REPORT OF THE

DEFENSE SCIENCE BOARD

TASK FORCE

ON

ACQUIRING DEFENSE SOFTWARE

COMMERCIALLY

JUNE 1994

#859

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION & TECHNOLOGY
WASHINGTON, D.C. 20301-3140

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OFFICE OF THE SECRETARY OF DEFENSE
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DEFENSE SCIENCE
BOARD

30 JUN 1994

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION & TECHNOLOGY)

SUBJECT: Report of the Defense Science Board Task Force on Acquiring Defense Software Commercially

I am pleased to forward the report of the Defense Science Board Task Force on Acquiring Defense Software Commercially. The Task Force, co-chaired by Dr. George H. Heilmeier and Dr. Larry Druffel, was chartered to determine the conditions under which defense software could be procured using commercial practices and to develop a strategy for procurement that incorporates such practices.

In its investigation into applying commercial practice to DoD software procurement, the Task Force reviewed a broad spectrum of interrelated elements from software program management policy and DoD software acquisition practices to DoD's investment in the software technology base. I wholeheartedly concur with the group's key finding that DoD must develop a more coordinated approach to the oversight of its diverse software capabilities and programs. The Task Force's report provides an outstanding point from which to begin addressing revamping DoD's software procurement practices.

Paul G. Kaminski
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

30 JUN 1994

DEFENSE SCIENCE
BOARD

Dr. Paul Kaminski
Chairman, Defense Science Board
Office of the Undersecretary for Acquisition and Technology
The Pentagon
Washington, D.C.

Dear Dr. Kaminski:

Enclosed is the final report of the Defense Science Board Task Force on Acquiring Defense Software Commercially. We were tasked to determine the conditions under which procurement of defense software can use commercial practices and to define needed changes to permit such use. In the attached report, we make specific recommendations with regard to DoD process credibility, software program management, required expertise of DOD personnel using modern software practices, use and integration of commercial off-the-shelf software, DoD software acquisition practices, use of software architectures by DoD as a management tool, and DoD's investment in the software technology base.

Based on our review, we concluded that issues associated with defense software are applicable across the wide spectrum of DoD software intensive systems. However, to reap maximum benefit from improvements related to the myriad aspects associated with software, the DoD requires a more coordinated approach to the oversight of its diverse software capabilities and programs.

To provide such Department-wide oversight and to facilitate implementation of the other specific recommendations contained within this report, the Task Force recommends that the Secretary of Defense assign to the Under Secretary of Defense (Acquisition and Technology) the responsibility for DoD-wide software technology, policy, practices and acquisition. This centralized approach will best serve the Department for all software intensive systems and programs. To support the implementation of this recommendation and to ensure that the key stakeholders are participants in the process, the Task Force further recommends the formation of an Executive Council consisting of the appropriate principals from OSD, the Services, and the Defense Agencies.

We thank all of the members and government advisors of this Task Force for their dedicated efforts and significant contributions to this study.

Larry Druffel
Co-Chairman

George H. Heilmeier
Co-Chairman

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Executive Summary

The Defense Science Board Task Force on Acquiring Defense Software Commercially recognizes that DoD systems are becoming increasingly dependent on the use of software as the mechanism for implementing operational capabilities. To adapt to changing military and national security situations, DoD is more dependent than ever on its ability to modify mission software rapidly, often in near real-time. However, software remains the schedule and cost driver for the development and maintenance of many important defense systems.

In its review of current DoD and commercial software acquisition practices, the Task Force found notable differences, as evidenced in Appendix C. There are, however, many similarities between the various categories of DoD and commercial software systems. Although there are indications that commercial development efforts have achieved better predictability and lower costs, the Task Force noted a significant lack of credible, quantitative data to substantiate this assessment.

In general, the Task Force concluded that DoD's investment in software requires greater DoD-wide management control and oversight in the coming years if the Department is to exploit the use of commercial software acquisition practices fully, as well as rapid advances in software technology. The following is a summary of selected findings and recommendations toward that end.

Process Credibility: Current DoD practice is not compatible with commercial business practices. DoD should work to make necessary changes to acquisition regulations such as:

- Having program managers manage 3 of 3 (price/schedule/functionality) but only constrain 2 of 3
- Defining successful performance on contracts as delivering a solution (with predictable price, schedule and functionality) not adherence to government processes, procedures and specifications
- Not requiring c-level specifications for software projects developed in Ada
- Establishing mechanisms to allow both current ability to perform as well as past performance as key factors in source selection
- Encouraging offerors to demonstrate as much functionality as possible as part of bid without eliminating domain knowledgeable competition

DoD Program Management: DoD program management approaches discourage the use of commercial practices. Program managers lack incentives to tailor procedures to fit individual program needs or to develop "corporate" solutions (e.g., employ common architecture or common software components). DoD should establish and implement overarching software life cycle guidelines more conducive to the use of commercial practices and products, such as:

- Defining software architectures to enable rapid changes and reuse
- Facilitating early system engineering and iterative development
- Participating in development of commercial and international standards
- Allowing the fielding of software directly from test beds with user consent
- Requiring program managers to stay with programs at least through beta testing to maintain continuity of understanding of original nuances in requirements

DOD Personnel: There is currently a shortage of sufficiently qualified software personnel at all levels within the Department. DoD should establish a Department-wide software program management education and training initiative that includes: changing courses for PMs to reflect best commercial practices and other recommendations of this task force and providing for changes to reflect the dynamics of the software industry; rotating government and contractor personnel between PM and developer organizations to build understanding and trust; encouraging use of IPA's from industry; and integrating software-qualified personnel into senior DoD acquisition staff.

Use and Integration of Commercial Off-the-Shelf (COTS) Software: DoD has not fully identified the pros and cons associated with the use of COTS software and, as a result, has not determined when and how best to use COTS software. To facilitate this process, DoD should require trade studies and analysis of the use of COTS software in DoD's software acquisition process where appropriate. Further, DoD should establish "customer friendly," application-specific information technology "component stores" to enable program managers to assemble systems rather than develop them through use of reusable, prequalified components. DoD should also increase technology base funding for security audit tools for systems employing COTS software and should capitalize on innovative cost-effective techniques for acquiring and using COTS software products, such as the use of enterprise licenses.

Software Architecture: Software architecture was emphasized by the Task Force as a means for achieving important ends. There is currently little emphasis on architecture in DoD software programs or regulations. As a result, DoD is not benefiting from architecture as a key tool for evolutionary development and for early (and frequent) involvement of users with functional capability and facilitating reuse, requirements changes with minimum cost and schedule, and "product line" management. DoD should require vendors to propose, manage and control the architecture and should establish an early architecture deliverable in all developments.

Software Technology Base: The current DoD software technology base investment does not adequately take advantage of commercial R&D. Further, software technology transfer (both internal and external) is not receiving adequate emphasis within DoD. DoD should provide for the evolution of the DoD Software Technology Strategy to align with emerging commercial technology and practices.

Overarching Recommendations: To facilitate implementation of the many recommendations contained in this report, the Task Force concluded that DoD's investments in software require greater management control and DoD-wide oversight. To this end, the Task Force recommends that the Secretary of Defense (SECDEF) assign the Under Secretary of Defense (Acquisition and Technology) (USD (A&T)) the responsibility for DoD-wide software technology, policy, practices and acquisition. In carrying out this responsibility, the Task Force recommends that the USD (A&T) consider forming an executive council with the Director, Defense Research and Engineering (DDR&E), the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) (ASD (C3I)) and appropriate representatives from the Services and Defense Agencies as members. Further, USD (A&T) should provide for a supporting "process action team" to assist in implementation of the recommendations of this Task Force study.

Defense Science Board Task Force on Acquiring Defense Software Commercially

1.0 TASK FORCE OVERVIEW

1.1 TERMS OF REFERENCE

Terms of Reference

Objectives:

- **Determine:**
  - Conditions Under which Procurement of Defense Software Can Use Commercial Practices
  - Changes Required to Permit Such Use
- **Develop Strategy that Incorporates Such Practices**
  - Not Constrained by Existing DoD Standards
  - Viewed as Coexisting Alternative Strategy
  - Includes DoD Use of Commercial Software Products
- **Compare Proposed Strategy with Current DoD Strategy, Indicating Circumstances Where Each is Most Beneficial**

Scope:

- **All Software Intensive Systems**
- **All Stages of the Software Life-Cycle**

Appendix A provides the Terms of Reference by which the Task Force was established. The objectives and scope of this Task Force are outlined above. At the first meeting of the Task Force, the sponsor of the study (the Director, Defense Research and Engineering) requested that the Task Force provide a strategy that: was sensible, pragmatic, and unconstrained by current DoD acquisition practices; was based on evaluation of mechanisms for integrating defense software efforts with commercial software efforts; did not require legislative relief; and addressed the full spectrum of DoD software applications.

1.2 CAVEATS

Caveats

- **Relied on Inputs from DoD and Industry Experts**
- **Provided No Detailed, Quantitative Assessment or Evaluation of Individual Topics**
- **Did Not Address:**
  - **Success or Failure of Ada**
  - **Recommended Software Development Approach for Specific Programs**
  - **Specific COTS Products for DoD to Exploit**
  - **Trade-Offs Between Hardware and Software**

The Task Force relied heavily on inputs from a variety of DoD and industry experts regarding a wide range of topics related to defense software technology, policy, practices and acquisition. Appendix B lists the many briefings that were provided. Although the Task Force chose not to provide detailed, quantitative assessments or evaluation of individual topics, it used the information associated with these topics in the formulation of findings and recommendations. The areas not addressed by the Task Force, while important in and of themselves, were determined not to be directly germane to the development of an overall defense software strategy.

1.3 TOPICS ADDRESSED

Topics Addressed

Topic
Management:
● DoD Software Acquisition Policies
● DoD Management of Commercial Development Process
● Software Risk Management Techniques and Supporting Tools
● Minimum Effective Delivery Time
● Affordability
● Maintenance After Product Delivery
● Post-Deployment Product Enhancement
● Software Process Support Tools
● Quality
● Assured Availability
● Use of Development and Maintenance Tools
Contracting:
● Technical Data Rights
● Intellectual Property Rights
● Liability
● Alternative Forms of Procurement Agreements
● Incentives for Creation/Use of Reusable Software Components
● Economic Incentives
Technical:
● Importance of Software Architecture
● State-of-the-Art and Best Commercial Practices
● Development Tools
● Reusable Software Components
● Techniques/Tools for Tailoring Commercial Components for Defense Use

In its efforts to assess the appropriateness of DoD use of commercial practices, the Task Force addressed software management, contracting, and technical issues. The above viewgraph lists the primary topics considered within each of these categories.

1.4 MEMBERSHIP

Members

Co-Chairmen:	
• Dr. George H. Heilmeier	Bellcore
• Dr. Larry Druffel	Software Engineering Institute
Members:	
• Dr. Jacques Gansler	TASC
• Mr. Jack Hancock	Retired Exec VP, Pacific Bell
• Mr. Patrick Hillier	EDS
• Mr. Arthur E. Johnson	Loral Federal Systems
• Dr. Bruce Johnson	Andersen Consulting
• Mr. Alan McLaughlin	MIT Lincoln Laboratory
• Dr. Alvin E. Nashman	Computer Sciences Corporation
• Mr. John Stenbit	TRW
• Dr. Terry Straeter	GDE Systems, Inc.
Independent DSB Reviewers	
• Mrs. Joan Habermann	Logistics Management Institute
• Mr. Philip A. Odeen	BDM International, Inc.
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• Ms. Virginia L. Castor	ODDR&E/AT
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Joint Staff:	
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• LTG Peter Kind	Army
• RADM John G. Hekman	Navy
• Mr. Lloyd K. Mosemann II	Air Force
Agencies:	
• Ms. Belkis Leong-Hong	DISA
• Dr. Ed Thompson	ARPA

Task Force members represented a valued cross section of software expertise within both the DoD and commercial sectors. The government advisors represented senior executives (including the three Service Software Executive Officials) from the major software management organizations within the Department.

