USAF expects new weapons to be twice as reliable—and require only half as much maintenance—as their predecessors.

—Photo by Paul Kennedy

R&M Is Serious Stuff

BY PETER GRIER

THE missile guidance set on the Minuteman III ICBM is hard to service. The problem lies not in the subsystem itself, but in its location beneath the missile reentry system. To reach the guidance set, the Minuteman silo door must be opened and the reentry system with its nuclear payload must be removed—a procedure that requires five maintenance personnel, three vehicles, eight security police, and daylight.

Designers of the Peacekeeper ICBM learned from this maintainability problem. In the Peacekeeper, the missile guidance set also has been positioned underneath the reentry system, but it is mounted in a sliding drawer. Repair does not require warhead removal. The silo does not have to be opened, only one security guard is needed, and work can be carried out any time, day or night.

By decreasing ICBM downtime, this designed-in maintainability improvement, in effect, multiplies the US nuclear deterrent force. It reflects one of the primary goals of the Air Force's R&M (Reliability and Maintainability) 2000 initiative: increasing combat capability by buying weapons that perform reliably over time, instead of systems that promise much but are always in the shop.

The Air Force's headquarters office for R&M declares that the policy for new weapons is "Double-R/Half-M," meaning that next-generation systems should be twice as reliable and should require half the maintenance of the generation they replace.

Making this quantum leap will require, among other things, better design, more attention to quality, contractor incentives, and a commitment by the Air Force leadership to make the requirement stick. "We're talking about a cultural change, not just in the way the Air Force does business but in the way industry does business," says Brig. Gen. William Collins, Air Force Special Assistant for Reliability and Maintainability.

Official requirements for both the SRAM II (Short-Range Attack Missile) and the Advanced Tactical Fighter (ATF) take the R&M benchmark to heart. ATF requirements call for a break rate of eight to ten percent, compared to fifteen per-

Designers of the Peacekeeper ICBM learned from the Minuteman's maintainability problem. Repair of the missile guidance set does not require warhead removal.

cent for the F-15. Seventy-five percent of ATF problems should be fixable in four hours, as opposed to forty-two percent for the F-15. The requirement for ATF maintenance personnel is set at eight per aircraft, as opposed to the F-15's eighteen.

Response on ATF

The ATF's contractors are taking these goals seriously, according to the Air Force. General Electric is assigning top engineering talent to work on the controls, actuators, and piping that hang on the outside of its ATF engine prototypes. Although these units are the cause of most engine maintenance actions, GE officials say they haven't made them a top priority in the past. Pratt & Whitney says its ATF engine competition entrant will have forty percent fewer parts and require sixty percent fewer depot- and support-level tools than do current-generation fighter engines. Any main unit on the ATF engine will be replaceable in twenty minutes, says Pratt & Whitney.

Improved R&M isn't just the province of next-generation systems, notes General Collins. Upgrades and retrofits can greatly ease the burden of supporting currently deployed weapons. The new APG-68 Programmable Signal Processor for the F-16 will use VHSIC (Very-High-Speed Integrated Circuit) technology and have a mean time between failures of 2,000 hours. The MTBF rate for the unit it replaces is about 200 hours. Two-thousand-hour reliability is the goal for most fighter electronics. An Air Force R&M overview report points out that "many operating commands project that 2,000 hours for LRUs [Line Replaceable Units] would eliminate the requirement for intermediate-level maintenance."

R&M retrofits don't have to be driven by new technology. Take the case of LANTIRN (Low-Altitude Navigation and Targeting Infrared for Night) Targeting Pod laser alignment. In initial production units, maintenance personnel had to take off a large access panel held on by many small screws to get at the laser adjustment screws. Putting the panel back on often knocked the new adjustment out of whack. Laser adjustment often took longer than the predicted four hours.

Later LANTIRN production models have a small hatch on the access panel that can be quickly popped open. Average laser alignment time has been reduced by over seventy-five percent. "It's so obvious. Why didn't we do it in the first place?" says General Collins.

Poorly designed panel fasteners hold a particular horror for aircraft technicians. One FB-111 panel is held on with 187 screws of six different lengths. Nothing on the screw holes indicates which length fastener they take. A mechanic who threads a long screw in a short hole can sever wires behind the panel, grounding the plane for hours.

Trying to prevent such nightmares from happening in new systems is "pick-and-shovel work," the daily fare of his office, says General Collins.

Five Main Objectives

The R&M 2000 initiative is a focus for Air Force efforts to make reliability and maintainability of equal importance to weapon cost, performance, and acquisition schedule. R&M 2000 goals are an attempt to get away from traditional mean-time-between-failure bean-counting, says General Collins, listing five main objectives:

Increase combat capability. The overarching point of better R&M is to enable the Air Force to do more with less. Less time in the shop means more time spent over target. Fighters should be able to fly ten straight sorties without maintenance; ground radars should operate for thirty days without a critical failure.

"If you double reliability, you only need half as many planes to do the same job," says General Collins.

