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Report to the Ranking Minority Member, Committee on Governmental Affairs, U.S. Senate

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Its Potential Battlefield Contribution Still in Doubt

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United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-205804

October 26, 1987

The Honorable William V. Roth, Jr.
Ranking Minority Member
Committee on Governmental Affairs
United States Senate

Dear Senator Roth:

In your letter of February 5, 1986, and in subsequent discussions with your representatives, you requested that we continue our evaluation of the Army's Aquila remotely piloted vehicle program. On January 4, 1986, we reported to you on the Aquila's performance in Army tests conducted in 1985.[1] In July and November 1986, we briefed your office on the Aquila's performance in contractor testing and in Army development tests and training exercises.

This report covers operational testing conducted at Fort Hood, Texas, from November 17, 1986, to March 25, 1987. The purpose of the test was to assess the Aquila's ability to accomplish its mission in its planned operational environment and to evaluate other key characteristics, such as reliability and maintainability. This report assesses the Aquila's readiness for production based primarily on its performance in operational testing and the adequacy of the test. As you requested, we also reviewed the results to determine whether the Aquila's 3-hour flight endurance capability was sufficient to perform its mission. (See app. I.)

The Aquila is intended to provide ground commanders with battlefield information about enemy forces located beyond the sight of the Army's ground observers. Its mission is to detect targets in enemy territory and to direct conventional artillery and laser-guided munitions against them. Targets are detected with an optical sensor carried aboard the aircraft. The Army plans to field the Aquila initially with a television sensor whose use is limited to daytime operations. This is the sensor that was used during operational testing. An infrared sensor is also being developed to provide night and adverse weather capabilities. It is estimated that it will be available 12 to 18 months after the television sensor is fielded. The Aquila's great advantage over other reconnaissance assets, such as manned aircraft, is that it can conduct these operations with less risk to human life.

[1] Aquila Remotely Piloted Vehicle, Recent Developments and Alternatives (GAO NSIAD-86-41BR).

The Aquila program began development in 1979 and has experienced considerable cost growth due to technical problems, schedule delays, and expanded performance requirements. Development and production costs are currently estimated at $2 billion. The Army plans to buy 376 aircraft at a unit production cost of $1.8 million (in escalated dollars). Included in the aircraft unit cost is about $900,000 for either the television or the infrared sensor. The Aquila would carry one or the other of these sensors, depending on the mission.

Deficiencies in the test criteria and limitations in the operational testing make it difficult to project the Aquila's likely performance when it is fielded. The test showed that the Aquila performed well in some important areas but that overall it is not ready for production. It seldom was able to complete its mission, and military personnel found it difficult to maintain or to support logistically. The sufficiency of the Aquila's 3-hour flight endurance for performing a successful mission will not be known until the Army completes an analysis of the effect of changes in the planned use of the Aquila. The changes increased the distance from the Aquila's launching site to positions where the enemy would be located, consequently reducing its time for flying over target areas. The number of targets the Aquila could detect during a flight, therefore, could be lowered, but the effect of this reduction on combat operations has yet to be analyzed.

The Army is working on resolving problems disclosed in testing and also on developing an infrared sensor which could further improve the Aquila's performance. However, the Army does not plan to test most of the corrective actions until after production begins, and the infrared sensor's development has been slowed by technical problems and funding shortages.

At the conclusion of our review, the Army's Operational Test and Evaluation Agency was still refining test data and preparing its evaluation. Refining the test data is not unusual in weapon system testing. It is done to account for any anomalies occurring during the testing which, in the judgement of the test evaluators, cause a result to be distorted or skewed. In this process, care must be taken to weed out only those occurrences which were truly unrepresentative of normal test conditions. Based on discussions with test officials, it appears that the net result of changes to the test data made subsequent to our review could lead to some performance elements being scored more favorably than they might have been before the revisions. We do not believe, however, that these changes will be significant enough to affect our conclusions.

The Aquila's performance during the test was to be the basis for Army and Department of Defense (DOD) decisions, scheduled for July and August 1987, on whether the system should enter production. The production decision has since been postponed and will be rescheduled for sometime in 1988.

System Performance During Operational Testing

Operational test results showed that the Aquila did not meet two basic requirements the Army prescribes for a system before it enters production: that the system (1) be effective in performing its intended mission and (2) be reliable, maintainable, and otherwise logistically supportable. The Aquila performed well or experienced only minor problems in flight and recovery operations, in directing artillery fire at targets, in mobility, and in its electromagnetic compatibility. These successes, however, were offset by its difficulties in consistently achieving a successful launch, in detecting targets, and in reaching acceptable levels of reliability and maintainability. Major problems also surfaced in survivability and in human engineering (which refers to how proficiently the system can be used by its intended operators). Figure 1 summarizes our assessment of operational test results for each of the essential characteristics the Army established for the Aquila.

Figure 1: GAO's Assessment of the Aquila's Performance During Operational Testing

Essential Characteristic	Major problems	Minor problems	Successful
Mission effectiveness			
Launch	X		
Flight and recovery			X
Detection recognition and location	X		
Artillery adjustment		X	
Survivability	X		
Reliability and maintainability	X		
Mobility			X
Human engineering	X		
Electromagnetic compatibility			X
Growth potential		X	

Mission Effectiveness

To effectively complete a mission, the Aquila must (1) be launched within a specified period of time after orders to launch are received, (2) complete its flight operations, (3) detect, recognize, and locate enemy targets, (4) direct artillery to the designated targets, and (5) be successfully recovered. Operational test data showed that the Aquila successfully fulfilled all of these requirements in only 7 of 105 flights. In the remaining flights, the Aquila did not successfully complete one or more of its required tasks.

Numerous launch delays were experienced primarily because of technical problems in the launcher and in the aircraft. Test officials noted that possible reasons for the difficulties in detecting targets were the sensor's technical limitations and poor techniques used to search for targets. The sensor, which is basically a television camera, could not see well through camouflaging. Also, the use of a jam-resistant communication link, a distinguishing feature of the Aquila, degraded video quality. Test officials believed that target detection rates would have been higher had operators used better sensor positioning and more methodical search patterns.

Survivability

Earlier tests showed that electronic surveillance could not locate the Aquila's ground systems, thus making the systems less vulnerable to attack. In view of the success in earlier testing, the Army did not repeat testing of the ground system's vulnerability in the operational testing. However, the operational testing indicated that the Aquila aircraft will probably be susceptible to detection by enemy air defense weapons with good target acquisition capabilities. Information collected during the test showed that such a weapon was able to acquire, track, and lock onto the aircraft with some consistency. However, the likely effect of these weapons on the Aquila's mission performance was not assessed during the test. Thus, computations of the Aquila's performance in areas such as flight and target detection were based on an environment free of enemy air defense weaponry.

Reliability and Maintainability

In some respects, the Aquila's reliability during the operational test was higher than in previous tests, but there are questions concerning the reliability computations.

The Aquila's technical reliability, computed on the basis of how frequently problems occurred that were traceable to system components, showed improvement over what it had been in previous tests. On the basis of technical reliability scores, Army test officials calculated that the Aquila could perform its mission 69 percent of the time without a serious failure. This approaches the Army's 75-percent technical reliability requirement. Operational reliability, which, in addition to problems chargeable against the system, reflects problems traceable to actions by personnel operating the system, was calculated at 49 percent. The Army, however, has not established an operational reliability requirement to which this achievement can be compared.

How much confidence can be placed in the reliability computations is unclear. Several significant failures were not counted because they occurred before orders to start a mission had been received. In doubtful situations, scorers had a tendency to attribute problems to actions by personnel rather than to the system itself. In addition, contractor personnel were involved to an inordinate degree in assessing a number of reliability failures; their arguments that the system was not at fault were accepted by the scorers with little debate or without validated supporting data.

Several types of problems were encountered with the Aquila's maintainability. It took military personnel too long to locate and correct problems. These difficulties occurred because diagnostic equipment to detect system faults was not fully developed, troubleshooting procedures were incomplete, and repair parts were unavailable when needed. Contractor personnel were needed to perform the more difficult maintenance tasks that military personnel will be required to perform in combat. In short, logistics support has not kept pace with the system's development.

Human Engineering

The test also showed that the system was too complex for its operators. Human engineering problems accounted for many of the difficulties experienced in launches, target detections, reliability, and maintenance. According to an analysis by the Army's Human Engineering Laboratory, certain subsystems may have to be redesigned and operators' skills and capabilities may have to be upgraded.

