Logistics Management Institute

Using Technology to Reduce Cost of Ownership

Volume 1: Annotated Briefing

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The Deputy Under Secretary of Defense (Logistics) tasked the Logistics Management Institute (LMI) to assess the leverage available to reduce operations and support (O&S) costs through insertion of technology in fielded weapon systems. LMI evaluated the tools DoD is currently using to identify cost drivers and characterized the ongoing programs targeted at reducing O&S costs. This provided a basis for identifying the best practices in DoD and for developing recommendations for a new program.

The initial phase, documented in the Volume 1 annotated briefing, concluded that cost-tracking systems and sustaining engineering are not the limiting factors in reducing O&S costs. Rather, production funding for technology insertion is the most serious obstacle. A cost of ownership reduction investment program funded by the Defense Business Operations Fund capitalization is proposed.

Volume 2 contains a business case to test whether currently available investment candidates could provide an adequate return on investments (ROI) to justify such a program. LMI developed a Microsoft EXCEL spreadsheet model and used it to evaluate nine potential Service projects. The business case confirmed that an ROI of 9:1 in 20 years for currently available Service candidates was feasible.

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PREFACE

This study, undertaken to meet the tasking of Deputy Under Secretary of Defense (Logistics) memorandum subject: Logistics-Related Costs of Ownership Study dated 30 March 1995, is published in two separate volumes. Volume 1 provides the results of the study in the form of an annotated briefing. Volume 2 contains a business case that examines the return on investment possible with specific current investment candidates. Appendices in Volume 2 contains the full analyses for the investment candidates, a description of the model used to calculate return on investment, and instructions for use of the model.

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Introduction

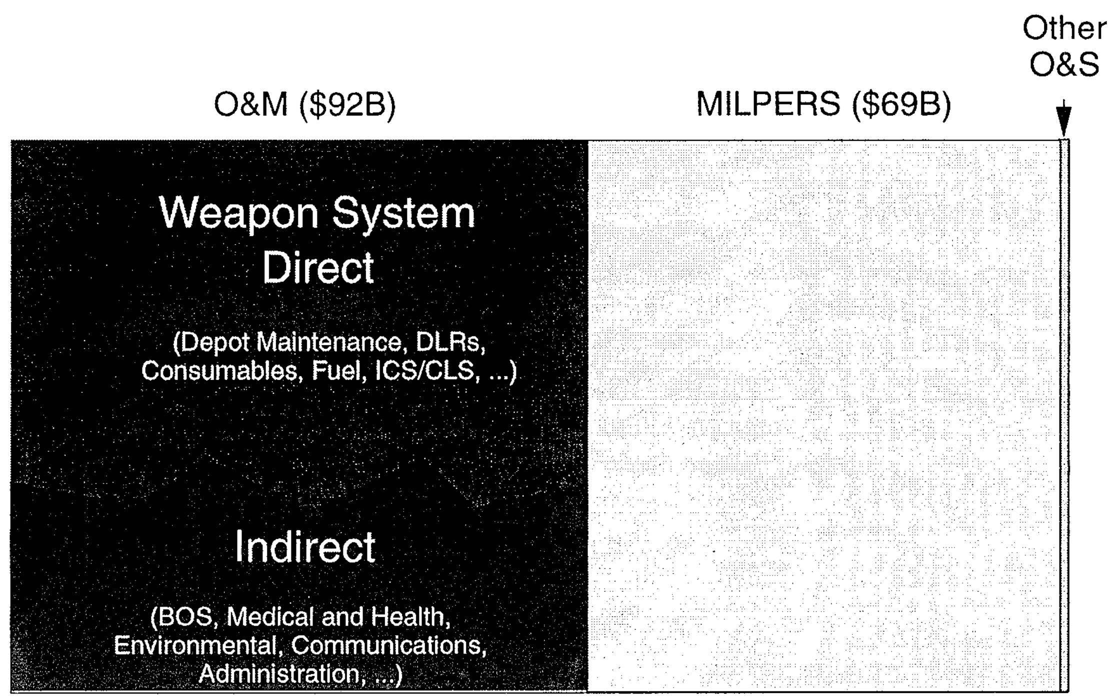
In 1994, the Under Secretary of Defense for Acquisition and Technology identified control over weapon system cost of ownership as key to modernizing U.S. armed forces. The term "cost of ownership" encompasses all life-cycle costs from acquisition through disposal, including the associated basing infrastructure for deployed weapon systems.[1]

The emphasis in this briefing is on one component of cost of ownership: operation and support (O&S) cost. Since resources expended on operation and support of existing forces are not available to be spent on modernization, opportunities to reduce O&S costs are of considerable importance.

The Assistant Deputy Under Secretary of Defense for Maintenance Policy, Programs, and Resources (ADUSD[L]/MPPR) tasked the Logistics Management Institute to assess the leverage available to reduce O&S costs. The initial phase of the study, now completed, emphasized leverage available from technology insertion (in particular technology with improved reliability and maintainability). This briefing reports the results of the initial study phase.

In order to maintain a reasonable scope, this initial phase primarily focused on aircraft and ground vehicles. Explicit treatment of other types of systems, such as ships and communication-electronics, is planned for follow-on study. In the interim, because we have not yet examined ships or communications-electronics, the results of the initial study should only be extended to these other systems with caution.

Operation and Support Costs



Operation and Support Costs

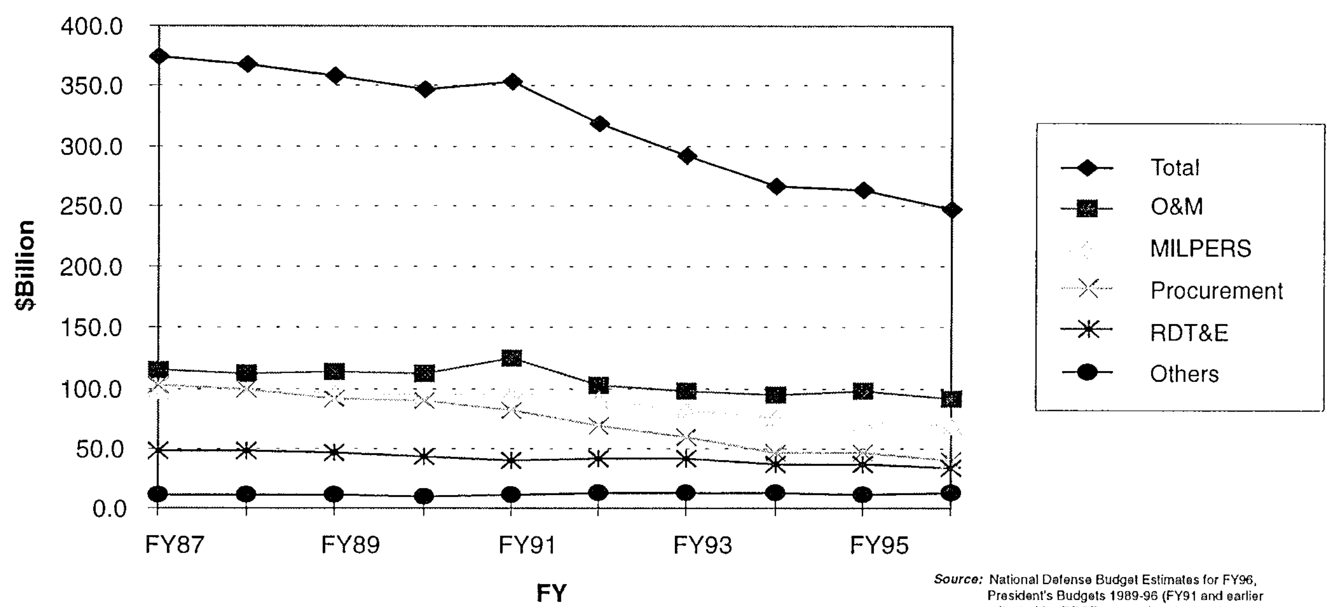
O&S cost is the sum of the weapon system operations and maintenance (O&M) budget appropriation, the military personnel (MILPERS) appropriation, and a small amount of costs in other appropriations (e.g., military housing maintenance).

Direct O&M costs comprise fuel, depot maintenance, depot-level repairs (DLRs), interim contractor support (ICS), contractor logistics support (CLS), consumables, and like expenditures.

Indirect O&M costs comprise base operations support (BOS), medical support, individual training, PCS moves, communications, administration, and related expenditures.

This briefing primarily concerns direct O&M costs and MILPERS. It is these costs that are most directly tied to the technical design characteristics of weapon systems.

DoD Appropriations (FY96 $Billion)



Source: National Defense Budget Estimates for FY96, President's Budgets 1989-96 (FY91 and earlier adjusted for DBOF accounting changes).

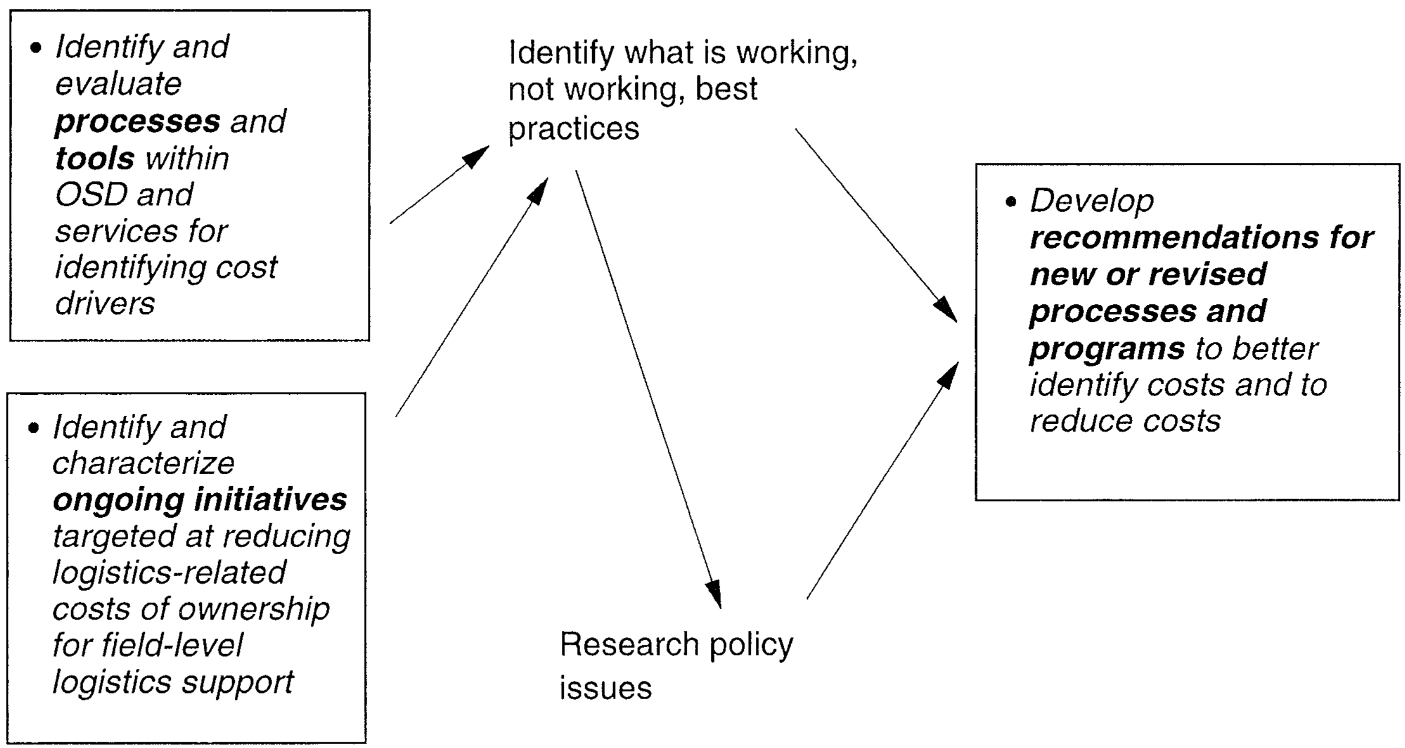
DoD Appropriations (FY96 $ Billion)

This chart illustrates the reason for the present study. In conjunction with the reduction in force structure, DoD total obligation authority has decreased more than 25 percent since 1987. Budget data indicate that most of this decrease has been absorbed in the procurement account and proportionately less in the O&M, MILPERS, and other accounts. The problem is that force modernization depends on a healthy procurement account.

