchanged, the level of engineering information exchanged was very high. The introduction of a new requirement, for example, forced Collins into a situation where modifications were necessary and where it was sending software links to McDonnell Douglas. The prime contractor would test the software and transfer the data back electronically. The prime contractor and supplier worked closely together as a team on these problems.

Collins implemented design changes to reduce system costs without having to justify their pricing methods with backup data. The benefits of working together on design problems were not sacrificed by the restriction of pricing strategies. Collins illustrated, by its restriction of pricing strategies and its openness with regard to engineering data, that the prime contractor may be able to give subcontractors greater design and pricing control without losing the benefits of improved product results. The amount and type of information shared by Collins follows the desire to maintain a commercial pricing strategy. By understanding the underlying subcontractor strategies and the experiences which shaped its strategies, the parties may have been better able to avoid unnecessary conflicts.

3.3.3 Strategy 3: To Win the Contract in a Situation of Financial Uncertainty

Honeywell, the supplier of the Inertial Measurement Unit (IMU), recognized the importance of the JDAM contract to competitive corporate strategy.[29] In the recent past, Kerfott, a main competitor, had won the JSOW and Wind Corrected programs. Litton, another main competitor, had been selected for the AMRAAM program as well. Litton and Kerfott were Honeywell's two main competitors in the IMU market. The JDAM program was attractive to the company for its anticipated stability and high volume.

[29] Interview with the author, Honeywell, March 28, 1996.

The 74,000 units to be purchased would be an ambitious goal for Honeywell. Honeywell needed a large volume contract and a long term commitment, both of which were satisfied by the program. Without a long term commitment, Honeywell would have had difficulty exposing the IMU components to the team, making the up-front investment (which was substantial for the JDAM program), and convincing the design team to share information and work together with other organizations on the design.

Based on its position, Honeywell was willing to cooperate with McDonnell Douglas' procedures of flowing requirements relief to the suppliers from the start of the program. The supplier was willing to implement workshare just as the other suppliers were. For example, Honeywell changed its connector assembly to save money on other suppliers' hardware.

3.3.4 Strategy 4: To Win Long Term Relationship in Military Sales

The JDAM contract was a small portion of Loral's business, never more than 5% of the overall business, but was perceived as a stable, ongoing, predictable business and a good starting point for military sales and for a working relationship with McDonnell Douglas. The company therefore made an exception for the program to its policy of not giving out backup pricing data and rates to enter the military market in a stable, long term arrangement.

The Mission Computer was designed by McDonnell Douglas, but the layout and list of components became Loral's responsibility. The company operated as a large scale build-to-print manufacturing operation. The defense aerospace method of running small production runs did not precisely match the flexible manufacturing environment at Loral. For example, it was estimated that running just 5% of Loral's capacity (10,000 parts per hour) would require only one month for full JDAM program volume.

Loral focused on winning the contract as a means of entering a stable, long term relationship in military sales. Although the company primarily

operated as a commercial manufacturing facility, the reform initiatives of the JDAM program allowed Loral the possibility of entering the military market. The company helped implement commercial manufacturing parts and practices and eliminated a number of mechanical elements (connectors) as part of the major GCU re-design effort.

To reiterate, JDAM was not a major contract for Loral, representing not more than 5% of their business and employing only a few full time personnel for the program. The program was essentially a pilot program for Loral to examine whether the military product could be incorporated into pre-existing commercial lines. This premise may have resulted in a willingness on Loral's part to win the contract even if it meant scaling back portions of Loral's contribution to the final product.

3.4 IPT Formation and Architectural Design Changes

The integration of the GCU IPT members over the course of EMD-1 resulted in specific types of innovation. Moreover, architectural design changes, as opposed to component design changes, resulted from the nature of the integration. By understanding the dynamics behind the GCU team formation in the JDAM program and the resulting innovations, the prime contractor may be able to use the information to encourage various types of innovation or manage innovation in future programs.

3.4.1 Integration of Black Box and Build-to-Print Suppliers into IPT

The GCU IPT included the key suppliers, Rockwell Collins (GPS Receiver Module), Honeywell (Inertial Measurement Unit), and Loral (Mission Computer) along with McDonnell Douglas as the system integrator. The team was organized at the start of the 18-month EMD-1 phase of development. Just a few months before the scheduled final downselect, however, the entire McDonnell Douglas JDAM Team was faced with the risk of losing the competition if they could not bring down the Average Unit Procurement Price (AUPP). The goal of affordability became a requirement. A more aggressive approach was needed to achieve a lower AUPP. The need to heavily involve the suppliers became imperative. Total

supplier involvement was necessary for all the members of the JDAM team. This competitive pressure pushed the GCU Team into action.

The effect of the competitive pressure was to integrate the existing individual designs of suppliers. The design of the old Guidance Control Unit actually existed prior to the program. It was selected for its applicability and perceived as a "head start" on the competition. The suppliers had responsibilities of either interfacing, building, or assembling the old GCU. The integration of suppliers for the GCU, suppliers whose designs were already in place, resulted in an integration of mainly existing hardware. Military parts were exchanged for commercial parts in line with acquisition reform measures, but, overall, the resulting design was a repackaging of the existing hardware.

3.4.2 Architectural Innovation (vs. Component Innovation)

The concepts of innovation and invention are generally familiar: whereas invention refers to the creation of new ideas, innovation refers to putting new ideas into practice. Architectural innovation differentiates between a system and its components and refers to the way that components are integrated and linked together into a system. Henderson and Clark offer a framework for defining innovation, shown in Figure 3-7.[30] The framework introduces the concepts of incremental and radical innovation in the context of core concepts and the linkages between core concepts and components. Incremental innovations are those innovations which reinforce core concepts while radical innovations force the establishment of whole new approaches to problem-solving, causing major changes in the links between components and overturning the fundamental core concepts. Modular innovation changes components and core concepts without changing the relationships between the components.

[30] Henderson, Rebecca M. and Kim B. Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," *Administrative Science Quarterly*, 35, 1990, pp. 9-30.

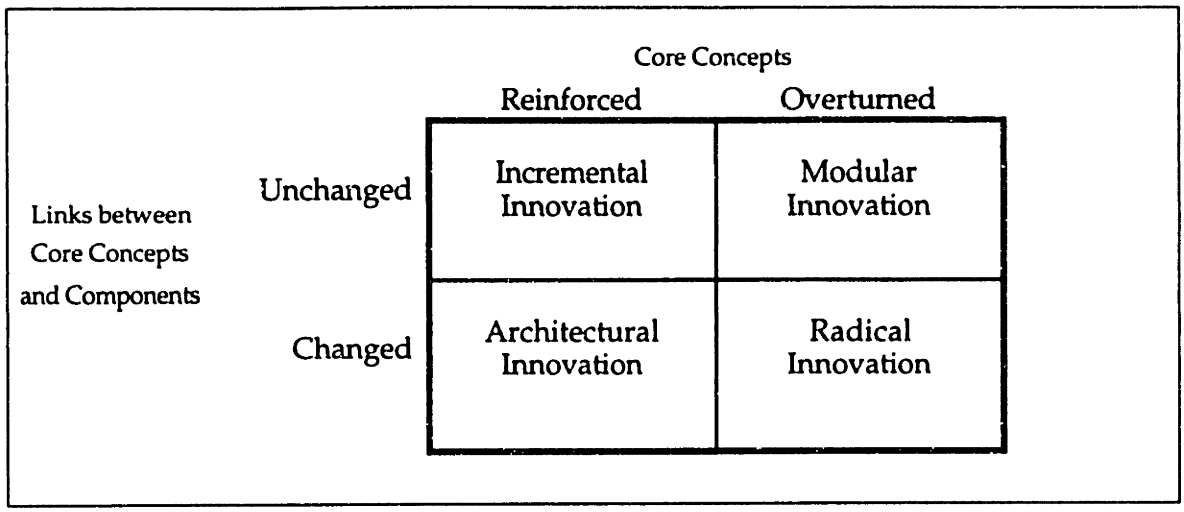


Figure 3-7: Framework for defining innovation. [31]

The nature of architectural innovation is best described in the words of Henderson and Clark:

> *The essence of architectural innovation is the reconfiguration of an established system to link together existing components in a new way. This does not mean that the components themselves are untouched by architectural innovation. Architectural innovation is often triggered by a change in a component--perhaps size or some other subsidiary parameter of its design--that creates new interactions and new linkages with other components in the established product. The important point is that the core design concept behind each component--and the associated scientific and engineering knowledge--remain the same.*[32]

Established firms may have difficulty in adapting to architectural innovation. The emergence of a dominant design may inhibit further experimentation and innovation. Architectural knowledge can also often become imbedded in a firm's communication channels, information filters, and problem-solving strategies.

For the JDAM program, acquisition reform initiatives of the Government and contractor initiatives led to the JDAM team formation. The initiatives

[31] Henderson, Rebecca M. and Kim B. Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," *Administrative Science Quarterly*, 35, 1990, p. 12.
[32] Ibid., p. 12.

opened up communication channels among the Government, prime contractor, and supplier organizations that were, in general, previously difficult to use, ineffective, or nonexistent. Some information filters were removed as suppliers were allowed direct contact with the Government during reviews. Rather than discovering customer demands and requirements through the prime contractor, the supplier was able to find out directly from the Government. Internal information filters were removed with the formation of the Executive IPT. The Vice Presidents became dire y aware of the program issues. The Government, prime contractor, and suppliers had to develop new ways of approaching problems with the acquisition reform measures (e.g. making cost-performance trades).

The competitive pressure sparked a new approach to solving the GCU design problem, but the dynamics of the JDAM team formation and the GCU team formation facilitated the possibility of architectural innovation. The opening of communication channels, elimination of information filters, and introduction of different problem-solving approaches made architectural innovation possible. The decision to use a different problem-solving approach for the GCU, after the design had already been set, resulted in architectural innovation. The GCU re-design was architectural because the core components were retained and the resulting design was an integration and simplification of the original design. The members of the GCU Team referred to the re-design as a "repackaging" of the components. This repackaging and its substantial (undisclosed) cost savings demonstrate the importance of architectural innovation, particularly with the acquisition reform changes implemented. Finally, the architectural innovation of the GCU was significant not only for its cost savings but also for showing other IPTs the possibility of finding new ways to solve a design problem.

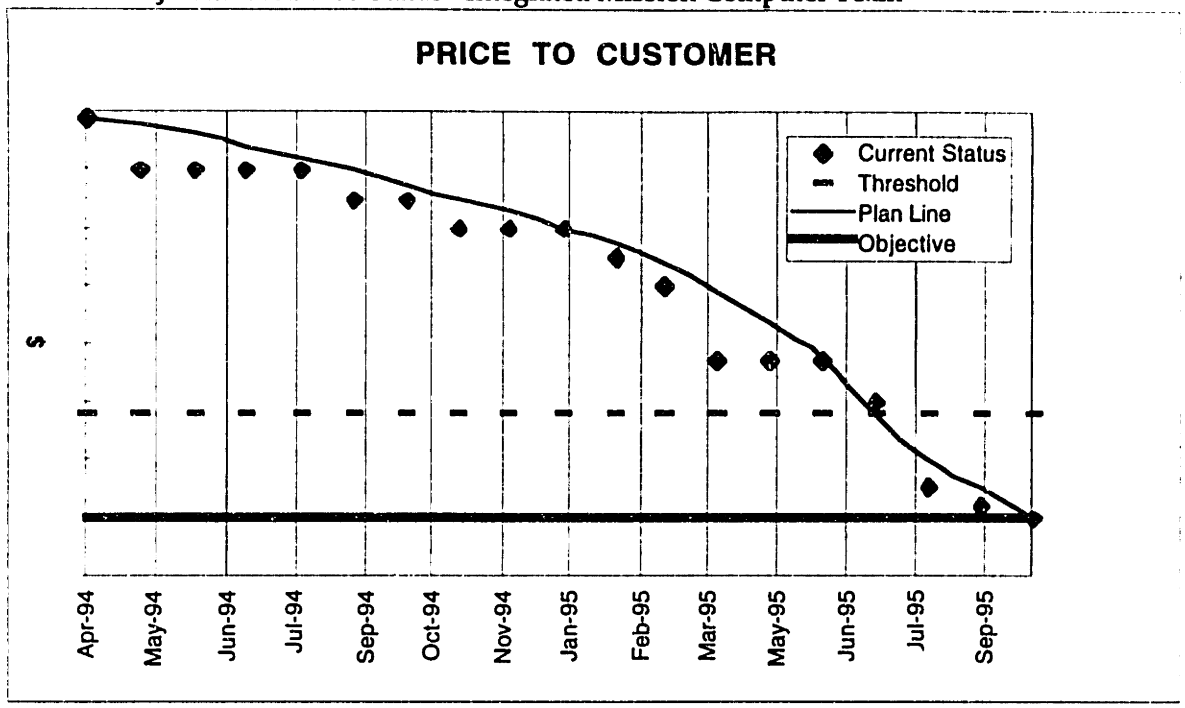
3.4.3 Examples of Resulting Architectural Innovation

The main components of the GCU include the inertial measurement unit (IMU), GPS Receiver Module (GPSRM), and the mission computer, as well as a power conditioning unit. The GCU Team began with the SEM-E Configuration, which was a previously existing design chosen for its low

risk and modularity at the start of EMD-1. The new design, the "Low Cost GCU," was driven by the focus on affordability as well as the need for a more efficient thermal design profile.

The team was able to realize substantial cost savings through the use of industrial grade components instead of military components. The decomposition of the cost reduction initiatives is presented in Figure 3-8. (The actual cost data is not given for proprietary reasons.)

JDAM AUPP TP Status - Integrated Mission Computer Team



	Near Term AUPP Reduction Initiatives	
Item	**Description and Status**	**Delta ($)**
1	Utilize Industrial Grade (rather than full-Mil Components)	
	-68040 Processor	
	-68360 Microcontroller	
	-PAL	
	-SRAM	
	-Transceivers	
	-EEPROM	
	-Drivers/Receivers	
2	Low Cost GCU Design (mechanical)	
	-Wedge Lock & Frame	
	-Motherboard Connector	
	-1 Printed Circuit Board	
	-Crossovers	
3	Commercial Acquisition Reform (component savings above)	
	-Commercial Production Practices	
	-Commercial Business Practices	
	Future AUPP Reduction Ideas	
A	Strategic Business Alliance	
B	Piece Part Procurement Strategies	

Figure 3-8: AUPP Tracking Data Sheet for the Integrated Mission Computer[33]

[33] "JDAM AUPP Status--IPTs," McDonnell Douglas Corporation, December 1995.

Although the re-design incorporated lower cost commercial parts to replace military parts, the new design represented a physical integration of the parts from the existing SEM-E Configuration. Most of the actual circuitry did not change, but the original components (or industrial-grade replacements) were repackaged. The new design managed heat more effectively at a lower cost and provided inherent EMI (Electromagnetic Interference) shielding. More circuit board space was achieved through the combination of functions and the elimination of a printed circuit board. Open access packaging architecture also represented design for ease of assembly. The repackaging of the SEM-E Configuration solved thermal management problems, achieved dramatic cost savings, maintained the low risk of the original design, and was a culmination of the effort of the entire GCU team over a detailed design period of only two months.

Total supplier involvement was necessary to accomplish the Low Cost GCU. The team was encouraged by the need to win the downselect and the pressures of competition. The members integrated their efforts, brainstorming for Design for Manufacturing (DFM) and Design for Assembly (DFA) ideas, with a positive attitude. The open communications forum, supported by the non-disclosure agreements and the formal and informal lines of communication created by the prime contractor and the Government, facilitated the integration of team ideas and the resulting architectural innovation. Workshare was the result of true team integration, when one supplier would give up part of the design that was previously under their design control. The benefit of the whole system and the entire JDAM team was the goal of each of the members. The change in design from the SEM-E configuration was unprecedented. The following figures represent the changes in the mission computer design for the original and the "low cost" GCU designs.

