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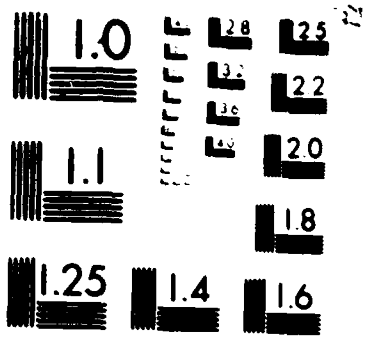

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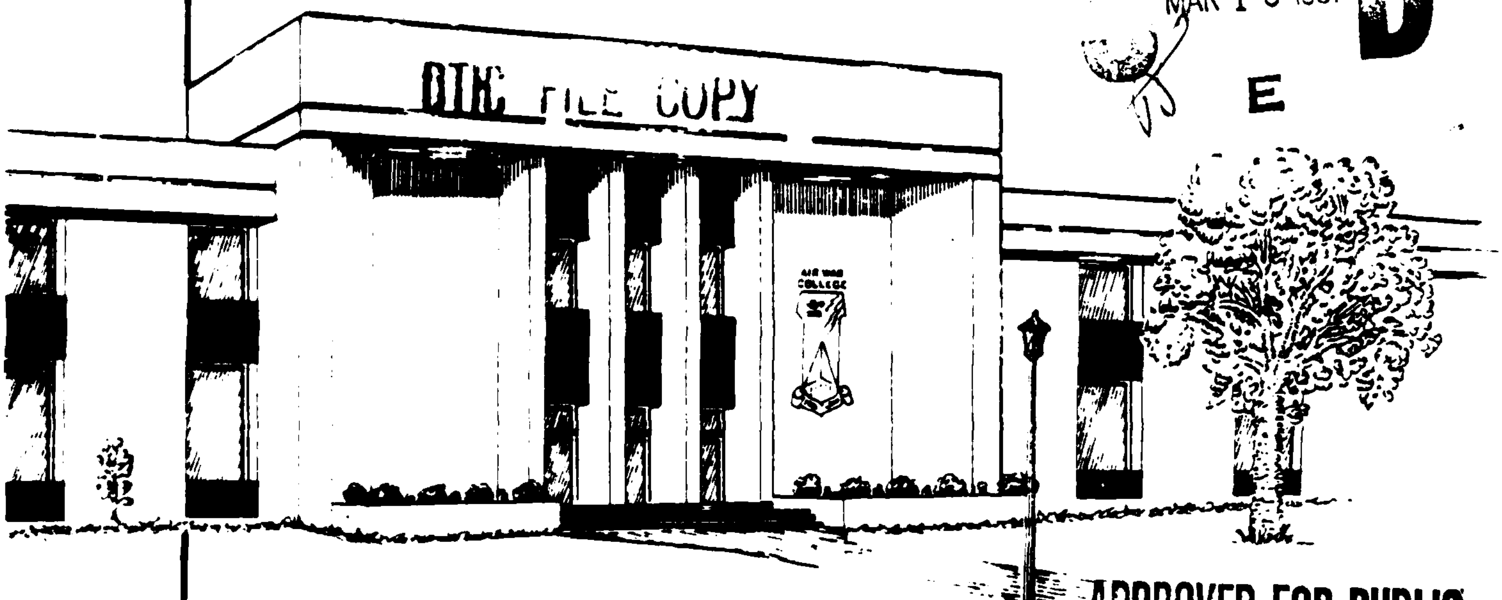
AIR WAR COLLEGE

RESEARCH REPORT

No. AU-AWC-86-013

FUTURE FIGHTERS: WILL THEY BE SUPPORTABLE?

By COLONEL GEORGE T. BABBITT



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FUTURE FIGHTERS: WILL THEY BE SUPPORTABLE?

by

George T. Babbitt
Colonel, USAF

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Lieutenant Colonel John A. Brantner

MAXWELL AIR FORCE BASE, ALABAMA

March 1986

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Future Fighters: Will They Be Supportable?

