

August 1999

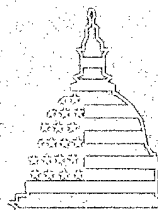
# UNMANNED AERIAL VEHICLES

## DOD's Demonstration Approach Has Improved Project Outcomes



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

National Security and  
International Affairs Division

B-276812

August 30, 1999

The Honorable William S. Cohen  
The Secretary of Defense

Dear Mr. Secretary:

The Department of Defense (DOD) needs Unmanned Aerial Vehicles (UAV) for surveillance and reconnaissance missions. Since the end of the Vietnam War, DOD began at least nine UAV acquisition programs that were later canceled, spending \$4 billion in the process.<sup>1</sup> (See app. I.) In 1994, as part of its acquisition reform efforts, DOD adopted an Advanced Concept Technology Demonstration (ACTD) strategy for assessing UAVs.<sup>2</sup> We reviewed current UAV projects to determine whether DOD's strategy of conducting ACTDs before developing and producing UAVs provides an improved knowledge base for making acquisition decisions. DOD has completed ACTD projects for the Predator and Outrider UAV systems and has an ongoing ACTD for the Global Hawk UAV. DOD terminated a fourth UAV project, DarkStar, before its ACTD was completed.

## Results in Brief

The ACTD strategy of focusing on mature technology and proving military utility before committing to a UAV has expanded DOD's knowledge base, allowing it to make some well informed acquisition decisions. For example, when DOD began the Predator ACTD in 1994, the Predator was considered technologically mature because its design was based on an existing UAV, the Gnat 750. Nevertheless, DOD still required that the Predator's performance be demonstrated. Prototypes of the Predator were deployed in Bosnia in 1995 and 1996, allowing users to determine whether the UAV would meet their needs. Only after this performance data was gathered and analyzed in 1997 was DOD willing to formally commit to the UAV's acquisition.<sup>3</sup> In another case, the ACTD for the DarkStar UAV, DOD

<sup>1</sup>The canceled programs were Compass Cope, Compass Dwell, Aquila, Amber, Condor, Hunter, Raptor, a classified program, and the Medium Range UAV.

<sup>2</sup>ACTDs are carried out to demonstrate, within 2 to 4 years, that a technologically mature system has military utility before DOD formally commits to develop and produce it.

<sup>3</sup>Defense Acquisition: Advanced Concept Technology Demonstration Program Can Be Improved (GAO/NSIAD-99-4, Oct. 15, 1998).

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gained knowledge early on that led to its decision not to acquire that system. Likewise, for the same reason, DOD decided not to acquire the joint-service Outrider UAV on a sole-source basis. DOD's ACTD approach to UAV acquisition is consistent with the best practices of leading commercial developers, which require proof of technological maturity and performance before they will develop or produce a product.<sup>4</sup>

On the other hand, DOD's formal acquisition process, used during its earlier UAV efforts, allowed programs to proceed with much less knowledge (and thus higher risk) of technologies, design, and potential production problems. Problems with development and production, along with the associated cost and schedule increases, were a predictable consequence of proceeding on such limited knowledge. For example, when DOD committed to the Aquila UAV in 1979, the system was not technologically mature. Several of Aquila's key planned subsystems—such as a miniaturized jam-resistant data link and a day-night sensor with laser designator—did not even exist at the time. As a result, by 1982, in large part due to numerous problems in developing subsystem technologies, Aquila development costs had almost quintupled, and the schedule had slipped 27 months.<sup>5</sup> Nevertheless, DOD continued the program until 1987, when, after spending more than \$1 billion, it terminated Aquila.<sup>6</sup>

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## Background

UAVs are pilotless aircraft used in reconnaissance and surveillance and in the identification, location, and designation of targets. A UAV system includes one or more aircraft, a launch and recovery system, and a ground station for flight control. During the Vietnam War, target drones were modified to carry cameras and were used extensively for intelligence gathering missions, avoiding risk to manned aircraft.<sup>7</sup> After the war, DOD began several UAV programs to capitalize on these demonstrated

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<sup>4</sup>Before proceeding into product development, leading commercial firms require that technology development be complete. They also place a premium on demonstrated performance. See Best Practices: Successful Application to Weapon Acquisitions Requires Changes in DOD's Environment (GAO/NSIAD-98-56, Feb. 24, 1998).

