Air Force Systems Command Approach to R&M

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Reader Aids —
Purpose: Describe the AFSC approach to implement R&M 2000 initiatives
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Special math needed to use results: None
Results useful to: Corporate executives, program managers, R&M engineers, system engineers

Abstract — This paper describes the approach to reliability and maintainability taken by the US Air Force Systems Command in response to R&M 2000 initiative. Effective management, proper engineering, and new technology are discussed as the major elements of the approach.

1. INTRODUCTION

Improved system reliability and maintainability (R&M) are not ends in themselves — they are means to increase combat effectiveness and operational supportability. As such, R&M improvements are important for their effects on warfighting capability, survivability of the support infrastructure, mobility requirements, manpower needs, and support costs. Air Force leadership has recognized the force multiplier inherent in improved R&M and has directed the operating commands to plan accordingly.

Implementing R&M 2000 within the Air Force Systems Command (AFSC) is a team effort that addresses management, engineering, and technology. This paper discusses efforts in each of these areas. Each field organization helps to develop goals, identify tasks, and apply the resources needed to do the job. The individual program offices, laboratories, centers, and product divisions then deliver the R&M that is required by the operating forces. As the command principally responsible for research, development, and acquisition, AFSC develops the generic technology, methodology, and design tools that are needed to field reliable and maintainable systems. In addition, AFSC ensures that R&M are considered an integral part of overall system performance by incorporating R&M oriented design features on a program-by-program basis. AFSC motivates contractors to make R&M integral considerations in their design and manufacturing processes by making R&M key criteria during source selection, specifying R&M requirements in contracts, and by the use of product performance agreements. Contractors deliver systems that can defeat the threat through the application of proven tasks such as reliability growth, derating, environmental stress screening, failure modes effects and criticality analysis, and effect corrective action.

AFSC works in close partnership with Air Force Logistics Command (AFLC) and the using commands. Critical issues, such as product performance agreement implementation, developing R&M technology requirements, and test criteria are worked through close cooperation with the using and supporting commands, the Air Force Operational Test & Evaluation Center, the Air Staff, and other Department of Defense (DOD) agencies.

2. MANAGEMENT

AFSC has, over the past two years, initiated several management actions to improve the R&M of the systems it acquires. R&M are now essential criteria for source selection and mandatory subjects for business strategy panels. For new designs, AFSC policy is to identify R&M and producibility as specific source selection evaluation items. To reinforce this, the command requires that these be ranked as the first items in the highest ranked area.

Air Force Business Strategy Panels (BSP) serve as early planning sessions to develop a systematic and disciplined approach toward achieving an economical, efficient, and effective acquisition. The BSP is composed of knowledgeable functional experts who, in an advisory role, recommend acquisition strategies for a specific product or service. HQ AFSC is now conducting two-part BSPs on all major weapon system programs for which the Secretary of the Air Force is the Source Selection Authority and for those that are reviewed by the Joint Requirements Management Board or by the Air Force Systems Acquisition Review Council. The two-part BSP consists of two sessions: The Product Assurance (PA) Session and the Business and Contract Strategy Session. The PA session covers reliability, maintainability, quality, producibility, acquisition logistics manufacturing, and mission-critical computer resources. These two-part BSPs focus attention on the necessity of a sound PA approach in system acquisition.

Product Performance Agreements (PPA) make an important contribution to the AFSC R&M effort. These agreements provide a contractual motivation for the right kind of R&M effort through warranties, incentives, and awards. Since the intent of the PPA is to create a positive influence on the design process, the contractor is notified of the PPA intent early in the design process so that he has an opportunity to deal with risk by doing trade-off studies. The PPAs are constructed so that they are win-win situations. The successful contractor gets a good reputation and a financial reward; the Air Force gets higher R&M in the field.

The Product Performance Agreement Center (PPAC) provides the Air Force expertise necessary to improve the
use and effectiveness of PPAs. The functions of the center include:

- Providing technical assistance to acquisition managers in the selection, tailoring, and administration of PPAs
- Reviewing the application and effectiveness of existing warranties
- Developing improved techniques and methodologies such as cost/benefit analysis and selection criteria
- Recommending new or revised PPA policy and guidance
- Serving as a central repository for the collection and analysis of PPA data.