AUTHOR: George T. Babbitt, Colonel, USAF

The author discusses requirements for support of future fighters. Conceptual design work is underway for the Advanced Tactical Fighter which the Air Force hopes to field in the mid to late 1990s. Two areas critical to improved supportability are examined: defining the combat environment and improving reliability. Both areas are discussed in terms of new policy guidance and in terms of technical issues now under study. The author concludes that important changes have been made to the way the Air Force approaches the problem of supportability and that research currently underway promises to make future fighters more supportable than current fighters.

BIOGRAPHICAL SKETCH

Colonel George T. Babbitt (M.S., Air Force Institute of Technology) is an aircraft maintenance officer who has spent most of his career assigned to fighter aircraft wings. His most recent assignment prior to attending the Air War College was as Deputy Commander for Maintenance, 36TFW, Bitburg A.B., Germany. Colonel Babbitt has also had fighter maintenance assignments in South Vietnam, England, and in the Tactical Air Command. From 1971 to 1978 he served as a maintenance planner supporting the acquisition of new weapon systems. During that period he developed a keen interest the techniques required to improve the supportability of new aircraft. Colonel Babbitt is a graduate of the Defense System Management College, the Armed Forces Staff College, and the Air War College, class of 1986.

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CHAPTER I

INTRODUCTION

The F-15, F-16, and A-10 now comprise a large portion of the fighter force of the United States Air Force. The development cycle for these aircraft began in the middle to late 1960s. Some have been in the active inventory for as much as 10 years.

We now begin another round of fighter development. The Advanced Tactical Fighter (ATF) is in the conceptual phase and Air Force and industry planners are expending great effort to define the characteristics required of this new generation fighter. Much of this planning is necessarily based on the lessons learned from the current fleet of aircraft.

Planning for aircraft maintenance is an important part of this process because there are, unfortunately, a number of reasons to be concerned about the support requirements of current fighters. Deployment of a single squadron of F-15 or F-16 aircraft can require as many as 600 support personnel. (1:3) The airlift required varies from 13 to 18 C-141 aircraft loads even when deploying to a prepared operating location. Even more is required when deploying to an unprepared location. (2:3) This very large "logistics tail" inhibits mobility, increases vulnerability to enemy attack, and often constrains the sortie generation capability of the unit. Reducing the impact of these limitations is an important part of enhancing the combat capability of future fighters. A review of current literature led the author to conclude that significant work is being done to ensure that the limitations of current fighters are not repeated on future fighters. Considerable effort has gone into defining the combat environment in which the aircraft and support system must operate. Such definition will hopefully lead to better understanding of the impact of design options during the development phase.

Much work continues to be done to improve system reliability. This has always been treated as an important design characteristic because of its impact on the probability of single mission success and on life cycle support costs. But increasingly, it is being viewed in light of its impact on the size and nature of the support system and the resulting ability of the support system to operate in the combat environment.

The remainder of this paper describes in greater detail the work that is being done to ensure future fighters are supportable. Chapter II describes efforts to define the combat environment. Chapter III describes efforts to improve reliability. Chapter IV provides some conclusions.

CHAPTER II

DEFINING THE COMBAT ENVIRONMENT

Traditionally, the Air Force maintenance system has been viewed in a rather static way. Most often it is described as having three levels: organizational, intermediate, and depot. This static description was usually included in some portion of the system specification whenever the Air Force chose to develop a new aircraft. The contractor was charged with reducing support costs within the framework of the "existing system" and many contractors pursued this goal with great diligence. In a few cases support requirements actually drove design as was the case in the engine change time requirements for the F-15 and F-16. But more often, support requirements were simply tallied up when the design was complete.

The best example of the latter approach was the design of an avionics support system. Off-aircraft maintenance (maintenance performed after the electronic component has been removed from the aircraft) can logically be performed either at the operating base, a regional repair location, or at a designated depot. The Air Force has in the past advocated two possible methods of analyzing this decision. One approach, called base self sufficiency, grew up in the Strategic Air Command (SAC) in the late '50s. The concept was appropriate for SAC at the time. The guiding rule was fix it at the operating base if at all possible. This approach ensured that each combat wing was as independent and autonomous as possible. Dependence on a logistic pipeline back to a depot repair facility was kept to a minimum. The second approach was known as optimum repair level analysis (ORLA). ORLA analyzed the costs involved. Depot repair requires more spare parts (longer pipelines) but less test equipment (fewer repair locations). Field repair requires fewer spares (short pipelines) but test equipment at each operating location. Depending on the approximate costs of individual items of electronic equipment and the cost of the associated test equipment, repair levels were selected.