2.0 CURRENT DOD AND COMMERCIAL SOFTWARE ACQUISITION PRACTICES

2.1 BACKGROUND

Background: Previous Studies

- DSB Summer Study on Technology Base (1981)
- Joint Service Task Force on Software Problems (1982)
- AF SAB High Cost and Risk of Mission Critical Software (1983)
- CODSIA Report on DoD Management of Mission-Critical Computer Resources (1984)
- DSB Task Force on Military Software (1987)
- Ada Board Response to DSB Task Force (1988)
- Summer Report on Defense-Wide Audit of Support for Tactical Software (1988)
- Workshop on Executive Software Issues (1988)
- Workshop on Military Software (1988)
- Army Materiel Command Study (1989)
- Software Technology Development and Deployment Plan for DoD Technology Base (1989)
- AF SAB Adapting Software Development Policies to Modern Technology (1989)
- Draft DoD Software Master Plan (1990)
- Draft DoD Software Technology Strategy (1991)
- AF SAB Study on Information Architecture (1993)
- Study on Military Standards Impacts on the Acquisition Process (1993)
- Draft Software Action Plan Working Group Report (1993)
- Evolutionary Acquisition Study, AFCEA (June 1993)

As a point of departure, the Task Force noted a number of previous studies addressing issues related to the defense software technology, policy, practices and acquisition. Despite the increased emphasis given to software issues by the DoD (as evidenced by the above list), the majority of the recommendations resulting from these studies have not been implemented.

Background: Impediments to Change

- **DoD Software Management**
  - No Single Operative Mechanism Exists to Implement Change
    - Three Separate Domains: MIS, C3I, Embedded
    - Two Separate Acquisition Management Structures
  - Bureaucratic "Turf" Inhibits Real Reform
- **Acquisition Process**
  - 5000 and 8000-Series Developments Typically Employ "Waterfall" Approach; Not Incremental/Spiral Approach
- **Culture**
  - Systems Are Stove Pipe -- My System, My Program (PM is King)
  - DoD Acquisition Training Reinforces the Wrong Approaches
- **Procurement**
  - The Contracting Process Inhibits Creativity and Investment by Contractors; Limits Options
  - Interpretation of Competition in Contracting Act

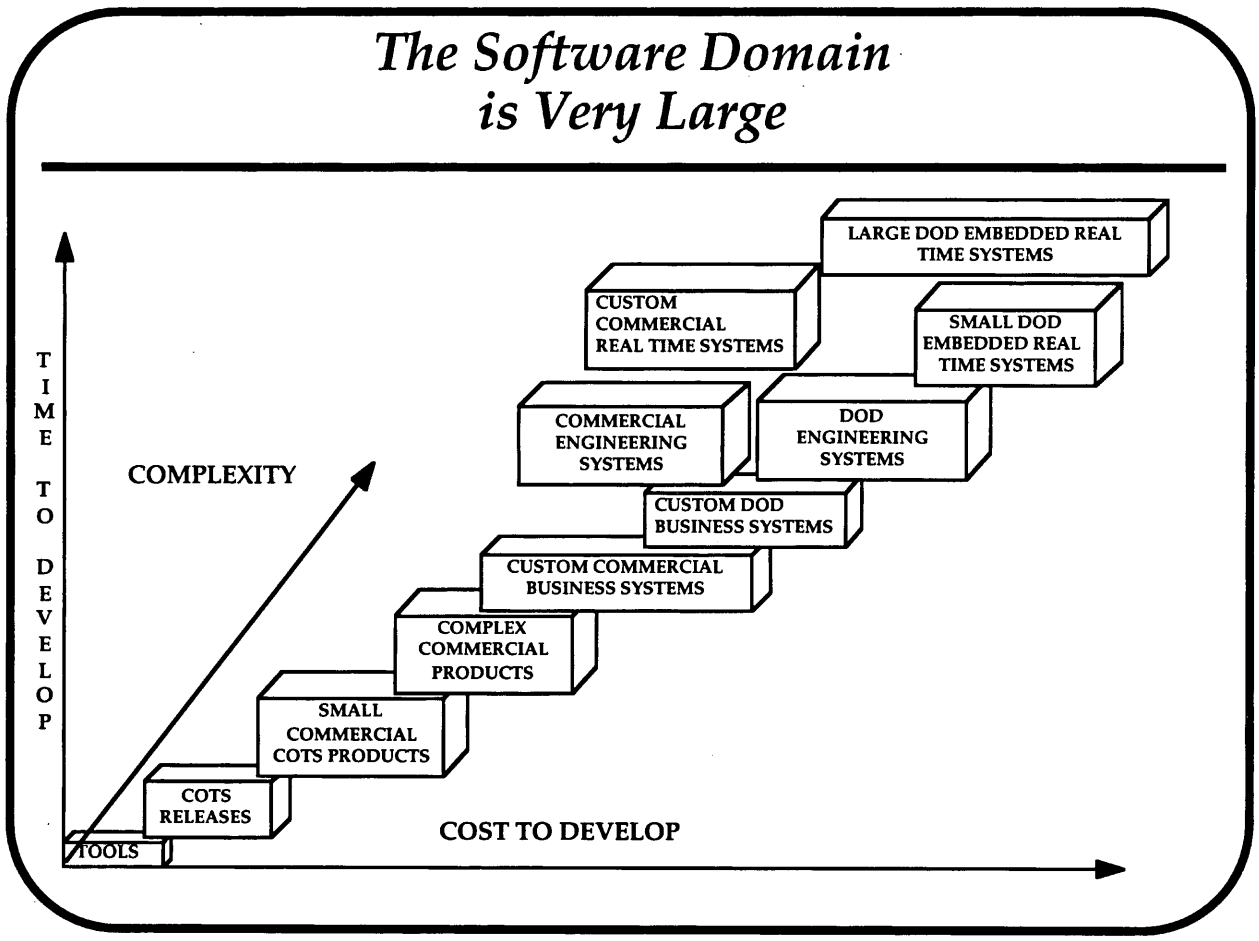
To ensure that its recommendations could be readily implemented by the DoD, the Task Force identified the primary reasons why recommendations from previous studies had not been acted upon. The Task Force then formulated its recommendations to appropriately address these impediments.

Why Is This Study Important?

- **DoD Military Capability Increasingly Software Dependent**
- **Software One of Few DoD Budget Areas That is Projected to Grow**
  - **Software Has Become the Overall Defense System Schedule and Cost Driver**
    - » **Declining DoD Budget -- Affordability a Major Concern**
    - » **Escalating Costs of Software Development and Life Cycle**
  - **Significant Level of DoD Resources To Be Spent on Information Technology:**
    - » **FY92- FY94: ~$10 Billion/Year***
    - » **EIA Forecast for FY95 - FY98: ~$10 Billion/Year**
    - » **In-House vs. Contracted Out: 30% In; 70% Out**
  - **Will Require Greater Management Control**
- **Rich Commercial Base to Tap; Many Opportunities**
  - **Custom Software**
  - **Off-the-Shelf Products**
  - **Acquisition Methodologies**
  - **Approach to Requirements Determination**
- **Functionality and Flexibility More Embedded in Software than Hardware**
- **Study is Timely Because DoD Leadership is Focused on Acquisition Reform**
  - **Something May Actually Get Done**

**Source: EIA*

Given its increasing reliance upon software as the mechanism for implementing system capabilities, coupled with the rising costs associated with software development and maintenance, DoD must take action now to address the issues associated with software acquisition. The commercial sector provides numerous opportunities upon which the DoD could readily capitalize. The time is ripe for assertive DoD action, particularly since the current leadership is so strongly focused on acquisition reform.



The software domain reviewed by the Task Force encompasses a wide variety of DoD systems, ranging from software tools to large embedded real-time systems. The associated cost, complexity, and time required to develop these systems vary widely, both for commercial and military applications.

Background: DoD Software Acquisition Management

- **Two Different Sets of Software Policies/Rules Managed by Two Different Organizations**
  - **USD (A&T) for Software Embedded in Weapons/Systems**
  - **ASD (C3I) for C3I Software and MIS Applications**
- **Majority of Software Issues are Applicable to <u>All</u> DoD Systems**
- **Growing Similarity Between DoD and Commercial Software Developments Across the Various Types of DoD Software**
  - **Modern Software Tending to Blur Distinction Between DoD and Commercial Applications**
- **Central DoD Leadership Needed More than Ever**
  - **Major Revisions Needed in DoD Software Policies/Rules and Management Across All DoD Applications in Order to Meet SECDEF's Acquisition Reform Goals**
  - **Interpretation and Implementation of DoD-Wide Policies/Rules by Management is a Central Issue**

Today, the management of DoD software acquisitions is quite complex. There are two sets of software policies/rules managed by two different organizations

- USD (A&T) for software embedded in weapons/systems
- ASD (C3I) for C3I software and MIS applications

There currently exists within the DoD a dichotomous organizational structure for the management of DoD software intensive systems. The Under Secretary of Defense (Acquisition and Technology) is responsible for weapons systems; the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence (C3I)) is responsible for C3I systems and Management Information Systems (MIS). However, as technology has evolved over the years, the issues associated with the use of software in all of these systems have become essentially the same. The issuance of different software-related policies and regulations that are oriented according to the type of system is no longer appropriate. If the DoD is to adequately address this fundamental issue, central focused management is required.

2.2 COMPARISON OF DEFENSE AND COMMERCIAL SOFTWARE

Comparison of Defense and Commercial Software Needs

- **Defense and Commercial Software Applications Needs Are Merging**

	Breadth of Application	Typical Size (SLOC)	Upgrade/ Change	Sensitivity to Errors
Real Time Applications				
- DoD Real Time Software	Unique	400,000	Complex; Inflexible	High
- Commrcial Custom Software Integrated Into Real-Time Operations	Unique	400,000	Complex; Inflexible	High
Command and Control Applications				
- C3I	Moving Toward Wide	200,000	Complex; Flexible	Moderate
- Commercial Custom Software Integrated Into Business Operations	Moving Toward Wide	200,000	Complex; Moving Toward Flexible	Moderate
MIS Systems				
- DoD Automated Information Systems	Very Wide	200,000	Moving Toward Commercial	Low
- Commercial Automated Information Systems	Very Wide	200,000	Exploits Object Oriented Technology	Low
Reusable Components/ Products				
- DoD Component Stores	Very Wide	50,000	Tied to Weapon System Cycle	Low to High (Depending on Use)
- Commercial Shrink Wrapped	Very Wide	50,000	Tied to Commercial Cycle	Low

DoD and commercial applications for software are different in some ways but very similar in others. The above table highlights these similarities and differences for real-time applications, command and control applications, MIS systems and reusable components and products. This apparent disparity in the classification of software between DoD and commercial vendors increases the complexity of DoD's management task. Companies (people, methods, and organizations) are usually specialized to one or more commercial type systems, not to DoD type systems. Defense and commercial software applications needs are merging, providing the potential that DoD can exploit commercial capabilities more effectively over time. Major revisions are needed in DoD software management across all DoD applications in order for DoD to capitalize on the evolving commercial base.

