Ensuring Successful Implementation of Commercial Off-the-Shelf Products (COTS) in Air Force Systems

Study Chair - Jeff Grant

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Background

1.1 THE STUDY INITIATIVE

This study was sponsored by the Air Force Scientific Advisory Board. The study was conducted last year. Its final report is nearly approved and will be available soon.

Panel Members

Mr. Jeff Grant, Chair	Hughes Electronics (Ret.)
Dr. Bob Rankine	Hughes Electronics
Mr. Ken Brown	Raytheon Systems
Mr. Roger Carter	Lockheed Martin
Mr. John Foreman	SEI
Mr. Don Reifer	Consultant
Dr. Will Tracz	Lockheed Martin
Dr. Nick Tredennick	SAB (Army)
Mr. Frank Willis	DY 4
Paul Schubert, Lt Col	SAB Secretariat
Rob Block, Capt	USAFA (Tech Editor)

Fig. 1: Members of the COTS Study Group

1.2 THE STUDY CHAIR

Jeff Grant, Chairperson of the study group reporting on "Ensuring Successful Implementation of Commercial Off-the-Shelf Products (COTS) in Air Force Systems," is retired from Hughes Electronics.

When Grant was asked to conduct a study on the success of COTS purchasing in the Air Force, he found that request amusing. Although half of his career had been in defense systems, he spent the latter part of his career in purely commercial acquisition.

Grant viewed the proposed COTS study as difficult to accomplish. At the same time, he concluded that, if done correctly, the study would have potential for a huge payoff. Like many people, Grant views the Department of Defense's (DoD) transition to COTS-based systems as largely inevitable. Therefore, capturing lessons learned thus far would be very valuable.

1.3 EXISTING INFORMATION ON COTS

When the study group surveyed existing data, the group was surprised at the amount of information available on COTS.

There are research projects. There is a magazine devoted to COTS. There are white papers. There are COTS conferences — two of them, in fact, one on each coast.

In short, it is astounding how much information is out there.

Therefore, Grant's first reaction was, "What, in a few short months, can a bunch of a SAB (Air Force Scientific Advisory Board) people contribute to the understanding of COTS, compared to all these other efforts?"

Quickly, however, it became evident that very little effort had been made to *integrate* the copious information on COTS.

1.4 SCOPE OF THE STUDY

The study group interviewed 34 programs and organizations. Of that, 24 programs represented the four services: Army, Navy, Air Force and Marine Corps.

Interviews

- AAAV (GD Amphibious Sys)
- AFOTEC
- AFPEO/LI for Logistics Info SPO at Gunter AFB
- AFRL COTS Initiatives
- AWACS (Computer Modernization)*
- B-2 Data Storage
- B-2 EFX 99
- Boldstroke (Boeing commonality initiative)
- Bradley Fighting Vehicle*
- Calce (University of Maryland)
- DCAC/MRM (Boeing engr/mfg system)
- DY 4 (COTS supplier)
- Earth Sensor
- F117 engine electronics
- F-16 upgrade
- F-22
- GBS
- GPS (Ground Control Segment)
- GPS Receiver
- Ground Station
- GTE Info Systems Division
- JASPO (Sigint infrastr)
- JDAM*
- Large ADP system (TRW)
- MRP II**
- Mobility SPO
- NSSN C3I (LM Undersea Systems)
- OSD Major Policy Initiatives
- OSD/C3I
- PVS/EVS (Boeing info sys)
- SAF/AQX
- T-38C Avionics Upgrade Program
- T-6A Joint Primary Aircraft Training System (JPATS)
- Tactech (parts mgt)

*COTSCON Conf Presentation
** Teleconference

Fig. 2: Organizations and Programs Assessed by the COTS Study Group

Review of COTS applications was limited to engineering disciplines where commercial markets are really driving the technology. The products of primary interest to DoD are: electronics, computers, and software.

In that context, the study group also reviewed management information systems, such as Manufacturing Resources Planning (MRP). The group also reviewed C3I and weapons systems. The group concluded that COTS is applicable in all three areas.

After determining basic applicability, the study group looked at implementation. Implementation intensity varied.

Scope of Study

- Applications
  - Management information systems
  - C3I
  - Weapon systems
- Engineering discipline
  - Electronics
  - Computer systems
  - Software
- Implementation extent
  - COTS solution systems (One substantial product)
  - COTS aggregate systems (Multiple products from multiple suppliers)
  - COTS components (Develop with commercial components)

Fig. 3: The COTS Study: Parameters

1.5 RESULTS OF THE STUDY

1.5.1 Quantified Results

Although it is tempting to quantify the results of the study, the study group concluded that the statistics do not justify quantification.

1.5.2 Qualitative Results

Qualitatively, the study group concluded that the success of COTS implementation is limited. Moreover, the quality of COTS implementation ranges from the spectacular to the disastrous, with a whole lot in between. Finally, regardless of where on that spectrum a program fell, it was clear that everyone was struggling with the new technology and the processes.

1.6 GOALS OF THE STUDY

One of the goals for the study became to integrate, not only some of the existing information on COTS, but also the information developed by the study group. Then, on that foundation, the group would develop recommendations to accelerate the implementation of COTS throughout the acquisition community. In particular, the group determined that the report should educate people on the complexities of COTS and the COTS decision-making process.

1.7 OVERVIEW OF THE STUDY CONCLUSIONS

COTS purchasing is not a panacea. Many people believe it is simple, straightforward, and that DoD ought to "just do it."

Often missing from the discussion on COTS, however, is an understanding of all the complexities of this type of acquisition. Therefore, one of the overarching objectives of the report is to educate people on those complexities.

Summary

- Interviewed 34 programs or organizations
- Successful exploitation of COTS is limited
  - Struggling with new technology, processes and issues
  - Huge learning curve for both Government and Industry
  - Hardware more successful than software
  - Total Ownership Cost not considered or understood
- Applicability of COTS requires careful consideration
- Well defined processes are essential
- Roles and responsibilities change dramatically
- Pervasive changes are needed to harness COTS
- Acquisition policy must address COTS-based systems

COTS-based solutions are inevitable

Fig. 4: Overview of the COTS Study: Scope and Conclusions

2
COTS and New Thinking

2.1 NEW THINKING

In the decision whether to utilize COTS, the initial question must be: "Is what we need already available, and is there somebody doing this task that is really good at it?"

If the answer to that question is "yes," the study group found that the whole product family must be viewed differently than in the past. This new thinking is focused on buy-and-integrate, rather than design-and-develop.

What is COTS?

- Product sold, leased or licensed to the public
- Supplier is a commercial entity in the business of making a profit
- Integrators use the product without modification
- Supplier retains intellectual property rights
- Supplier provides product support and evolution
- Commercial market drives product evolution

Fig. 5: Buy-and-Integrate: Characteristics of COTS

2.2 OLD THINKING

DoD's acquisition history has trained the workforce to think about developing a product, not buying it off-the-shelf.

2.3 TRANSITION FROM OLD TO NEW THINKING

The study group concluded that decision makers must be aware that, vis-à-vis COTS, roles and responsibilities are very different. From the point of view of a prime contractor, for example, COTS is a switch from the design-and-build mode to the buy-and-integrate mode. That is dramatic change.

2.3.1 New Thinking, New Culture, New Organizations

2.3.1.1 Cultural Change. The average aerospace engineer is probably somewhere between 45 and 50 years old, with 20 to 25 years of experience, all of it in a design-and-build or develop mode.

With the transition to COTS-intensive systems, DoD is asking these engineers to stop designing, stop building, and learn how to buy and integrate. That is a dramatic cultural, and, thus, personal change. Frankly, people are going to fight it. Many people will feel threatened.

People Issues

- Unrealistic expectations by leaders
- Dramatically altered roles and responsibilities
- Lack of skills, knowledge, and abilities
  - At all levels, both Government & Industry
- Perceived loss of control and job security

Fig. 6: Features of the Cultural Change Associated with COTS Implementation

2.3.1.2 Organizational Change. With the transition to COTS-intensive systems, the person who builds black boxes for an organization, for example, quickly realizes those boxes no longer are going to be designed and built in-house. Rather, most of those boxes are going to be bought off-the-shelf.

From a personal point-of-view, it does not take a lot of imagination to extrapolate a worst-case scenario here. That causes a lot of fear, both in the government and in industry—and fear often is the biggest enemy of change.

2.4 VEHICLE FOR TRANSITION FROM OLD TO NEW THINKING

2.4.1 The Decision Process for Implementing COTS

To transition to COTS, the study group found that pervasive changes are needed—in how DoD operates, but also in how DoD "thinks" about acquisition.

The most important change the study group recommended is that acquisition policy needs to address the *implementation decision process* for COTS-based systems. That is, to move toward successful implementation of COTS-intensive systems, DoD must begin emphasizing the COTS thought process—when, why, and how to integrate COTS—rather than simply attempt to mandate use of COTS.

2.4.1.1 Historical Context of the COTS Decision Process. In 1986, Congress passed legislation requiring DoD to give consideration to non-developmental items (NDI). Then, in 1994, the Federal Acquisitions Streamlining Act (FASA) required DoD to give preference to commercial items, then to NDI, and "oh, by the way," the law said, "don't do anything from a contractual point of view that impedes the use of commercial items," and so on and so forth. There were provisions for customers to perform market research and other familiar functions.

The result is COTS, government off-the-shelf, modified off-the-shelf, research off-the-shelf. There are NDIs. There is re-use. And, in the midst of all these off-the-shelf options, there is custom design—which is very appropriate in many cases.

Clearly, there are cases where an organization could spend more time and dollars trying to integrate commercial products into a program than if the product simply had been designed from scratch. This fact is one of the reasons it is so important that, rather than automatically looking to COTS products, detailed trade studies be completed, including a focus on Total Ownership Cost (TOC).

Legislation

- 1986 - Congress passed legislation requiring DoD to give preference to NDI
- 1994 - Federal Acquisition Streamlining Act (FASA)
  - Contract requirements and market research should facilitate use of commercial items
  - Preference for NDI when commercial not available
  - Eliminates contract requirements that impede acquisition of commercial items
  - Requires agency to conduct market research prior to development of a new specification

Fig. 7: Historical Context of the COTS Initiative

2.5 TIMETABLE FOR TRANSITION FROM OLD TO NEW THINKING

The pace of the transition from old, design-and-build thinking to new, buy-and-integrate thinking is determined, in part, by the number of new program starts.

2.5.1 New Thinking Must be Adopted at Project Conception

In general, the need to change thinking from the design-and-build mode to the buy-and-integrate mode must take place at the conception of the project, not in mid-stream.

2.5.1.1 Case Study: F-22 Program. An example of how these two very different acquisition perspectives can collide is the F-22 program.

The F-22 originally was designed as a typical design-and-build project. That is, it did not incorporate COTS at all. Some time into the program, Congress imposed a cost cap. This led the program managers to manage the F-22 program like a fixed-fee, rather than a cost-plus contract. That, in turn, led to an attempt to incorporate COTS.

Incorporating COTS into a program that is already designed is extremely difficult. In fact, according to the study Chair, it may not be too strong to say that it is impossible. All the leverages that have to be built into the architecture—the open system architecture, common busses, things that facilitate plug-and-play integration—all these things are missing in a designed program. And it is too late to go back and build these COTS-friendly prerequisites into the design once a program is launched.

2.6 INEVITABLITY OF THE TRANSITION TO COTS-BASED SYSTEMS

Despite the proliferation of "off-the-shelf" terms, the overarching message is clear: Stop reinventing the wheel. Leverage commercial products when it makes sense and achieves the best value. "Best value" means the lowest TOC.

Similarly, in the acquisition community today, a consensus is forming that DoD has no choice but to "make the trip"—the trip from the old thinking of design-and-build to the new thinking of buy-and-integrate.

The transition from old to new thinking obviously is fraught with issues, many of them huge.

If, however, the transition to COTS-based systems is inevitable—and the study group concludes that it is—many people further conclude that it is imperative to engage those issues, deal with them, and get on with it.

In short, two courses of action are presented:

- get out in front of what is happening to DoD and influence the transition; or,
- react to the change as it is imposed on DoD by external circumstances.