Decrease support structure vulnerability. Destruction of vulnerable airfield maintenance shops grounds airplanes. Aircraft that don't need so much field support are more combat-capable, because if support structures don't have to be in place, they are not vulnerable.

Destruction of base plants that supply liquid oxygen for pilots' breathing would ground fighters in days. So the F-15E (as well as the B-1B) has an on-board oxygen-generating system, which takes bleed air from the engine and runs it through a molecular sieve, eliminating the liquid oxygen plant requirement.

Cut mobility requirements. Aircraft that are more reliable and maintainable don't need so much logistics baggage. Hence, they're easier to shift between bases—multiplying the force by improving its flexibility.

The Mobile Electronic Test Set for the F-15E is only one-eighth the size of equipment fielded with other F-15 versions. In terms of mobility, that represents one C-141 trip that doesn't have to be made. Requirements call for an ATF squadron to be deployable with six to eight C-141-sized loads, as opposed to the eighteen necessary for an F-15 squadron deployment.

Reduce maintenance manpower needs. The Air Force thinks it should be possible to reduce the number of personnel needed to maintain new-generation systems by one-third to one-half, freeing personnel slots for distribution throughout the rest of the service. The KC-135 reengining program shows the possible effect: Reliability improvements with the plane's new F108 engine have now saved fifty manpower spaces in Strategic Air Command, according to the Air Force, with an additional savings of forty spaces to materialize by 1991.

Reduce maintenance costs. Obviously, fewer maintenance actions taken for new systems can help lower their overall maintenance costs. Less obviously, designing with R&M in mind can lower the cost of individual parts. Advances in electronics can be the key.

The redesigned Central Air Data Computer for the C-141 costs $20,000 less than the original model, while providing ten times the reliability. Use of VHSIC technology in the new F-111D Signal Transfer Unit has reduced parts costs from $24,000 to $2,000.

Such new technologies are the breakthroughs that have brought R&M 2000 goals within reach, says General Collins. Merely replacing the old with the new can pack a large increase in R&M punch. Use of fiber optics in place of copper cable in mobile ground radar, for instance, can save 1,000 pounds per set while increasing survivability and reliability.

Constant Attention Pays

The largest improvements may come just by keeping R&M in mind during development. "That really pays big dividends," says General Collins.

Take the C-17 transport aircraft. When McDonnell Douglas was setting up the new airlifter's production line, it conducted a study of the problems it had had manufacturing wide-body airliners in the past. One thing the engineers found was that with big planes, assembly workers typically crawled over fuselage sections and often slipped or dropped tools, causing dents and damage.

So McDonnell Douglas built huge jigs to hold fuselage sections and rotate them on stands in front of workers. That cuts down on dents and quality problems, increasing C-17 reliability.

The "Blue Two" program for sending engineers out to the field to see the real-world problems of maintaining systems is also a crucial R&M tool, says General Collins. (See "Blue Two," April '89 issue, p. 56.)

How can the Air Force ensure that its contractors take R&M seriously? "The timing is with us," says General Collins. "You're using their recognition that they're going to have to do this if they're going to compete."

R&M incentives can be written into contracts. Westinghouse recently won a $67 million bonus for meeting R&M goals on its APG-68 F-16 radar. Warranties can be written to hold contractors responsible for making sure their products perform up to standards over time. Effective R&M warranties should include, among other things, provisions for fixed-price repairs and no-cost retrofit of engineering changes.

Industrial cultural change, say officials, will have to be part of the R&M revolution too. Without it, defense contractors may find it next to impossible to produce systems with the built-in quality and reliability the Air Force says it's going to demand. The US defense industry prides itself on being the last bastion of American industrial superiority, but General Collins says even weapons makers have a lot to learn from the Japanese.

Beyond Inspection

When defective products start rolling off the assembly line, Japanese manufacturers don't just tighten the inspection net. "They go back and find out why," says General Collins.

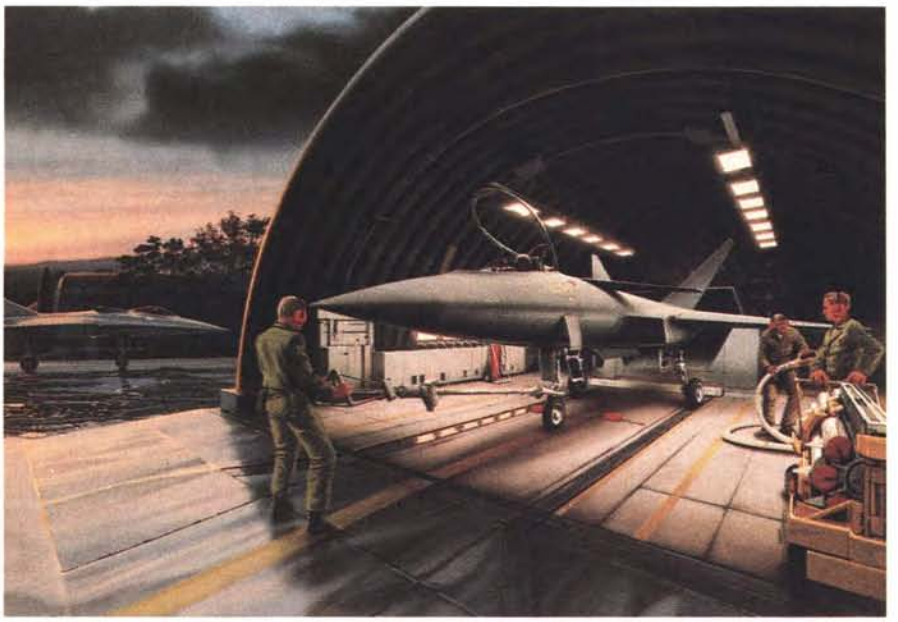
As a result, Japanese weapons are as well-made as Japanese VCRs. Last year, General Collins's office sponsored a joint industry-DoD trip to study Japanese licensed production of an F-15 variant, the F-15J. "There are some strong indications that the F-15J is more reliable than its American counterpart," says an Air Force report on the trip. "The predominant reason appears to be the emphasis on quality during manufacturing and depot activities."

