Operations of Suborbital Research Platforms to Obtain Remote Sensing Data

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3 November 2014
NASA Armstrong Mission

Advancing technology and science through flight

1. Perform flight research and technology integration to revolutionize aviation and pioneer aerospace technology

2. Validate space exploration concepts

3. Conduct airborne remote sensing and science observations
Center Locations

Edwards AFB, California
Palmdale, California
Dryden Aircraft Operations Facility (DAOF) Palmdale

- U.S. Air Force Production Flight Test Installation (Plant 42)
- Palmdale Site 9 Complex
  - Ready access to USAF Plant 42 runway and facilities
  - 35 miles from NASA Dryden Flight Research Center
  - 422,000-square-foot floor space, including 210,000 square feet in central hangar area
Science Mission Directorate

NASA observes the Earth from Space

- Satellite calibration and validation
- New sensor and algorithm development
- Process studies
- Next generation NASA scientist and engineer development
Suborbital Research Platforms

- NASA Armstrong operates 6 “Core” science research platforms and 2 “As Required” platforms
  - Core: DC-8, ER-2 (2), C-20, Global Hawk (2)
  - As Required: B-200, Predator-B (Ikhana)
- We conduct deployed operations around the globe
- High demand for summer and fall deployments requires innovative solutions to meet requirements
DC-8
Long-range airborne science laboratory

- Ceiling: 42,000 feet
- Duration: 12 hours
- Range: > 5,400 nautical miles
- Payload: 30,000 pounds
- More than 100 instruments integrated into the DC-8

DC-8 Highlights

- Operation IceBridge, NASA’s airborne mission to study the Earth’s polar ice, is in its fourth year
- DC-8 supports atmospheric “greenhouse” gas studies around the globe and satellite instruments development and calibrations
Airborne Science Program
Operation IceBridge Antarctic

Filling the Ice Cap Knowledge Gap

DC-8 Science Platform
Collect data during IceBridge operation to bridge data gap in polar observations between NASA's Ice-, Cloud-, and Land-Elevation Satellite (ICESat), inactivated in 2009, and ICESat-2’s planned launch in 2016

What’s Happening:
- Since 2009, the NASA DC-8 operating out of Punta Arenas, Chile, has supported Antarctic ice studies annually except for 2013 when the NASA P3 made an exploratory trip to McMurdo Station
- NASA’s DC-8 is scheduled to return to Punta Arenas, Chile, in October 2014 to continue overflights of the Antarctic Continent’s ice sheets and offshore sea ice areas

DC-8 overflights sea ice as part of annual Antarctic ice studies.

Partners:
- NASA Glenn Flight Research Center
- NASA Ames Research Center
Airborne Science Program
Active Sensing of CO₂ Emissions Over Nights, Days, and Seasons (ASCENDS)

Using Aircraft to Develop Satellite Instruments

DC-8 Science Platform
Support NASA’s development of future space-based instruments measuring atmospheric CO₂ and O₂

What’s Happening:
- During the three previous years the DC-8 has supported the ASCENDS in the development of what are planned to be future Earth orbiting satellite based instruments
- DC-8 again supporting ASCENDS in August-September 2014

CO₂ and O₂ atmospheric remote measuring LIDARs collecting data during flights over varying backgrounds (deserts, forests, oceans, snow).

Partners:
- NASA Headquarters, Goddard Space Flight Center, Jet Propulsion Laboratory, and Langley Research Center
- NASA Earth Science Technology Office
Gulfstream C-20A

UAV synthetic aperture radar (UAVSAR)

- Ceiling: 45,000 feet
- Duration: 6+ hours
- Range: > 3,400 nautical miles
- Payload: 2,610 pounds

C-20A (G-III) Highlight

Equipped with Jet Propulsion Laboratory’s UAV synthetic aperture radar, platform is used to gather scientific data on earthquake fault zones, volcano glaciers, wetlands, and surface deformation regions for geological studies.
Airborne Science Program
Subsidence and Oil Spills – New Orleans

**Imaging Louisiana’s Gulf Coast**

**Gulfstream C-20A Science Platform**

Study causes of subsidence of Gulf Coast and predict future subsidence rates to determine how to manage protection of infrastructure

**What’s Happening:**

Imaged the Golf Coast in late March 2014; expect to return to the Gulf Coast in late August 2014

