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NRC Airborne Research: Facilitates and Research Focus

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Collaborators: EC Cloud Physics and Severe Weather Research Section

Workshop on Suborbital Platforms and Nanosatellites
Montreal, 14-16 April 2010

National Research Council Canada | Conseil national de recherches Canada

Canada

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IAR buildings and facilities

- 4 sites (2 in Ottawa, 2 in Montreal)
- 15 buildings (565,000 sq.ft.)
- Major facilities:
  - 8 wind tunnels
  - 9 research aircraft
  - Full-scale structural test rigs
  - Engine and combustion test cells
  - Materials characterization and testing equipment
  - Aeroacoustic reverberant chambers
  - Lubrication/tribology test rigs
  - Flight Recorder Playback Centre
  - Manufacturing research facilities

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Flight Research Laboratory

Expertise and facilities in full-scale aircraft-based experimentation for flight test and airborne research

- Flight mechanics & avionics
- Airborne research
- Flight Recorder Playback Centre

Capabilities:

- Flight test
- Modeling and simulation
- Aircraft systems evaluation
- Airborne sensing of the earth and atmosphere
- Aircraft accident and incident analyses

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Our Program of Work

Airborne Research

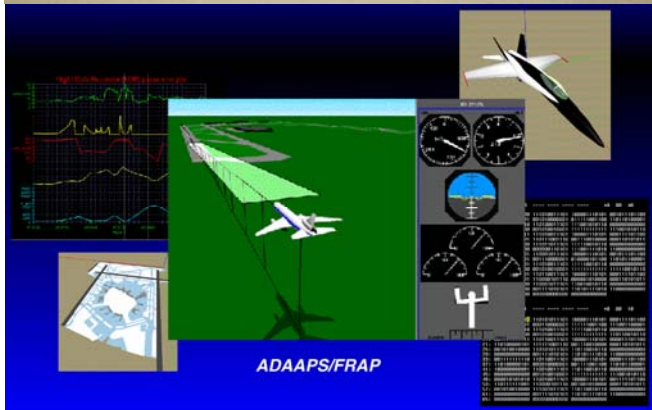
- Instrumented access to the atmosphere and environment.