Neither of these techniques addresses the combat environment. In the case of the F-15 and F-16, repair level decisions resulted in a requirement for a large and complex set of avionics test equipment known as the avionics intermediate stations (AIS) to be positioned at each operating location. An F-15 AIS requires at least three C-141 aircraft to transport it and 4500 sq. ft. of level, air-conditioned floor space to operate in. (2:3) The AIS is expensive, vulnerable to enemy attack, and difficult to move; exactly the sort of thing that, from an operational point of view, we should try to do without.

This is not to imply that simply making a different repair level decision would have solved the problem. It would not. The cost of depot repair on all avionics would have been prohibitive for both the F-15 and F-16 given the current reliability of that equipment. But had the focus been on the combat environment and the need for mobility, elimination of the AIS may have been made a design requirement along with the associated requirement for better avionics reliability.

There is ample reason to believe that current logistic planners do not suffer from this same short-sightedness. The USAF Logistics Long-Range Planning Guide: FY1988-2002, describes the operational support strategy as follows:

> The two fundamental and enduring characteristics of that support are the ability:
> - o To deploy and employ responsive combat-ready forces worldwide; and
> - o To survive and sustain combat forces for the duration of conflict. (underlining added) (3:2)

The same document goes on to describe the combat environment in which the support system must operate:

> Warfare going into the 21st century will be dynamic and fast-moving, characterized by the expanding threat of highly accurate and destructive enemy capabilities to the operational support structure and weapon systems it supports. Airlift and sealift will be vulnerable en route and at key ports of embarkation and debarkation; command, control, and communications will be susceptible to disruption by extensive application of new electronic warfare systems; and massed air raids with the possible use of chemical, biological, and nuclear weapons could reduce the sanctuary of air bases. At the lower end of the warfare spectrum, guerrilla warfare may require long-term support of remote operations constantly subjected to terrorist and clandestine attack. These enemy threats could significantly degrade logistics support and combat effectiveness. (3:3)

The USAF Reliability and Maintainability Action Plan: R&M 2000 cautions readers that,

> Until now, our emphasis on reliability and maintainability (R&M) has been focused primarily on cost effeciency considerations. Today, however, operational necessities and logistic support considerations such as mobility, vulnerability, and manpower limitations demand we rethink this focus and work for more rapid improvements in our weapon system R&M. To be successful, this requires a fundamental change in the way the Air Force approaches, considers, and manages R&M. (4:i)

So where is this new emphasis on the combat environment likely to lead the maintenance planner? Can we estimate, based on this new view, where changes are likely to be made? I believe so. The next several paragraphs provide four examples of how operational necessities can and should drive maintenance planning.

The first operational necessity is to rapidly turnaround and relaunch each fighter on its next combat sortie. In many respects this is the same problem faced by artillerymen for centuries: the problem of reloading. With fighters, replacing expended munitions is part of the process. The remainder of the process is the inspection of the aircraft for flight worthiness and replenishment of aircraft consumables such as fuel and oxygen. The tactical air forces of the United States have attempted to standardize this procedure using Tactical Air Command Regulation 60-6. Emphasis has been placed on pushing needed resources to the designated combat turnaround area to minimize delays and on refining the actual turnaround process by designing specific integrated combat turnaround (ICT) procedures for each aircraft type.

ICT times for fighter aircraft are already very good. The Tactical Air Command standard for training and exercises for A-10, F-15, and F-16 aircraft is 1.25 hours (landing time until on-status for next sortie while conducting sustained combat operations). (5:6-6) However the potential benefit from even modest improvements are great. A reduction in ground turnaround time from 1.25 to .75 hours would reduce the total aircraft cycle time (including a 1.2 hour mission time) by 20 per cent. This can also be viewed as increasing the number of combat sorties available over a given interval by 20 per cent. Are reductions possible? Definitely. Competition crews from all commands and on all types of fighter aircraft regularly and dramatically beat these standard times. True, these competitions are held under ideal conditions, but they still point the way to the possibility of significant time reductions.