There are structural reasons for the differences in rates of decrease. As an example, it costs money to bring troops back from overseas and to close bases. Thus, O&S would be expected to lag force structure. And some costs, such as medical and environmental, have upward pressures in DoD, just as they do in society at large.

Our task, however, was to take as given the structural realities and determine how much leverage technology insertion can provide to reduce O&S costs.

Study Objectives



Study Objectives

The study objectives and approach are shown graphically on this chart.

Study Objectives

The first two tasks were to

- identify and evaluate the processes and tools that the Office of the Secretary of Defense (OSD), the Army, Navy, Air Force, and Defense Logistics Agency (DLA) are currently using to identify cost drivers; and
- identify and characterize their ongoing programs that are targeted at reducing operating and support costs through insertion of newer technology.

The results of these two tasks provided a basis for determining what approaches were working or not working and for identifying the best practices in DoD.

During the study, we also looked for issues that required policy changes to improve processes or remove obstacles to O&S cost reduction.

The final part of the study involved developing recommendations for new or revised processes and programs to better identify and reduce O&S costs.

Approach

Based on an initial literature search, preliminary interviews, and a preliminary evaluation of cost-tracking methods, we developed a set of working hypotheses that were subject to confirmation or refutation on the basis of study research.[2] More importantly, they guided the main body of research, which largely consisted of semistructured interviews with representative key organizations in Army aviation and ground vehicles, Navy aviation, and the Air Force. Our interviews included service headquarters, intermediate commands, service program management and engineering staffs, and operational units. In addition to covering broad policy questions, the interviews were the mechanism for reviewing service programs. A list of the principal organizations visited is at Appendix B.

Processes and Tools for Identifying Cost Drivers

- No service is capturing actual costs by weapon system
  - Typically capture maintenance rates and demand rates, then compute costs, allocate by weapon system
  - Processes error-prone, subject to data losses and erroneous factors
- For purposes of determining technology insertion opportunities (e.g., reliability improvement), tools are generally adequate
  - Can determine reliability bad-actors, cost drivers

Processes and Tools for Identifying Cost Drivers

We found that each of the military services has automated methods in place to characterize O&S costs. These include the various service-specific Visibility and Management of Operation and Support Cost (VAMOSC) implementations, as well as other systems.[3]

No service is capturing actual costs by weapon system. Typically, the services capture maintenance rates and supply demand rates, compute O&S costs using standard labor hour and supply prices, and allocate costs by weapon system. These processes are error-prone, subject to data losses (such as lost computer tapes), and also subject to erroneous input factors.

Despite such limitations, existing automated cost systems are good enough to support O&S cost reduction. The reason is that for purposes of determining O&S-related opportunities for technology insertion (e.g., reliability improvement), the methods are generally adequate. Although the systems cannot accurately determine absolute costs, they can establish relative costs, and this is what is needed to identify the cost drivers. It is the cost drivers that are prime targets of opportunity.

Technology Initiatives to Reduce Cost of Ownership – Fundamentals

- Availability of technology
  - Infrastructure
  - Embedded in weapon systems
- Requirement and determination to use technology for this purpose
- Opportunity to do so

Technology Initiatives to Reduce Cost of Ownership — Fundamentals

Three fundamental factors must be in place to use technology to reduce O&S costs.

First, the technology itself must be available. That is, it must be developed and proven sufficiently to be adapted to specific weapon systems, and it must provide a cost reduction opportunity. Application could be either to the weapon support infrastructure, or to an embedded subsystem or component of a weapon system itself.

Next, there must be resolve to use the technology to pursue cost reduction. This resolve includes both the requirement to use technology to achieve cost reduction and a determination to dedicate the resources to this end.

Finally, there must be an opportunity to apply technology.

Three Windows of Opportunity

- New systems
- Major modifications and upgrades
- In-service systems

Three Windows of Opportunity

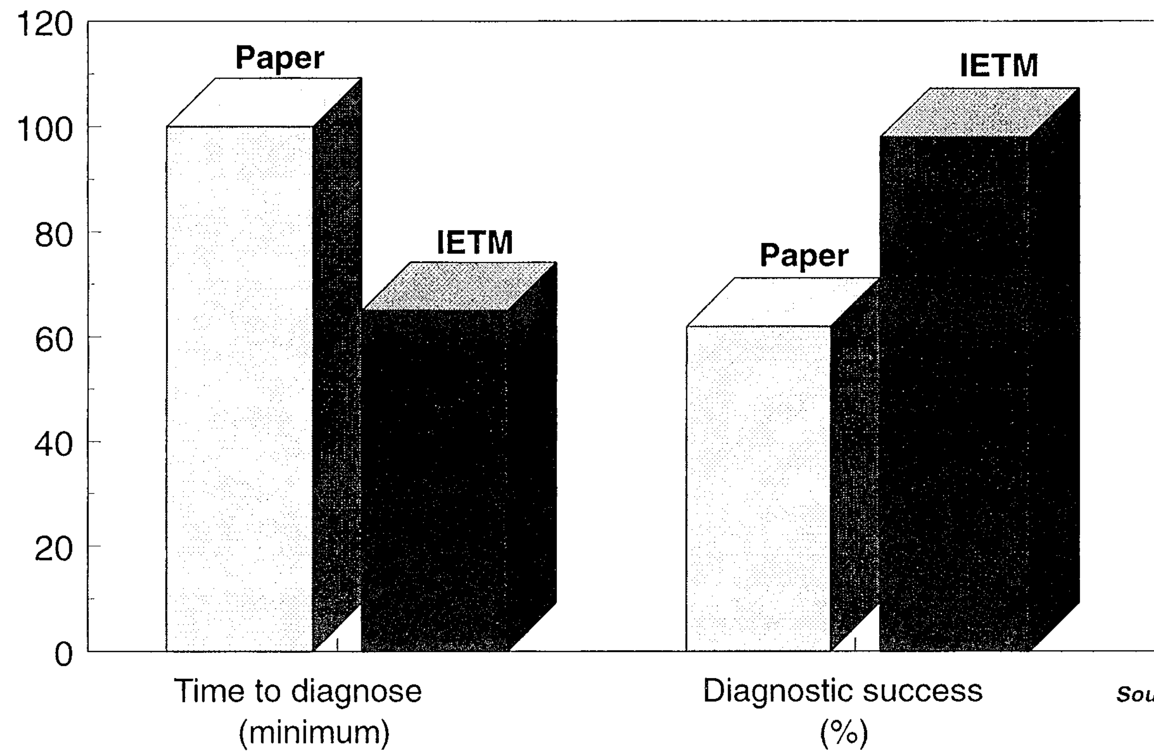
The life cycle of a weapon presents three basic windows of opportunity.

The most obvious opportunity is in the concept and early development phases of a new weapon system. The largest return on investment for O&S cost reduction may be possible at this stage, since it provides the greatest latitude in design.

The second opportunity, during major modifications, is also a large-scale design opportunity. Hence, it can also be an opportunity to reshape the O&S costs of a weapon system. We group these first two windows in our analysis because they both provide large-scale design opportunity and because they are often subject to the same acquisition process (i.e., scrutiny by the Defense Acquisition Board).

The third window of opportunity is the primary focus of the study: insertion of technology in in-service weapon systems.

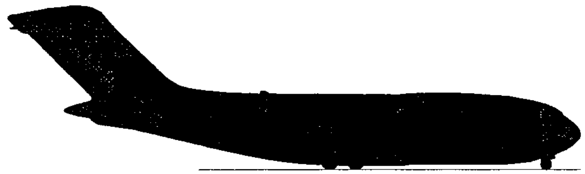
Infrastructure Technology Example: Interactive Electronic Technical Manual (IETM)



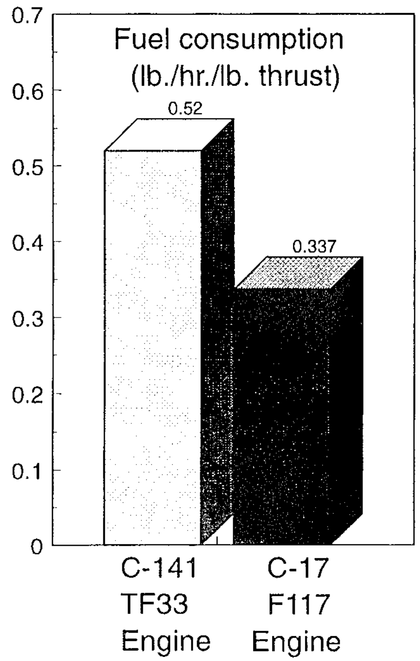
Source: CALS Journal
Winter 1992

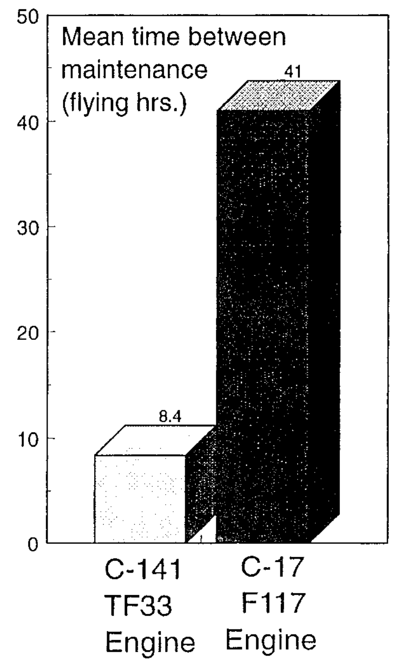
Infrastructure Technology Example: The IETM

As indicated, technology can be inserted into the infrastructure or into weapon systems themselves, and cost reduction opportunities exist in both cases. As an infrastructure example, this chart compares the time to diagnose and diagnostic success for paper and electronic technical manuals. (The data on this slide are from a demonstration test the Air Force ran on F-16 aircraft.) Note that using electronic technical manuals reduces diagnostic time by approximately 40 percent, with a correspondingly large increase in diagnostic success. Both are important to cost, but diagnostic success is particularly so: it influences retest-OK rates, and they influence spares pipeline requirements.



Embedded Technology
Example: C-17 (F117 Engine)





Sources: Pratt & Whitney, Air Force Reliability and Maintainability Information System (REMIS)

Embedded Technology

As an example of reducing costs by inserting technology into a weapon system, this chart compares fuel consumption and reliability for the engines that power the Air Force's new C-17 transport aircraft and its predecessor, the C-141. Fuel consumption of the C-117 engine on the C-17 aircraft is about 60 percent of that of the TF33 engine. Fuel, of course, is a major part of cost-of-ownership for aircraft.