Flight Mechanics and Avionics

- Studying the aircraft, the pilot and related systems

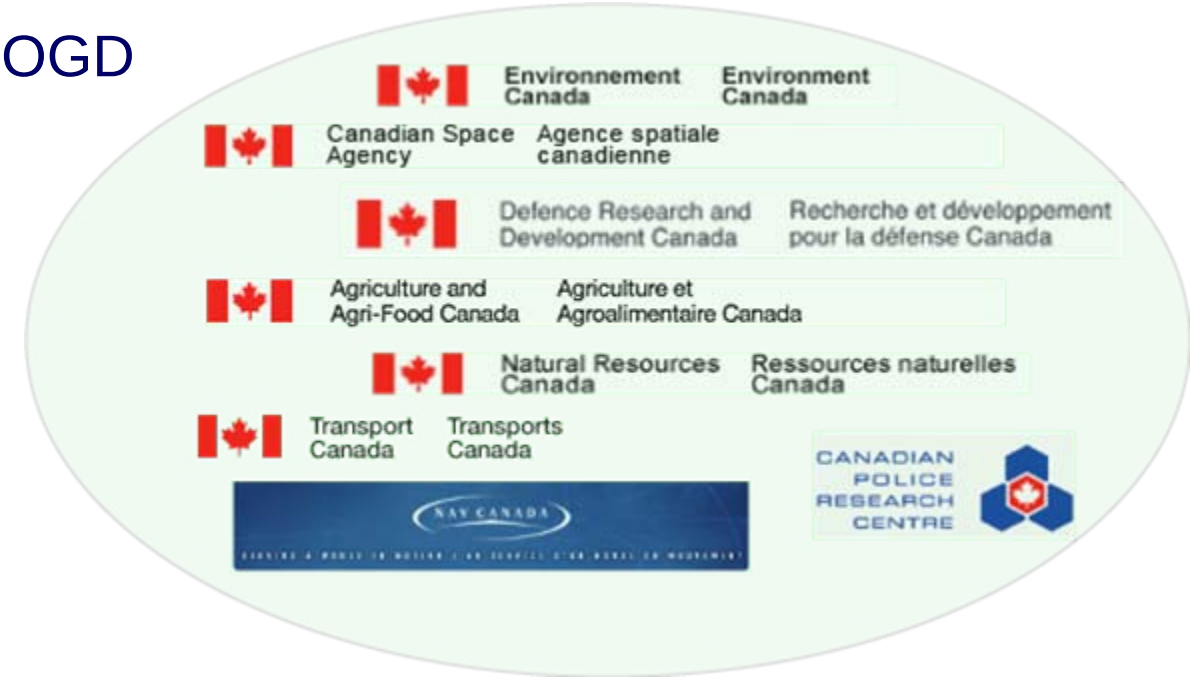
Flight Recorder Playback Centre

- the investigation of aircraft accidents and incidents and the improvement of safety related systems



Who we work with
(Clients and Collaborators)

- OGD



- Universities

- International

- Industry

BAE SYSTEMS

THALES
THALES CANADA SYSTEMS DIVISION

L3 communications
WESCAM

itres
www.itres.com

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NRC Fleet

Flight mechanics
Test Pilot Schools
UAV collision aviodance

NVG Flight Tests
Forest fire detection
Test pilot school

Helicopter handling qualities,
Modern control systems
Helicopter/pilot interface

Microgravity – CSA, Universities
De-icing and anti-icing technologies-
TC, NASA, FAA

Flight Test Courses – Universities
Airborne symbology
Test Pilot Proficiency Flying

Test Pilot Proficiency Flying
Aeromedical physiology
Aerodynamics research

Airborne Research

- ***Support Airborne Research in Canada***
  - ***Instrumented by NRC, EC and DND, Universities and Others***
  - ***Multiple aircraft supporting diverse research applications***

Convair-580

T-33

Twin Otter

Program Manager:
Dave Marcotte

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The NRC Twin Otter Atmospheric Research Aircraft

Ramesh Srinivasan
TO – Facility Manager

NRC Twin Otter - *DHC-6*
Atmospheric Research Facility

- Experiments in :
  - Flux measurement (surface-atmosphere exchange of energy and GHG).
  - Remote sensing of the cryosphere (microwave radiometers)
  - Air pollution
  - Atmospheric turbulence
  - Flight mechanics
  - Remote sensing for agriculture (hyperspectral)
  - Remote sensing for defence (electro-optics)
- The Twin Otter is supported by a research team with many years' experience in conducting airborne field experiments.

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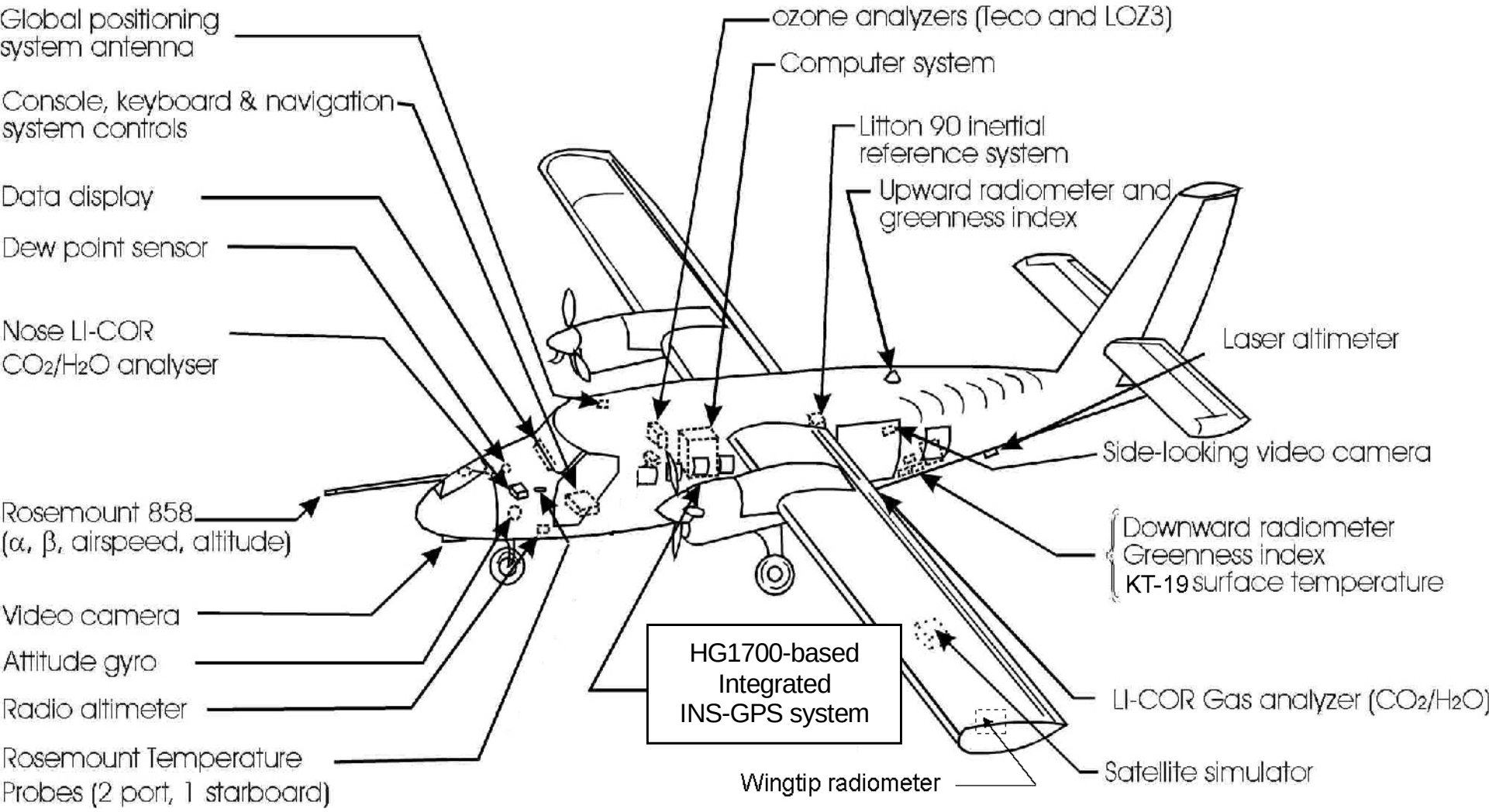
Twin Otter Instrumentation



