

Potential use of the BAe-146-301 ARA for satellite instrument testing (Then EUFAR)



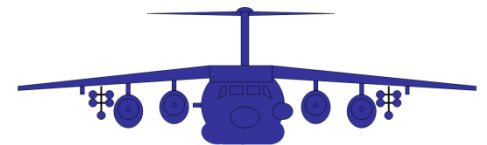
**National Centre for
Atmospheric Science**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Guy Gratton

Head of Airborne Science and Technology

National Centre for Atmospheric Science



FAAM

Why do aircraft testing?

- De-risking
- Fix-fly-fix testing
- Intercomparison
- Evaluating new concepts
- Validation and characterisation
 - Including satellite underflight

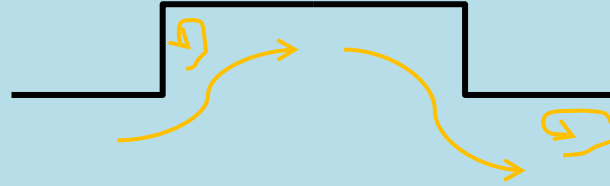
Using aircraft for pre-space testing

- Ability to place instruments well above surface
 - Unpressurised aircraft to ~6km
 - BAe-146 to ~11km
 - HALO or Falcon 20 to ~15km
- Typical flight times 2.5 → 8 hours
- Typical costs ~£5-£25k.ph + £10-£100k integration costs
- Advantages of human oversight
- Typically 9-18 months from concept to flight

Technical issues

- Certification

- Cavity flows



- Air pressures

- Surface 101 kPa, pressurised cabin 75kPa, outside to 18 kPa

- Consider differences across aircraft skins

- Tropopause level

	Typical altitude	Typical temperature
Polar tropopause	25,000 ft/7,620 m	-45°C
Temperate tropopause	40,000 ft/12,190 m	-55°C
Tropical tropopause	55,000/16,760 m	-75°C

- Aircraft capability

- Range, endurance, payload, airspace....

Some Highlights of Satellite instrument testing

- 1973

- Selective Chopper Radiometer [SCR]
- NASA Nimbus- 5 / MRF Canberra PR3



- 1989 onwards

- (US) National Polar-orbiting Operational Environmental Satellite System [NPOESS] Aircraft Sounding Testbed [NAST]
- ER-2 aircraft at ARFC [formerly DFRC]



- 1998 onwards

- Microwave Airborne Radiometer Scanning System (MARSS)
- MRF Hercules W2 and FAAM BAe-146 ARA



- 2012 onwards

- International SubMillimetre Airborne Radiometer [ISMAR]
- ESA future / FAAM BAe-146 ARA



The ARA



The BAe-146-301 Atmospheric Research Aircraft (ARA)

Started 2001, CofA 2004, UK government owned

Operated by FAAM from Cranfield Airport & University

Instrumentation and data system



Basic numbers

- BAe-146-301
 - 50ft asl → 35,000ft (15m – 10.7km)
 - Typically 4,000kg science payload
 - Up to 21 total crew
 - Max 305kn / 0.72M
 - (Science speed 210kn EAS: 100-150m/s TAS)
 - Typically 1,800nm range, 5:20 endurance
 - Running cost ~£14k/hr to UK public science, £17k+/hr for commercial uses (+ any additional engineering and “superstructure” costs)

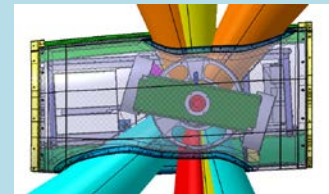
Existing instrumentation

- Primary flight instrumentation (IAS, TAS, sHp, Radalt, INS and GPS positions, heading + strain gauging)
- Temperature, humidity, turbulence
- Basic cloud microphysics and (greenhouse gas) chemistry measurements
- Non-core, available instrument groups
 - Aerosol
 - Cloud microphysics
 - Aerosol
 - Chemistry
 - Remote sensing
 - Enhanced turbulence
- DECADES dispersed data system