In addition, the C-117 engine is roughly five times as reliable as the TF33.

It is relatively easy to marshal examples of this kind. In general, succeeding generations of technology normally offer both improved performance and improved supportability.

What is particularly interesting about this example, however, is that the five-to-one gain in reliability was achieved without it having been requested. We explain what we mean by this comment on the next slide.

New Systems and Major Mods: Logistics Requirements

Classical

C-X (1980)

- "Reliability and maintainability for the mature C-X will equal or exceed the best of the in-service airlift aircraft."

Major C-130 Mod (1990)

- "All modified/added aircraft systems or equipment must either meet or exceed the R&M values obtained by the same system equipment installed on similar aircraft."

More recent

JAST

- Logistics level of effort measured as part of early campaign-level needs/deficiency analysis.

JDAM

- Source selection plan ranked affordability #1 criterion.
- Contractors graded every four months on O&S cost drivers.
- "No-quibble" warranty.

New Systems and Major Mods: Logistics Requirements

In the upper left hand corner of this slide is a quotation from the Mission Element Need Statement (MENS) for the C-X aircraft (later the C-17). Note the very conservative statement of reliability and maintainability requirements, essentially asking for results the same as those from the C-141 aircraft, not markedly better. One has to wonder: If a five-to-one gain in reliability was achieved without it having been requested, what would have been the result if a marked improvement had been a requirement?

Unfortunately, conservative logistics requirements have been the norm, not the exception. In 1990, 10 years after the C-X MENS, very nearly the identical language stipulated the reliability and maintainability requirements for a major C-130 modification. Nor are conservative requirements limited to the Air Force. During our field research we found equivalent examples from the Army and fully expect that; had we looked for them, we would have found examples in the Navy as well.

One may call the kind of requirements language found on the left side of this chart "classical." Compared to them, a cultural shift is at least beginning in more recent acquisition programs. Two of the most recent multiservice programs can illustrate the point.

The Joint Advanced Strike Technology (JAST) program, for which affordability is a major issue, is measuring logistics level of effort as part of early campaign-level needs and deficiency analysis. The JAST office talks in terms of a "logistics mold-line" in the same sense that one speaks of the mold-line of the physical aircraft. As a result, the logistics cost drivers are being identified and addressed as part of the early design of the aircraft.

The Joint Direct Attack Munitions (JDAM) program is a second exception. The JDAM is a global positioning system (GPS)-guided munition — a kit that attaches to existing bombs such as the MK80 series. The phase II engineering and manufacturing development (EMD) source-selection plan for this program ranked affordability (overall cost of ownership) as the No. 1 source-selection criterion. During EMD phase I, contractors were graded every four months on O&S cost drivers. Placing emphasis on affordability (said another way, placing emphasis on using technological advances for this purpose) lowered projected O&S cost (and unit cost) much more than had been anticipated. The JDAM program office was also able to obtain a no-quibble warranty from the winning contractor.

We concluded that the technology to reduce O&S cost is there; arguably it has always been there. What is needed to capitalize on this opportunity is a requirement to use it for cost-of-ownership reduction purposes. DoD should take deliberate action to institutionalize the kind of behavior represented on the right side of this chart.

Three Windows of Opportunity

- New systems
- Major modifications and upgrades
- In-service systems
  - Reliability and maintainability
  - Technology insertion examples
  - Technology insertion processes

Three Windows of Opportunity

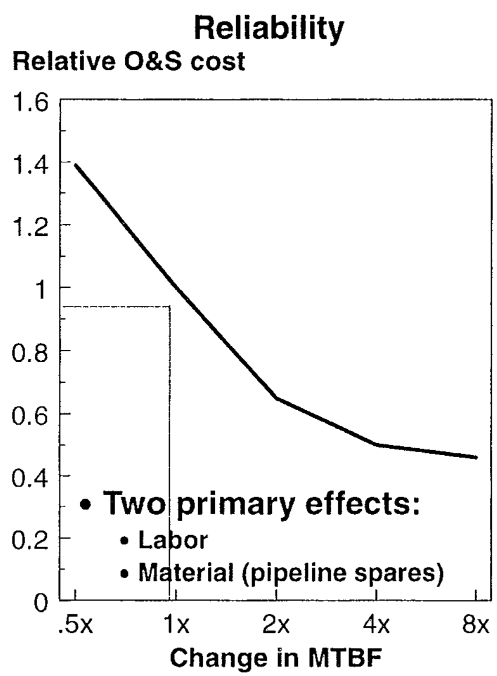
Thus far, we have discussed new systems and major modifications. There were reasons for restricting the amount of attention that we spent on these two. First, not that many major new systems or major modifications are in the acquisition pipeline. Second, the technology to reduce the O&S costs of new systems is demonstrably available, and programs like JAST and JDAM offer some reason for optimism that there will be a requirement to use technology for this purpose. (And third, when we performed this research, we were aware of an OSD integrated product team that was specifically looking at cost of ownership in the context of new system and major modifications.)

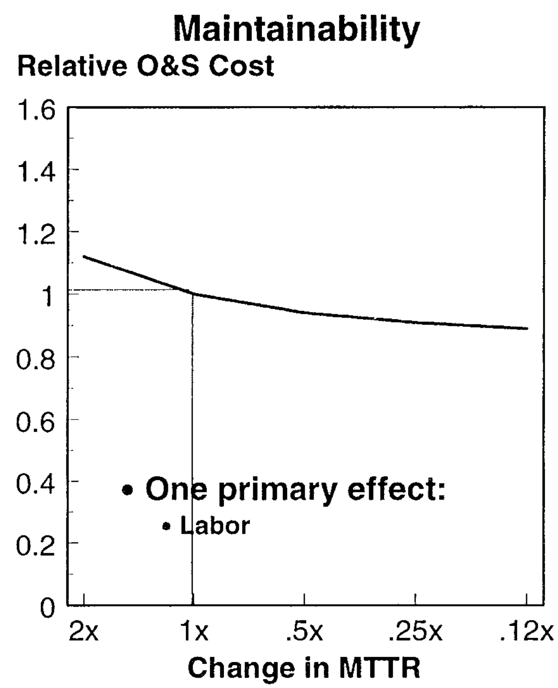
For the remainder of this briefing, we will turn attention to in-service systems. Specifically, we will cover three topics:

- the relative O&S reduction leverage available from reliability and maintainability;
- what real-world opportunities look like, using specific examples of technology insertion; and
- the processes for inserting technology.

We will show that it is the processes for inserting technology, not its availability, that are the major impediment to using technology to reduce O&S cost.

Reliability Provides More Leverage





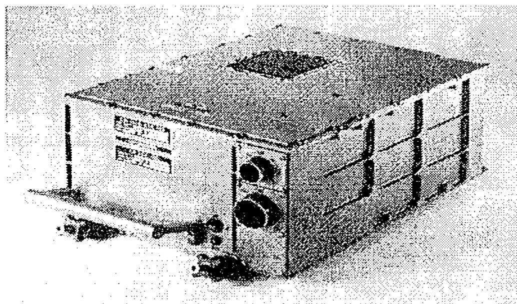
Source: Cost Analysis, Strategy Assessment Model

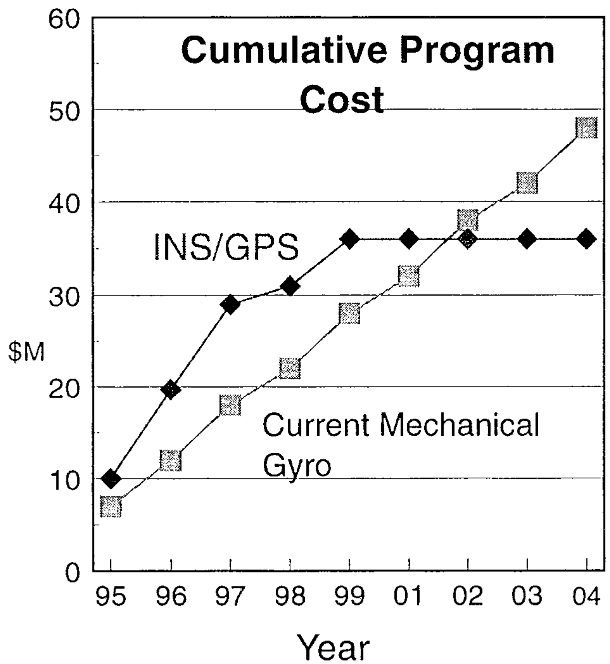
Reliability Provides More Leverage

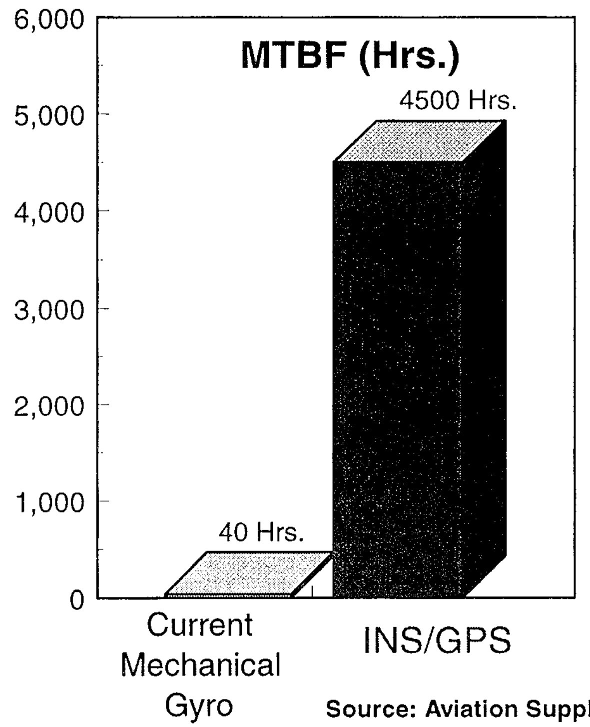
It is generally recognized that, for in-service systems, reliability and maintainability are key to reducing cost of ownership. Much more leverage, however, is available by improving reliability than maintainability.

These two charts illustrate the difference.[4] They are scaled to show equivalent improvements in reliability and maintainability on the horizontal axis — doubling the mean time between failures for each tick mark on the left chart, and halving the mean time to repair for each tick mark on the right chart. The relative change in O&S cost is much greater for a doubling of reliability than it is for a halving of mean time to repair. That is because maintainability affects primarily one production factor, labor, whereas reliability affects not only labor (a unit that does not fail consumes no repair labor) but also material. Reliability is one of the primary determinants of spares pipeline quantities and cost.

Technology Insertion:
F-14A/B Inertial System







Source: Aviation Supply Office (ASO) BOSS III Program Office

Technology Insertion

The data behind the charts on the previous slide were calculated using a model, so the results were somewhat hypothetical. These next two charts illustrate how improved reliability translates into cost reduction in the real world. This chart depicts the results of a Navy project to replace older mechanical gyroscopes with modern electronic ring-laser gyroscopes. First, we will discuss reliability (on the right chart) and then cost (on the left).

The current mechanical gyroscopes on the F-14A/B aircraft are demonstrating a mean time between failure of about 40 hours. Under the Best Overall Support Solutions (BOSS-III) program, the Naval Inventory Control Point (NAVICP, previously the ASO) is replacing these gyros with a new subsystem that also integrates GPS functionality. This Embedded GPS Inertial (EGI) system is demonstrating approximately 4,500 hours MTBF, more than a 100-fold improvement.