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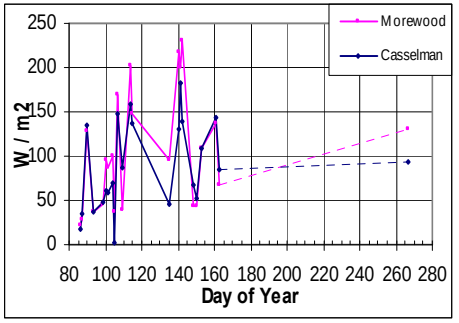
Airborne Flux Measurement

In partnership with Agriculture Canada

The Eddy Covariance method requires:

The vertical wind from the nose gust-boom, and

- Temperature (3 probes) → Sensible Heat flux (H)
- H_2O mixing ratio (2 LiCors) → Latent Heat flux (LE)
- CO_2 mixing ratio (2 LiCors) → Carbon dioxide flux
- O_3 mixing ratio (TeCO & LOZ3) → Ozone flux



? Lack of fast-response analyzers for:

- Nitrous oxide N_2O
- Methane CH_4
- Other trace gases

Requires more ingenious methods of measurement.

… Internal R&D project might offer a solution … in the future.

Current solution is the REAS …

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- Alternate to Eddy Covariance (EC) technique.
- Measures trace gas fluxes, when fast-response analyzers N/A.
- Air is sampled from up & down drafts into 2 separate reservoirs.
- In EA, sample flow-rate proportional to vertical gust velocity, w.
- In REA, this requirement is 'relaxed', (i.e. flow-rate kept constant, with full flow into up OR down reservoir)

$$F_\chi = \overline{w'\chi'} = A\sigma_w\left(\chi_{\text{Up}} - \chi_{\text{Down}}\right)$$

