# Airborne Measurements Programs

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# Summary

- Why airborne measurements
- Available platforms in Europe and USA
- Ongoing and future activity
- Outlook

# Observation Systems

- **Satellite: global coverage**
- **Ground remote sensing: fixed location**
- **Instrumented aircraft: mobile, in situ**

**Airborne platforms vastly extend the range of scientific exploration that can fill critical gaps in data about our atmosphere and earth system**

# Instrumented aircraft: Constraints

- ATC and Air Worthyness limitations
- Fly almost horizontally (± 15 m/s max ascent/descent rate)
- Airflow disturbance
- Limited payload, space, endurance
- Speed: 100 m/s (turboprop)
  200 m/s (jet)

# A survey of european research aircraft: EUFAR - Toward an integrated European fleet

**EUFAR is an Integrating Activity of the 7th EU Framework Program for Research Infrastructures**

**Objectives:** **To provide scientists with access at equal terms to the most complete range of research infrastructures**

**To develop trans-national access to national infrastructures**

**To reduce redundancy and fill the gaps**

**To promote the use of research infrastructures, especially for young scientists from countries where such infrastructures are lacking**

**25 aircraft or instruments, 205 users, 520 flight hours**
**Networking (2 M€) , TA (3 M€), JRA (2,3 M €), MGT (0,7 M€)**
**TOTAL : 8 M€**

# Aims of Transnational Access in EUFAR

- To provide access to research aircraft or instrumentation that is not available via the user's own national research funding.
- Available to both expert and non-expert users
- Principal eligibility criteria:
- The proposer and the majority of the user group should be employed at institution in an EU Member State or Associated State
- The infrastructure (aircraft or instrumentation) to which they propose access should be from a different EU Member State

| OPERATORS | CATEGORIES | | | | |
|---|---|---|---|---|---|
| | 1. Strato. jet | 2. Jets | 3. Large A/C | 4. Medium A/C | 5. Small A/C |
| Geophysica EEIG | Geophysica | | | | |
| DLR | | HALO | | Cessna 208B | |
| NLR | | Citation | | | |
| ENVISCOPE | | Learjet | | | Partenavia |
| SAFIRE | | F-20 | ATR-42 | | Piper-Aztec |
| MetOffice | | | BAe-146 | | |
| NERC | | | | Do-228 | |
| INTA | | | | 2 CASA-212 | |
| TAU | | | | King-Air 200 | |
| GTK | | | | Twin-Otter<br>Caravan | |
| TU-BS | | | | Do-128 | |
| FUB | | | | | Cessna 207<br>TMG-ASK-16 |
| UNIMAN | | | | | C-182 |
| CNR-IBIMET | | | | | ky-Arrow |
| IFU | | | | | Microlight |
| **TOTAL AIRCRAFT : 24** | **1** | **4** | **2** | **8** | **9** |

| k€ /flight hour: | 16 | 9 - 28 | 9 - 11 | 3 to 6 | 0.8 to 3 |
|---|---|---|---|---|---|




