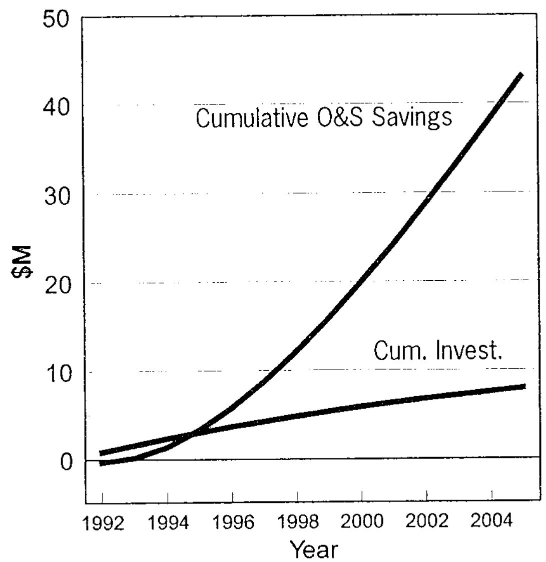
On the left is the cost behavior. It is important to understand what costs are being counted. Under BOSS-III accounting rules, the NAVICP addresses those costs and savings for which they are responsible — that is, changes in material costs to repair or replenish spare parts. Excluded are field-level costs such as military labor. One reason for defining costs this way is intentional conservatism when calculating the expected benefits from technology insertion. There is an argument that the improved reliability does not generally reduce the numbers of military technicians.[5]

Given those ground rules, the chart on the left compares the cost to continue to support the current mechanical gyro with the cost to do the necessary installation engineering, procure, install, and then support the EGI. The EGI cost is higher initially but reaches the break-even point in approximately five years. (Breaking even in five years, incidentally, is a requirement of the Defense Business Operation Fund [DBOF]-financed BOSS-III program.) After that point, support costs for the EGI virtually disappear as a result of the much higher reliability of this unit. Hence, the good news is that reliability can make a very large difference in O&S costs. Also true, however, is that this improvement is not free.

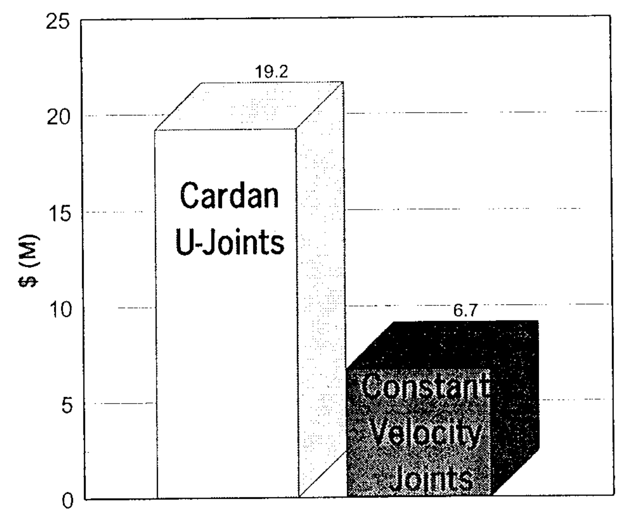
Using the conservative accounting rules described above, overall return on investment (ROI) for NAVICP BOSS-III projects has been about 2.8:1, calculated over the lifetimes of the weapon systems supported.

Technology Insertion:
M939 5-Ton Truck Constant Velocity Joints

Constant Velocity Joint Investment and Savings



Tire Cost Comparison (Annual Fleet Average)



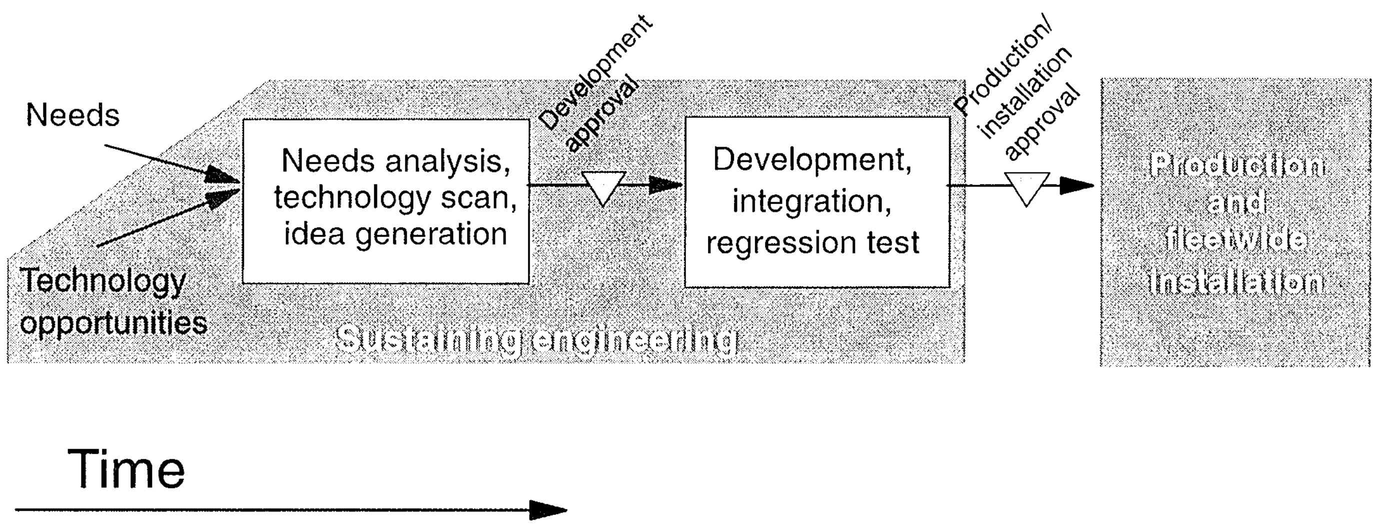
Source of data: Tank-Automotive and Armaments Command

Technology Insertion

Technology insertion opportunities, of course, are not limited to aircraft. This example from the Army Tank-Automotive and Armaments Command (TACOM) illustrates the opportunity for inserting technology in something as prosaic as a 5-ton truck. The example also illustrates the point that cost reductions do not always depend on reliability improvements.

The Army's 5-ton trucks are 6-wheel drive vehicles. They were designed with Cardan universal joints on the front axles. Due to their simple geometry, U-joints cause a sinusoidal variation in tire rotation speed when the vehicle is turning. This results in accelerated tire wear in turns. (That is why automobile manufacturers have designed front-wheel-drive cars with constant velocity [CV] joints.) TACOM has introduced a program to opportunistically replace U-joints with form-fit-compatible CV joints: whenever a U-joint fails, both U-joints on that axle are replaced with CV joints. The savings here result not from higher reliability of the joints, but from decreased tire wear. This program achieves very rapid savings, with a break-even point in about two years.[6] TACOM's Technology Insertion-Operation and Support Cost Reduction (TI-OSCR) program under which this modification is funded is, like BOSS-III, a DBOF program.

In-Service Systems: Technology Insertion Process



In-Service Systems: Technology Insertion Process

The previous slides discussed reliability and maintainability and provided two technology insertion examples. The purpose of those slides was to make the point that technologies are available to reduce O&S costs. The next several slides address the DoD processes for inserting technologies.

DoD technology insertion for in-service systems is an instance of the classic innovation process. That process has three basic stages. In the first stage, user needs are married with technology opportunities through needs analysis, technology scanning, and idea generation. This stage is followed by a gate, the purpose of which is selection of those opportunities that are worthy of development. The process of development, integration into weapon systems, and regression testing then provides "production-ready" modification designs. We will refer to the combination of the first two stages as sustaining engineering.

Sustaining Engineering Status

- Engine Component Improvement Program (CIP)
  - $140 million/year (R&D)
  - In practice, cost of ownership projects consistently below "cut line"
- Other commodities (avionics, hydraulics, electrical, ...)
  - No equivalent to CIP – isolated, individually small projects
  - Funding fragmented, limited, unreliable
- Consumables
  - Services have engineering responsibility
  - DLA has demand data
  - Effectiveness limited
- But ... sustaining engineering is generating candidate projects, not a major bottleneck

Sustaining Engineering Status

It is useful to think of sustaining engineering as comprising three different components: for turbine engines, for commodities other than turbine engines, and for consumables.

Sustaining engineering for engines is supported by the engine CIP.

- CIP has been funded in recent years at about $140 million annually, almost all of which is research and development (R&D) funds. Although this is less than the CIP managers believe necessary for the program, they made the point during interviews that as important to them as the absolute level of funding is consistency of funding from year to year. Generally, CIP is free from wild year-to-year variability in funding level. As a result, a knowledgeable engineering team is maintained and CIP management is able to work with engine users to prioritize projects and be reasonably certain that they can execute as prioritized.

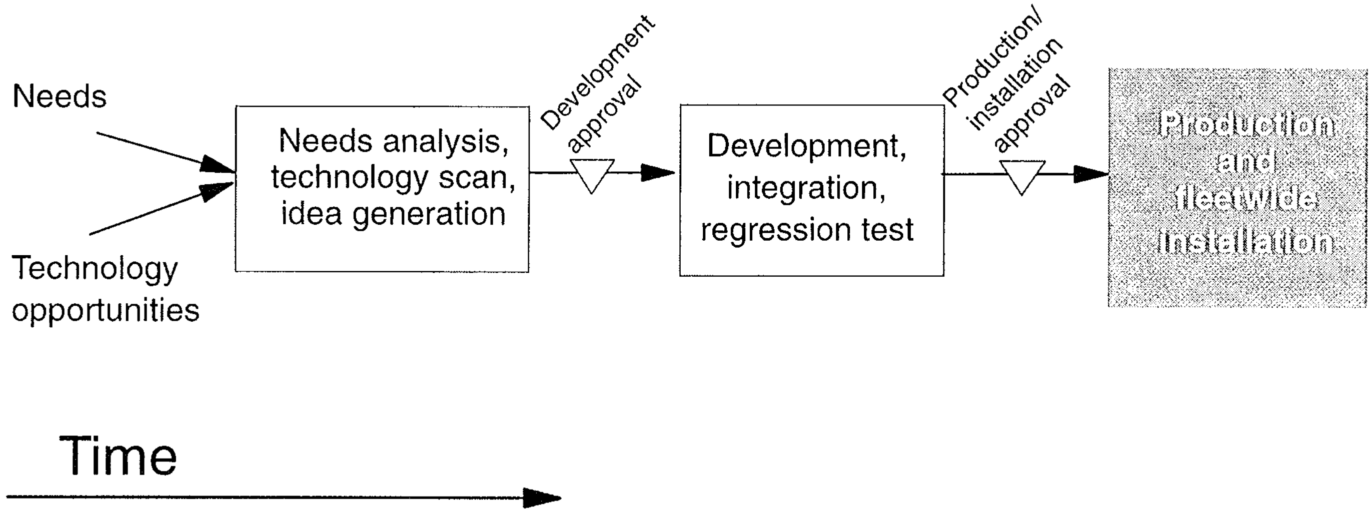
- In practice, however, projects whose purpose is reducing cost of ownership have consistently been prioritized below the "cut line" — that is, prioritized too low to be funded. (This is not to say that CIP projects do not result in reduced O&S costs. They do, but as a side-effect of engineering redesign undertaken for safety or operational purposes.)