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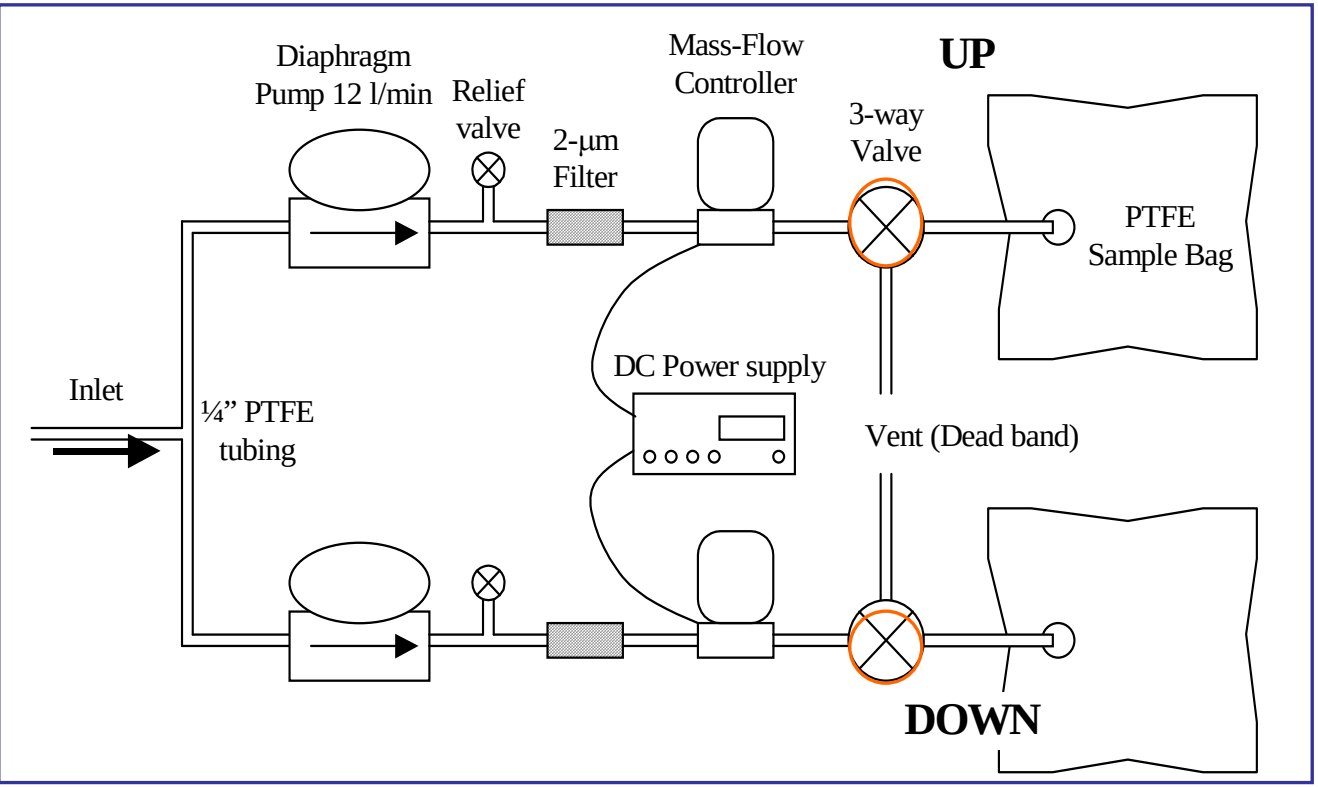
The Twin Otter REA System



Tunable Diode Laser

- Flow rates 12 liters/min
- Valve time constants approx. 10 ms

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NRC Hyperspectral SWIR Airborne Spectral Imager (SASI) – Dr. G. Leblanc

Obtained in 2003 from ITRES Ltd., can currently can be installed aboard the NRC's Convair and Twin Otter Aircraft.

Specifications:

- Pushbroom Imager
- FOV: 37.7degrees
- IFOV: 1.14mrad
- f-number: 1.8
- Spatial Pixels: 644
- Spectral Channels: 160
- Spectral Range: 850nm-2500nm
- Output Image: 14 bit
- Frame Rate: 16ms
- GPS/INS: CMIGIT III

Past/Present Projects:

- Camoflauge Detection
- Ice In-Cloud Determination
- Bio-Mass Determination
- Water Stress
- Roadside IED Detection
- Police Research
- Mass Graves Detection
- Integration of Aeromagnetics and Hyperspectral Data
- Validation of Radiometric Calibration
- Real-time Hyperspectral Processing

Collaborators:

- Defence Research and Development Canada
- Agriculture and Agro-Food Canada
- Canadian Police Research Center
- Royal Canadian Mounted Police
- McGill University
- University of Alberta
- York University
- McMaster University

We intend on having a VisNIR (300-1000nm) companion instrument by the summer of 2010

HAARC

- **Project:** Re-development of the NRC T33 for High Altitude Atmospheric Research (HAARC) - a NIF initiative

- **Need:** The diverse and rugged aircraft suitable for high altitude research (turbulence, aircraft emissions etc)

