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## British Aerospace 146 Atmospheric Research Aircraft (BAe-146)



Figure 1. BAe-146 ARA (source: [www.directflight.co.uk](http://www.directflight.co.uk)).

CAST campaign (Co-ordinated Airborne Studies in the Tropics) will be using the UK atmospheric research aircraft for taking measurements in Guam, West Pacific. The modified British Aerospace 146-301 large Atmospheric Research Aircraft (the ARA) will be used for this purpose. BAe-146 is owned by *BAE Systems* and operated for them by *Directflight* it is kept at Cranfield University, Bedfordshire. It has been used in multiple campaigns so far with a great record of efficiency and reliability in taking airborne measurements (included detachments to the Arctic, North and South America, the Caribbean, North and West Africa, the Far East and Europe).

General applications of BAe-146 include:

- Radiative transfer studies in clear and cloudy air
- Tropospheric chemistry measurements
- Cloud physics and dynamic studies
- Boundary layer and turbulence studies
- Remote sensing: verification of ground based instruments
- Campaigns in the UK and abroad

BAe-146 provides comprehensive airborne research capability for the benefit of the environmental science community. Configured as a highly specialised meteorological research platform, BAe-146 operates around the globe on major international projects (MAMM, BORTAS, CAST), providing vital support to UK science programmes.

The aircraft has a range of about 1800 nautical miles, a ceiling of 35000 feet and maximum flight duration of a little more than 5 hours. It will carry 2 pilots, a crew cabin member and up to 18 scientists. Most of the scientific instrumentation in the aircraft is mounted in racks constructed to a common design. Core instruments are provided and can be operated by FAAM. The FAAM BAE 146 aircraft allows for in-situ measurements taken by core and non-core instruments onboard the aircraft. The in-situ measurements will then be transported to the research organisations' respective laboratory for analysis.



**Figure 2. BAe-146 in Palau, CAST 2014 - Palau.**

Aircraft specifications(\*based on [www.faam.ac.uk](http://www.faam.ac.uk) and [www.directflight.co.uk](http://www.directflight.co.uk))

Dimensions: Length: 31.00 m; Height: 8.58 m; Wingspan: 26.00 m;

Flying performances:

Speed: Min speed: 60 m/s Max speed: 215 m/s; Usual speed during measurements: 100 m/s; Usual speed during transit flights: 215 m/s

Altitude:(1 ft = 0.31 m) Min altitude: Above sea: 50 ft, Above ground: 250 ft; Max ceiling: 35000 ft; Usual ceiling during measurements: 30000 ft; Ceiling limitations:With a typical scientific payload, max ceiling (35000ft) can normally be achieved only during last 2hrs of a flight.

Payload: Empty weight: 25400 kg; Max take-off weight: 42000 kg; Max payload: 16600 kg; Max scientific payload: 11000 kg; Usual scientific payload during measurements: 5000 kg; Scientific payload for max endurance: 1100 kg.

Endurance: Max endurance: 6 h (at min scientific payload and max fuel); Endurance at max scientific payload: 2 h.

Range: Max range: 3700 km (at min scientific payload and max fuel); Conditions for max range: at 29000 ft, 220 kts; Range at max scientific payload: 1100 km; Usual range during measurement flight: 3000 km.

Crew and scientists on board: Crew (pilots + operators): 2 pilots; Seats available for scientists: Max of 18 project participants.

Aircraft modifications: windows, openings, hard points, inlets - yes



**Figure 3. BAe-146 during CAST/CONTRAST Open House Day, CAST Guam 15.02.2014.**

### ***List of instruments – CAST 2014 measurements***

FAAM (Faculty for Airborne Atmospheric Measurements) will provide the BAe-146 research aircraft with instruments making 'core' measurements of: ozone (TE49C), water vapour (General Eastern 1011 & BuckCR2), carbon monoxide (Aerolaser 5002), nitrogen oxides (AQD NOx analyser), carbon dioxide and methane (Los Gatos). Other instruments on BAe-146 will be provided by York (NOx; short-lived halocarbons: GC-MS WAS; NMHC, OVOCs, DMS: GC-FID Whole Air Samplers), Manchester (carbon dioxide, methane: Los Gatos; N<sub>2</sub>O: aerodyne QCLAS, BrO: CI-MS) and Cambridge University (iodine, IO, OIO: BBCEAS) teams. Measurements of nearly all these species will be made by ATTREX and CONTRAST at higher altitude levels, noting the use of different instruments. Most CAST raw/uncalibrated data will be obtained and processed for preliminary analysis few hours post flights.



**Figure 4. Broadband cavity enhanced absorption spectrometer, BBCEAS, Cambridge University.**

Cambridge University CAS group will provide BBCEAS (broad band cavity enhanced absorption spectrometer) to measure IO, I<sub>2</sub> and OIO (spectroscopy technique using two wavelength ranges: green 480-540 nm – for IO and OIO and purple 400nm – for I<sub>2</sub>; enhanced referred to applying very reflective mirrors to increase sensitivity by decreasing noise; broadband refers to the light used covering a broad range of the spectrum ~40 nm compared to lasers, allowing different molecules to with different absorption cross sections to be identified – as well as scattering/absorption by aerosols to be accounted for).

Table 1. CAST 2014 measurements.

Parameter	Species	Atmospheric Lifetime	Instrument	LOD	Institution
Ozone	O <sub>3</sub>	22 days	UV Photometric Ozone Analyser	1 ppb	FAAM
Water vapour	H <sub>2</sub> O	10 days	General Eastern 1011 Buck CR2		FAAM
Carbon monoxide	CO	0.4 year	Aerolaser 5002 VUV Fast Fluorecence CO Analyser	2 ppb	FAAM
Carbon dioxide, methane	CO <sub>2</sub> CH <sub>4</sub>	5-200 yr CO <sub>2</sub> , 8-12 yr CH <sub>4</sub>	Los Gatos Isotope Analyser	200/1 ppb	FAAM + Manchester
Nitrogen Oxides	NO <sub>x</sub>	0.01-0.03 yr	Air Quality Design dual channel chemiluminescence NO <sub>x</sub> analyser	10ppt (NO) 20 ppt (NO <sub>2</sub> )	FAAM + York
Nitrogen (I) oxide, water vapour, methane, carbon dioxide	N <sub>2</sub> O, H <sub>2</sub> O, CH <sub>4</sub> , CO <sub>2</sub>	115 yr N <sub>2</sub> O	Quantum Cascade Laser Absorption Spectrometer (QCLAS)	0.2 ppb	Manchester
Bromine oxide, radicals	BrO	Mins-hrs	CIMS	2.6ppt	Manchester
VSL Halocarbons	CHBr <sub>3</sub>	<0.5yr by definition	In-situ Agilent GCMS and WAS	0.01-0.05 ppt	York
Whole air samplers:			Perkin Elmer GC-FID (WAS)	2.5-1ppt	York
NMHC	C <sub>1</sub> -C <sub>6</sub>	0.2yr-hrs			
Small OVOCs		Few hrs			
DMS	(CH <sub>3</sub> ) <sub>2</sub> S	1-2 days			
Iodine, iodine oxides	I <sub>2</sub> , IO, IO <sub>2</sub>	Days-hrs	BBCEAS	ppt	Cambridge

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1. FAAM website: [www.faam.ac.uk](http://www.faam.ac.uk)
2. Directflight website: [www.directflight.co.uk](http://www.directflight.co.uk)
3. CAST proposal