Designers of future fighters should also be challenged to find ways to reduce the manpower required to perform an ICT. Technical and safety considerations now require six ground personnel (not including refueling equipment operators) to be present during the turnaround of each fighter. Personnel include a three man weapon load crew, a crew chief and assistant, and an overall supervisor.(5:2-1) Fewer personnel required for each turnaround would mean more ICTs could be done simultaneously thereby increasing the capacity of the combat unit.

The next operational necessity is to be able to mass the fighter force. Along with the inherent capability of the aircraft for maneuver, mass is the principle that allows the concentration of firepower to overwhelm an enemies defenses.(7:2-7) The logistics corollary requires that as many fighters as possible be made ready for combat at a single point in time. Rapid turnaround helps but only deals with the current pool of serviceable aircraft. Either through material failure or battle damage, some aircraft will require maintenance prior to being returned to combat. The extent to which this maintenance can be done quickly will determine to what extent maintenance satisfies the operational necessity.

Every effort must be made to ensure that all aircraft systems can be quickly and reliably diagnosed. Long drawn out troubleshooting procedures lead to extensive non-operational time. Although progress has been made in avionic systems little progress has been made in mechanical, hydraulic, and pneumatic technologies. This fact was recognized by a joint Air Force/Industry panel sponsored by Air Force Systems Command which concluded that reliability and maintainability improvements in these technologies is "...lagging and creating costly logistics tails." (8:6-6)

Battle damage repair technologies must be expanded. Although the Air force has come a long way in this field and most fighter aircraft now come equipped with a basic technical order to describe battle damage repair techniques, more work will be required. Future fighters are likely to have increasing numbers of structural members formed from composite or advanced metallic materials. Quick on-aircraft repair techniques are essential. Future fighters are likely to use advanced avionics architectures involving high degrees of system integration. These avionics schemes may also use fiber optic data busses.(9:14) Battle damage repair techniques to include both diagnosis and repair must be developed.

Although the requirement to maximize the number of operational aircraft seems somewhat obvious, it is still occasionally forgotten. A current example is the unfortunate interpretation sometimes given to the work being done by Tactical Air Command with a computer model known as Dyna-METRIC. The model is used to estimate the impact on a fighter wing of beginning a war with a given level of spare parts. The model assess whether or not the minimum daily sortie requirements of a war plan can be supported by the available spares. A description of the model and some of the assumptions inherent in it can be found in the Spring 1983 edition of the Air Force Journal of Logistics. (6:23)

The model has proven useful as a tool to help commanders better understand the significance of certain spare part shortages. But if one is not careful it is easy to see the operational need as only a continuous flow of sorties and to forget that at times it will be necessary to group together large numbers of aircraft as part of a mass raid or, in defensive terms, to be prepared to scramble all of your aircraft in response to an enemy raid.

The third operational necessity is European theater war survivability. As the size and complexity of our support systems has grown making them increasingly more subject to attack, the Soviets have simultaneously increased their ability to launch that attack.(2:2) Although aircraft may be parked in hardened aircraft shelters and command centers are often underground, maintenance facilities are very lightly protected. Some avionics facilities at main operating bases have recently been hardened, but jet engine repair shops, electric and hydraulic repair shops, and structural repair shops are unlikely to survive a concentrated enemy attack. Dispersal on base offers little advantage because of the small amount of real estate usually available.

One option currently being examined is dispersal to multiple operating locations. From a purely airframe point of view, this option is feasible. Future fighters are likely to possess some short take-off and landing (STOL) capability which would make possible the use of a larger number of airfields within any theater of operation.(2:7-9)

The nature of the support system is more likely to be the stumbling block to effective use of such an option. Berman, in his study of future fighter basing concepts, estimates that a 72 aircraft wing of current fighters dispersed to 12 separate operating sites would require the addition of some 300 to 600 flight line maintenance personnel.(2:13) Such dispersal would also require substantial amounts of additional equipment and frequent resupply of spare parts.