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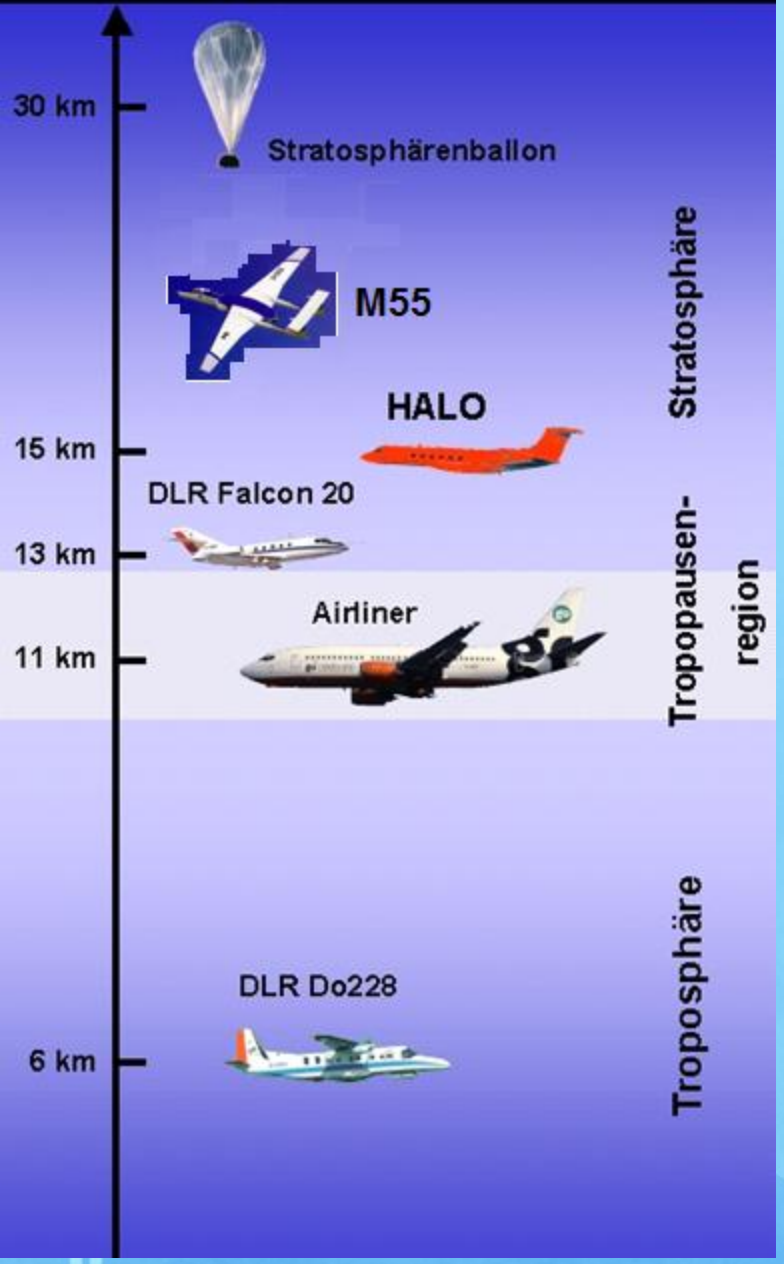