Adequacy of Operational Test and Evaluation

Although the operational test was the most comprehensive effort to date to collect information about the Aquila's performance in its intended operational environment, certain deficiencies in the test and evaluation make it difficult to project the Aquila's eventual performance when fielded.

The Army established quantitative criteria to evaluate specific functions, such as launch, flight, target detection, directing artillery fire to targets, and recovery of the aircraft. However, no analysis was made to determine whether meeting these criteria, either individually or cumulatively, would produce an operationally effective system. The criteria for the mission functions, when taken together, demand only a 24-percent or less overall probability of successfully completing an entire mission from launch to recovery.

Criteria for evaluating other important factors, including survivability, reliability, maintainability, mobility, and human engineering, were not established for the test.

Several test conditions existed which may impair an accurate assessment of the Aquila's potential performance in the field. For example, in addition to their involvement in maintenance, contractor personnel participated in, and appeared to influence, Army deliberations on scoring reliability failures. They were involved to a greater extent in these deliberations than we had noted on other weapons systems, such as the M1 tank and the High Mobility Multipurpose Wheeled Vehicle. In those cases, contractor participation was limited to furnishing technical advice on the equipment. Contractor involvement raises questions of compliance with 10 U.S.C. 2366(b)(2) (1987) which restricts the participation of contractor personnel in operational test and evaluation.

Other potentially limiting test conditions included (1) a combination of test range restrictions, low visibility and limitations of the television sensor which precluded flights in adverse weather, and (2) the use of a test site which was not characteristic of the more rugged terrain and denser vegetation found in the region of central Europe for which the Aquila was designed and will be fielded.

Sufficiency of Aquila's Flight Endurance Capability

When the Army established Aquila's 3-hour flight endurance requirement, it planned to locate launch and recovery operations entirely within forward combat areas. This operational concept allowed 30 minutes for traveling to and from the target area and 2-1/2 hours to perform missions over the target area.

In 1983 the Army decided to locate launch and recovery operations in rear areas to take advantage of the Aquila's ability to perform additional combat missions that were yet evolving. This meant the aircraft would spend more time flying to and from target areas and less time over the target area itself. In 1986, Army development tests showed that additional allowances for fuel consumption, flight warm-up, and unsuccessful recovery attempts might have to be made. The changes could shorten the Aquila's available time over target areas to 1-1/2 to 2 hours and, consequently, reduce the number of potential targets it could detect. The Army is assessing whether the 3-hour endurance capability is still sufficient for the Aquila to successfully perform its mission, given this potential reduction in productivity. The Army planned to complete its assessment in November 1987.

Planned Improvements

Efforts underway to improve the Aquila's performance and capabilities include (1) modifications to correct problems disclosed in testing, and (2) development of an infrared sensor. If successfully developed, this sensor would not only provide a capability to operate at night, but also overcome limitations of the television sensor to see through obstructions, such as clouds, smoke, and camouflaging.

The Army does not plan to demonstrate most of the corrections to technical problems encountered during testing until after the production decision. The Army has scheduled additional testing to begin in October 1987, which will be limited to demonstrating improved target search techniques. Successful development of the infrared sensor will depend on (1) overcoming technical problems, particularly compatibility with the aircraft's hardware and software, and (2) having funds available to complete development.

Conclusions

Major problems should be corrected before the Army makes its production decision on the Aquila. Frequent inability to launch the aircraft, difficulty in detecting targets, and survivability require priority attention from a mission performance standpoint. However, of these three problems, only the target detection capability was to be reassessed in testing before the production decision.

Most of the other planned improvements for resolving problems identified during operational testing are not scheduled to be demonstrated until after the production decision. We believe the Army should demonstrate that the problems critical to mission performance have been corrected and that progress has been made in making the system more easily operable and maintainable by Army personnel before the Aquila enters production.

The larger question is how useful the Aquila will be even with these improvements. The Aquila did not perform well against modest test criteria in daylight and good weather conditions. Also, its performance did not reflect the effect of enemy weaponry on mission operations. The ability to see well at night and through clouds, smoke, and camouflage is beyond the technical limits of the current sensor. The infrared sensor could potentially overcome several of these limitations and is estimated to cost about the same as the television sensor. If successful development of the infrared sensor appears unlikely, the benefits of fielding the Aquila with only the television sensor would be uncertain. The Army should determine whether the limited benefits to be derived from fielding the Aquila with the television sensor warrant entering production before the infrared sensor's successful development is certain.

Recommendation to the Secretary of the Army

We recommend that the Secretary of the Army postpone production of the Aquila until the Army

- demonstrates, through selective testing against sound criteria in an operational environment, solutions to the key mission performance problems and other system deficiencies identified through a full assessment of operational test results, and
- determines whether initiating production of the Aquila with the television sensor is warranted before the infrared sensor's successful development is certain.

Agency Comments and Our Evaluation

DOD agreed that our concerns about the Aquila's performance in the operational test were valid and stated they will be discussed when the Aquila comes up for the production decision following its newly scheduled, 2-month test (see app. II). The upcoming test will reflect improvements in training made since the operational test but will be limited to measuring the Aquila's target detection capability. It may be difficult to make a meaningful comparison of the upcoming test results with the operational test results because (1) target areas to be searched will be smaller and no targets will be camouflaged (conditions which would seem to improve target detections with no real improvement in the Aquila system), and (2) the test will be conducted with the Aquila aircraft attached to a manned airplane, which will not enable further assessment of launch performance, maintainability, reliability, and survivability (other areas of major problems). Also, the test is not an operational test and is not being designed and conducted by the Army Operational Test and Evaluation Agency.

DOD believed that the television sensor should be fielded as planned, on the basis of the television sensor's ability to provide a capability that does not currently exist and its availability 12 to 18 months sooner than the infrared sensor. DOD also noted that the television sensor could detect targets better than the infrared sensor in desert-like environments where the temperature difference between the target and background is small. In our opinion, it is not certain that the television sensor's earlier availability would provide the 12 to 18 month advantage the Army envisions in light of the Aquila's other unresolved problems. Also, while the television sensor may have advantages in a desert environment, the Aquila's intended environment is Europe, where the infrared sensor has advantages.

DOD believed that our criticism that the Aquila could not be depended on to perform its mission, that military personnel had difficulty maintaining and supporting it, and that the television sensor was incapable of performing the target acquisition function in difficult field conditions was unduly harsh. DOD contended that the Aquila is the most advanced remotely piloted vehicle available and that the problems during testing largely stemmed from the troops' lack of knowledge about how to use it. Although further training of the troops could improve the Aquila's showing, we believe the test results indicate that the more serious problems such as launch operations, target detection, and aircraft survivability, stem more from system deficiencies than from errors by the operating personnel. Most of the maintenance deficiencies will require additional development of fault diagnostic equipment and troubleshooting procedures.

DOD maintained that contractor officials had not gone beyond their usual role of technically advising and assisting the Army and did not unduly influence the Army's scoring of the reliability incidents. The Army plans to formally advise us on its views as to whether the contractor's role in the testing was consistent with legislation that restricts contractor participation. At that time, we will provide you with our analysis of its views.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 5 days from the date of issue. At that time we will send copies to interested parties, including the Chairmen of the House and Senate Committees on Armed Services and on Appropriations and the Secretaries of Defense and the Army and to others upon request.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