<sup>5</sup>Results of Forthcoming Critical Tests Are Needed to Confirm Army Remotely Piloted Vehicle's Readiness for Production (GAO/NSIAD-84-72, Apr. 4, 1984).

<sup>6</sup>Aquila Remotely Piloted Vehicle: Its Potential Battlefield Contribution Still in Doubt (GAO/NSIAD-88-19, Oct. 26, 1987).

<sup>7</sup>The terms "drone" and "unmanned aerial vehicle" can be used interchangeably to refer to remotely controlled aircraft.

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capabilities. However, nearly all these UAV programs were terminated before reaching completion.<sup>8</sup>

DOD initiated its ACTD program in 1994 as an acquisition reform initiative to lower system costs and reduce acquisition time, and DOD modified its UAV acquisition strategy to incorporate the ACTD approach. The approach responded to the recommendations of the 1986 Packard Commission, which was created to review defense acquisitions and determine how weapon systems could be made faster and at lower cost. The Commission recommended, among other things, that prototypes be built and tested to assess military utility and provide a basis for realistic cost estimates before a commitment to acquisition is made. We reported in October 1998 that the ACTD approach can potentially cut a weapon system's development and acquisition time.<sup>9</sup>

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## ACTD Results Provide Better Basis for Decisions

ACTD results provide DOD with a better basis for making UAV acquisition decisions. DOD has completed ACTD projects for the Predator and Outrider UAVs. On the basis of the knowledge it gained during these demonstrations, DOD committed to acquiring Predator UAVs and chose not to acquire joint-service Outrider UAVs on a sole-source basis. Additionally, because of performance and cost concerns, DOD terminated the ACTD project for the DarkStar UAV before its demonstration was completed.

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## Predator Demonstrated in Bosnia Before Commitment to Production

When DOD began the ACTD for the Predator UAV in 1994, its technologies were considered mature because the aircraft was based on an existing UAV, the Gnat 750, which had been developed previously for the Central Intelligence Agency. DOD nevertheless required that the Predator's performance be demonstrated to ensure it would meet user needs before DOD committed itself to acquiring the system. Predator prototypes were deployed in Bosnia in 1995 and 1996 as part of the ACTD. The performance

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<sup>8</sup>The one exception, the Navy and the Marine Corps' Pioneer, was not acquired through the formal DOD process but was procured directly from a joint venture of Israeli and U.S. firms. When it deployed Pioneer on Navy ships, DOD had to spend considerable time and money resolving a number of significant problems. See Unmanned Aerial Vehicles: Realistic Testing Needed Before Production of Short-Range System (GAO/NSIAD-90-234, Sept. 28, 1990).

<sup>9</sup>Defense Acquisition: Advanced Concept Technology Demonstration Program Can Be Improved (GAO/NSIAD-99-4, Oct. 15, 1998).

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data gathered there convinced military users that Predator was worth acquiring.

The Predator effort began with a 30-month ACTD contract awarded in January 1994 for 3 systems and 10 air vehicles. Predator's mission is to provide long-range (500 nautical miles), long endurance (more than 20 hours), near real-time imagery to satisfy reconnaissance, surveillance, and target acquisition requirements. These capabilities were demonstrated in Bosnia. The demonstration also identified some problems such as the UAV's inability to see through cloud cover and icing of its wings in cold weather. However, the contractor incorporated solutions, including a synthetic aperture radar and a wing de-icing system. Predator systems are now in production, and the Air Force has had Predator UAVs deployed in two reconnaissance squadrons: one in Hungary supporting operations in Bosnia and one in Nevada.

