

# Airborne Atmospheric Research Capabilities of the British Antarctic Survey Twin Otter Aircraft

The British Antarctic Survey has a Twin Otter aircraft with a certified fit of airborne atmospheric instrumentation suitable for atmospheric, boundary layer and cloud/aerosol studies.

The Twin Otter aircraft is a very adaptable platform used the world over as a 'bush' aircraft. Its twin turbo-prop engines and 'Short Take off and Landing' (STOL) capability allow it to be used from small, remote unpaved airfields and the addition of skis or tundra tyres also allows operation on snow and from remote camps.

The aircraft can be operated single pilot and a long range fuel tank is also available. Double cargo doors provide good access for installing instrument racks.

In general the aircraft works in the Antarctic from October through to March each year depending on projects. The first Arctic project is scheduled to be with the NERC ACCACIA consortium grant starting from Svalbard in February 2013.



Aircraft Operations	
Range	1000km including skis. Increased with extended range tank depending on configuration.
Airspeed	Cruise 65m/s. Data collection 60m/s.
Complement	Single pilot and up to 4 mission operators / scientists.
Altitudes	Low level to 5000m . Unpressurized but with oxygen fit for pilots and operators.

The instrument suite includes standard temperature and water vapour sensors as well as a turbulence probe allowing full atmospheric profile measurements of temperature, dew point and winds.

The fast turbulence probe also facilitates sensible heat flux measurements by the eddy covariance method. These boundary layer measurement capabilities are complemented by incoming and outgoing radiation instruments and a downward looking infra-red thermometer.

The floor hatch opening can also accommodate a fixed laser range finder or scanning laser which has been used for measuring ice floe topography. The required GPS and attitude measurements to support this are available. Video and digital SLR cameras can also be fitted here. The camera bay can also be configured to drop airborne deployable buoys.

Hard points and pylons are available on each wing. A DMT Cloud and aerosol spectrometer (CAPS) probe is used for cloud studies. Other standard PMS pod instruments can also be accommodated. There is also a mount under the nose for a DMT Cloud Droplet Probe. We run a closed path Licor H<sub>2</sub>O/CO<sub>2</sub> instrument, Grimm optical particle counter and TSI condensation particle counter fed from a Brechtel Isokinetic inlet. Further aerosol instruments can be accommodated.

Further details of the instrumentation are given overleaf.

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## Atmospheric Instrumentation

Total Temperature	Goodrich Rosemount Probes mounted on the nose. A non de-iced model 102E4AL and a de-iced model 102AU1AG logged at 0.7Hz.
Altitude and Air Speed	Static and Dynamic pressure from the aircraft static ports and heated pitot tube, logged using Honeywell HPA sensors at 5Hz.
Cooled-Mirror Hygrometer	A Buck 1011C cooled mirror hygrometer is fitted. Chamber pressure and mirror temperature are recorded at 1Hz. A Rosemount mounted Vaisala Humicap sensor is also logged.
Radiometers	Eppley PIR and PSP sensors fitted to the roof and underside of the aircraft. Logged at around 10 Hz.
Infra-red Thermometer	Heimann model KT19.82 infra-red thermometer mounted in the floor hatch panel. There is a solenoid-operated, ambient temperature, black-body calibration target that can be brought into view during flight. Data are recorded at around 10Hz.
Laser Altimeter	A Riegl LD90-3800VHS-FLP Laser Altimeter is fitted in the floor hatch. Returns up to a few hundred metres are possible depending on the surface at repetition frequencies up to 2 kHz.
Cameras	RePlay XD1080 bullet video cameras are used as forward and downward facing videos. A downward looking Canon EOS7D with 15mm lens can be triggered to take 18MP images at up to 1 frame/sec.
Laser Scanner	A Riegl Q240 80 degree laser scanner has been used for mapping sea ice.
Radar Altimeters	Data are recorded from the aircraft's two radar altimeters at around 10Hz. These have a range of 1000m with a wider beam compared to the laser altimeter.
Turbulence Probe	A NOAA/ARA BAT 'Best Aircraft Turbulence' probe is fitted on a boom extending forward from the roof of the aircraft. This 9 hole probe records pressures and exposed thermocouple temperatures for measuring turbulence by eddy covariance in conjunction with attitude measurements. 3-axis accelerometer data are also recorded from the BAT Probe. Heaters are fitted inside the hemisphere to enable the instrument to be usable even after encountering icing.
GPS Position	Around 5m position accuracy recorded at 10Hz from the JAVAD 4-antenna GPS attitude system. For greater accuracy this is supplemented by a Trimble 5700 survey system using an antenna mounted above the laser altimeter and processed in kinematic mode with a second ground based unit.
GPS Attitude and Reference System	A JAVAD AT4 4-antenna GPS system records heading, pitch and roll at 20Hz and velocities at 10 Hz. Antennas are permanently fitted to each wingtip and fore and aft of the fuselage.
Inertial Attitude and Heading Systems	An OXTS Inertial+ GPS linked INU that stores data internally and operates at 100Hz is now generally used in preference to the JAVAD GPS based system.
Wing Hard points	Both wings have hard points, Zivko carbon fibre pylons and cabling to accept PMS footprint instruments.
Cloud Probes	An under-wing pylon mounted Droplet Measurement Technologies CAPS Probe comprises of a 2D imaging probe(25µm -1550µm), aerosol spectrometer (0.5µm-50µm) and liquid water content probe (0.01-3.0g/m <sup>3</sup> ). The probe has a dedicated logging PC and comprehensive instrument de-icing heaters. An under-nose mount for a DMT CDP instrument has also been fitted.
Closed Path water vapour and CO <sub>2</sub> sensor	A LICOR LI-7000 closed path infra-red gas analyser is fitted. Sampling is from a Rosemount inlet and readings are triggered at 50 Hz.
Inlets	A Brechtel Model 1200 iso-kinetic Inlet is fitted. >95% efficient for 0.01µm to 6µm. There are also two stainless steel ½" OD chemistry inlets that can be PTFE lined.
Condensation Particle Counter	A TSI 3772 CPC is available.
Aerosol Spectrometer	A Grimm model 1.109 portable aerosol spectrometer. 31 channels 0.25µm to 32µm.
Central Logging System	All instruments apart from the CAPS probe are logged to a single rack PC using Labview and associated National Instruments hardware including networked compact Fieldpoint modules in the roof and floor. The logging can be monitored and controlled from the main rack in the cabin as well as a remote touch screen in the co-pilot's seat. CAPS has a dedicated computer. Dual KVM switches allow both the rear operators screen and the cockpit display to switch to either PC.

