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# The NASA Dryden Flight Research Center Unmanned Aircraft System Service Capabilities

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**May 2007**

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## ABSTRACT

Over 60 years of Unmanned Aircraft System (UAS) expertise at the NASA Dryden Flight Research Center are being leveraged to provide capability and expertise to the international UAS community. The DFRC brings together technical experts, UAS, and an operational environment to provide government and industry a broad capability to conduct research, perform operations, and mature systems, sensors, and regulation. The cornerstone of this effort is the acquisition of both a Global Hawk (Northrop Grumman Corporation, Los Angeles, California) and Predator B (General Atomics Aeronautical Systems, Inc., San Diego, California) unmanned aircraft system (UAS). In addition, a test range for small UAS will allow developers to conduct research and development flights without the need to obtain approval from civil authorities. Finally, experts are available to government and industry to provide safety assessments in support of operations in civil airspace. These services will allow developers to utilize limited resources to their maximum capability in a highly competitive environment.

## INTRODUCTION

The rapid maturity of unmanned aircraft systems (UAS) and the increasing number of applications for UAS has created the following needs. First, the need for an accessible platform is caused by the unavailability of large high-altitude systems for testing. Each system that is produced is immediately put in to service. This leaves developers of software and sensor systems without access to these platforms to develop critical systems and capabilities, such as collision avoidance systems.

Second, there is a need for ready access to an authorized area for research and development testing of UAS for commercial ventures that do not have a federal government sponsor. The lack of policy and regulation with respect to routine operations of UAS in civil airspace has effectively made it illegal in the United States for a developer to operate his system in civil airspace without an experimental certificate or, if he is lucky enough to have a government sponsor, a Certificate of Authorization from the Federal Aviation Administration (FAA). The time and effort required to obtain approval is generally too great for many developers. This is especially true for small UAVs.

Third, many companies that have entered the UAS market lack the experience in conducting the rigorous risk assessments that are required to obtain experimental certification or a Certificate of Authorization for operations in civil airspace. This lack of experience also exists in governmental agencies that have only recently become operators of UAS. The availability of personnel experienced in risk assessment would address this need.

This paper will discuss how the NASA Dryden Flight Research Center (DFRC)(Edwards, California) is working to address these needs.

## APPROACH

In response to the requirements noted above, the DFRC is focusing its UAS expertise in three major areas. The first is access to high-altitude, long-endurance (HALE) UAS. The second is the establishment of a test range for small UAS. The third is safety case assessment support.

### Access to High-Altitude, Long-Endurance Unmanned Aircraft Systems

The DFRC has acquired a standard MQ-9 Reaper (General Atomics Aeronautical Systems, Inc., San Diego, California) airframe with digital engine control and a mobile ground control station. The airframe has been named Ikhana, a Choctaw Native American word meaning intelligent, conscious, or aware. The ground control station supports Ku satellite communications for over-the-horizon command and control and includes six engineering monitoring stations. The entire ground control station is transportable by air in either a C-130 (Lockheed Martin Corporation, Bethesda, Maryland) or C-17 (The Boeing Company, Chicago, Illinois) airplane.

In addition to the standard equipment necessary for operations, an external pod is being developed to allow for the quick integration of payloads. An interface handbook is also under development that will permit payload developers to design with known vehicle interfaces in mind.

Of special interest is a research flight control computer being developed for integration on the Ikhana system. This computer will be capable of autonomous control of the aircraft and some aircraft systems (waypoint commands, autopilot commands, or pilot stick/rudder commands); it will have the capability to host research control laws (autonomous mission management, collision avoidance, precision trajectory, autonomous refueling, etc.) without compromising the integrity of the basic system. The computer is being implemented in a manner similar to that used at DFRC on other research aircraft (ref. 1).

In addition to the Ikhana system, the DFRC is expected to receive two of the three preproduction Global Hawk airframes. The only preproduction airframe that is not being transferred will be retired to a museum. Efforts are underway to obtain a ground control station that would lead to operational capability for the system. It is expected that the ground control station will be portable to allow for remote operations to be conducted from any suitable airfield, thus enabling global operations.

The air vehicle and payload command and control communications streams will be independent to ensure inherent vehicle integrity while allowing for the widest possible payload opportunities. An experimenter's interface handbook, containing payload integration and environmental requirements will be available for payload developers.

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Figure 1. The NASA UAV, Ikhana.

Photo courtesy Brent Cobleigh

Figure 2. An outside view of the Ikhana ground control station.

Photo courtesy Brent Cobleigh

Figure 3. An inside view of the Ikhana ground control station.

