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RELIABILITY NEEDS IN FUTURE DoD SYSTEMS

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ABSTRACT

An overview will be presented of the military challenge we are currently facing along with our investment strategy for developing advanced weapons systems. The major role of improved reliability in reducing both the operation and maintenance costs as well as increasing our military combat capability will be examined along with the key role of R&D programs in meeting future reliability requirements. Finally, some of the new policies we have initiated aimed at developing a more effective DoD R&D program will be presented.

Good morning, Ladies and Gentlemen. It is a distinct pleasure for me to join with you in the sixth annual DARPA/AF review of progress in quantitative nondestructive evaluation. The agenda certainly promises a very stimulating and technically exciting meeting.

I would like to provide you with a cursory overview of current OSD thinking as to the threats we are facing, and the future capabilities we are currently developing. The role of improved reliability in both reducing operation and maintenance costs as well as increasing our military capability will be examined and the key role of R&D programs in meeting future reliability requirements will be discussed. Finally, some of the new policies we have initiated to develop a more effective R&D program will be presented.

The Challenge

For years we have acknowledged that the Soviet Union held a quantitative lead in military equipment but believed that our qualitative lead would more than compensate for this. It is time to re-examine that belief and to reject the complacency that went with it. During the decade of the 1970s, the Soviet Union made a major advance in the development and production of defense material, and as a consequence will enter the 1980's in a dramatically different defense posture than they had as they entered the 1970's.

Their objective was to challenge the U.S. lead in defense technology while maintaining their numerical advantage. They have had a remarkable degree of success in achieving that objective by making an enormous investment, and by maintaining an unwavering emphasis on technology. The Soviet Union started the 1970's with an annual defense investment (RDT&E, procurement and military construction) approximately equal to that of the U.S. But they have increased at a steady rate of four percent per year since then, while the U.S. investment decreased in real terms every year until 1975. As a result, the Soviet Union invested over the decade about $240 billion (in FY 1981 dollars) more than the U.S. This differential exceeds the estimated acquisition cost (in 1981 dollars) of 1,000 F-16s, 1,000 F-18s, 10,000 XM-1 tanks, 20 CG-47 guided missile cruisers, 50 SSN attack submarines, 20 TRIDENT submarines (with missiles), the entire M-X program, and an additional $70 billion in R&D.

Generally speaking, they have used this investment increment to produce large quantities of equipment, thus maintaining their numerical advantage. But as they try to match the sophistication of U.S. equipment, the unit cost of Soviet equipment has substantially increased. For example, we estimate that the cost of their MIG-23 approaches that of our F-16.

Another indicator of future plans is the Soviet R&D program. While our estimates of Soviet investment in R&D have significant uncertainties, the evidence is compelling that their program is about twice the size of ours. We can make a fair evaluation of this by observing their test programs, where we can identify about 50 major systems (ships, submarines, aircraft, and missiles) in various stages of test and evaluation. Some of these systems are quite significant. We can also assess some portions of their technology programs. By observing laser test activity, for example, we estimate that their high energy laser program is about four times the size of ours. Overall, during the decade of the 70's, the Soviets invested about $70 billion more than we did in Defense R&D. It is quite clear that their R&D program has had the highest priority access to funds, to trained personnel and to scarce materials, to the extent that they have imposed serious hardships on their non-defense industry. As a result, their non-defense industry is not competitive in world markets.

In summary, we can see the Soviets entering the decade of the 1980's with a commitment to compete in quality with U.S. weapon systems. A major start has already been made in that direction, with the acceptance of the much higher unit cost implied by this commitment. They are accepting this increased unit cost without decreasing their traditional emphasis on quantity, simply by increasing their total investment in weapons production to where it is now 85 percent greater than ours. That they plan to continue this emphasis throughout the 1980s is made clear by the major increases made in the 1970's in production plants and in defense RDT&E.