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### Outrider ACTD Allowed DOD to Avoid Unwise Commitment

In our 1997 report on the joint-service Outrider ACTD, we concluded that DOD had underestimated the time and effort needed to successfully integrate nondevelopmental items into the Outrider prototype.<sup>10</sup> In 1998, after a 2-year effort, the Outrider ACTD was completed. The ACTD demonstrated that the Outrider prototype did not exhibit the necessary military utility for its expressed objective of meeting the combined tactical UAV requirements of the Army, the Navy, and the Marine Corps. The Navy then withdrew from the project in favor of pursuing a vertical take-off and landing UAV system, although on the basis of the knowledge gained during the ACTD, the Army determined that Outrider had sufficient military utility to continue as a competitor for the Army's tactical UAV solution. However, DOD determined there was not enough justification to continue in a sole-source arrangement with the Outrider system. Rather, DOD directed the Army to conduct a full and open competition for a tactical UAV system.

The objectives of the joint Outrider ACTD included determining whether the UAV could (1) operate for 3 to 4 hours at a range of 200 kilometers, (2) be transported on one C-130 cargo aircraft, (3) operate on automotive gasoline, and (4) be used aboard ships. These objectives were not met. The demonstration showed that Outrider (1) had a 200-kilometer range for only 2 hours, (2) needed two C-130 aircraft to transport it, and (3) required

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<sup>10</sup>Unmanned Aerial Vehicles: Outrider Demonstrations Will Be Inadequate to Justify Further Production (GAO/NSIAD-97-153, Sept. 23, 1997).

aviation fuel. The demonstration of shipboard operations was not attempted. Moreover, the demonstration results showed no evidence that Outrider could achieve two longer-term objectives: replacing its analog data link with a digital one and installing a heavy fuel engine.

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### **Better Knowledge Base Allowed DOD to Terminate DarkStar ACTD Early**

DOD terminated the DarkStar ACTD in January 1999, well before the planned completion date, after it was determined that DarkStar was not aerodynamically stable and not meeting cost and performance objectives. The ACTD required the contractor to demonstrate that the UAV had military utility and that future production versions could be built for \$10 million each. By requiring that DarkStar demonstrate its ability to meet military requirements before a commitment to acquisition was made, DOD was able to acquire knowledge about cost and performance relatively quickly compared with the time usually needed under the formal acquisition process.

DarkStar was meant to be a stealthy, high-altitude reconnaissance UAV to be used in high threat environments. It was expected to reach an altitude of 50,000 feet, have a range of 500 nautical miles, and be able to operate for 8 hours. The first prototype crashed on its second flight in 1996. Correcting the design problems that had caused the crash became expensive and time consuming. In December 1998, we reported that DOD projections showed that the unit price for future production versions of DarkStar would be about \$13.7 million, well above the \$10 million goal.<sup>11</sup>

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### **Global Hawk High-Altitude Endurance ACTD Is Progressing**

The Global Hawk high-altitude endurance ACTD is progressing toward an October 2000 program decision point. At that time, DOD will have completed a military utility assessment of Global Hawk and hopes to have a sound knowledge base for deciding whether to convert the UAV to a formal acquisition program. Global Hawks have flown more than 135 hours and have reached altitudes in excess of 66,000 feet. By the end of our review, four prototype Global Hawks had been built. The Air Force was scheduled to formally begin assessing the Global Hawk's military utility in April 1999 for the ACTD sponsor, the U.S. Atlantic Command, but this assessment was delayed by a crash.

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<sup>11</sup>Unmanned Aerial Vehicles: Progress in Meeting High Altitude Endurance Aircraft Price Goals (GAO/NSIAD-99-29, Dec. 15, 1998).

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DOD pursued several programs for a high-altitude, long-endurance UAV through the 1960s and 1970s without successfully fielding such an aircraft. The Global Hawk is considered technologically mature because many of its components are adapted from other proven aircraft. It is intended to reach altitudes of 65,000 feet, have a range of 3,000 nautical miles, and conduct reconnaissance missions for more than 24 hours. According to DOD's plans for airborne reconnaissance, high-altitude UAVs such as Global Hawk would initially augment and eventually could replace manned aircraft in performing high-altitude intelligence gathering missions.