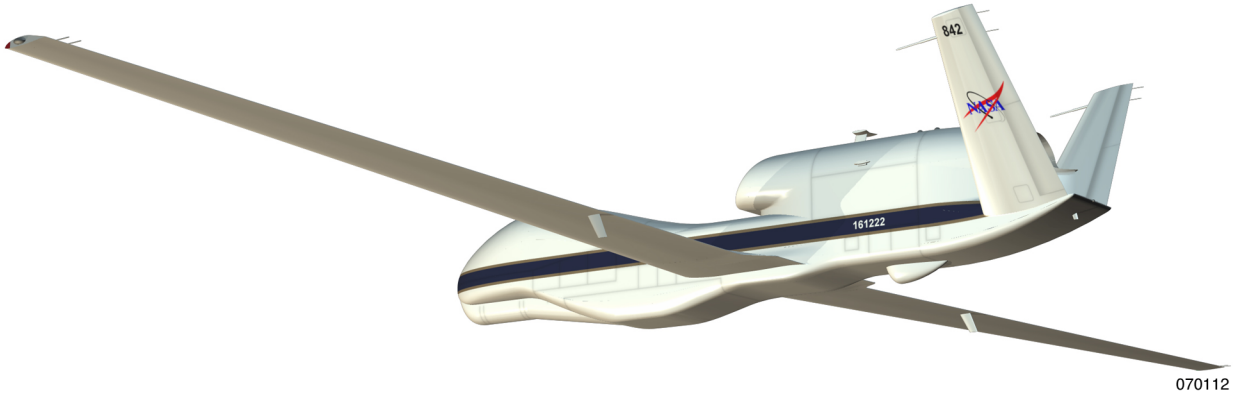


Figure 4. Artist's rendering of the NASA Global Hawk.

These systems will be available to conduct missions in support of the international science community and for sensor development and characterization, including collision avoidance work.

In addition to the HALE UAS described here, the DFRC can readily access the entire suite of aircraft and services it possesses to ensure each operation achieves its objectives as efficiently as possible. Examples of the other aircraft and services include: small UAS, piloted airplanes (both general aviation and high-performance fighter jets), the ER-2 (Lockheed Martin Corporation, Bethesda, Maryland) airplane, ground facilities that include a small UAS fabrication shop with the ability to fabricate one of a kind airframes, environmental test chambers, and simulators.

## Small Unmanned Aircraft System Test Range

In cooperation with the United States Air Force at Edwards Air Force Base, NASA is creating a test area for small UAS that can be used by industry to enable developmental testing, acceptance testing, or capability demonstration for potential customers. The test area is being established in response to the need by industry to legally conduct research and development activities in the interim while the Federal Aviation Administration develops policy and regulation to allow such activities to occur in civil airspace, and to respond to the increasing use by NASA and the U.S. Department of Defense of small UAS to conduct basic aeronautics research.

Located approximately 700 m (2300 ft) above sea level in the Mojave Desert, the test range at Edwards provides many opportunities for small UAS testing. The dry lakebeds, clear skies, and low humidity provide ideal test conditions for many types of UAS testing. Projects at NASA have used several locations on the base over the years for UAS testing of all kinds. What distinguishes the test area from prior UAS operations is the fact that a block of airspace will be designated for small UAS operations, thus allowing it to be scheduled on a routine basis. In the past, operations were conducted in airspace available to all users on the range and, as such, UAS testing could be relegated as a lower priority.

The test area will be based at an improved landing strip in a remote area of the base. From this strip, line of sight flight operations can be conducted. If operations require, a nearby section of airspace 9.26 km (5 nautical miles) in diameter up to 914 m (3,000 ft) above the ground can be utilized. The remote location is ideal for testing proprietary configurations. The area is accessed via an improved dirt road.

In addition to a specific area being designated, a streamlined approval process and standard agreements are being developed in an effort to reduce the time required to obtain test approval and reduce the cost to the user and to the government for providing the service.

The ability to obtain a streamlined approval will be contingent on the operation being able to comply with a set of predefined operational requirements. Operations are being categorized into classes based on vehicle capabilities and operational approaches. For example, UAS that operate strictly within the line of site of the operator, have no autonomous capability, and limited altitude and duration capability will have a less stringent set of operational requirements than UAS that can operate at higher altitudes for long periods of time, beyond the line of site of the operator.

The final element necessary for an efficient operation is an agreement between the user and NASA. Efforts are currently underway to develop a standard agreement that would require less internal NASA review to be approved. Provided the user can comply with the terms and conditions of the standard agreement, the time required to enter into an agreement will be significantly reduced. Typically, negotiating unique agreements for each user has been the pacing item in getting approval to operate.

While the designated test area, standard pre-approved operating requirements, and standard agreement are being developed to accommodate the majority of test scenarios, it is recognized that not every operation will conform to the standards. In those situations, case-specific issues can be negotiated.