Process Comparison Summary

Process Attribute	Custom DoD	Custom Commercial	Commercial Product	Civilian/ Commercial Result
Problem Definition	Owned by Originator	Shared (Includes Market Analysis)	Market Place	More Practical Requirements
Process Definition	By Spec, Rigid	Internal/Evolving	Internal/Evolving	Reduced Cost/ Schedule
Flexibility	Very Limited	Not Constrained	Essentially Unlimited	Process Improvement Ease, Enabling Technologies
Milestones/Reviews (Duration, Formality)	Long, Formal, Heavy Document	Short Informal Incremental Document	Short, Informal	Reduced Cost/ Schedule
Customer/User Involvement in Development	Low User, High Customer Intervention User≠ Customer	High User at Prob. Def. and Acceptance User = Customer	Beta	Less Requirements Churning. Reduced Cost/Schedule
Process Monitoring by Customer	Heavy	Some	None	Reduced Cost/ Schedule
Customer Acceptance Process	Rigorous	Simple	Market Place	Reduced Cost/ Schedule
Inspection/Testing	Rigorous /Formal	Rigorous/Formal	Rigorous/Formal	Similar Product Quality
Subcontracting	By Spec	Brief Product Spec ISO Possible	Brief Product Spec ISO Possible	Quality/Dependability of Subcontractor May Be Less
Use of Advanced Development Techniques (i.e. Reuse/4GL/OO)	Implicitly Discouraged	Extensive	Extensive	Reduced Cost/ Schedule Higher Quality

Source: IBM Federal Systems

As is evident from the process comparison summary above, there are not only differences between commercial and defense applications, but also in the process used by each to develop, acquire and support complex software systems. Defense and other federal acquisition regulations and detailed specifications require a much more complex set of deliverables within the context of DoD's contracting process.

Comparison of DoD and Commercial Software Acquisition Practices

- **Requirements Definition**
  - Commercial
    - More flexible and open between users and supplier
    - Based on strategic plan and usually cost/schedule driven
    - More willing to adjust requirements based on availability of off-the-shelf products
    - Evolves capability
- **Vendor Selection**
  - Commercial
    - Much more flexible; no requirement for fairness or to maintain the public trust
    - Encourages vendors to offer best solution, not meet 100% of requirements
    - Accommodate teaming and long-term relationships
- **Development Process**
  - Commercial
    - More flexible; product improvements anticipated
    - Team approach with bias toward reuse and tailoring of existing systems
    - Multi-year acquisitions not re-justified each year.

In essence, the Task Force found major differences between DoD and commercial software acquisition practices, as outlined above and on the next page.

Comparison of DoD and Commercial Software Acquisition Practices (Cont.)

- **Business Practices**
  - Commercial practice more flexible with greater incentives
- **Integration Testing and Delivery**
  - Commercial provides integration and functional testing according to need
  - DoD uses separate test agency with added time and complexity
  - Absence of beta testing within DOD increases costs
- **Rights in Data**
  - Commercial more flexible, especially regarding resales
- **Maintenance**
  - Commercial: Maintenance considered and integrated with development
  - DoD: Maintenance not major factor in development process

Appendix C provides a more complete comparison of DoD and commercial software acquisition practices as developed by this Task Force.

Assessment of Current DoD Software Acquisition Approach

- **Strengths**
  - **Highly Structured Process Tied to Individual System Developments**
  - **Tightly Defined Requirements**
  - **Produces High Quality Product for Mission Critical Systems That Demand Extremely Low Failure Rates (e.g., Flight Controls for Man-Rated Platforms)**

The strengths of the current DoD approach to software development, acquisition and operation are summarized above. The Task Force found that the highly structured DoD process has, in fact, provided a high quality software product, in most cases.

Assessment of Current DoD Software Acquisition Approach

- Weaknesses
  - High Life Cycle Cost in Time and Dollars
  - Software Development Cycle Tied to Weapon System Developments
    - » Incredibly Long , Typically 13 to 15 Years from Concept to Fielding
  - Encourages Excessive Acquisition Agent Involvement in Design Detail and Process
  - Based on Mistrust vs. Mutual Trust
    - » Excessive Documentation
    - » Excessive Formal Review
    - » Excessive Testing of Non-Critical Systems
    - » Poor Communication Between Vendor, Acquisition Agent and User
  - No Requirements Addressing Cost and Schedule
  - Traditional Approach Used: Design it All and Then Build it
  - Little or No Requirements Relaxation for High Cost Items
  - Inadequate Beta Testing in Early Phase
  - Little Focus on Designing in Reusability

However, there are a number of weaknesses associated with the current defense approach, as summarized above. Many of these weaknesses derive from the need for a fair and open procurement process and the necessity to prove that public dollars are wisely spent.

Assessment of Current Commercial Software Acquisition Approach

- Strengths
  - Open Architecture Compatible with Usage of COTS Software
  - Much Less Formal Competitive Procurement Process
    - » Includes Prior Performance as Major Selection Criterion
  - Trend Toward Joint Assumption of Risks Between Buyers and Suppliers Across Development, Operation, Maintenance and Modernization
  - Process is More Flexible
  - Shorter Cycle (Product Release) Times
  - Tailorable Level of Documentation and Oversight
  - Emphasis on Reuse and Tailoring Requirements to Existing Products
  - Beta Testing Widely Used
- Weaknesses
  - Less Responsive to Continual Changes in Requirements
  - Less Assurance that Software Will Function Properly Under All Situations
  - Potentially Locked into One Vendor's Proprietary Application

The strengths and weaknesses of the current commercial approach to software development, acquisition and operation are summarized above.

Principal Reasons DoD Software Programs Get Into Trouble

- **Poor Requirements Definition**
  - Lack of User Involvement in Development Process
  - Inability of Users to Foresee Benefits of Automation Without Incremental Capability
- **Inadequate Software Process Management and Control by Contractor**
- **Lack of Integrated Product Teams**
  - Failure to Establish "Team" With Vendors and Users
  - Little Participation of Functional Area Experts
- **Ineffective Subcontractor Management**
- **Lack of Consistent Attention to Software Process**
- **Too Little Attention to Software Architecture**
- **Poorly Defined and Inadequately Controlled Interfaces Between Computer Hardware, Communications and Software**
- **Assumption That Software Upgrades Can "Fix" Hardware Deficiencies (Without Assessment of Cost and Schedule Risks)**
- **Focus on Innovation Rather than Cost and Risk**
- **Limited or No Tailoring of Military Specifications Based on Continuing Cost-Benefit Evaluations**

Over the last two decades, a number of DoD software development efforts have gotten into trouble, particularly in terms of actual costs and schedule vs. expected or predicted costs and schedule. The Task Force heard briefings from a number of DoD program managers where this was the case. Based on the specific programs discussed and on other inputs, the Task Force prepared a listing of the principal reasons DoD software programs have gotten into trouble as shown above. Certain of these reasons are a reflection of DoD practice. Others are tied to the software engineering level available at the time such programs were initiated. The Task Force believes that today's software technology and practices can directly address many of the root causes for such past problems.

Resource Allocation: Where Does the Effort Go?

	Military	Commercial
• Engineering	30%	50%
• Evaluation	20%	20%
• Management	15%	10%
• Meeting Support	15%	5%
• Documentation	15%	7%
• Customer/User Support	5%	8%

Source: Magnavox and Capers Jones

There are some indications that commercial development efforts have achieved better predictability and lower costs than DoD counterparts. The Task Force solicited quantitative data on this issue from both government and commercial software experts. The figure above summarizes one type of indicator of the difference between commercial and government projects (in terms of the percentage of the effort expended for different aspects of a typical development).

Comparison of Commercial and Government Projects

Application Type	Number of Projects	Average Size (SLOC-New and Modified)	Schedule/Time (Months)	Effort (Staff Months)
Small Information Systems				
Commercial	1491	26,000	12.52	
Government	75	26,000	15.1	
Percent Difference			+17.09%	+44.24%
Small Engineering Systems				
Commercial	259	26,000	17.4	65.7
Government	29	26,000	20.9	117.3
Percent Difference			+16.75%	+43.99%
Large Information Systems				
Commercial	295	212,000	22	150.2
Government	21	212,000	25.6	242.9
Percent Difference			+14.06%	+38.16%
Large Engineering Systems				
Commercial	56	442,000	45	1736
Government*	7	442,000	52	2740
Percent Difference			+13.46%	+36.64%
Summary of Average Percent Difference			+15.34%	+40.76%

** Small sample may be statistically invalid.*

Source: QSM, Inc.

This figures summarizes other quantitative indicators of the difference between commercial and government projects (in terms of the typical size of the code, time to develop the application and overall level of effort).

It should be noted that the Task Force was unable to find reliable, quantitative data supporting the notion that commercial practices are more cost-effective than DoD practices. This lack of reliable indicators was a major concern of the Task Force.

3.0 MAJOR FINDINGS AND RECOMMENDATIONS

3.1 PROCESS CREDIBILITY

Process Credibility

Findings

- **Attempts to achieve absolute fairness in competition in contracting (fair and reasonable pricing) have led to a lack of trust between government and individuals/contractors**
  - **Current DoD practice:**
    - » **Is not compatible with commercial business practices**
    - » **Is focused on contractor management/audit activities and costs**
    - » **Hinders flexibility (managers take no personal risk)**
    - » **Is not well suited to procuring complex, knowledge-intense, "first of a kind" systems**
    - » **Is too costly**
    - » **Does not prevent malfeasance or incompetence**
    - » **Leads to adversarial relationships**
    - » **Reduces reuse and contractor incentive to invest because of stringent data rights interpretation**
  - **Contractors must make profit on single contract; no long term relationship (DoD business practices do not view profit as a legitimate cost of doing business)**
  - **No individual fully understands or owns total process**

The Task Force spent considerable effort on how the requirement for DoD to ensure public trust in its acquisition process influences DoD's ability to employ "commercial best practices." The Task Force found that attempts to achieve absolute fairness in competition in contracting have, in fact, led to a lack of trust between the government and individuals/contractors. DoD acquisition processes are focused on contractor audit activities to an extent that hinders the flexibility of Program Managers and contractors. DoD PMs are not incentivized to assume any personal risk associated with allowing for flexibility comparable to commercial practice. Criminal sanctions are a significant disincentive for such efforts.

DoD's acquisition system still does not prevent malfeasance or incompetence and leads to adversarial relationships rather than partnerships which are the norm within commercial industry software developments. One problem highlighted by the Task Force was that the current DoD system does not allow one individual or manager to control the total process, even for a specific project. This lack of control leads to a diffusion of accountability and hinders DoD's ability to oversee complex "first of a kind" software developments.