Berman suggests that improvements to the maintenance system can be made which would, in turn, make dispersal a feasible technique for enhanced survivability. He proposes research into three areas. First, equipment reliability must be substantially improved. Berman sites the Minuteman I inertial guidance system as an example of the success that is possible from programs to improve hardware reliability. Second, there must be increased use of built-in support systems. For example, the need for large numbers of complex bomb loading equipment may be reduced by designing on board weapon loading aids. Third, we must decrease reliance on ground support personnel. Berman feel great strides could be made in this area by reevaluating the classification of personnel. He believes that the number of Air Force specialties required for flight line maintenance could be reduced to between four and 15 from the current 22.(2:22)

The Air Force has already begun to move in this direction. The Logistics Long-Range Planning Guide lists the following as primary objectives of future systems:

- o Design future weapon systems to maximize on-equipment maintenance capabilities, independent of complex support equipment, facilities, and large numbers of maintenance personnel.

- o Decrease specialization and improve productivity by making maintenance personnel weapon system oriented. (3:17)

The fourth operational necessity is for power projection. Although the defense of Europe is certainly one of our most important missions, there is a greater probability of hostilities in some other part of the world. U. S. Air Force units must, therefore, be prepared to deploy on short notice. Fighter aircraft are inherently capable of supporting this mission with tanker support. The support system, again, may be the problem. It was mentioned earlier that a single fighter squadron requires as many as 600 personnel and 13 to 18 C-141 loads of cargo. Competition for airlift from other deploying forces will be fierce. There may not be sufficient airlift.

Conveniently, the actions necessary to ensure improved deployability are the same as the actions required to improve survivability: improve reliability, reduce equipment requirements, and reduce personnel requirements. Improvements are possible and each improvement will help to reduce the required airlift. Some actions could lead to major reductions in airlift. For example, improvements in avionics reliability and on-aircraft diagnostics could allow a change in maintenance concept to leave the avionic intermediate stations (AIS) behind.

In summary, defining the combat environment is key to developing supportable fighters. In years past, logistics issues have often been evaluated in terms of cost effectiveness. Current operational and maintenance planners view this as a mistake and are focusing on the impact of the support system on operational needs. Rapid sortie generation, massing of aircraft for offense or defense, ground survivability, and deployability are all operational needs that are frequently degraded by support considerations. Future fighters and their support systems must be designed to reduce this degradation.

CHAPTER III

IMPROVING RELIABILITY

No matter how you view the problems of fighter support, one thing can be said for sure: it all gets better when reliability improves. Personnel and equipment requirements are reduced, mission readiness gets better, the cost of spares goes down, sortie rates go up. In fact, improved reliability has no draw backs. Well, maybe one: it has been terribly difficult to achieve. Emphasis on reliability has been an important part of the defense acquisition process for over 25 years.(10:14) Department of Defense reliability objectives have ranged from improving equipment operating time to improving the probability of mission success to reducing logistic support costs to improving readiness to reducing maintenance manpower. (10:15) Techniques for improving reliability have included math models, parts selection techniques, component demonstrations, and reliability improvement warranties.(10:16) Each objective and each technique has had some success but overall the results have been dismal. Poor reliability in aircraft avionics continues to be a primary limiting factor. A recent Rand study concluded that the primary constraint on F-16 sortie generation capability was the "unscheduled removal of avionics line replaceable units."(11:66) The report further stated that the bulk of the removals occurred in only 10% of the avionics units, all of which were in the radar system. The author arbitrarily reduced the removal rate by 75%, a reduction she feels is achievable in future fighters. The analysis revealed that the more reliable aircraft could achieve twice the sortie rate of the current F-16.

If a 75% reliability improvement in the F-16 radar could produce even half the results indicated by the above analysis, the effort must obviously be worthwhile. What then, is the Air Force doing to improve the reliability of future fighters.

On 1 February 1985 The Chief of Staff and Secretary of the Air Force approved the Reliability and Maintainability Action Plan: R&M 2000, the purpose of which is to institutionalize the commitment to improved reliability and maintainability. Six objectives were set forth. Establish clear command goals and weapon system goals. Establish an organizational infrastructure to build advocacy, authority, and accountability. Establish a planning system. Establish a system for review and feedback. Establish a communication and motivation program. Establish industry commitment.(4:i)

With this action plan, the system engineering disciplines of reliability and maintainability have been raised from their traditional place in the acquisition process to a new and important position in aerospace doctrine. The plan defines reliability and maintainability as fundamental building blocks of operational supportability. (4:1)

Whether or not this new approach to reliability will work remains to be seen. It will be several years before the organizational changes just described can have an effect. One can, however, examine the current reliability literature to see what sort of research is being conducted and what the future appears to hold. The following example addresses a topic that is of critical importance in avionic reliability.