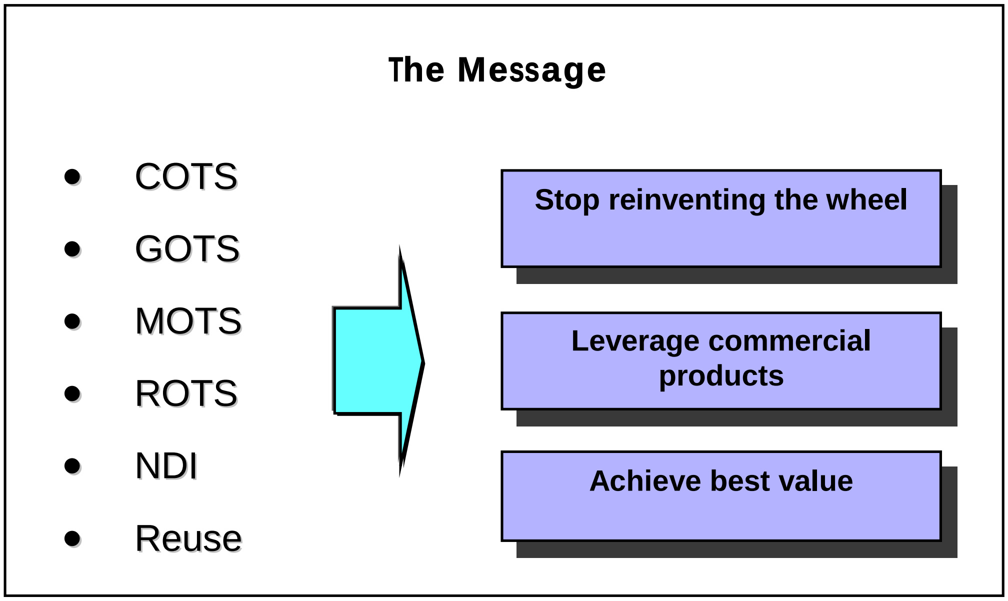

Fig. 8: The COTS Imperative

2.7 SUMMARY OF THE NEED TO TRANSITION FROM OLD TO NEW THINKING

The study group found that the acquisition world has placed too much emphasis on COTS. There ought to be more emphasis on the process to determine the applicability—the appropriateness—of COTS in a particular acquisition strategy.

Another way of stating this increased emphasis on the COTS decision process is that there must be a transition from a design-and-build mentality—old thinking—to a buy-and-integrate mentality—new thinking.

3
The Present COTS Environment

3.1 THEORY vs. REALITY

The simplicity of the COTS vision tends to obscure the complexity of the COTS reality.

Management is very frustrated right now because COTS often is presented as very straightforward. There is almost a "just go do it" mentality among the leadership.

While there is general agreement that DoD ought to be implementing COTS, the devil is in the detail. And this is a terrible devil. Therefore, while most people have the vision, the reality is that nothing is happening very fast in the real world.

3.1.1 Naivete Regarding the Complexity of Implementing COTS.

The study group found that, unfortunately, COTS lends itself to a certain amount of naivete—the idea that "It's just a matter of picking these commercial products and using them." The reality is that it is much more complicated than that.

There are tools being developed to facilitate COTS implementation. But that's in the future. Right now people are struggling.

One of the biggest factors in this lack of progress is a failure, up and down the organization, to understand just how complex COTS implementation issues are. Until management faces up to the complexities of the transition, and starts to organize that transition based on reality, progress in implementing COTS will continue to be slow.

3.1.2 The Potentially High Cost of Product Integration.

In regard to COTS, people commonly think that the cost of development is low. But part of development is integration. Since integration of COTS products can be very difficult, in that sense, the risk of development can be high.

At least part of this development risk is attributable to the fact that there is a huge learning curve for everyone involved in implementing COTS. It cannot be overemphasized how vastly different COTS is from other types of acquisition.

3.2 COMPLEXITY OF COTS IMPLEMENTATION

The study group found programs, for example, that are attempting to integrate 40, 50, or 60 COTS software packages. Moreover, each software package is on an 18-month, asynchronous upgrade cycle.

This situation is comparable to a performer on stage trying to balance plates on the end of poles. The plates start spinning on one side and he runs over here. Then they start spinning on the other side and he runs over there.

The study group found that in the COTS implementation world, it often seems that the plates are about to spin off the poles. People just get one product working, and then they've got to run over here and incorporate upgrades, and then run over there and work interface problems, and then run back in this corner and work interoperability problems, and on and on and on. It's really difficult.

3.3 PROFITABILITY ISSUES

3.3.1 Profits Flow from Defense to Commercial Contractors

The transition to a COTS-based system raises profitability issues. In the present system, defense contractors garner the majority of profits generated by DoD acquisition. Under COTS, more and more profits will flow away from defense contractors to commercial contractors. The cost of technology change also will cause profits to flow from defense to commercial contractors.

3.3.2 "Turf Protection" and Performance Claims

COTS have the potential to wipe out whole departments, such as military products organizations within large semi-conductor companies.

In the face of this type of change, it is natural for people to want to safeguard their departments and those profits. It is just as natural for people who have devoted themselves to designing and building a particular product to feel that it is the best, that no other product can compete with, much less surpass, their product.

Buyers evaluating products, such as the controversial plastic encapsulated micro-electronics (PEM), must be aware that there are arguments on both sides of the performance debate that can be colored by personal and institutional bias.

3.3.3 Imperative to Leverage Commercial Development

Using defense contractors, a pentium class processor, for example, costs between $250M and $400M to develop. And that development cost is going up at an annual rate of 40 percent.

DoD cannot afford the type of development costs cited in the pentium example. The answer is going to be that DoD must leverage commercial development. If DoD wants to field advanced systems, DoD must take advantage of commercial technology, period. DoD simply cannot afford to duplicate that technology.

3.3.4 Suppliers Adapt

Contractors—whether defense or commercial—are in business to make a profit. The good companies make it their business to figure out where a market transition such as COTS is going and how they can operate profitably within that new environment.

DoD's challenge is to get out front, get the attention of suppliers, and help push companies up the COTS learning curve as quickly as possible.

3.4 CHANGE IN BUYING PRACTICES

When implementing COTS, DoD's traditional way of buying products may conflict with commercial practices.

DoD acquisition managers are accustomed to being in charge of the buying process. Managers want information on a product, the designer gives them the information.

Commercial suppliers are accustomed to being in charge of the buying process. You want their product, they sell you the product. That's it.

When Hughes, for example, first began to buy commercial parts for satellites, Hughes went directly to the commercial suppliers. The suppliers put up a terrible fight. They kept diverting Hughes to their military products organizations.

Commercial suppliers don't want to provide the data DoD is accustomed to receiving. They don't want to go through the harangues and negotiations that typify the traditional DoD buying process. The mindset of the commercial supplier is, "You want it, you order it out of the catalog; you don't ask questions."

3.5 COTS SUCCESS IN THE PRESENT ENVIRONMENT

3.5.1 Longevity in the System

The good news is that everyone is learning how to implement COTS-based systems. The bad news is that everyone is learning how to implement COTS-based systems.

The study group observed that those who are best at following good COTS practices are those who have been implementing COTS for the longest period of time.

By contrast, those who are implementing COTS for the first time almost invariably fail. That failure was ascribed primarily to what the study group described as naivete about the complexities of COTS systems.

3.5.1.1 Requirement for Inside Assessment. Of the companies the study group reviewed, their COTS abilities varied from very good to very poor. But it would not be accurate to say a Lockheed or a Hughes or a Raytheon is good or not good at COTS. The only reliable way to determine COTS ability was to go inside the company, get inside the specific organization, and assess that organization or program on a case-by-case basis.

3.5.2 Hardware vs. Software

COTS success stories tend to be more about hardware than software. Hardware has more standards associated with it. There is less variability.

3.5.3 Total Ownership Cost (TOC)

Success in COTS-intensive systems depends upon a focus on TOC, as opposed to acquisition cost or flyaway cost or the initial recurring cost. One of the reasons for COTS programs' limited success to date is the fact that TOC is rarely considered. TOC often is not even understood.

3.6 DECISION PROCESS FOR COTS SUCCESS

The decision to use COTS demands careful consideration.

The "when" and "how" to integrate COTS are not decisions that should be mandated by senior-level management. It is important to let the people close to the hardware and software make these critical decisions. Decisions should be based on trade studies, not on some edict from on high. With very few exceptions, because of the complex dynamics of COTS, it is not appropriate to mandate COTS percentages.

To enhance decision-making on when and how to use COTS, the study group found requirements for:

- well-defined, well-documented processes;
- people that are trained on those processes;
- people that follow those processes and execute them well.

4
COTS and Modification

4.1 OVERVIEW OF CONCLUSIONS ON MODIFICATION

The study group concluded that the case studies it reviewed demonstrate that modification of COTS is the most glaring source of system complication and outright failure.

People who buy COTS products and integrate them into larger systems generally should not modify those COTS. This has been a much-repeated mistake.

Indeed, the study group observed that those who attempted to modify COTS products were unsuccessful *in every single instance*.

The bottom line is, if anyone is proposing to modify COTS for a government application, red flags should to go up. Would the study group say *never* modify a COTS? No, but when a modification is proposed, everyone needs to fully understand the implications.

4.2 WHAT IS MODIFICATION?

4.2.1 Modification of Software

Modification of software means modifying the source code. If the user can put wrappers around the software to interface into the larger system, that's fine, as long as the basic product itself is not touched.

4.2.2 Modification of Hardware

Modification of hardware means modifying the board or components in any way. It is acceptable, for example, to buy a single-board computer and put it into a (hardened) case, again, as long as the basic product—the board and components—is not touched.

4.2.3 Modification, General Principle

Distilling the general principle from the definition of modification of software and hardware, "modification" means that the change in a commercial item is not minor; rather, the item has been changed in its inherent application.

Another way to determine if a COTS has been modified—that is, to determine if the product changes were minor or went to its inherent application—is to evaluate whether the change slipped the product off its natural evolutionary track. The product's natural evolutionary tract is the track set for it by the commercial marketplace. Product evolution is discussed further below.

4.3 MODIFICATION AND NOMENCLATURE

4.3.1 Modified COTS is Not COTS

Again, the study group found that modifications generally just don't work. Moreover, modifications often defeat the purpose of buying a product off-the-shelf.

In fact, the study group concluded that if COTS are modified, those products should no longer be called COTS. Call it something else—because, if it's been modified, it *is* something else.

4.3.2 Accounting and Quality Review

When a COTS has been modified, it should not be "counted" as a COTS. This principle is particularly important for accounting and quality review purposes. If someone is keeping score on the percentage of COTS in a system, don't count modified "COTS."

4.3.3 Modified Non-developmental Items

In some areas—NDIs and modified NDIs, for example—there may be a generally accepted term for modified products. A similar term may be coming into vogue for COTS that have been modified. Nevertheless, that fact is not relevant to the strong conclusion of the study group regarding modification of COTS. Again, that strong recommendation is to avoid modifying COTS whenever possible.

4.4 CASE STUDIES ON COTS MODIFICATION

4.4.1 Scope of the Case Studies

The study group interviewed 34 programs and organizations. Of those 34 cases, 24 programs had modified at least one COTS product.

4.4.2 Conclusions Based on the Case Studies

In all 24 cases where COTS had been modified, the program ran into enormous difficulties with COTS modifications.

Is 24 cases a huge sample? Does the sample indicate that there could never be a program that could have a positive experience with COTS modification?

No, on both counts.

The study group comes on strong against modification, however, because there continues to be a lot of naivete out there—people thinking, "Well, I can make this one little change and everything will be fine."

The problem, as is well-known, is that one little change leads to another and, pretty soon, the project is in a real fix. That result is supported by what the study observed. And that's why the study group concluded that, at the minimum, everyone must be very careful when considering a proposed modification.

4.4.3 Illustrative Findings in the Case Studies

The study group repeatedly emphasized that its review of the case studies lead to a strong recommendation against modification of COTS products. The comparison of two programs illustrated the reasons for this caution.

The Story of Two Real Projects

	DMMIS	MRP
Requirements	Fixed	Flexible
COTS Selection	No pre-selection demos	"Try before you buy"
User	Late involvement	Early involvement
Source	COTS product	COTS product
Modification	Allowed	Not allowed
Acq Cost	$200M+	$40M
1st Delivery	Never Delivered	90 days
Result	Project terminated	Successfully Deployed

Fig. 9: DMMIS and MRP II - Comparison of COTS Integration Results

The first program, the Depot Maintenance Management Information System (DMMIS), did not follow good COTS practices. The second program, Manufacturing Resources Planning (MRP), did follow good COTS practices.

