Chapter Five

COMPARISON TO OTHER AIRCRAFT PROGRAMS

This section compares the Global Hawk flight test experience with that of other aircraft programs. The Global Hawk ACTD ended with a system that was more developmentally mature than what is typically seen at the conclusion of an advanced technology demonstrator (ATD) or demonstration/validation (dem/val) program. At the same time, the Global Hawk ACTD did not attain the system maturity typically seen at the conclusion of a traditional EMD program. Because the flight test portion of the Global Hawk ACTD was unique, direct comparison to ATD, dem/val, or EMD flight test programs should be interpreted with caution.

The conditions of flight testing in the Global Hawk program differ considerably from those of other air vehicle types mainly because the system is an autonomous UAV and because it was used in operational demonstrations. Its innovative acquisition approach appears to have had little effect either on the number of sorties or on the accumulation of flight hours for basic and follow-on engineering development and air vehicle checkout flight testing. The innovative acquisition approach does account for earlier user involvement and operational-style testing (the D&E phase) as well as for relatively more substantial participation on the part of the contractors.

An autonomous UAV requires a better understanding of the system earlier in testing because there is no real-time human input or real-time human feedback from the air vehicle as it is tested. By contrast, remotely controlled UAVs have a human in the loop if not onboard and thus gain the advantage of real-time human input. These systems still suffer from a lack of real-time human feedback, as the remote pilot cannot “feel” the air vehicle during test. Manned aircraft have the benefit of both pilot feedback and pilot reactions to identify and mitigate problems during flight testing. The very early operational tests conducted as part of the ACTD are not part of traditional programs, which do not begin operational test until DT has been completed and the system configuration is stable and well understood.

Comparisons with different aircraft types are further complicated by differences in the area and composition of each aircraft type’s flight envelope. Fighter, bomber, attack, and cargo are different aircraft types, each generally having a different flight envelope. The Global Hawk mission profile is specifically and narrowly defined, giving the air vehicle a flight envelope with a very small area. Other aircraft types have missions that rely on great aerodynamic flexibility, dictating a much larger-area flight envelope that must be explored during flight test.[1]

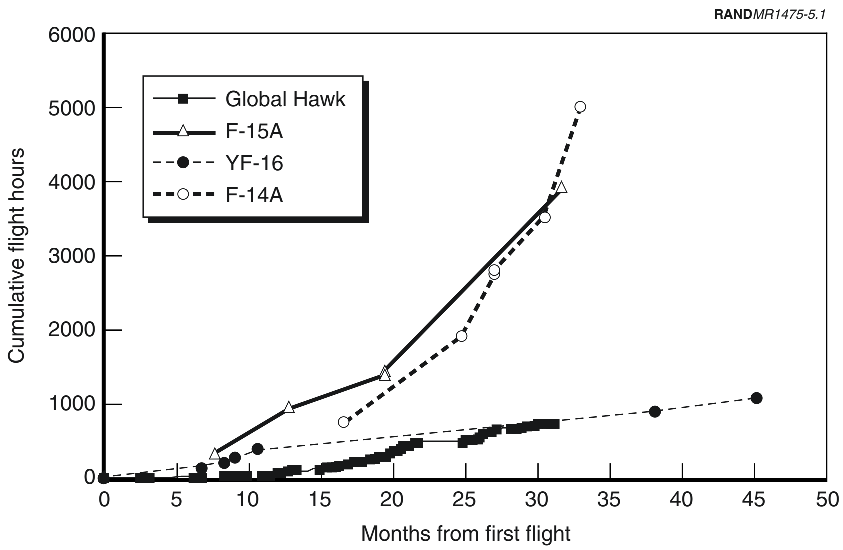
Figure 5.1 presents a rough comparison of aircraft flight test programs. Global Hawk’s flight test experience is compared with that of several fighter aircraft during their ATD and EMD development phases. We observe a very different pattern of flight-hour accumulation over time in the Global Hawk ACTD. Fighter aircraft tend to accumulate hours much faster as multiple aircraft fly multiple short sorties each month. Global Hawk had only two aircraft in flight-ready status at any one time and generally flew no more than three long-duration sorties per month.

A comparison of the Global Hawk ACTD to prototype programs provides a different perspective.[2] The Attack Aircraft Prototype (AX) program, which involved two pairs of attack prototype aircraft, included a very short, seven-month flight test program. The first five months were conducted by the contractors, and in the next two a

---

[1]There are no precise comparisons to Global Hawk. Data on the U-2 flight test program, the system in the current inventory that is most similar to Global Hawk, were unavailable.

[2]Data on the Attack Aircraft Prototype (AX) and LWF programs are taken from Giles K. Smith, A. A. Barbour, Thomas L. McNaugher, Michael D. Rich, and William L. Stanley, *The Use of Prototypes in Weapon System Development,* R-2345-AF, Santa Monica: RAND, 1981.



