NASA Global Hawk Overview

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24 March 2011
Edwards Air Force Base and NASA Dryden Flight Research Center

Dryden Flight Research Center

NASA Dryden Aircraft Fleet

Edwards Air Force Base
NASA Global Hawk System

- Two USAF Pre-Production Global Hawk aircraft were transferred to NASA in September 2007. (A third aircraft arrived in January 2010)

- A combined NASA/Northrop Grumman team is maintaining, modifying, and operating the UAS through a 5-year partnership. (2008-2013)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endurance</td>
<td>&gt; 30 hours</td>
</tr>
<tr>
<td>Range</td>
<td>&gt;10,000 nmi</td>
</tr>
<tr>
<td>Service Ceiling</td>
<td>65,000 ft</td>
</tr>
<tr>
<td>Airspeed (55K+ ft)</td>
<td>335 KTAS</td>
</tr>
<tr>
<td>Payload</td>
<td>1,000-1,500 lb</td>
</tr>
<tr>
<td>Take-off Weight</td>
<td>26,750 lb</td>
</tr>
<tr>
<td>Length</td>
<td>44 ft</td>
</tr>
<tr>
<td>Wingspan</td>
<td>116 ft</td>
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</tbody>
</table>

Altitude
- 65,000 ft
- 30,000 ft
- 50,000 ft

Cruise Climb
- ~20 hours
- ~320 knots
- ~7,000 NM

Maximum Altitude
- ~9 hours
- ~340 knots
- ~3,000 NM

Initial Climb Within Restricted Airspace ~30 min

Descent Within Restricted Airspace ~30 min

The numbers shown on this figure represent a nominal mission profile with a 1,200 lb payload. This profile may vary depending on individual payload and aircraft configurations.
Global Hawk Operations Center (GHOC)
Flight Control and Air Traffic Control Communications Architecture
Payload Communications Architecture

Payloads:
- Iridium
- Ku SatCom

Linking:
1. **Wideband Data**
   - S-Band (LOS)
   - Ku-Band (BLOS)
2. **C², Data, and Status**
   - & Master Control (6 links)
3. **DFRC**, **GHOC**
4. **LOS**, **BLOS**

Locations:
- **EAFB**
- **ATF2 Site**
- **DFRC**
- **GHOC**
Payload Integration Process

• Site visit at customer’s location; initial discussion of payload details and operational concept.
• Receipt of payload solid model(s) and design/integration data from customer.
• Integration engineering (at DFRC and/or NGC).
• Avionics harness manufacture at DFRC.
• Fabrication and fit-check of payload mounting structure.
• Initial mechanical integration on aircraft.
• IT assigned configuration of instrument.
• Electrical integration on payload test bench.
• Final integration on aircraft.
• GHOC payload instrumentation setup.
Payload Integration and Accommodations

- Experiment Interface Panel & Ethernet Switch
- Payload Integration Software T&E
- Wing Pods (future capability)
- Mounting Rails
- Bay Under the Nose
- Pallets and Hatches
- Mounting Hard Points
## NASA Global Hawk Missions During First Year of Flight Operations

<table>
<thead>
<tr>
<th>Date</th>
<th>TN871 (AV-1) Flight Number</th>
<th>Duration, hr</th>
<th>TN872 (AV-6) Flight Number</th>
<th>Duration, hr</th>
<th>Flight Objective</th>
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<tbody>
<tr>
<td>10/23/09</td>
<td>0044</td>
<td>4.0</td>
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<td></td>
<td>Return to flight for AV-6, Functional Check flight</td>
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<tr>
<td>10/29/09</td>
<td>0045</td>
<td>2.8</td>
<td></td>
<td></td>
<td>Completion of Functional Check Flight objectives</td>
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<tr>
<td>11/4/09</td>
<td>0046</td>
<td>1.4</td>
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<td>Pilot Proficiency</td>
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<tr>
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<td></td>
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<tr>
<td>3/3/10</td>
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<td>Checkout flight for Payload Support System</td>
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<td>3/5/10</td>
<td>0050</td>
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<td></td>
<td>Checkout flight for Payload Support System</td>
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<tr>
<td>3/11/10</td>
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<td>10.3</td>
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<td></td>
<td>Checkout flight for Payload Support System</td>
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<tr>
<td>4/2/10</td>
<td>0052</td>
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<td>GloPac Instrument check-out flight in the range</td>
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<td>GloPac Science Flight #1</td>
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</table>