Contents

Abbreviations

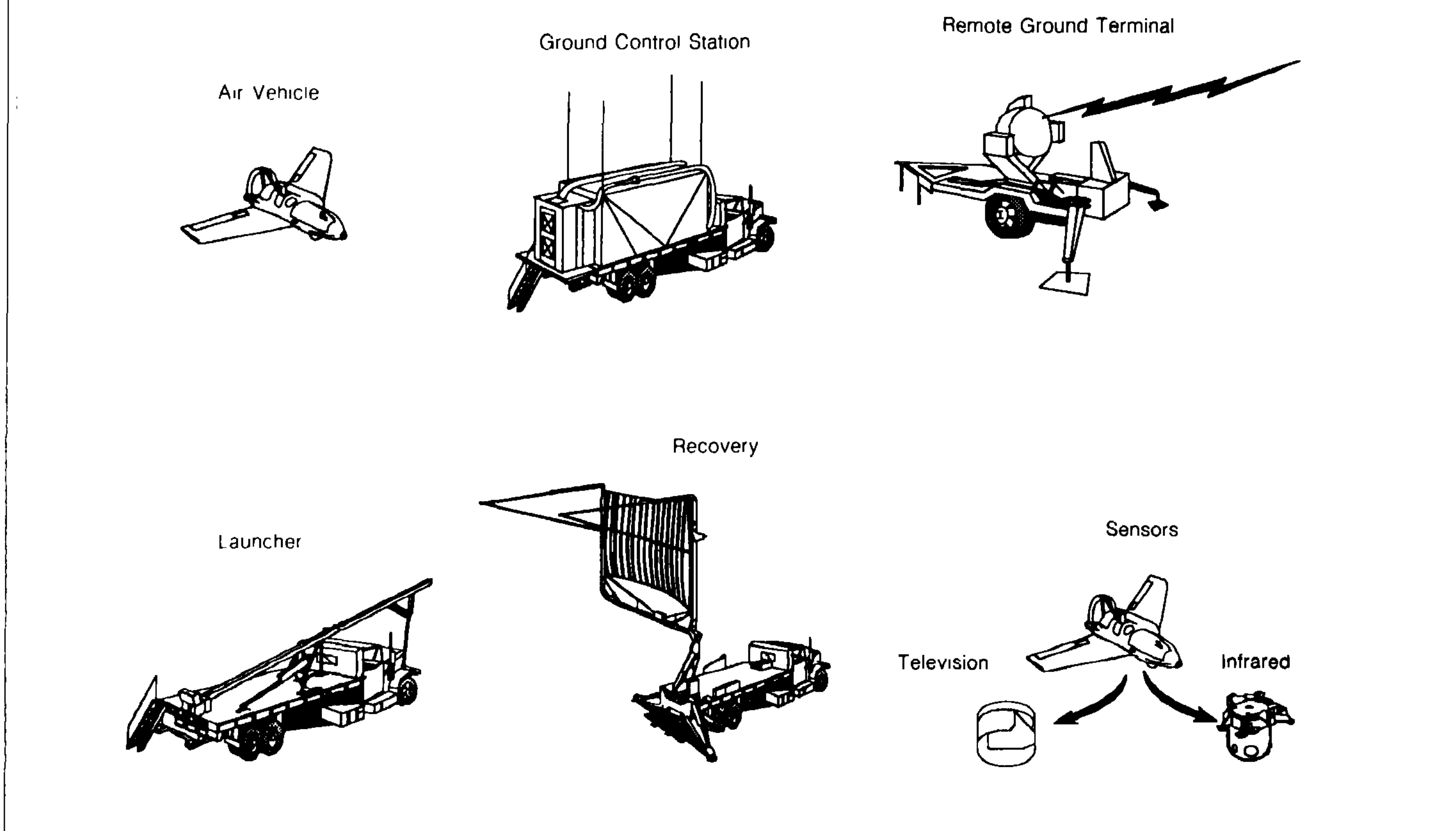
DOD	Department of Defense
OTEA	Army Operational Test and Evaluation Agency

Assessment of Aquila's Readiness for Production

Introduction

The Aquila is a small, remotely piloted aircraft designed to provide ground commanders with real-time battlefield information about stationary and moving enemy forces located beyond the line of sight of ground observers. It can be launched and recovered by mobile launch and recovery vehicles even in rugged terrain. An optical sensor and a laser designator/rangefinder aboard the aircraft allow operators to search for targets and perform reconnaissance beneath the aircraft's flight path. The Army is completing development of a television sensor for initial fielding that is limited to daytime operations. A forward-looking infrared sensor, being developed to provide night and limited adverse weather capability, would be available for fielding after the television sensor. Figure I.1 shows the main operating components of the Aquila system.

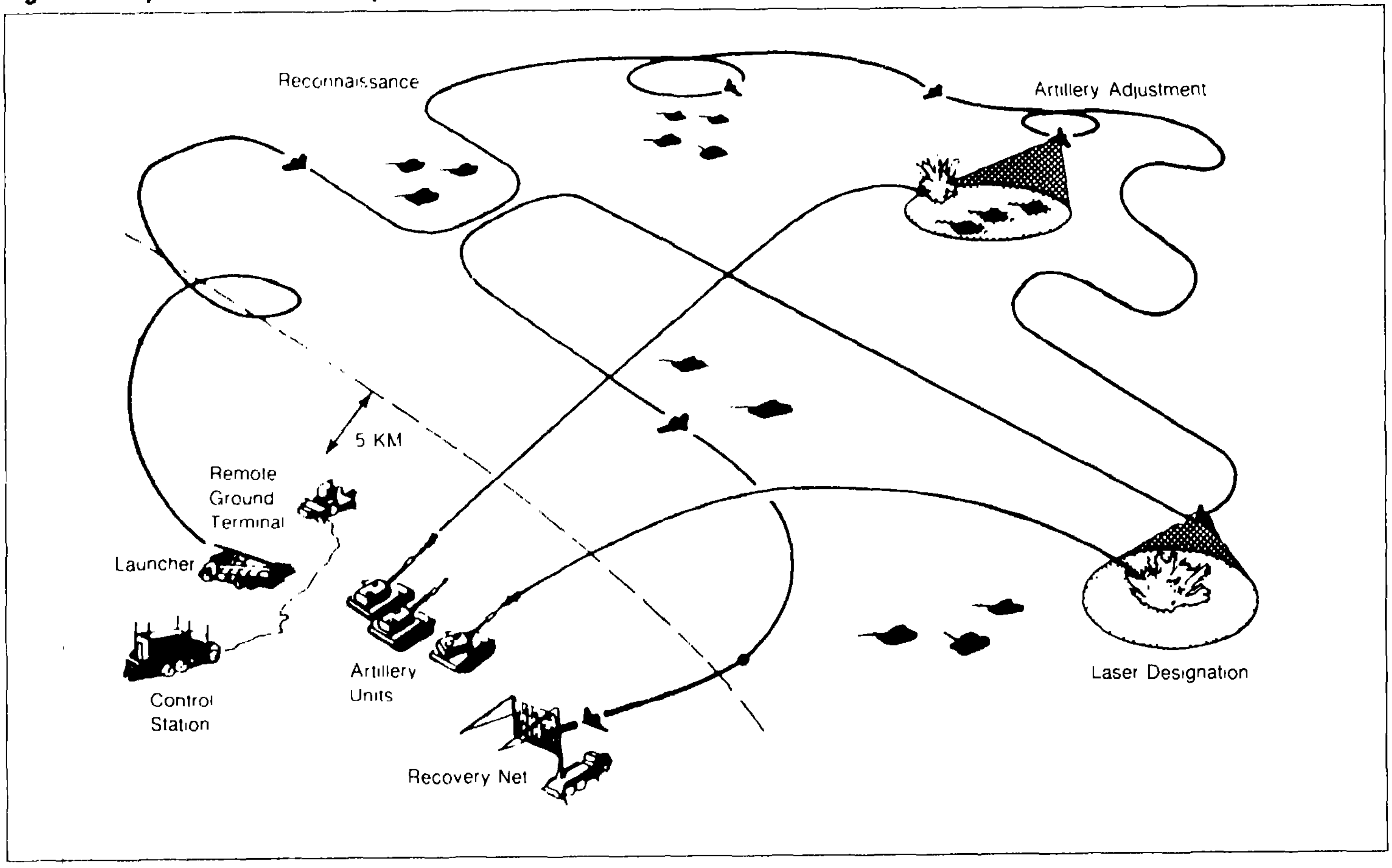
Figure I.1: Major Components of the Aquila System



The remote ground terminal and the air data terminal aboard the aircraft constitute the data link through which commands are sent to the aircraft and sensor information is transmitted to the ground. The aircraft, including the sensor, weighs about 265 pounds and carries enough fuel to fly for up to 3 hours. It can fly up to an altitude of 12,000 feet and at speeds ranging from 54 to 108 miles an hour. The Aquila will be fielded in a unit referred to as a battery which will consist of 13 aircraft, 5 ground control stations, 2 launch vehicles, 2 recovery vehicles, and 5 ground terminals.

A typical Aquila mission begins when the mobile launcher catapults the aircraft into the air from a central launch and recovery site located in rear combat areas. (See fig. I.2.)

Figure I.2: Representation of an Aquila Mission



The aircraft is then flown on a preprogrammed course controlled from a ground control station through the jam-resistant data link. Operators can modify the flight path while the aircraft is in flight. Control of the aircraft can remain with the rear area control station or can be transferred to a control station located in the forward combat area.

Using the video and other information sent to the ground control station, operators can detect and identify targets, provide target locations for adjusting artillery fire, use a laser designator on board the aircraft to spot targets for precision-guided munitions, perform reconnaissance missions, or assess damage to enemy positions. After these tasks are completed, the aircraft is returned to the launch site and an automated recovery system guides the aircraft into a vertical net for recovery.