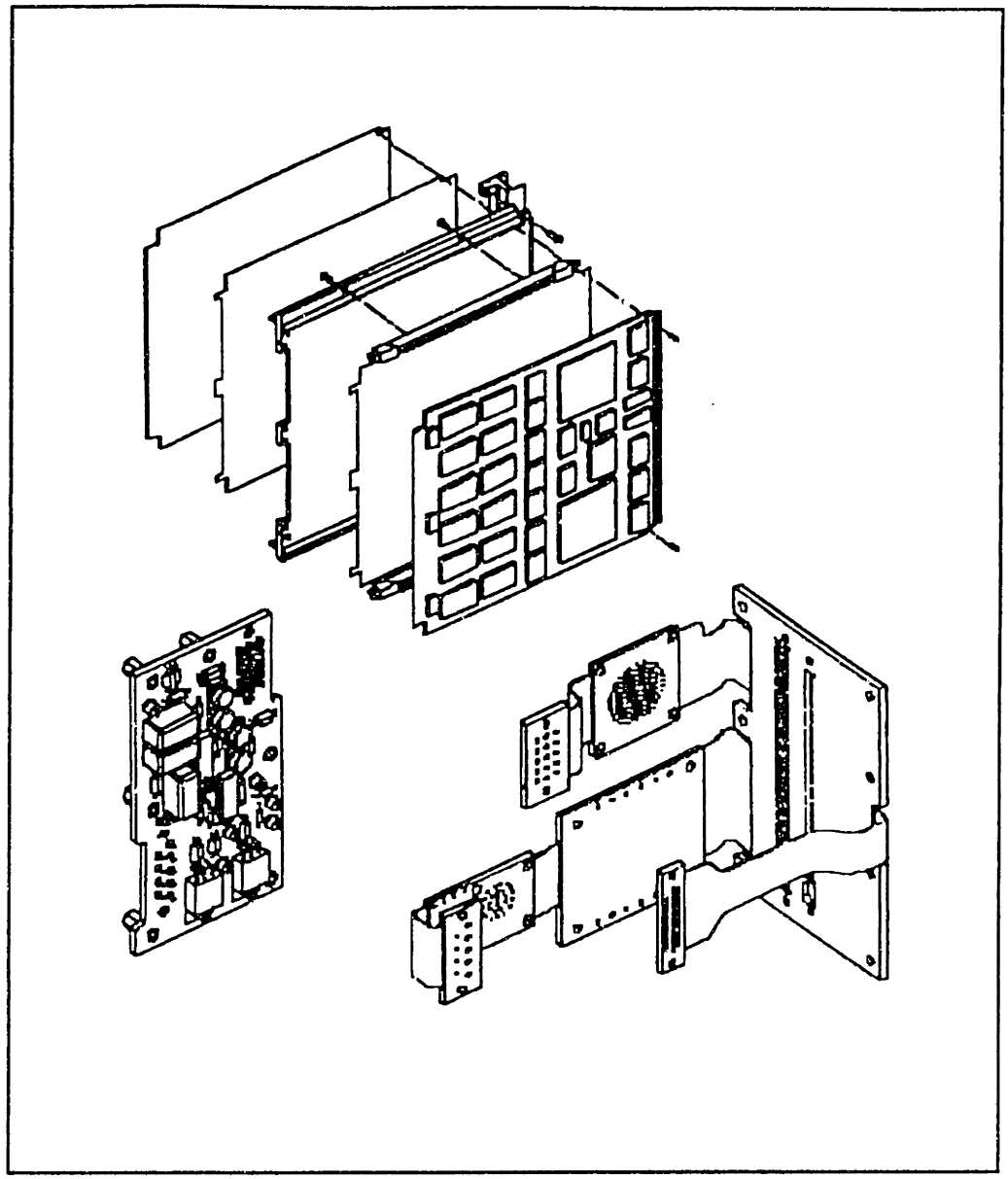


Figure 3-9: Original Mission Computer Design Concept[34]

[34] Source: "Mission Computer Design Evolution," McDonnell Douglas Presentation, October 16, 1995.

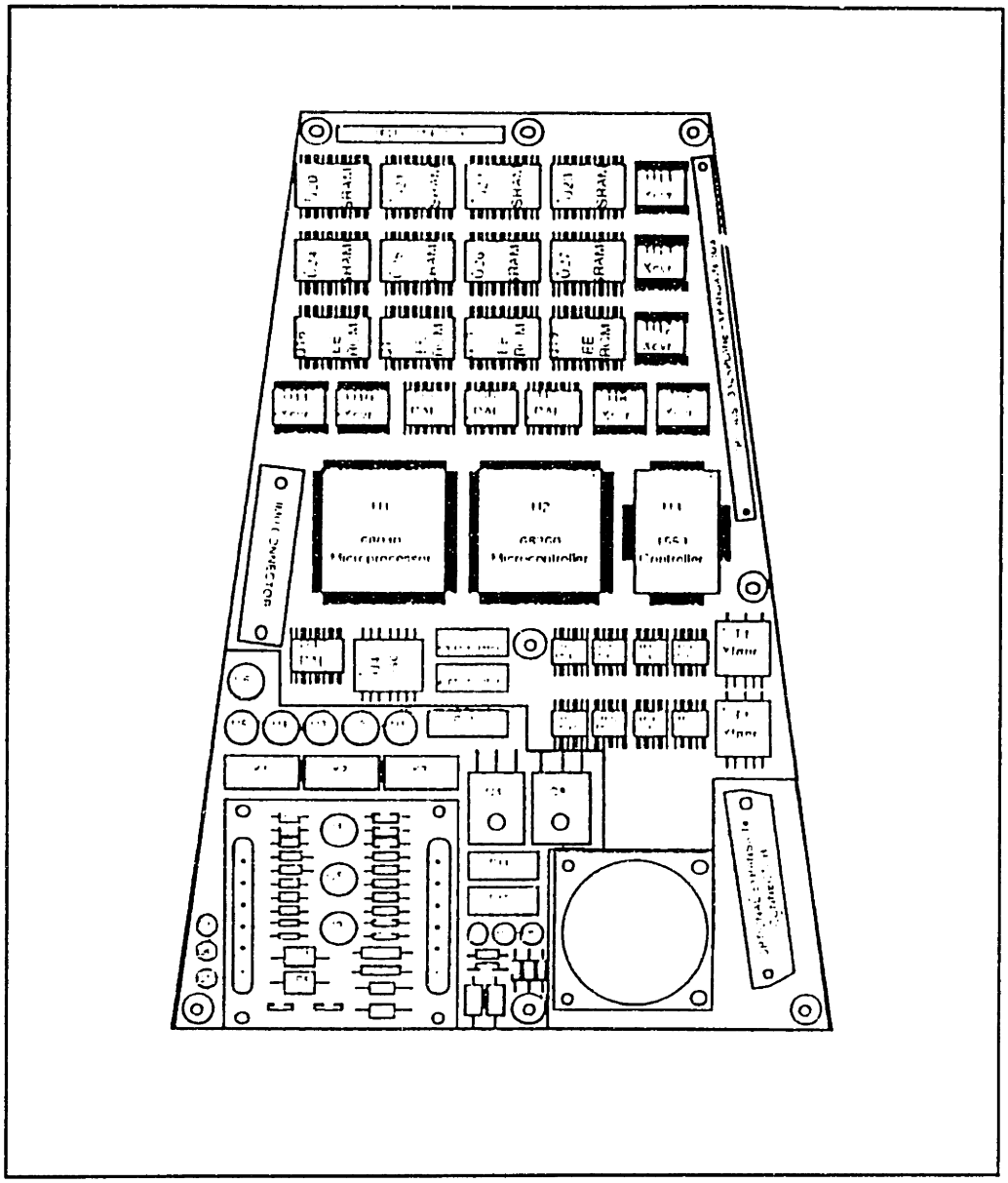


Figure 3-10: Mission Computer Design for the Low Cost GCU[35]

The architectural innovation of the GCU repackaging resulted in secondary benefits. The repackaging allowed for extra board space. The performance problem of vibration rectification errors was then eliminated by adding vibration isolators. Better performance of the electronics also resulted in higher reliability. Thus, the linkages between the components of the old design were changed and became important to solve different performance issues with the GCU.

[35] Source: "Mission Computer Design Evolution," McDonnell Douglas Presentation, October 16, 1995.

The repackaging also resulted in a reduced number of interconnects, thereby increasing reliability. The connectors for the wire harness assembly were reduced from (approximately) 11 to 4 connectors. The "rigid flex" wire harness was eliminated by the repackaging of the GCU and the concept of a single mission computer motherboard. The entire rigid flex wire harness assembly was then replaced by a simple interconnect. The simple producible harness was part of a team procurement effort in which the harness was outsourced to a single low cost, high quality supplier. The harness integration also represented an architectural innovation. This innovation linked across the GCU team members; after replacement of the rigid flex assembly with a simple interconnect, the IMU supplier took action to use low cost, integrated interconnects. The concept of re-designing the connector interfaces was also suggested to Honeywell by Loral. The connector between the Mission Computer board and the IMU was driven by the high density connector of the IMU. Loral recommended that Honeywell use a compliant pin connector to alleviate the problem (almost without McDonnell Douglas' knowledge). Cost savings were realized by both Loral and Honeywell as a result.

The repackaging and the re-design of connector assemblies also resulted in an outburst of cost-saving re-design activity. Honeywell, who had historically used an AMRAAM connector for the IMU, switched to an alternative protocol so that the Mission Computer board could eliminate a few piece parts. Honeywell, in effect, reduced the cost to the Mission Computer (and not to their own IMU).

Another architectural innovation was part of the re-design activity: Collins offered to move some GPS receiver functions out to the antenna. Collins was responsible for the GPS receiver and board (and not the antenna), but offered to move functions of the receiver out to the antenna to lower the overall system cost. Moving the function to the antenna would allow for less expensive components on the antenna side, and, for Collins, the reduced functionality would allow them to produce a board with fewer and less expensive parts. Despite the benefits that could be realized from the changes, McDonnell Douglas was not aware that the functionality could be

removed from the GPS board and therefore did not know how to change the specifications for the board and the antenna. As a result, Collins offered to write the specifications for the antenna and for the GPS board.

The result of the re-packaging and re-design of the GCU interfaces, the cost of the GCU was reduced by an estimated overall 40% to 60%.

CHAPTER 4

Conclusions and Recommendations

The Government introduced reform initiatives which gave prime contractors more decision-making authority, changed program relationships, and made noticeable cultural changes--moving the Government-contractor relationship towards a more collaborative relationship. These initiatives (which are discussed in detail in Appendix C) included: the formation of Government Advocacy Teams; a rolling downselect process; a focus on Average Unit Procurement Price; a limited project scope and "live-or-die" requirements; an accelerated schedule; total contractor configuration control; cost-performance trades and Cost As an Independent Variable; commercial design trades; streamlining of standards, specifications, "how-to's," and requirements; reduced oversight; emphasis on Integrated Product and Process Development; a twenty-year warranty; contractor incentives; the expectation of a stable, multi-year procurement; contractor training; an emphasis on Design for Manufacturing and Assembly; and Alternate Dispute Resolution as a forum for solving disagreements. These initiatives were managed by the prime contractors to make the changes in Government-contractor relationships possible. The McDonnell Douglas contractor team, which was selected for EMD-2, effectively managed the Government reforms of affordability, teamwork, and the use of commercial practices and added organizational structure to the program which facilitated the transformation of the Government-contractor relationship.

The Government reform measures had a significant impact on program relationships by generating the JDAM team model discussed in the previous chapter. The corporate strategies of the subcontractors also had an influence on the team dynamics which could be identified in the JDAM program. The Government policies to implement acquisition reform--generating the new supplier model--indirectly affected the types of innovation in the program. The dynamics of the formation of the JDAM team influenced the contractor-subcontractor team's innovation in product development. Thus, the policies of the Government, along with the unique management policies of the prime contractor and the cooperation of the subcontractors, influenced both the relationships among the parties and the design changes implemented in the development of the JDAM product.

4.1 Role of Policy in Team Formation

The formation of the JDAM team model for supplier relationships was enabled by the Government acquisition reform initiatives and the contractor affordability management initiatives. The team formation required Government anticipation of resistance to change and steadfast encouragement of cultural change to accommodate reform initiatives. The traditionally hierarchical structure of the military services may have made the adaptation to changing Government roles especially difficult. The implementation of Advocacy teams demonstrated Government effort to help the prime contractor implement change. The formal adoption of acquisition reform initiatives through the Federal Acquisition Streamlining Act of 1994 (and other legislation) demonstrated more widespread, formal support of the Government. The legislative policy and the program policies enacted by the Government, including the dynamics of the rolling downselect process, were catalysts for team integration. Contractor configuration control, reduced oversight, and the implementation of commercial practices and purchases changed the relationships between the Government and the prime contractor.

The management policies of the prime contractor and suppliers were also vital to team formation. The prime contractor used organizational structure to create additional lines of communication. The formation of the

Executive IPT helped the team formation through a sustained commitment on the part of top management. The cultural changes among the Government, prime contractor, and suppliers--taken together--were a necessary force in team integration.

4.2 Strategy-Driven Information Flow

The level and types of information exchange were partially driven by the internal corporate strategies of the key subcontractors. The limitations to information flow are better understood once the corporate strategies are revealed. In the case of trade secret technology, the limitation of the information flow may not necessarily limit the contribution to affordability goals. The desire to maintain pricing strategy based on past commercial experiences may also not necessarily limit the contribution to the team. The desire to win the contract in a situation of financial uncertainty may cause information flow to increase. The desire to enter into a new, military market, as well as to establish a long term relationship, was a strategy, however, that did not match the goals of the program well. While corporate strategies may inhibit information flow in some areas, the same strategies may be completely open in other areas. The suppliers and the prime contractors entering into relationships might consider more deeply whether the information exchange expectations match the goals of the program. The desire to open communication channels for effective team formation does not necessarily translate into total open communications (including pricing backup data).

4.3 IPT Formation and Architectural Design Changes

Working in teams at several levels in the program, with heavy involvement from the Government, prime contractor, and supplier, facilitated the GCU Team's ability to create architectural design changes. The outbreak of re-designs that occurred as a result of competitive pressure and the need to resolve thermal management issues for the GCU were architectural in nature, dealing with the inter-relationships among components. The pre-existence of a dominant design, the SEM-E Configuration, the desire to

preserve low system risk, and the tenuous relationships among the parties preserved the componentry of the previous design and created architectural innovations. Working together as a team earlier in the design phase may offer the possibility of more radical innovations. If the cultural barriers that existed during the JDAM program were broken down by the end of EMD-1, then the future, anticipated relationships may allow the prime contractor to involve the suppliers in the system design and to manage technological innovation--by focusing on supplier relationships and team dynamics.

4.4 Recommendations for Future Work

The JDAM program illustrated the ability of the Government to initiate measures, acquisition reform measures, that affected the relationships between the Government and prime contractor as well as between the prime contractor and suppliers (and between the Government and suppliers). While the program illustrated tremendous changes as a result of combined efforts by the parties involved, the JDAM program was a relatively small defense aerospace program. More revelations may result from studying a larger program and from studying programs not designated as Defense Acquisition Pilot Programs.

The program illustrated many important factors for acquisition reform success and for the transformation of program relationships from traditional, arm's length relationships to strategic partnerships. These factors, however, were difficult to quantify. Many factors, including the pages of documentation and the numbers of military specifications reduced, may not have a clear connection to reduced costs and reduced cycle time. There may be other metrics or external measures of what constitutes a successful program. The study of these metrics or a better understanding of what program "goodness" is may be not only revealing, but important for the implementation of future reform measures.

APPENDIX A

Description of the Lean Aircraft Initiative

A.1 Background

The Lean Aircraft Initiative is an MIT-led consortium jointly funded by the U. S. Air Force and about 20 major aerospace companies, with participation by the Navy and Army. The program has been undertaken to discover and put into practice initiatives that will achieve advances in the productivity, quality, and affordability of military aircraft.

In the summer and fall of 1992, the program entered into an exploratory phase to determine whether "lean" manufacturing principles derived from the automotive industry could be applied to the aircraft industry. The principles of "lean" manufacturing were first characterized by members of the International Motor Vehicle Program (IMVP) at MIT. The , *The Machine That Changed the World.* The Lean Aircraft Initiative was officially launched in mid-1993 under MIT's Center for Technology, Policy and Industrial Development in collaboration with the Department of Aeronautics and Astronautics.