3. ENGINEERING

AFSC employs a system approach to acquiring weapon systems that can perform the mission when required, are supportable and supported, possess the necessary characteristics of mobility and survivability, and are affordable on a life-cycle cost basis. The approach has 6 steps:

**Step 1.** To identify the operational requirements and to assist the users in understanding what is technically feasible and where technology can help address deficiencies in current operations and maintenance. The objective of this effort is to establish realistic operational R&M requirements.

**Step 2.** To derive quantitative contractual requirements that support the operational requirements. The program manager performs this by determining the operational factors, such as incorrect maintenance, that the contractor cannot control and using these to establish an audit trail that leads from the operational requirement to the contract requirement.

**Step 3.** To integrate the product assurance logistics disciplines into the design process. Contract requirements for the application of these disciplines provide a starting point. The contractor design team is encouraged, through program manager monitoring, to employ techniques such as derating, stress analysis, and failure modes effects and criticality analyses to improve the system design.

**Step 4.** To implement a comprehensive development testing program that includes tests for function, for tolerance to operating, transportation and storage environments, and for material or process variations. Failures during this testing are carefully investigated, so that appropriate corrective measures can be initiated. A test-analyze-fix discipline generally is applied to all test results prior to establishing the production design baseline. This provides reliability growth during development, contributes to high acceptance test yields in production and results in trouble-free operation in service.

**Step 5.** To use operational test and evaluation and early field experience to identify deficiencies, develop corrective actions, and implement these actions in a timely manner.

**Step 6.** To plan for product improvement. Although a system may meet all the current requirements, new technologies, new threats, or new tactics may require improvements. Early planning makes these improvements more feasible and more economically attractive.

An important part of the system approach is making the designer fully aware of the operating environment. This is achieved through active support of the Air Force Blue Two Visit (BTV) Program. Named for the blue suit, two-stripe airmen on the flight line, this program exposes industry design engineers and Air Force acquisition personnel to real-world operating environments experienced by maintenance technicians. During a typical visit, designers visit several operating locations to experience, in person, the weapon system supportability concerns they only read about in Air Force maintenance data collection and company equipment failure reports. The visits usually are made at the beginning of demonstration/validation and full-scale development phases of programs. The contractor and Air Force people who make visits are:

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<th>Contractor</th>
<th>Air Force Program Office</th>
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<tr>
<td>Program manager</td>
<td>Program manager</td>
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<td>Integrated Logistics Support manager</td>
<td>Deputy program manager for logistics</td>
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<tr>
<td>Chief engineer</td>
<td>Chief engineer</td>
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<td>Key design personnel</td>
<td>Director of projects</td>
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<td>Key system engineers</td>
<td>Director of tests</td>
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<td>Test manager</td>
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The program office and contractor personnel go to the field units not only to receive a briefing by the user. They spend a significant amount of face-to-face time with the operators and maintainers. This gives the acquisition and design personnel the opportunity to experience the operator's and maintainer's environment.

Two engineering programs that support better R&M are the Productivity, Reliability, Availability, Maintainability (PRAM), and the Reliability and Maintainability Technology Insertion Program (RAMTIP). PRAM is a quick reaction program that enhances combat capability by solving R&M and productivity problems with off-the-shelf technologies. PRAM projects consists of projects as small as providing a replacement microcircuit for an obsolete or unavailable part, and as large as an electronic counter-countermeasure flight testbed. During its 10-plus year history, the PRAM program has saved the Air Force over
3 billion dollars and maintained a consistently high return on investment. PRAM welcomes the participation of industry in the challenge of reducing operational and support costs. Each major command, each AFSC product division, and AFLC air logistics center have PRAM focal points who submit candidate projects to the PRAM program office at Wright-Patterson AFB for consideration. Recently, the Air Force expanded its Suggestion Program to include the PRAM program. The PRAM program is a showcase for the Air Force commitment to do the right things to improve its combat capability and reduce the cost of defense.