- **Clients & Collaborators:**
  - FAA, EuroControl, TSB, Transport Canada, ICPET, GTL of IAR, Environment Canada; NR Canada, NASA, Aerodyne

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HAARC

- **Major Achievement/Highlights:**
  - Successful development of flight profiles for turbulence and emissions research, using jets in commercial service
  - Application of 600 Hz sophisticated data acquisition instrumentation to the research – wake turbulence
  - Impact: WakeNet, AIAA, EC etc
  - $300k+ Aviation Emission Environmental Measurements (AEEM) PERD Award

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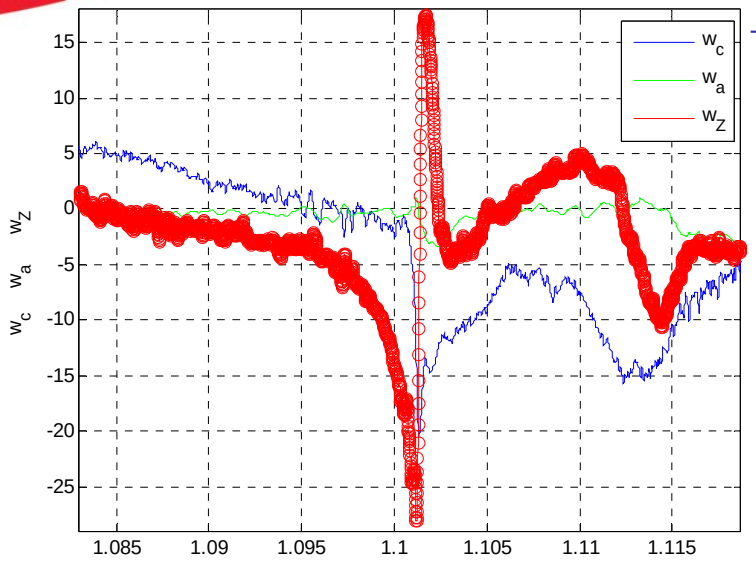
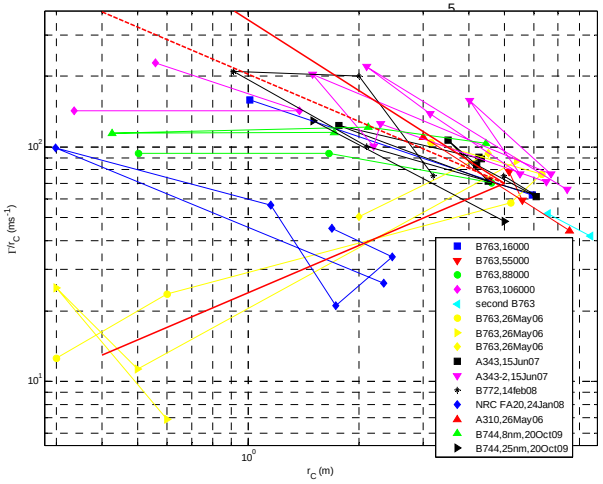
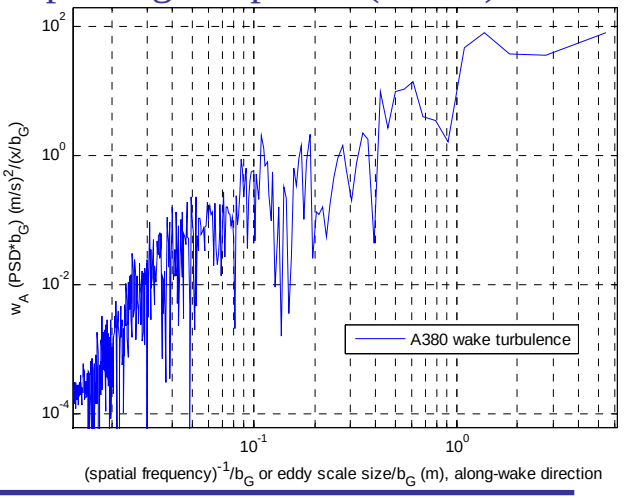
Vortex Γ (based upon V_T) and r_C identification:

(trace, B777-200, 23rd Oct 09)