The Lean Aircraft Initiative at MIT builds on and extends the lean paradigm by seeking to improve productivity and affordability in the defense aircraft industry. By building on and extending the lean paradigm

through an organized process of research, the program seeks to develop the knowledge base that will lead to greater affordability of systems, increased efficiency, and higher quality.

Define and help implement road maps for fundamental change in both industry and Government operations, based on best lean practices, resulting in:

- Greater affordability of systems
- Increased efficiency
- Higher quality
- Enhanced technological superiority
- Stronger U.S. defense aircraft industrial base

A.2 Program Structure

Through the development of a systematic knowledge base, the Lean Aircraft Initiative aims to create and implement road maps for change in the US defense aircraft industry and the broader manufacturing base supporting it. The LAI takes a broad view of the defense aircraft industry, encompassing all sectors of defense aircraft production, including airframe integrators and major supplier groups, such as producers of engines, avionics and electronic systems, and other equipment suppliers. The program has undertaken research in four major areas: Product Development, Factory Operations, Supplier Systems and Relationships, and Policy and External Environment. A sixth focus area, probing environmental issues and practices, is being explored. It is anticipated that major strides in efficiency and quality, as well as enhancements in both the economic and technological viability of the industry, could be affected over the next decade.

A.3 Sponsors and Other Participants

Table A.1: Sponsors

Government
U.S. Department of the Air Force
Industry
AIL Systems
AlliedSignal Aerospace
Boeing Defense & Space Group
General Electric Aircraft Engines
Hughes Aircraft Company
Lockheed Martin Aeronautical Systems Company
Lockheed Martin Electronics & Missiles
McDonnell Douglas Aerospace
Northrop Grumman Corporation, including Vought Center and Electronic Sensors and Systems Division (formerly Westinghouse Electronic Systems Group)
Pratt & Whitney (United Technologies Corporation)
Raytheon Aircraft Corporation
Rockwell International
Sundstrand
Texas Instruments Defense Systems & Electronics Group
Textron Systems Division
TRW Avionics Systems Division

Table A.2: Other Participants

Government
U.S. Department of Defense
Defense Advanced Research Projects Agency
Defense Logistics Agency
U.S. Department of the Air Force
Office of the Assistant Secretary for Acquisition
U.S. Department of the Army
Office of the Assistant Secretary for Research Development and Acquisition
U.S. Army Aviation and Troop Command
U.S. Department of the Navy
Office of the Assistant Secretary for Research Development and Acquisition
Air Programs Office
Naval Air Systems Command
Defense Systems Management College
Labor
International Association of Machinists (IAM)
United Auto Workers (UAW)
Industry Associations
Aerospace Industries Association of America (AIA)
National Security Industrial Association (NSIA)
Other Universities
Georgia Institute of Technology
University of Michigan, Dearborn
Williams College

APPENDIX B

Background to the JDAM Program

The first section of this appendix will provide a description of the technical capabilities of the Joint Direct Attack Munition (JDAM) program. A brief description of the program schedule is given in the second section of this appendix. The third section specifies the purpose of the program. The JDAM program played a key part in the acquisition reform movement and in weapons systems acquisition reform. The program was designated as a Defense Acquisition Pilot Program (DAPP) to implement the measures spearheaded by the Federal Acquisition Streamlining Act (FASA) of 1994. To contrast the acquisition process of the JDAM program, a detailed look at traditional acquisition is taken, including a history of the defense acquisition system and a description of the traditional acquisition process. The problems with the traditional acquisition system, the goals of current reform, and the current status of acquisition reform are also identified. Finally, the measurable results of acquisition reform in the JDAM program are highlighted. Many of the results from JDAM involve the changing relationships among the Government, prime contractor(s), and suppliers. The implementation of acquisition reform in the JDAM program had a significant impact on these relationships and the product development administration of the program. The changing relationships between the Government and the prime contractor(s) are characterized in appendix entitled, "Product Development Administration of the JDAM Program." The changes in supplier relationships and management is the subject of the body of the thesis. These relationships are inter-related with the acquisition reform movement that is delineated in this appendix.

B.1 Program Description

The Joint Direct Attack Munition (JDAM) Program is a joint development and production activity for the Air Force and Navy. JDAM "tail kits" are attached to general-purpose bombs to provide accurate delivery at an affordable price. JDAM kits provide accurate weapon delivery capability by incorporating an Inertial Navigation System/Global Positioning System (INS/GPS) guidance control units onto existing 1000- and 2000-pound unguided, general-purpose bombs. The tail kit thereby converts these bombs into precision-guided "smart" munitions.

The need for accurate weapon delivery capability in adverse weather conditions was clearly identified in Operation Desert Storm (1991). With the addition of JDAM to the military arsenal, existing limitations of adverse-weather or man-made obscurants would be overcome. The goal of JDAM is to provide an affordable, accurate, autonomous, adverse-weather solution to fixed attack. For this purpose, kits are configured for a variety of Air Force and Navy aircraft (see Table C-2).

The JDAM Kit consists of a bomb tail structure, a set of strakes for increased maneuverability, and the storage container. A typical JDAM mission would begin with planning the mission, loading the missile onto the aircraft, and loading the mission data on the aircraft prior to departure. Subsequent to take-off of the aircraft, power would be supplied to the JDAM kit for warm-up, checkout, alignment of the Inertial Measurement Unit, and loading of the target information. Following "transfer alignment" with the acceptable launch region, the thermal battery would activate, and the JDAM assembly would be ejected from the aircraft. Finally, the aircraft would return to base after safe separation of the missile.

In-flight re-targeting capability is a unique feature of the JDAM. This feature allows the pilot the choice of designating a new target in flight from the cockpit prior to release of the JDAM. (Following release from the aircraft, the JDAM is designed to be completely autonomous.) In-flight re-targeting allows the pilot to drop multiple bombs on one target or

individual bombs on separate targets in the same pass. Not only does this improve the functionality and flexibility of the weapon, but it also reduces the need to make flights directly over the target. thereby increasing survivability.

B.2 Program Schedule

Chapter 3 and Appendix C also describe the program schedule. This section provides a brief overview to introduce the program before analyzing the impact of acquisition reform on the JDAM program and the role that JDAM played in the acquisition reform movement.

In April of 1994, two 18-month EMD-1 contracts were awarded to McDonnell Douglas and Lockheed Martin. During this phase, the two prime contractors focused on lowering the Average Unit Production Price (AUPP) and reducing the manufacturing risk. EMD-1 was based on a cost plus fixed fee contract structure. October 11, 1995 marked the downselect to one prime contractor, McDonnell Douglas. EMD-2 is scheduled for 40 months, with Lot 1 Production beginning delivery in FY98. EMD-2, which consists of the phases of fabrication, Developmental Test and Evaluation, and Initial Operational Test and Evaluation, will complete development and operational testing and is based on a cost plus award fee contract structure. The contract structure for initial production (Lots 1 and 2) is a firm fixed price. Lots 3 through 5 (Rate Production) are expected to be based on production cost curves.

The schedule for JDAM development was accelerated. EMD-2 was shortened from 46 months to 40 months. Milestone III is scheduled to be 15 months earlier than a traditional schedule. The contract structure was also designed to incorporate flexibility into the development. The departure of program development from the traditional development process reflected the desire to streamline cost and schedule in the acquisition reform movement.

B.3 Purpose of the Program: Acquisition Reform

The Joint Direct Attack Munition (JDAM) Program is a pilot program for weapon systems acquisition reform and a model for general aerospace defense acquisition reform. JDAM was designated by the Department of Defense (DoD) as an Defense Acquisition Pilot Program (DAPP) under the Federal Acquisition Streamlining Act (FASA) of 1994. After an 18-month competition, the program demonstrated on several levels that the Government could streamline its buying practices to minimize excessive costs and time associated with the production of military products. The desire to implement cost-saving and time-saving acquisition reform was coupled with the knowledge that excessive amount of time were being spent evaluating proposals in the acquisition process. The strategies and methods that were used to create changes in acquisition reform were novel in the aerospace defense industry. The benefits that the JDAM Program achieved through reducing development costs, development time, and acquisition paperwork also extend to benefits for the tax-paying American public as more efficiently used federal funds.

Initial reform measures that were used in JDAM were enabled by statutory authority granted by Congress, allowing relief from existing, strict acquisition regulation. Acquisition reform gave defense aerospace contractors the opportunity to: challenge excessive requirements through the requirements review process, focus on performance requirements, use commercial parts and practices, and eliminate "how-to" specifications. The excessive requirements that were typical of the traditional requirements process were criticized for generating distrust and encouraging gamesmanship, as well as wasting money. Implementation of acquisition reform changed the relationships between the major players in the JDAM program by permitting new, more collaborative relationships to develop. Acquisition reform helped to break down the barriers of traditional arm's length relationships. Eventually, these new, collaborative relationships, along with the acquisition reform changes, resulted in significant cost and development time reductions for the program.

Although the ability to challenge existing norms was critical to the JDAM program, acquisition reform initially met significant resistance and was difficult to implement. The skepticism and suspicion that had accompanied traditional acquisition practices was difficult to replace with collaborative and trusting relationships. Acquisition reform in the JDAM program, however, was implemented successfully and reached far beyond requirements reform and customer relationships to impact the product development process and supplier relationships.

To comprehend the full impact of the JDAM program on acquisition reform and the business relationships between parties, it is necessary to understand the traditional weapons systems acquisition process and its limitations. The next three subsections provide a brief history of weapon systems acquisition, an overview of the traditional acquisition structure and process, and a description of the problems with the system. Some of the problems with the traditional acquisition process are then cited, followed by the goals of acquisition reform, the current status of acquisition reform, and their impact on the JDAM program. Program members developed successful solutions to many of the problems with the traditional acquisition process.

B.3.1 A Brief History of Weapon Systems Acquisition

In 1947, when the Department of Defense (DoD) was first formed, the acquisition of weapon systems was focused on simplicity, reliability, and producibility, similar to the automobile industry. The DoD provided loose guidance to the three military departments, and, as a result, did not have any formal authority to control acquisition. Thus, each military Service conducted its own acquisition autonomously through the 1950s.

The decline in defense business that was witnessed after World War II was reversed as the United States entered the Korean conflict. The United States defense budget increased after the Korean conflict, and the United States had to manage the first peacetime defense industry in its history. Two major trends were introduced during this era. The first of these trends was toward cost-reimbursement contracts, which refers to the type of

contract between the Government and prime contractor(s) once the source is selected (or sources are selected). In cost-reimbursement contracts, the Government agrees to reimburse the prime contractor for all valid costs incurred in pursuing the contract objective, with some variation. In the cost-plus-fixed-fee (CPFF) contract structure, the Government promises to pay a fixed amount on top of the cost of reimbursement. The cost-plus-incentive-fee is an alternative to the percentage profit scheme of the CPFF structure. Having the option of cost-reimbursement contracts relieved prime contractors of the high costs of development that were characteristic of fixed-price contracts. Under fixed price contracts, the prime contractor must forecast the costs and incur the risks associated with unexpected cost overruns. The firm fixed-price (FFP) contract structure provides for a firm price before work is started, and no changes may be made to the price regardless of actual cost. The prime contractor has an incentive to cut costs so that final costs are less than the agreed-to price. If final costs are more than the agreed-to price, however, the prime contractor must take the loss. The second trend introduced was toward custom design and development. Before and during World War II, the defense industry was compared with a typical manufacturing industry--with heavy emphasis on simplicity, reliability, and producibility. Since the late 1950s, however, the industry has been compared with a custom design and development industry.

The Department of Defense Reorganization Act of 1958 established the next landmark in acquisition policy. This legislation authorized the Secretary of Defense to assign the design, development, production, and use of weapon systems to any military department or Service. In 1961, McNamara took on the role of Secretary of Defense and established many prevalent acquisition processes. McNamara initiated: the planning , programming, and budgeting system; integrated logistics support planning; increased competition; network planning and scheduling; incentive contracting; source selection and proposal evaluation procedures; improved quality assurance; information systems; value engineering; technical data management; configuration management; the Work Breakdown Structure

(WBS)[4] ; defense standardization; and the use of more paper studies (as opposed to system prototyping) in the earlier acquisition phases as a cost savings measure. McNamara was also a proponent for active management from the top and centralization of program authority in the DoD.

Large cost overruns of the 1950s again resulted in contract structure changes from cost-reimbursement to fixed-price and incentive. Changes in contract requirements and weak enforcement of fixed price contracts, however, resulted in continued cost overruns through the 1960s.

In 1968, Deputy Secretary of Defense David Packard instituted the Development Concept Paper--later the Decision Coordinating Paper and now the Integrated Program Summary--to maintain DoD involvement while largely decentralizing control of acquisition programs. Packard created the Defense Acquisition Board (formerly the Defense Acquisition Review Council) to review and inform him of program status at each phase of development. The Cost Analysis Improvement Group was also established to develop independent cost estimates and uniform cost estimation standards. Packard's DoD Directive 5000.1, "Acquisition of Major Defense Systems," called for an increase in program manager authority, a provision for awards, and an increase in accountability, but received little support. Packard also reversed some of the initiatives that McNamara had pressed for in the 1950s. Namely, paper studies were replaced by a push toward hardware prototyping for improved contractor selection. Contracts were also pushed back to cost-reimbursement and incentive contracting. The cost overruns, nevertheless, continued despite these efforts.

In 1976, the Office of Management and Budget (OMB) Circular A-109, "Acquisition of Major Systems," showed support for 5000.1, but also highlighted the need for increased competition in the acquisition process. The Circular also addressed the need for each department to perform

[4] The Work Breakdown Structure (WBS) is a device for project or program managers to engage in planning and controlling their programs, with MIL-STD-881B as a guide. Contractors and DoD components use a WBS to define the program's total objectives and to relate the work efforts (parts) to the overall system. The WBS provides a foundation for program and technical planning, Statement of Work preparation, schedule definition, cost estimation and budget formulation, and progress status reporting and problem

"mission area analyses" to determine their needs throughout the entire acquisition process. The direction of the control was also reversed to a system that was more centralized in the DoD.

With the Reagan Administration in the 1980s, a large defense buildup and a controlled, decentralized acquisition process were advocated. Among the 32 initiatives that Deputy Secretary of Defense Frank Carlucci designed were: multi-year procurement; greater competition in contracting; stabilized budgets; more realistic budgeting; and a return to fixed-price contracts. Cost overruns, however, still continued. In 1986, a blue ribbon panel chaired by David Packard, known as the Packard Commission, was created in response to problems with the B-1 program. Results of the commission's national survey showed that the public held the military in high regard but held the prime contractors in low regard. The public also believed that as much as half the defense budget was lost to waste and fraud. The Packard Commission cited the lengthy acquisition process (seven to ten years, or longer) for major weapon systems as a central problem, leading to: unnecessarily high costs of development, obsolete technology at the time of deployment, and, because of the uncertainty of long-term forecasts, a tendency to severely overstate the threat. Four new positions (or types of positions) were recommended to mitigate the problems of the defense acquisition process: an Under Secretary of Defense for Acquisition, acquisition executives in each component (that reported to the Under Secretary of Defense for Acquisition), Program Executive Officers that would oversee specified programs within each Service and report to the Component Acquisition Executive, and the extension of the role of the Vice Chairman of the Joint Chiefs of Staff. The Under Secretary of Defense for Acquisition would be in charge of procurement, research and development, and test and evaluation for all weapon systems. The Vice Chairman of the Joint Chiefs of Staff would help prevent overlap of system development between the Services. In addition to the Packard Commission recommendations, the Goldwater-Nichols Defense Reorganization Act of 1986 made recommendations to

analysis. The Statement of Work (SOW) defines non-specification tasks or requirements and defines the work effort to define the scope of the contractor's effort.

trim headquarters staff and increase inter-Service coordination. Most of the Packard Commission and Goldwater-Nichols recommendations, however, were not enacted until the Defense Management Review of 1989 agreed to implement the changes.

The effects of the Defense Management Review and the Packard Commission are seen today. In February 1991, the DoD Directive (DoDD) 5000.1 was updated and released, along with DoD Instruction (DoDI) 5000.2, "Defense Management Policies and Procedures," and DoD Manual (DoDM) 5000.2-M, "Defense Acquisition Management Documentation and Reports." Continued cost and schedule overruns in the industry have returned contracting to cost type contracting.