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### ACTD Approach Consistent With Commercial Best Practices

DOD's approach to acquiring UAVs using the ACTD process is consistent with the focus on mature technology and proving performance that we found in our 1998 review of leading commercial development efforts. Commercial firms make a distinction between technology development and product development, and they demand proof of performance before committing to production.

The purpose of technology development is to foster technological advances for potential application to a product. Product development in commercial ventures is a clearly defined undertaking aimed to design and manufacture an item that the customer needs and wants. The process of discovery—the accumulation of knowledge and the elimination of unknowns—is completed for the best commercial programs well ahead of commitment to development of a product. Immature or undeveloped technology is kept out of commercial product development programs.

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### Prior UAV Acquisitions Accepted Significant Unknowns

In contrast to the ACTD approach, DOD's formal acquisition process allows technology development to continue after product development has begun. As a result, the distinction between technology development and development of an individual product is much less clear. Consequently, DOD may have much less knowledge about technologies, design, and potential production problems when it commits to development or acquisition of a product. Problems with development and production, along with the associated cost and schedule increases, are a predictable consequence of such limited knowledge.

Under previous programs, accurate data of a UAV's performance, military utility, and cost was not generally available when DOD made a commitment

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to acquisition.<sup>12</sup> As a result, DOD spent far more than it anticipated and obtained far less than it expected in terms of capabilities. Examples include DOD's acquisition efforts for the Aquila, Pioneer, and Hunter UAV systems.

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## Aquila

Several planned key subsystems of the Aquila UAV did not exist when DOD committed to developing the Aquila in 1979. These included a modular integrated communication and navigation system, an anti-jam data link, and a forward-looking infrared payload and laser designator. After about 4 years, Aquila development costs had grown from \$123 million to \$590 million, and numerous problems with subsystem development had stretched the development schedule from 43 months to 70 months.<sup>13</sup> Nevertheless, DOD continued until 1987, when operational testing revealed that the Aquila did not meet requirements. Ultimately, after spending 8 years and \$1 billion in development funds, the Army terminated the program.

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## Pioneer

DOD also committed to acquire the Pioneer UAV in the face of significant unknowns. Subsequently—but only after the Navy and the Marine Corps had begun taking delivery of Pioneer systems—numerous problems emerged, requiring extensive investment of resources to solve.

Before deciding to acquire Pioneer UAVs, the Navy acquired several Mastiff UAVs from Israel for Naval Gunfire Support while expediting a procurement program for Pioneer. The Navy, however, wanted Pioneer to be adapted so it could take off from and land on ships. No performance data on how the Pioneer design would accommodate shipboard requirements was collected before an acquisition decision was made. Thus, Pioneer immediately began to encounter problems. Recoveries aboard ship and electromagnetic interference from other shipboard systems led to a significant number of crashes. The Pioneer also suffered from numerous other shortcomings. Ultimately, the Navy was forced to spend \$50 million in research and development to bring nine Pioneer prototypes up to a level of "minimal essential capability." Although

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<sup>12</sup>Unmanned Aerial Vehicles: DOD's Acquisition Efforts (GAO/T-NSIAD-97-138, Apr. 9, 1997).

<sup>13</sup>Results of Forthcoming Critical Tests Are Needed to Confirm Army Remotely Piloted Vehicle's Readiness for Production (GAO/NSIAD-84-72, Apr. 4, 1984).



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Pioneer's performance never met its original requirements, the Navy and the Marine Corps were able to use the improved Pioneer systems in the Persian Gulf War and more recently in Somalia, Bosnia, and Yugoslavia.