Sustaining engineering for other commodities (such as avionics, hydraulics, and electrical systems) is much more fragmented than for CIP. Instead of a single, reasonably coherent program, one finds many small projects. The natural result of this is that funding is also fragmented, limited in amount, and inconsistent. In turn, this generates considerable frustration on the part of engineers. They find themselves spending a disproportionately large amount of their time trying to find funds rather than doing engineering.

Sustaining engineering for consumables presents a third situation. The services have engineering responsibility for consumables. DLA, however, has item management responsibility. The result of this split is that the service engineers understand the systems in which consumables are used but do not have ready access to demand data, which resides with DLA. DLA item managers understand the demand data but are remote from the applications. The result is that the effectiveness of sustaining engineering for consumables is limited. (We are not certain, however, that this is a major stumbling block. There is an argument with at least face validity that problems with consumables are better worked from the assembly level down than from the consumable level up.)[7]

In spite of the various shortcomings described above, sustaining engineering is not a major bottleneck at present; it is generating candidate projects. However, two caveats are in order. First, it is clear from the field research that engineers are not bringing their best candidates forward. Lacking a consistent source of production funding for cost of ownership reduction projects, there is little or no incentive for them to do so. Second, if there were a sustained source of production funding, it is possible that the current backlog of ready candidates might be quickly dried up. In the long term, sustaining engineering for in-service systems does require attention. It is not the most important problem today.

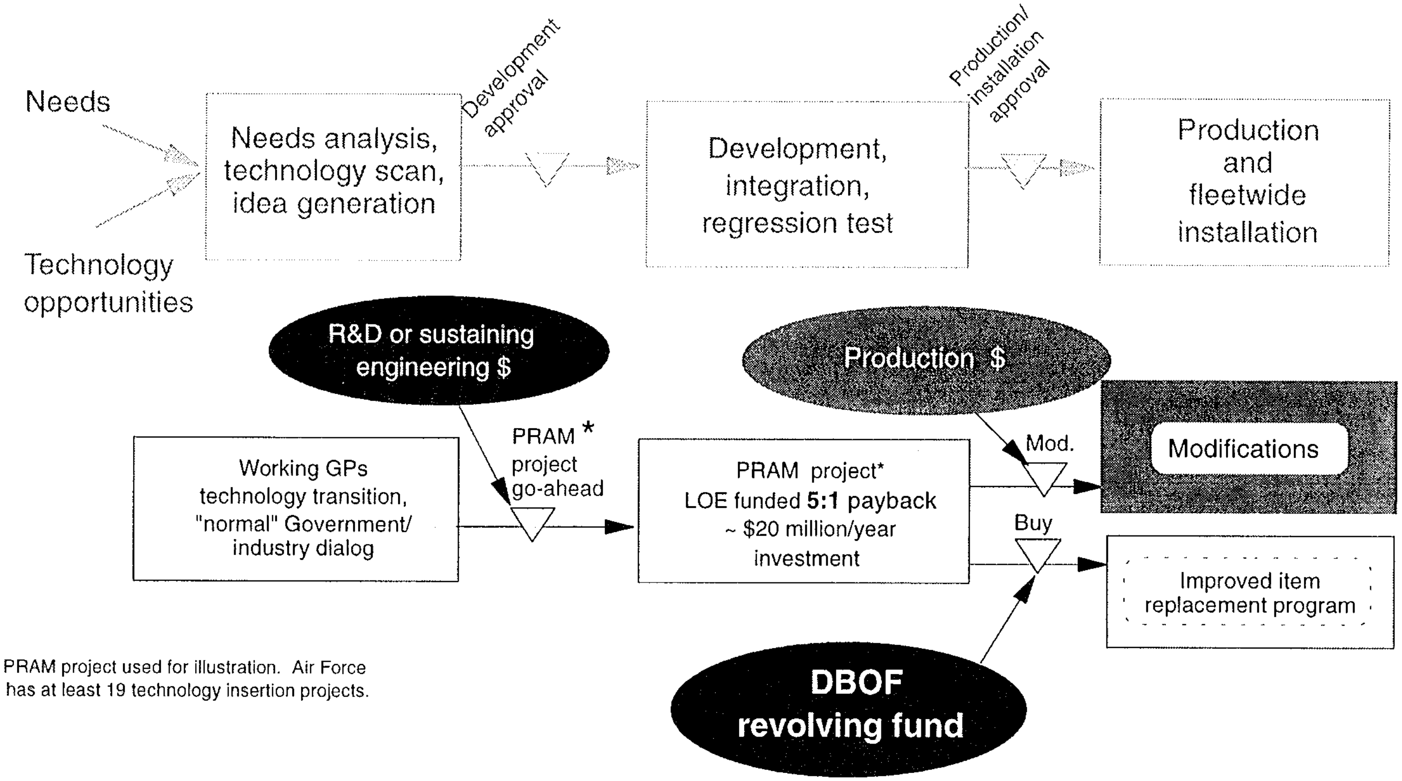
Technology Insertion Process: Production and Fleetwide Installation



Technology Insertion Process

The most important problem today is not sustaining engineering but production and field installation. We will focus on these processes on the next two slides.

Air Force Technology Insertion Process



* PRAM project used for illustration. Air Force has at least 19 technology insertion projects.

Air Force Technology Insertion Process

This chart is a sketch of the Air Force Technology Insertion Process. In order to discuss Air Force production and installation funding, it is useful to begin, first, with the early stages of the process on the left side of the chart.

The Air Force has a relatively structured method for matching user needs and technology opportunities. It includes formal product improvement working groups and a Technology Transition Office located at Wright-Patterson Air Force Base, Ohio. Both augment normal government-industry dialog.

The Air Force has at least 19 specific projects for taking the output of the first stage and doing development. Total funding for the 19 projects is about $200 million annually. One of these, the Producibility, Reliability, and Maintainability (PRAM) project, will serve to illustrate how they all work.

PRAM is level-of-effort funded at about $20 million per year.[8] The project's intended output is producible designs, missionized for specific aircraft or other systems. PRAM is successfully generating these designs. Overall PRAM return on engineering investment is about 5:1.[9]

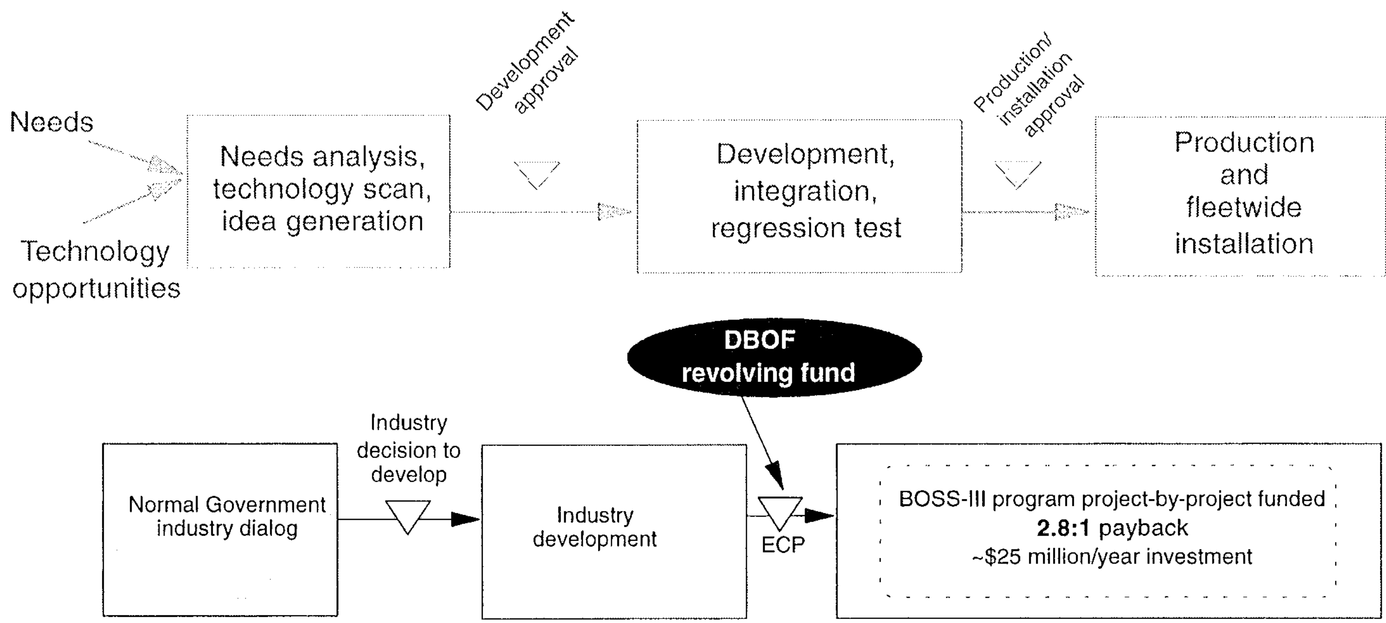
The problem is in production. The Air Force has two routes to production. It can use either procurement funds via the formal modification process, or it can use the Defense Business Operations Fund.

Our interviews with personnel in both HQ Air Force and a major operating command indicate that since the early 1990s no procurement funding has been available for projects whose purpose was to reduce O&S costs.

The second route is via the DBOF-based Air Force Improved Item Replacement Program (IIRP). IIRP was created in 1991 but was unfunded until 1995, when it was funded with $15 million.

Thus, the Air Force has two methods for funding production of cost-reduction modifications, but with the exception of $15 million in the 1995 IIRP, neither has been funded since the early 1990s.[10]

Navy (BOSS-III) Technology Insertion Process



Navy (Boss-III) Technology Insertion Process

Neither the Navy nor the Army uses production funds to reduce operation and support costs. Both use DBOF funds for this purpose. Since the two services use similar approaches, we will illustrate just one, the Navy BOSS-III process. (The equivalent in the Army is the OSCR program mentioned earlier.)

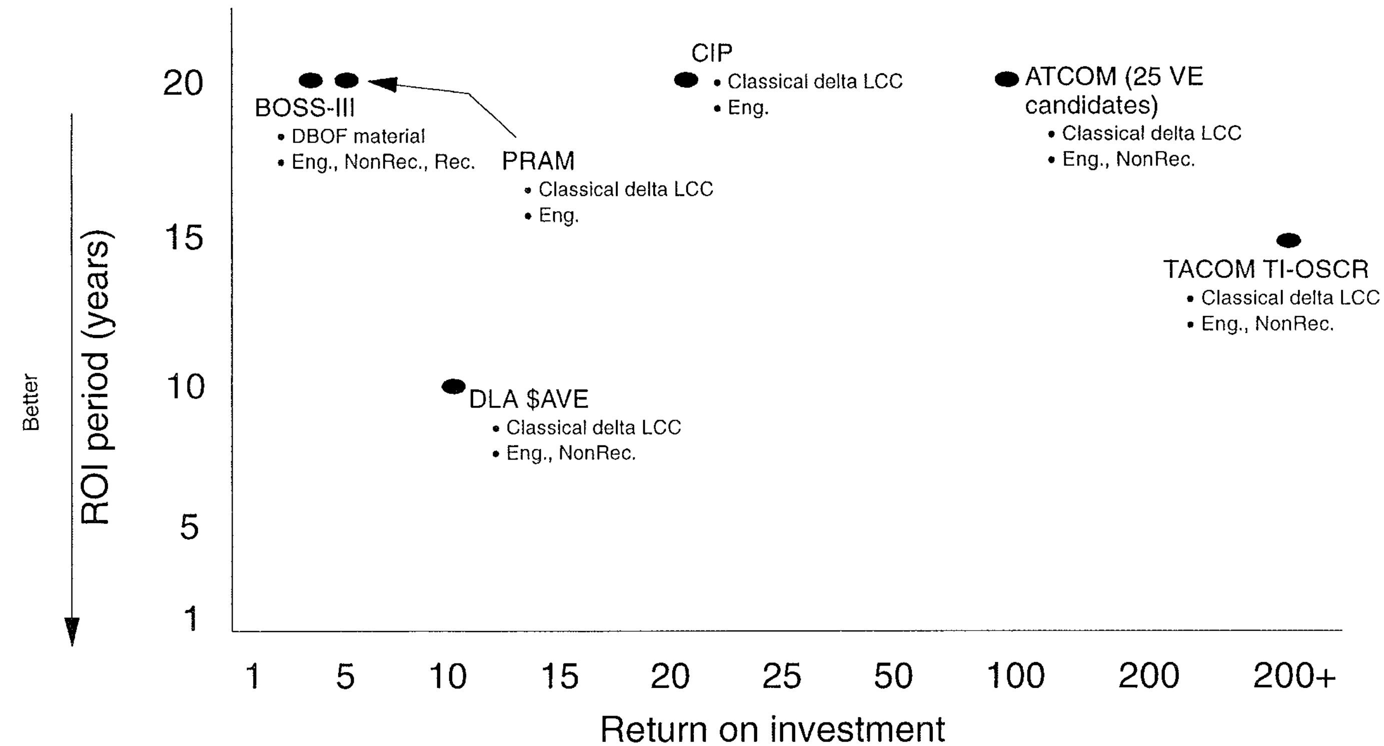
There are some fundamental differences between the Air Force approach and that of the Navy and Army. One is the absence of a structured first stage; both the Navy and Army rely on normal government-industry dialog. Additionally, the Navy and Army make one decision, to fund an engineering change proposal (ECP), not two as was the case for the Air Force.