The cyclical nature of acquisition management is demonstrated by the movement from cost- to fixed-price contracting, centralized control to decentralized control, and separated commands to unified commands for acquisition and support. This cyclical nature suggests that acquisition management problems require different types of changes than in the past. Perhaps the root causes of acquisition management problems had not been clearly identified. Acquisition reform changes that produce visible and beneficial effects were certainly anticipated.

B.3.2 An Overview of the Traditional Acquisition Structure and Process

The traditional acquisition process has a management structure that is separate from normal operational chains of command. The management acquisition structure of the Air Force is divided into three tiers: the technical support (Product Centers), test support (Test Centers), and logistics support (Logistics Centers). In the acquisition structure, program managers (PMs) are responsible for ensuring on-time development and delivery schedules and ensuring delivery of required performance. The PM reports directly to the Program Executive Officer (PEO), who is responsible for the execution and information validation of a limited group of mission-related acquisition programs. The PEOs then report directly to the Component Acquisition Executive (CAE), the assistant secretary in charge

of all Service acquisition programs. The CAE is responsible to the Under Secretary of Defense for Acquisition [USD(A)], who is designated as the Defense Acquisition Executive (DAE). The DAE is ultimately responsible for all acquisition within the DoD according to the Secretary of Defense's 1991 Annual Report to the President and Congress.

Programs are assigned an acquisition category (ACAT) based on the dollar size and interest in the program. Major Defense Acquisition Programs (MDAPs), or ACAT I programs, have either been designated as a MDAP by the USD(A) or meet certain dollar threshold criteria for the category. DoD 5000.1 offers some suggestions or "rules of thumb" to identify major program prior to Milestone I, or in the early stages of the process: "(a) a capability that may require the use of new, leading edge technologies and an extensive development effort, (b) initiation of a major performance upgrade to an existing system that is fielded in significant quantities, or (c) when in doubt the program should be treated as if it will result in a major program."[36]

The acquisition process consists of preparatory and formal phases. The preparatory acquisition process consists of the Requirements Definition Process and the Concept Exploration and Definition (CE) phase. The formal acquisition process begins with the Demonstration and Validation (DEM/VAL) phase and continues with the Engineering and Manufacturing Development (EMD) phase, Production and Deployment phase, and Operations and Support (O&S) phase. Figure B-1 describes the system acquisition life cycle process.

[36] DoD Directive 5000.1, "Defense Acquisition," Office of the Secretary of Defense, Under Secretary of Defense for Acquisition, 23 February 1991, as cited by Przemieniecki, J. S. (Ed.), *Acquisition of Defense Systems*, Washington, D.C.: American Institute of Aeronautics and Astronautics, Inc., 1993, p. 20.

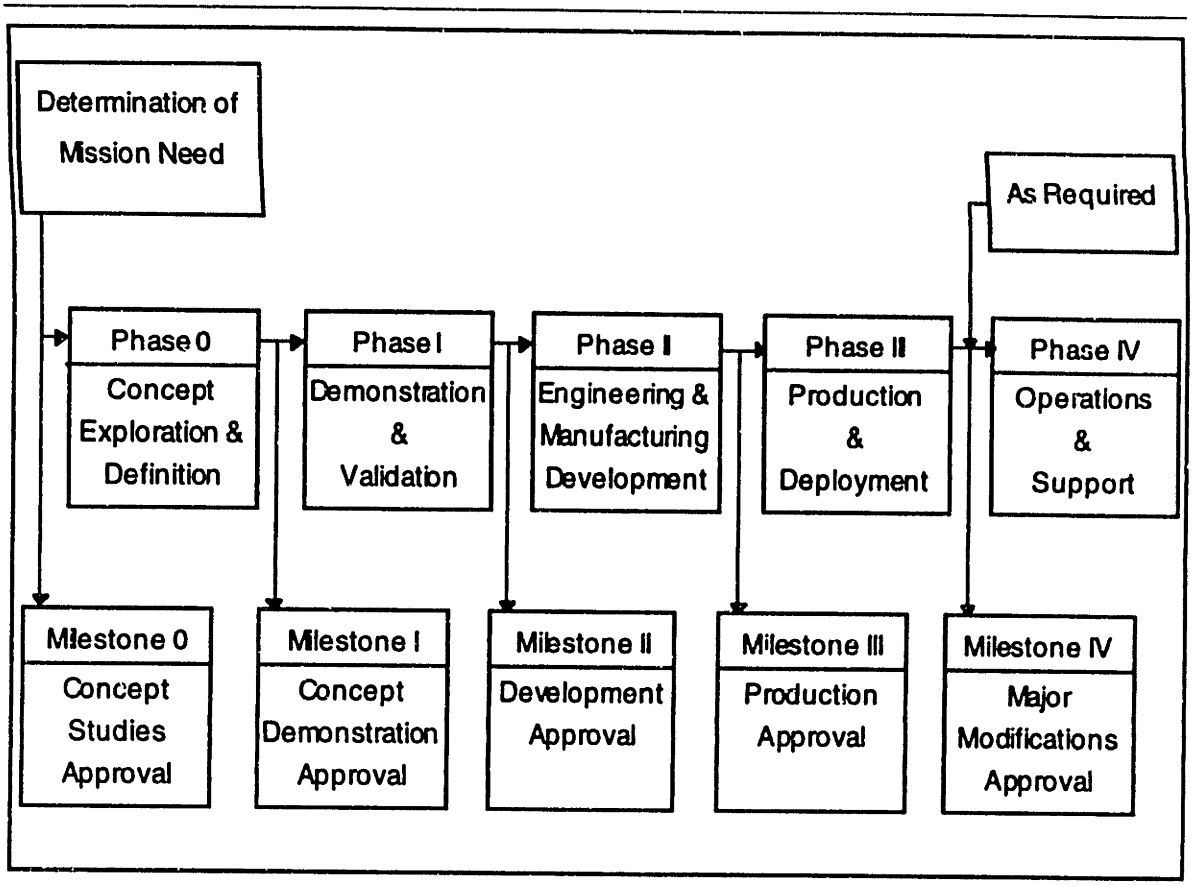


Figure B-1: The System Acquisition Life Cycle Process[37]

[37] Source: Przemieniecki, J. S. (Ed.), *Acquisition of Defense Systems*, Washington, D.C.: American Institute of Aeronautics and Astronautics, Inc., 1993, p. 22.

Requirements Definition

Prior to the "Milestone 0" decision, Concept Studies Approval, operational mission needs are determined by performing a mission area analysis, examining changes in policy, examining cost reduction, and taking advantage of a technological opportunity. Mission area analysis or a change in policy such as the cancellation of a program could identify a threat that cannot be countered with current capabilities. A Mission Need Statement (MNS) captures operational needs for a potential new program and is sent to the Joint Requirements Oversight Council (JROC), which consists of the Vice Chairman of the Joint Chiefs of Staff, Vice Chiefs of Staff (Army and Air Force), Vice Chief of Naval Operations, and Commandant of the Marine Corps. Mission Need Statements that are approved by the JROC are considered by the Defense Acquisition Board (DAB) approximately once a year in the Milestone 0 review. In this Concept Studies Approval decision process, the DAB determines whether the need is based on a validated threat, cannot be satisfied by a non-materiel solution, merits funding, and warrants further study of alternative concepts. If these conditions are met, the DAB also determines which alternative concepts will be studied to meet the need. Concurrence with the MNS by the DAB and the USD(A) results in the issuance of an Acquisition Decision Memorandum (ADM) by the USD(A) to the Service office responsible for acquisition.

Phase 0: Concept Exploration and Definition

Milestone 0 acceptance marks the beginning of Phase 0, Concept Exploration and Definition. During this phase, the Operating Command initiating the MNS leads paper studies of alternative solutions, establishes a concept action group, performs a Cost and Operational Effectiveness Analysis (COEA), prepares an Operational Requirements Document (ORD) with a Requirements Correlation Matrix (RCM). A Program Manager (PM) is appointed to establish the System Program Office (SPO) and to prepare acquisition strategy and program management plans. The PM also prepares an Acquisition Program Baseline (APB), the Concept

Baseline for Milestone I, which provides initial cost, schedule, and performance objectives for Phase I and is required for the Milestone I review. The results of the phase activities are summarized by the SPO in coordination with the Operating Command in the Integrated Program Summary (IPS). An IPS is prepared at the end of every phase to initiate the milestone review process. The IPS is submitted through the PEO and CAE for JROC and DAB review. At Milestone I Concept Demonstration Approval, the DAB reviews the validity of the threat, analyzes the Concept Baseline, and reviews affordability of life cycle costs and funding requirements for the concept to proceed to Phase I, the beginning of the formal acquisition process.

Phase I: Demonstration and Validation

A Milestone I Acquisition Decision Memorandum (ADM) issued by the DAE initiates Phase I by approving the acquisition strategy and Concept Baseline, establishing requirements, and identifying cost constraints. For major acquisitions, two designs typically compete in Demonstration and Validation (DEM/VAL) to ensure high quality at the lowest price. The goals of the SPO during Phase I are to prove technical feasibility, reduce program risks, establish a Development Baseline (the second acquisition program baseline), identify the "best solution" to the identified need, propose low-rate initial production (LRIP) quantities, and conduct prototyping, test, and evaluation. Tests focus on Development Test & Evaluation (DT&E); Operational Test & Evaluation (OT&E) is usually limited to the further definition of test approaches, schedules, facility requirements, and required resources. The development of another prime contractor for full scale development and production is considered, but cost usually restricts the final choice to one system and prevents a competitive alternative development and production. Phase II, Engineering and Manufacturing Development, is triggered by the preparation of the IPS by the PM and Milestone II review, Development Approval.

Phase II: Engineering and Manufacturing Development

If the DAE approves the proposed updated acquisition strategy and Development Baseline, the Milestone II ADM is issued and Phase II, Engineering and Manufacturing Development (EMD) begins. Along with cost, schedule, and performance criteria, the Milestone II ADM will baseline low-rate initial production (LRIP) quantities. Scaling up the weapon system design to full scale development during EMD represents one of the most difficult challenges of the acquisition life cycle process. As a result, major acquisition programs entering this phase gain attention from Congress, the Office of Management and Budget (OMB), the Office of the Secretary of Defense (OSD), and the Service Chiefs.

The goals of EMD are to validate the manufacturing and production processes and to show that the product will meet contract specifications and minimum acceptable operational performance requirements. The SPO revalidates the threat, tests the design under as realistic operational conditions as possible, and refines the acquisition strategy and cost estimates. The SPO develops the Production Baseline (the final acquisition program baseline) and the System Configuration Baseline, performs an environmental impact assessment, and confirms life cycle and annual operational affordability. Testing in EMD is a combination of DT&E and IOT&E, Initial Operational Test and Evaluation, with an emphasis on IOT&E. IOT&E is required to be completed and reported to the Director of Operational Test and Evaluation at OSD prior to DAB review. Pursuant to meeting all technical, operational, and funding thresholds, the PM prepares the IPS to trigger a Milestone III, Production Approval decision review, by the DAB.

Phase III: Production and Deployment

If the cost, schedule, and performance objectives are met in Milestone III according to the criteria of the DAB and DAE, then an ADM is issued to initiate Phase III, Production and Deployment. A Program Management Directive (PMD) is issued subsequent to the ADM. Weapon system quality and performance, while producing in quantity, must be maintained during this phase. Acceptance testing of production line items and quality assurance methods, as well as the implementation of logistics support plans, are emphasized in this phase. Follow-on OT&E (FOT&E) is conducted to ensure that effectiveness and suitability criteria are met. Managing problems or unplanned changes is the greatest challenge of this phase because these problems can be costly, affect other areas of production, and cause schedule slips. As a result, improvements that are not incorporated into the original design are scheduled into future production lots.

Phase IV: Operations and Support

If a system is no longer effective--because of a new threat, a change in policy, prohibitive costs, technical obsolescence, or aging–measures may be taken to address deficiencies and restore system usefulness after the system is fielded. Changes may be made in operations, maintenance, or training. If these options are inefficient, however, then the PM will prepare an IPS for Major Modification Approval, Milestone IV. If the system, on the other hand, is out of production, the Operating Command must prepare a MNS, competing with other proposed programs in Requirements Definition.

B.3.3 Problems with the Traditional Acquisition Process

The traditional acquisition process has been characterized with problems of: excessive costs, excessive delays in program decision approval, expensive management layers, extensive program changes, excessive oversight and regulation, and extreme inefficiency. The cyclical changes–in cost-plus or fixed-price contract structure, centralization within the DoD or

decentralization among the Services, and separated or unified command of programs--represent attempts to prevent cost overruns through acquisition reform (see Appendix B).

In June 1994, the need for change was characterized by Secretary of Defense William Perry's report, "Mandate for Change," as necessary to meet the security challenges of the post-Cold War era. One problem cited in the report is the DoD's inability to acquire state-of-the-art commercial technology. DoD requirements restrict the exemption of commercial suppliers from providing cost data. The DoD is subsequently often unable to buy from commercial companies despite lower priced products. In some cases, however, the Government must buy a commercial product because it is the only one available or it is from the only source willing to comply with Government requirements. Commercial companies have cited several reasons for refusing to do business with the Government: the inability of commercial division accounting systems to provide Government-required cost data; additional costs of complying with Government-unique terms; the risk of giving the Government the right to audit proprietary cost information; and the risk of losing commercial proprietary data; and the length of standard Government solicitation procedures. Government requirements and policies therefore limit or block access to advanced technologies, threatening the defense aerospace industry with technological obsolescence.

Policies of the traditional acquisition system that limit the achievement of high quality, low cost acquisition are based on bureaucratic philosophies, including: specialization as the most efficient way to produce products; rigid lines of authority and reporting; rules and procedures designed to account for every contingency possible; extensive documentation required to ensure that appropriate actions were taken; detailed design and "how-to" specifications designed to ensure high quality; in-process inspections, audits, and reviews; and "programming" people to conform to established procedures; and the encouragement of predictable, workable, and safe systems. These philosophies result in, according to Michael Hammer and James Champy's *Reengineering the Corporation: A Manifesto for Business*

Revolution, the creation of functional "stove-piping" in which no one person is accountable for an entire process; so many hand-offs that errors and waiting time are dominant features of the system; and the improbability of one person being able to make changes.

The problems of the traditional acquisition system may be historical or result from the nature of the system. Previous corrective actions resulting from the Packard Commission recommendations and the Goldwater-Nichols Reorganization Act of 1986 made significant changes to the acquisition process, but were not sufficiently comprehensive. Current changes in legislation, including the Federal Acquisition Streamlining Act of 1994, represent an extensive effort to approach the problems that have continued to characterize the acquisition process.

B.3.4 The Goals of Acquisition Reform

In his June 1994 report, "Mandate for Change," Secretary of Defense William Perry established the importance of acquisition reform and streamlining: "If DoD is going to be capable of responding to the demands of the next decade, there must be a carefully planned, fundamental re-engineering or re-invention of each segment of the acquisition process."[38] He recognized that "Acquisition reform shares a common border with many of our most important goals: saving the taxpayer money; reinventing Government; strengthening our military; and improving our economy." The goals of the acquisition reform process, as described by Perry, may be divided into three categories: requirements determination and resource allocation, the acquisition process, and the terms and conditions of the contracts negotiated with prime contractors.

[38] Cited by "Building a Lean, Agile Acquisition System: Acquisition Reform Trims Modernization Bill By $13 Billion," *Air Force Acquisition Reform*, Secretary of the Air Force for Acquisition, Department of the Air Force, March, 1996, p.1.

Requirements Determination and Resource Allocation

The goals of acquisition reform in the area of requirements determination and resource allocation are to strengthen the preference for commercial items and allow for the purchase of commercial items; reassess the allocation of resources, the ways in which needs are established, and the translation of mission needs and requirements into best value military solutions; allow for the timely infusion of new technology; include potential contractors in DoD process action teams and working groups early in the life cycle; improve the DoD's ability to develop and transfer technology from defense laboratories to commercial companies; and increase the purchase of commercial products.