SOURCE: Global Hawk data are from quick-look and flash reports (as of October 2, 2000). Data on the F-14A, F-15A, and YF-16/F-16 were collected by an industry source and validated with other information collected by RAND. The F-14A data include the period from December 1970 through September 1973. The F-15A data include the period from July 1972 through March 1975. The YF-16/F-16 data include both the LWF program and some full-scale development from January 1974 through October 1977.

Figure 5.1—Comparison of Aircraft Flight Test Programs

formal competitive fly-off using Air Force pilots was undertaken. In the first five months, the YA-9 accumulated 162 hours using two aircraft and an additional 145.5 hours (in 123 sorties) in the two-month competitive evaluation. The competing YA-10 accumulated 190 hours in the first five months with its two aircraft and 138.5 hours (87 sorties) in the two-month fly-off. The YA-10s were then used for 16 months during full-scale development (FSD) for follow-on development test and evaluation (DT&E) and initial operational test and evaluation (IOT&E) prior to the low-rate production decision. In contrast, Global Hawk accumulated 20.5 flight hours in five sorties in the first six months of its flight test.

The LWF program of the early 1970s was a highly streamlined effort involving two pairs of prototype fighter aircraft. In 11 months in

1974, the YF-16 accumulated approximately 450 hours in 320 sorties. The YF-17 flew 230 sorties and accumulated approximately 350 hours in a seven-month period that same year. Clearly the pace of the LWF program flight test was much faster than that of Global Hawk. This is due in part to Global Hawk's system type—a large autonomous UAV. Global Hawk requires much more preparation for each mission, specifically in the area of mission planning.

Both competitive prototype flight test programs described above had informal MUAs in the form of participation on the part of operationally oriented test pilots. The use of JFCOM as the architect of the D&E phase of the Global Hawk ACTD, with a focus on formal demonstration of the UAV as a joint warfighting asset and a military utility decision based on that approach, is very different from the "ACC-equivalent" user involvement seen in these comparative programs from the 1970s.

The F-22 flight test program planned an average of 25 flight hours per month during EMD along with the use of multiple aircraft and sorties.[3] Global Hawk can accumulate that in a single sortie. The F-22 also planned to accumulate 1400 hours prior to production authorization but will attain less. The F/A-18E/F logged a total of 4673 flight hours in 3172 flights over 3.5 years of EMD testing at Patuxent River, Maryland, using seven aircraft.[4] Global Hawk has accumulated 737.1 hours in 31 months using five aircraft, never flying more than one at a time.

In general, traditional fighter aircraft EMD flight test programs fly more sorties per month and accumulate more flight hours than did Global Hawk during its ACTD. The main explanation for this difference lies in the vastly larger flight envelope for fighter systems and the need to satisfy myriad requirements, as is traditionally the case in an MDAP-compliant EMD program.

---

[3]See *Aviation Week & Space Technology*, March 27, 2000.

[4]See *Defense News*, June 7, 1999, p. 21.

Figure 5.2 compares the flight test experience of Global Hawk with that of the F-117 EMD program.[5] The two programs show more similarities than do the other comparisons. This pattern is due to flight test constraints, characteristics of the F-117 itself, and the streamlined acquisition approach adopted. Although mission profiles for the F-117 are undoubtedly classified, it is reasonable to assume that the aircraft's flight envelope has a relatively small area. This presumption is driven by the relatively poor aerodynamic characteristics of the F-117, which stem in turn from the aircraft's first-generation LO design.

Like Global Hawk, the F-117 was not held to a long list of technical requirements; instead, the dominant emphasis was on low observability. The program's classified status and subsequent restriction to flight testing only at night slowed the pace at which flight hours

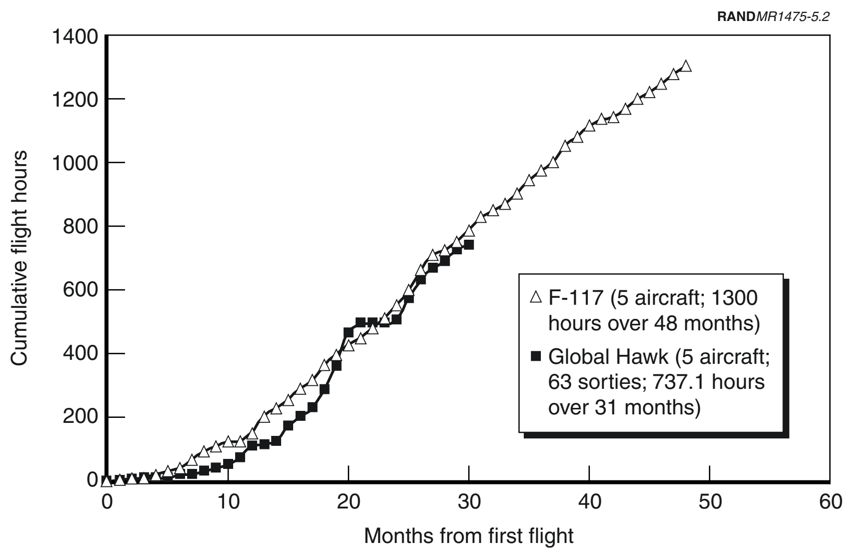


Figure 5.2—Comparison of Global Hawk and F-117 Flight Test Programs

---

[5]See Giles K. Smith, Hyman L. Shulman, and Robert S. Leonard, *Application of F-117 Acquisition Strategy to Other Programs in the New Acquisition Environment,* MR-749-AF, Santa Monica: RAND, 1996.

could be accumulated, much as the mission planning process slowed the Global Hawk program. Similarly, the F-117 generally did not fly all five aircraft in the same month.