Japanese attention to detail is apparent. Workers sweep their own space on the factory floor, says the Air Force report. Tools are stored on rubber mats, with drill bits covered. Parts that aren't in use are covered with clear plastic. Plastic sleeves are slipped over the threads of finished bolts.

At Mitsubishi Heavy Industries, one of four major Japanese F-15J contractors, about two percent of domestically supplied parts are found to be defective. In contrast, parts imported from the US prove to be defective about nine percent of the time.

Improvement of F100 engine-turbine blades made at Ishikawajima-Harima Heavy Industries shows the Japanese commitment to quality, according to the Air Force. The problem was that too many blades were going through the grinding process and coming out too long to be used.

Tracking the problem back to the factory floor, Japanese managers discovered that they had one star grinding machine that was producing virtually perfect parts. Ripping it apart to find out why, they discovered that it was the only machine



The ATF must have a break rate of eight to ten percent; the F-15's rate is fifteen percent. The ATF will need eight maintenance personnel per aircraft; the F-15 requires eighteen. ATF contractors are taking the R&M benchmarks seriously.

Computer analysis of the F-16A concluded that its combat capability could best be increased by improving the reliability of its weapons delivery system.

whose jig had been put together without locknuts. That meant it held blank pieces more tightly, resulting in more accurate work.

The locknuts were quickly stripped from all the grinding machines. Blade quality improved dramatically, to the point where none came out too long.

Quality improvements such as this can have a ripple effect that increases reliability and saves money all down the line, says General Collins. "If you get all the turbine blades right on target, you don't have to balance the engine," he points out.

Weapon systems often fail because of variability in the design and manufacturing process. Ishikawajima-Harima's turbine-blade detective work is an example of what General Collins calls the Variability Reduction Process (VRP). Use of VRP is a significant contributor to the F-15J's high reliability, according to the Air Force report on the R&M 2000 trip to Japan.

Air Force leaders say that VRP is the sort of quality-control technique that US contractors will have to make part of their everyday routine if they want to remain competitive. General Collins says his message to contractors is, "We're not going to pay more for quality. You're going to have to learn how to do it."

Finding the Payoffs

R&M is a good thing not for its own sake but because of what it makes possible. If total weapon system reliability isn't improved, then an R&M upgrade for a subsystem isn't worth making.

UHF radios are already the aircraft equivalent of an AM/FM transistor: reliable, cheap, and not too glamorous. General Collins says he probably wouldn't pay for a longer-lasting radio, because broken receivers aren't keeping planes out of the air. Resources should be concentrated on more delicate systems, where the payoff for improvement would be much greater.

The Air Force is developing a computer program named MARGI (Methodology for Analyzing Reliability and Maintainability Goals and Investments) to help it get the biggest increase in combat capability it can out of R&M retrofit dollars. By analyzing the importance of a particular subsystem to an aircraft's mission, then mixing in predicted parts failure rates, the program can point to the things that most need to be made more reliable.

A MARGI analysis of the F-16A concluded that the plane's combat capability could best be increased by improving the reliability of its weapons delivery system. MARGI also calculates the estimated impact of specific part changes. If ring-laser gyros were inserted in all F-16As, for instance, the resulting increase in fleet reliability would be equivalent to the purchase of seven new aircraft.

Strategic Air Command and Tactical Air Command are now using the MARGI model, with Military Airlift Command to come on line soon. General Collins says the software will be a valuable tool in the hunt for such items as the F-111D Signal Transfer Unit, where a relatively small investment in R&M has meant a big jump in aircraft availability.

After all, the ATF may represent a new level of reliability and maintainability, but current-generation aircraft will be the backbone of the Air Force for many years to come. Even next-generation systems will break and undoubtedly will be worked on in the open, in bad weather, by crew chiefs muttering about the boneheaded engineers who designed them.

"There's a lot more pick-and-shovel work still out there," says General Collins. ■

Peter Grier is a Washington-based defense correspondent for the Christian Science Monitor. *His most recent article for* AIR FORCE *Magazine was "Squeezing More from the Logistics Dollar" in the August '89 issue.*