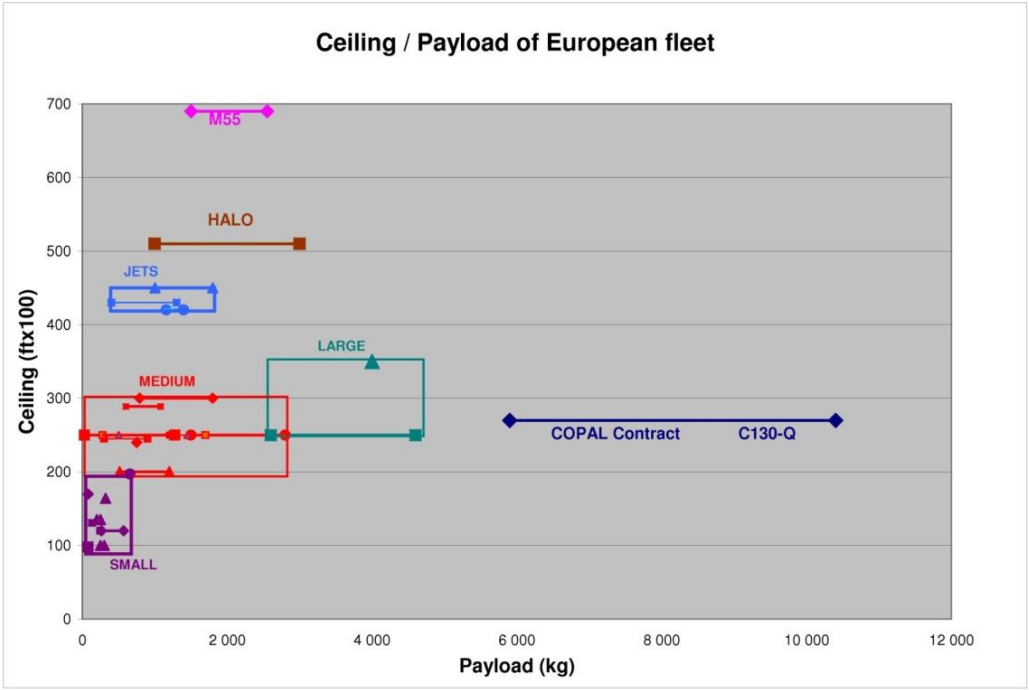
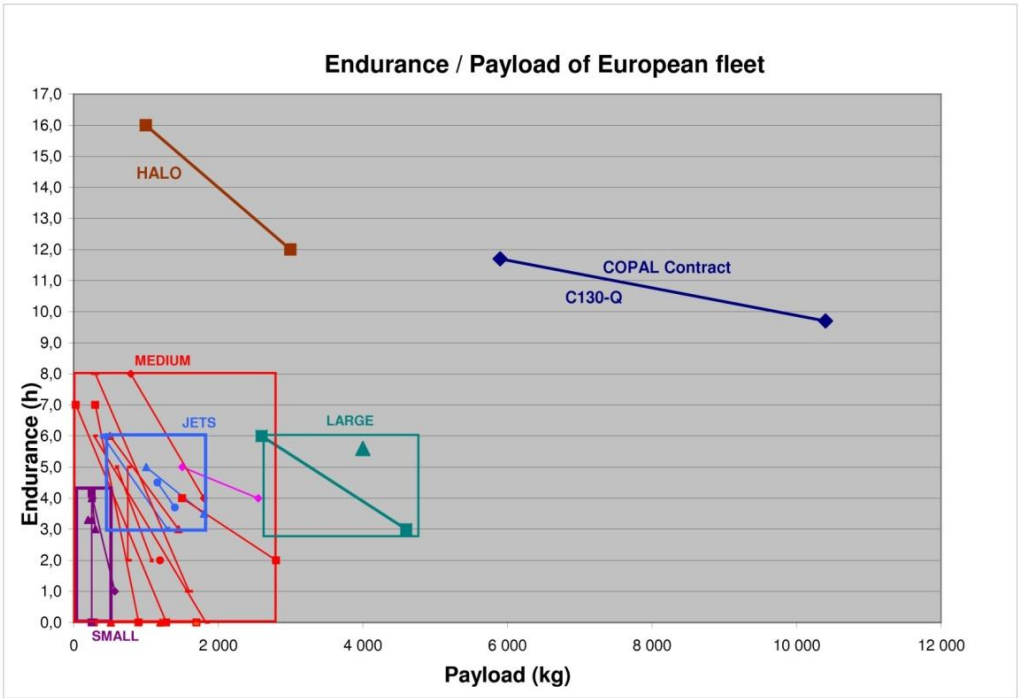