**Totals:** 29 Flights 253 hours

**First Year of Operations**

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<th>Date</th>
<th>Flight Number</th>
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<td>1.7</td>
</tr>
<tr>
<td>10/21/10</td>
<td>0076</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Totals:** 9 flights 15.2 hours
Flights Outside the EAFB Airspace During the First Year

Flight Summary
- 9 Flights
- 190.5 Total Hours
- ~64,000 nmi

Certificates of Authorization
- Pacific-Alaska-Arctic
- Western Atlantic-Caribbean-Gulf of Mexico
First Global Hawk Science Mission (March-April 2010)
GloPac Objectives

- First demonstration of the Global Hawk unmanned aircraft system (UAS) for NASA and NOAA Earth science research and applications.
  - Development of science-operation protocols & procedures.
  - Long duration Pacific Ocean and Arctic flights.

- Exploration of trace gases, aerosols, and dynamics of remote upper troposphere and lower stratosphere regions.
  - Aura satellite instrument validation.
  - Sample Arctic vortex fragments, and aerosol plumes.

- Risk reduction for future Global Hawk missions.
  - Hurricane and severe storm missions.
  - Earth Venture (EV-1) proposed missions.
# GloPac Instrument Overview

## Table

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACAM</td>
<td>Airborne Compact Atmospheric Mapper (GSFC)</td>
<td>Cross-track scanning spectrographs of NO2, O3, &amp; aerosols.</td>
</tr>
<tr>
<td>CPL</td>
<td>Cloud Physics LiDAR (GSFC)</td>
<td>Backscatter LiDAR for hi-res profiling of clouds &amp; aerosols.</td>
</tr>
<tr>
<td>FCAS</td>
<td>Focused Cavity Aerosol Spectrometer (U. of Denver)</td>
<td>Aerosol size and concentration measurements.</td>
</tr>
<tr>
<td>MMS</td>
<td>Meteorological Measurement System (ARC)</td>
<td>Science quality aircraft state variable measurements.</td>
</tr>
<tr>
<td>MTP</td>
<td>Microwave Temperature Profiler (JPL)</td>
<td>Passive microwave radiometer meas. of O2 thermal emissions.</td>
</tr>
<tr>
<td>HDVis</td>
<td>HiDef Video System (ARC)</td>
<td>Time-lapse nadir color digital imagery with georeferencing.</td>
</tr>
<tr>
<td>Ozone</td>
<td>UAS Ozone (NOAA)</td>
<td>Dual-beam UV photometer for accurate O3 measurements.</td>
</tr>
<tr>
<td>UCATS</td>
<td>UAS Chromatograph for Atmospheric Trace Species (NOAA)</td>
<td>Dual gas chromatographs for N2O, SF6, H2, CO, &amp; CH4 meas.</td>
</tr>
<tr>
<td>ULH</td>
<td>UAS Laser Hygrometer (JPL)</td>
<td>In-situ hi-accuracy atmospheric water vapor measurements.</td>
</tr>
</tbody>
</table>
Global Hawk Pacific 2010 (GloPac)

First Science Flight
(April 7, 14.1 hrs)
- Arctic Vortex Fragment Measurements
- Satellite Validation

First Arctic Flight
(April 23-24, 28.6 hrs)
- Envelop Expansion
- Arctic Research
- Dust Plume Rendezvous

First Tropics Flight
(April 13-14, 24.3 hrs)
- Satellite Validation
- NCAR Aircraft Over-flight
- Tropics Measurements
GloPac 2010 Science Highlights

Intercept an Arctic vortex fragment that broke off on about March 28

Sample Asian dust from the Gobi Desert

Rendezvous with the NSF GV aircraft and underfly the Aura satellite.
Second Global Hawk Science Mission
(August-September 2010)
GRIP Goals

• Demonstration of Global Hawk Capabilities for Severe Storm Research

• Multi-agency, Multi-aircraft Research Campaign

• Improve Intensification Forecast Models

• Integration of New Global Hawk Payloads and New Aircraft Systems
GRIP Instrumentation