DMMIS and MRP basically are single, large, inventory management systems (although they do a lot more than that). DMMIS preceded MRP.

4.4.3.1. Overview. DMMIS spent over $200M and the program ended by cancellation. For MRP, the acquisition cost was quite a bit less than $200M and the program still is being implemented. But the initial software implementation started three months after go-ahead.

4.4.3.2. Mistakes Made by DMMIS. According to the study group, arguably the most important mistake that led to COTS implementation failure in DMMIS was that the program had inflexible requirements.

The program managers had processes in place that they were unwilling to change. Therefore, rather than changing the way the managers did business to accommodate the existing (off-the-shelf) software, the managers changed the COTS software to fit the processes. To that end, DMMIS modified about two million lines of code.

4.4.3.3. Causes of DMMIS COTS Implementation Failure.
DMMIS's extensive modification of COTS software led to:

- loss of the software's natural (i.e., market-driven) evolution;
- loss of concomitant supplier support;
- vastly complicated and, in the end, an inability to manage system integration.

4.5 HUGHES ELECTRONICS' EXPERIENCE WITH COTS MODIFICATION

In addition to the case studies, some members of the study group also drew on personal experience on the issue of COTS modification.

In the study Chair's company, Hughes Electronics, there were numerous times Hughes modified COTS software. Result? It was a disaster every time.

4.5.1 Hughes Electronics Repeated DMMIS's Mistakes in COTS Implementation

4.5.1.1. Inflexible Requirements. Hughes modified a MRP program to fits its existing processes. Over time, Hughes modified 75 percent of the code. It was an utter disaster. The company wasted a fortune. No one even wanted to go back and count how much was spent—it was that terrible.

4.5.1.2. Product Support. As soon as the product was modified, Hughes could forget about product support. The supplier simply was not going to support the modified product. First of all, the supplier does not know how the product has been modified. Essentially, it's not their product any more. Therefore, those who modify COTS are on their own.

4.5.2 Specific "Red Flags" Identified in Hughes' Experience with COTS Implementation

The Chair identified a number of factors that can lead to attempts to modify COTS. These factors should serve as "red flags" for those implementing COTS-based systems. These red flags include:

- The fact that a demo was not reviewed sufficiently early in the selection process;
- A tendency for people to become enamored with the claims that were made for the software, as opposed to obtaining information on the software's actual operation;
- Failure to understand the scope of the software's potential applications;
- Failure to evaluate the software against potential applications;
- Failure to involve the user sufficiently early in the selection process.

4.6 SUMMARY FINDINGS BASED ON THE CASE STUDIES

Modifications that maintain a product's capacity to evolve with the marketplace—i.e., minor modifications—have fewer implications for system integration. Therefore, there may be situations where those types of modifications are acceptable. Nevertheless, it is important to emphasize that *the study group found no examples of successful modification of COTS.*

5
Product Evolution

5.1 EVOLUTION AND THE BUYING PROCESS

5.1.1 DoD Does Not Control COTS Evolution

The supplier—and, ultimately, the market—determines the evolution of a COTS product.

For those who are accustomed to working within the military system, the "thinking" of the commercial market is very, very different. In military systems, the military and the prime contractors drive product evolution.

Again, that is not true in regard to COTS. In COTS, the purchaser is the tail on the dog. That fact can be hard for some people to recognize.

5.1.2 The Value of Buying Evolution

When a COTS product is purchased, the purchaser is buying: (1) the product; and (2) the evolution of that product. This is the reason one aspect of the COTS buying process must include an understanding of where that product is headed—that is, its evolutionary track.

When DoD "buys" a COTS product's evolution, DoD buys into the fact that the best practice companies literally revamp their research and development (R&D) organizations on a continual basis.

These companies devote a portion of their expenditures to nothing but keeping track of what's going on in the commercial marketplace relative to their specific interests—i.e., their products.

These companies constantly are bringing in products and evaluating them thoroughly before they make contractual commitments to customers.

This is not a process that allows a purchaser, at the last minute, to look in a catalog and say, "Well, that product looks like it will do the job." Even so, the study group found numerous examples where that's exactly what occurred—and disaster usually followed.

5.1.3 Evolution and Product Support

5.1.3.1 Planning for Product Support. Product evolution generally involves product features, improvements, new applications and so on. It is important, however, to articulate the integral role that product support plays in the evolution of a particular end item.

Product support is driven by the supplier as well as, in the larger context, the commercial market. One of the advantages of COTS products is that they allow managers to plan on supplier support.

5.1.3.2 Pace of the Upgrade Cycle. While COTS allow managers to plan for supplier support, we all have experienced how supplier support (or the lack of it) can push product evolution, even if the user doesn't need a more highly evolved product at that time.

The most common example of this point is software. If a program doesn't maintain relative currency on software updates, the program loses supplier support. Typically, suppliers will support one, or perhaps two, superceded versions of software, but nothing beyond that.

The end result is that the user is forced to upgrade the software, irrespective of any task-related need. And that more rapid upgrade cycle creates a need for new procedures, retraining of personnel, and so on. But if the program elects not to upgrade, pretty soon the program is on its own.

In effect, then, the good news about COTS products is that they bring with them supplier support and that support evolves with the product. The other side of that coin is that evolution in supplier support may force a customer to upgrade a product even though the customer doesn't have the need to upgrade.

5.2 EVOLUTION AND MODIFICATION

5.2.1 Advantage in Buying Product Evolution

One of the advantages of COTS is that if you pick the right COTS products and COTS standards, the product will evolve on a track based on where the market is headed.

In fact, best practice companies will sign non-disclosure agreements (NDAs) with COTS suppliers. As discussed, this fact allows the supplier as well as the purchaser to understand fully, and plan for, where the manufacturer is headed with the product. This understanding is crucial to maintaining modernization.

By contrast, if a purchaser has a supplier modify a COTS product for a particular application, there's a great chance that that application is will be unique. The product's uniqueness takes it off the evolutionary track it otherwise would have been on. In short, the buyer loses out on the natural evolution of that product.

5.2.2 Evaluating Proposed Modifications in Light of Product Evolution

Evaluating how a proposed modification will, or might, affect the ability of the product to evolve along the manufacturer's or market track is very important.

Understanding changes in a product's potential evolution also is one of the key ways to determine if, in fact, a COTS has been modified. To repeat, in this context "modification" means that the change in a commercial item is not minor; rather, the item has been changed in its inherent application.

Generally, modifications are minor if they do not slip a product off the evolutionary track it otherwise would have followed in the marketplace.

Modifications that maintain a product's capacity to evolve with the marketplace—i.e., minor modifications—have fewer implications for system integration. Therefore, there may be situations where those types of modifications acceptable. Nevertheless, it must be repeated that *the study group found no examples of successful modification of COTS*.

5.2.3 Evolution and Integration of Modified Products

When the study group addressed unsuccessful modifications, one of the primary factors in that failure is the fact that the product no longer can be evolved. This lack of market-driven evolution has myriad implications for system integration.

Of course, modifications bomb in other ways as well. They may, for example, be outright failures; they may ruin products; they may decrease rather than increase the capacity to accomplish the task; they may work but cause a system crash.

The inability to take advantage of a product's evolution also creates issues of configuration management. That is, keeping track of what has been modified and how those modifications affect—or may in the future affect—the system. None of that is easy.

6
Total Ownership Cost

6.1 TOTAL OWNERSHIP COST (TOC)

TOC is a life cycle cost. TOC includes the cost of future upgrades, technology refresh, and improvements.

6.2 TOC AND COTS IMPLEMENTATION SUCCESS

Success in COTS-intensive systems depends upon a focus on TOC, as opposed to acquisition cost or flyaway cost or the initial recurring cost.

Based on the design of the COTS system, it is imperative to give particular consideration to future upgrades, technology refresh, and improvements. If these costs are not adequately considered, when a software upgrade comes along, for example, suddenly the product is going to cost a lot more than planned.

6.2.1 Program-Wide Failure to Focus on TOC

The study group found that one of the reasons for COTS programs' limited success to date is the fact that TOC is rarely considered. TOC often is not even understood. The failure to consider or even understand TOC happens across the board, at the systems design level and the user level.

6.2.2 Flyaway Cost

For a variety of reasons, purchasers tend to focus on the flyaway cost. But if it is a COTS-intensive system, optimizing the initial cost likely will lead to disastrous subsequent maintenance costs.

6.3 DISINCENTIVES TO FOCUS ON TOC

There is some sentiment that, in the present acquisition environment, neither the seller nor the buyer has an incentive to use a life cycle cost such as TOC.

6.3.1 Congressional Budget Process.

Presently, DoD must deal with how to incorporate TOC-based thinking into how it historically has conducted business, including its interaction with Congress.

6.3.1.1 Congressional Oversight. Congress' role in shaping the DoD budget profoundly affects—and will continue to affect—DoD's ability to transition to a focus on TOC.

Clearly, there are still more old systems in existence than new systems. Nevertheless, for the newer programs—and, again, that's only a handful—the mindset really is changing in favor of TOC. The new mindset, a focus on TOC, is not prevalent, however, and it won't be prevalent so long as there are so few new starts.

A big part of the learning curve for DoD is learning how to drive TOC into the existing system, the system that is absorbing most of today's DoD budget. As programs are modified and updated, the study group concluded that DoD must start incrementally changing the way it thinks about those programs. It is a huge challenge.

6.3.1.2 Ongoing Funding Requirements. Besides the issue of how Congress shapes the DoD budget, DoD must deal with its own historical budgetary and funding practices. Those practices cannot be changed overnight: funding must be secured now. But, internally, programs can still push for and work toward implementing TOC concepts.

6.4 TOC AND SYSTEMS DESIGN

It is crucial that TOC issues be addressed in COTS-based systems. For one thing, TOC influences the system design.

6.4.1 Open Architecture

Open system architecture sometimes is called plug-and-play. This architecture is very important when handling subsequent upgrades and technology refresh in a COTS-based system.

If a system has a unique architecture, it is very difficult, for example, to plug in a modern computer without significant additional cost. Therefore, that eventuality needs to be addressed upfront, not downstream.

6.5 CASE STUDY: TOC AND NAVY ATTACK SUBMARINE

The study group reviewed about three years' worth of field data on COTS implementation from the Navy's new attack submarine. The group compared this data with the earlier designed program.

6.5.1 COTS Cost-Effectiveness

6.5.1.1 Total cost-effectiveness. The total cost-effectiveness of the earlier program vs. the COTS upgrade program is debatable. The data does not definitively answer the question of which one was more cost-effective.

6.5.1.2 Other Cost Savings. On other relevant scales, the study group found that the cost of the COTS upgrade compared to the earlier program was:

- for development, 75 percent less;
- for acquisition (recurring cost), 80 percent less;
- for support, 75 percent less.

6.5.1.3 Time Savings. In the COTS upgrade compared to the earlier program, the development time was reduced by 50 percent.

6.5.1.4 Performance Improvements. The study group found that the performance of the COTS submarine upgrade compared to the earlier sub was:

- power usage, reduced by 75 percent;
- through-put of the computer, reduced by 50 percent;
- most strikingly, the mean time between critical failures improved.

6.5.1.5 Data Limitations. One limitation of this data, however, is that the comparison was not done over an extended life cycle, such as 40-50 years. It compared costs only in the shorter commercial life cycle of the product.

7
COTS and Program Criteria

7.1 OVERVIEW

In the DoD acquisition environment, old thinking is that which focuses on design-and-build. New thinking is that which focuses on buy-and-integrate.

7.2 PROGRAM CRITERIA AND PRODUCT INTEGRATION

One of the points at which old thinking often conflicts with COTS-intensive systems is in the area of program criteria. Criteria continue to reflect the dynamics of design-and-build, rather than buy-and-integrate acquisition modes.

7.3 PROGRAM CRITERIA AND SEI CERTIFICATION

7.3.1 Software Engineering Institute (SEI) Certification

In the old, design-and-build thinking, policies, for example, may require that, on an Acquisition Category I (ACAT-1) program, a software developer must have attained level three or higher on the Software Engineering Institute (SEI) scale or equivalent.

This type of criteria simply will not be met in the commercial world. Many commercial suppliers have not even gone through the certification process. This fact, then:

- creates conflict between the standards imposed on developers who are under DoD control and standards applicable to commercial developers;

- eliminates suppliers who otherwise would have been qualified bidders in a COTS system.