DoD Acquisition Process

The reform goals in the area of the acquisition process include streamlining the process by focusing on continuous process improvement, active team participation, and process control rather than using after-the-fact inspection methods; minimize the obtrusiveness of oversight, testing, and inspection; minimize burdensome reporting requirements; provide incentives for acquisition personnel to innovate; adopt new acquisition strategies that allow for flexibility; provide more funding stability and flexibility; encourage innovation in products and practices; encourage risk management rather than risk avoidance; streamline the source selection process for major systems; and implement integrated decision teams and employee training.

Contract Terms and Conditions

The goals regarding contract terms and conditions acknowledge the necessity of making commercial purchases to meet new military challenges. The underlying goal of the Government is not to impose any unnecessarily Government-unique law, regulation, policy, practice, process, procedure, standard, or specification when purchasing a commercial item. Additionally, reform would initiate buying on the basis of "best value"

rather than "lowest bid." Awards for contractor performance would be initiated. A large part of this reform area is the transition from a traditionally cost-based system to a price- or market-based system.

Acquisition reform is necessary because of the changing nature of the national security environment as well as the integration of military and commercial elements of the national industrial base. The goals of acquisition reform are based on the need to change how the DoD determines what to buy, the process of major systems acquisition, and the terms and conditions that are negotiated with the prime contractor. The current state of reform represents a significant effort to achieve these goals through legislation and cultural change.

B.3.5 The Current State of Acquisition Reform and the Federal Acquisition Streamlining Act of 1994

Several recent actions have been taken to achieve the goals of acquisition reform. On March 3, 1993, President Clinton created the National Performance Review (NPR) with Vice President Al Gore as its leader. The NPR initiated many of the federal and OSD acquisition reforms. Secretary Perry created the Office of the Deputy Under Secretary of Defense for Acquisition Reform, responsible for identifying and initiating necessary changes at the DoD, federal, and legislative levels of the Government. He appointed Colleen A. Preston as the Deputy Under Secretary of Defense for Acquisition Reform [DUSD(AR)] in June of 1993. The DUSD(AR) championed the Administration effort on the Federal Acquisition Streamlining Act (FASA) of 1994.

FASA '94 was a major piece of legislation that designated several Defense Acquisition Pilot Programs (DAPPs), established streamlined rules for commercial buys, increased the use of Electronic Commerce (EC), established the Simplified Acquisition Threshold, and eliminated many of the burdensome acquisition laws. FASA '94 provisions included Simplified Acquisition Procedures/Federal Acquisition Computer Network; commercial item acquisition; market research; new rules in cost and price analysis; task order contracts; contract award and debriefings; past

performance evaluations, protests, disputes, and appeals rules; and how to form and work in Integrated Product and Process Teams. Preston, requested that each Service nominate programs for consideration as DAPPs. The DAPPs are the Joint Direct Attack Munitions (JDAM), Fire Support Combined Arms Tactical Trainer (FSCATT), Joint Primary Aircraft Training Systems (JPATS), and Commercial Derivative Engine (CDE) and Aircraft (CDA), the Non-Developmental Airlift Aircraft (NDAA).

To evaluate the benefits of approved regulatory and statutory relief and the implementation of innovative commercial practices in DoD acquisition, the DoD Pilot Program Consulting Group (PPCG) was formed. The group is composed of representatives from the DoD Comptroller, DoD Inspector General, Defense Contract Audit Agency, Defense Contract Management Command, the Defense Systems Management College, and the Component Services. The PPCG helps the DAPPs develop focused metrics and appropriate baselines to evaluate these impacts. According to the March/April 1996 edition of *Acquisition Reform Today*, cost and schedule savings of as much as 50 percent have been reported in the programs designated as Defense Acquisition Pilot Programs (DAPPs). The PPCG cited four categories of significant gains permitted by the FASA '94 statutory and regulatory reforms: the use of military standards, contract data requirements, solicitation length and complexity, and source selection cycle time.[39]

The DUSD(AR) also established Process Action Teams (PATs) to propose recommendations for acquisition process improvements. Some PATs were established to focus on the procurement process, contract administration, acquisition oversight and review, and Electronic Commerce/Electronic Data Interchange (EC/EDI). Currently, the PATs are complete and many of the recommendations are being implemented. The Office of Federal Procurement Policy (OFPP), led by Steve Kelman, is heading an effort to streamline Federal Acquisition Regulation (FAR) and is currently rewriting FAR Part 15, Contracting by Negotiation.

[39] "FASA '94: Pilot Programs Show New Law Big Step in AR," *Acquisition Reform Today*, Office of the Deputy Under Secretary of Defense for Acquisition Reform, Vol. 1, No. 2, March-April, 1996, p. 1.

The DoD 5000 series documents have been revised as part of the acquisition reform movement. Revisions of the Directive 5000.1 and Instruction 5000.2 were produced by a joint OSD-Component team under the general direction of the DUSD(AR) Colleen Preston and Director of Acquisition Program Integration Irving Blickstein. The Directive 5000.1 was revised for general principles while the 5000.2 was revised for mandatory instruction. Six over-arching themes were drawn from the revised 5000 series which are undoubtedly part of the acquisition reform movement: (1) there is an emphasis on teamwork, a collaborative spirit, and the use of cross-functional teams to maximize overall performance; (2) Milestone Decision Authorities should strive to tailor program documentation, acquisition phases, and the timing, scope, and level of decision reviews; (3) the empowerment of the Program Managers is essential within the bounds of statute, Executive Order, FAR/DFARS, or the 5000 series documents to balance responsibility and authority; (4) cost must be considered an independent variable in programmatic decisions, (5) integration of a constricting industrial base that was primarily dedicated to supporting DoD requirements with a fast-paced technology sector requires that statutory regulations allow for the acquisition of commercial items.

Along with the major legislation of FASA '94, the FY96 Defense Authorization Act is moving the reengineering of the acquisition system further along with several reform measures. The legislation repeals the 1965 Brooks Act which gave all federal information technology (IT) acquisition and management authority to the General Services Administration (GSA)--impeding the fast, efficient purchase of IT and creating the problem of obsolescent equipment. Under the new legislation, agencies were given the authority to acquire IT directly within the framework established by the Office of Management and Budget (OMB). Authority to limit the number of bidders in the competitive range was given to contracting officers when it would promote efficiency. Post-employment restrictions on disclosing or obtaining contract award information were simplified and clarified. For a three-year pilot period, commercial items up to $5 million in contract value may be purchased through simplified procedures. Excessive and burdensome cost or pricing data requirements are also lifted from all competitive commercial item procurements as a result of this legislation.[40]

Another round of acquisition reform legislation, FASA II, is set to provide relief for restrictive statutes not dealt with in the first version. The institutional barriers of the traditional system of acquisition are being eroded by the implementation of FASA '94, the Defense Authorization Act, and future reform.

B.3.6 JDAM Results

The Joint Direct Attack Munition (JDAM) program is a significant manifestation of the benefits resulting from commercial-style environment created by the Federal Acquisition Streamlining Act (FASA) of 1994.

[40] Squillacote, Terry, "New Changes in Legislation Big as FASA '94 for AR," *Acquisition Reform Today*, Office of the Deputy Under Secretary of Defense for Acquisition Reform, Vol. 1, No. 2, March-April, 1996, pp. 3-4.

Table B-1 summarizes the effects of acquisition reform on the program. The program lowered the costs of developing and producing the weapons system (based on baselines for a traditional acquisition process), reduced development time, and acquisition paperwork, all while meeting or exceeding every requirement. The affordability benefits are staggering: a 34 percent reduction in development time and a reduction in Average Unit Production Price by 76 percent (over $2B in total production cost savings). The Unit Production Price for the container alone was reduced by 80 percent, representing $75M savings. Similarly, the Operation & Support (O&S) costs were reduced by 97 percent for $375M in savings with the addition of a 20-year contractor warranty. In addition to the affordability benefits, the program benefited from the ability to procure proven technology with reduced oversight and streamlined documentation. An average 85 percent reduction in in-plant oversight was experienced. The streamlining of procurement documentation was unprecedented. The Statement of Work was reduced from 137 to 2 pages by the contract award date (for production). Government-mandated MIL-SPECS and MIL-STDS (87 in total) were eliminated. Government-mandated contract delivery terms, Contract Data Requirements Lists (CDRLs), were reduced from 243 reports to 15 by EMD-2.

The results of the JDAM program were unprecedented, and the JDAM team received recognition for their pioneering achievements in acquisition reform. The JDAM Program Team was awarded the Air Force Association's 1995 Outstanding Achievement Award for Acquisition Reform and the Air Force Acquisition "Lightning Bolt Award" by the Acting Assistant Secretary of the Air Force for Acquisition Darleen Druyun. The results of JDAM extend well beyond the streamlining of documentation and (the reduction of cost and development time) to effects on the product development administration of the program and the actual design of the JDAM kit. JDAM is a major turning point in the acquisition system--with significant effects on the decision-making processes, organizational structures, and cultural behaviors of those involved in its product development administration.

Table B-1: JDAM Measurements of Effectiveness: The Results[41]

	Program Milestone Events and Dates		
Measurement	R&D Startup RFPs (10/19/93)	R&D Contract Award (6/94)	Contract Award-Production (10/95)
AUPP (FY 93$)	68,000	48,000	15,000
R&D Costs (FY 93$)	380M	380M	310M
R&D Program Length	46	46	30
Procurement Cycle Length (years)	15	15	10
Warranty Length (years)	5	5	20
Military Performance: CEP[a]	13M/30M	13M/30M	<13M/<30M
Government-Mandated MIL-SPECs and STDs (number required)	87	80	0
Government-mandated SOW[b] specifying contract scope (pages)	137	100	2[c]
Contractor Proposal Length (page count)	1000+	--	15
Government-mandated contract delivery terms (number of reports)	243	250	15 EMD 2
Government program office staffing (manning level)	70	70	59 (1/96) 40 (4/96) 10 (12/97)

SIGNIFICANT ACCOMPLISHMENTS

- $2.1B was saved by the AUPP reduction from $68,000 to $15,000 (76%) for 40,000 production units.
- Reductions in contractual paperwork are unprecedented.
- Military requirements of the operational user were not compromised.
- This is the historic first application of a fix-or-replace warranty to a major weapons system.[d]

[41] Source: "JDAM Program: Current Status, Lessons Learned, and Future Direction as a FASA Designated Pilot Program (4/11/94) through MS II Down Select (11/11/95), JDAM Program Office, January 19, 1996.
[a] Circular Error Probability: miss distance from aim point, measured in meters with/without GPS aided guidance.
[b] Statement of Work
[c] Statement of Objective
[d] See Appendix C, Product Development Administration of the JDAM Program.

Figure B-2 breaks out the effects of some affordability initiatives on the Average Unit Procurement Price of the JDAM kit. A significant amount of savings was realized through the implementation of Design for Manufacturing and Assembly, as advocated by the Government in the Manufacturing Development Initiative. The ability to purchase commercial parts and materials resulted in a 30 percent savings. Other commercially driven initiatives--such as the tailoring of MIL-SPECs, MIL-STDs, and "how-to" requirements; the use of commercial facilities to reduce overhead; and the use of commercial business practices--also accounted for a significant portion of the savings. The savings achieved were, thus, the direct result of many reform initiatives as part of the acquisition reform movement.

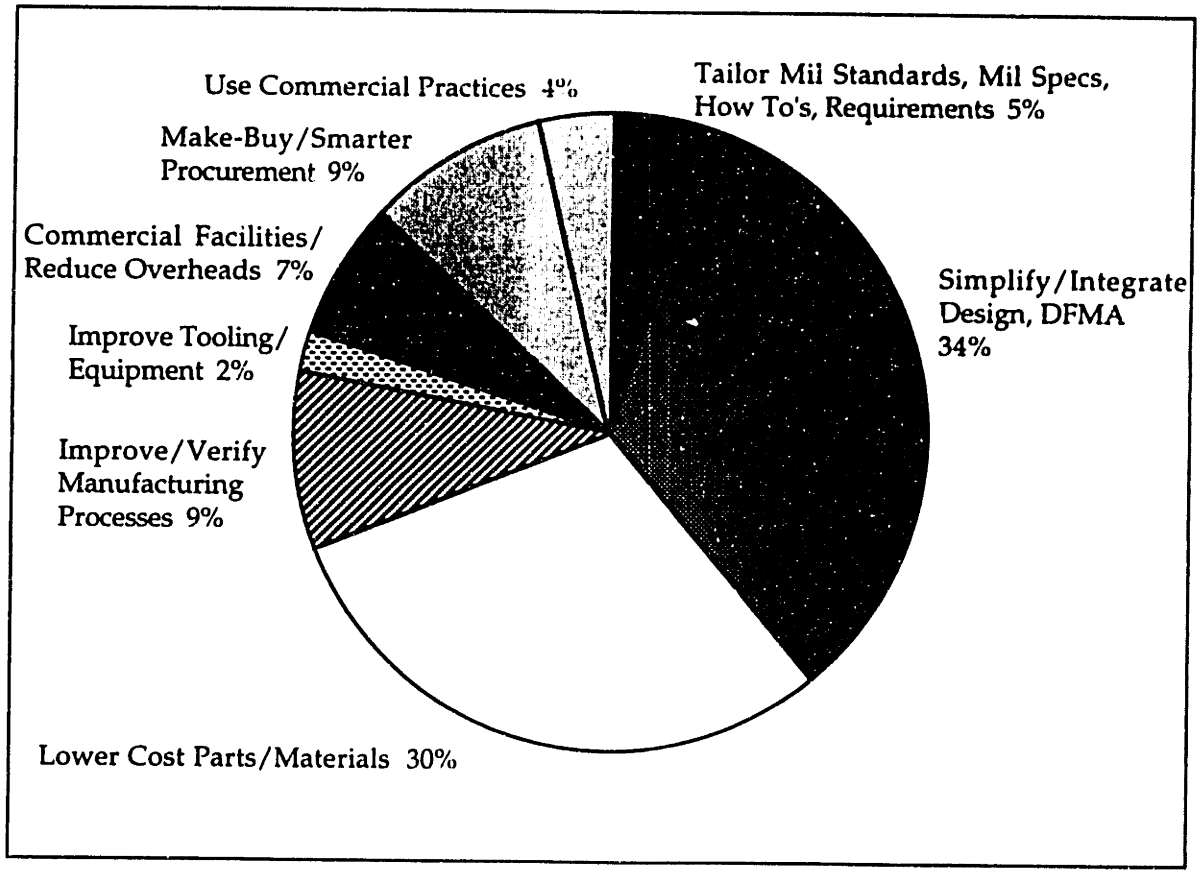


Figure B-2: Effects of Various Affordability Initiatives on Program

APPENDIX C

Product Development Administration of the JDAM Program

Widespread legislation, including the Federal Acquisition Streamlining Act of 1994, answered the pervasive and continued need to eradicate large cost overruns associated with the traditional defense aerospace acquisition process. The Joint Direct Attack Munition (JDAM) program pioneered the implementation of those reforms. Appendix B introduced the JDAM program with a description of the product, the program schedule, and the program goal of acquisition reform. The role of the JDAM program in the acquisition reform movement was described in the historical context of the acquisition process. While Appendix B highlighted the major results of implementing acquisition reform, this appendix describes the implementation of acquisition reform initiatives and their impact on the product development administration of the program. The focus on affordability, competition to achieve high quality, teamwork, and commercial practices changed the decision-making, program structure, and organizational culture within the program. The Government introduced reform initiatives which gave prime contractors more decision-making authority, changed program relationships, and made noticeable cultural changes--transforming the Government-contractor relationship from a traditional arm's length relationship to a more collaborative relationship. These initiatives included: the formation of Government Advocacy Teams; a rolling downselect process; a focus on Average Unit Procurement Price; a limited project scope and "live-or-die" requirements; an accelerated schedule; total contractor configuration control; cost-performance trades and Cost As an Independent Variable; commercial design trades;

streamlining of standards, specifications, "how-to's," and requirements; reduced oversight; emphasis on Integrated Product and Process Development; a twenty-year warranty; contractor incentives; the expectation of a stable, multi-year procurement; contractor training; an emphasis on Design for Manufacturing and Assembly; and Alternate Dispute Resolution as a forum for solving disagreements. These initiatives were managed by the prime contractors to make changes in Government-contractor relationships possible. The McDonnell Douglas contractor team, which was selected for EMD-2, effectively managed the Government reforms of affordability, teamwork, and the use of commercial practices and added organizational structure to the program which facilitated the transformation of the Government-contractor relationship.