30 km
Stratosphärenballon
M55
HALO
15 km
DLR Falcon 20
13 km
Airliner
11 km
6 km
DLR Do228
Stratosphäre
Tropopausen-
region
Troposphäre


Ceiling / Payload of European fleet
Ceiling (ftx100)
Payload (kg)
M55
HALO
JETS
LARGE
MEDIUM
SMALL
COPAL Contract
C130-Q
0
100
200
300
400
500
600
700
0
2 000
4 000
6 000
8 000
10 000
12 000


Endurance / Payload of European fleet
Endurance (h)
Payload (kg)
HALO
COPAL Contract
C130-Q
MEDIUM
JETS
LARGE
SMALL
0,0
1,0
2,0
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11,0
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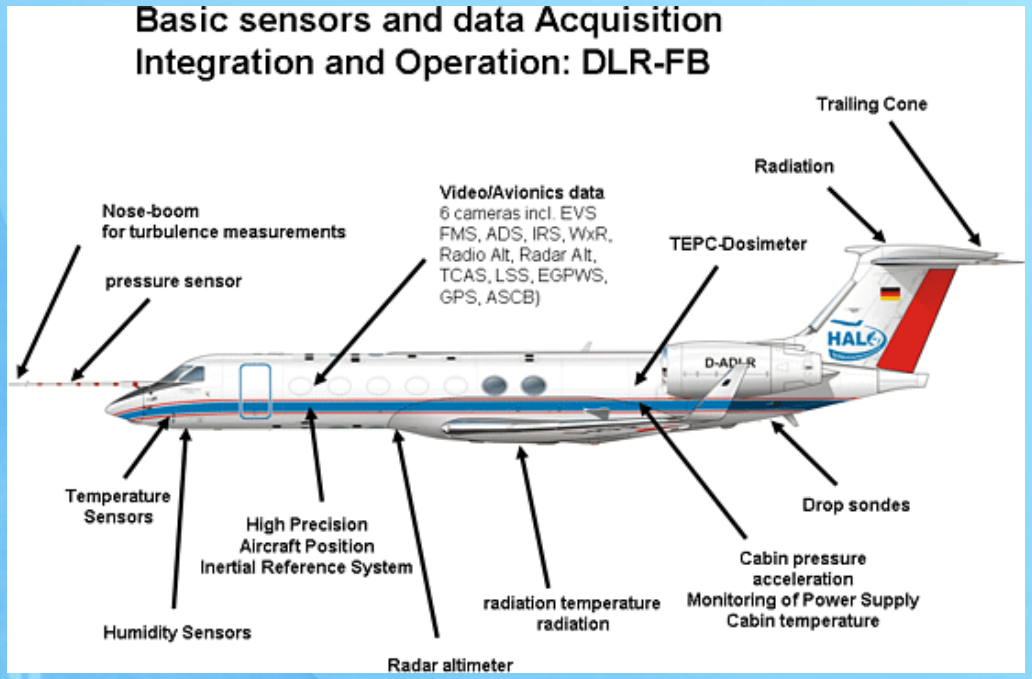
15,0
16,0
17,0
0
2 000
4 000
6 000
8 000
10 000
12 000

# Strato-jets : M55 Geophysica

**Ceiling: 65,000 ft**
**Range: 4000 km**
**Endurance: 5 hrs**
**Payload: 2250 kg**
**www.geophysica-eeig.eu**

**Currently an MoU has been signed between MDB and key users defining the frame of the cooperation, while contracts are negotiated for the individual missions.**

# High altitude jets: G-550 Halo




**50,000 ft**
**Range: 12000 km**
**Endurance : 10 hrs**
**Payload: 3000 kg**
**http://www.halo.dlr.de/**

DLR (Deutsches Zentrum für Luft- und Raumfahrt) and MPG (Max-Planck-Gesellschaft) are the main promoters of this major research facility ithat will be open to German as well as international users.

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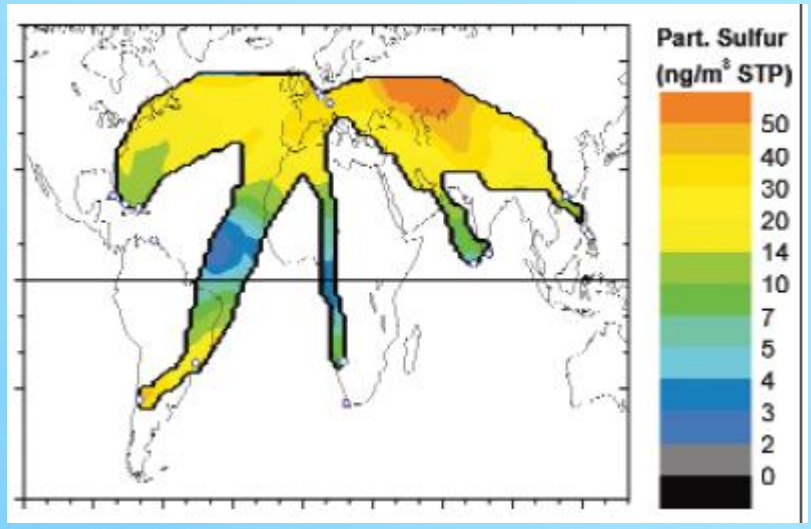
# High altitude jets: Falcon F-20


**42,000 ft**
**Range: 8000 km**
**Endurance : 5 hrs**
**Payload: 1200 kg**
**http://www.safire.fr/**

The SAFIRE Falcon 20 is available for research experiment for the French and international community since the beginning of 2006. It is an original Dassault Falcon 20 GF specially modified to scientific use. It is registred as F-GBTM.