7.3.1.1 SEI Certification and Risk Modification. While there is some correlation between SEI certification levels and quality, at best, certification is a risk modifier. It is not a guarantee.

By contrast, COTS software presumably is out there in quantity. It is being used by many different types of users, potentially in many different types of applications and environments. This widespread use, and the supplier's desire to build a market and make a profit, can function as better quality control than mandated certification levels.

The real risk-reducer, however, is for buyers to become much more knowledgeable about what they are buying than they have been in the past.

7.3.1.2 SEI Certification, Scope. One of the problems inherent in relying on SEI certification is that it is the organization as a whole, not particular individuals or groups of individuals, that is certified.

Certifying the organization does not necessarily mean that the people the organization puts to work on a particular program will bring to it the level of quality supposedly "guaranteed" by the corporate seal.

Nevertheless, the utility of the SEI certification process is that it provides a means for reducing risk, not guaranteeing success. The higher the SEI certification level, in general, the lower the risk.

- One of the major sources of risk at level one is the hero phenomenon. The shop consists of one hero who writes the software. When the hero goes, so does the program—right down the tubes.

- By contrast, at the higher levels (three and up) the program is not dependent on a single hero. Rather, it is supported by institutionalized training, by a knowledge base that is disbursed among many people in the organization. This reduces risk.

7.3.2 SEI Certification and COTS Success

Often there exists the expectation that lower-level contractors will not have the skill to be successful with COTS. The study group, however, did not find any strict correlation between SEI certification level—or certification at all, for that matter—of the developer and the quality of the software product.

To the contrary, the study group found that working with a level-five contractor does not assure a better software product than one that comes from, for example, a level-three contractor or even a shop that is not certified at all.

To illustrate that point, some people say that video game software developers are creating packages that are as complicated as anything in the field of weapons systems, yet it is unlikely that any of those developers are certified even at level one. Regardless of certification level, in successfully implementing COTS, the challenge is to understand what is being bought and how that product will be taken care of.

7.4 ENVIRONMENTAL CRITERIA

7.4.1 Over-Specification of Environmental Criteria

Because it is difficult to limit the various environments in which a product might be deployed, traditionally DoD has tended to over-specify environmental parameters.

Not only are products designed for various possible environments, designed products are tested in various environments. Few commercial products are subjected to the type and extremes of environmental testing historically required by DoD.

7.4.1.1 Balancing Environmental Criteria. In general, the more extreme the environmental conditions, the less opportunity exists to use COTS. This means that two facts are in counterbalance:

- DoD cannot choose or limit a COTS product's intended environment; but

- DoD cannot, at least for long, avoid using COTS products.

7.4.1.2. Response. While DoD looks for a resolution of this dilemma, the immediate response must start with awareness of the significant environmental issues—pro and con—that may be associated with COTS.

7.4.2 Case Study: Plastic Encapsulated Micro-Electronics (PEM)

7.4.2.1 Background. One of the controversies related directly to COTS performance, rather than implementation or integration, involves plastic encapsulated micro-electronics (PEM).

Micro-electronics are used throughout military systems. Traditionally, micro-electronics were constructed with hermetically-sealed ceramic packages. These packages provide excellent insulation for electronics.

The commercial marketplace, however, would not dare use a ceramic package for electronics. A ceramic package costs ten times more than the electronic component that is inside.

Commercial manufacturers encapsulate micro-electronics in plastic—hence PEM. They use big, automated injection molding machines that bang out PEM by the zillions.

7.4.2.2 Environment and Hermeticity. The controversy over the advisability of using PEM in military systems centers on questions regarding PEM hermeticity. Will the plastic capsule keep out moisture? Will it withstand pressure changes? Will it keep its integrity under temperature fluctuations that never, ever entered into the manufacturer's calculations?

7.4.2.3 Survivability. Fundamentally, the PEM debate is about survivability. This debate highlights one thing that has not been discussed so far, and that is the major distinction between what DoD needs products to accomplish and what the marketplace needs them to accomplish.

Acquisition managers are asking people to depend on these products as they go into harm's way. Far from the daily grind, our highest calling is to maintain the trust that our warfighters have in their equipment. They must believe that everything about their equipment is going to perform the way we said it would, when we said it would, under the conditions we said it would.

7.4.2.4 Verifying PEMS for Intended Environment. As with designed products, understanding the intended environment is critical to appropriate use of COTS. Also as with designed products, the "intended environment" actually is a wide spectrum of diverse environments, each with their own subset of extremes. Military units today could be in the Arctic one month, in a desert the next month, and in a jungle the following month.

- Testing and Staff Resources. One way to resolve, or at least address, the PEM controversy is to establish a thorough testing program. Knowledgeable semi-conductor people must verify that PEM will work in the intended environment.

- Erasing Cost Benefits. Establishment of a testing program, however, brings us back to the issue of cost. It is the tremendous cost benefit that is driving the proposal to use of PEM in the first place. Testing is very difficult, subtle, and expensive. Moreover, any program that's even contemplating using PEM probably ought to have a few semi-conductor experts on staff. So testing and staffing requirements can end up boosting the cost of using PEM, thus wiping out the initial cost benefit.

7.4.3 Case Study: AWACS

7.4.3.1 Overview. To accommodate commercial computers, Airborne Warning and Control Systems (AWACS) took a hard look at their environmental requirements. Upon review, AWACS substantially modified their requirements.

7.4.3.2 Environmental Criteria Modified.

- The original AWACS temperature range was minus 54 degrees to plus 50 degrees Centigrade. That range was reduced to zero degrees to plus 50 degrees Centigrade.
- The shop requirements regarding G-force parameters were reduced.
- The vibration parameter was reduced from the standard airborne Mil-Spec number to what was measured, plus a margin.
- A salt spray parameter was eliminated.
- The operating humidity parameter was reduced from 100 percent to 85 percent.

7.4.3.3 Result of Criteria Modification. More realistic environmental requirements allowed AWACS to use commercial computers and still ensure safety and mission performance. Basically, AWACS determined it was appropriate to make some concessions in order to use COTS computers.

7.4.4 Case Study: JDAM

7.4.4.1 Overview. Joint Direct Attack Munitions (JDAM) is another example of a program that, like AWACS, took a hard look at its environmental requirements.

7.4.4.2 Environmental Criterion Modified. JDAM had an initial requirement that the bomb be able to fly captive to the plane at 500 feet for three hours. That requirement drilled the temperature within the bomb dramatically.

When the contractor asked, "Can we get some relief on that?," JDAM went back to its pilots and discussed the requirements. The pilots said they never flew at 500 feet for three hours, and for a whole host of reasons, including safety.

7.4.4.3 Result of Criterion Modification. Based on input from the users—pilots—JDAM revised its overly-restrictive captive-bomb flying parameter. This revision allowed JDAM to incorporate COTS.

8
COTS and Best Practices

8.1 THE NEED TO IDENTIFY BEST PRACTICES

The study group revealed that successful implementation of COTS-intensive systems has been hampered by too much emphasis on COTS—a "just do it" attitude, if not outright policy. On the other hand, not enough emphasis has been placed on understanding and implementing the process to determine the applicability (that is, the appropriateness) of COTS in a particular acquisition strategy.

8.2 METHODOLOGY FOR IDENTIFYING BEST PRACTICES

To support an increased emphasis on the process of determining the applicability of COTS, the study group followed the traditional SAB process to identify existing processes and standards in best-practice companies.

While the report does not literally set out processes, it does provide guidelines and lessons learned sufficient for subsequent capture in written procedures.

Key Success

- Acquisition
  - Flexible requirements
  - Contractor incentivized to consider sustainment
  - COTS-experienced contractor
- System Development
  - Technology refresh major architectural consideration
    - Open system architecture
  - Trade study process
  - Understand and influence the marketplace
  - Application closely matches COTS features
- Management
  - Collocated IPT including field operator
  - No modification of COTS products permitted
  - Strong leadership

Fig. 10: Overview of COTS Best Practices

8.3 BEST PRACTICES

8.3.1 Product Familiarity

8.3.1.1 Increased Buyer Participation. With the increased emphasis on COTS, one of the things that government acquisition officers now must do is become familiar with the array of commercially available products that may be proposed to fill a mission need.

This requirement to become familiar with available products and understand how those products will or will not contribute to the final product—accomplishment of the mission—is not unlike building a custom house. The buyer goes to an architect and a builder and, all along the way, participates in the selection of many, many COTS products: kitchen cabinets, flooring, fixtures, siding, brick. There are myriad decisions that the custom home buyer must make. It would be crazy to turn the process totally over to the architect or the builder and say, "You pick out the cabinets and the countertop and give me the keys when the house is done."

The same thing is true when the government buyer is "building" the mission. The buyer has to be more knowledgeable—much more knowledgeable—about the COTS products that are being proposed for use in their "house."

8.3.1.2 Decreased Participation from "On High." Because the COTS selection process requires close-in knowledge of both the need and the available products, COTS mandates rarely are appropriate. The best practice, in the vast majority of situations, is to leave the decision whether or not to use COTS to those people who are closest to the hardware and software.

8.3.2 Flexible Requirements

A corollary to leaving the decision to the people who are the most hands-on is having flexible requirements. If program requirements are inflexible, there is less opportunity to use COTS. Moreover, inflexible requirements make it less likely that COTS implementation will be successful.

Indeed, the study group found that flexibility, that is, the ability to conform the process to COTS rather than attempting to modify COTS to fit the process, was the most important parameter in successful implementation of COTS.

8.3.3 Software Wrappers

Those who execute the best security practices will provide wrappers for COTS software.

Wrappers limit what the software can do. For example, if the software is not supposed to write a file, a wrapper can prevent the software from writing a file. Wrappers will set restrictions on parameters. These restrictions can prevent the software from going haywire. Wrappers also can prevent a bug that is hiding in the software from damaging the system (although success at this task is limited).

8.3.3.1 Larger Security Issues. Security is far and away the most complicated aspect of the COTS buying process. It is obvious that security is an enormous issue in using COTS products in DoD and subordinate department missions.

8.3.3.2 Proposed Security Solutions. To address the issue of sabotage, "Trojan horses," and other potentially deleterious acts, the study group heard a proposal to allow third party access to the source code. This third party would then scour the code for potential security threats.

8.3.3.3 Recommendations on Security Outside the Scope of the Study Group's Report. The security issues inherent in buying COTS products are highly complex. The report addresses security somewhat. At bottom, however, the study group concluded that security is such a complex issue that it deserves a separate study.

8.3.4 Longevity in the COTS-Based System

The study group found that those programs and organizations following the best practices for COTS-based systems were those that had been operating a COTS-system for the longest period of time.

8.3.4.1 Case Study: Navy Attack Submarine. An example of this payoff of sheer experience and longevity is the Lockheed program in Manassas, Virginia, for the new Navy attack submarine.

This program's COTS process was very in-depth. They have been at it for ten years. They freely admit that they have made virtually every mistake in the book. But their longevity in the system has allowed them to evolve and develop very specific, very detailed COTS processes, as well as to develop the personnel to implement those processes expertly.

8.3.5 Leadership and a "Burning Platform"

Simply developing COTS processes, however, does not always further the required transformation from "old thinking" (design-and-build) to new thinking (buy-and-integrate). That transformation requires leadership, sometimes even from the customer.

8.3.5.1 Case Study: Navy attack Submarine and the "burning platform." As it turned out, with the Lockheed Navy attack submarine program, it was the customer that put Lockheed on a "burning platform." The customer said, essentially, "Do this (implement COTS) or I'm going to shut you down." Hot feet tend to help people overcome their natural resistance to this type of change.

To review the Lockheed program, the study group attended whole days of briefings, yet no one mentioned the burning platform. Nevertheless, it was obvious to the study group that something had jumpstarted the program's movement toward COTS. Finally, Lockheed personnel acknowledged the most important thing that happened in the program was the fact that they became convinced that they *must* use COTS. What convinced them was the leadership, in this case, of the customer, putting them on a burning platform.

8.3.6 Road Maps

Best practice suppliers have a technological road map—a long-term game plan—for their products.

Buyers must understand that road map, before they buy and then throughout the product's life cycle. Using the road map, buyers must take it upon themselves, so far as possible, to:

- minimize the potential for an artificially quickened technology change rate (by ensuring, for example, that the capability to fully automate upgrades is designed in);

- avoid, minimize, or redirect wrongway evolution—that is, evolution that takes the product away from the track that ensures the product will continue to contribute to the mission.