System History

The Aquila program, currently estimated to cost about $2 billion, has experienced considerable cost growth due to technical performance problems, schedule delays, and the addition of the infrared sensor. When the Aquila entered full-scale development in 1979, the Army envisioned a 43-month engineering development program. This was extended to 52 months because of technical problems with the communication link and again to 70 months because the Army eliminated fiscal year 1982 funding. In 1984, 1985, and 1986, the program was extended to 79 months, 92 months, and 95 months, respectively, because of continued performance difficulties. Table I.1 shows the increase in estimated development and procurement costs since full-scale development began.

Table I.1: Aquila Costs and Quantities

	1978	1987[a]	Change
Estimated acquisition costs in millions			
Development	$123	$868	$745
Procurement	440	1,157	717
Total	**$563**	**$2,025**	**$1,462**
Procurement quantities			
Aircraft	780	376	−404
Ground control stations	72	53	−19

[a]Includes costs for the infrared sensor

The estimated procurement unit cost for an aircraft, including the television sensor, is currently $ 1.8 million (in escalated dollars). The sensor accounts for about one half of the unit cost. Because of performance problems during developmental testing (designed to ensure that the Aquila met technical performance specifications) the Army convened a special task force in May 1985 to evaluate the Aquila's readiness for operational testing (designed to assess performance in a realistic combat environment). The task force findings, which were reported in July 1985, led to (1) shifting program management responsibility from the Army's Aviation Systems Command to its Missile Command, which senior Army management believed had greater expertise in the remaining areas of development, and (2) extending the program's schedule to allow more time for technical fixes and additional testing.

The Army conducted additional development testing of the Aquila from February through October 1986 and determined that the system had made enough progress to begin operational testing.

Operational testing was conducted at Fort Hood, Texas, between November 17, 1986, and March 25, 1987. The Army's Operational Test and Evaluation Agency (OTEA) was responsible for conducting the test, and is preparing an independent evaluation of the test's results for Army decisionmakers. The test consisted of the following four phases.

- Phase I (Nov. 17-Dec. 12, 1986) involved integrating the Aquila battery, an Army brigade, and an artillery unit and training them to conduct tactical operations in a combat environment.
- Phase II (Dec. 15, 1986-Jan. 17, 1987) represented pilot testing. OTEA tested and refined methods for collecting operational test information. Also, the battery unit conducted exercises to ensure the readiness of personnel to operate the system and to institute procedures for controlling the test.
- Phase III (Jan. 20-Mar. 21, 1987) represented the record test phase. The Aquila made 105 flights, and test information to be used for the independent evaluation of the system was collected.
- Phase IV (Mar. 23-Mar. 25, 1987) involved various side tests and demonstrations.

Other organizations responsible for assisting DOD and Army decisionmakers include (1) DOD's Office of Operational Test and Evaluation, which approved operational test plans and will prepare an independent assessment of the adequacy of operational test and evaluation, (2) the Army's Training and Doctrine Command, which identified the Aquila's requirements and is responsible for ensuring that the system adequately satisfies user needs and for performing cost and operational effectiveness analyses of the system, and (3) the Army's Materiel Systems Analysis Activity, which will evaluate the Aquila's technical performance.

Performance During Operational Testing

Operational testing indicated that the Aquila performed well in some areas, but several major problems still need to be overcome. Essential operational and technical characteristics of the Aquila system are

- effective target acquisition, designation, artillery adjustment, and reconnaissance mission capabilities during daylight hours;
- survivability against enemy ballistic, nuclear and chemical threats, and electronic/electro-optical countermeasures;
- reliability and maintainability in a battlefield environment;
- tactical mobility in a battlefield environment;
- compatibility with human engineering, safety, and health requirements;
- electromagnetic compatibility (among Aquila subsystems and other Army systems); and
- growth potential to facilitate the incorporation of preplanned product improvements.

The Aquila performed well, or experienced only minor problems, in flight and recovery operations and in directing artillery fire at targets. However, it had difficulty in launch operations and in detecting targets, and military personnel had difficulties in operating and maintaining the system. In addition, simulated sophisticated enemy air defense weapons were able to detect and lock onto the aircraft, raising a question about its survivability.

Target Acquisition, Designation, Artillery Adjustment, and Reconnaissance Capabilities

The Aquila was unable to perform its mission—target acquisition, designation, artillery adjustment, and reconnaissance—with any significant degree of consistency. To effectively complete a mission, the Aquila must (1) be launched within a specified period of time, (2) complete flight operations, including transferring control of the aircraft from the central launch and recovery station to the forward control station when required, (3) detect, recognize, and locate enemy targets, and (4) direct artillery to the designated targets. Operational test data showed that the Aquila successfully fulfilled all of these requirements in only 7 of 105 flights.

Launch Delays

Launch delays were a major reason for the Aquila's failure to successfully complete operational missions. A timely launch capability is essential in a rapidly changing battlefield environment.

The operational test criteria stated that in daylight Aquila personnel should be able to plan, coordinate, and effect a launch within 60 minutes of receiving a mission order or arriving at the tactical location. After allowing for administrative delays, such as test range restrictions, the test showed that 36 of 105 flights had been launched within the required time, a 34-percent success rate. According to the test criteria, 80 percent of all launches must be within the 60 minutes to be considered successful. In the remaining flights, launches were delayed primarily because of hardware and software problems. Operator errors were also responsible for several delays. While a launch criterion of 90 minutes was established for night launches, operators were not asked to launch during darkness. In only 4 cases were operators asked to launch immediately after arriving at a new site.

In its analysis of the results, OTEA adjusted launch times to eliminate delays caused by a failure during a previous mission. For example, if the first launch of the day had been delayed, causing a commensurate delay in the second launch, the delay in the second launch was not counted. After making these adjustments, OTEA's analysis shows that 53 of 105 launches were successful.

Flight Performance

Once launched, the aircraft completed flight operations successfully 84 percent of the time. This was better than the test criterion that, given a successful launch, the probability of completing flight operations (including flight to intended destinations, transfer of control, and net recovery) should be 70 percent or greater. In 6 of the 17 unsuccessful flights, the aircraft's parachute was deployed because of technical problems with the aircraft or the ground systems. The parachute is deployed when the Aquila experiences a failure (such as a stalled engine) which would otherwise result in a catastrophic crash. The remaining 11 flights were aborted because of difficulties with recovering the aircraft or other technical problems.

Detection, Recognition, and Location

The Aquila's performance in detecting, recognizing, and locating targets was significantly below operational test criteria. The test criteria specified a 50-percent or greater probability of detecting, recognizing, and locating moving target arrays and a 30-percent or greater probability of performing the same functions with (the more difficult to detect) stationary target arrays. A target array is a grouping of three or more armored vehicles, such as tanks.

During the record test period (Phase III), Aquila operators detected 22.7 percent of the moving target arrays and 12.3 percent of the stationary target arrays in the planned mission reconnaissance area. Overall, the operators detected 15.1 percent of the target arrays. (See table I.2.)

Table I.2: Moving and Stationary Target Arrays Detected

Type of target array	Arrays presented	Arrays detected	Percent detected
Moving	428	97	22 7
Stationary	1,139	140	12 3
Total	**1,567**	**237**	15 1

Test data and discussions with test officials suggest that possible reasons for low detection rates were the technical limitations of the sensor and the poor target searching techniques employed.

The sensor, which is essentially a television camera system, cannot clearly see through obstructions, such as clouds, smoke, and camouflaging, and its video quality is degraded by its jam-resistant communication link. Thus, as shown in table I.3, operators experienced difficulties in detecting individual targets that were camouflaged either by vegetation (hasty camouflage) or under netting (full camouflage).

Table I.3: Effect of Camouflaging on Detecting Stationary Targets

Type of camouflage	Targets presented	Targets detected	Percent detected
None	766	169	22 1
Hasty	1,800	202	11 2
Full	709	70	9 9
Total	**3,275**	**441**	13 5

In addition, the methods used to locate targets affected the number detected. Using the Aquila to find targets has been likened by test officials to searching an expanse of territory by looking through a soda straw. Thus, it is important that mission commanders limit search areas and that operators use optimum flight altitudes and better sensor aiming to find targets. Test officials believed that detection rates would have been higher if operators had used better down-look angles and more methodical search patterns. The Army plans to demonstrate these improved search techniques when it conducts a Force Development, Test, and Experimentation program in late 1987.

Artillery Adjustments

Based on test results, the Aquila system exceeded the accuracy requirements for engaging stationary targets using laser guided Copperhead artillery, but it did not meet requirements for directing conventional (unguided) artillery fire to targets. According to OTEA officials, the performance shortfall was due more to training than to hardware or software problems. They expect artillery adjustments to improve with additional training of artillery units and Aquila operators.