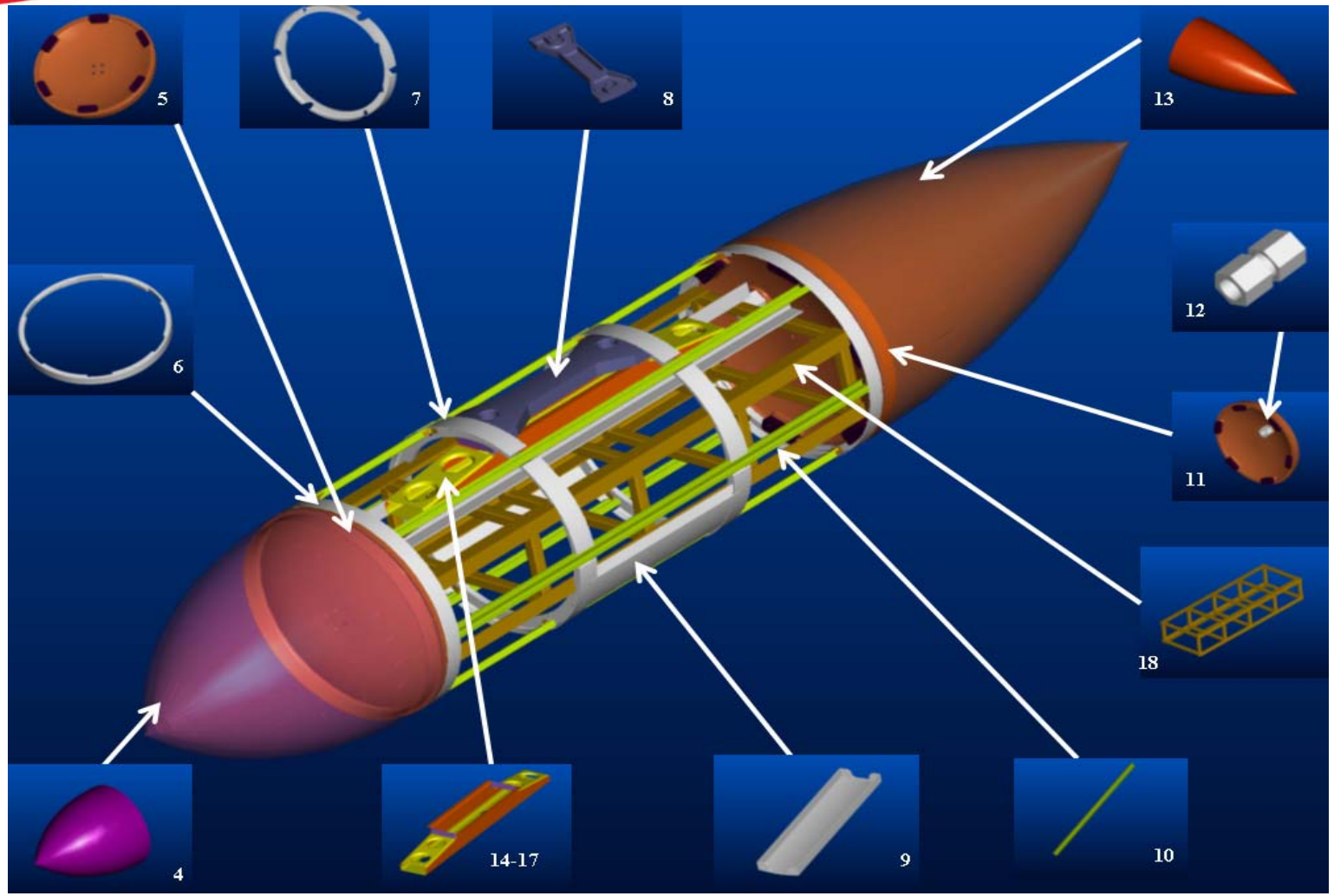


- Time-space analysis of V_C, V_Z & V_A
  - Cross-referred to $V_T=\sqrt{(V_C^2+V_Z^2+V_A^2)}$ time-traces ('M' signatures)
  - Shown at left, identification of a small, very intense vortex element (r_C approximately 0.2m)
  - Shown left (lower), identified vortex strength ~ size relationship;
  - Spatial gust spectra (below)





T33 Instrumentation Pod – in design



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NRC CT-133 HAARC

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NRC Convair-580

- ***Atmospheric and aircraft state parameters – NRC/EC***
- ***Cloud microphysics – EC/Others***
- ***Atmospheric chemistry (Aerosol, IN, CCN…)***
- ***Airborne remote sensing – radar, radiometer – NRC/EC***