**Partners:**

- Jet Propulsion Laboratory
- U.S. Department of Homeland Security
Imaging Sacramento Delta Levees, San Andreas Faults, and Slumgullion Landslides

Gulfstream C-20A Science Platform

Monitor Sacramento Delta (under continuous threat of levee failure)

Study surface deformation of San Andreas Faults to understand fault slip variations

Understand mechanisms controlling landslide motion

What’s Happening:

- Imaged northern and southern California, plus the Colorado Slumgullion region in March 2014
- Acquired more data during Summer 2014

Partner:

- Jet Propulsion Laboratory

+ Link: NASA Model Provides a 3-D Look at L.A.-Area Quake
Single polarization quick look imagery of volcanoes between Nagano and Takayama
Will repeat observation in a year to detect any surface deformation due to volcanic activities
ER-2
High-altitude science platform

- Ceiling: > 70,000 feet
- Duration: > 10 hours
- Range: > 6,000 nautical miles
- Payload: 2,600 pounds

ER-2 Highlights

- Hyper- and multi-spectral imaging aided in assessing the environmental impact of the 2010 Gulf Oil Spill

- In 2012, deployed to Iceland and NASA's Wallops Flight Facility for research using a new laser altimeter, the Multiple Altimeter Beam Experiment LIDAR (MABEL), which was developed at NASA's Goddard Space Flight Center
**Airborne Science Program**

**Satellite Simulators**

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**Developing NASA’s Next Generation Earth-Observing Satellites**

**ER-2 Science Platform**

High-altitude flights conducted to calibrate, validate, and develop algorithms for Earth science satellites

**What’s Happening:**

- Completed 21-flight, 113-hour Integrated Precipitation and Hydrology Experiment (IPHEX) campaign May-June 2014 in Warner-Robins, Georgia
- Completed 12-flight, 76-hour Multiple Altimeter Beam Experimental LIDAR (MABEL) campaign July-August 2014 in Fairbanks, Alaska
- Supporting Hyperspectral Infrared Imaging (HyspIRI) flights August-October 2014

**Partners:**

- Jet Propulsion Laboratory
- NASA Goddard Space Flight Center and other NASA Centers
- Multiple universities

**+ Link: Collecting Data on Earth’s Ecosystems**

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Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) image mosaic of HyspIRI targets in California
Global Hawk

Long range, high altitude, high endurance UAV

- Endurance: > 30 hours
- Range: > 10,000 miles
- Service ceiling: 65,000 feet
- Payload: 1,000-1,500 pounds

Global Hawk Highlight

Global Hawk flew five science missions over Tropical Storm/Hurricane Nadine, plus the transit flight circling around the east side of Hurricane Leslie, in September 2012.
Airborne Science Program
Airborne Tropical Tropopause Research Experiment (ATTREX) Climate Study

Predicting Changes in Stratospheric Humidity

Global Hawk Science Platform
Study physical processes in Tropical Tropopause layer of atmosphere to better understand Stratosphere
Platform equipped with science instruments that collect air samples scientists use to study chemical composition of Tropical Tropopause

What’s Happening:
- ATTREX missions were conducted at Guam from January to March 2014
  - 12 science instruments were integrated on tail number (TN) 872, including the wing-mounted Hawkeye
  - Seven ATTREX science data gathering flights were completed for a total of 121 hours
  - Flights in Japanese and Australian airspace

Partners:
- Northrop Grumman Aerospace Systems
- National Oceanic and Atmospheric Administration (NOAA)

+ Link: NASA Brings Science to Life in Guam
Airborne Science Program
Hurricane and Severe Storm Sentinel (HS3)

**Predicting How Tropical Storms and Hurricanes Are Formed**

**Global Hawk Science Platform**

Equipped with science instruments, unmanned Global Hawk monitors environment around storms, looking for conditions favorable for storm formation and intensification.

Second Global Hawk flies directly over storms to collect data on inner-core structures that lead to storm intensity change.

**What’s Happening:**

Two Global Hawks deployed August-September 2014 to Wallops Flight Facility for missions during the Atlantic Basin hurricane season.