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## Hunter

The Hunter UAV program entered production in January 1993, before its performance had been tested under realistic conditions.<sup>14</sup> Seven Hunter systems, at a cost of \$171 million, were already being built when testing disclosed serious problems with engines, software, equipment, and logistic support.<sup>15</sup> After spending an additional 3 years and a total of about \$700 million on the program, DOD chose not to contract for further production of Hunter. The seven existing Hunter systems are now deployed in contingencies such as Yugoslavia, are being used for testing and training, or are in storage.

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## Conclusions

By taking an ACTD approach that focuses on mature technology and proves performance and military utility before acquisition, DOD is basing its UAV acquisition decisions on an improved body of knowledge. The approach is also consistent with best commercial practices, which place a premium on demonstrated performance when deciding whether to develop a new product. As we have previously reported, DOD's standard acquisition process did not provide the same level of data and knowledge under previous UAV programs.

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## Agency Comments

DOD partially concurred with a draft of this report. DOD stated that although the draft report was favorable to the UAV ACTD process, it did not outline critical factors that led to DOD's decision not to pursue Outrider UAV acquisition. We have made changes in the body of this report to reflect DOD's concerns. DOD's comments are reprinted in appendix II. Additional technical comments from DOD have been incorporated as appropriate.

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<sup>14</sup> Unmanned Aerial Vehicles: Performance of Short Range System Still in Question (GAO/NSIAD-94-65, Dec. 15, 1993).

<sup>15</sup> Unmanned Aerial Vehicles: No More Hunter Systems Should Be Bought Until Problems Are Fixed (GAO/NSIAD-95-52, Mar. 1, 1995).

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## Scope and Methodology

To determine whether the ACTD approach provides an improved knowledge base for making UAV acquisition decisions, we reviewed and analyzed the history of DOD's previous UAV acquisition efforts and the results of two completed UAV prototype demonstrations, for Predator and Outrider. We also reviewed the DarkStar High Altitude Endurance UAV's history and the status of the ongoing Global Hawk High Altitude Endurance UAV ACTD project. We observed flight tests and reviewed test reports. We interviewed DOD, Air Force, Army, Marine Corps, and Navy requirements, acquisition, and testing officials; service user representatives; and contractor officials. In addition, we leveraged from our past and ongoing work in the area of best practices.

We performed our work at the offices of the Secretary of Defense, the Air Force, the Army, the Marine Corps, and the Navy in Washington, D.C.; the UAV Joint Projects Office, Patuxent River, Maryland; the Air Force Air Combat Command, Langley Air Force Base, Virginia; the U.S. Atlantic Command, Norfolk, Virginia; the Army Training and Doctrine Command, Fort Monroe, Virginia; the Air Force Aeronautical Systems Center, Wright-Patterson Air Force Base, Ohio; the U.S. Army, 15<sup>th</sup> Military Intelligence Battalion, Fort Hood, Texas; the 304<sup>th</sup> Military Intelligence Battalion, Fort Huachuca, Arizona; the U.S. Air Force, 11<sup>th</sup> Reconnaissance Squadron, Indian Springs, Nevada; the U.S. Marine Corps, Pioneer Company at 29 Palms, California; and at various contractor facilities.

We performed our review from April 1997 to May 1999 in accordance with generally accepted government auditing standards.

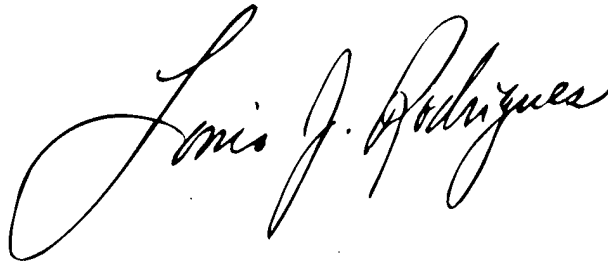
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We are sending copies of this report to Senator John Warner, Chairman, and Senator Carl Levin, Ranking Minority Member, Senate Committee on Armed Services and Representative Floyd Spence, Chairman, and Representative Ike Skelton, Ranking Minority Member, House Committee on Armed Services. We are also sending copies to the Honorable Louis Caldera, Secretary of the Army; the Honorable Richard Danzig, Secretary of the Navy; the Honorable F. Whitten Peters, Acting Secretary of the Air Force; and the Honorable Jacob Lew, Director, Office of Management and Budget. Copies will also be made available to others upon request

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Please contact me on (202) 512-4841 if you or your staff have any questions concerning this report. Major contributors to this report were Michael Aiken, Terrell Bishop, Terry Parker, and Charles Ward.