The Global Hawk ACTD program has also been described as comparable to the development of the F-117 in culture. The comparison to the F-117 EMD flight test program supports the belief that what was accomplished in the Global Hawk ACTD includes many tasks not usually undertaken until well into an EMD program.

One major difference between the two programs lies in the earlier attention paid to supportability in the Global Hawk program. At the end of the ACTD, 300 of the 900 troubleshooting procedures had been documented. These 300 procedures cover all the usual day-to-day operations of the aircraft. The remaining 600 apply to specialized procedures that are required on a less-than-regular basis. Very little attention was paid to supportability issues during the Have Blue and initial F-117 FSD program.

UAV Comparisons

Boeing's Condor, an autonomous UAV and the indirect predecessor to Global Hawk, flew 141 hours in eight sorties during its flight test program in 1988–1989.[6] Boeing funded most of Condor's development, with some additional funding from DARPA. Condor used two 175-hp piston engines, unlike Global Hawk's use of a single turbofan. Condor's test program did not include payload tests or user demonstrations. Unfortunately, the lack of data for the Condor program, together with the program's composition, does not allow for a meaningful comparison to the Global Hawk.

The Medium-Altitude Endurance (MAE) UAV (Predator) ACTD program was the only other major ACTD program to transition to major program status with operational forces. This program was accelerated even in comparison to the HAE UAV. Its initial flight testing was scheduled for six months in one configuration, with another six-month period planned one year later in a different sensor and com-

---

[6]See Breck W. Henderson, "Boeing Condor Raises UAV Performance Levels," *Aviation Week & Space Technology*, April 23, 1990.

munications configuration. Multiple air vehicles were available to support both test periods. Four D&E exercises were identified in one of the earliest management plans,[7] along with the promise of contractor support in an operational deployment if required.

The development challenge the Predator ACTD faced was much less than that of Global Hawk in several important respects: the Predator is smaller, cheaper, much less complex and capable, and based on an existing system (GNAT-750). However, this comparison illustrates that in the ACTD environment, testing focuses heavily on what the designated user wants in order to assess military utility. This approach implies combined DT/OT without reference to a stable set of system specifications. The Global Hawk experience appears to be similar to that of Predator in this respect.[8]

Similarly, the Tactical UAV (TUAV) ACTD program identified the operational test organizations in the Army, Marine Corps, and Navy as the lead test agencies, just as AFOTEC was the lead test agency in the HAE UAV. This reflects the operational demonstration focus of ACTDs, as opposed to the demonstration of mature technical development.

A Different Metric: Early Identification of Major Design Flaws

Another metric for comparison concerns the ability of the test program to find significant technical or performance flaws prior to the commitment of major funding (e.g., production). Earlier RAND work on the adequacy of test programs examined past aircraft programs to better understand the point at which significant design flaws affecting mission capability are discovered during flight test.[9] Table 5.1 provides data on a sample of programs. The overall conclusions suggest that such problems (e.g., the F-117 tail, C-5A wing fatigue, and

---

[7]Defense Advanced Research Projects Agency, *HAE UAV ACTD Management Plan*, December 15, 1994.

[8]See Thirtle, Johnson, and Birkler, *The Predator ACTD: A Case Study for Transition Planning to the Formal Acquisition Process*, 1997.

[9]See Giles K. Smith, "Use of Flight Test Results in Support of F-22 Production Decision," internal document, Santa Monica: RAND, 1994; and Giles K. Smith, "The Use of Flight Test Results in Support of High-Rate Production Go-Ahead for the B-2 Bomber," internal document, Santa Monica: RAND, 1991.

Table 5.1

Major Problems Revealed During Flight Test

Program	Major Problem Identified	Percentage of Testing Complete
C-5A	Static test failure in wing root	20
	Hydraulic leaks/engine	25
	Landing gear mechanisms	2
	Multimode radar deficiencies	15
	Wing fatigue problem	40–50
B-1A	Weapon bay acoustics	5
	Shock-induced oscillations	60
	Horizontal stabilizer fatigue	10
B-1B	Defensive avionics	10
	Terrain-following radar	10
F-117	Tail size	1
	Wing structure	10
	Infrared Attack and Designation System	10
	Rudder	50
F/A-18A	Excessive drag	15
	Bulkhead fatigue cracks	10
	Inadequate roll rate	20

SOURCE: Giles K. Smith, "Use of Flight Test Results in Support of F-22 Production Decision," internal document, Santa Monica: RAND, 1994.

B-1B defensive avionics) are rare and usually occur early in the test program. Global Hawk was clearly well past that point by the end of the ACTD; DarkStar illustrates the point.