Many of the contributions of the Government to the new model for Government-contractor relationships witnessed in the JDAM program were the direct result of acquisition reform implementation. The Government implemented specific formal changes in its structure with regard to the program with the use of advocacy teams and the Core Integrated Product Team. The goals of affordability changed the focus of the acquisition process and of the product development administration of the program. The team structure of the program was a novel idea for defense acquisition. The JDAM program moved from the use of a hierarchical, historical organizational structure to one more oriented toward collaboration. The Government's focus on acquisition reform, and affordability, also led to the benchmarking of commercial practices which changed the face of Government-contractor relationships. The ideas of a program team and the use of commercial practices, along with the goals of affordability, extended across the entire program from the Government to the prime contractor to the suppliers. In addition to these over-arching ideas, the parties involved made some sweeping changes to the face of defense acquisition program relationships. Other changes included a limitation of the program scope to avoid the problems of requirements "creep." The Government also used elements of the acquisition reform such as the emphasis on commercial practices to encourage cost-performance trade-offs and to streamline the requirements (including "how-to's"), documentation requirements, and specifications. A special reward and punishment system was also devised to implement affordability goals and to make the prime contractor more accountable for the product.

Although most of the acquisition reform initiatives originated from the Government–including the emphasis on affordability and commercial practices--the success of these initiatives rested on the ability of the prime contractor teams to implement them. Putting these reform initiatives into practice shifted the culture of McDonnell Douglas Aircraft (MDA) and its team members within the JDAM program. The cultural changes within the prime contractor organization helped, in turn, to change the face of the Government-contractor relationship.

The focus on affordability gave McDonnell Douglas and its key suppliers a common goal for which to strive. The nature of the rolling evaluation pushed the level of competition high. The MDA team, as it was known, included its key suppliers as teammates. McDonnell Douglas made strong management changes to incorporate the priority of affordability. MDA's formation of Integrated Product Teams (IPTs), however, would not have been possible without the cooperation, collaborative spirit, and innovation of its suppliers. The changes that the Government and McDonnell Douglas implemented regarding affordability therefore changed not only the Government-contractor relationships, but also changed the Government-contractor-supplier relationships because the key suppliers were integrated into the prime contractor team. The prime contractor managed the suppliers but also relied on them for their IPT involvement (in other words, their ability to change their own corporate culture for the program to become part of the prime contractor team) and their ability to challenge the requirements to create a better (more affordable) design.

With this introduction to the acquisition reform changes implemented by the Government and the prime contractor, this chapter outlines each of the key reforms in depth.

C.1 Average Unit Procurement Price (AUPP)

During the first development phase of JDAM, EMD-1, the primary objective was to develop an affordable product while meeting or exceeding performance requirements--within an accelerated time frame. The goals of achieving affordability and implementing the acquisition reform changes

called for by the Federal Acquisition Streamlining Act 1994 affected Government and industry management practices, decision-making, organizational structure, and organizational culture within the JDAM program. The concept of achieving affordability through acquisition reform was pervasive throughout EMD-1. The focus on affordability, along with teamwork and the use of commercial business practices, affected the ways in which decisions were made, the attitudes toward change, and the structure of the program.

To achieve affordability goals, a measurement of life cycle costs--the costs to design, develop, purchase, and support the product over its life cycle--was required. A measurable cost could be compared against historical precedents and against what the cost would be under a traditional acquisition system. The change in development cost was tracked over time as the program evolved. The term, "Average Unit Procurement Price," or AUPP was developed for tracking life cycle costs over the course of the program. The AUPP was used to directly measure the results the team was achieving over time.

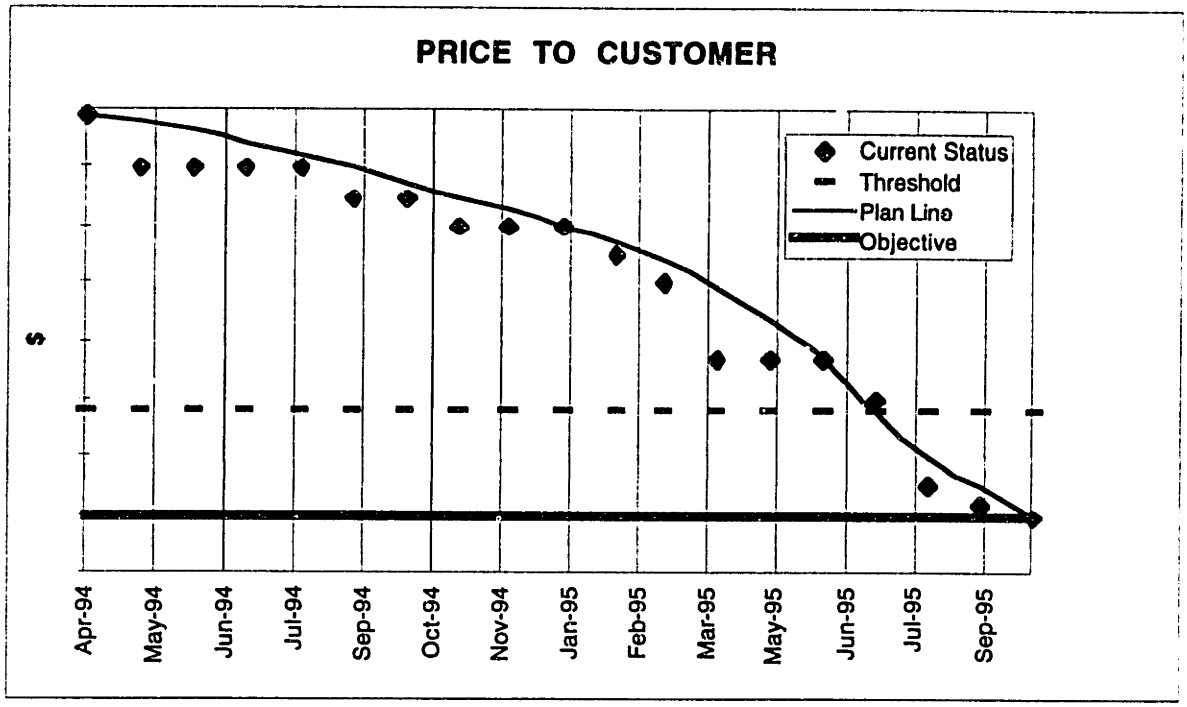
The AUPP is the price for that part of the production cost within prime contractor control, including both the product price and the price of an associated warranty (discussed later in this appendix). In addition to the warranty, the contract cost is adjusted by Engineering Change Proposals (ECPs), unamoritized tooling and test equipment, and long lead times. The AUPP is calculated by dividing the adjusted contract cost by the number of units to be produced.

An AUPP tracking data sheet was the tool developed by McDonnell Douglas and used by the Government and the prime contractor. The data sheet could track the AUPP as well as aid in seeking methods of improvement. In the plot of the price to the customer in Figure C-1, the current status of the customer price and plan line were graphed, as well as threshold and final objective targets. (The actual prices are masked for competitive reasons.) The threshold was the minimum value that must be achieved, while the final objective target represent an aggressive price

objective that the MDA Team attempted to achieve (and met). The current status of the price was marked and updated over time to show the effect of team efforts.

The AUPP tracking data sheet provided a disciplined process for considering near-term AUPP reduction methods as well as future ideas and goals. For the near term, the AUPP tracking data sheet allowed for the allocation of target AUPP reductions for specific design iterations or reduction initiatives. The AUPP reductions resulted from a combination of, among other things, Government standard and specification relief, incorporation of an extended 20-year warranty to be provided by the prime contractor, a major re-design effort on the part of the contractor-supplier design teams, and low-cost commercial component substitutions. It provided a visible tracking system which could be monitored and shared. The AUPP tracking data sheet shown in Figure C-1 was shared with the Government in a data base, in affordability reports, and in meetings or interchanges. Near-term initiatives were created by the component teams, such as Guidance and Control (G&C) and Airframes, or by other teams, such as support or procurement. The items were specified in detail along with the estimated or actual change in Average Unit Procurement Price (Delta $). Future initiatives were contributed by the Government, prime contractor, and suppliers, (individually or in combination). As a result of the tracking mechanism, the goals and achievements of affordability were readily visible to all members of the program. The tracking sheet therefore emphasized the goals of affordability as well as the setting of realistic and aggressive objectives by the prime contractor and suppliers.

JDAM AUPP Status - IPTs



Near Term AUPP Reduction Initiatives

Item	Description and Status	Delta ($)
1	G&C Initiatives	
2	Airframe Initiatives	
3	Support Equipment	
4	Procurement Initiative	
5		
6		
	Future AUPP Reduction Ideas	
A		
B		
C		
D		
E		
F		

Figure C-1: AUPP Tracking Data Sheet for the Customer[42a]

[42] Source: "JDAM AUPP Status--IPTs," McDonnell Douglas Corporation, December 1995.
[a] Note: AUPP dollars represented on linear scale. Objective line represents final objective.

C.2 Competitive Acquisition and the Rolling Downselect Process

The JDAM source selection process was a variation on the traditional selection process, involving a rolling downselect process. The JDAM rolling downselect had unique consequences which affected the character of the decision-making, structure, and culture of the program. The process shaped the product development administration along with the acquisition reform goal of affordability. This section first describes the traditional source selection process and then describes the unique JDAM rolling downselect process that was used during the EMD-1 phase of development.

C.2.1 Overview of the Traditional Source Selection Process

Under the federal contracting process, the method of solicitation may take the form of a sealed bid or a competitive proposal. The Competition in Contracting Act (CICA) of 1984 emphasized the importance of competition in the contracting process. The act also acknowledged both processes as legal and effective methods.

Sealed Bids

The sealed bidding process was formerly named "formal advertising," with the original purpose of precluding special consideration to any group and to allow for open competition. The Invitation for Bids (IFB) provided potential bidders with information about the requirements, how the resulting contract would be structured, and what formal steps of the bidding process were required. A formal process was used to review and award the lowest bidder. The complexity of major weapons systems and the limitations on detailed technical information, however, makes the sealed bid process impractical for these systems. Competitive proposals are generally used.

Competitive Proposals

In the competitive proposal process, Requests for Proposal are sent to solicit bids, the proposals are then received and analyzed, technical requirements are discussed, and conditions of the contract (including price and delivery schedule) are negotiated. The competitive proposal process is therefore more flexible than the sealed bidding process and is used almost exclusively with major systems acquisitions.

C.2.2 The JDAM Rolling Downselect

While the JDAM source selection process could be compared to the competitive proposal method, it was non-traditional because it was based on a rolling evaluation. Therefore, rather than basing the final selection on the initial bid proposal, two prime contractors were selected for continuous evaluation through EMD-1. This allowed the prime contractors to work on achieving lower cost objectives at a lower level of risk. The prime contractors were given contracts for the entirety of EMD-1, with the knowledge that the final selection would be made at the end of EMD-1. Furthermore, no indication was given of who was "ahead" or "behind" in the evaluation process.

The rolling downselect encouraged a competitive spirit, keeping a "level playing field." In this way, the Government managed the quality of the product and of the service provided. The Government monitored not only the system performance, but also the affordability and contractor performance. The Government benefited by seeing the differences and similarities of the prime contractor experiences. By using clear downselect criteria and weightings, the Government could make a final selection based on actual past performance rather than a "paper" proposal. The evidence of the prime contractor's ability to deliver was clear.

By encouraging competition, the rolling evaluation, together with the focus on affordability, created a visible and clear goal. The prime contractors were given further incentive to increase system affordability within the

bounds of the program. The competitive spirit of the rolling evaluation essentially made creativity and innovation necessary.

C.3 Expectation of a Stable, Multi-Year Procurement

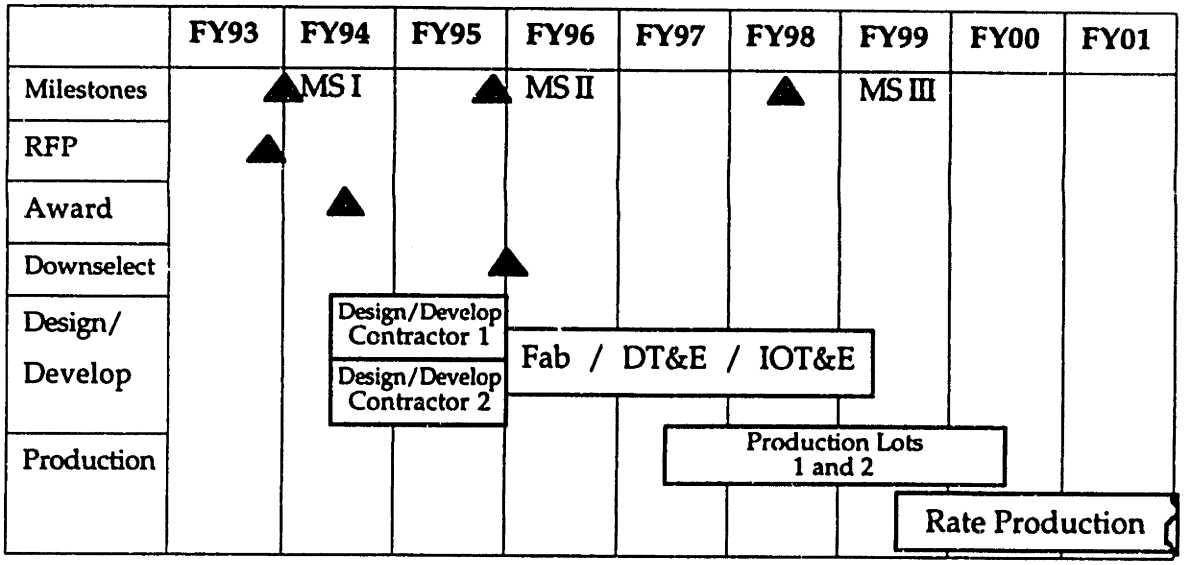
The expectation of a stable, multi-year procurement was an initiative that gave prime contractors and suppliers the incentive to enter into a long term relationship with the Government and with one another. The production of 74,000 units was expected. This represented a relatively high volume for some key suppliers. The high volume provided an incentive to apply commercial practices and achieve economies of scale.

The decision of the Government to designate a stable contract, extending it over several years was in stark contrast with prior contract relationships established by the Government for defense aerospace programs. The change in contract length and stability is offered in Chapter 1 as a progression from adversarial and arm's length relationships toward goal-congruent and partnership relationships.

C.4 Accelerated Schedule

The use of an accelerated schedule was an acquisition reform measure intended to force a reduction in development and cycle time. The accelerated schedule and the attempt to reduce cycle time were enabled by the competitive spirit of the rolling evaluation and source selection process. The schedule is presented in Table C-1 below. Chapter 3 also provides some detail regarding the accelerated program schedule. The competitive development phase of EMD-1 was 18 months in duration from mid-1994 through the end of 1995. EMD-2 was shortened from 46 months to 40 months, and production is planned to start six months earlier than previously scheduled. Milestone III is also scheduled 15 months earlier.

Table C-1: Accelerated JDAM Program Development[43]



C.5 Limited Government Role, the Government Advocacy Teams, and Open Communications

The competitive spirit of the rolling evaluation during EMD-1 was accompanied by the collaborative relationship between the Government and prime contractors. The JDAM program used a special advocacy arrangement between Government and industry, as illustrated by Figure C-2.

[43] Source: "JDAM Development: Accelerated Program," McDonnell Douglas Presentation, June 28, 1995.