# Commercial aircraft




IGAC newsletter 37

**IAGOS-ERI is one of the new European Research Infrastructures on the ESFRI Roadmap 2006, to establish and operate a distributed infrastructure for long term observations of atmospheric composition, from a fleet of 10-20 aircraft.**

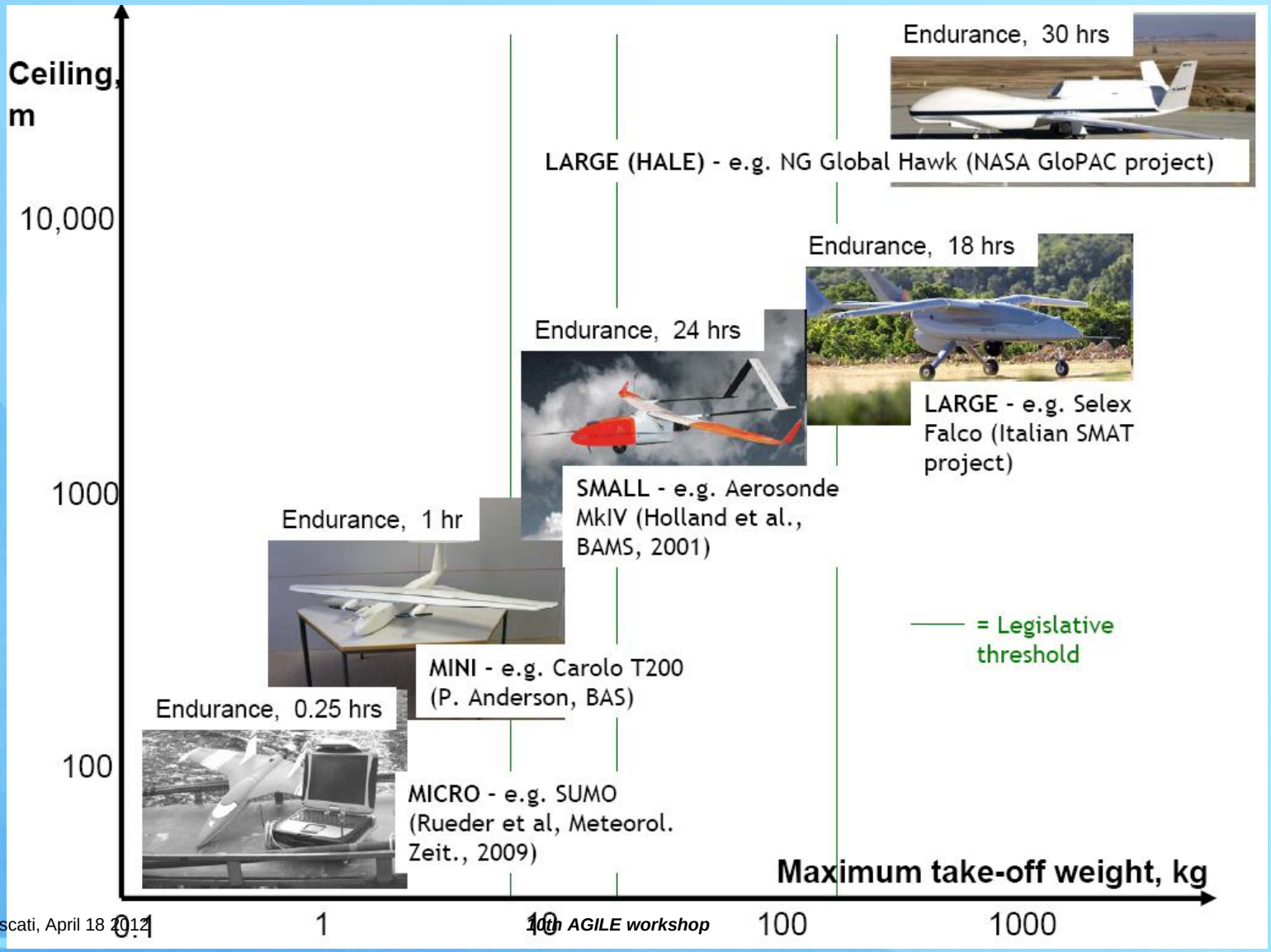
# USA platforms

**ER-2 NASA Dryden Flight Center:**
**70,000 ft**
**Range: 8000 km**
**Endurance : 10 hrs**
**Payload: 1300 kg**
**http://www.nasa.gov/centers/dryden/aircraft/ER-2/index.html**