During the test, the Aquila directed Copperhead artillery to detected stationary targets 83 percent of the time, as shown in table I.4. The operational test criterion called for at least a 50-percent success rate.

Table I.4: Success in Directing Copperhead Rounds to Stationary and Moving Targets

Detected target	Rounds[a]	Hit	Miss	Percent success
Stationary	12	10	2	83
Moving	5	3	2	60
Total	**17**	**13**	**4**	76

[a]Nineteen rounds were actually fired, but 2 rounds were deemed unreliable and therefore were not counted.

Our analysis of test data showed that 49 percent of the conventional artillery adjustments were successful against stationary targets, compared with a test criterion of 85-percent probability of success. In a conventional artillery adjustment mission, the Aquila would locate a target and transmit the target coordinates to the artillery unit. One round of artillery would then be fired, and the Aquila would note the round's distance from the target, compute the needed adjustment, and communicate the adjustment to the artillery unit. A volley of 2 to 5 rounds would then be fired at the target. To be successful, a volley of artillery rounds had to impact within 50 meters of the target, based on the average impact of the individual rounds in the volley. In addition, the Aquila crew had to compute and communicate the adjustment within 5 minutes.

According to OTEA, the test criterion for conventional artillery accuracy was not operationally usable because the average impact of a volley of rounds as the measure of effectiveness does not recognize that a single successful round could disable a target. Thus, the Aquila failed an engagement when the volley's average impact point from the target exceeded 50 meters, even if one of the rounds in that volley impacted within 50 meters of the target. By counting as successes those volleys in which at least one round impacted within 50 meters of the target, as suggested by OTEA, 78 percent of the engagements would have been successful, nearly meeting the criterion of 85 percent.

Survivability

To effectively accomplish its mission, the aircraft and ground system must be survivable against enemy ballistic, nuclear, and chemical threats and against electronic/electro-optical countermeasures. The communication data link appeared to be effective against enemy countermeasures and earlier studies showed that the Aquila's ground systems could not be intercepted or located by enemy forces. The operational test, however, indicated that the aircraft probably would not survive against certain enemy air defense systems.

According to a 1985 Army threat assessment, enemy air defense systems with good target acquisition capability would have a high probability of acquiring, tracking, and destroying the aircraft. During operational testing, two of these weapons were portrayed by surrogates, but valid data was collected on only one. This air defense weapon acquired, tracked, and locked onto the aircraft during operational testing. At the conclusion of our review, these results were being analyzed to determine the probability of the air defense systems actually destroying the aircraft after locking onto it. According to project officials, certain changes in system design and operational tactics could make the aircraft more survivable. The Army is assessing these changes, but will not have them implemented by the time the system is scheduled to enter production. In addition, the effect that changes in tactics may have on the Aquila's ability to perform its mission has not been assessed.

The likely effect of these weapons on the Aquila's mission performance was not assessed during the test. Thus, computations of the Aquila's performance in areas such as flight and target detections were based on an environment free of enemy air defense weaponry. DOD noted that the susceptibility of the Aquila to a certain class of air defense systems was not a problem unique to the Aquila, and that there were a variety of ways to reduce this susceptibility.

Reliability and Maintainability

Required reliability and maintainability levels were not achieved during the operational test. Reliability levels were not met primarily because of hardware and software problems. System maintenance was only partially performed by Army personnel, who found it difficult to locate and correct system failures. The frequency of repairs and the ease in making them are major determinants of the amount of time the system will be available for its mission and of the burden of keeping the system supported in the field.

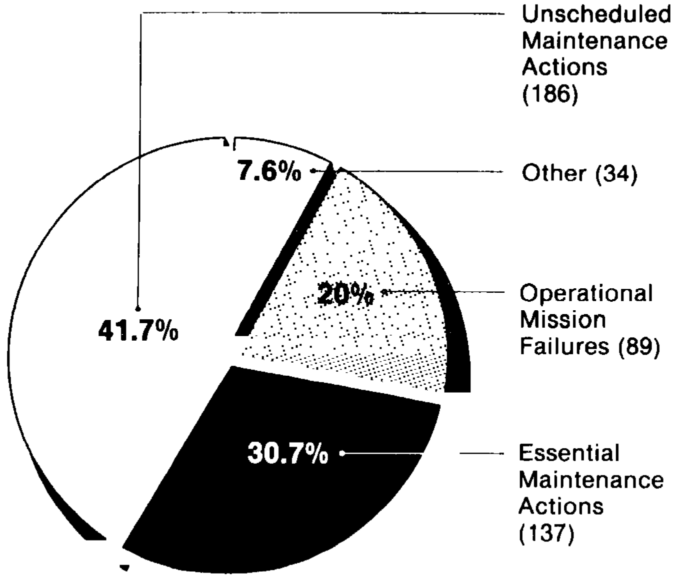
Reliability

Reliability measures the ability of a system to operate without problems necessitating corrective action. While many such breakdowns, or incidents, can occur during testing, those serious enough to prevent the system from completing its intended mission are of particular concern. These are referred to as operational mission failures. The Aquila's reliability in operational testing was measured (1) from a technical standpoint, which considers those failures attributed to the system's components, including hardware and software, and (2) from an operational standpoint, which combines technical failures with those associated with the personnel operating and maintaining the system.

During Phase III of the operational test, 446 incidents were experienced—336 were caused by hardware, 69 were caused by personnel, 15 were caused by software, and 26 were ruled as accidents or otherwise unavoidable. The Army panel convened to assess the severity of the incidents determined that 89 of the 446 incidents were operational mission failures, as shown in figure I.3.

Of the 89 operational mission failures, 64 were assessed as technical failures, 24 failures were determined to be caused by Army personnel, and 1 was ruled an accident. Based on the 64 failures attributed to technical failures, Army test officials calculated an overall system reliability of 69 percent. This means that the Aquila, from a technical standpoint, was assessed as being able to be launched, conduct its flight operations, and be recovered 69 percent of the time without experiencing an operational mission failure. Table I.5 shows the individual technical reliability scores for the launch, flight, and recovery phases and the overall system reliability for both development and operational testing.

Figure I.3: Distribution of Failure Incidents During Operational Testing



Total: 446 Incidents

Table I.5: Comparison of Required Reliability With Actual Development and Operational Test Results

Figures in percent

Phase	System requirement	Development testing	Operational testing
Launch	95	93	81
In-flight	82	69	92
Recovery	96	96	93
Total system	**75**	**62**	**69**

Operational test results indicated that overall technical system reliability had improved since development testing and is approaching the requirement. The overall improvement relates primarily to reliability while in flight, indicating that hardware and software changes to improve the aircraft and its on-board systems were effective.

However, technical reliability may be overstated because some operational mission failures were attributed to system operators when the operators were not necessarily at fault. According to the guidance for scoring incidents, incidents were to be attributed to operators rather than to the system when the operators had not followed procedures. Incidents of this nature were not counted against technical reliability. We found that some failures were attributed to operator errors without clear evidence that this had occurred. In one case, for example, the aircraft parachute had deployed while still on the launcher, resulting in an operational mission failure. The failure was attributed to operator error based on the contractor's contention that the parachute would only deploy on the launcher when the electrical cord that connects the aircraft with the launcher was not seated properly. However, there was no evidence that the operators did not seat the cord properly. Other factors, such as the cord's design or faulty built-in test equipment, may have caused the problem In fact, seating the cord was also identified as a problem during developmental testing and redesign is planned.

A human engineering analysis of the operational test prepared for OTEA also questioned the reliability scores. We believe the analysis also showed there was a tendency to attribute failures to operator error. The analysis showed that 24 incidents, including 7 operational mission failures, were scored as operator errors or training deficiencies when other possible contributory factors existed, such as hardware, software, quality control, and diagnostic procedures.

Operational reliability considers the system's performance when operated by military personnel and includes the combined effects of design, quality, installation, and personnel and support systems. Army guidance requires the use of operational reliability values, and we believe they are more meaningful expressions of suitability in an operating environment than technical reliability. While operational reliability data were collected during operational testing, the Army has not established operational reliability standards for the Aquila. According to DOD, the Army is currently conducting sensitivity analyses to determine what the operational reliability thresholds should be.

A preliminary analysis of operational test results by OTEA showed that the overall system's operational reliability was 49 percent. This included 62 percent for the launch phase, 86 percent for the in-flight phase, and 92 percent for the recovery phase.