Process Credibility

Findings

- **Requirements and Source Selection Inflexibility**
  - Vendors attempt to meet every requirement
  - Ease of protest
  - Requirements focus vendor on particular solution
  - Requirements have become alternative to professional judgment
  - Departures from requirements have caused protests and bad publicity
- **Price/Schedule/Functionality**
  - In commercial sector, managers constrain 2 out of 3 (e.g., cost and schedule)
  - In DoD, managers constrain 3 out of 3
- **Constrained Communication During Solicitation**
  - Questions are provided to competitors (can give away proprietary concepts)
  - Questions are often misinterpreted and answered incorrectly
  - Guarded way of asking questions limits substantive feedback
- **Complicated Regulations**
  - Restrict variety of proposals
  - Restrict competition and limit government options
  - Consume time and resources
  - Drive government employees to follow conservative procedures as safest path (inhibits "best value")
- **Government-Unique Accounting Procedures and Audits**
  - Audit requirements limit available vendors
  - Add substantial cost
  - Create need for separate accounting systems
  - Drive vendor to lowest labor cost solution rather than best value solution
  - Lead to rejection of good solutions based on value pricing vs cost-based pricing

The viewgraph above lists important hindrances that the Task Force sees with regard to the adoption of commercial software practices. Many of the Task Force recommendations address these hindrances.

Process Credibility

Recommendations

- Make necessary changes to acquisition regulations
  - Have Program Managers Manage 3 of 3 (Price/Schedule/Functionality) But Only Constrain 2 of 3
  - Define Successful Performance on Contracts as Delivering Solution (with Predictable Price, Schedule and Functionality) Not Adherence to Government Processes, Procedures and Specifications
  - Do Not Require C-Level Specifications for Software Projects Developed in Ada
  - Prior to RFP, Government Should Perform Independent Market Analyses of Off-the-Shelf and Contractor Products to Assure "Best Value" Solution
  - Establish Mechanisms to Allow Both Current Ability to Perform as Well as Past Performance as Key Factors in Source Selection
    - » Require Source Selection Evaluation of Development Contractors Through a Formal Software Process Capability Evaluation
  - Encourage Offerors to Demonstrate as Much Functionality as Possible as Part of Bid Without Eliminating Domain Knowledgeable Competition
    - » Executable Architecture as a Minimum
    - » Weight Heavily in Selection

The Task Force makes the above recommendations with regard to process credibility.

3.2 DOD PROGRAM MANAGEMENT

DoD Program Management

Findings

- **Program management does not encourage "80% solution for 20% cost"**
- **Users often not significantly involved in process**
- **Little emphasis on life-cycle issues (including maintenance and support)**
- **Existing policies, methodologies, and procedures, and their implementation are inadequate**
  - **Little evidence that policies are influenced by actual experience and vice versa**
  - **Little effort to measure effectiveness and costs of policy directives**
- **Some indication that DoD is migrating toward development and use of standards-based architectures**
- **Program Managers lack incentives to allow tailoring of procedures to fit individual program needs or to develop "corporate" solution (e.g., employ common architecture or common software components)**

The Task Force found that the DoD program management system itself discourages the use of commercial best practices. These findings are not unique to software, but are particularly important for software given the significant cost savings associated with software reuse. There are few incentives for Program Managers (PMs) to develop or even employ corporate solutions (common architectures/software components), particularly if they are more expensive to acquire. Rather, each PM will tend to optimize his/her development for its own purpose. Further, it is difficult for users to be significantly involved until late in a software development process, unless some sort of prototype can be constructed. DoD PMs place little emphasis on life-cycle issues (such as software maintenance and support). Existing DoD-wide software policies, methodologies, and procedures, and their implementation by PMs are inadequate. There is little evidence that policies are influenced by actual experience and vice versa and there is little effort to measure the effectiveness and costs of policy directives.

DoD Program Management (cont.)

Recommendations

- **Establish Overarching Software Life Cycle Guidelines**
  - **Tools/Methods**
    - » Define Software Architectures to Enable Rapid Changes and Reuse
    - » To Achieve the Benefits of Using Standards-Based Architectures, DoD Must Manage Programs Using:
      - Early system engineering
      - Iterative development
      - Proactive participation in development of these standards
    - » Promote Development/Use of Community-Wide Metrics and Models (e.g., SEI's Capability Maturity Model)
  - **Acquisition**
    - » Revise the Milestones for Software-Intensive Development
      - Address the need for a software-first philosophy
      - Provide for a layered software/hardware standards based architecture
      - Acquisitioin and life cycle planning should now separate hardware and software fieldings based on the business sense of the specific project
    - » Require Early Interaction Between User, Acquisition Agent, and Developer; Identify and Get Early User Involvement
    - » Apply Evolutionary Development with Rapid Deployment of Initial Functional Capability
    - » Encourage Competition of Technical Approach vs. Cost
    - » Provide Incentives and Guidelines to Encourage Software Reuse (Architecture-Based Reuse)
    - » Reduce Documentation and Review Requirements for "Mature" Companies (i.e., Companies Determined to Be "Mature" Through Evaluation Mechanisms)
    - » Tailor operational testing to develop DoD "Beta Test" philosophy
      - Allow fielding of software direct from test beds with user consent
    - » Have Program Manager Stay with Programs at Least Through Beta Testing to Maintain Continuity of Understanding of Original Nuances in Requirements

The Task Force makes the recommendation that DoD establish overarching software lifecycle guidelines directed at facilitating program manager employment of commercial practices and software and that a DoD-wide effort be made to oversee implementation of these guidelines. The tools, methods and acquisition approaches recommended by the Task Force are listed above.

DoD Personnel

Findings

- **A shortage of sufficiently qualified software personnel currently exists at all levels within the DoD**
  - **Expertise for software acquisitions, software evaluations, and software maintenance/support**
  - **Expertise to represent DoD (customer) interests with commercial sector**
  - **Expertise in domain software design and applications**
  - **Expertise in software technology to develop policies, standards, and guidelines**
  - **Expertise in software program management**

Based on the inputs provided, the Task Force found that a shortage of sufficiently qualified software personnel exists at all levels within the DoD. Without personnel who are highly qualified in modern software practices, DoD will not be as capable of effectively exploiting complex software within its systems. This personnel shortage has been a major contributor to the problems that have arisen in past DoD software development programs.

DoD Personnel (Cont.)

Recommendations

- **Establish DoD-wide software program management education and training initiative**
  - Change DSMC and IRMC courses for PMs to reflect best commercial practices and other recommendations of this Task Force and Provide for changes to reflect the dynamics of the software industry
  - Develop and provide interactive training tools for senior managers to perfect software management skills
  - Rotate government and contractor personnel between PM and developer organization to build understanding and trust; encourage use of IPA's from industry
  - Incorporate software management principles in senior management education and seminars (including senior services colleges)
  - Provide mechanisms for keeping software expertise current in the workplace
- **Develop Acquisition Managers with software program management expertise**
  - Integrate software-qualified personnel into senior acquisition staff
- **Establish Norms for the Number of Software Experts in Program Offices**
- **Upgrade Educational Requirement for Personnel Assigned to Acquisition, Management, Development and Oversight of Software Intensive Programs**
- **Develop Expertise in Analysis of Domain Software Design**
  - Promote Software Reuse in the Design

The Task Force makes the above recommendations with regard to DoD software expertise of its personnel. The Task Force strongly recommends an emphasis on increasing the capability of its personnel in modern software practices and techniques.

3.4 USE AND INTEGRATION OF COMMERCIAL OFF-THE-SHELF SOFTWARE

Use and Integration of Commercial Off-the-Shelf Software

Findings:

- **DoD Does Not Normally Perform COTS Market Analyses Incident to Requirements Definition**
- **DoD is Beginning to Exploit Evolutionary Development Approaches**
- **Tools/Methodologies Are Evolving to Facilitate Use of COTS**
  - **Computer Aided Software Engineering (CASE)**
  - **Object oriented methods**
  - **Reuse repositories**
  - **Integrated product teams**
  - **Integrated risk management**

DoD does not routinely perform COTS software market analyses during the requirements definition phase of an acquisition program. Nor does it employ prototypes or simulations of new capability in a way that could influence the requirement process. Rather, requirements are evolved in a manner that is disconnected from the availability of commercial applications and are not typically influenced by such available capability. This situation is true for both hardware and software. Today's technology can facilitate early interaction between users and available capability, particularly in software. Further, DoD is beginning to exploit evolutionary software development approaches that could provide for the inclusion of existing commercial software functionality into early prototypes and allow users to test such capabilities. Modern software tools and methodologies have evolved that facilitate use of COTS, such as those listed above.

Use and Integration of Commercial Off-the-Shelf Software

Findings (Cont.)

- **DoD has not fully identified the pros and cons associated with the use of COTS**
  - **Pros**
    - » Saves money in design and development of those components
    - » Can Significantly Reduce Development Risk
      - Support is Concern
    - » Selection of COTS products early in project cycle will enable requirements to be driven by commercial software capabilities
    - » Very useful in rapid prototyping
  - **Cons**
    - » Commercial products must still be integrated into system and qualified with system
    - » Difficulty in Configurement Management and Support for Older Releases
    - » Additional testing may be required to qualify system with commercial components
    - » Subsequent releases determined by vendor, not DoD
    - » Security Aspects of Use of COTS Not Well Understood
      - DoD not addressing multiple aspects
        - Development environment
        - Tactical computer program
        - Virus protection
        - Commercial Espionage
      - Classified software systems a problem for commercial companies
- **In addition, DoD has not determined when to use COTS**
  - **Commercial Off-the-Shelf Software Products May Not Apply to All DoD Systems**
  - **Should be used as is - avoid tailoring or special features**
  - **Most weapon system/real-time application software for DoD will not exclusively be "custom," but will involve some COTS**

In general, DoD has not identified the pros and cons associated with the use of COTS. DoD must learn how to balance the cost savings associated with design and development of commercial software products and the significantly reduced development risk with the concern for longer term support and system security. Commercial products must still be integrated into and qualified within each defense system and there is difficulty in configuration management and support for older releases. The latter point is important since many DoD software systems are not deployed before a commercial software product is retired or replaced. DoD is not addressing many aspects of the use of COTS software:

- Development environments
- Virus protection
- Commercial espionage

In essence, DoD has not developed a corporate way to decide when to use COTS software. Commercial off-the-shelf software products do not apply to all DoD systems. Most weapon system/real-time application software for DoD will not exclusively be "off-the-shelf." Integration and configuration control for COTS software then become important concerns. Further, DoD must learn to use COTS so that it avoids tailoring or special features.

Use and Integration of Commercial Off-the-Shelf Software

Recommendations

- **Require Trade Studies and Analysis of the Use of COTS in DoD's Software Acquisition Process Where Effective**
  - Performed by Acquiring Organization as Essential Part of Defining Requirements and in Rapid Prototyping Situations
    - » Employ Broad Agency Announcements or Similar Contractual Approaches to Facilitate Such Studies
  - Use of COTS Appropriate When:
    - » Defining Requirements
    - » Rapid Prototyping Situations
    - » Not Required to Tailor COTS Source Code to Application
    - » Not Required to be Error-Free
    - » COTS Software is "Close Enough" to Tailor Requirements
- **Establish "Customer Friendly" Application-Specific Information Technology "Component Stores"**
  - Generic Architectures for Specific Domains
  - Rapid Requirements Definition Process and Prototyping
  - Reusable, Prequalified Components
  - Assemble Systems Rather than Develop Them
  - Reduce Lead Time
  - Security is not Paramount
- **Increase tech base funding for security audit tools for systems employing COTS**
- **Capitalize on Innovative Cost-Effective Techniques for Acquiring and Using COTS Software Products**
  - Such as Use of Enterprise Licenses

Given these findings, the Task Force makes the above recommendations with regard to DoD use and integration of commercial off-the-shelf software. The Task Force sees great benefit to be gained through exploitation of COTS software; however, DoD must develop corporate approaches to the use and integration of COTS software, if it is to gain this benefit.