BOSS-III is project-by-project funded under DBOF. The overall funding level is about $25 million per year, and the ROI is about 2.8:1.

Although the BOSS-III ROI appears lower than the PRAM ROI, the difference results from different counting rules. The Naval Inventory Control Point estimates both the return and investment components of ROI conservatively. For investment, it accounts for all implementation costs, including engineering, testing, nonrecurring tooling, and kit production. For return, it counts only the cost benefits to the DBOF account for which it is responsible — that is to say, it takes credit only for reduced spare parts purchases and reduced repair costs. Potential savings in second-destination transportation or field-level repair are not included, since these are outside DBOF. (The Army does two calculations, both with and without field labor.)

The annual $25 million in BOSS-III funding is not the result of a decision to establish a certain budget for this purpose. Rather, what it represents is the funds needed to support candidate projects that meet the BOSS-III approval criteria and that industry is willing to bring forward. BOSS-III is starved for candidates, not starved for funding. A significant reason for this situation is the amount of risk that is transferred upstream to industry. BOSS-III takes over once the technology itself is proven and once industry has come forward with an ECP. Industry is being asked to absorb the initial development costs and the costs of preparing an ECP that may or may not be implemented. Naturally, industry managers bring forward only those opportunities that they view as highly likely of being funded.

Technology Insertion ROI (Project • Numerator • Denominator)



Technology Insertion ROI

Thus far, we have mentioned two specific ROI examples, 2.8:1 for the Navy's BOSS-III program and 5:1 for the Air Force PRAM program. It had been our initial intent to normalize the various ROIs reported by the services and the DLA into a single number. This proved impractical; there are too many differences in accounting rules and the periods over which ROI is being claimed. Instead, we have simply arrayed the raw data on this slide.

The vertical scale represents the period over which ROI is being calculated. For a given ROI, a shorter period is better because savings are achieved in less time. The horizontal scale is the ROI itself. Portrayed on the graph are the ROIs we found. For each we have shown in summary form the rules that were used to determine return (the numerator in the ratio) and investment (the denominator).

For example, as discussed earlier, the NAVICP in computing return took credit for material savings only. It calculated these savings over 20 years or the expected life of the weapon system supported, whichever was shorter. It recognized *all* implementation costs, including the engineering needed to adapt technologies for a particular mission, regression testing, nonrecurring tooling, and recurring production. The conservative accounting rules give the NAVICP BOSS-III program what appears to be a low ROI compared to other programs.

Next to NAVICP's BOSS-III is the Air Force's PRAM at 5:1, also over 20 years. In this case, the savings being recognized are what we would call a "classical delta Life Cycle Cost (LCC)." They include all of the classical operation and support costs (e.g., military unit-level labor, inventory management, transportation, and various indirect costs such as base operating support). In the cost of implementation, only the engineering performed under the PRAM program is recognized; not the missionization to marry a particular technology to a specific platform, the regression testing to assure operability, nonrecurring tooling, or the cost to produce retrofit kits.

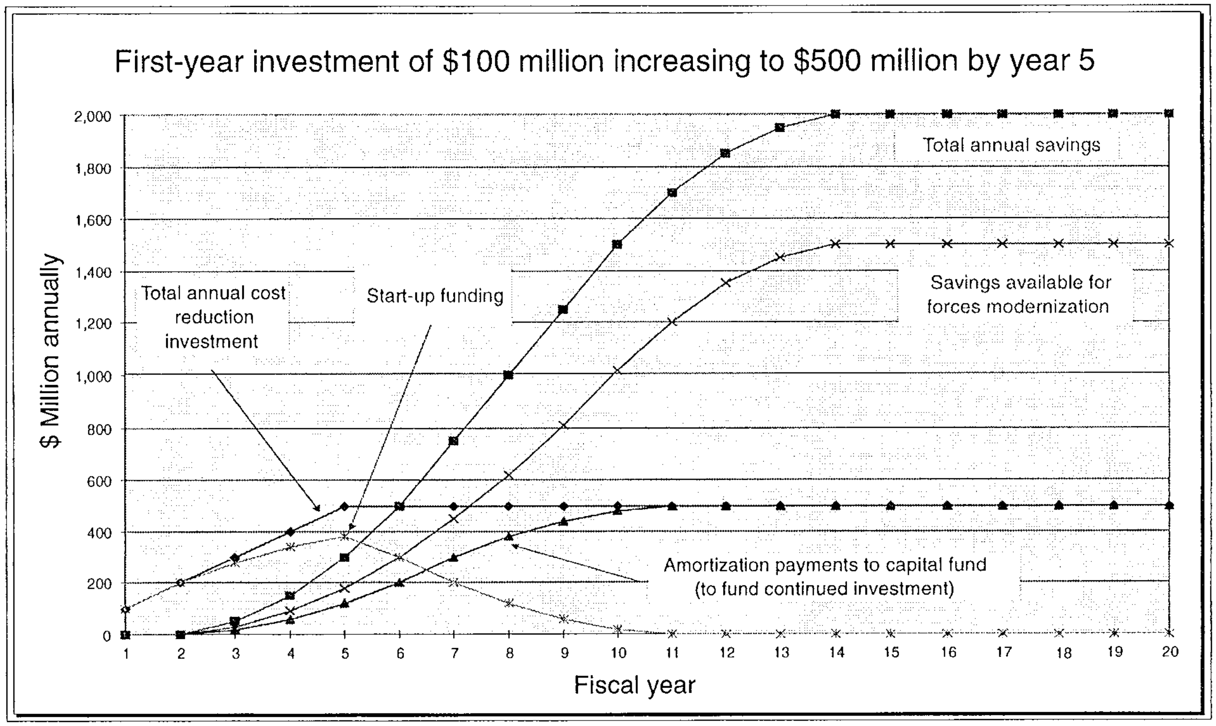
The other ROIs on the chart can be interpreted from the notations shown with each of them.

If we were asked to identify a single number that best represents what can be achieved today, it would be a 5:1 ROI over a 20-year period, following ground rules essentially similar to those adopted by NAVICP. It was clear from our interviews that this relatively low ROI is as much a result of the limited production funding as any other factor. Lacking an expectation that production funding will be available, industry or service engineering staffs have little or no incentive to bring forward the best cost-reduction opportunities.

Given the very soft empirical base, the most optimistic we are willing to be, at present, regarding potential ROI from a more aggressively funded production program is on the order of 9:1 over a 20-year period.

Subsequent to this portion of the study, we developed a spreadsheet model to compute ROI for evaluation of future projects. This model, which is discussed in Appendix A, uses a rule set that represents the best practices seen in this portion of the study.

Potential Savings from an Aggressive Technology Insertion Program



Assumptions: 9:1 ROI over 20 years, project life 10 years. Amortization over 5 years; savings and amortization start year 2.

Potential Savings from an Aggressive Technology Insertion Program

The purpose of this chart and the next is to illustrate how a sustained program of investment in O&S cost-reducing technologies might behave. In generating these graphs, we made some basic assumptions:

A 9:1 ROI would accrue over 20 years, with savings starting in the second year.

Any given investment would generate a saving stream for at least 10 years. (Thus, the total annual savings level off as 10-year-old investments stop generating savings.)

Each year's investment is amortized over 5 years, also starting in the second year to coincide with savings generated by that investment.

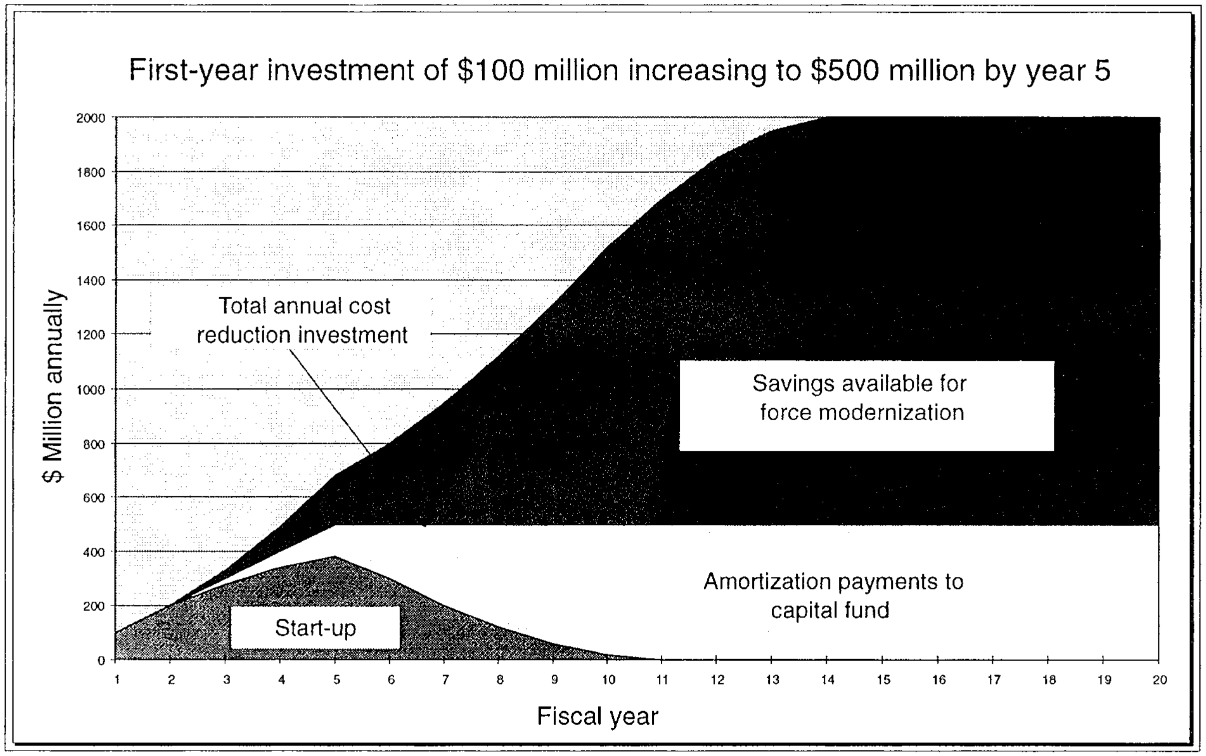
The amortization payments are returned to the DBOF capital fund to fund subsequent investments and thus reduce the annual appropriated cost-reduction investment. (At the steady-state condition, the amortization payments equal the total annual cost reduction investment and no appropriated funds are needed — i.e., the program is self-financing.)