It is not clear how much confidence can be placed in the reliability scores from operational testing. We observed that not all incidents were counted as operational mission failures when the evidence strongly suggested they should have been. Only failures that occurred after a mission order to launch had been received were counted as operational mission failures. In some instances, for example, the Aquila crew began readying the aircraft for launch before receiving the mission order. Failures discovered during these preparations were not counted as operational mission failures even if they would have prevented the mission from being completed. Test officials also informed us that they did not issue a mission order if a problem was discovered that would prevent mission accomplishment. The involvement of contractor personnel in assessing reliability failures also reduces confidence in the reliability scores. This involvement is discussed in detail on pages 33-34.

DOD believes that all incidents were properly scored in accordance with the failure definition and scoring criteria by government representatives at the scoring conference. According to DOD, the contractor was the primary source for technical analysis, reconstruction of the failure, and evidence as to the actual cause of the failure.

Maintainability

Military personnel found it difficult to accomplish the maintenance tasks because they did not have the necessary test equipment, troubleshooting procedures, and maintenance manuals. Consequently, contractor personnel had to perform the more difficult maintenance tasks. This situation is the result of logistic support development lagging behind the development of the rest of the Aquila system. Efforts that address logistic support are essential to fielding a useful system, as they help determine the capabilities needed to operate and support the system, including maintenance procedures, test equipment, repair parts, and training.

Test results showed that military personnel needed a mean time of 34 to 59 minutes to repair faults for various subsystems compared with a requirement of 30 minutes. Even these computations are conservative because, in several instances, contractor personnel either performed or assisted in performing maintenance assigned to military personnel.

Maintenance difficulties arose for several reasons. Poor performance of test equipment and inadequate troubleshooting procedures made it very difficult to locate system faults. Built-in test equipment correctly detected and isolated faults only about 38 percent of the time. At other times, the equipment falsely reported malfunctions or failed to indicate that a fault was present. For example, a fault isolator was inadequate in detecting problems in the aircraft. Troubleshooting procedures and maintenance manuals contained numerous errors and did not provide a systematic process for isolating faults. These problems were aggravated by some repair parts not being available at the right maintenance levels and by the lack of needed repair tools.

According to OTEA, fault isolation was particularly difficult during launch operations. Test equipment did not detect many faults before launches, yet many launch attempts failed. Following the failure, test equipment still showed no fault, which forced the operators to rely on the inadequate troubleshooting guides.

Because these problems must be resolved, and test equipment and procedures have to be developed for the more difficult maintenance tasks before Army personnel can perform all required maintenance of the Aquila system, contractor personnel will be used to perform higher level maintenance tasks until 1995—4 years after deployment begins. This span of about 7 years between the production decision and full support by military personnel is too long, according to a May 1987 evaluation by the Army Logistics Evaluation Agency. Moreover, the Army cannot rely on contractor personnel being available in the event of hostilities, leaving the question open of how the Aquila would be supported under such circumstances. The cost of having the contractor provide maintenance services for this period of time has yet to be estimated.

In addition, the technical data package, consisting of design drawings and parts listings, will not be under Army control until February 1990. This will add further to the initial maintenance burden because, until the design drawings and parts listings are available, the Army cannot (1) accurately ascertain the types and quantities of spare parts required to maintain the system or (2) complete development of test equipment used to troubleshoot and diagnose equipment failures. Fielding the right mix and quantities of spare parts is complicated further because efforts normally conducted during full-scale development to identify needed parts were not completed.

Mobility

The Aquila system proved to be tactically mobile in a battlefield environment. The system was moved frequently, on and off primary and secondary roads; in most cases, the moves were made at night so that daylight hours were available for flight operations. Moves were conducted without problems, except for a 1-week period, when heavy vehicles (launcher, recovery vehicle, and ground control station vans) could not be moved because heavy rains left open fields extremely muddy.

Human Engineering

The Aquila proved to be very demanding on the operators. Human engineering problems accounted for many of the difficulties encountered in mission performance. The difficulty the operators experienced in working with the Aquila contributed to the numerous launch aborts and missed target detections. The numerous reliability incidents attributed to operator error were also indicative of the system's complexity. In addition, the crews' difficulties in following troubleshooting procedures were due, at least in part, to the maintenance manuals not being well-suited to the soldier. As a result, certain subsystems may have to be redesigned and the skills and capabilities of the operators may have to be upgraded before the Aquila can be fully effective and suitable for military use.

A May 1987 draft report by the Army's Human Engineering Laboratory described several major issues regarding the compatibility of the Aquila equipment with its operators. According to the report, lack of management continuity within the Army and in the prime contractor's operations has resulted in insufficient attention to human engineering considerations in the development of the Aquila system.

The report noted that, while no single hardware or software problem may prevent the Aquila from conducting its mission, the combination of problems may severely limit mission effectiveness, degrade an operator's ability to function efficiently, or impose a personnel or training burden upon the Army; for example, operations within the ground control station impose workloads on the operators that may exceed human performance capabilities. Also, the station is not configured to enhance operator effectiveness and efficiency. The operators need access to information and controls that are not located at their respective consoles or are not readily accessible consistent with their importance and frequency of use.

Additional human factors problems cited in the report are as follows

- Numerous software problems (i.e., faulty display indications, the system not accepting control inputs, and the aircraft flying in directions not in accordance with commands) caused operator confusion and reduced the operators' confidence in the system.
- When communication with the aircraft was lost during flight, the operator did not immediately recognize that an abnormal condition existed, often did not know the aircraft's location, and did not understand the action needed to locate it.

- Inadequate workspace in the maintenance shelter hindered personnel in performing required operations.
- The launcher and recovery subsystems had many unprotected pressurized hydraulic lines, thereby exposing personnel to potentially hazardous conditions.

According to DOD, certain software modifications are being implemented to aid the operators in conducting aerial reconnaissance. The Army, however, does not intend to redesign the ground control station and other subsystems because of the added costs and because it believes that the greatest improvement will be realized through training.

Electromagnetic Compatibility

Electromagnetic compatibility—the ability of the various subsystems to work together without electronic interference—was not specifically tested in operational testing. Although there was no evidence of major problems in this area, a restriction on the use of radios or other transmitting devices near the launcher was necessary because, according to a project engineer, they could interfere with the launcher and cause a launch abort.

Developmental testing of electromagnetic compatibility was not complete at the conclusion of our review. According to test officials, some compatibility problems had been identified which may require design changes to correct.

Growth Potential

When development of the Aquila began, the Army required that the system be designed to facilitate future improvements. As the system progressed, the primary improvement to the Aquila became the addition of the infrared sensor for night operations. Operational testing indicated that the Aquila's ground equipment may require some changes for night operations if the infrared sensor is fielded, such as providing enough lighting compatible with night vision goggles for the crew to perform all functions. Such changes should be considered before the Aquila's production configuration is set so it will not have to be modified later.

Adequacy of Operational Test and Evaluation

The operational test was the most comprehensive and realistic test of the Aquila system to date. However, certain test and evaluation limitations must be recognized before projecting the Aquila's eventual performance in the field. No test criteria were set for several important areas of performance such as survivability and maintainability. In other areas, it is not evident that meeting the criteria is indicative of the performance required of the Aquila in the field. Also, several test conditions were not representative of the Aquila's intended field environment.

As a practical matter, operational testing cannot replicate all operational conditions. For example, restrictions regarding safety during the test and the limitations of test instruments cannot be avoided. However, since operational test and evaluation is the primary means of assessing a weapon system's performance and is important in deciding to proceed from full-scale development to production, its limitations must be recognized to accurately project a system's effectiveness and the ability of the troops to operate and maintain it in the field.

Insufficient Test Criteria

The criteria used to measure the Aquila's performance may not be indicative of performance needed in the field. Further, no criteria were established to measure such factors as the system's ability to be operated and maintained by troops in the field.

According to Army officials, test criteria were based on what seemed to be reasonable levels of performance for each of the Aquila's tasks (launch, flight, target detection, target engagement, and recovery). However, no quantitative analysis was performed to ensure that the criteria were representative of the performance needed in the field. For example, meeting the test criterion of successfully completing flight operations 70 percent of the time might not be enough to meet mission objectives in a combat environment.

When looked at cumulatively, the test criteria do not demand a high probability of successfully completing a mission from start to finish. For example, the Aquila would have only a 14-percent probability of successfully completing conventional artillery missions against stationary targets, if it met all the individual criteria for launch (80 percent), flight and recovery (70 percent), target detection (30 percent) and artillery adjustment (85 percent). Considering the different missions (directing Copperhead or conventional artillery to targets) and the types of targets (moving or stationary), the test criteria for the individual functions would translate into a 9 to 24-percent overall probability of successfully completing a mission. Although performing more than one mission in a single flight could raise overall success somewhat, there is no standard against which to assess the acceptability of overall performance. The

Army has not analyzed the prospects for mission success based on the cumulative performance derived from the test criteria.