Our Investment Strategy

The challenge described in the previous section is formidable. We are behind quantitatively in deployed equipment and are falling further behind because of disparities in equipment production
terms of a capability level achieved at some date, the availability of individual systems to conduct combat missions, the sortie success of that weapon system in the conduct of its mission and the mission effectiveness in terms of the criteria of interest. (In the case of a close-air-support mission, for example, this includes payload capacity, radius, loiter time, maneuverability, delivery accuracy, and survivability.) The design criteria is the component of military capability that is most easily addressed during the development and acquisition of a new weapon system. However, our overall military capability is directly dependent on the availability and reliability of these systems for performing their mission.

In order to illustrate the importance of these issues I have chosen to review with you some of our experiences with the life cycle costs and operational capability of the Air Force A-7D aircraft.

There are obvious problems with examining a specific system. First of all, no one system is really representative. Thus, it is difficult to generalize any lessons which might be learned. Second, the acquisition process is in a constant state of evolution and therefore, it is difficult to discern legitimate similarities between past problems and present procedures. Notwithstanding these difficulties, one way of improving upon our past acquisition performance is to first identify the deficiencies in past programs and second evaluate alternative policies in the "real-world" contexts of those program environments.

Life Cycle Cost of the A-7D

A measure of a weapon's "total cost" is the present value of all previous and forthcoming expenditures directly related to the RDT&E, procurement, and ownership (i.e., operation) of the system. Such a "total cost" is referred to as a life-cycle cost. At the time that a life-cycle cost is calculated, forthcoming expenditures can only be estimated, whereas expenditures to date should be measurable with a fair degree of accuracy. In theory, the life-cycle cost measure is very attractive for indicating the magnitude of the potential tradeoffs of resources among the development, production, and operating phases of a system in order to optimize capability and cost characteristics.

Figure 1 presents an FY 1973 calculated projection of life-cycle cost for the A-7D in terms of FY 1973 dollars. Since the aircraft was still in production during FY 1973, the life-cycle cost is stated in terms of a per aircraft cost rather than a fleet cost. The acquisition cost is based upon the total planned buy (411 aircraft) as of FY 1973. The estimated costs of ownership are based upon the assumption that the FY 1973 observed average per unit operating cost is representative of the ownership costs for the duration of the aircraft's useful life, which is assumed to be 15 years.

With certain assumptions as to discount rate and inflation this viewgraph shows that the cost of ownership is approximately 30 percent higher than the acquisition cost. Since the ownership
costs are so dependent on several unknowns, it is sufficient to conclude that the ownership costs will generally exceed the acquisition costs.

Several of the costs of ownership are not very sensitive to the reliability and maintainability of the weapon system (e.g., training (TNG), petroleum, oils, and lubricants (POL), and base operating support (BOS)). However, the largest portion - the remaining 79 percent of the ownership costs (e.g., operation and maintenance (O&M), depot, and investment) - are very sensitive to weapon-system reliability and maintainability as well as manning, support, and deployment decisions. The base-level O&M costs alone account for nearly 50 percent of the ownership costs. One of the elements of the O&M cost which is particularly sensitive to the weapon system's reliability and maintainability is the labor cost for unscheduled maintenance at the base.

Therefore, we can potentially avoid major future costs associated with weapon systems by improving the reliability and maintainability of these systems. Clearly we have to address these issues both before, during and after production of weapons systems.

Military Capability of the A-70

The capability of the weapon system is the other key issue that is impacted by reliability and again I would like to use the A-70 as an example. The tactical mission of the A-70 makes the number of combat sorties that can be generated per day of major importance in determining the military utility of this weapon system.

As shown in Fig. 2, even if no subsystems fail, there is an upper limit to the number of combat sorties that can be launched by the average aircraft in a combat day. For example, for a two hr close air support mission, about 3.3 hours are needed for fueling, gun loading, bomb loading, and preflight and postflight inspections. This means that at most, four and a half sorties can be flown per aircraft in a twenty-four hour combat day.

First, let's focus on the combat readiness assessments for 1968 and 1970. The 1968 assessment is based upon LTV's subsystem reliability estimates which were made midway through the research and development phase. As you can see, the contractor estimated that the A-70 could provide over three combat sorties/day/aircraft. In 1970, towards the end of the test program, the contractor revised its subsystem reliability estimates, and estimated that only 2.5 sorties/day was possible. At about the same point in time, the Air Force made an independent estimate of the subsystem reliability and projected less than a two sortie/day capability. An initial user oriented operational test in 1970 was also conducted and resulted in a sortie rate of slightly over one sortie/day.

