SUMMARY

The United States has seen a three-decade-long history of poor outcomes in unmanned aerial vehicle (UAV) development efforts. Technical problems have led to cost growth and schedule slip as well as to disappointing operational results. Costs have tended to escalate so much during development that the resulting systems have cost more than users have been willing to pay, precipitating program cancellation in almost every case. This history prompted the unique developmental approach adopted at the beginning of the High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) program.

There has also been a long history of efforts made to improve the efficiency and effectiveness of weapon system acquisition policy, processes, and management. Capturing the experience from ongoing or recently completed efforts employing nonstandard or innovative acquisition strategies can facilitate such improvements. This research contributes to that effort.

In 1994, the Defense Advanced Research Projects Agency (DARPA), in conjunction with the Defense Airborne Reconnaissance Office (DARO), began the development of two UAVs. These systems were intended to provide intelligence, surveillance, and reconnaissance information to the warfighter. As such, they responded both to recommendations made by the Defense Science Board and to operational needs stated by DARO on behalf of military service users.

With congressional support, DARPA adopted an innovative acquisition strategy that differed from normal DoD procedures. The strategy's innovations are embodied in seven specific elements: designation as an Advanced Concept Technology Demonstration (ACTD)

program; use of Section 845 Other Transaction Authority (OTA); use of Integrated Product and Process Development (IPPD) and a management structure based on Integrated Product Teams (IPTs); contractor design and management authority; a small joint program office; user participation through early operational demonstrations; and a single requirement—unit flyaway price (UFP)—with all other performance characteristics stated as goals.

The HAE UAV ACTD program included two air vehicles: a conventional configuration and a low-observable (LO) configuration. A common ground segment (CGS) was added not long after program initiation. The ACTD program was structured into three phases. Phase I was a design competition for the conventional Tier II+ system. Phase II included the development and test of both the Tier II+ (Global Hawk) and the LO Tier III– (DarkStar). Phase III involved the demonstration and evaluation (D&E) activity leading to a military utility assessment (MUA).

RAND has been assessing the execution of the HAE UAV ACTD program's innovative acquisition strategy since the program's inception in 1994. Previous reports have documented the effects of that strategy on Phase I and Phase II of the ACTD program.[2] The current research addresses the completion of Phase II, the transition to Phase III, and the transition to post-ACTD activities. This report specifically addresses the ACTD flight test program. Two companion documents (MR-1474-AF and MR-1476-AF) describe transition issues and outline program activity content. A separate executive summary (MR-1473-AF) presents our overall assessment of the acquisition strategy and suggests improvements.

Excluding the two initial DarkStar flights in early 1996, the HAE UAV ACTD flight test program was fairly cautious. A pattern of learning—test, analyze, fix, and test—is clearly evident for both Global Hawk and DarkStar. Master test plans were developed that included detailed objectives for each engineering test flight. The MUA process

---

[2]See Geoffrey Sommer, Giles K. Smith, John L. Birkler, and James R. Chiesa, *The Global Hawk Unmanned Aerial Vehicle Acquisition Process: A Summary of Phase I Experience*, MR-809-DARPA, Santa Monica: RAND, 1997; and Jeffrey A. Drezner, Geoffrey Sommer, and Robert S. Leonard, *Innovative Management in the DARPA High Altitude Endurance Unmanned Aerial Vehicle Program: Phase II Experience*, MR-1054-DARPA, Santa Monica: RAND, 1999.

was reasonably well documented both in planning and in execution, but some detail, including exit criteria and priority setting, was missing from the plans. Moreover, limited personnel and funding resources constrained flight test execution.

DARKSTAR

The first DarkStar flew in March 1996 and crashed on takeoff on its second flight attempt in April 1996. The second DarkStar air vehicle first flew 26 months later and flew only five times, accumulating six flight hours before the program was terminated in January 1999. DarkStar did not participate in D&E flight test activity. Thus, very little can be concluded from its limited flight testing. Our reading of DarkStar test results suggests that the performance of the air vehicle would have been considerably less than the stated goals, but any prediction of ultimate mission performance would be highly uncertain.

Not enough flight experience was accumulated to allow for an understanding of the flight characteristics of DarkStar. Unexplained oscillation problems during flight were not resolved. The performance of the ground segment was not determined. DarkStar sensor payloads apparently performed well in tests but were never flown onboard the DarkStar air vehicle.

GLOBAL HAWK

Table S.1 summarizes the Global Hawk flight test program by phase and air vehicle. The first flight was in February 1998. The first air vehicle was clearly the workhorse of the program, participating in both Phase II and Phase III. The third through fifth air vehicles participated only in Phase III. Although shorter in calendar length and flying fewer hours than initially planned, the flight test program did accumulate enough experience to demonstrate Global Hawk's military utility.