The savings available for forces modernization equal the total annual savings less amortization payments to capital fund.

This chart and the following chart show the savings generated from a cost of ownership reduction program that invests $100 million in the first year, increases by $100 million per year to $500 million, and then remains at that rate.

With these assumptions, the steady-state $500 million annual investment (totally funded by amortization payments) generates $2 billion in savings each year and thus makes $1.5 billion available for modernizing forces.

Potential Savings from an Aggressive Technology Insertion Program



Assumptions: 9:1 ROI over 20 years, project life 10 years, amortization over 5 years, savings and amortization start year 2.

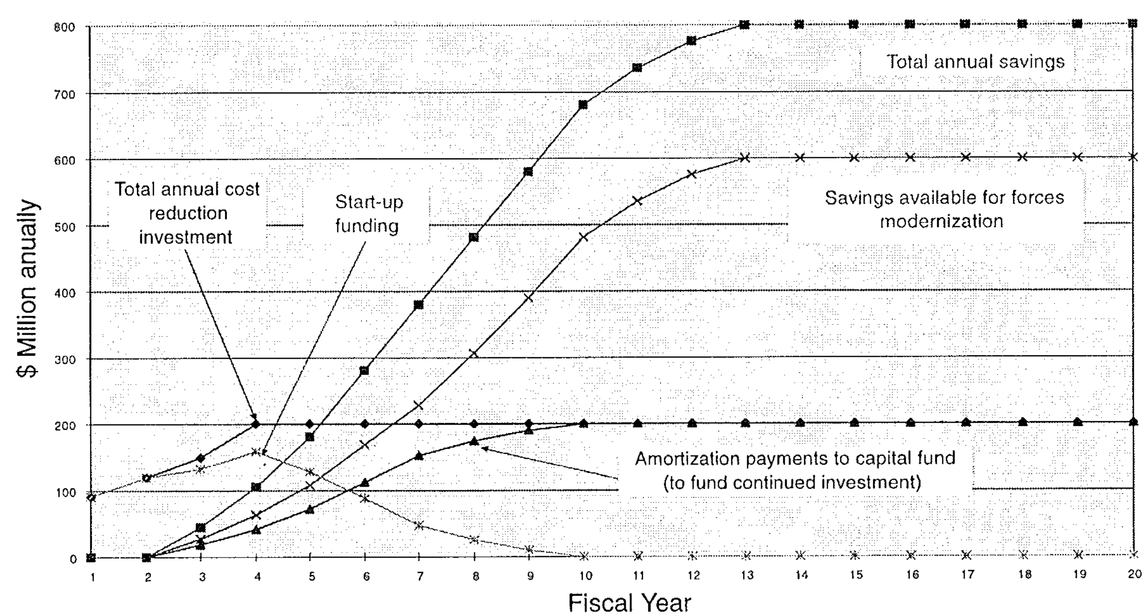
Potential Savings from an Aggressive Technology Insertion Program

This chart depicts the data from the aggressive program on the previous chart in a summary form. The start-up funding (the source of these funds will be discussed on a later chart) is shown initially making up the primary portion of the total annual cost-reduction investment. As amortization payments begin, they off-set start-up funding until the point they totally sustain the investment program. The program is then self-financing.

This chart assumes that the O&S savings are used to fund the amortization payments and the remainder of savings ($1.5 billion at steady state) are made available for force modernization. This assumption allows the users to pay for the investments (amortization payments in the form of DBOF surcharge) during the time they are realizing reduced O&S cost. This will be discussed on a later chart.

Potential Savings from a Modest Technology Insertion Program

First-year investment of $90 million increasing to $200 million by year 4



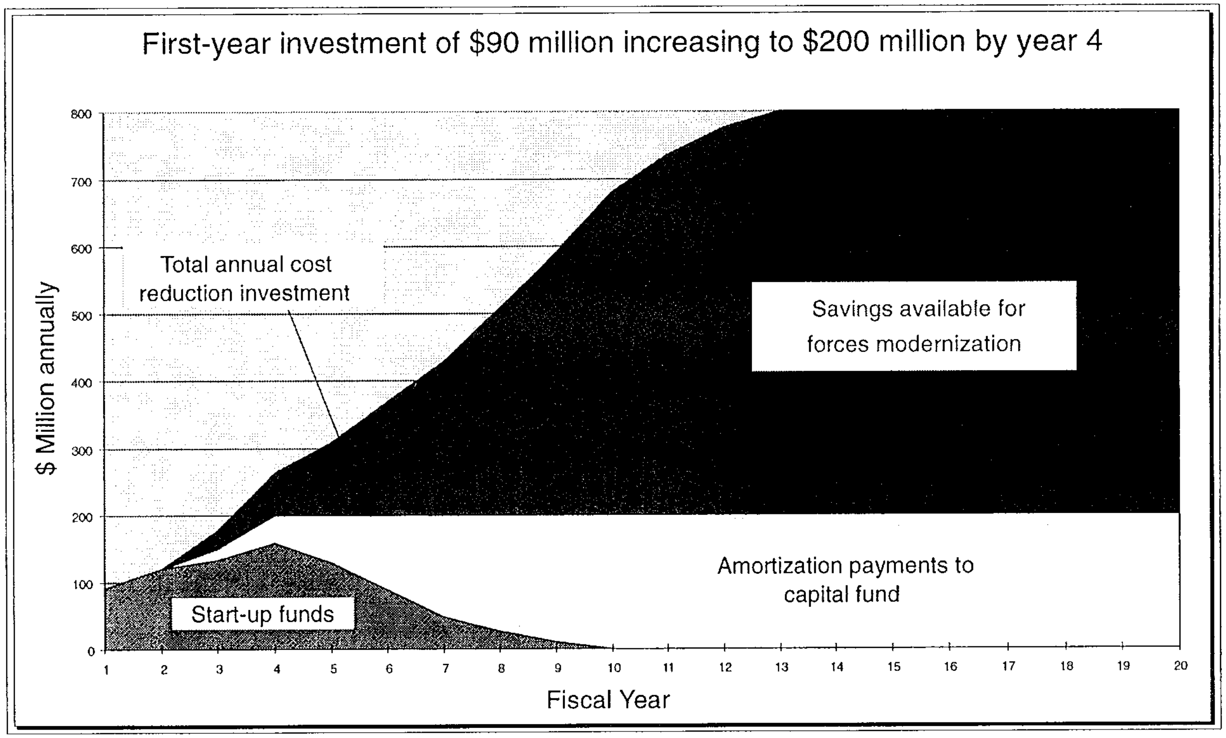
Assumptions: 9:1 ROI over 20 years, project life 10 years, amortization over 5 years, savings and amortization start year 2.

Potential Savings from a Modest Technology Insertion Program

This chart shows a more modest program that invests $90 million in the first year and increases to $200 million in the fourth year. This investment profile yields $800 million in total annual savings annually at steady state for the $200 million annual investment.

This profile results in $600 million each year available for forces modernization compared to $1.5 billion on the previous chart.

Potential Savings from a Modest Technology Insertion Program



Assumptions: 9:1 ROI over 20 years, project life 10 years, amortization over 5 years, savings and amortization start year 2.

Potential Savings from a Modest Technology Insertion Program

This chart depicts the data from the modest program on the previous chart in a summary form. Here again, the start-up funding is shown initially making up the primary portion of the total annual cost-reduction investment. As amortization payments begin, they off-set start-up funding until the point they totally sustain the investment program. The program is then self-financing.

This chart also assumes that the O&S savings are used to fund the amortization payments and the remainder of savings ($600 million at steady state) are made available for force modernization. This assumption allows the users to pay for the investments (amortization payments in the form of DBOF surcharge) during the time they are realizing reduced O&S cost. This will be discussed on a later chart.

Three Financing Alternatives

- Appropriated funds
- Defense Business Operations Fund (DBOF)
- DBOF with appropriated start-up funding

Three Financing Alternatives

The preceding charts show the need for substantial start-up investment before an investment program would be self-financing. Thus, it is important to explore the alternatives for marshaling such an investment. There are three: appropriated funds, the DBOF, and a combination of the two DBOF with appropriated start-up funding). We will now examine each of these alternatives.

Appropriated Funds

- Service-budgeted
  - Has not worked well in past, cost reduction projects historically fall below cut line
  - Evidence indicates not working today
- OSD-budgeted
  - Might work if some variant of Productivity Enhancing Capital Investment (PECI) model is used

Appropriated Funds

Either the military services or OSD could budget appropriated funds.

Historically, service attempts to budget funds for cost-reduction have not worked well. Typically, cost-reduction projects (as in the example of the CIP program mentioned earlier) fall below the prioritization cut line. As a further example, although all services have procurement accounts within which they fund modifications, no service is using procurement funds to fund cost-reduction projects today.

Appropriated funding might work if some variant of the PECI model were used.

PECI was instituted in the late 1970s to accelerate the substitution of capital for labor. OSD programmed funds for projects valued at greater than $100,000, and the services budgeted for smaller projects. Investment under PECI peaked in the early 1990s at $200 million annually. PECI claimed an ROI of 17:1 and an average payback period of under two years.

After 1993, OSD funding was ended and funding was inserted into service and agency budgets. Only the Air Force still has an active program. (The fate of PECI tends to reinforce the point made earlier regarding the problems of service funding.)

DBOF Financing – Three Approaches

	Approach	Comment
1	Include in DBOF operations budgets	Recovers investment Affects user prices in year of investment (pay now, benefit later)
2	Request direct appropriations for DBOF components	Investment not necessarily recovered User prices unaffected, amounts to a pass-through
3	Use DBOF capital budgets	Recovers investment Depreciates investment over period of expected savings

DBOF Financing — Three Approaches

A potentially attractive alternative to appropriated funding is DBOF funding. We already showed that both the Navy and the Army have some current success with this approach. Three DBOF approaches could be considered:

1. First, the funds needed to finance cost-reduction modifications could simply be included in the DBOF operations budgets. This has the advantage of recovering the investment (and doing so immediately). However, it also affects user prices in the year of investment, forcing them to pay up-front for an investment that will produce savings later. Users understandably are not enthusiastic about this approach.

2. Second, it is possible to request direct appropriations for insertion into the DBOF components (Army, Navy, and Air Force). The problems with this approach are that the investment is not necessarily recovered (there is no obvious mechanism to do so) and that the approach amounts to a pass-through of appropriated funds. Hence, it adds little or no value while placing DBOF administrative procedures on top of appropriated procedures.

3. The third approach would be to use the DBOF capital budgets. This would permit recovery of the investment. Additionally, by amortizing the investment over the period of expected benefits, from the operational user's point of view it would match the cost and benefit streams in time. It is this approach that we recommend for serious consideration.