Now look at the 1973 operational data in which we obtained a capability of less than 1 sortie/day.

The difference between the limiting number of 4.5 sorties/day and the top of the three bars is totally due to the down-time for unscheduled maintenance which is incurred because of subsystem failures. If no failures occurred, there would be no unscheduled downtime.

Thus far, we have been considering this sortie generation capability on an average aircraft basis. In Fig. 3 we will consider it on a fleet basis. If the aircraft, which were delivered to the Air Force, were as reliable as the contractor's pre-production estimate, then the fleet sortie generation capability would have built up according to the top curve. The 1975 capability would have been about 1400 sorties/day. Of course, the actual buildup followed the bottom curve to a 1975 capability of about 400 sorties/day.

Therefore, we obtained in 1975 only 28% of the military capability that we had planned for in 1968.

Clearly there are many actions that have been taken since we acquired the A-70 to improve the acquisition process. We are continuously striving to develop improved management procedures to obtain the most cost effective weapons system.

However, there is a limit to the reliability improvements we can obtain from management and policy changes alone. We have to develop an engineering capability to "design-in" and "manufacture-in" and not just "test-in" reliability. We are concerned about the entire area of quality and with it the classic problems of accelerated testing and the nondestructive
The funding for the NDE technology base within DoD has increased significantly over the last five years. Since FY 1975 the DoD technology base for NDE has increased from less than 2 million dollars per year to over six million dollars per year. In addition, the Air Force has initiated a major Manufacturing Technology thrust in NDE to reduce this technology to practice that has increased from no investment in FY 1975 to almost $4 million in FY 1980 to a planned expenditure in excess of 18 million dollars over the next three years. The Army is also currently investing several million dollars per year in Manufacturing Technology NDE programs.

We have increased our interaction with our allies in NDE through bilateral agreements, NATO workshops and TTCP activities. For example, the U.S. has proposed that a new panel be established under the TTCP materials subgroup to provide the necessary framework for joint programs and technical exchange between the member countries (US, UK, Canada, Australia and New Zealand).

As you can see from Fig. 4, the increasing investment in NDE is still a very small percentage of the total DoD Science and Technology Program. However, the increasing recognition of the importance of quality in DoD weapon systems, the additional requirements placed on NDE by the desirability of using new materials, design concepts and processing methods to exploit rapid solidification technology, metal matrix and carbon/carbon composites as well as ceramic materials clearly will require increased emphasis for advanced quantitative NDE capabilities to ensure the reliability of future weapons systems.

Fig. 4 DoD Science and Technology Program

If you will continue the excellent research progress you have been making in this field and focus your research on the critical technical issues required to transition this technology to the user, I will work to ensure that the necessary policy issues are addressed to provide the Department of Defense with the technical capability to field and maintain reliable military systems. We must develop the capability to "design-in" and "manufacture-in" reliability. We can't afford to continue to only "test-in" reliability with future weapons systems.
SUMMARY DISCUSSION

Don Thompson, Chairman (Ames Laboratory): Thank you very much. We have a few minutes before break for questions and answers.

Doug Ballard (Sandia Laboratories): Could you predict or project what percentage of this downtime for sorties is attributed to electronic gear that we do not test normally by NDE methods? In other words, is the electronics part of the business a major factor rather than structural downtime?

Arden Bement (Deputy Undersecretary of Defense): I can't give you precise numbers on that, but I know for a fact that it is, especially in radar systems, such as the replacement of traveling wave tubes; and it certainly is a very significant contributor in communication systems.

Doug Ballard: Those areas are traditionally neglected by NDE right now. We don't even pay any attention to them.

Arden Bement: Yes, I agree.

Don Thompson, Chairman: Other questions?

Arden Bement: I might say, however, during that era that this aircraft operated, we were still in vacuum-tube technology and are hoping that large-scale integrated circuits will provide improved reliability in some of those systems.

Don Thompson, Chairman: Any other questions? If not, Arden, we thank you very much for your talk and presentation.