9
COTS Implementation

9.1 OVERVIEW

The study group reviewed applicability (i.e., appropriateness) of COTS in various systems. Then it examined the intensity of COTS implementation in the programs and organizations studied.

9.2 LEVELS OF IMPLEMENTATION INTENSITY

9.2.1 SEI Categories of COTS Intensity

The study group applied the following SEI categories in reviewing COTS-system intensity:

- Implementation of COTS solution systems. COTS solution systems entail one substantial product, such as a **Management Information System (MIS)** program.
- Implementation of an aggregate system. This involves integration of multiple COTS systems, although not necessarily exclusively COTS.
- The least intensive level of implementation is taking COTS electronic components, such as processors or micro-electronics, and designing up from that.

9.3 BENEFITS OF COTS IMPLEMENTATION

Most of the benefits of COTS are obvious and have been touted for some time. These benefits can include:

- lower cost (both initial and logistic);
- faster time to market;
- improved quality and reliability;
- the ability to leverage fast-paced commercial technology;
- reduced risk of development (although, as discussed previously, various risks associated with integrating COTS software programs may be offsetting);

- a product support system is in place; if the product is left on its evolutionary tract, upgrades and other enhancements become available; tracking the product's evolution can then provide secondary, or follow-on, benefits to the organization or program.

Taken together, these potential benefits of using COTS give managers the ability to maintain modernization. In the judgment of the study group, it is completely possible that, correctly implemented, COTS can achieve each of these benefits simultaneously.

Potential Benefits	
Primary	**Secondary**
• Lower cost (initial procurement and logistics support) • Faster deployment (time to market) • Improved quality and reliability • Leverage fast-paced commercial product evolution • Reduced development risk • Support system in place • Upgrades provided	• More stable industrial base • Decreased reliance on sole providers • Improved surge capability • Facilitates innovation from small businesses/academia • Easier to attract new employees – Mainstream development environment

Fig. 11: Benefits of COTS Implementation

9.4 DETERMINING WHETHER COTS IS BENEFICIAL IN A PARTICULAR APPLICATION

9.4.1 Sustainment and/or Logistics Costs

There is data that supports the conclusion that, implemented correctly, COTS systems' sustainment and/or logistics costs should be no higher, and perhaps lower, than a professional (i.e., a designed) system.

- Data demonstrating considerably lower support costs for COTS comes from the summary program. That program has been fielded for about three years. An important counterpoint, though, is that the ability to maintain modernization can lead to a more rapid upgrade cycle for software (for example, an 18-month cycle) and the desire to refresh technology more regularly. More rapid upgrading and more frequent refreshing will drive costs up again.

- The study group compared effort vs. years in a traditional Mil-Spec—that is, a custom designed system—to a well-run COTS system. What became clear, at least to the study group, was that the COTS system accomplished the front end of the program cheaper and sooner. What is not so clear is future sustainment or logistics costs.

9.4.2 Maintaining Modernization

The real and substantial advantage to COTS is the ability it gives managers to maintain modernization.

Despite the cost potential of more rapid upgrade and refresh cycles, the study group concluded that the ability to maintain modernization was a very big advantage for COTS. There is not yet enough data on COTS-intensive systems to make quantitative judgments about its costs. One thing that is clear, however, is that costs are influenced—up or down—by how well modernization is maintained.

Product Issues

- Trend towards integrated vs. federated
- Evolving industry standards
- Claims and performance don't always match
- Interoperability
- Performance/feature clash
- Frequent upgrades
- Questionable trust (Trojan Horse)
- Right to use, not own
- Source code not available
- Lack of support for niche features
- Environmental performance
- Plastic encapsulated microcircuits (PEMs)

Process Issues - Acquisition

- Inappropriate application
- Inflexible requirements
- Inadequate treatment of Total Ownership Cost
- Lack of thorough COTS products search & evaluation
- Inadequate product volatility consideration
  - Open system architecture
  - Spiral development
- Difficulty of maintaining configuration control
- Complexity of integrating multiple products
- Misunderstanding of commercial practices
- Inability to incrementally perform operational test and evaluation (OT&E) on an evolving product

Fig. 12: Pitfalls of COTS Implementation

9.5 PITFALLS OF COTS IMPLEMENTATION

The pitfalls of COTS probably are of more interest than the benefits.

9.5.1 Methodology Used to Evaluate Pitfalls

To see the big picture of possible pitfalls in COTS implementation, the study group compared effort vs. years.

"Effort" is a concept similar to manpower or expenditure rate.

"Years" is the time period from program start to milestone or program completion.

9.5.2 "Corporate Retirement Plans"

9.5.2.1 Potentially Perpetual or Inordinate Corporate Involvement. One of the objections to COTS-based systems is that they may create a "corporate-world retirement plan."

The idea is that if a corporation can convince the government to buy a COTS system, and the corporation controls the technology and its evolution, then the corporation can generate a new cycle as soon as it has the technology in hand. The corporation can, as previously discussed in the context of supplier support, in essence force the government to buy a continuous cycle of new technology as rapidly as that technology can be put on the street.

In short, the objection is that COTS gives the commercial vendor control over when, where, and how an organization must reissue hardware or software.

9.5.2.2 Considerations. The objection has some merit. The key points to consider in response to this objection are:

- The commercial marketplace, not any given vendor, controls the technology. That is a subtle, but very important difference.

- In most cases, COTS products are available from multiple sources. This prevents a particular vendor from driving the upgrade and refresh pace faster than the pace set by the commercial marketplace.

9.5.2.3 Response. Because there is the potential for perpetual—or potentially inordinate—corporate involvement in COTS-based systems, it is very important to carefully select suppliers and be aware of the danger of being locked in.

Moreover, the study group strongly advocates that a core team of people from the prime contractor be kept in place during the sustainment of the system. This team is necessary to respond, for example, to issues of obsolete parts and diminished manufacturing. These problems, which plague programs now, can be exacerbated in the COTS environment.

Process Issues —
Logistics and Support

- Short commercial product life cycle
- Multiple configurations
- Software upgrades
- Technology refresh
- Frequent procedure updates and retraining
- Diminishing manufacturing supply/obsolete parts

Fig. 13: Technology Change Cycle: Issues

9.5.3 Artificially Quickened Change Cycle.

9.5.3.1 The Impact of the Change Cycle on Operational Readiness. Another objection sometimes raised to COTS-based systems is that the potential for the vendor to quicken the upgrade and refresh rate ultimately impacts negatively on operational readiness.

The fast pace of technology change, in some instances, can cause considerable headaches; it seems to create constant rollover and recycling, increased training requirements, changes in configuration management, the development and dissemination of new documentation.

To the extent that the vendor is pushing technology change faster than the marketplace (i.e., "artificially quickened change"), some managers may feel they do not have the option to say, "I'm going to skip a generation (or two) and simplify my problem of retraining the troops, reissuing the documentation, having multiple variations of the system in the field." Otherwise, it can seem that by the time one version is fielded, it is time to turn around and do it all over again.

9.5.3.2 The Change Cycle and the End User. Because of the rate of technology change, COTS-based systems often look ugly to end users. From their perspective, there simply isn't enough time to get up to speed and really proficient on one system before it is time to roll over and start learning a new one.

A change requires swapping out electronics boxes, for example, and a technician comes in and says, "There's a new box. Where is my new automated test program? Where's my new interface system? Where is my new documentation?" This is what the potential for a negative impact on operational readiness (including morale) looks like to the user.

9.5.3.3 Considerations.

- Market-rate change. The important point here is to recognize that, while the rate of technological change often is disruptive, some of that disruption is unavoidable. The rate of change—that is, *the rate set by the commercial marketplace*—is simply the rate of change. It is very important, up and down the organization, to parse the effects of technology change that, because of the pace of evolution in the commercial marketplace, are unavoidable. We, as technology users, must adapt to that change or die.

- Artificially quickened rate of change. A problem may arise, however, if, by whatever mechanism, a vendor is able to push the rate of technology change beyond what the market otherwise would require. Such a change rate is artificial, in the sense that it is not propelled by market dynamics.

- Scope of the change. In evaluating any potential for the rate of technology change to impact negatively on operational readiness, the type of change must be articulated. It is not safe to assume that every change is as disruptive as "remove and replace." To the contrary, software modifications often add only functionality. In that case, the follow-on impact—training and so on—is limited to those new functions.

9.5.3.4 Response. As previously emphasized, some critical aspects of the COTS decision-making process are:

- avoiding the potential to be locked in to a particular vendor;

- maintaining a sustainment team from the prime contractor;

- understanding that a certain amount of technology change is unavoidable.

9.5.3.5 Artificially Quickened Change Cycles and the Selection Process. The challenge as well as the imperative for managers is to limit technology change, and its follow-on impacts on operational readiness, to the bare minimum consistent with marketplace dynamics.

That challenge once again focuses on the selection process. It is up to the acquisition workforce to ensure that, at the outset, we buy systems that are designed so well that follow-on impacts of upgrades and so on were addressed fully in the design phase. An example of good design that preempts readiness problems later is one that builds in the capacity to fully automate upgrades.

Data supports the achievability of such designs. The problem usually is on the buyer's part. Traditionally, during development, DoD does not pay a lot of attention to how well a product will minimize the disruption of change in the future. But one of the most efficient ways to minimize change-related disruption is to design and buy programs with that goal in mind.

9.5.4 Human Skills Acquisition

9.5.4.1 Change Rate and Human Skills Acquisition. Another pitfall inherent in using COTS—and thus becoming subject to the rate of technology change set by the marketplace, whatever that rate is—appears when software capabilities and human capabilities must intersect to accomplish a task.

9.5.4.2 Case Study: Software to Detect Man-Made Noise. An example of the intersection of software and human capabilities occurs in the use of software to detect man-made noises.

While the software enhances detection, the actual detection and identification of various man-made noises requires human skill and experience. This task involves subtle differences and nuances that are recognizable only through substantial hands-on training.

In this situation, a typical refresh rate of 18 months can negatively impact human skills acquisition.

9.5.4.3 Response. The potential that the technology change rate—*even if that rate is not artificially quickened*—will negatively impact human skills acquisition, and, therefore, operational readiness must be addressed at the front end, before a COTS product is selected.

9.5.5 Integration

9.5.5.1 Integration and Unused Functionality. Unlike a designed product, a COTS product (at least in theory) often delivers much more functionality than is required. These unused functions have a way of interacting with the rest of the system in a highly unpredictable way.

The interaction of unused functionality must be thoroughly wrung out during the integration process.

When the COTS product is upgraded, the same situation presents itself. Some unused function either has been changed or added. This necessitates going back through the integration process and again wringing out any negative interactions between unused functions and the rest of the system.

9.5.5.2 Highly Integrated vs. Federated Systems. Commonly, problems with COTS implementation occurred in highly integrated systems. It is easier to use COTS in a federated system.

A federated system is a system where the architecture is partitioned by function. These partitions make it easier to plug in a COTS product.

9.5.5.3 Trend Toward Greater Integration. There is a trend toward greater systems integration. The more integrated the system is, however (such as when functions such as flight critical/non-critical flight functions are integrated), the more difficult it is to take advantage of COTS products. Therefore, this trend is counterproductive to COTS implementation.

9.5.5.4 Configuration Control. Particularly because of the performance/feature clash arising from unused functionality, in COTS systems, it can be difficult to maintain configuration control.

9.5.6 Wrongway Evolution

9.5.6.1 Downsides of Product Evolution. One of the advantages of COTS is their inherent evolution. Obviously, however, in some cases, this evolution can have a downside of pushing technology change faster than the user requires or can absorb. Yet another factor to consider regarding a product's evolution is wrongway evolution.

9.5.6.2 Considerations. Wrongway evolution occurs when the commercial marketplace evolves a product in the "wrong" direction—that is, away from the track DoD needs the product to follow in order for the product to continue to meet DoD's requirements.

Clearly, wrongway evolution can leave a user "hanging." A buyer, for example, may purchase a software package specifically to obtain a niche feature. Over time, the commercial marketplace begins to dislike that niche feature. So support goes down.

9.5.6.3 Response. The answer here again comes back to the initial buying process and ongoing interaction with suppliers.

Best practice companies participate in standards committees (not with the idea that the committees can be influenced very much, although companies certainly try). Best practice companies have a technological road map—a long-term game plan—for their products.