RAMTIP transfers new, high-leverage R&M technologies into weapon systems. The program funds the development of first time capabilities that are based on laboratory technologies that exhibit a high payoff in terms of R&M and enhanced combat capability. RAMTIP accepts the development risks and provides funding until these risks are substantially reduced for the program manager. Current projects include the development of an On-Board Inert Gas Generating System for the C-17 aircraft, an application of artificial intelligence to B-1B diagnostics, and a tomograph system to inspect small ICBM rocket nozzles during manufacturing. Future efforts will enhance the F-15E, E-3A, C-141 aircraft, the SEEK IGLOO, and TPS-43 radars, selected next generation engines and munitions, and air-launched missiles.

Test equipment is a major ingredient in the maintainability of systems. Modular Automatic Test Equipment (MATE) is the Air Force approach to the preferred design and acquisition of automatic test systems. The MATE standards were developed to provide continued and uninterrupted support for the weapon life. They require that MATE systems be designed to be easily fault diagnosed and repaired, that calibration be accomplished on site to minimize downtime and spares requirements, and that MATE be easily modified.

MATE has passed several important milestones recently. The MATE operations center at Kelly AFB recently achieved initial operational capability. The center is now prepared to verify MATE module compliance with interface standards. The first MATE application, A-10 Intermediate Avionics Test Set, successfully passed operational test and evaluation.

4. TECHNOLOGY

Technology programs seek to address R&M challenges at the component or subsystem level. Therefore, their contribution to the achievement of the required system R&M can best be assured by managing technology programs with figures of merit such as: tensile strength, hardness, fatigue resistance, mean time between failures (MTBF), mean time to repair (MTTR), fault tolerance of design, tolerance to environmental stress, ease of fault detection & fault isolation, and producibility. AFSC is supporting technology efforts with significant payoff for R&M. These include:

- reliability
- maintainability
- diagnostics
- automated test equipment
- training and simulator systems
- technical data management
- maintenance and overhaul aids
- metrology
- weapon analysis, reporting and management systems
- automated spare parts
- material transportation, handling and distribution systems
- fuels and munitions
- facilities and field services
- logistics communication information and management systems.

Electronic R&M related technology development programs play a major role in the AFSC exploitation of technology to improve R&M. These include Very High Speed Integrated Circuit (VHSIC) technology avionics for aircraft, and the Ultra-Reliable Radar, which will improve the airborne radar MTBF by an order of magnitude over current radars. Other programs will demonstrate the integration of VHSIC technology and advanced architectures to provide highly reliable, fault tolerant, electronic systems with line replaceable modules. Payoff for VHSIC will be in reduced size, weight, and power with much greater availability, flexibility, and substantial fault tolerance & failure management capability included in the hardware and software.

Software technology development efforts also play a major role and include software tools (e.g., editors, compilers, and a knowledge-based software assistant) for more efficient software development. Software techniques are being developed for rapid prototyping, so the user can better specify what he wants before all the software development has to be done in detail, and for predicting how well software will perform. Techniques and tools for distributed data processing systems are being developed, demonstrated, and applied; these will provide survivability through reconfiguration in the event of lost components or nodes. The DOD Software Engineering Institute (SEI) is evaluating and integrating software engineering tools from DOD, industrial, and academic sources, and is exercising them for prototype use in order to accelerate the transition of state-of-the-art software engineering knowledge into wider use. The overall goal of these efforts is to improve software development acquisition, and support processes in order to increase software quality and reliability while reducing development and support costs.

The emphasis placed on R&M in the Air Force PROJECT FORECAST II is another example of how support for R&M has become institutionalized in AFSC. The principal purpose of PROJECT FORECAST II was to provide
deliberate technology push as a basis for major change in our science and technology investment strategy to break away from the cycle of responding to the pull of force requirements. By identifying emerging, high-leverage technologies and candidate systems for further development and acquisition, AFSC expects to make substantial improvements in future warfighting capabilities beyond those that would have been achieved pursuing business as usual.