**WB-57 NASA Johnson Space Flight Center:**
**60,000 ft**
**Range: 4000 km**
**Endurance : 8 hrs**
**Payload: 3000 kg**
**http://www.JSC-aircraft-ops.jsc.nasa.gov/wb57/index.html**

**PROTEUS Northrop Grumman Corp.:**
**55,000 ft**
**Range: 4000 km**
**Endurance : 8 hrs**
**Payload: 1000 kg**
**http://www.scaled.com/projects/proteusl**

# Toward the scientific use of UAS



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# Global Hawk – New Capability for High Altitude, Long Endurance Earth Science

***NASA has acquired two Global Hawk aircraft for Earth Science missions***

## *Configuration*

- **Wingspan: 116 ft**
- **Length: 44 ft**
- **Unmanned vehicle**
- **Highly reliable, fully autonomous control**

## *Performance*

- **Endurance > 30 hours**
- **Range > 20,000 km**
- **Altitude > 19 km**

**LEO satellites:**

**global coverage few minutes of observational time on target, twice per day**
**vertical (> 1-2 km) horizontal (10 km) resolution**

**GEO satellites:**

**coverage over a vast regions (1/6th of Earth) continuous coverage,**
**vertical (>5 km) horizontal (1 km) resolution**

**development ~5-10 years**

**Aircraft:**

**sub-synoptic coverage, few hours of observational time on target,**
**vertical (> 0.01km) horizontal (> 0.1 km) resolution**

**development ~5-10 months**

# Global Hawk

**synoptic coverage, several hours of observational time on target, vertical (> 0.01km) horizontal (> 0.1 km) resolution**

**development ~12-24- months**

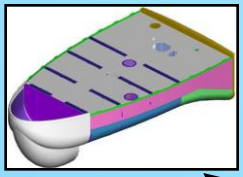
**GH has the great potential to fill gaps between space-borne and aircraft-borne observations and to provide a fast demonstration for future satellite sensors**

**Outstanding research fields in climate change studies have been considered :**

- **Upper Troposphere – Lower Stratosphere processes**
- **Earth Radiation Budget**
- **Greenhouse gases**
- **Air Quality**
- **Ecosystems and Climate**
- **Water Cycle**
- **Atmospheric Dynamics**

# Mission support features

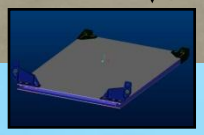
- Payload ~ 680 kg
- Experiment power
  - 2.0 KW DC
  - 8.8 KVA AC
- In-flight command and control of instruments

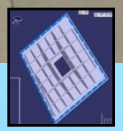


Bay Under the Nose

Mounting Rails


Wing Pods (future capability)





Pallets and Hatches



Mounting Hard Points

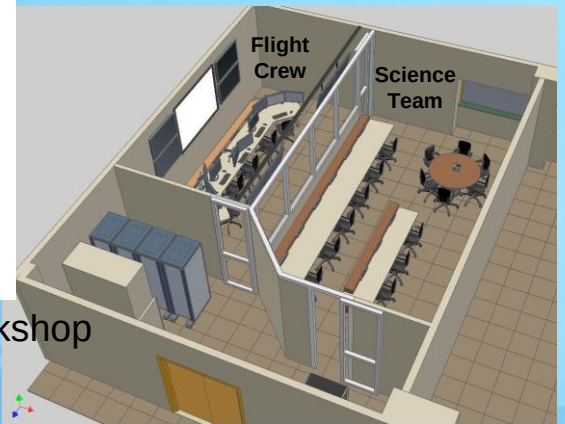
**Table 1.** Global Hawk *In Situ* Instrument Payload