Moreover, the test criteria significantly differed from or could not be directly traced to the requirements in the Aquila's required operational capabilities document, which states, for example, that there must be a 50-percent probability of detecting, recognizing, and identifying a single stationary or moving target. The test criterion was based on detecting, recognizing, and locating a target array (three or more targets) rather than an individual target, established a 30-percent probability for detecting stationary targets, and eliminated the need to identify the target. DOD officials said the requirements document contained only technical performance thresholds which were not intended as operational test criteria. However, the requirements document stated that it represented both the technical and operational requirements for the Aquila system.

No test criteria were established for measuring factors other than mission effectiveness, although they are to carry equal weight in deciding whether to begin production of the Aquila. These factors concern whether the system is suitable for use by troops in the field, including command, communications and control, survivability, human factors, reliability, maintainability, mobility, logistics, training, and safety. Instead, these factors were to be assessed in conjunction with the system's performance as they contributed to the accomplishment of operational mission standards.

It is not clear that these factors can be adequately assessed by looking at their contribution to mission effectiveness. For example, test standards for such mission tasks as launch, flight, and targeting may be successfully achieved but the equipment and operations may be deemed unsafe, operators could be overly fatigued, and maintenance tasks could be performed at levels higher than they should be. Logistic support requirements (including tools, test equipment, and manuals) beyond the unit maintenance level were waived for the test and were not evaluated. Also, OTEA does not plan to determine the effect that enemy air defense weapons and countermeasures would have on the mission performance.

According to OTEA's evaluator, it would be difficult, if not impossible, to adequately assess the Aquila's suitability for field use without clear and specific criteria to measure performance. He said that an evaluation of the Aquila's suitability would probably be based on subjective judgment rather than the quantitative analysis more typically seen in operational tests of other weapons.

DOD noted that a cost and operational effectiveness analysis was being conducted to validate the operational test criteria and to quantify thresholds for certain suitability factors, such as operational reliability and survivability. However, the analysis, which will be completed in November 1987, should have been made before the operational test. Army guidelines state that test criteria should be established using system requirements and a substantive, credible cost and operational effectiveness analysis.

Unrealistic Test Conditions

Test realism is critical to operational tests and evaluations and to the quality of test results. If the test conditions are not as representative as possible of those anticipated in combat, results may be invalid and decisionmakers may be deprived of important data needed to assess weapon system performance.

We found the following aspects of the operational test which, at least in part, could impair an accurate assessment of the Aquila's performance in the field: (1) the maintenance concept was not fully tested, (2) contractor's involvement could have influenced the Army's evaluation of the test results, and (3) certain test operations and restrictions affected realism.

Maintenance Concept Not Tested

In an operational setting, the Army expects to establish three levels of responsibility for maintaining the Aquila system. These are, in ascending order of complexity, unit maintenance, intermediate maintenance, and depot-level maintenance. When the system is fully deployed, military personnel will be required to perform all levels of maintenance.

The Army will not have valid operational test information on the system's maintainability and supportability in an operational environment beyond the unit maintenance level. During operational testing, contractor, rather than military, personnel performed intermediate and depot-level maintenance. Contractor personnel were also involved in unit-level maintenance to some extent. The Army waived the requirement for military personnel to perform maintenance above the unit level because they had not been adequately trained and test equipment to maintain the system had not been developed. Also, contractor personnel performed maintenance tasks using different equipment from what will be used in an operational setting.

Contractor Involvement During Testing

In addition to their involvement in maintenance, contractor personnel were involved to an inordinate degree in the reliability scoring process. We attended three of five scoring conferences and observed the scoring process. We observed that contractor representatives' roles often extended beyond providing technical information in that they argued for scores which would improve reliability and in some cases provided misleading information to support their arguments. For example, two launch failure incidents were incorrectly scored as essential maintenance actions[1] rather than operational mission failures after the contractor's representative argued that the availability of backup aircraft would have allowed successful launches. According to Army scoring criteria, it appears that availability of backup aircraft was not a valid reason for scoring the failures as essential maintenance actions rather than operational mission failures. The representative did not mention, however, that in one case the crew had attempted to use backup aircraft, but it was unserviceable. In the same case, the representative also argued that, regardless of the failure, the aircraft could not have been launched because the air space at Fort Hood was closed due to weather conditions. However, the aircraft could not be launched within the required time, regardless of the weather conditions. Weather conditions would have been a factor only to the extent that they precluded a timely launch from occurring.

The contractor representative argued that another incident should have been scored as a "no test" because an aircraft was flown outside its specified limitations when the engine malfunctioned and the aircraft lost altitude, but provided no evidence to support that claim. The representative further stated that the aircraft successfully conducted its mission despite the failure and, therefore, the incident should not be scored as a mission failure. The conference members neither questioned the representative's claim nor validated the information. Instead, they scored the incident as an essential maintenance action rather than an operational mission failure. Contrary to the representative's contention, test records showed that the aircraft did not successfully accomplish one of its mission essential functions. Therefore, the incident should have been scored as an operational mission failure.

Contractor involvement in maintenance and in reliability scoring raises questions of compliance with 10 U.S.C. 2366(b)(2) (1987), which

[1] An essential maintenance action is an unscheduled action needed to correct a problem before starting the next mission.

imposes a limitation on the involvement of contractor personnel in operational test and evaluation. Under this limitation, no personnel employed by the contractor for a system being tested may be involved in the conduct of the test or the evaluation of the results of that test. In a January 5, 1987, letter to the Secretary of Defense, the Chairmen of the House and Senate Committees on Armed Services stated that it was their intent that, during operational tests, weapon systems were to be operated, maintained, and otherwise supported by personnel typical of those who will carry out such duties when the systems are deployed in combat. The letter also stated that the processing and evaluation of test data should be carried out in a completely objective manner with no possibility or even appearance of system-contractor manipulation.

DOD did not agree that the contractor's involvement in the reliability scoring process was abnormal. The Army plans to give us its views as to whether the contractor's involvement was inconsistent with 10 U.S.C. 2366 (b)(2) (1987).

Test Operations and Restrictions

The Aquila system was tested under more favorable conditions than would be encountered in a battlefield environment. For the most part, however, the test restrictions, including the physical characteristics of the test range and weather conditions, were outside OTEA's control and were similar to those encountered in other operational tests.

The test was limited to the rolling, sparsely forested terrain found at Fort Hood, although the Aquila was designed for and is expected to be employed in Europe, where the terrain is typically hilly, mountainous, and heavily forested. OTEA considered the terrain features at Fort Hood of negligible consequence; however, the absence of trees and other vegetation would have likely affected the test results since the Aquila cannot perform tracking and laser designation when a target moves behind trees or other heavy vegetation.

Due to a combination of test range restrictions, low visibility, and limitations in the Aquila's television sensor, the system was not tested under adverse weather conditions. For safety reasons, Fort Hood management normally required that the cloud ceiling be at least 3,200 feet high for flight operations. During rain conditions, the clouds were below that level and flights were not permitted. The television sensor cannot see through clouds, but the aircraft can function underneath them as long as they are no lower than 1,000 feet. However, the range restrictions prevented testing of this capability. Due to sensor limitations, operations also were not conducted when the ground was obscured by fog.

Four persons were typically used in the ground control station, although it was designed for a three-person crew. The fourth person occupied the mission commander's console and performed tasks normally performed by the mission commander or other operators, which allowed the mission commander to spend more time overseeing the mission and supervising personnel. Using three crew members would have given OTEA a better indication of whether the workload exceeded the mission commander's capacity and the extent to which changes may be needed in the number of personnel needed to operate the system.

Because of installation boundaries at Fort Hood, the maximum range over which the aircraft was operated during the record phase of the test was about 22 miles. (In an operational environment the distance between the ground control station and the aircraft exceeds 24 miles.) Test officials stated that operating at shorter distances made it easier for operating crews to maintain the electronic line of sight between the ground terminal and the aircraft and allowed more time for reconnaissance and target acquisition because the aircraft spent less time traveling to the mission area.

The Aquila battery consisted of one central launch and recovery station (rather than two) and one forward control section (rather than three) because of shortages of aircraft and other subsystems. Thus, OTEA's ability to fully assess the capabilities of an Aquila battery's tactical operations was limited.