3.5 ACQUISITION

Acquisition

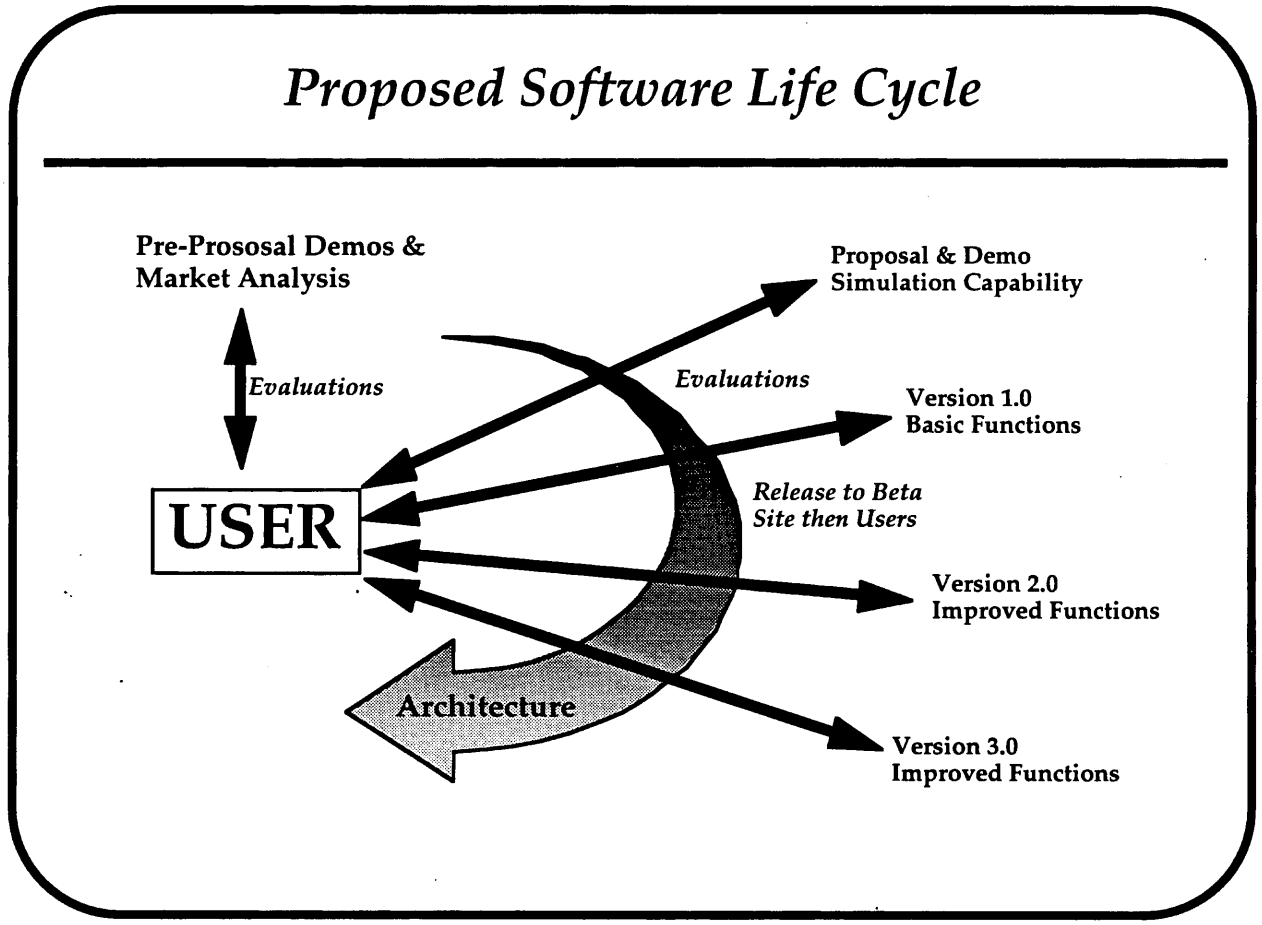
- Findings
  - Acquisition practices have led to:
    - » Distance between user and developer
    - » Limited participation by commercial software companies
  - Adherence to DoD regulations for reviews and documentation is increasing software costs
    - » DoD software costs are estimated to be increased by at least 20 % over commercial best practice
    - » Commercial best practice requires much less documentation than DoD
  - Funding for maintenance planning/execution starts late
    - » Maintenance assumed organic; inhibits teaming/partnerships
  - Acquisition focus is on mandatory "how to" specifications and standards rather than the product (what)
    - » Lengthens process and adds costs
    - » Discourages harmonization with commercial practice
    - » Creates adversarial relationship
  - Acquisition process does not reward development of reusable software

The Task Force was concerned that the specific acquisition and contracting approaches used by DoD inhibit use of commercial practices and software. The Task Force findings in this area are shown above. Strict adherence to DoD regulations for reviews and documentation is increasing software costs. DoD software costs are estimated to be increased by at least 20% over commercial best practices. The DoD focus on detailed technical specifications has lengthened the process, added costs, discouraged harmonization with commercial practice, and created a highly adversarial relationship between the Government and industry. There is a strong belief that certain commercial companies or divisions of companies have opted to stay away from government contracts due to the complexity of the acquisition rules and regulations.

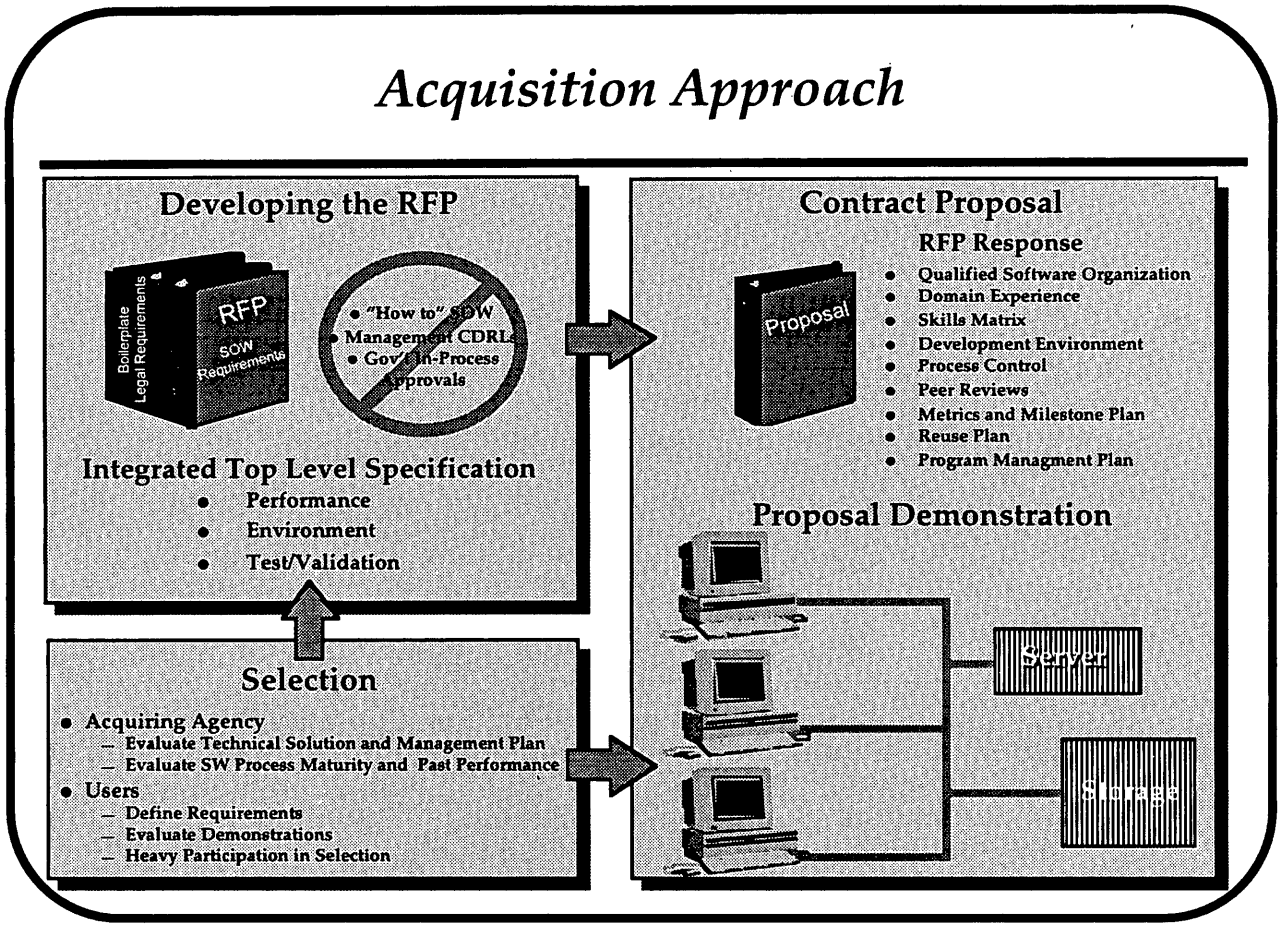
Recommendations-Acquisition

- **Recommendations**
  - **Implement the following acquisition approach:**
    - » **Establish acquisition focus on functionality and consistency with "commercial best practice"**
    - » **Revise procedures encouraging interaction between user and developer and achieving early functionality**
    - » **Minimize DoD regulations for review and documentation that are different than "commercial best practice"**
    - » **Require planning for maintenance at beginning of development process**
    - » **Provide government funded vehicle in contracts to incentivize development of reusable SW**
  - **Review all existing military standards and military specifications pertaining to software development and documentation, for continued applicability, such as DoD-STD 2167**

To this end, the Task Force makes the above recommendations with regard to DoD software acquisition practices. In essence, these recommendations can move DoD toward an acquisition approach that is more consistent with commercial approaches, while not requiring changes in statutes.



To implement this recommendation, the Task Force proposed that DoD evolve a more appropriate software life cycle approach as depicted above. This approach provides for early capability (even in the initial bidding process) and for a gradual enhancement in capability over time.



The Task Force proposed approach to competition is shown in the above figure. The core government role in such an approach would be to:

- Develop the RFP (no "How To" statement of work; no management CDRLs; no government in-process approvals)
- Provide an integrated "Top Level" specification (architecture, COTS/reuse, software engineering environment and test/validation approach).
- Employ software metrics as a key determinant,
- Evaluate proposed technical solutions and the proposed management plan

The contractor would then:

- Provide an execution plan, management controls and progress milestones/metrics
- Describe an in-place, mature software development organization and relevant domain experience
- Provide a skills matrix describing personnel to be employed
- Identify a robust development environment and describe applicable prior experience
- Describe automated process control software
- Describe the extent to which peer inspections will be used
- Provide a metrics usage plan and purposes for which they will be used
- Provide specific reuse and program management plans
- Propose specific architecture(s) in executable code

Software System Architecture: The Missing Link?

What is software architecture?

- **Software architecture consists of:**
  - **Software system components**
  - **The relationships among those components**
  - **Rules for their composition (constraints)**
- **Defining document would address:**
  - **System functionality**
  - **Software system components**
  - **Interfaces, standards, protocols**
  - **Execution model**
    - **Data flows**
    - **Control flow**
    - **Critical timing/throughput aspects**
    - **Error handling**

Software architecture was emphasized by the Task Force as a means for achieving important ends. Software architecture consists of software system components, the relationships among these components and the rules for their composition (constraints). To use architecture as a management tool, DoD needs to define: system functionality along with software system components to be employed; interfaces, standards, and protocols to be employed; and the execution model to include data flows, control flow, critical timing/throughput aspects, and error handling approach.