| In situ Instruments | Technique | Payload location | Principal Investigator | Institution |
|---|---|---|---|---|
| **Water vapor ($H_2O$):** | | | | |
| JPL Laser Hygrometer (JLH) | Tunable diode laser absorption | Fuselage (Zone 11) | R. Herman | Jet Propulsion Laboratory |
| **Ozone ($O_3$):** | | | | |
| NOAA UAS Ozone | UV absorption | Fuselage (Zone 12) | R. Gao<br>D. Fahey | NOAA/ ESRL |
| **Long-lived gases:** | | | | |
| Unmanned aircraft systems Chromatograph for Atmospheric Trace Species (UCATS)<br>Channel 1: $N_2O$, $SF_6$,<br>Channel 2: CO, $H_2$, $CH_4$<br>or CFC-11, CFC-12, Halon-1211 | Gas chromatography | Fuselage (Zone 16) | J. Elkins | NOAA/ ESRL |
| **Aerosol particles (0.008 - 2 µm diameter):** | | | | |
| Condensation Nuclei Counter (CNC) | Supersaturation & growth | Lower fuselage (Zone 25) | J. Wilson | University of Denver |
| **Aerosol particles (0.09 - 1 µm diameter):** | | | | |
| Focused Cavity Aerosol Spectrometer (FCAS) | Laser scattering | Lower fuselage (Zone 25) | J. Wilson | University of Denver |
| **Aerosol particles (0.05 - 200 nm diameter):** | | | | |
| Ultra-High Sensitivity Aerosol Spectrometer (UHSAS) | Laser scattering | Lower fuselage (Zone 25) | G. Kok<br>B. Gandrud | Droplet Measure-ment Techno-logy, Inc. |
| **Aircraft state parameters (pressure, temperature, winds):** | | | | |
| Micrometeorological Measurement System (MMS) | Aircraft probes and inertial navigation system | Forward fuselage (Zone 1) | P. Bui | NASA Ames |

**Table 2.** Global Hawk Remote Instrument Payload

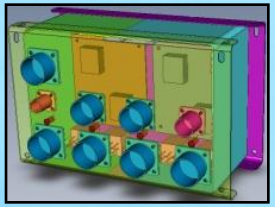
| Remote instruments | Technique | Payload location | Principal Investigator | Institution |
|---|---|---|---|---|
| **Boundary layer nitrogen dioxide ($NO_2$) retrieval:** | | | | |
| Airborne Compact Atmospheric Mapper (ACAM) | Scanning spectrographs & cloud cameras | Rear fuselage (Zone 61) | S. Janz | NASA/ GSFC |
| **Cloud and aerosol properties:** | | | | |
| Cloud Physics Lidar (CPL) | 3-wavelength backscatter lidar | Forward fuselage (Zone 3) | M. McGill | NASA/ GSFC |
| **Vertical temperature profiles:** | | | | |
| Microwave Temp Profiler (MTP) | Passive microwave sensor | Upper fuselage (Zone 22) | M. Mahoney | Jet Propulsion Laboratory |
| **Atmospheric radiation (infrared and solar emission):** | | | | |
| Autonomous Modular Sensor (AMS) System | Scanning multispectral sensor system | Lower fuselage (Zone 25) | J. Myers | NASA Ames |
| **Flight path and scene content documentation:** | | | | |
| MVIS Video Camera | Nadir-viewing color digital video camera | Lower fuselage (Zone 51) | J. Myers | NASA Ames |
| ***Under development*** | | | | |
| **Pressure, temperature, relative humidity, and wind vertical profiles to the surface:** | | | | |
| Dropsonde launch system | Release of disposable sondes with pressure, temperature, relative humidity sensors, GPS | Rear fuselage (Zone 61) | D. Fahey<br>T. Hock | NOAA/ ESRL<br>NCAR |

## Global Hawk Operations Center




## Standardized Instrument Interface

Data and Power Distribution



# The involvement of Italy

WHITE BOOK
FOR A JOINT U.S.A. - ITALY PROGRAM
FOR THE SCIENTIFIC USE OF THE GLOBAL HAWK
TO STUDY GLOBAL CHANGE

Contributors:

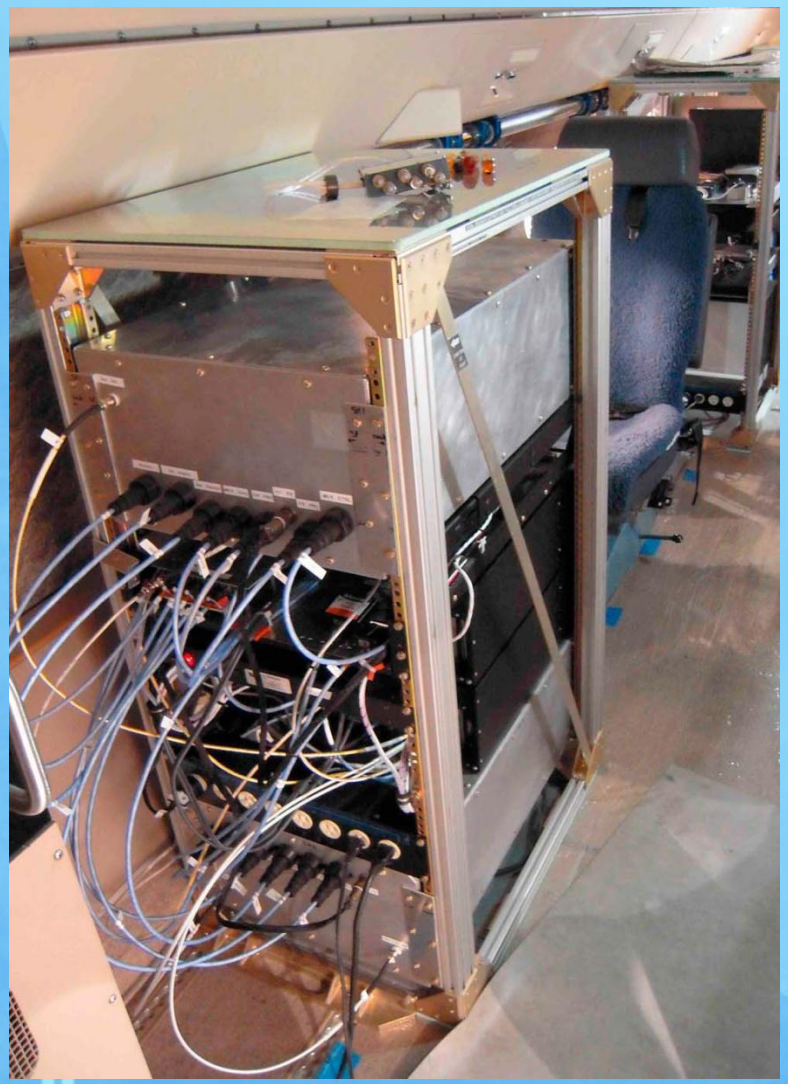
F. Battazza (ASI), F. Cairo (CNR-ISAC), B. Carli (CNR-IFAC), G. Cavarretta (CNR-DTA), G. Cecchi (CNR-IFAC), S. Fuzzi (CNR-ISAC), R. Guzzi (ASI), A. Mugnai (CNR-ISAC), G. Perona (Univ. Torino), A. Speranza (Univ. Camerino), L. Stefanutti (CNR-IRPI), A. Sutera (Univ. Roma I), D. Torri (CNR-IRPI).

| | |
|---|---|
| Rodolfo Guzzi<br>Italian Space Agency<br>Inspector General | Giuseppe P. Cavarretta<br>Consiglio Nazionale delle Ricerche -<br>Earth and Environment Department<br>Director |



**… the concept for the use of these or other NASA aircraft on a reimbursable basis would require a review by, and approval of, NASA Headquarters.**
**This process could be initiated.**

# One example from a past mission



**ADELE**

**Gulfstream V**

**Nine flights for 37 hours in the air**

**10 km horizontal distance from lightning area**

**1213 discharges seen**

**One interesting event detected**

**The low frequency of events may suggest measurement on a routine basis more than an event-chasing approach. An agreement with commercial airliners may be seeked for.**

**Air traffic policies toward flying over intense thunderstoms may hamper the chances of detection.**

# Thank you!