**Partners:**

- Northrop Grumman Aerospace Systems
- NOAA
Global Hawk flies over and around hurricanes Nadine and Leslie.
September 2012
Airborne Science Program
Laser Vegetation Imaging Sensor (LVIS) Arctic Flight

Studying Earth’s Topography, Hydrology, and Vegetation

Global Hawk Science Platform

Combined with aircraft position and attitude information, the LVIS collects data to produce topographic maps of vertical height and structural measurements of various vegetation.

What’s Happening:
- LVIS was integrated on TN 871 and flown for the first time in June 2013
  - A 7-hour mission was flown within the Edwards AFB range to check out operation of the instrument
  - Instrument operated nominally and data was collected during the mission

Partner:
- Northrop Grumman Aerospace System
King Air (B-200)

Research, mission support aircraft

- Service ceiling: 32,800 feet
- Payload: Up to 11 passengers; 400 pounds baggage

King Air (B-200) Highlights

- Hi-rate Wireless Airborne Networking Demonstration tested wireless modem and data transmission capability over the Internet from the aircraft
- The X-38 Space-integrated GPS inertial navigation system experiment led to the guidance, navigation, and control system used on the International Space Station
Airborne Science Program

Airborne Surface Water and Ocean Topography (AirSWOT)

King Air (B200) Mission Support Aircraft and Science Platform

Gathering data off California coast, Ka-band radar interferometer helps science team determine kinetic energy of ocean circulation and how ocean uptake of heat and carbon is being transferred into the atmosphere.

What’s Happening:

- Full AirSWOT payload of Ka-band SWOT Phenomenology Airborne Radar (KaSPAR) and Digital Camera System (DCS) is integrated and system performance is being evaluated with ground and airborne activities.
- Ocean topography and hydrology missions planned September 2014 to January 2015.

Partner:

- Jet Propulsion Laboratory
Ikhana

Predator B UAS adapted for science missions

- Ceiling: > 40,000 feet (high 30,000s for sustained operations with payloads)
- Duration: > 24 hours
- Payload: Potential for 2,000+ pounds
- Deployable worldwide

Ikhana is NASA’s primary UAS in the medium-altitude and long-endurance class.
Ikhana

MQ-9 Predator B UAS Adapted for Science and Research Missions

World-Class UAS Capability

NASA’s primary UAS in the medium-altitude, long-endurance class; deployable world-wide

USAF Block 1 configuration: sustainable and compatible with majority of fleet and associated ground support systems

Aircraft reconfigurable to U.S. Air Force or Customs and Border Protection (CBP) configurations

Reconfigurable science pod available (> 500 pounds of payload)

What’s Happening:

Project team is preparing Ikhana to conduct Airborne Collision Avoidance System (ACAS)-Xu flights in support of the NASA UAS Integration in the NAS project

Ceiling: > 40,000 feet (high 30,000s for sustained operations with payloads)

Duration: > 24 hours

Payload: Potential for 2,000+ pounds

Range: > 3,000 miles

Partners:

- General Atomics-Aeronautical Systems, Inc.
- Raytheon
- U.S. Air Force
Ikhana
NOAA Science and U.S. Navy Rim of the Pacific Exercise (RIMPAC) 14

**Demonstrating UAS and Sensor Technology for Science, Navy Ops**

**NOAA/RIMPAC Missions:**

Conduct disaster relief exercise

Support fisheries protection against affects of illegal foreign fishing activities

Track marine mammals; enable future science missions

Provide intelligence,

**What's Happening:**
First Ikhana deployment late June to mid August 2014 to Hawaiian Islands

**Partners:**
- General Atomics-Aeronautical Systems, Inc.
- Raytheon
Operational Challenges

- Conducting simultaneous deployments presents scheduling challenges
  - Define missions up to 2 years in advance
  - Lock in dates at the beginning of the Fiscal Year
- Simultaneous missions strains the resources
  - Try to limit the length of time people are on deployment
  - Require a break in between deployments
  - For long deployments we plan on swapping crews
- Good logistical planning is essential for success
  - Taking care of people
  - Taking care of assets
- Detailed planning and coordination among deployed crew is essential to insure success
Summary

- NASA Armstrong operates a number of suborbital platforms to support NASA’s science mission.
- Each platform fills a unique niche to gather critical science data.
- There are a number of operational challenges in deploying aircraft around the world.
- NASA Armstrong has a dedicated group of people who enable the success of the NASA science mission.