Sincerely yours,

A handwritten signature in black ink that reads "Louis J. Rodrigues". The signature is written in a cursive style with a large, looping initial "L".

Louis J. Rodrigues  
Director, Defense Acquisitions Issues



# Unmanned Aerial Vehicles Program Cancellations Through 1996

<b>Program</b>	<b>Dollars spent (approximate)</b>
Compass Cope	\$200 million
Compass Dwell	200 million
Aquila	1 billion
Amber	200 million
Condor	400 million
Medium Range	210 million
Special Program	1 billion
Raptor	200 million
Hunter	700 million
<b>Total</b>	<b>\$4.1 billion</b>

Source: Defense Airborne Reconnaissance Office.

# Comments From the Department of Defense

Note: GAO comment supplementing those in the report text appear at the end of this appendix.



COMMAND, CONTROL,  
COMMUNICATIONS, AND  
INTELLIGENCE

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE  
6000 DEFENSE PENTAGON  
WASHINGTON, DC 20301-6000

Mr. Louis J. Rodrigues  
Director, Defense Acquisition Issues  
National Security and International  
Affairs Division  
U.S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Rodrigues:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "UNMANNED AERIAL VEHICLES: DOD'S Demonstration Approach Has Improved Project Outcomes," dated June 25, 1999 (GAO Code 707245/OSD Case 1854).

The DoD partially concurs with the draft report. Although the overall draft report is favorable to the Department's Advanced Concept Technology Demonstration (ACTD) process, the report does not outline the critical factors that led to the DoD's decision not to pursue the Outrider "sole-source" following the ACTD. Since the final report does not logically connect the Outrider ACTD results to the Full and Open competition strategy currently being pursued by the Army, it is feared that readers will draw the conclusion that the Army is undertaking a new UAV development program.

It is recommended the entire section on the Outrider, starting on page 6, be reworded as follows:

In 1998, after a 2-year effort, the joint-service, Army, Navy, and Marine Corps, Outrider ACTD was completed. The Services were able to assess the performance of the Outrider during the Military Utility Assessment (MUA) portion of the ACTD and drafted their Operational Requirements Documents (ORD). The ACTD demonstrated that the Outrider prototype did not exhibit the necessary military utility for its expressed objective of meeting the Services combined tactical UAV requirements. The Navy chose to pursue a Vertical Take-off and Land (VTOL) UAV type system for shipboard operations, and although not meeting all their requirements, the Army determined that Outrider represented sufficient military utility to continue as their Tactical UAV (TUAV) solution. However, because the Outrider did not meet all of the requirements that formed the basis of the original ACTD competition, and because post-ACTD market surveys and cost analysis determined sufficient other UAVs existed in the marketplace, the DoD determined there was not enough justification to continue "sole source" under the 1984 Competition in Contracting Act (CICA). Therefore, open competition for TUAV was directed. The Outrider UAV system was welcomed to compete in this ongoing Army competition.



See comment 1.

See comment 1.

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**Appendix II**  
**Comments From the Department of Defense**

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Suggested technical changes for clarification and accuracy have been provided separately.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, please contact Col Joe Spivey, ISR Systems, 703-607-0410.

Sincerely,

A handwritten signature in cursive script, appearing to read "Robert M. Nutwell for".

Robert M. Nutwell, RADM, USN  
Deputy Assistant Secretary of Defense  
(C3ISR and Space)

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**Appendix II**  
**Comments From the Department of Defense**

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The following is GAO's comment on the Department of Defense's (DOD) letter.

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**GAO Comment**

1. We have made changes in the body of this report to reflect DOD's concerns.