The combination of a designated test area, standard, pre-approved operating requirements, and a standard agreement will all significantly reduce the time, labor, and thus cost of the testing approval process.

## Safety Analysis

The third area of focus is the existing expertise available to assist government and industry in obtaining mission approval or certification. The rapid proliferation of UAS, and in particular small UAS, has allowed nontraditional aerospace users and developers to acquire or produce UAS. A lack of experience with flight and mission planning, flight safety approval processes, and system safety has hindered the effective utilization of some systems.

The DFRC has developed the Joint Advanced Range Safety System (JARSS) software specific to UAS operations. It will assist the UAS community in assessing the risk to the public of conducting flights outside traditional range airspace boundaries. The software assists in developing flight routes that minimize the risk to the public in the event of an accident. The JARSS software uses demographic data as well as vehicle reliability data to compute a causality expectation. This can be a powerful tool in making the safety case in applications for a Certificate of Authorization.

Over the years, the DFRC has established a robust system safety analysis capability associated with aircraft and aircraft systems. This expertise can assist the UAS community by providing overall or specific subsystem safety analysis and assessment. The approach used on Dryden research projects is especially well suited to collecting the information necessary to submit an application for experimental certification of a new UAS or to assist other government agencies in obtaining a Certificate of Authorization from the FAA for operations of a UAS in U.S. civil airspace.

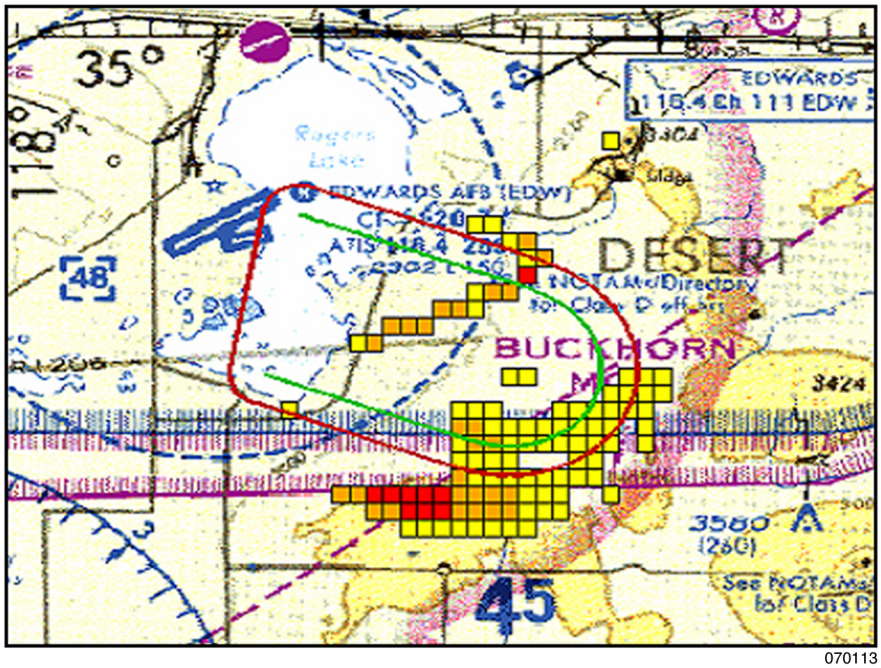


Figure 5. Example output of the JARSS program.

Specific skills, like fault tree analysis, can be applied to systems or operational concepts to assist the developer in identifying potential vulnerabilities in their design, allowing them to design out potential deficiencies, thus improving reliability and the chances of obtaining greater operational access to civil airspace. Likewise, the experts at the DFRC can be helpful to potential operators of UAS by helping them establish the necessary processes and procedures to ensure safe, reliable operations of the systems they are acquiring.

## RESULTS

At present, there are two major missions planned for the Ikhana system in 2007. One is a fire detection and mapping mission with the U.S. Forest Service. This mission will continue to develop techniques for the utilization of UAS as platforms for the early detection of forest fires and as sensor platforms to provide fire fighters with data critical to responders. The other major mission activity is sponsored by the NASA Aeronautics Mission Directorate and will investigate the use of fiber optic sensors to determine wing shape of large flexible wings in flight. Data collection for this effort is expected to span several years. In 2008, the Ikhana is to participate in a satellite validation activity for the NASA Science Mission Directorate.

Several small UAS operations have been conducted and several more are in the planning stages. Efforts are underway to add additional staff to keep up with the demand for this service.

## CONCLUSION

To focus its UAS expertise, the NASA Dryden Flight Research Center has taken a three-pronged approach to assisting the global UAS community in advancing the development and practical utilization of UAS. Through access to the HALE UAS, establishment of a small UAS test range, and safety case analysis, DFRC is leveraging years of experimental flight expertise to provide value to the UAS community while continuing the tradition of advancing aeronautics technology.

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