Buyers need to understand that road map, before they buy and then throughout the product's life cycle. Buyers must take it upon themselves, so far as possible, to avoid, minimize, or redirect wrongway evolution.

9.5.7 Performance Claims

The study group found that many problems arose from the fact that claims for products and performance of those products often do not match. This was a cause of the failure of the COTS system at DMMIS.

It's common sense. Programs and organizations cannot buy things based solely on an advertising brochure.

9.5.8 Interoperability and Debugging

9.5.8.1 Performance/Feature Clash. Particularly with software, COTS can create interoperability problems. These problems primarily were manifested as clashes between performance and features, especially in regard to unused functionality conflicting with the rest of the system. This is an integration issue that requires careful attention.

9.5.8.2 Source Code Issues. One change COTS create is the fact that, in a COTS system, DoD buys the right to use software and hardware. DoD doesn't own it. That locks DoD engineers out of the source code; that's hard for engineers to accept. Engineers want to get inside the software and fiddle and tweak and they can't do that with COTS.

Because engineers cannot get inside COTS software, COTS make debugging difficult. In owned products, software engineers are accustomed to penetrating the source code, installing flags, and overseeing the debugging process. With COTS, that cannot be done. In this regard, COTS software is more like hardware. That fact requires a new mentality and approach to debugging.

9.5.9 Mandates to Utilize COTS

The overarching conclusion of the study group was that COTS-based systems could be successful only to the extent there was less emphasis on using COTS and more emphasis on the process of determining when it is appropriate to use COTS.

There are some situations that simply are not good candidates for a COTS-intensive system. Fighter aircraft avionics upgrade is one such situation. Nuclear reactor controls is another situation where COTS won't fit. The same goes for controls for any nuclear weapon.

While there are some situations where it is obvious COTS are a no-go, in the vast majority of cases the decision to use or not use COTS should be left up to the people who are closest to the hardware and software.

9.5.10 Failure to Understand Costs

Although TOC is important to the long-term understanding and evaluation of COTS systems, people don't even talk about TOC.

The University of Southern California has been working for years to formalize the concept of TOC. They have identified all the cost factors and created cost models. Apart from a TOC model, cost projections for COTS will be inaccurate.

9.5.11 Static Roles and Responsibilities

Implementation of COTS-based systems changes roles and responsibilities dramatically. This is, and should be, a point of great concern.

To succeed, any major change initiative—and certainly the transition to COTS is a major change initiative—requires a comprehensive, multifaceted game plan. Part of that game plan has to be someone making it clear to everyone involved that, "if you don't get on board, you're out—literally."

In sum, if a major change initiative ever is going to get off the ground, it requires a burning platform. It takes leadership to construct that platform.

9.5.12 Logistical Volatility

As to logistics, we all know the commercial marketplace is very volatile. To the extent DoD has COTS-intensive systems in place, that volatility has a ripple effect in the field.

9.5.13 Unrealistic Expectations

The people issue in COTS comes down to the fact that leaders have unrealistic expectations. Leaders conclude that COTS is straightforward, but it is not. COTS is the opposite of straightforward.

9.5.14 Internal Use Products

The danger exists that people can buy what they think is a COTS product from a public company, only to discover later that the product was developed for internal use.

Internal use products, as opposed to for-profit, commercially available products, are highly unpredictable as to the availability and cost of technical support and upgrades. Therefore, the study group strongly advises that the product be commercially available and sold for a profit, rather than for internal use. That is, the product should be truly "off the shelf."

10
COTS and Funding Issues

10.1 OVERVIEW

COTS-based systems require new thinking in funding procedures. Moreover, budgetary cycles must be more flexible and more synchronous with technology cycles.

10.1.1 From Color of Money to TOC

New concepts are necessary to transition the current funding system from a color-of-money focus to a focus better adapted to the realities of COTS systems. That new focus may be on TOC.

10.1.2 Funding Issues and Supporting Data

Presently, the support for a TOC-focused funding system is mainly philosophical—the study group fundamentally believes that using commercial processes, practices, and products will drive down costs.

While there exists some data that tends to support the conclusion that COTS result in lower costs, more data must be developed.

10.2 TRADITIONAL FUNDING CURVE

A traditional military specification (Mil-Spec), that is, design contract, has a particular life cycle.

10.2.1 Life Cycle

First, in a traditional Mil-Spec setting, the design goes into research, development, test and evaluation (RDT&E). After successful completion of that phase, the product is procured. At that point, the product is an Operational and Maintenance (O&M) item, usually long-term. Over the life cycle of the product, O&M funds are used for upgrades and modifications.

10.2.2 Color of Money

This traditional funding curve—RDT&E to procurement to O&M—demonstrates the historical separation of funds, often called the "color of money," that characterizes DoD's present funding system.

10.3 COTS AT ODDS WITH CURRENT FUNDING PROCESSES

The current funding system, which requires strict separation of the various colors of money, tends to be at odds with a COTS system.

10.3.1 Traditional Life Cycle Events vs. Commercial Evolution

In the traditional Mil-Spec setting, it is easier to budget for life cycle events—precisely because DoD controls the design and, therefore, DoD exercises more control over design changes.

By contrast, COTS systems track changes dictated by the commercial marketplace. Indeed, one of the advantages of COTS is that purchase of a product also, in essence, purchases that product's commercial evolution.

10.3.2 Funding Processes and Product Evolution

While product evolution, and the concurrent ability to maintain modernization, is one of the chief advantages of COTS, the buyer receives the benefit of that evolution only to the extent funding systems permit. The marketplace can drive all kinds of technology change, but if funds are not available to buy that change (upgrades and so on), as a practical matter, product evolution is lost.

10.3.3 Budget Cycles and Product Evolution

Besides color of money issues raised by the present funding system, there often exists a timing disconnect between budget cycles and market-driven technology change cycles—i.e., product evolution.

Presently, it can take 18 months, two years, even three years to put in place a new budget in the software/technology community. In that timeframe, technology in the marketplace could have changed two times or more.

10.3.4 TOC

Although TOC is important to the long-term understanding and evaluation of COTS systems, people don't even talk about TOC—much less has TOC been driven into DoD funding practices. There are not even tools to facilitate a discussion of TOC and how to incorporate TOC in the transition to COTS.

The University of Southern California has identified all the cost factors and created TOC models. More use must be made of TOC models in evaluating bidders or suppliers.

11
Critical Factors in COTS Success

11.1 BACKGROUND

The study group reviewed the top five COTS success stories to determine the ten or twelve factors critical to that success.

Exemplary Programs

- Advanced Amphibious Assault Vehicle (AAAV)
- New Attack Submarine and Rapid COTS Insertion (NSSN/RCI)
- Airborne Warning and Control System (AWACS) upgrade
- Joint Direct Attack Munitions (JDAM)
- Manufacturing Resource Planning II (MRP II)

Fig. 14: Top Five COTS Success Stories

11.2 FACTORS CRITICAL TO COTS IMPLEMENTATION SUCCESS

11.2.1 Flexible Requirements

The first, and most important, factor in COTS success is flexible requirements. The report emphasizes this point repeatedly. Flexible requirements are critical for multiple reasons.

Examples of flexible requirements leading to successful implementation of COTS is the AWACS and JDAM programs. The AWACS and JDAM experiences with flexing environmental criteria are set out above.

The AWACS and JDAM examples demonstrate that sometimes environmental specifications are not backed up with a lot of thought. Those types of specs should not stand in the way of COTS.

11.2.2 Incentives to Contain Sustainment Costs

How DoD handles sustainment costs in a COTS system is another area that requires a change in philosophy.

11.2.2.1 AWACS. AWACS succeeded in implementing COTS because the contractor was incentivised—big-time—to consider sustainment. Major financial penalties were imposed if the product exceeded its projected sustainment cost.

11.2.2.2 Navy Attack Submarine. In the case of the Navy attack submarine program, Lockheed is on the hook for sustainment for the first five years. In fact, the ship is not "DD 250'd" (Material Inspection and Receiving Report) or sold off for five years. Lockheed is arguing for a contract that provides them with sustainment for the long term. The Navy, however, is taking a wait-and-see-and-reassess approach.

11.2.2.3 Other Contractual Settings.

- In the case of an award fee-based contractor and developer, sustainment costs were handled by sharing a portion of the award fee with employees, based on sustainment costs. This incentivized the employees to design the system for subsequent support and maintainability.

- A similar approach also could be used in a fixed-price contract setting.

11.2.2.4 Goal of Incentives. The teaching point is that incentives must be tied to financial performance. The contractors must be made to suffer if they don't contain sustainment costs. Without incentives, sustainment costs are not going to receive the attention they deserve on the front-end of the design.

11.2.3 Up-front Awareness of Design Considerations

Up-front design considerations remain important in the new thinking of buy-and-integrate. In systems development, for example, technology refresh and upgrades are a major architectural design consideration from the beginning.

Most refresh and upgrade changes are supported by very detailed trade studies. That is, the proposed changes were subjected to rigorous study to determine the trade-off between an enhanced product and TOC. For best practice companies, the impact of technology refresh and upgrades on TOC is knowable because these are design considerations from the beginning.

11.2.4 Matching COTS Functionality with Requirements

While flexible requirements are one of the most important factors in success of COTS-based systems, clearly flexibility has limits.

COTS products that deviate too far from requirements should be avoided. Such products may seem usable at first, but they lead to modification, such as software wrappers and other jury-rigging. COTS should not be modified. Rather, in the buying process, the COTS functionality must be matched closely with requirements.

11.2.4.1 Evaluating Functionality Against Requirements. From management's perspective, ensuring COTS are a good fit with requirements must involve input—in all cases—from:

- the integrated product teams (IPT);
- users;
- operational testers; and,
- the acquisition community.

In short, everyone who has a stake in the system should be involved in calibrating COTS testing. This is necessary so that an appropriate decision on whether or not to use the COTS is made before, not after, the product is purchased.

11.2.5 Changing the Culture

The transition from the old thinking of design-and-build to the new thinking of buy-and-integrate necessitates a major cultural shift.

The spiral process of not only going with, but also understanding the market flow, is very different from DoD's historical linear process of taking a product from start to finish, irrespective of what is happening in the marketplace.

11.2.5.1 From Linear to Spiral Processes.

- The old linear process. Design-and-build was a process that was not very vulnerable to the volatility of the marketplace. It was a very linear process. It did not lend itself to evolution or multiple simultaneous changes to accommodate the volatility of the marketplace. Therefore, by the time DoD finished developing systems requirements and specifications, the technology available in the marketplace had completely changed. Buy-and-integrate, on the other hand, ties DoD to the marketplace—a marketplace that DoD does not control and which changes very rapidly.

- The new spiral process. Buy-and-integrate is like a spiral, rather than linear. Its distinguishing feature is its concurrency—that is, it does evolve and go through multiple simultaneous changes to accommodate the volatility of the marketplace. By definition, a spiral process is a process characterized by simultaneity.

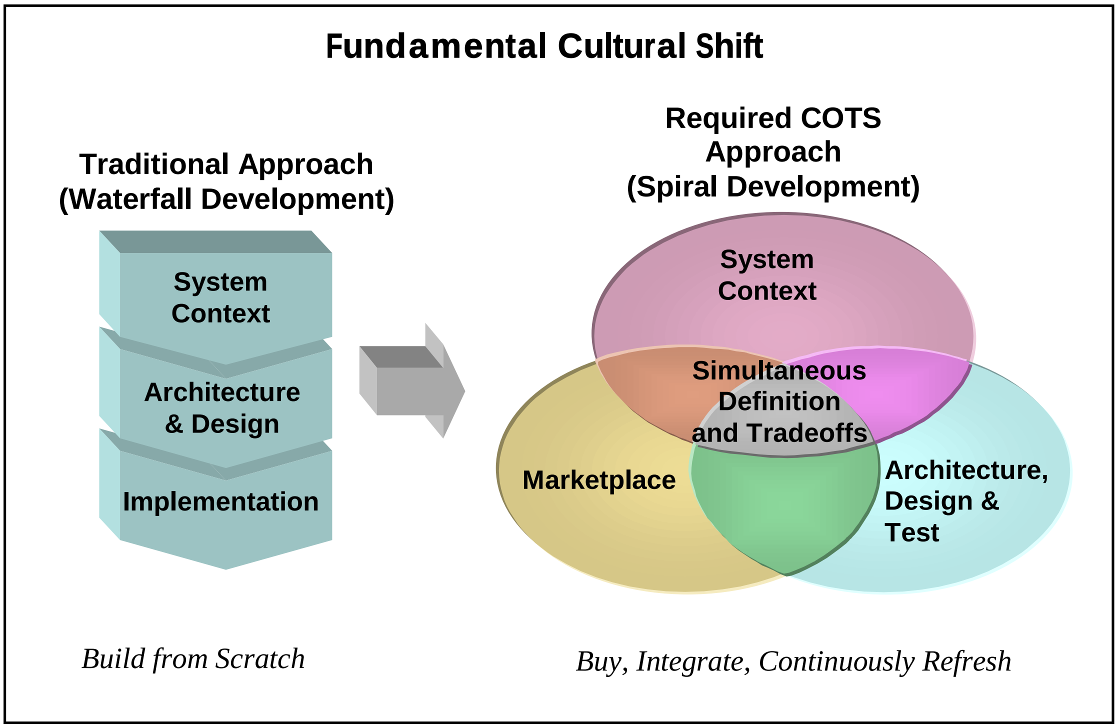

Fig. 15: Linear vs. Spiral Processes

11.2.5.2 Case Study: Lockheed. An example of how a spiral, as opposed to linear, process looks in practice occurred at Lockheed.