Air defense systems designed to portray enemy forces to collect information on the system's survivability in a battlefield environment were used only during the first 2 weeks of the record test. These systems were needed for testing other than the Aquila's. Whether having enemy air defense systems present for the remainder of the test would have affected the conduct of the test, such as by causing changes in aircraft flight patterns, is not known.

Sufficiency of the Aquila's Endurance Capability

The Army's original concept for employing the Aquila system was to locate launch and recovery operations entirely within forward areas. The relative high mobility of these forward units dictated several of the Aquila's requirements, including a vehicle light enough to be carried by four soldiers and a precision recovery system, such as a net, rather than a landing strip. Since the forward artillery units must move frequently, the aircraft's maximum flight time was limited to 3 hours, which became the basis for the Aquila's 3-hour flight endurance specification.

In 1983 the Army revised the employment concept to respond to evolving missions that the Aquila could perform. The new concept called for launch and recovery by sections located in rear areas that would pass flight control to forward area sections. According to the Army, rear basing required significantly less mobility than deployment in the forward area. However, the Army did not modify the Aquila's weight and endurance requirements.

The new concept brought into question whether the Aquila's 3-hour endurance left sufficient time to complete the mission since it would take longer to fly the aircraft to its target area from the rear than from the forward area. Under the original concept, the Army envisioned 30 minutes to travel to and from the target area and 2-1/2 hours to perform mission operations. The change in employment concepts, however, added another 30 minutes of flying time, thus reducing the time over target areas to 2 hours. In addition, developmental testing showed that another 30 minutes might be needed for pre-flight warm-up and as a contingency for possible excessive fuel burn rates and unsuccessful recovery attempts.

At the time of our review, the Army had not analyzed whether the Aquila could perform its mission with less time over the target area. According to DOD and Army officials, an assessment of the sufficiency of the Aquila's 3-hour flight endurance capability will be completed in November 1987 as part of an overall cost and operational effectiveness analysis.

If the results indicate that the Army should increase the Aquila's endurance capability, modification may be necessary to increase the fuel capacity. In either case, the Army would like to eventually modify the system to allow a 9-hour endurance capability which would permit the aircraft to probe deeper into enemy territory or to spend more time over target areas within the current range capabilities. However, project officials said that no specific actions had been taken to change the current capabilities.

Planned Improvements

Several efforts are underway to improve the Aquila's performance, but most of the corrections to technical problems encountered during the tests are not planned to be demonstrated until after the Aquila is scheduled to enter production. Also, limited funding could curtail efforts to develop the infrared sensor.

Resolution of Problems Identified During Tests

Actions to correct many problems identified during development and operational tests will not be implemented until after the system is scheduled to enter production.

At the conclusion of development testing, the Aquila project office formed a working group to resolve the performance problems identified. For most of the problems, the project office either implemented corrective action or developed plans for fixing them.

Some of the planned fixes involve redesigning hardware and software. For example, the alternator is being redesigned to add more dependable bearings to make it less susceptible to handling damage and the ignition switch is being redesigned to make it more reliable. As for software, the main computer in the ground control station will be redesigned to reduce operator workload and the potential for operator error.

The Army has not yet fully identified and resolved problems encountered during operational testing. Project office and contractor representatives advised us that they have initiated corrective action for some of the problems but others are still being studied. For example, software and signal processing improvements are needed to prevent navigation errors caused when the remote ground terminal does not properly track the aircraft. Also, modifications will be needed to equipment that controls communication signals before launch because the existing equipment requires excessive warm-up times. Another change to improve launch performance involves the redesign of a ground control station panel to prevent operators from entering erroneous codes before launch.

The Infrared Sensor

The Army has been developing an infrared sensor which, if successful, will be available for fielding sometime after the television sensor. The infrared sensor is to be capable of performing missions at night and seeing through clouds, smoke, and camouflage. The infrared sensor development has encountered problems and funding constraints. Problems identified during contractor qualification tests of the television sensor resulted in changes that affected the infrared sensor's compatibility with the aircraft's hardware and software. These changes increased its development costs and resulted in congressional action that reduced the Aquila's fiscal year 1987 development budget by $30 million. The Army formed an investigation team to examine the technical capabilities of the contractors to complete development of the infrared sensor and the team concluded that the sensor showed promise of completion without serious operational performance shortfalls. However, specifications for temperature, weight, and vibration would probably not be met. The team also found that efforts to integrate the sensor into the Aquila system were behind schedule. In its opinion, this created an unnecessarily high technical risk because until the integration is complete, the sensor's performance in such key functions as target detection, focus, and laser designation could not be fully demonstrated.

The Army requested $20.8 million for fiscal year 1988 to continue development of the infrared sensor. The Senate Armed Services Committee agreed to authorize this amount, but the House Armed Services Committee recommended that further development funding be deleted. The future of the infrared sensor is now being considered by the Joint House and Senate Authorization Conference Committee.

Objectives, Scope, and Methodology

At the request of Senator William V. Roth, Jr., Ranking Minority Member of the Senate Committee on Governmental Affairs, we assessed (1) the Aquila's readiness for production based primarily on operational testing completed in March 1987 and (2) the adequacy of the operational test. We also reviewed whether the Aquila's 3-hour flight endurance capability is sufficient for performing its mission.

We met with cognizant officials and reviewed applicable laws and regulations, requirements documents, test plans, and other pertinent documents to determine how the test should have been conducted and how the Aquila should have performed during the test. Throughout the test, we observed operations, including the launch and recovery of the aircraft, and collected results of the test while it was in progress. We also observed the process of validating test information and conducting reliability scoring conferences. At the conclusion of the test, we met with Army officials to obtain their views on the results of our evaluation.

Our analysis of test results was based on information collected by OTEA during the record phase (Phase III). At the conclusion of our fieldwork in June 1987, OTEA was still refining test data and compiling its independent evaluation. Based on discussions with OTEA officials, it appears that contemplated changes in test data could result in some elements of performance being scored more favorably. We believe, however, that these potential changes are not significant enough to affect our conclusions.

Our work was performed at the U.S. Army's

- Operational Test and Evaluation Agency, Falls Church, Virginia;
- Missile Command, Redstone Arsenal, Alabama;
- Materiel Systems Analysis Activity, Aberdeen Proving Ground, Maryland;
- White Sands Missile Range, New Mexico;
- Field Artillery School, Fort Sill, Oklahoma; and
- III Corps and OTEA Field Office, Fort Hood, Texas.

We conducted our field work from August 1986 through June 1987. Our review was performed in accordance with generally accepted governmental audit standards, except that, because of time constraints, we did not fully assess the reliability of computer generated data used to compile operational test results. Nevertheless, we performed limited tests of the data and, in several cases, corrected errors and omissions because OTEA had not tested and verified the reliability of the computer programs. Test officials assured us that OTEA planned to validate computer programs before issuing its final report.

Comments From the Under Secretary of Defense (Acquisition)

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301

ACQUISITION

14 SEP 1987

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and
International Affairs Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to General Accounting Office (GAO) Draft Report, "AQUILA REMOTELY PILOTED VEHICLE: Its Potential Battlefield Contribution Still in Doubt", dated August 3, 1987, (GAO Code 393200/OSD Case 7367).

The Department recognizes the validity of the issues raised by the subject report and is certain that these very issues will be the subject of discussion and decision at the Milestone III decision meeting on the program. The Army has reached substantially similar conclusions and, consequently, has postponed the Milestone III review of AQUILA until after it has conducted a Force Development, Test and Experimentation (FDT&E) program to develop techniques for the conduct of aerial reconnaissance with the AQUILA.

The Department cannot support the GAO allegation of abnormal involvement by contractor personnel in the reliability, availability, and maintainability (RAM) scoring process. The Department provided its position on this issue during the August 14, 1987, meeting with the GAO and the subject will be addressed further by the Department of the Army under a separate cover. Contractor assistance is often necessary in order for the data analysis group to understand the technical ramifications of a given problem. Since the contractor is not allowed to vote, it cannot be deemed to exercise undue influence.

While the essence of the issues raised by GAO is not disputed, the highly negative characterization of the capabilities of the AQUILA system seems unduly harsh, like the statement on page two, "...it cannot yet dependably perform its mission and cannot be adequately maintained or logistically supported by military personnel", or the implication that the day TV sensor's technical limitations preclude target acquisition. Not only are such comments unjustified, they can also easily mislead the readers of the report. While we do not have the perfect system in the

AQUILA, it promises great battlefield potential, once we learn how to use it. AQUILA is the only unmanned aerial vehicle in the free world developed and tested to military specifications. Its deficiencies notwithstanding, AQUILA is still the most advanced and capable system of its kind in existence.

Sincerely,

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