Six outcomes of Global Hawk's ACTD flight test experience are either partially or wholly attributable to the program's novel acquisition approach:

Table S.1

Summary of the Global Hawk Flight Test Program by Phase and Air Vehicle (number of sorties/flight hours)

Phase	Air Vehicle 1	Air Vehicle 2	Air Vehicle 3	Air Vehicle 4	Air Vehicle 5	Total
II	12/102.9	9/55.1				21/158.0
III	13/225.4		9/121.8	11/167.8	4/39.0	37/554.0
III+					5/25.1	5/25.1
Total	25/328.3	9/55.1	9/121.8	11/167.8	9/64.1	63/737.1

- The mission planning process was cumbersome and time-consuming, affecting the pace of the flight test program as well as the workload of flight test personnel. The contractors knew at the time of the Phase II bid that significantly more funds would be required to develop a mission planning system suitable for sustained operations. However, because the focus of the ACTD was on demonstrating military utility, which at the time was not well defined and did not specify timely sortie generation, a conscious decision was made not to make this investment. Had mission planning been made a priority (i.e., incorporated into a definition of utility early in the program), more funding might have been committed to it, albeit at the expense of other activities.

- The program lacked sufficient resources in terms of both personnel and spares. This paucity of trained personnel and spares limited the number of vehicles that could be flown at any one time during the latter portion of the flight test program. This was attributable in part to the reallocation of resources within the program to cover increased nonrecurring engineering activity, and in part to a highly constrained budget throughout the duration of the ACTD.

- The pace of the flight test program was fast given its cumbersome mission planning process and limited resources. Test personnel were clearly overburdened, which appears to have been a contributing factor in the taxi mishap of air vehicle 3.

- The contractors were designated the lead for flight test program execution, with the government program office assuming re-

sponsibility for liability and contingency planning. Contractors thus held significantly more responsibility than is the case in traditional programs, creating a somewhat different program management dynamic. Yet contractors do not have the necessary capabilities, experience, and perspective (culture) to run all aspects of a test program. The government test and operational communities thus took on a large portion of the planning and execution of the flight test program. Their assistance was essential to the accomplishments of the program.

- ACTDs are specifically intended to explore innovative concepts of operations (CONOPS) throughout the D&E phase of the program. Yet differences in perspective between the ACTD and post-ACTD user communities regarding CONOPS proved to be a serious impediment to the program's transition into the Major Defense Acquisition Program (MDAP) process. The initial CONOPS was generated by the DARPA joint program office and was then modified and expanded by the Joint Forces Command (JFCOM) as part of its responsibility as the designated ACTD user. The post-ACTD CONOPS of the Air Combat Command (ACC) is similar to current systems in terms of its access to sensor retasking and dissemination pathways. JFCOM's CONOPS takes advantage of advances in communications and processing technology and adopts a joint orientation. The ACTD demonstrated the JFCOM CONOPS; ACC has not demonstrated its CONOPS with respect to Global Hawk.

- ACTDs do not have approved operational requirements; they are intended to help refine operational requirements through lessons from flight test experience. Differences in operational requirements definition between ACTD and post-ACTD users also inhibited the program's transition to the MDAP. The extent to which the capabilities of the ACTD configuration should determine the requirements for a post-ACTD system is the underlying issue. The spiral development concept planned for use in post-ACTD development implies that requirements will evolve as the system's configuration evolves via block upgrades. As a result of this process, early configurations will not have the full capability that ACC, the force provider, desires. Nevertheless, the ACTD D&E phase did provide information critical to developing an operational requirement for the MDAP program.

The performance of Global Hawk was close to predicted goals but fell short in several significant areas. Empty weight increased 16 percent, and lower-than-predicted aerodynamic performance resulted in a 24 percent endurance shortfall (32 hours versus 40 hours) and a 7.7 percent shortfall in mission cruise altitude (60 kft versus 65 kft).[3] The program demonstrated the feasibility of autonomous flight and long endurance at altitude, and most of the communications and data links were demonstrated sufficiently. The synthetic aperture radar (SAR) sensor appears to provide high-quality imagery. However, the program did not demonstrate CGS control of multiple vehicles; nor was the electro-optical/infrared (EO/IR) sensor characterized sufficiently.

Some participants believe that neither the content of the flight test program (what was done) nor the approach used (how it was done) was greatly affected by the acquisition strategy. Evidence suggests that the dominant influence on the test program was the nature of the system. Until the HAE UAV ACTD program, very little experience had been accumulated with large autonomous UAVs. System characteristics determined the pace of the program, the profile in which flight hours were accumulated over time, and the scope of envelope expansion testing. The acquisition approach did, however, influence some key elements of the test program: the increased contractor responsibility for test program planning, direction, and execution; the early operational testing in the form of user demonstrations; and the explicit exploration of operational concepts and requirements.

One important lesson from the flight test program was the necessity for early involvement on the part of operational users—in this case the 31st Test and Evaluation Squadron (TES). The operational users not only provided much-needed skills and capabilities in support of the test program but also introduced a critical operational perspective into the conduct of the flight test program.

---

[3]The original DARPA mission profile shows a 3000-nm ingress, a 24-hour on-station segment at 65 kft, and a 3000-nm egress. It is this on-station "cruise" segment that Global Hawk cannot achieve. Global Hawk can achieve an altitude of 65,000 ft for shorter periods of time under certain environmental and weight-related (e.g., fuel remaining) conditions.