A review of a particular program revealed a "hole" in the system. In other words, completion of the project would require a particular type of commercial product, but that product simply was not available at the time.

In the old thinking, this "hole" might have been a show-stopper. But in the new thinking—thinking more adapted to the gyrations of the market—project managers were extremely familiar with the commercial marketplace.

In the view of the project managers, the COTS they needed to complete the project would be available in the marketplace within a year. The customer agreed. They worked that assumption into their planning.

In fact, the COTS was available within the year. Lockheed plugged it in, and it worked.

Of course, the outcome of a spiral process is not always so successful as in the Lockheed example. By the time a system is proposed, the product could be no longer available.

- Summary: Clearly, the volatility of the marketplace makes the spiral process of buy-and-integrate difficult to manage. But it is the volatility of the marketplace—the pace and scope of technology change—that makes the transition to buy-and-integrate necessary in the first place.

11.2.5.3 Risk-Sharing. Changing the acquisition culture from design-and-build to buy-and-integrate impacts on how acquisition managers traditionally think about risk-sharing.

The study group concluded that it is possible to reduce development risk by transitioning to the COTS environment because experienced contractors have:

- picked standards;

- developed systems;

- knowledge of which commercial products work;

- defined standard busses and open architecture.

When all that experience is brought to bear on decisions on buying and integrating COTS, these contractors should have a better handle on development costs than in the design-and-build environment.

11.2.6 Using the Right Tools

The following are some of the tools required to successfully implement COTS-intensive systems:

- Total Ownership Cost (TOC) models are required to evaluate proposals to use COTS. These models presently are being evolved.

- Systems to manage obsolete parts. There exist excellent COTS products to help manage issues of diminishing manufacturing (i.e., sources) and obsolete parts. Demand likely will cause these COTS to continue to evolve.

- Processes must be written. An appropriate starting point for this task is the guidelines produced by the study group. Process-writers should pay particular attention to the pitfalls identified by the group.

- Training is essential. SEI has been working on training modules for several years. They have some very good ones that are designed for particular audiences.

- Managers at all levels must redefine roles and responsibilities.

- Effective incentives must be established. In the view of the study group, the Air Force, for example, has not used incentives effectively—and by incentives the report indicates tough contractual terms that ensure the contractor pays if sustainment costs are not contained. It is going to take tough incentives to get people's attention in such a way that everyone gets on board supporting the COTS environment. Some examples of effective incentivizing are the Material Inspection and Receiving Report (DD 215) and then the Navy's submarine program five years later. Another example is the JDAM warranty that put the contractor on the hook for 25 years.

- The acquisition community must establish policy that will become a framework for COTS success. Once a framework is in place, the acquisition community can drive industry to support what DoD wants to do with COTS much faster than DoD has in the past.

- Personnel evaluation techniques must be developed specifically to identify the skills and experience the acquisition community wants people to bring to COTS-intensive systems.

- Education and training on COTS systems should be incorporated into the Defense Systems Management College (DSMC) curriculum.

- Lessons learned must be captured regularly. As COTS-based systems are still evolutionary, the study group recommends periodic (at least annual) review and, as new lessons are learned, revision.

12
Acquisition Strategy and COTS Success

12.1 OVERVIEW

Acquisition law generally is adequate to support COTS, although there still exist color of money and depot issues. The study group believes these issues can be resolved in the near term.

COTS implementation policy must drive the acquisition strategy, including subsequent source selection and program management.

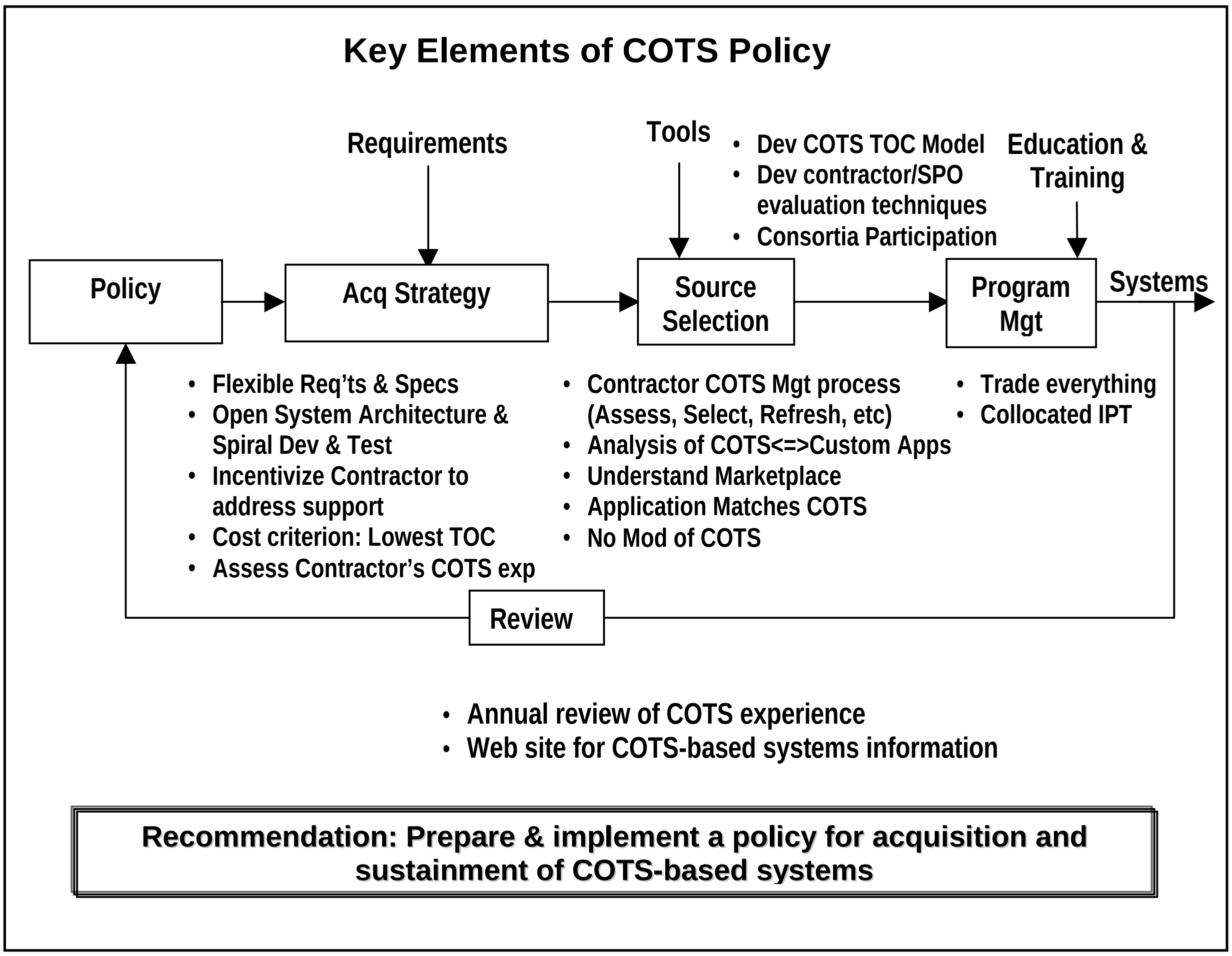

Fig. 16: COTS and Acquisition Strategy

12.2 ACQUISITION STRATEGY AND FLEXIBLE REQUIREMENTS

The study group repeatedly emphasizes how important flexible requirements are to COTS-system success. This fact must be incorporated into acquisition strategy. Strategists and those who review the strategy must ask: are the requirements appropriately flexible? Which requirements, if any, are negotiable?

The crucial point is to ask this question, to conduct this review. Without this type of review, someone might pull a requirement out of boilerplate somewhere, fail to tailor it to the task, and end up driving the project away from appropriate COTS utilization.

12.3 ACQUISITION STRATEGY AND INDUSTRY AND USER INVOLVEMENT

To make a COTS system effective, the acquisition strategy also must involve industry. Industry involvement must take place in the conceptual planning phase, in concert with users—in other words, *before* the Operational Requirements Document (ORD) and the Request for Deviation (RFD).

The users bring to the strategy table their need and their ideas and concepts on how to meet that need. Industry can bring to the table information on how that need can be addressed by COTS.

12.4 ACQUISITION STRATEGY AND OPEN ARCHITECTURE

Open system architecture is critical to successful implementation of COTS. Plug-and-play allows COTS-based systems to evolve with the technology and seamlessly make upgrades. One aspect of acquisition strategy review must be to ensure open system architecture is in place.

12.5 ACQUISITION STRATEGY AND INCENTIVIZING CONTRACTORS

Acquisition strategy review must include an evaluation of incentives. In particular, what incentives exist for the supplier to provide credible estimates of sustainment costs and to contain sustainment costs once the product is selected?

12.6 ACQUISITION STRATEGY AND TOC

TOC, not acquisition or flyaway costs, must be the source selection criteria. One support tool that is required for successful COTS implementation is the TOC model. Models are commercially available.

TOC must determine the suitability of COTS. Perhaps a custom design is appropriate. But this decision should be made based on trade analysis, not by edict.

Program managers (PMs) must support COTS by conducting appropriate trade-offs that impact TOC. PMs also must enforce ongoing interaction between the government and the contractor, through IPTs (preferably collocated). IPT collocation can be difficult; at the minimum, IPTs should meet in common facilities when they get together.

Key Elements of COTS Policy -
The Program Management

- Conduct **trade-off analyses of all changes** vs TOC
- **Enforce** ongoing interaction between government personnel (ops & acquisition) and prime contractor in **Integrated Product Teams**
  - Facilitates trades between requirements & TOC
  - Collocate is preferable

Fig. 17: Acquisition Strategy and Total Ownership Cost

12.7 ACQUISITION STRATEGY AND SOURCE SELECTION

Acquisition strategists must develop techniques to evaluate the potential contractor and the government program office on their ability to develop and manage a tough COTS-intensive system.

12.7.1 Contractor Experience with COTS

The acquisition strategy review must assess the contractor's past experience with COTS. In COTS systems, there is a very strong correlation between experience (including longevity) and success.

As with any new system, it may be that, initially, not that many contractors have experience; in fact, every bidder might be eliminated on that ground. Nevertheless, making experience a factor in acquisition strategy tells potential bidders that DoD is serious about COTS. Bidders will figure out a way to obtain experience and to demonstrate that they have processes in place to be successful.

12.7.2 Contractor Processes

For COTS, the source selection evaluation must determine if processes are in place for selecting, integrating, supporting, and refreshing COTS.

12.7.3 Contractor Understanding of the Commercial Marketplace

The government must evaluate whether contractors understand the commercial marketplace. What is the contractor doing, for example, in the area of R&D? This evaluation, incidentally, is exactly what happens when commercial companies evaluate potential suppliers.

An electronics company, for example, may go into a potential supplier's semi-conductor operation and scrub it for two weeks. It is not enough for the electronics company to evaluate the product. They want to know: what processes are in place? Can the semi-conductor department make it in the manufacturing race? Are the equipment and personnel sufficient and up to speed?

The study group strongly concluded that the acquisition workforce no longer can let the product do all the talking. Rather, acquisition personnel must dig into the supplier's whole situation. Too many times COTS have failed because no one looked behind the product, for example, to the processes or personnel or R&D department.