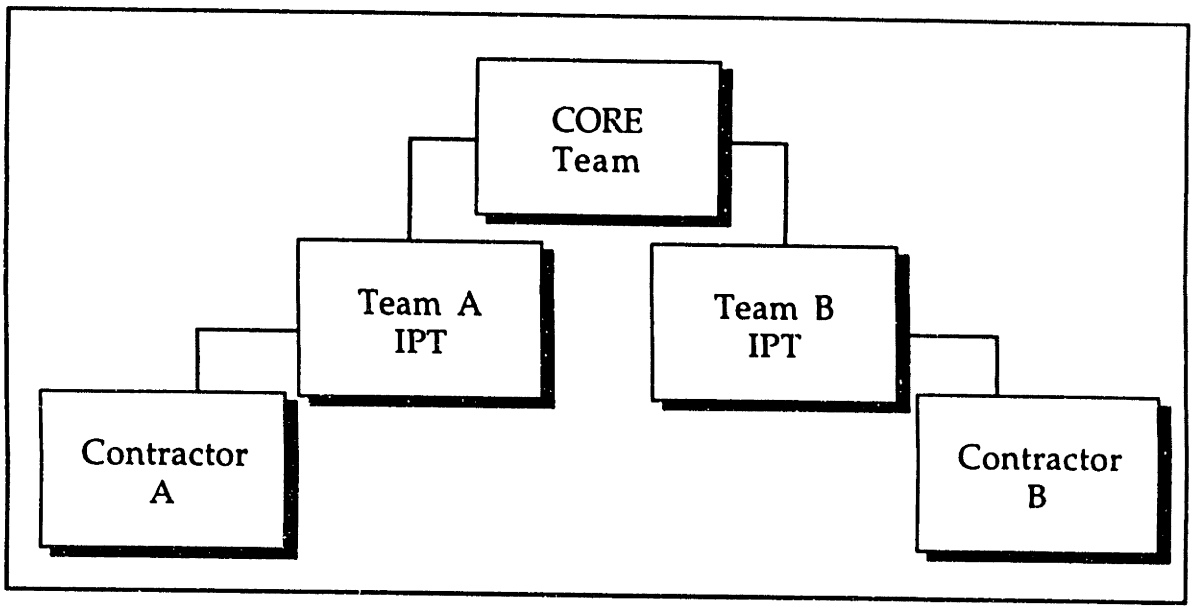


Figure C-2: JDAM Organization

Many of the Government initiatives for acquisition reform, including changes in its treatment of affordability, commercial practices, and the rolling evaluation process encouraged a collaborative Government-contractor arrangement. In addition, the formal teams developed by the Government emphasized a collaborative Government-contractor relationship.

Advocacy teams are Government teams which help the prime contractor to achieve its affordability and reform goals. The advocacy teams (Team A IPT and Team B IPT) were direct communication links with the Government, but were also isolated from one another to encourage the spirit of competition. The advocacy IPTs were devised of Government team members who were encouraged to work with each prime contractor (separately) to work the interfaces with the various Government organizations. The advocacy teams (one for each prime contractor during EMD-1) worked as a direct link to the "pulse" of the Government, including the Core team and the Source Selection Team (SSET).

The responsibility of the advocacy teams shifted the role of the Government away from the traditional audit, oversight, and inspection to one that emphasized integration of Government-contractor interfaces, meeting affordability goals, and helping the prime contractor with the downselect competition. Decision-making authority was delegated to the prime contractor, as the purpose of the Government advocacy teams was to advocate for the prime contractor goals during evaluations with the SSET. The Government allowed the prime contractors "total configuration control" in which the design of the system became the responsibility of the prime contractor within the scope of the program--within the bounds of the primary "live-or-die" requirements. The Government teams helped the prime contractors eliminate barriers within the control of the Government, providing requirements relief and streamlining documentation required. The advocacy teams worked closely in the day-to-day decision-making with the prime contractor and were therefore accountable for the performance as members of the prime contractor IPTs. An unprecedented level of communication and cooperation resulted from the use and role of the Government teams. This partnership facilitated their ability to solve management and engineering problems quickly. While there were difficulties in implementation of the Government teams and the new Government role, the effort was uncontested as a worthwhile event.

The use of advocacy teams in the program structure deviated from the typical hierarchical, often adversarial relationships of Government procurement offices and the prime contractor. In the past, the Government role in the procurement process was essentially one of inspection and auditing. The Government, in addition to helping the prime contractor achieve its cost, schedule, and performance goals, reduced its oversight role and took on the responsibility, instead, of working the interfaces for the entire team. Previously, the excessive oversight forced the Government-contractor relationship into a restrictive one. Also, the final selection process could easily result in protest because the prime contractors did not have the same type of timely feedback characteristic of the JDAM program administration. The role of the Government changed from one traditionally focused on auditing, oversight, and inspection to one focused on advocacy

and achievement of common goals. The Government-contractor Integrated Product Teams actually incorporated Government personnel as part of the prime contractor's team at their facilities. The hierarchical structure of typical procurement processes was replaced by two teams during the EMD-1 development phase.

The "Core" Team is composed of Government members from the Joint System Program Office (JSPO), involving the functions of contracts, program control, integration and test, projects, and logistics. The Core Team allows the prime contractors to have direct contact with the Government through advocacy teams. The structure and involvement of the Core team also changed the relationships between the Government and the prime contractor. The direction and support of the Assistant Secretary of the Air Force for Acquisition was centralized in the Core team. The Core team also was able to form close working relationships with the different operational communities (the U.S. Air Force and Navy), the requirements community, and the Program Executive Officer of Tactical Systems. The Core Team helped to ensure that the JDAM teams were able to gain a focused report from the Government of their expectations and evaluations.

The rolling evaluation process therefore encouraged the prime contractors to cooperate and trust the Government Integrated Product Teams because they were aware that there was a valued competitor who was using their resources to gain any competitive advantage possible during this first phase of development. The downselect process thereby affected the relationships between the Government and the prime contractors (as well as with the suppliers). The rolling downselect helped improve communications and the relationships between the Government and prime contractor. Contractors were evaluated periodically on their performance. Timely feedback was provided to each prime contractor in private. The prime contractor was therefore not only encouraged to correct the deficiencies in the system but given ample opportunity to do so. Thus, the rolling evaluation opened up lines of communication and made clear communication desirable and necessary for final selection.

These Integrated Product Teams were also unique because they incorporated not only the prime contractor but also the subcontractors (suppliers). The spirit of collaboration between the Government and industry was therefore extended to the subcontractor level. The McDonnell Douglas Team consisted of McDonnell and the Government as well as the following subcontractors: Honeywell, Loral, Rockwell International (Collins Avionics & Communications Division), HR Textron, and Lockley. McDonnell Douglas was selected as the total weapon system integrator. Honeywell, an experienced producer of 90,000 ring laser gyros (RLGs) was selected for development of the Inertial Measurement Unit (IMU). Loral was selected to contribute the Mission Computer (MC). The Collins Avionics and Communications Division of Rockwell International was chosen for the GPS Receiver. The Tail Actuator Subsystem was the responsibility of HR Textron. Finally, Lockley, known as a low-cost producer of 20,000 munition tails, was responsible for the tail fairing and structure. The incorporation of the subcontractors was a deviation from the traditional system, which did not provide much Government-subcontractor interaction. Program decision-making was necessarily changed to incorporate the suggestions of subcontractors. These suggestions often became imperative to the team for final selection. The subcontractor interaction was also important because they were more deeply involved in the design and development and could provide realistic recommendations for change.

The teams that the Government created to direct Government efforts in the JDAM program necessarily helped to improve communication and information flow. Together with the competitive rolling downselect process, the teams ensured periodic and timely formal feedback. The feedback enabled the timely remedy of design and management problems. The communication and cooperation between Government and prime contractor was facilitated by the Government's new policy of not requiring the prime contractor to disclose cost or pricing data to back up the bottom-line prices in the required affordability reports. Electronic documentation

systems also eliminated the traditional paper ("hard copy") information bottlenecks and increased the speed of information transfer. Finally, communications were improved by the reduced amount of classified data required. With the JDAM classification system, only the absolute minimum amount that was consistent with national security requirements was used.

C.6 Total Contractor Configuration Control

Total contractor configuration control was fully implemented in the JDAM program. This was a significant measure because it allowed the prime contractor to be able to make full Class II changes in design. In other words, as long as the primary requirements were met, the prime contractor (together with the suppliers) could make changes as they saw fit in the design of the system. As long as "form, fit, and function" were met or exceeded, then the design was in the control of the prime contractor. The ability of the Government to limit the scope of the project and instigate a firm set of "live-or-die" requirements was unique to the program and allowed for true total contractor configuration control. The risk taken by the Government of giving the contractor design control was balanced by the warranty, a 20-year extended warranty, provided by the prime contractor.

C.7 Limited Project Scope and Six Live-Or-Die Requirements

Typical military procurement was plagued by the problem of "requirements creep," in which the performance of the system greatly exceeded given requirements despite marginal cost increases as part of the bid proposal process. To avoid the problem, the Government emphasized the limited scope of the project. The prime contractors would be evaluated on their ability to deliver the requirements and any additional features or performance differentiators that added significant cost to the system were discouraged.

The prime contractors were given total configuration control beyond this limited project scope. To maintain the scope of the project, the Government established six "live-or-die," or necessary, requirements along

with the focus on affordability. These requirements were: (1) a low unit cost (with a target of $40K per weapon), (2) adverse weather accuracy, (3) aircraft compatibility, (4) Naval aircraft carrier suitability, (5) in-flight captive carriage re-targeting[a], (6) and warhead compatibility[b]. The aircraft compatibility requirements are summarized in Table C-2 below for the U.S. Air Force (USAF) and the U.S. Navy (USN).

Table C-2: Aircraft Compatibility Requirements

USAF	USN
B-1	F/A-18C/D [c]
B-2	F/A-18E/F
F-22 [d]	AV-8
F-16	F-14
F-15	P-3
F-117	S-3
B-52 [e]	

C.8 The 20-Year Warranty

In accordance with granting the contractor total configuration control, providing requirements relief, and reducing oversight, the Government required increased accountability on the part of the prime contractor to ensure that the quality of the design was high. The 20-year warranty was introduced in the midst of EMD-1 to increase contractor accountability. At McDonnell Douglas, the warranty became part of an affordable maintenance plan. Along with the 20-year warranty provision, the plan would include provisions for: no preventive maintenance, affordable Operations and Support (O&S) cost, no new or additional resources for support (including personnel or equipment), and meeting or exceeding all support requirements.

The 20-year warranty was a significant deviation from traditional programs. The original contract requirements called for a 5-year warranty, but a 20-year warranty would require undoubtedly high quality and low

[a] Discussed in Appendix B.
[b] MK-84, BLU-109, MK-83 [F-22 only].
[c] Threshold Requirements.
[d] F-22 with only 1000 lb. JDAM. All other aircraft as objectives.
[e] Threshold Requirements.

maintenance on the part of the prime contractor team. The warranty guarantees performance of the product, including the guidance kit hardware, software, and container for a 20-year shelf life and a 5-year service life (cumulative time out of the container). By guaranteed performance, McDonnell Douglas agrees to: repair or replace any kit that fails, pay round trip transportation, guarantee the repair kits for the remaining duration, dispose of failed kits or components, and maintain a data base including failure analyses and reliability and warranty data.

Streamlining of the Operations and Support costs with provisions for no maintenance in the next 20 years will save the JDAM program close to an estimated $370 million for a total of 74,000 units. Table C-3 shows the tremendous difference between the historical Operations and Support features, or "business as usual," the streamlined organic version, and finally the streamlined version with a 20-year warranty. McDonnell Douglas achieved the majority of its price reduction through tailored maintenance, increased reliability, the focus on affordability, and the elimination of the 5-year recertification requirement that would have existed previously. The elimination of the 5-year recertification requirement eliminates the need to replace life-limited components and to recalibrate subsystems. Reduced sustaining engineering support staff further increases savings. Finally, the extended warranty in which failed units are repaired by McDonnell Douglas further increases savings by passing the 20-year warranty provision on to the suppliers for major subsystems.

Table C-3: Operations and Support Cost Analysis (20 Year Operational Life for 74,000 Units)[44]

Business as Usual	Streamlined Organic	O&S Concurrent with Extended Warranty
• Spec Reliability	• Exceed Spec Reliability	• Failed Units Repaired by MDA
• Spec AUPP	• Exceed (lower) Spec AUPP	• Major Subsystems Warranted by Suppliers
• Traditional Maintenance Concept	• Tailored Maintenance Concept	• Sustaining Support Staffed for "No Quibble" Warranty • Little Paperwork Required • S/W Maintenance Performed by MDA
• Five Year Recertification • Replace Life Limited Components • Recalibrate Subsystems • Comprehensive Inspection	• No Recertification Required • No Life Limited Components • No Recalibration Required • Inspection of All Units Not Required due to Deployment/Storage Concept	
• Sustaining Support Staffed for all Contingencies	• Sustaining Support Staffed for Streamlined Program	
$373M O&S Cost	**$50M O&S Cost**	**$5M O&S Cost + Warranty Price**

C.9 Commercial Benchmarking

The Government-contractor-supplier relationships were greatly influenced by the focus on affordability and acquisition reform and by the rolling evaluation process. The implementation of commercial practices also changed the face of Government-contractor-supplier relationships. The use of commercial practices was advocated by the acquisition reform movement to facilitate the purchase of high technology equipment and to lower acquisition costs. The Government buying office benchmarked its processes against those that world class commercial companies use for the products they buy.

[44] "Operations and Support Cost Analysis (20 Year Operational Life for 74,000 Units)," McDonnell Douglas Corporation Presentation, 1995.

The buying office made several major findings regarding the commercial practices. Table C-4 summarizes these findings. A noticeable difference was found between the buyer/seller relationships of the historical DoD and of commercial companies. Whereas the relationships between the Government and the prime contractor were historically adversarial and opportunistic, the commercial contractors forged strong partnerships with their suppliers. These partnerships are characterized in Chapter 1 and may be described as long-term, collaborative relationships. The Government also told the prime contractors how to build products as a means of ensuring quality, but commercial companies, they found, did not tell their suppliers how to build products but specified only the product in terms of its performance. Oversight that is common in Government relationships is at the top level in industry, mostly by exception. Commercial companies also tended to rely more on past performance than lowest cost in selecting their vendors. Price, rather than cost, was used as a basis for negotiation in industry. Price was as much a technical requirement that the supplier could suggest trading performance requirements to deliver the product at a lower price.

Table C-4: DoD and Commercial Benchmarking

	DoD Historical	Commercial
BUYER/SELLER RELATIONSHIPS	Adversarial, opportunistic	Collaborative, long term
BUYER SPECIFICATION	Detailed "How-To's"	End Item Performance
BUYER-IN PROCESS OVERSIGHT	Lots (with flow down)	Little (without flow down)
PRIMARY AWARD CRITERIA	Technical Promises and Lowest Cost	Past Performance and Best Value
BASIC FOR NEGOTIATION	Costs	Price

All of the commercial practices discovered through commercial benchmarking were put into practice in the JDAM program. Collaborative,

long term relationships were encouraged through many means, including joint goals, advocacy teams, and commitment. The Government made a long term exclusivity commitment to McDonnell along with a promise to help McDonnell increase affordability by reducing oversight and eliminating regulations that presented non-value-added costs. McDonnell also showed its commitment by agreeing to a long term warranty, backing up its commitment to price, quality, and schedule. Rather than specifying how to build the JDAM product, the Government also specified end item performance. Government oversight was reduced to the top levels and eliminated where unnecessarily obtrusive. Instead, the Government took on the role of working the interfaces of the program. The rolling downselect helped the Government to focus the primary award criteria on past performance and "best value" rather than technical "promises" and lowest cost criteria. Finally, price was added as a technical requirement. This transition from cost to price as the basis for negotiation was essential to the affordability initiatives and to the Government-contractor relationship.

C.10 CAIV and Cost-Performance Trade-offs

The concept of "cost as an independent variable" (CAIV) or, more appropriately, price as an independent variable, which accompanies the focus on affordability, raises the importance of cost to the same level as performance requirements. Thus, cost-performance trade-offs become a plausible concept. Until recently, the goal-setting processes have largely been driven by military threat or available technology, not consistently emphasizing the role of cost-performance trade-offs in setting goals. CAIV allows cost (price) to be thought of as a goal and a part of the design rather than strictly a constraint. CAIV also impacts the manner in which cost objectives are set, the metrics for tracking progress, the manner in which risks are managed to achieve objectives, and the motivating factors for achieving program objectives. These ideas are expanded upon in the discussion of Government-contractor relationships. The AUPP metric for tracking life cycle costs with respect to an evolving program is also related to the CAIV concept, however.