Software System Architecture (Cont.)

Findings

- **Why is it important?**
  - **Essential for effective management over the lifecycle**
    - » **Software system lifecycle costs ~ 65% for maintenance**
    - » **~ 65% of maintenance costs are due to changes/modifications/upgrades**
  - **Software architecture is a prime enabler of flexibility and reuse**
  - **Well-formulated architecture might reduce costs of changes/upgrades by 30-50% ($4-$7B/year assuming software expense ~ $30B/year)**
- **Why doesn't it play a larger role?**
  - **Focus is usually on initial cost, schedule, functionality – not lifecycle**
  - **2167A reinforces this approach – requires proof that design satisfies functionality**
  - **Difficult to specify, test, etc.**
  - **Not well understood**

Software architecture is a prime enabler of flexibility and reuse, and a well-formulated architecture might reduce costs of changes/upgrades by 30-50% ($4-$7B/year assuming software expense ~$30B/year). Software architecture has not been emphasized because PM focus has usually been on initial cost, schedule, and functionality and not on the life cycle. DoD-STD-2167A reinforces this approach by requiring only proof that a design satisfies the required functionality.

Software System Architecture (Cont.)

Findings (Cont.)

- **Little emphasis on architecture in DoD software programs or regulations**
- **Impact of software architecture issue**
  - **DoD not benefitting from architecture as a key tool for:**
    - » **Evolutionary development**
    - » **Early (and often) involvement of users with functional capability**
    - » **Ability to include changing commercial technology**
    - » **Reuse**
    - » **Facilitating requirements change with minimum cost and schedule**
    - » **Facilitating product line management**
- **Insufficient Progress in:**
  - **Developing models/standards for domain specific software architectures**
  - **Open system architectures work**

There is currently little emphasis on architecture in DoD directives or regulations. As a result, DoD is not benefiting from architecture as a management tool. Further, the Task Force sees insufficient progress in developing models and standards for domain specific software architectures.

Software System Architecture (Cont.)

Recommendations

- **Emphasize Use of Software Architecture**
  - **Establish model and context for architecture selection**
    - » **Standards-based with emphasis on "implementable"**
    - » **Require vendors to propose, manage and control the architecture**
  - **Require delivery of software architecture definition as first step in any software acquisition**
  - **Foster migration strategies at architecture level**
- **Assign responsibility within Government for domain analysis and product line developments**
- **Provide expertise and resources to ensure coordinated DoD participation in commercial/international standards bodies and users groups**

The Task Force makes the above recommendations in order to facilitate greater use of software architecture as a management tool for DoD software programs and activities. In particular, the Task Force sees great value in requiring the delivery of software architecture definition as a first step in any software acquisition. Where possible, such software architecture definition should be operational (i.e., executable).

Software Technology Base

Findings

- **The current DoD software technology base does not adequately take advantage of commercial R&D**
- **Software technology transfer (internal and external) is not receiving adequate emphasis within DoD**
- **There is a paucity of data to support prediction of cost, schedule and performance**

The software technology base (both defense and commercial) provides DoD with ample opportunity for significantly improving the defense software acquisition life-cycle.

Software Technology Base (Cont.)

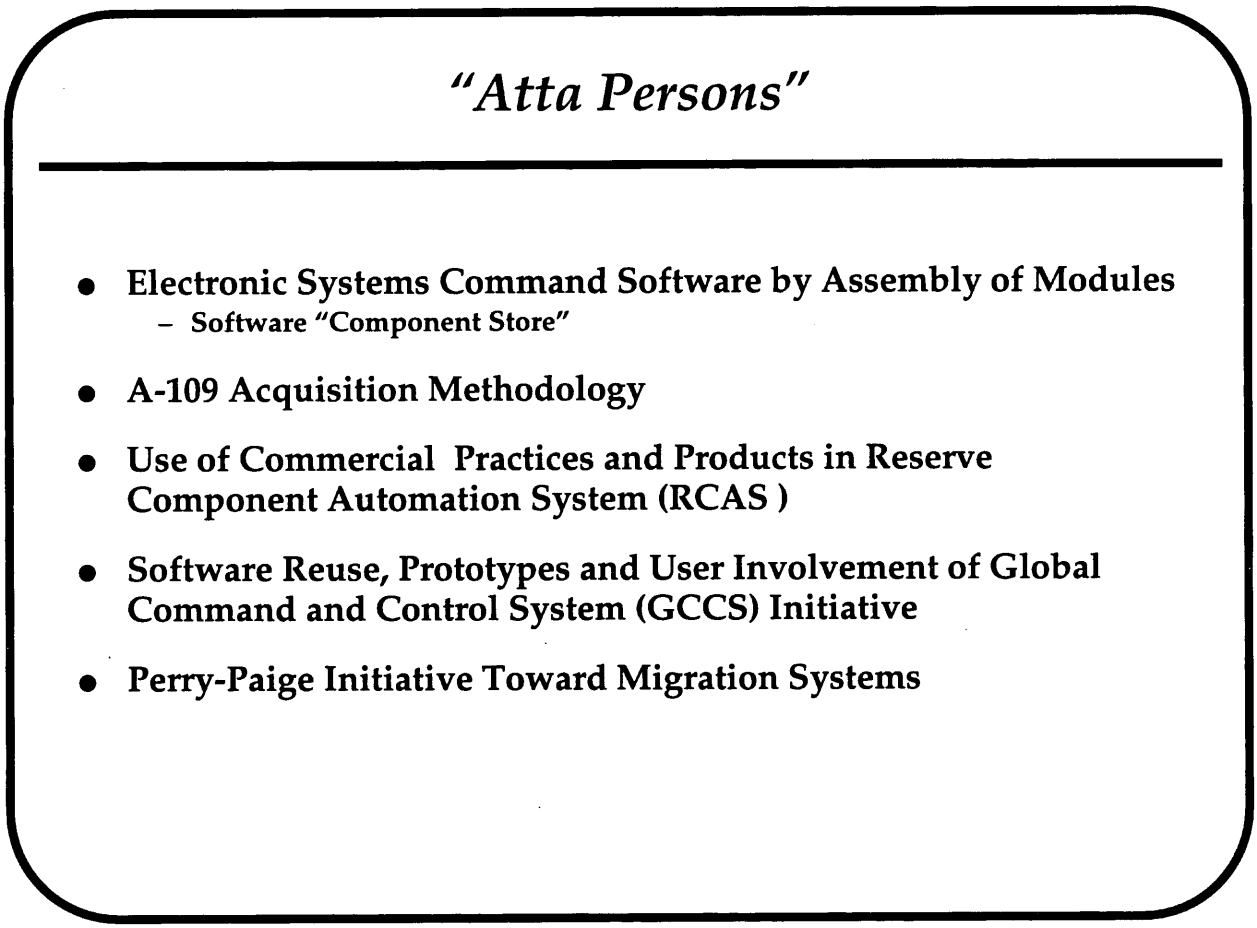
Recommendations

- **Provide for the evolution of the DoD Software Technology Strategy to align with emerging commercial technology and practices**
- **Emphasize Technology Transfer (External and Internal)**
  - **Fund technology transfer programs in such topics as:**
    - » **Architectural principles,**
    - » **Architecture description languages,**
    - » **Standard interfaces, and**
    - » **Integration technologies**
  - **Initiate demonstration programs (e.g., ATDs) to facilitate software technology insertion into systems. Examples of candidate criteria:**
    - » **Open standards**
    - » **Use of COTS and GOTS**
    - » **Frequent releases to include a number of users**
    - » **Multiple platforms**
    - » **Satisfies commercial standards and interoperability standards across DoD organizations**
- **Initiate formal data collection and analysis**

The Task Force makes the above recommendations with regard to DoD software technology base investments. The Task Force supports a DoD technology base program that is more closely aligned with the wide range of similar efforts ongoing in commercial organizations.

4.0 SUMMARY

4.1 "ATTA PERSONS"



The Task Force identified several ongoing efforts worthy of note.

- The Air Force Electronic Systems Command (ESC) has defined an approach for software system development through the assembly of pre-qualified software modules (PRISM). ESC is pursuing the development of such software modules. The Task Force was very supportive of this program.
- Office of Management and Budget (OMB) Circular A-109 outlines an approach for major Federal system acquisitions that encourages: definition of top level needs vs. detailed specifications; exploitation of innovative private sector contributions and use of early competitive demonstrations of competing approaches. These all are acquisition attributes recommended by the Task Force.
- The Reserve Component Automation System (RCAS) is an ongoing MIS development to support the reserves. The program has successfully employed the A-109 acquisition approach and extensively used commercial acquisition practices and products. The Task Force commends this approach.
- The Global Command and Control System (GCCS) is an initiative of the Joint Staff (J3 and J6) to provide vertical and horizontal interoperability of combat information systems across Services, Combatant Commands and Agencies. It was highlighted for its software reuse approach, its use of prototypes and its emphasis on operational user involvement.
- The Perry-Paige migration systems initiative has established a focus on selecting a set of target computing systems (including MIS, C3I and embedded) towards which DoD will aim. This migration strategy will enable a more cost-effective DoD investment in software across the life-cycle.

4.2 OVERARCHING RECOMMENDATION

Overarching Recommendation

- **SECDEF Assign USD (A&T) the Responsibility for DoD-Wide Software Technology, Policy, Practices and Acquisition**
- **This Responsibility Includes Allocating Resources and Assigning Responsibility for:**
  - **Drafting and Institutionalizing a New Software Acquisition Policy That Includes the Recommendations of this DSB Task Force**
  - **Creating Incentives and Ensuring Compliance to the Policy**
  - **Creating Terms and Conditions and Financial Rewards to Maximize the Ability of DoD to Realize the Benefits of Commercial Best Practices**
  - **Requiring Source Selection Evaluation of Development Contractors Through a Formal Software Process Capability Evaluation**
  - **Advising the Acquisition Executive on Matters Concerning Software Technology, Acquisition and Architecture for Major Programs**
  - **Maintaining a Digest of Lessons Learned and Best Practices and Communicating the Same to Program Managers and Contractors**

Throughout its deliberations, the Task Force acknowledged that the issues associated with defense software were applicable across the spectrum of DoD software intensive systems. The Task Force also frequently learned of obstacles based, in part, on the current dichotomous DoD structure associated with software technology, policy, practices and acquisition. In order to ensure that the DoD reap maximum benefit from its recommendations, the Task Force formulated the above overarching recommendation.

Overarching Recommendation (Cont.)

- **In Carrying Out This Responsibility, Consider Forming an Executive Council**
  - **Including the DDR&E, the ASD (C3I) and Appropriate Representatives from the Services and Defense Agencies**
  - **Provide Supporting "Process Action Team" to Assist in Implementation**

The Task Force also identified the mechanism by which its overarching recommendation could be readily implemented.

APPENDIX A
TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301-3000

ACQUISITION

DEC 06 1993

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference--Defense Science Board Task Force on Acquiring Defense Software Commercially

You are requested to form a Defense Science Board Task Force on Acquiring Defense Software Commercially. Determine the conditions under which the procurement of defense software (i.e., operational software, support software, and software tools) can appropriately use commercial practices and develop a strategy for defense software procurement that substantially incorporates such practices. Specifically address within this strategy DoD use of commercial software products.