HIWRAP - High Altitude Imaging Wind and Rain Profiler
DropSonde - NOAA DropSonde System
HAMSR - High Altitude MMIC Sounding Radiometer
LIP - Lightning Instrument Package

2 Cameras - HDVis and Low Light for Pilot Situational Awareness
Storm Scope - Lightning Detection Display in the GHOC
Accelerometers - Real-time Turbulence Time-history Display in the GHOC
GRIP Challenges

• Flight Environment
  – No Global Hawk flight data over tropical storms
  – Limited flight envelope & FOM restrictions
    • No flight in moderate or severe turbulence
    • No flight within 25nm of lightening

• Aircraft
  – Limited hazardous weather detection systems
    • Integrated storm scope, 2 cameras, & vibration sensor
  – Additional aerodynamic drag of larger radome
  – Staffing surge for multiple long duration flights
    • Multi-shift operations
    • Edwards closed field operations
Genesis and Rapid Intensification Processes (GRIP) 2010 Global Hawk Flights

- **Tropical Depression Frank** (Aug 28, 15.3 hrs)
  - First GRIP Mission
  - First Storm Over-Flight

- **Hurricane Earl** (Sept 1-2, 24.2 hrs)
  - First Hurricane Mission
  - First Atlantic Flight

- **Tropical Disturbance AL 92** (Sept 12-13, 24.3 hrs)
  - First Caribbean Flight
  - First Genesis Flight

- **Hurricane Karl** (Sept 16-17, 25.2 hrs)
  - Intensification (Cat 1-3)
  - 20 Eye Overpasses
  - 15.5 hrs Over the Storm

- **Tropical Storm Matthew** (Sept 23-24, 25.1 hrs)
  - International Cooperation
Hurricane Earl, Sept 2010
First Global Hawk Pass over the Eye of a Hurricane
Hurricane Earl, Sept 2010
Global Hawk Over the Eye and DC-8 Passing Through Eye
Hurricane Karl

- Cat 1 to 3 in 18 hrs
- 5 Research Aircraft
- Global Hawk
  15.5hrs on Station
Winter Storms Pacific and Atmospheric Rivers (WISPAR), Feb-March 2011

Vibration Testing on Airborne Vertical Atmospheric Profiling System (AVAPS)

Sonde Description

Test Flight in EAFB Range

First AVAPS Operational Flight
Upcoming Projects
Capability Developments for Deployments

All Three Systems will be on-line by September 2011

Aircraft Command and Control Facility

A Payload Operations Facility, with extendable sides and accommodations for 14 Scientists, is in development
Future Missions

ATTREX (2012-2014)
Airborne Tropical TRopopause Experiment
(Base of Operations either Hawaii, Guam, or Australia)

HS3 (2012-2014)
Hurricane and Severe Storm Sentinel
(Base of Operations on the East Coast)

UAVSAR
Reconfigurable polarimetric L-band SAR designed for repeat pass deformation measurements.
Global Hawk Project Team

Project Summary

• NASA Global Hawk is operational and supporting Earth science research.

• 29 Flights were conducted during the first year of operations, with a total of 253 flight hours.

• Three major science campaigns have been conducted with all objectives met.

• Two new science campaigns are in the planning stage.
Operations Summary

• Airspace Challenges
  – ATC system is challenged by HALE UAS
    • Limitation of number of UAS in one ARTCC
      – Increase tempo and number of UAS
      – Deconfliction between organizations
    • Most ATC personnel have little UAS technical understanding
    • Flight plans
  – COA process
    • Regional UAPO extremely helpful
    • Not knowing what the COA will stipulate until issued
    • Emergency landing/divert in non-positive controlled airspace
    • Renewal / extension processing
  – ICAO Airspace
    • International operations and state aircraft
    • RVSM and RPN certification issues
Operations Summary (continued)

- Technical Challenges
  - Need for predictability with autonomous systems
    - C-1 Altitude cannot be pre-selected with Global Hawk
    - New squawk code for UAS lost link, 7400
    - Machine / Human Interface
      - GCS designed by engineers sometimes with little pilot input
      - Pilots must become experts on non-intuitive logic of UAS
  - New system requirements
    - ADSB
    - TCAS
  - System reliability and pilot proficiency to level of manned aircraft
    - Communications
    - Training
    - Experience