Current ARA “space” instruments

- ARIES – Airborne Research Interferometer Evaluation System
 - 550-3000 cm^{-1} ($\Delta = 0.5 \text{ cm}^{-1}$)
- MARSS – Microwave Airborne Radiometer Scanning System
 - 89, 157, 183 GHz
- ISMAR – International Sub-Millimetre Airborne Radiometer
 - Test-bed for future monitoring of deep ice-cloud systems from space
 - 118, 243 (V/H), 325, 424, 448, 664 (V/H) and 874 GHz (V/H)
- SWS/SHIMS – Short-Wave Spectrometer / Spectral Hemispheric Irradiance Measurement System
 - 0.3 – 1.7 μm (two modules, visible and NIR)



Resources

- The ARA
 - Potentially ~300hrs.pa available
 - Possible ride-along science / instrument testing
- FAAM
 - Team of 16
- Directflight and Avalon
 - Full aircraft operator and maintenance support
- Partner Universities and Met Office
 - Availability of expert Co-Is in instrument and atmospheric science.



Transnational and Open Access to Research Aircraft in the EUFAR Fleet

Guy Gratton

Co-ordinator

Research Aircraft Operations and Certification Working Group

European *Facility* for Airborne Research

(With Phil Brown, Met Office & EUFAR)

European Facility for Airborne Research



Integrating Activity of the EC FP7



Budget ~ € 6 M Duration 4 years (2014-2018) 24 Partners
3 instruments and 19 aircraft open to Trans-national Access
Building on previous activities, 2000-2013

www.eufar.net



Objective.... for each European scientist to get access at "equal terms" to the airborne facility the most suited to his scientific objectives, irrespective of his origin and of where the facility is operated.

EUFAR fleet: satellite instrument potential?

Operator	Categories			
	High-altitude	Large-capacity tropospheric	Medium-capacity tropospheric	Small tropospheric
Met Office		FAAM BAe146		
CNR			Partenavia	
				ERA SkyArrow
VITO				
DLR			Caravan	
			Do-228	
		Falcon-20		
SAFIRE				
		ATR-42		
NERC				Piper Aztec
			ARSF Do-228	
INTA			BAS Twin Otter	
			CASA-212-RS	
Enviscope			CASA-212-AR	
		LearJet 35		
KIT			Partenavia	
FUB				Enduro
AWI				Cessna C207
U.Edinburgh		Polar-5 (Basler)		
				EcoDimona



Highlighted aircraft carry hyperspectral surface-imaging Systems

In red: recommended for first evaluation for space applications

Transnational Access

- Fully-funded flight hours on an aircraft appropriate to the user's requirements
 - Plus limited travel funds for PI and others
 - **NOTE: not modification costs.**
- Open to users without access to those facilities in their country of employment
- Typically 10-15 flight hours per award
 - Larger awards available on the low-cost aircraft
 - Project clustering possible: promotes more hours and collaboration between scientists.
- ~38 projects supported between 2014-2018
 - 430 flight hours
 - 402 individual scientists

Also facilities available under TNA

- INTA C212
 - AHS – Airborne Hyperspectral Scanner
 - 80 channels in near-, mid- and thermal-IR
 - In demand for e.g. Soil / vegetation studies
 - CASI-1500i – Compact Airborne Spectrographic Imager
 - 288 channels in the Visible/NIR
- APEX – Airborne Prism Experiment
 - 380-2500nm (Vis/NIR * 300 channels)
 - Operated by VITO (Belgium)
 - Commonly flown on DLR Do-228 aircraft
 - Access costs quoted separately from those of the aircraft platform
 - Used in several TA projects for studies of e.g. Vegetation properties, soil hydrology, surface mineralogy, satellite validation (Sentinel 2)

EUFAR Open Access – a proposal

- Most EUFAR aircraft have spare capacity
- Effective use above these limits requires:
 - More users
 - More expert resources
- EUFAR proposes broader sharing of aircraft flight time amongst scientific institutions and users,
 - Not dependent upon EC funding
- Open Access by exchange of resources
 - Engineers or instrument scientists?
 - New instrumentation and implementation costs?

EUFAR further information

TNA & OA: EUFAR Scientific Coordinator

- phil.brown@metoffice.gov.uk

EUFAR Office

- bureau@eufar.net

Discussion