The scope of this effort should include all DoD systems that are software intensive. It should address all stages in the life cycle of a software component from initial procurement to evolutionary upgrade of software or of software/hardware combinations. This commercially-based strategy should not be constrained by existing DoD standards; it should be viewed as a coexisting alternative to, rather than replacement of, the current DoD procurement strategy. Accordingly, you should compare your proposed strategy to the current DoD strategy to indicate circumstances in which each strategy is most beneficial.

To assess the appropriateness of DoD use of commercial practices, the Task Force should identify and apply objective measures such as elapsed development time, software life-cycle cost, management risk, as well as measures of software product quality.

The Task Force should consider at least the following topics:

- Technical: state-of-the-art and best commercial practices, development tools, reusable software components, and techniques and tools for tailoring commercial software components for use in defense systems.

- Management: DoD management of the commercial development process, software risk management techniques and supporting tools, minimum delivery time, affordability, maintenance after product delivery, post-deployment product enhancement, software process support tools, quality and assured availability, and use of development and maintenance tools.

- Contracting: technical data rights, intellectual property rights, liability, alternative forms of procurement agreements, and incentives for creation of reusable software components as well as their subsequent reuse.

The Director, Defense Research and Engineering will sponsor this study. Dr. George H. Heilmeier and Dr. Larry E. Druffel will serve as Co-Chairmen. The Office of the Director, Defense Research and Engineering will provide the necessary funding and support contractor arrangements. The Executive Secretary will be Ms. Virginia L. Castor. Commander Robert C. Hardee will be the Defense Science Board Secretariat representative. It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

John M. Deutch

APPENDIX B

BRIEFINGS PROVIDED TO THE TASK FORCE

Briefings Provided to the Task Force

Joint Staff Views on How DoD Can Adopt Commercial Software Practices	MG David Kelley, Vice Director J6
Army Views on How DoD Can Adopt Commercial Software Practice	LTG Peter Kind, Director, Information Systems for C^4
Naval Views on How DoD Can Adopt Commercial Software Practice	RADM John Hekman, Commander, NISMC
Air Force Views on How DoD Can Adopt Commercial Software Practices	Mr. Lloyd Mosemann, Deputy Assistant Secretary of Air Force (Communication, Computers & Support Systems)
DISA Views on How DoD Can Adopt Commercial Software Practices	Dr. Mark Scher, Director of Infrastructures, Defense Information Systems Agency
DoD 5000 Series Regulations	Mr. Gene Porter, Director, Acquisition Program Integration
DoD 8000 Series Regulations	Mr. Harry Pontius, Director, C^3I Policy
DoD-STD-2167A/MIL-STD-498	Dr. Singh, Senior Manager, Space & Naval Warfare Systems Command
Draft White Paper on Software Acquisition	Dr. Jack Ferguson, Program Manager, Software Engineering Institute
Data Modeling vs. Data Standards	LTG Peter Kind, Director, Information Systems for C^4
Case Study: B2	Mr. Fred Schwartz, Director of Engineering,
Case Study: Ensemble of Real-time Software Systems	MajGen Israel, Director, Defense Airborne Reconnaissance Office
Case Study: Reserve Component Automation System (RCAS)	MG Gary Stemley, Program Manager for RCAS
Case Study: AEGIS	CAPT. Richard Cassidy, AEGIS Technical Director
Case Study: PRISM	Mr. Robert Kent, ESC/ENS
Case Study: BMC3	Lt Col Robert Phelps, BMDO
Boeing Views on DoD vs. Commercial Software Practices	Mr. John Hanson, Director, Systems Software & Engineering, Boeing
McDonnell Douglas Views on DoD vs. Commercial Software Practices	Mr. L. George Hite, Senior Manager, McDonnell Douglas
IBM Views on DoD vs. Commercial Software Practices	Mr. Dave Coyer, Program Manager, IBM Federal Systems Company
Object Technology and a COTS Product Called "SNAP"	Mr. Joe Fox, Chairman, Template Software Inc.
Procurement Regulations/Issues	Mrs. Eleanor Spector, Director, Defense Procurement OUSD(A&T)
Integrated Computer Aided Software Engineering (ICASE) Program	Col Gary Case, ICASE System Program Director
Computer Sciences Corporation Case Study on Commercial Software Development	Mr. Daniel Kemp, Senior Partner, Computer Sciences Corp.
Commercial Software Acquisition Practices	Mr. Alex Morrow, General Manager, Lotus Development Corp.
Experiences in DoD Software Maintenance	Mr. Bobby McDonald, Deputy Director, Electronic Warfare Directorate, Warner Robins ALC
MITRE Corporation Experiences in Exploiting Commercial Practices	Mr. Steven Crisp, Dept. Head, MITRE Corp.
FAA Study on the Use of Commercial Software	Mr. John Stenbit, Vice President & General Manager, TRW Systems Integration Group
NSIA Study on the Use of COTS Software	Gen. William Richardson, USA(Ret), Executive Vice President Army Programs, Burdeshaw Associates, Ltd. and Ms. Linda Connor, Program Manager, Rockwell International
DoD Software Reuse Initiative	Ms. Linda Brown, ODASD(IM)/Information Technology
MITRE Study on Feasibility of Using a Software Acquisition Maturity Model in DoD	Ms. Judith Clapp, Division Assitant, The MITRE Corp.
Software Management Metrics and Reliability	Mr. Douglas Putnam and Mr. Lawrence Putnam, Jr., Quantitative Software Management, Inc.
Innovative Techniques in DoD SW Acquisition: F-22 Integrated Product Team Approach	Colonel Robert Kayuha
Legal Impediments to Acquiring Defense Software Commercially	Mr. Robert Gorman, OSD General Counsel

APPENDIX C

COMPARISON OF SOFTWARE ACQUISITION METHODS

Comparison of Software Acquisition Methods[1]

Requirements Definition	
Best Commercial Practice	**Current DoD Practice**
Requirements based on strategic plan and market analysis.	Requirements based on using command Mission Need Statement, master plans, and top-level certification.
Requirements based on life-cycle resource constraints.	Requirements based largely on annual budget resource constraints.
Detailed requirements generated by interdisciplinary team including users, domain experts, and system engineers.	Detailed requirements generated by buyer in collaboration with user. Team generally includes domain experts and acquisition personnel.
Buyer, user, and vendor are a team. Attitude of partnership, trust and cooperation. Presumption of trustworthiness for reputable commercial organizations.	"Us vs. them" mentality about contractors. Government thinks in terms of control, accountability, detailed auditing, and double checking. Presumption that contractors cannot be trusted.
Functional specification is modified by knowledge of availability of existing products.	Functional and/or performance specification; little to no regard for existing products.
Vendors involved early in study, analysis and prototyping with emphasis on reuse and evolution of existing systems.	May contract for prototypes, but contractor involvement in pre-award discussions is discouraged.
Need is based on business case and decisions are based on return on investment. ("time to make")	Need based on Mission Need Statement; decisions based on need, economics, and politics. ("time to field")
Efficient decision processes.	Decision processes formal and time-consuming.
Level of documentation is negotiable based on individual user needs and complexity of system being developed.	Extensive (often redundant or unnecessary) documentation required under 2167A. Tailoring of documentation requirements is often minimal or discouraged.
More detailed analysis of cost versus feature. Dropping lower value/higher cost options or reducing requirements is practiced.	Little or no requirements reductions on high cost items.
More requirements trade-off decisions (involving complexity and schedule) for reduced time to field.	Very little flexibility to trade-off requirements creep versus complexity and schedule.
Selected vendors may assist in preparing specifications.	Vendors not involved in preparing specifications.
Tools used to create system models for use in requirements definition; e.g., GUI Building.	Requirements definition based on Mission Need Statement.
Flexibility allowed in choice of programming language.	Specific requirements regarding use of programming language; e.g.,, CMS-2, etc.
Evolutionary and incremental approach favored.	Requirements defined up front with little flexibility for modifications.
Summary	
Commercial is more flexible and open between users and suppliers, and requirements are based on a strategic plan. In the commercial world, there is more willingness to adjust requirements based on availability of products and thus to filed a system sooner and evolve it to include more capability at significant cost savings.	

[1] This appendix was initially derived from a White Paper on software acquisition methods prepared by the Software Engineering Institute. The resulting content represents the consensus of this Task Force.

Vendor Selection	
Best Commercial Practice	Current DoD Practice
Solicit multiple (but not all) qualified vendors -a selected few. Encourage teaming with a view to attaining a long term relationship that covers the entire life cycle and fosters trade-offs in cost and schedule.	Solicit all possible vendors. Vendor proposals must meet 100% of requirements. Teaming seldom encouraged; development and maintenance usually separate entities.
Compare vendor history and experience. Maintain long-term relationships.	Can compare previous performance, but normally can't have long-term relationships.
The organization that will be responsible for a system over its full life cycle is heavily involved from the beginning.	Maintenance organization not usually involved in vendor selection process.
Use site visits and demonstrations to gain knowledge of vendor capabilities.	Site visit only by capability evaluation team, or other expert teams. Visits are very structured.
Negotiate for best values based on: (1) trade-offs of costs and requirements licensing; and (2) consideration of both vendor and buyer best interests.	Negotiation based on lowest cost and shortest schedules, endangering maturity of finished product.
Overall goals: (1) obtain product at reasonable cost as soon as possible; and (2) achieve the business case for the system.	Overall goal: Obtain lowest cost product that rigorously meets all requirements, but be fair.
Relatively few review and approval steps once vendor is selected.	Review and approval process more structured and complex once vendor selected.
Past performance weighted heavily (sometimes primary factor) in selection process.	Past performance considered, but only as a minor factor.
More flexibility in vendor selection based on metrics and overall assessment.	Selection of vendor forced by use of pre-defined metrics for proposal evaluation.
Modifications made as procurement proceeds in order to get best results.	Change difficult once process begins.
Summary	
Very different processes with commercial much more flexible, but with no requirement for fairness, or to maintain the public trust. Commercial encourages vendors to offer best solution, but solution may not meet 100% of the requirements. Teaming and long-term relationships are more easily accommodated by industry.	

Development Process	
Best Commercial Practice	**Current DoD Practice**
Vendor often tailors existing systems and uses COTS. System designed to fit in a defined product or product line architecture.	Varies with application. Some systems use COTS. However, usually a new system that doesn't reuse legacy software. Unique systems are built with little regard for architecture.
Buyer may have heavy involvement in design and development as part of the team (Integrated Product Development team).	Formal, structured spiral, or waterfall model. Buyer oversees, but team approach is not usually emphasized.
Reviews typically informal and stress progress against goals.	Reviews usually very formal and include technical design details in addition to progress metrics.
Buyer actively involved as co-participant in management of technical details.	Micro management of technical details.
Heavy user involvement.	Limited user involvement. Heavy buyer involvement.
Vendor embraces one or more industry standards which improves interface and integration with COTS products.	Government and industry standards called out. Not all government standards enhanced by COTS products.
Buyer requirements may be translated to more "general purpose" requirement for potential software reuse.	Tailored system; little, if any, focus on designing in reusable code.
Management reviews and degree of oversight are commensurate with size and risk of program.	Notably more detailed reviews and oversight performed.
Prototyping common, with joint applications development teams (user and developer) working to clarify requirements and incorporate new requirements that do not affect cost or schedule.	Prototyping seldom used.
Use of flexible architectures allows insertion and plug and play of COTS products.	Use of MIL standard computers and legacy instruction set architectures restricts new development.
Summary	
Commercial more flexible with likelihood of a team approach and is biases toward reuse and tailoring of existing systems. Multi-year acquisitions not re-justified each year. Product improvements are anticipated.	