DBOF Capital Budgets – Two Ways to Fund Until Self-Financing

- DBOF cash
  - Assumes cash is available
- Appropriated input

Either way

- Requires initial start-up funding
- Magnitude of funding scales with magnitude of benefits desired

DBOF Capital Budgets — Two Ways to Fund Until Self-Financing

To implement the capital budget approach, it is still necessary to provide up-front funding until the program is self-financing. This funding could come from two sources: first, DBOF cash can be used, assuming cash is available; second, an initial appropriated input can be used.

To reiterate what we said earlier, a substantial initial investment will be needed for some time until the program becomes self-financing. The investment required depends on the magnitude of benefits desired. The period until the program becomes self-financing will depend on both the actual rate of return and the amortization schedule.

Findings

- Ability to measure O&S costs good enough to rank-order cost drivers
- Sustaining engineering problematic, but is generating opportunities
- Production funding is the showstopper
  - < $60 million annually, well under what worthy candidates can absorb
  - Elaborate, Service-specific funding rules add to problem
- Lack consistency in approaches to estimating benefits and not clear that benefits are being translated into reduced cost of ownership
- Technology can reduce O&S costs
  - Not a "silver bullet" because takes up-front investment
  - Is risk that estimated benefits will not be realized
  - But, overall, is reasonable to expect substantially reduced cost of ownership from expanded program
- DBOF capitalization (with appropriated input) appears preferable to other financing options
  - Recovers investment, self-finances
  - Matches customer charges with customer benefits

Findings

Our findings, then, are as follows.

Although systems for tracking service operation and support costs have difficulties, the systems are good enough to rank-order weapon system cost drivers. This, in turn, is sufficient to begin an O&S cost reduction program, and we would not council delaying such a program until the cost systems were improved.

Similarly, sustaining engineering is good enough to get started.

Production funding is the most seriously flawed. The sum across all services and DLA of funds presently available for reducing O&S costs is less than $60 million annually, and this is well under what worthy candidates can absorb. Additionally, elaborate, service-specific funding rules make it bureaucratically difficult to employ even this limited amount of funding.

The approaches to eliminating benefits lack consistency. Furthermore, because of the absence of processes for tracking what is done with benefits, it is not clear that they are being translated into reduced cost of ownership.

Insertion of technology clearly can reduce O&S costs, but it does not require an up-front investment. There is also some risk that estimated benefits will not be realized (e.g., if a weapon system is retired earlier than planned). But overall, it is reasonable to expect substantially reduced cost of ownership from an expanded program.

DBOF capitalization (with an initial appropriated input, if necessary) appears preferable to other financing options. Because it recovers the investment, it self-finances. Additionally, from the customer's viewpoint, it provides the opportunity to match the cost and benefit streams in time.

Recommendations

- Initiate program to more fully exploit technology insertion opportunities
  - Focused on production
  - Additive to current service funding
  - Meaningful in size ($\geq$ $100 million annually)
- Define rules of engagement
  - Incentives to participate
  - Methods for estimating and recovering savings
  - Approval criteria
  - Who budgets for and approves (e.g., services budget, select projects; OSD establishes program size, criteria)
- Use DBOF capital budgets (with initial appropriated input) to facilitate financing

Recommendations

Our recommendations, then, are as follows.

Initiate a program to more fully exploit technology insertion opportunities. Focus the program on production. Add it to current service funding. And, to make sure the program commands an appropriate level of respect, make it meaningful in size — notionally $100 million or more annually.

At the OSD level, define the rules of engagement. These need to include the incentives to participate, methods for estimating and recovering savings, approval criteria, and the budgeting process. Notionally, the services would budget (but against OSD-established budget targets), select projects, and execute the program.

Use DBOF capital budgets, with an initial appropriated input if needed, to facilitate financing.

Appendix A

Return on Investment Spreadsheet Model

As part of this study, the Logistics Management Institute developed a business case to assess the feasibility of a potential DoD-sponsored cost of ownership reduction program. Volume II of this report describes the business case and its results. The business case looked at available technology insertion opportunities and what leverage such a program could provide if it were initiated in the near future.

During field research for the study, we reviewed examples of technology insertion by the military services to determine "best practices." We found different approaches used to evaluate technology insertion opportunities and to determine return on investment (ROI). Because a common method of computation was needed to support the business case, we developed a spreadsheet model as a tool for reviewing potential service projects to reduce cost of ownership.

The model defines ROI as SAVINGS divided by COST OF THE INVESTMENT. More specifically:

SAVINGS = (Cost of operations with existing approach) - (Cost of operations with the cost reducing technology implemented).

COST OF INVESTMENT = [Summation of costs of development (i.e., tailoring of technology to weapon system application), integration, testing, production, and fielding of upgraded weapon system.] Sunk costs are not included.

ROI is computed with and without field personnel costs since any labor-hour reduction may not result in DoD personnel cost reductions. In many situations, labor hours freed up on a specific weapon system are applied to other DoD labor requirements. Thus, it is important for the decision-maker to know the magnitude of the personnel component of savings when evaluating an investment. The time value of money is included by using the Office of Management and Budget Circular A-94 discount rates for future savings and investments. In the model, ROI is computed with and without discounting.

The ROI model is in the form of a Microsoft Excel spreadsheet and has a sensitivity analysis capability. The model guides input of annual data over the remaining life cycle of the weapon system. With this data, the model computes the ROI and magnitude of investment and savings for the remaining weapon system life (up to 20 years).

The ROI model consists of five sheets. The first contains assumptions and a summary of results. The next two sheets provide a format to input the existing and alternative programs, and the last two compute ROI.

Additional information on the model and examples of its application are available in Volume II of this report.

Appendix B

Principal Organizations Visited

March 1995 – October 1995

AIR FORCE

Headquarters, Air Force/LGS

Secretary of the Air Force/AQK

Secretary of the Air Force/AQPF Component Improvement Program (CIP)

Engine CIP Program Manager

Aeronautical Systems Center/EN

Air Force Technology Transition Office (TTO)

SA-ALC Commander and Propulsion DAC

SM-ALC/LH, Chairman, Product Management Mission Element Board

Air Combat Command/LG

Air Combat Command/DRMR Major Modifications Executive

4th Wing Seymour Johnson AFB, Commander

NAVY

CNO/N881

NAVAIR 3.6 Logistics

NAV SPT 412, Policy,

NAMO-5041,2 LMDSS, HONA

BOSS-III Project Manager, Aviation Supply Office (ASO), Philadelphia

NAV Inventory Control Point, Philadelphia, Executive Director

ARMY

Deputy Assistant Secretary of the Army for Procurement (SARD-ZP)

Army Material Command, Assistant Deputy Chief of Staff, Logistics

ARMY (Continued)

Logistics Deputy Assistant Secretary of the Army

Assistant Deputy Chief of Staff, Logistics (DCSLOG)

DALO AV

PEO AVIATION, Assistant Program Executive for Concurrent Engineering

Aviation and Training Command (ATCOM) Executive Director, Integrated Material Management Center

ATCOM Development and Engineering Center, Executive Director, Aviation Research

Tank-Automotive Command (TACOM) OSCR Director

Fort Hood, 1st Cavalry Division, Aviation Brigade Commander

Fort Hood, III Corps, Science and Technology Advisor

OSD and OTHER

OSD DoD Comptroller (Deputy Director of Revolving Funds)

JAST Program Director

OUSD (A&T) Deputy Director Strategic and Tactical Systems

DLA – MMS

End Notes

[1] McDonald, Frank, DPA&E, Resource Analysis, Briefing titled "Cost of Ownership," Jan. 1995 Congressional Budget Office, *Operation and Support Costs for the Department of Defense*, July 1988.

[2] The five hypotheses as refined during the research were as follows:

1. Each of the military services (and Defense Logistics Agency) is able to identify ownership cost drivers with adequate fidelity to determine what weapon system and subsystems offer the ripest targets for O&S cost reduction.
2. In each service, there are candidate O&S cost-reduction projects that are worth pursuing (i.e., return on investment that results in projects comparing favorably with other uses of funds).
3. Current funding rules and processes, in themselves or as implemented by the services, impede implementing cost of ownership reduction projects.
   a. Sources of engineering funding are inadequate.
   b. Production funding is inadequate and transition from engineering to production is a significant impediment.
   c. The Defense Business Operating Fund funding rules, as implemented by the Services, work against item improvement.
4. There is an absence of incentives to reduce cost of ownership on the parts of users, item managers, and system managers or program executive officers.
5. It is possible to construct a viable cost of ownership reduction program that will identify, fund, and successfully execute worthy cost of ownership reduction initiatives.

Hypotheses 1, 2, 3.b, and 5 were supported by the field research. Hypotheses 3.a and 3.c were not. Hypothesis 4 was weakly supported.

[3] The operation and support cost-related systems examined were:

- U.S. Air Force
  - Visibility and Management of Operation and Support Costs, including both the Weapon System Support Cost and Component Support Cost Subsystem
  - Weapon System Cost Reduction database
  - Reliability and Maintainability Information System
- Naval Aviation Command
  - Logistics Management Decision Support System
  - Health of Naval Aviation Spreadsheet
- U.S. Army
  - Tank and Automotive Command Fleet Vehicle Performance Data System
  - Aviation and Troop Command Fielded Equipment Performance Data System, an adaptation of the FVPDS

Our assessment of these systems is based on briefings, live demonstrations, review of documentation, and, for Air Force VAMOSC and Air Force REMIS, fairly extensive on-line use.

[4] These charts were generated using the Defense Systems Management College Cost Analysis Strategy Assessment (CASA) model and engineering data from the V-22 mid-wing gearbox. The then current (February 1995) nominal values of reliability and maintainability were used to establish the reference (1x) point on each chart. The experience of the authors of this briefing is that equivalent results would be obtained with essentially any subsystem and weapon system. CASA was especially convenient for this analysis because it contains built-in sensitivity analysis on R&M values. Like most O&S models, CASA is intended for trade-off analysis and calculates relative costs, not absolute (or actual) ones.

[5] This argument recognizes three realities. First, numbers of unit-level military technicians are often determined on the basis of post-manning considerations rather than average workload. Second, unit commanders are generally reluctant to reduce the number of technicians in their units because these technicians are viewed, with some justification as the most flexible and responsive source of repair. Third, manpower ceilings at the Service levels are generally less than the expressed needs of the Services. As a result, personnel freed-up by efficiencies in one area are moved to other, under-manned areas, and thus often result in no overall cost reduction.

[6] Analysis that produced this chart considered only reduction in tire cost for cumulative O&S savings. Included in cumulative investment are both development costs and the increase in replacement cost (i.e., CV joint cost minus U-joint cost).

[7] The problem is one of a tyranny of numbers. The engine on the F-14 aircraft, as an example, has over 8,000 stock-numbered consumable components. The median demand rate is about four per calendar quarter per component, and 66 percent of the components experience fewer than 25 demands per quarter. Similarly, 74 percent of the components cost less than $25 each. (Source: F-14 engine consumable parts listing provided by DLA.)

[8] Down from over $90 million annually in the late 1980s and early 1990s.

[9] Auditor General, USAF, *Value Assessment of Reliability and Maintainability Efforts*, 1995. PRAM managers have historically claimed an ROI of 12:1. It is our understanding that the reason that the auditor's report found 5:1 is that the auditor recognized all engineering costs, including costs of projects that did not go into production.

[10] It is reasonable to question how PRAM could have a non-zero ROI if there have been no funds for production. The ROI of 5:1 for PRAM is a historical average; further, it includes projects for which production funding was not needed.