Each candidate technology and system concept was evaluated as to how it would contribute to potential future warfighting capability. R&M characteristics were included among the considerations used to evaluate these concepts. A special panel for R&M was one of the ten technology panels. This panel reviewed all of the systems and technologies, and judged the expected R&M features related to their application to operational systems. The output from the R&M panel was included in the individual technology and system descriptions.

In addition to the consideration of R&M in each of the 70 FORECAST II initiatives, five FORECAST II initiatives have enhancement of R&M as their primary objective.

Initiative 1. Smart Built-In Test. It addresses the problems that many electronic equipment failures are false alarms and that, of those items removed for repairs, a third of the failures cannot be duplicated (CND) during bench tests. Efforts to repair equipment that may not be broken tie up a substantial portion of scarce electronic repair resources. The key to eliminating this problem will be widespread use of microprocessor based decision rules coupled with micromechanical environmental sensing devices. When a failure indication occurs, the chips will sense the environment (e.g., temperature or acceleration) at the time of the event, store the information, retest to determine whether the problem is permanent or transitory, and, if it is permanent, work around it so that the system continues to operate. Later, during routine maintenance, the chips will dump all their information pertaining to the event to help the maintainer identify, isolate, and correct the problem.

Initiative 2. Ultra-High-Quality-Software. It will use artificial intelligence to help develop ultra-high-quality software for mission-critical computer applications. Efforts such as creation of practical software engineering environments will produce quality software that is efficient, standardized, and repairable. This will solve one of the chronic problems confronting the Air Force.

Initiative 3. Robotic Telepresence. Rather than pursuing autonomous robotics, the objective is the creation of a relatively sophisticated manipulator, one with good eyes and strong arms but virtually no brainpower. The person controlling the device would see (in virtual three dimensions) whatever the robot is “seeing” and would feel (through tactile feedback) whatever the robot is feeling. These robots would permit humans to operate from a safe environment while conducting hazardous activities, such as aircraft repair and replenishment in a chemical/biological/radiological environment. The robots could be used at remote locations, e.g., North Warning radar sites or placed into geosynchronous orbit and used whenever satellite repairs are needed. Another feature of these robots would be the ability to scale their operations up or down. For example, robots could perform heavy construction, doing 10 or 100 times the work being done by the operators to which the robots are slaved. On the other hand, in the scaled-down mode, a human could manipulate a large mock-up of a circuit board while the robot performs the same task at the microchip level.

Initiative 4. Fail-Soft, Fault-Tolerant Systems. They involve the allocation of system hardware and software under an artificial intelligence manager. New generations of multipurpose computers and signal processors will permit the sharing of functions and data in a way that will overcome the effects of battle damage or electronic failure, either of which would result in loss of capability in current systems.

Initiative 5. Unified Life Cycle Engineering (ULCE). It is a major effort over the next few years to improve and integrate the databases and software architectures essential to improvements in computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided support (CAS). The objective of ULCE is to develop the technology for a computer-based system that will permit trade-offs among performance, producibility, supportability, and cost early in the design phase — before bending any metal. While it will take at least a decade to produce fully integrated CAD/CAM/CAS systems, application of intermediate technology improvements can pay immediate dividends in terms of lower-cost systems that are more easily manufactured, more reliable, and more supportable as well as more combat capable. This effort could ultimately save billions of dollars each year in acquisition and support costs.

Technology being developed under ULCE directly applies to the DOD Computer Aided Logistics Support (CALS) initiative. CALS addresses the application of technology to automation and integration of engineering, with specific focus on digital technical data. The CALS objective is to develop and apply an integrated capability to create, accept, retrieve, and store digital technical data in order to design more-supportable weapon systems.

One example of ULCE technologies which support the CALS effort is Reliability and Maintainability in Computer Aided Design (RAMCAD). RAMCAD will be included as one of the first modules of the CALS engineering data bases. A significant issue for insertion of RAMCAD, as well as CALS, into the design process is determining how to encourage its use appropriately through contracts for weapon system acquisition.

CONCLUSION

AFSC is proud of the strides it has made toward making R&M coequal to cost, schedule, and performance. It recognizes that effective management, thorough engineering, and the infusion of new technology are essential elements for making Air Force systems meet their operational requirements. These make R&M 2000 a reality.

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