Key Elements of COTS Policy -
Source Selection Evaluation

- Evaluate **contractor's COTS processes** for assessing, selecting, integrating, supporting and refreshing
- Use TOC to determine **suitability of COTS** vs. custom products
- Assess contractor's **understanding of the commercial marketplace** and relevant COTS products
- Ensure system **application matches the COTS** product functionality
- Verify contractor proposes to use COTS products **without modification**

Fig. 18: Role of the Contractor in COTS Implementation Success

12.8 ACQUISITION STRATEGY AND PRODUCT SELECTION

Functionally, COTS products must fit requirements fairly closely. To make that call during the acquisition strategy review, the acquisition community and others must become very familiar with these products.

To facilitate product knowledge, DoD should seek commonality across systems. Because of the economies—knowledge and otherwise—best-practice companies also are working to enhance commonalities across product lines.

12.9 ACQUISITION STRATEGY AND COTS MODIFICATION

The study group made a strong statement that modifications of COTS are inadvisable. Again, if a modification is proposed, it is critical that everyone understand all the implications.

Key Elements of COTS Policy -
Acquisition Strategy Review

- All operational **requirements** and procurement **specifications** should be **negotiable**
  - Focus on the output rather than the input
  - Involve industry before ORD and RFP are finalized
- **Open system architecture** & **spiral development** essential
- Incentivize **prime contractor to provide** a credible estimate of support costs
- Use **Total Ownership Cost** as source selection cost criterion
- Assess the contractor's **past experience employing COTS** products

Fig. 19: Strategic Goals for COTS Implementation Success

13
The Training Imperative

13.1 INFORMATION SHARING

As a backdrop to formal training programs, the study group recommends participation in consortia as a way to become educated on both software and hardware COTS. Computer-Aided Life Cycle Evaluation **(CALCE)**, for example, at the University of Maryland is doing a lot of good work in obtaining government funding.

Another consortium is the Interoperability Clearinghouse. The Clearinghouse is just getting off the ground, so there is not much information about it. Presumably, the Clearinghouse will be a repository of experiences with COTS. Ideally, if someone proposes a COTS, acquisition managers should be able to check with the Clearinghouse to see how that product has worked for others, what problems arose, what questions should be asked.

Key Elements of COTS Policy -
Source Selection Support Tools

- Develop **TOC analysis Model/Tools** with COTS cost factors
  - Refresh, rewrite procedures, retrain, etc.
- Develop **evaluation techniques** that focus on **contractor & program office capability** to produce COTS-Based systems
- **Participate in consortia** that share COTS product experiences
  - CALCE for electronic components
  - Consider Interoperability Clearinghouse for software, based on progress assessment of this emerging organization

Fig. 20: Tasks to Support COTS Training

13.2 THE COTS TRAINING IMPERATIVE

DoD must conduct a substantial amount of training to support effective implementation of COTS systems.

The study group encouraged DSMC, the Armed Forces Institute of Technology (AFIT), and others to incorporate COTS systems into the curriculum. SEI already has developed a number of training modules.

There must be a process of certification at all levels.

Key Elements of COTS Policy -
Education and Training

- **Increase COTS competency at all** levels for workforce
  - Identify audiences, required skills, knowledge and abilities
  - Develop required education and training courses
  - Require training at front end of programs assigned to Program Executive Officer (PEO) and Designated Acquisition Commander (DAC)
- Encourage **DSMC, AFIT** to incorporate COTS topics **into their curriculum**
- Include COTS material in **contracting officer and acquisition officer certification programs**
- Make COTS guidelines available via Defense Acquisition Deskbook

Fig. 21: COTS Training Goals

13.2.1 Training Emphasis

To support the transition to COTS-intensive systems, education must take on an emphasis different from in the past: it must teach people how to ask the correct questions.

The challenge in COTS education is to translate the imperative—teach people to ask the correct questions—into a curriculum that focuses on "how to" rather than the theory of COTS systems.

A "how to" focus encompasses the way people think and behave. It is not something that can be accomplished, for example, in a two-day briefing. There must be sufficient time and opportunity for people to do exercises and internalize the analytical process.

13.2.2 The Role of the Burning Platform

Part of the knowledge of how to ask the correct questions comes from training. But another part of this knowledge is spurred by a burning platform—people must perceive that they must get with the program or they will be left behind. Only then will training turn people from the intellectually curious into real-world COTS-system analysts.

13.3 TRAINING AND RESOURCE ALLOCATION

Time—lack of it, of course—often is the problem in conducting adequate training. There are many pressing training needs that must be addressed, for example, in a 14-week long curriculum. How do we prioritize training? How do we justify the amount of time we require personnel to spend away from their programs and in training?

Ninety percent of programs are deficient in how they manage software. DoD must do more training on software management. Is that the biggest need for the person going back to the field? Or is COTS a higher priority?

This dilemma illustrates how critical it is that the COTS training that is conducted be effective. DoD cannot afford to put time into training that doesn't get the job done; that, when it's over, the training ends up in the "that was interesting, but not practical" file.

13.4 STRUCTURING COTS TRAINING

The majority of DoD educational requirements are determined by functional acquisition boards. COTS, however, are not within the purview of a defense functional acquisition board. This lack of board input makes it difficult to know how to structure COTS education. DoD must review training across all ten functional areas.

- What knowledge does DoD needs its people to acquire to successfully implement COTS?
- How do we measure when people have acquired sufficient COTS knowledge?
- Does the training link and integrate all the courses in a way that provides the acquisition workforce with a complete tool kit?

13.5 PAST TRAINING AND INFORMATION-SHARING INITIATIVES

In 1997, an acquisition council in the Pentagon created a comprehensive core body of knowledge on simulation. The intent was to give this core body of knowledge to each functional board. Each board, then, was to review how that core body of knowledge should be incorporated into their piece of the puzzle. While that goal was never reached, that is the sort of process needed for COTS.

13.6 TRAINING MATERIALS

COTS guidelines must be available. The SD2 handbook—DoD Standardization Directory (a handbook for buying commercial & NDIs)—covers COTS and NDI acquisition. It has been out quite a while. But the acquisition community must go beyond existing guidelines to look at the best practice companies; take their experience and use it to get a better understanding of "how to."

While a lot of information on COTS exists, relatively little of it is quality guidance. A good place to start is the SEI white paper. DoD trainers could take something like that and upgrade it with some good case studies.

Terms of Reference

- Case studies
- Identify existing processes and standards
- Provide guidelines
  - Applicability
  - Processes and standards
  - Field support
  - Metrics
  - Government oversight
  - Security

Fig. 22: COTS Training Materials: Content

13.7 TRAINING MUST BE CONDUCTED WITHIN A SUPPORTIVE POLICY INFRASTRUCTURE

DoD must ensure that its policy structure backs up the systems it is trying to implement.

Ninety percent of the time when the desired results are not being achieved, it is because either there is a structural limitation or people have not been provided the right tools to accomplish the change. Thus, COTS guidelines and COTS training are not the whole picture. DoD must ensure that those guidelines are operating, and that COTS training is being conducted, within a supportive policy infrastructure.

13.7.1 Case study: Performance-Based Service Contracting

Performance-based services contracting has been pushed since 1990. It is not a difficult style of contracting, but the problem was that the infrastructure and policy structure was set up to do something else. The regulations had not been changed to support performance-based contracting. No matter what system we *say* we want to see implemented, it is regulations that determine what happens in the field.

13.7.2 Case Study: Revision of Major Acquisition Directives

The DoD is in the process of revising its Major Acquisition Directives, 5001 and 5002R. The directives presently are in draft form.

This is an example of where the policy infrastructure must support COTS if COTS is to be successful. Some people, however, already see an intuitive disconnect between 5001, which puts a priority on COTS, and 5002R, which sets out the traditional decision-making hierarchy, and, thus, puts a priority on modifications and upgrades before considering COTS. The directives must make the priorities clear.

13.8 TRAINING MUST INCORPORATE LESSONS LEARNED

The study group recommended periodic (at least annual) review and, as appropriate, revision consistent with new lessons learned on COTS-intensive systems.

To that end, the Navy has a web site where they collect information on COTS. Acquisition Review has a web forum for commercial advocates.

The key point is that DoD must establish repositories to support the COTS learning curve.

Key Elements of COTS Policy - Review

- Sponsor **annual review of COTS experience** on AF systems
  - Focus on experiences and lessons learned; target policy /infrastructure improvements, updates to education & training
- Sponsor **web site for COTS-based systems information** (lessons learned, case studies, references, etc.)

Fig. 23: COTS Training: Periodic Review and Information Sharing

14
Conclusions

14.1 SUMMARY

The study group's overarching conclusion was that COTS is radically different from traditional acquisition in every dimension. This radical difference is not well-appreciated, and neither are the complexities of COTS systems. These are the pervasive reasons that progress toward COTS implementation is slow. It also is why people are struggling.

COTS is Radically Different

Mil Spec	COTS
Requirements driven	Market driven
Spec focus	Business plan focus
Rigid requirements	Flexible requirements
Unique architecture	Open system architecture
Owner controls evolution	Market controls evolution
Stable design	Constant changes
Ignore evolution	Design for evolution (tech refresh)
Cost emphasis	TOC emphasis
Make custom hardware	Buy from catalog
Develop software	License software
Obsolescence	Earlier obsolescence
Waterfall-style development	Spiral development

Fig. 24: Summary: Differences Between Mil-Spec and COTS

14.2 THE ROAD TO COTS SUCCESS IS LONG

There is a direct correlation between longevity in COTS-intensive systems and success with COTS. This is because COTS systems are difficult to implement. Moreover, COTS are not a panacea. That in itself is a surprise to some.

Nevertheless, the consensus view is that the transition from old design-and-build practices to new buy-and-integrate practices is going to happen, whether DoD likes it or not. The key is to make the transition happen more quickly, and to avoid, or at least minimize, all the pain and agony.

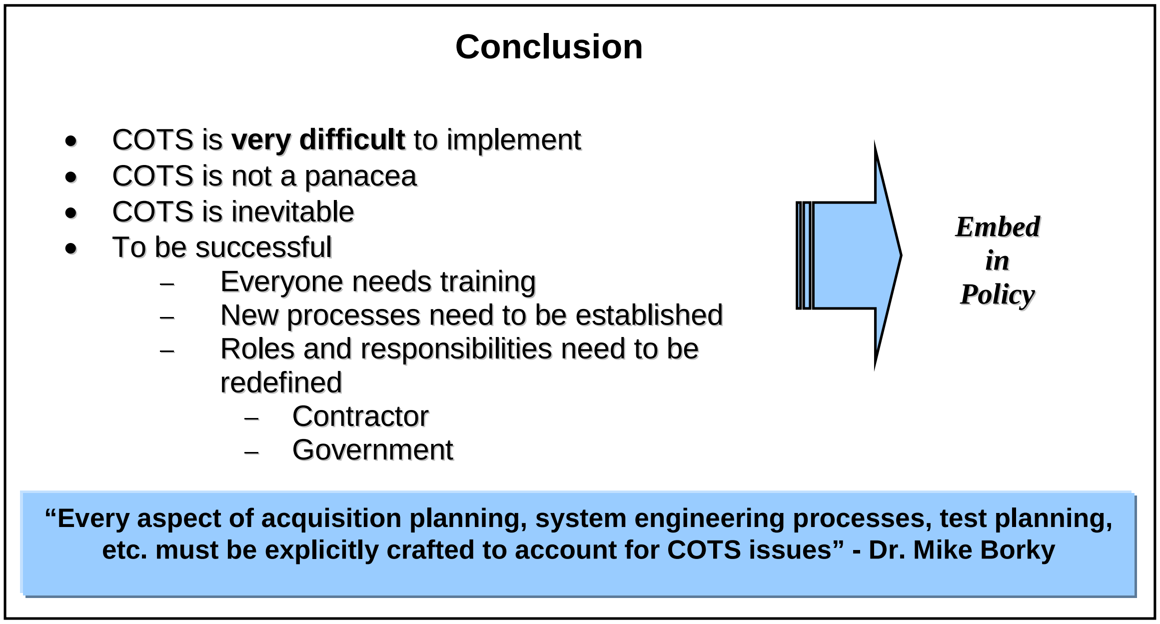

Fig. 25: Conclusions of the COTS Study Group

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