Airborne demonstrators: a small step from space?

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Objective and Contents

To identify benefits of airborne platforms to development of space EO instrumentation

- Development Drivers for Airborne Demonstrators
- Examples of Airborne Demonstrators
- Lessons Learned and Future Requirements
- Future Platforms - HAPs and UAVs
- Summary
Use of Airborne Platform as Route to Space

- Airborne Demonstrators can be a cost-effective method to prove principles prior to development of more costly space instrumentation
  - Collect preliminary science data
  - Provide data for performance optimisation
  - Used to test technologies and techniques
  - Reduce cost and development time eg by use of COTs
Some Example Airborne Projects

• MARSCHALS
  – Demonstrator of a limb sounding passive millimetre wave instrument

• PaRIS
  – Demonstrator of a GNSS Passive Reflectometry instrument for mesoscale ocean altimetry

• MicroSAR
  – Demonstrator for a multi-frequency low cost airborne SAR
MARSCHALS

Millimetre-wave Airborne Receivers for Spectroscopic CHaracterisation in Atmospheric Limb Sounding

- Developed as a MASTER precursor
  - Now being developed for PREMIER demonstration
- Flown on Geophysica Smolensky M55 aircraft
  - 21km altitude, no operator, turnkey operation
  - Compatible with CNES balloon platform
- More flight campaigns planned for early 2010
December 5th 2005 Measurement Flight, Darwin

- Flight optimised for limb-sounding
  - Long legs at high altitude
- Measurements demonstrate that UT limb paths remain semi-transparent in mm-wave in presence of cirrus
  - Observation of mm-wave spectra consistently down to ~10km in UT cf Tropopause at 17-20km
PaRIS Airborne Demonstrator

- Passive Reflectometry and Interferometry System (GNSS-R)
- To demonstrate the PaRIS principles from an aircraft as a step towards a space-borne instrument
  - Maximum altitude of 6km
  - Four digitally steerable beams at L1, L2 (CA) and L5
- Combination of COTs and specially developed hardware
- Aircraft is NERC Dornier 228
- Demonstration flight at 20,000 ft over Irish Sea - Jan 2009
Airborne Synthetic Aperture Radar instrument designed and built under a UK government contract

- Consists of "Low" band (100-1300MHz) and X-band (9.5-10.7 GHz)
- Provision for any additional band to be added (e.g. S-Band, C-Band, Ku Band)
X-Band Quad Polar

Image acquired 18.00 hrs, 14-Jan-09 18cm resolution
Experiences – good and bad (1)

• For GeoPhysica:
  – Very flexible platform - large high capacity (400kg) bays
  – ~5 hours at up to 21km altitude (typically 17km at start of flight)

• Instrument qualification
  – Qualification regime demands safety, rather than reliability.
  – Reliability is less critical if between-flight maintenance is possible
  – Aircraft environment much harsher than e.g. LEO
    • -90 to +50°C, 50 to 1000 mbar, 100% condensing humidity
Experiences – good and bad (2)

- Requires large hangar & dedicated technical staff
- Restricted operation from civilian airfields
- Reliability of service from aircraft operator
- Multiple (~ 16) instrument capacity
  + Shared deployment & flight costs
  - Conflicting flight requirements e.g. between remote sensing & in-situ instruments
Airborne vs. Spaceborne

• Main differences in development and operational environment:
  – Airworthiness certification vs space qualification
  – Thermal and pressure environment
  – Radiation environment
  – Maintainability, upgradeability and reliability
  – Availability of platform resources (mass, power)
  – Use of COTs components

• Design for operation at high altitude for long durations is much more similar to space

• There is not a single solution to fit all requirements
Future Platform Requirements (1)

For demonstrators under development:

- Lowest flying costs
- Good platform availability
- Flexible accommodation for equipment
  - Radome for side-looking radar antennas
- Manned platform essential
- Ready access to maintenance personnel
- Acceptable hangar environment - cleanliness, lighting, power supply, lab area, toilets!
Future Platform Requirements (2)

Stratospheric platform (> 20km cruise altitude)

• High priority –
  – Longer duration flights (> 10 hours at cruise)
  – Possibility to have windowless bays (open apertures)
  – Bays offering simultaneous views to limb & zenith, nadir & zenith
  – One or more bays able to accommodate up to 300kg payload
  – Extensive onboard auxiliary scientific instrumentation
  – High availability & flight hours p.a.

• Lower priority
  – Flexible deployment e.g. Civilian airfields
  – Ground telemetry & telecommand of instruments
Zephyr HALE UAV

Designed to fly for months at a time

• Solar electric power
• 18m wingspan & 30kg AUM
• 60,000ft+ operational altitude
• Autonomous flight and Satcom
• Stable payload platform
• Low through-life cost
• Payload limits typically 2 kg and 50W (15W at night)
HAPS
Air Quality Monitoring from High Altitude Platforms

CEOI HAPS Study:
➢ To define key requirements for air quality monitoring service to address public environmental interests
➢ Define requirements for technology and integration.
➢ To assess how technology may be developed for space flight

Courtesy ESA & Lindstrand

10th February 2009 Next Generation Platforms for Environmental Monitoring
LIDAR technologies in 1.5-2.5 μm range for CO₂ measurement

Millimetre wave radiometric sounding of the atmosphere

Integrated Optics Hollow Waveguide

QinetiQ with University of Leicester and CTCD

Spectrometers and detectors in UV/Vis/NIR for atmospheric composition measurement

Laser heterodyne sounding in 4-150 μm range

Millimetre wave radiometric sounding of the atmosphere

STFC/RAL with Astrium and QUB

SHIRM 360 GHz image separator mixer using Schottky diode technology

QinetiQ with University of Leicester and CTCD

Univ. of Leicester with SSTL and Astrium

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Courtesy SSTL

STFC/RAL with Astrium

Courtesy RAL

Univ. of Edinburgh with Selex Galileo

Hyperspectral Imaging Lidar

UCL/MSSL with Lidar Technologies
Summary

- An airborne demonstrator for a space instrument is not an easy option
- Different applications require different solutions
- Typically much lower development costs
- Opportunity for technology transfer
  - Airborne ↔ Space
- Can gain valuable scientific data and real understanding of an instrument operation
  - Demonstrated instrument and science concept may be necessary step for space
  - Can be used to optimise instrument design
- Conclusion – a useful step