The freedom allowed in using cost as an independent variable (CAIV) allowed the use of rational trade-offs between cost and performance with the full agreement of the requirements officers. This was a significant contribution of the Government to the new, collaborative Government-contractor relationship. Evidence of its significance is more readily visible in the role it played in product design and development from the point of view of the prime contractor and suppliers.

With the guiding principle that the "best value" product could be achieved by trading the AUPP requirement (AUPPR) against other technical requirements, McDonnell Douglas worked with the Government to develop affordable requirements. Some examples of the cost-performance trade-offs made include the following:

- streamlined container compatibility
- eliminated IMU and TAS reprogrammability
- reduced spare throughput and memory margins
- eliminated BLU-110 fuze removal
- increased allowable container width
- deleted Airborne Test Equipment mounting holes from production units
- adjusting mission profiles to reduce temperatures

In line with the goals of acquisition reform, the MDA team was able to make rational design trades for affordability, use commercial parts, incorporate highly integrated design concepts, and "flow down" the specification relief achieved through FASA '94 to their suppliers.

C.11 Streamlining of Standards, Specifications, How-To's, and Requirements

The acquisition reform initiatives changed the manner in which the Government conducted business with the prime contractor, giving the JDAM program the authority to make changes in its business practices within reasonable bounds. The Federal Acquisition Streamlining Act (FASA '94) expanded the definition of and extended the use of commercial practices. The designated Defense Acquisition Pilot Programs were granted

the authority to request statutory and regulatory waivers. Relief of certain Federal Acquisition Regulations (FAR) and regulations of the Defense Federal Acquisition Regulation Supplement (DFARS) was granted, with the use of "common sense," rational thinking. The streamlining of standards, specifications, "how-to's" and requirements gave the prime contractor greater design authority and improved relations between the Government and prime contractor.

Acquisition reform led to new attitudes toward the use of commercial parts, the adoption of commercial practices, and the ability to question the necessity of certain standards, specifications, "how-to's," and requirements. Rather than relying on certain "heritage" specifications and standards, the Government eliminated the mandated use of all military specifications and standards (MIL-SPECS and MIL-STDS). All "how-to" military specifications, standards, and handbooks that did no apply to safety-related issues were also eliminated. Thus, rather than telling the prime contractor how to design the product, the Government focused on end item performance--one of the findings of the commercial benchmarking study that the Government conducted. The number of required MIL-SPECS and MIL-STDS was reduced from 87 at R&D start-up to zero at the contract award (October 1995).

Table C-5: JDAM Streamlining Measures[45]

	PROGRAM DATES	
	10/93	10/95
MIL-SPEC/STD	87	0
CDRLs	243	15 (EMD-2)
SOW Pages	137	2[α]
Formal Reviews	23	20

In addition to the elimination of MIL-SPECS and MIL-STDS, the Government also streamlined acquisition documentation. As the

[45] Source: "JDAM Program: Current Status, Lessons Learned, and Future Direction as a FASA Designated Pilot Program (4/11/94) through MSII Down Select (11/11/95), JDAM Program Office, January 19, 1996.
[α] Statement of Objective

Government rejected its traditional role as the prime contractor's technical auditor, the number of Contract Data Requirements List (CDRL) deliverables was significantly reduced from 243 reports to 15 by EMD-2. The Statement of Work was reduced from 137 pages to only 2 pages. The number of formal reviews was also reduced from 23 to 20 reviews. These results are summarized in Table C-5.

From a regulatory standpoint, JDAM requested waivers to improve affordability (reduce AUPP). The waivers for Federal Acquisition Regulations and Defense Federal Acquisition Regulations, (FAR/DFARS), represented, along with the ability to perform cost-performance trade-offs, a means by which the prime contractor could use logical thinking to improve affordability while meeting or exceeding the primary requirements (and schedule). From lists provided by the JDAM program office, Table C-6 shows some of the FAR/DFARS regulatory waivers denied, and Table C-7 shows some of the regulatory waivers granted. The list includes 12 FAR regulations denied and 12 FAR regulations granted, as well as 6 DFARS denied and 12 DFARS granted.

Table C-6: JDAM Regulatory Waivers Denied[46a]

FAR 52.203-4	"Contingent Fee Representation and Agreement"
FAR 52.203-5	"Covenant Against Contingent Fees"
FAR 52.215-33	"Order of Precedence"
FAR 52.215-27	"Termination of Defined Pension Benefit Plan"
FAR 52.216-25	"Contract Definitization"
FAR 52.217-7	"Option for Increased Quantity"
FAR 52.242-13	"Bankruptcy"
FAR 52.243-6	"Change Order Accounting"
FAR 52.244-2	"Subcontracts (Cost Reimbursement)"
FAR 52.248-1	"Value Engineering"
FAR 52.252-2	"Clauses Incorporated by Reference"
FAR 52.252-6	"Authorized Deviations in Clauses"
DFARS 252.215-7002	"Cost Estimating System Requirements"
DFARS 252.242-7005	"Cost/Schedule Status Report"
DFARS 252.225-7002	"Qualifying Country Sources as Subcontractors"
DFARS 252.225-7025	"Foreign Source Restrictions"
DFARS 252.227-7034	"Patents-Subcontracts"
DFARS 252.227-7039	"Patents-Reporting of Subject Inventions"

[46] Source: "JDAM Regulatory Waivers Denied," McDonnell Douglas presentation, 1995.
[a] Note: These lists were developed prior to the end of EMD-1 and additional waivers may have been requested since that time.

Table C-7: JDAM Regulatory Waivers Granted[47]

FAR 52.203-2	"Certificate of Independent Price Determination"
FAR 52.215-21	"Changes to Make or Buy Program"
FAR 52.215-32	"Certificate of Commercial Pricing for Parts or Components"
FAR 52.215-37	"Commercial Pricing Certificate"
FAR 52.222-2	"Payment of Overtime Premiums"
FAR 52.232-13	"Notice of Progress Payments"
FAR 52.232-16	"Progress Payments"
FAR 52.232-17	"Interest"
FAR 52.237-2	"Protection of Government Buildings, Equipment, and Vegetation"
FAR 52.244-1	"Subcontracts (Fixed Price)"
FAR 52.244-5	"Competition in Subcontracting"
FAR 52.242-12	"Report of Shipment"
DFARS 252.203-7002	"Display of DoD Hotline Poster"
DFARS 207.103	"Acquisition Plans"
DFARS 252.209-7000	"Acquisition from Subs subject to On-Site Insp. under INF"
DFARS 252.210-7003	"Acquisition Streamlining"
DFARS 252.210-7005	"Bill of Materials"
DFARS 215.872	"Work Measurement Systems"
DFARS 232.102(e)(2)	"Contract Financing Methods"
DFARS 252.234-7000	"Notice of Cost/Schedule Control Systems"
DFARS 252.234-7001	"Cost/Schedule Control Systems"
DFARS 252.242-7000	"Post Award Conference"
DFARS 252.242-7002	"Commercial Freight Bills"
DFARS 252.248-7000	"Preparation of VECPs"

The fact that the Federal Acquisition Streamlining Act of 1994 allowed the use of commercial practices had significant effects on the buying strategies. Military documents were used only as required to define "performance requirements." Rather than relying on military "heritage call-outs", prime contractors could define the commercial specification equivalent to the military call-out. In this manner, the performance requirements were not sacrificed and the price and technology benefits of commercial equivalents could be realized when appropriate.

The acquisition strategy of buying commercial components and adopting a commercial buying approach for JDAM evolved over time. The process was unprecedented and was also successful for the program, but significant Government *and* prime contractor resistance to change was met. Both the

[47] Source: "JDAM Regulatory Waivers Granted," McDonnell Douglas presentation, 1995.

Government and prime contractor, for example, were initially opposed to the elimination of "how-to's." Members of the Government argued that the product quality would decrease without specifying "how-to's," while the prime contractor was wary of being evaluated on certain unspecified "how-to's." Only by building a trusting partnership over time could the benefits of teamwork and requirements relief be realized. The changes in the Government's manner of conducting business with the prime contractor, as evidenced by the requirements relief (among other factors) resulted in benefits of reduced Average Unit Procurement Price, accelerated program schedule, improved military performance (as measured by the Circular Error Probability, CEP), improved design, and increased teamwork.

C.12 Contractor Incentives and Pay for Performance

To implement acquisition reform and reach goals of increased affordability, reduced cycle time, and increased performance, the Government: managed affordability initiatives, implemented a non-traditional rolling evaluation process, used price-based negotiation practices, used commercial practices and methods (including cost-performance trade-offs and specification streamlining), formed special advocacy teams to help the prime contractors, limited the project scope, and encouraged the use of Design for Manufacturing and Assembly (DFMA). All of these initiatives contributed to the change in the nature of the Government-contractor relationship in the JDAM program as compared to the past. The Government also implemented a system of incentive and punishment to provide additional motivation for the prime contractor.

The Government communicated to the prime contractor various rewards for the prime contractor should the prime contractor price meet or exceed the price committed to the Government (for the first five lots of production price). If this condition were true, the prime contractor was guaranteed various incentives: the prime contractor would be asked only to submit a price, rather than supporting cost data; the prime contractor would continue to have full configuration control, allowing the prime contractor to make design changes as long as the changes would not affect the system

specifications ("live-or-die" requirements); the Government would not exercise in-plant, in-process oversight of the prime contractor or subcontractors; the Government would help the prime contractor to reduce price, not cost; the Government would include and incentive fee (in the contract structure) if the reliability was met or exceeded ("pay for performance"); and, finally, the Government would guarantee the prime contractor a long term commitment to the multi-year, high volume JDAM program and would not re-compete the contract for the program if the prime contractor could meet all stated commitments.

If, on the other hand, the prime contractor could not meet its price commitments to the Government, the prime contractor would lose certain incentives: the prime contractor would be required to deliver certified cost and pricing data; configuration control would revert to the Government; the prime contractor would be required to develop a second source at no cost to the Government; the Government would conduct in-plant, in-process oversight (or have the opportunity to do so); and the incentive fee for the prime contractor would be eliminated.

C.13 Contractor Training and Design for Manufacturing/ Design for Assembly

One additional method by which the Government managed the program was through the emphasis on Design for Manufacturing (DFM) and Design for Assembly (DFA). The Government not only emphasized the use of the Manufacturing Development Initiative (MDI), which concentrated hardware manufacture very early in the product development cycle, but the Government also provided rigorous training for the prime contractor. Similar early development of beta software was encouraged as well.

With the Manufacturing Development Initiative, the performance and design of the product would therefore include not only affordability initiatives but also manufacturing considerations. MDI emphasized many "lean" manufacturing principles, processes, and tools, including: the minimization of manufacturing risk, the identification of key characteristics

(KCs) and key processes (KPs), the use of design trades, the improvement and validation of key processes, the reduction of variability, the fabrication of tooling and test equipment, and the use of automated manufacturing simulation. The use of DFM/DFA early in the design process improves affordability and quality, as well as reduces the hardware risk involved. The implementation of DFM/DFA also encourages major secondary effects, including the smoothing of production transition. The implementation of "lean" manufacturing principles, processes, and tools encourages the focus on quality through the management of a quality program, encourages the tailoring of specifications through design trade-offs, and improves the prime contractor relationships with key suppliers.

By emphasizing the importance of Design for Manufacturing (DFM) and Design for Assembly (DFA), as well as providing information and training, the Government put into place manufacturing principles which increased product quality while reducing AUPP. The MDA team used producibility tools to support a simple, affordable design. The principles of DFM/DFA, as applied by the MDA team, reduced part count, complexity, and assembly time while increasing reliability. McDonnell Douglas also used Variation Simulation Analysis, a 3 dimensional analysis tool for checking tolerances to statistically predict assembly dimensional characteristics. The use of Key Product Characteristics enabled the team to determine the design details that would have the greatest influence on product specifications. Furthermore, the use of Factory Simulation Modeling, a dynamic manufacturing plan, enabled the MDA team to calculate resource utilization, costs, and other important parameters.

C.14 Alternate Dispute Resolution

The Government not only managed contractor incentives but also anticipated the possibility of Government/contractor conflicts. In the past, these conflicts had caused the Government programs additional costs and schedule slips. Rather than using the typical route for solving disputes through litigation, the Government allowed for Alternate Dispute Resolution (ADR). In ADR, an independent panel of three people would

mediate disputes and help develop a mutually agreeable solution. The panel would consist of one person nominated by the prime contractor, one by the Government, and a third selected by the first two panel members (that would therefore be agreeable for both the prime contractor and the Government).

APPENDIX D

Sample Questions from the Contractor and Customer Relations Survey

This appendix contains sample questions from the Contractor and Customer Relations Survey.

1.11 Characterize the information you provide to your counterpart in the following organizations: *(Circle appropriate number or check none.)*

		Detailed		Moderate		Summary	None
a)	PEO	1	2	3	4	5	❐
b)	SPO, PMA, or PM	1	2	3	4	5	❐
c)	Tech Support Lab	1	2	3	4	5	❐
d)	Test & Evaluation	1	2	3	4	5	❐
e)	Logistics	1	2	3	4	5	❐
f)	Training	1	2	3	4	5	❐
g)	DPRO	1	2	3	4	5	❐
h)	User Representative	1	2	3	4	5	❐
i)	User in the Field	1	2	3	4	5	❐
j)	Prime Contractor	1	2	3	4	5	❐
k)	1st Tier Subcontractor	1	2	3	4	5	❐
l)	1st Tier Supplier	1	2	3	4	5	❐
m)	Other *(Identify)*:___	1	2	3	4	5	❐

1.12 Characterize the information provided to you by your counterpart in the following organizations: *(Circle appropriate number or check none.)*

		Detailed		Moderate		Summary	None
a)	PEO	1	2	3	4	5	☐
b)	SPO, PMA, or PM	1	2	3	4	5	☐
c)	Tech Support Lab	1	2	3	4	5	☐
d)	Test & Evaluation	1	2	3	4	5	☐
e)	Logistics	1	2	3	4	5	☐
f)	Training	1	2	3	4	5	☐
g)	DPRO	1	2	3	4	5	☐
h)	User Representative	1	2	3	4	5	☐
i)	User in the Field	1	2	3	4	5	☐
j)	Prime Contractor	1	2	3	4	5	☐
k)	1st Tier Subcontractor	1	2	3	4	5	☐
l)	1st Tier Supplier	1	2	3	4	5	☐
m)	Other *(Identify)*:____	1	2	3	4	5	☐

1.13 Indicate how frequently you interact with your counterpart in the following organization:
(Circle appropriate number)

		Daily	Weekly	Monthly	Qrtrly	Annually	Rarely	
a)	PEO	1	2	3	4	5		❐
b)	SPO, PMA, or PM	1	2	3	4	5		❐
c)	Tech Support Lab	1	2	3	4	5		❐
d)	Test & Evaluation	1	2	3	4	5		❐
e)	Logistics	1	2	3	4	5		❐
f)	Training	1	2	3	4	5		❐
g)	DPRO	1	2	3	4	5		❐
h)	User Representative	1	2	3	4	5		❐
i)	User in the Field	1	2	3	4	5		❐
j)	Prime Contractor	1	2	3	4	5		❐
k)	1st Tier Subcontractor	1	2	3	4	5		❐
l)	1st Tier Supplier	1	2	3	4	5		❐
m)	Other *(Identify):*___	1	2	3	4	5		❐

1.14 Rank the importance to your project of the stakeholders identified below: *(Circle appropriate number)*

		Most important				Least important
a)	PEO	1	2	3	4	5
b)	SPO, PMA, or PM	1	2	3	4	5
c)	Tech Support Lab	1	2	3	4	5
d)	Test & Evaluation	1	2	3	4	5
e)	Logistics	1	2	3	4	5
f)	Training	1	2	3	4	5
g)	DPRO	1	2	3	4	5
h)	User Representative	1	2	3	4	5
i)	User in the Field	1	2	3	4	5
j)	Prime Contractor	1	2	3	4	5
k)	1st Tier Subcontractor	1	2	3	4	5
l)	1st Tier Supplier	1	2	3	4	5
m)	Other *(Identify)*:___	1	2	3	4	5

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