Business Practices	
Best Commercial Practice	Current DoD Practice
Informal contracting, joint ventures, partnerships with mutual economic benefit and vested interest in success.	Difficult to write contract to motivate contractors to reduce cost; expensive to terminate contractors.
Oversight built on established relationships.	Burdensome cost accounting procedures required; extensive oversight, reporting, and documentation requirements.
Can hire and fire vendors and managers.	Government personnel regulations, policies, and practices determine qualifications of its managers, rotations of assignment, and training.
Multi-year effort and funding.	Multi-year effort. Yearly, unpredictable funding.
Summary	
Commercial practice more flexible with greater incentives.	

Integration Testing and Delivery	
Best Commercial Practice	Current DoD Practice
Unless system is for a new plant, then there are major "cut-over" issues.	Similar "cut-over" or transition issues.
Sometimes difficult to assemble complete system in laboratory environment due to cost.	Usually integrate system in laboratory prior to operational testing. Development testing vs. operational testing via statutory mandate.
Beta testing widely used to quickly find errors.	Little beta testing.
Ultimate acceptance authority rests with buyer, not a separate organization.	Structured, specified operational testing conducted by separate authority. Acceptance authority rests with buyer.
Buyer/user/vendor are a team.	Emphasis on DoD as oversight and approval authority.
Summary	
Integration and functional testing seem appropriate to the need. DoD use of separate test agency adds time and complexity. Absence of beta testing increases cost to DoD.	

Rights in Data	
Best Commercial Practice	Current DoD Practice
If custom development, buyer gets all rights, but vendor may retain right to subsequent sales.	Specified by contract. Government usually demands all rights for government use due to organic support and maintenance needs, and competition (via statutory mandate).
If tailored version of standard system, buyer only gets rights to tailored parts.	Same as commercial. May have exceptions for proprietary material.
Summary	
Similar, but commercial is a little more flexible, especially regarding resales.	

Maintenance	
Best Commercial Practice	Current DoD Practice
Organic support shifting to outsourcing or vendor.	Organic support, with reluctance to be dependent on vendor. Use of depot maintenance makes interoperability issues more manageable. Also, must be responsive to user for critical systems.
Level of discrepancy reporting required is based on user needs. Problem resolution usually delayed until next major release of software. Buyer has limited power to implement fast resolution of problems.	Bureaucratic and paper-intensive discrepancy reporting and change control board often imposed. Award fees may be tied to problem workoff, resulting in fast resolution of problems.
COTS solutions take advantage of economics of scale since maintenance costs are leveraged across multiple buyers.	Unique software requires custom maintenance all borne by the single buyer.
Summary	
The DoD and industry currently have different requirements, and trends are moving apart. However, DoD is currently reevaluating its practices for hardware systems and perhaps should also reevaluate for software.	

APPENDIX D

PROPOSED ACTION PLAN FROM SERVICE SOFTWARE EXECUTIVE OFFICIALS

JOINT RECOMMENDED PROPOSED ACTIONS

I. DESIGNATE SINGLE, COMMON DOD SOFTWARE MANAGEMENT OFFICIAL (ACTION OFFICE (USD))

A. ESTABLISH DEPUTY ASSISTANT SECRETARY OF DEFENSE (SOFTWARE)

B. PROVIDE SUFFICIENT RESOURCES FOR MISSION

II. SOFTWARE ACQUISITION AND LIFE-CYCLE MANAGEMENT (ACTION OFFICE NEW DASD)

A. PROMOTE REUSE BASED ON DOMAIN MANAGEMENT
1. Define domains of interest or "areas of business"
2. Assign responsibilities to manage the domains
3. Establish and manage common architectures within the domains

B. REDUCE MONITORING OF MATURE COMPANIES
1. Identify criteria for assessing/determine process maturity
2. Consider maturity in source selection
3. Allow sole source extension for high quality vendors

C. PROMOTE GOVERNMENT/INDUSTRY TEAMING
1. Reduce Documentation Requirements to a minimum
2. Provide for electronic delivery/evaluation/exchange

D. MANAGE RISK
1. Mandate the use of market research
2. Use metrics effectively for management
3. Develop Risk Management Disciplines
4. Stick with a winner/punish poor performers

III. POLICY AND STANDARDS

A. ADOPT COMMERCIAL STANDARDS (ACTION OFFICE(ASD(C3I)))
1. DoD invests in commercial standards developments
2. Change FAR/DFAR and SD-1 as appropriate

B. REVISE THE MILESTONES FOR SOFTWARE-INTENSIVE DEVELOPMENTS (ACTION OFFICE USD(A&T)/ASD(C3I))
1. Address the need for a software-first philosophy
2. Provide for a layered software/hardware standards based architecture

C. DEVELOP DOD "BETA TEST" PHILOSOPHY (ACTION OFFICE OSD(T&E)

1. Team with Universities/other appropriate activities
2. Allow fielding of software direct from test beds with user consent

IV. PERSONNEL

A. DEVELOP SOFTWARE ACQUISITION MANAGERS (ACTION OFFICE USD(A&T))

1. Provide a career path for software managers
2. Integrate software personnel into senior acquisition staff

B. PROVIDE SOFTWARE EDUCATION FOR SENIOR MANAGERS (ACTION OFFICE USD(A&T))

1. Develop DoD Senior Software Managers Course
2. Develop and provide interactive training tools for senior managers to perfect software management skills

C. PUBLISH AND PROMOTE "BEST PRACTICES" HANDBOOK (ACTION OFFICE OSD(T&E))

D. ENSURE DOMAIN EXPERTISE (ACTION OFFICE MILITARY DEPARTMENTS/ AGENCIES)

V. SOFTWARE TECHNOLOGY BASE AND TRANSITION (ACTION OFFICE DDR&E)

A. PROVIDE FOR SOFTWARE TECHNOLOGY INSERTION INTO SYSTEM ACQUISITION

B. INVEST IN THE DOD SOFTWARE TECHNOLOGY STRATEGY

C. PROVIDE FOR THE EVOLUTION OF THE DOD SOFTWARE TECHNOLOGY STRATEGY TO CAPTURE EMERGING COMMERCIAL PRACTICES

DEPARTMENT OF THE ARMY
OFFICE OF THE SECRETARY OF THE ARMY
107 ARMY PENTAGON
WASHINGTON DC 20310-0107

Office, Director of Information
Systems for Command, Control,
Communications, & Computers

MEMORANDUM FOR THE EXECUTIVE SECRETARY, DEFENSE SCIENCE BOARD TASK FORCE ON DOD ACQUISITION OF COMMERCIAL SOFTWARE

SUBJECT: Proposed Action Plan with Regard to Common Changes Proposed by DoD Speakers to Revise the Software Acquisition Process

The DSB Task Force asked us to provide a list of common recommended changes needed to revise DoD's software acquisition process. Our recommended list of proposed changes is provided in the enclosure to this memorandum. As we worked together to develop this list, we found it useful to categorize the recommended changes into five major categories. Several of our recommendations did not receive adequate emphasis in our presentations, yet are important to the process we are studying. We feel that if OSD is serious about addressing Software Acquisition issues, a single senior office with primary responsibility for effecting the reforms proposed by the DSB will be essential. Further, such an official or office must receive "from the heart" sustainment and backing from the highest levels within OSD. The enclosed list addresses our concerns with regards to the questions before the DSB. We hope that this will be beneficial to the DSB Task Force and we all look forward to continued active participation in this effort.

PETER A. KIND
Lieutenant General, GS
Director of Information
Systems for Command, Control,
Communications and Computers

Date 4 Feb 94

LLOYD K. MOSEMANN II
Deputy Assistant Secretary
(Communications, Computer, and Support
Systems)

Date 4 Feb 94

JOHN G. HEKMAN
Rear Admiral, SC, USN
Commander, Naval Information
Systems Center

Date 4 Feb 94

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05 OCT 1994

Ref: 94-F-2088

Mr. Jerome S. Gabig, Jr.
Venable, Baetjer, Howard & Civiletti
Suite 1000
1201 New York Avenue, NW
Washington, DC 20005-3917

Dear Mr. Gabig:

This responds to your September 22, 1994, Freedom of Information Act (FOIA) request pertaining to the *Report of the Defense Science Board Task Force on Acquiring Defense Software Commercially*. Our September 30 interim response refers.

The Defense Science Board has provided the enclosed record as responsive to your request. There are no chargeable costs for processing this request, in this instance.

Sincerely,

SIGNED

A. H. Passarella
Acting Director
Freedom of Information
and Security Review

Enclosure:
June 1994 DSB Report

Prepared by Kahn:4F2088L1:10/4/94:DFOI:X71160:gr✓pk__yl__wh__

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REPORT OF THE

DEFENSE SCIENCE BOARD

TASK FORCE

ON

ACQUIRING DEFENSE SOFTWARE COMMERCIALLY

JUNE 1994

#859

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION & TECHNOLOGY
WASHINGTON, D.C. 20301-3140

Executive Summary

The Defense Science Board Task Force on Acquiring Defense Software Commercially recognizes that DoD systems are becoming increasingly dependent on the use of software as the mechanism for implementing operational capabilities. To adapt to changing military and national security situations, DoD is more dependent than ever on its ability to modify mission software rapidly, often in near real-time. However, software remains the schedule and cost driver for the development and maintenance of many important defense systems.

In its review of current DoD and commercial software acquisition practices, the Task Force found notable differences, as evidenced in Appendix C. There are, however, many similarities between the various categories of DoD and commercial software systems. Although there are indications that commercial development efforts have achieved better predictability and lower costs, the Task Force noted a significant lack of credible, quantitative data to substantiate this assessment.

In general, the Task Force concluded that DoD's investment in software requires greater DoD-wide management control and oversight in the coming years if the Department is to exploit the use of commercial software acquisition practices fully, as well as rapid advances in software technology. The following is a summary of selected findings and recommendations toward that end.

Process Credibility: Current DoD practice is not compatible with commercial business practices. DoD should work to make necessary changes to acquisition regulations such as:

- Having program managers manage 3 of 3 (price/schedule/functionality) but only constrain 2 of 3
- Defining successful performance on contracts as delivering a solution (with predictable price, schedule and functionality) not adherence to government processes, procedures and specifications
- Not requiring c-level specifications for software projects developed in Ada
- Establishing mechanisms to allow both current ability to perform as well as past performance as key factors in source selection
- Encouraging offerors to demonstrate as much functionality as possible as part of bid without eliminating domain knowledgeable competition

DoD Program Management: DoD program management approaches discourage the use of commercial practices. Program managers lack incentives to tailor procedures to fit individual program needs or to develop "corporate" solutions (e.g., employ common architecture or common software components). DoD should establish and implement overarching software life cycle guidelines more conducive to the use of commercial practices and products, such as:

- Defining software architectures to enable rapid changes and reuse
- Facilitating early system engineering and iterative development
- Participating in development of commercial and international standards
- Allowing the fielding of software directly from test beds with user consent
- Requiring program managers to stay with programs at least through beta testing to maintain continuity of understanding of original nuances in requirements