Previous Air Force reliability programs have concentrated on contractor efforts during system design and production. Key program elements were reliability testing and parts selection. Even the much used reliability improvement warranty normally included a method to allow the contractor to verify whether or not the component had actually failed and, if it had, whether or not the failure resulted from stresses outside those allowed by the specification. Recent studies indicate this approach may be ignoring a major part of the problem.

A 1981 study conducted for the Naval Air Systems Command indicated that only a very small portion of reported avionics failures could be attributed to the intrinsic failure of electronic components at the circuit card level.(12:43) The report concluded that as many as 60% of all reported failures were actually the result of cabling or connector problem, both aircraft mounted connectors and connectors internal to line replaceable units. Of those units which were repaired for other than connector and cabling problems, 62% of the parts replaced turned out to be serviceable. Of those replaced parts which had actually failed, 75% failed because they had been stressed beyond their specified limit. Verified electronic component failures accounted for only 3.8% of the reported avionics anomalies. It would appear that much of our equipment may be inherently reliable in a factory test sense, but when integrated into a combat aircraft and subjected to the rigors of flight line or ship board maintenance, that reliability is drastically reduced.

This helps to explain the great disparity which normally exists between contractor reliability goals and field results. The contractor considers most of the failure modes to be irrelevant (not his problem). He is usually right; that is the way we wrote the contract.

A study completed by the Boeing Corporation in 1983 was conducted to define requirements for onboard test systems for future fighters. Part of the study was a review of current systems. The review revealed the following facts. (13:308) Forty per cent of the avionic equipment removed from aircraft is fault free; the inability to identify malfunctioning equipment without ambiguity results in a 67% workload increase at the organizational and intermediate levels. Thirty per cent of the faults flagged by built-in-test (BIT) could not be duplicated on the ground and of those unit flagged bad by BIT on the ground, 20% to 30% were found to be fault-free in the shop. Neither is the problem limited just to the military. The report indicated that airlines find fewer than 50% of avionics boxes removed contain verified failures.

A synthesis of technical issues prepared by the Denver Research Institute for the Joint Services Working Group on Artificial Intelligence in Maintenance, October 1985, reports that high false removal rates due to diagnostic error result in 15% to 30% of all electronic units in the maintenance repair cycle being serviceable.(14:15)

These reports reveal serious deficiencies with current fighters, deficiencies that are reliability related and that degrade the effectiveness of the maintenance system. But these same reports offer possible solutions. The Boeing document proposes the architecture for an integrated test and maintenance system to be part of the basic avionic suite. The Denver Research report suggests ways to incorporate artificial intelligence technology into onboard diagnostic systems. This approach also offers significant benefits for technician training. Even if these techniques are never used, the well documented problems of current on-aircraft diagnostic systems will serve to remind the developers of future fighters that such problems must be solved and the solutions verified.

CHAPTER IV

CONCLUSIONS

Will future fighters be supportable in combat? The conclusion must be yes. Are all the problems solved? No, but the evidence indicates we understand what the problems are and that we are prepared to do what is necessary solve them.

A major step forward has been taken with the new Air Force emphasis on defining and evaluating support problems in relation to the combat environment. Overemphasis on peacetime cost effectiveness seems to be a thing of the past. The Air Force Logistics Long-Range Planning Guide contains strong indications of the degree to which we are committed to the premise that the logistics system must be prepared for combat.

The several Rand studies referenced indicate how conceptual work on future fighters can and should include analysis of basing and support alternatives. The Berman study showed how STOL capabilities combined with a significantly reduced on-aircraft support requirement could make dispersed basing an option in Europe and greatly increase the options for power projection in the third world.

Important work is also being done to improve equipment reliability. The Air Force Reliability and Maintainability Action Plan: R&M 2000 has raised reliability to a new level institutionally. Reliability need no longer be just a system engineering tool aimed primarily at contractors. All aspects of poor reliability are subject to review. Technical reports indicate one possible area where investment in reliability is required is in the area of on-aircraft maintenance diagnostics.

The future of fighter aircraft looks bright. Every indication is that we, the Air Force, understand the importance of combat support and that we have the resolve to do it right.

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