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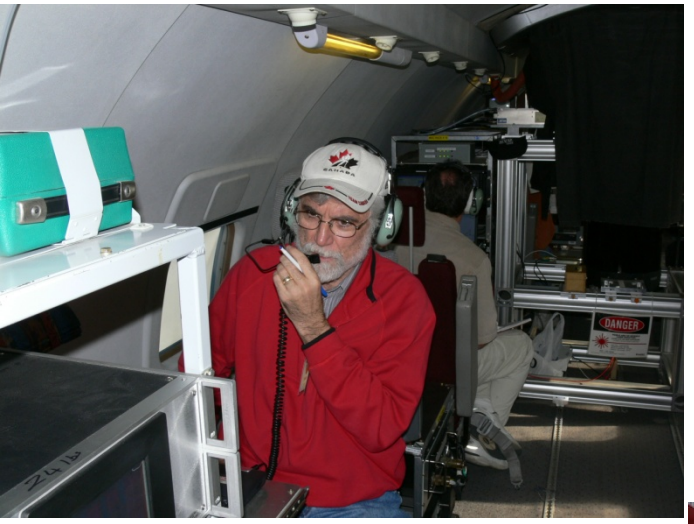
Projects - Collaborations



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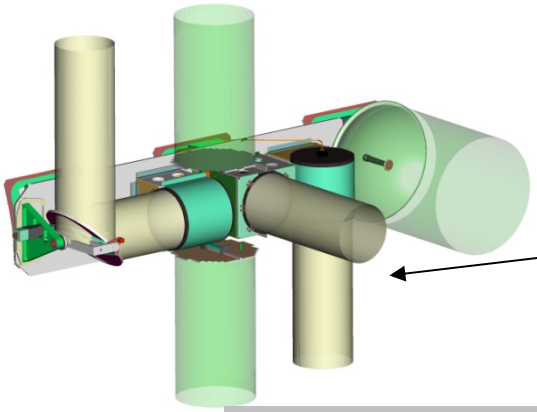
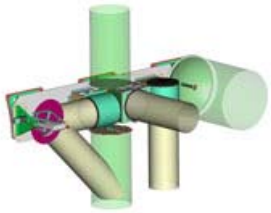
NRC Airborne W and X-bands radar (NAWX)





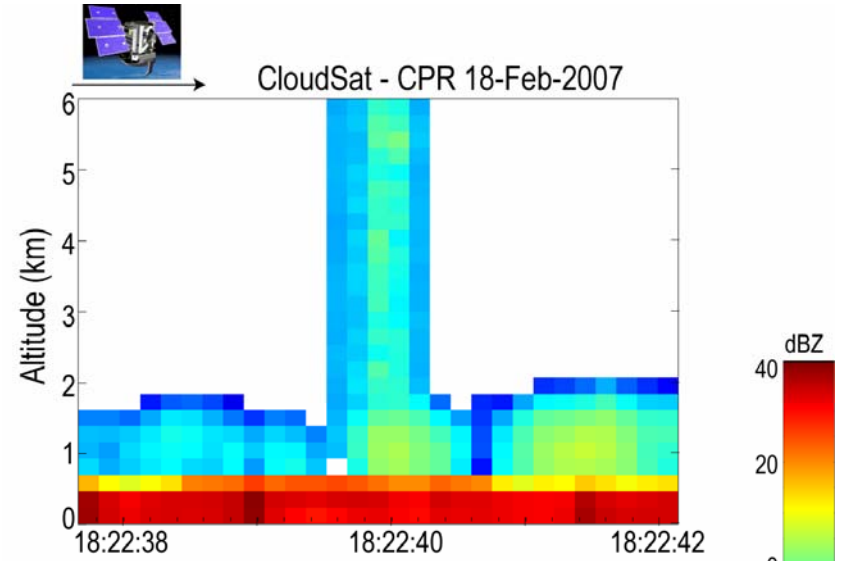
NAWX	W-band	X-band
Transmitted Frequency (GHz)	94.05	9.41
Peak Tx Power (KW)	1.7 - typical	25 (split b/n two ports)
Polarization	Co and Cross	Simultaneous H and V
Doppler	Pulse Pair and FFT	Pulse Pair and FFT
Pulse Duration (μs)	0.1 - 10	0.11-1
Max PRF (KHz)	20	5
Ant. 3 dB BW (°)	0.75	3.5
Antenna ports	5	4
View direction	Up, down and side	Up, down and side

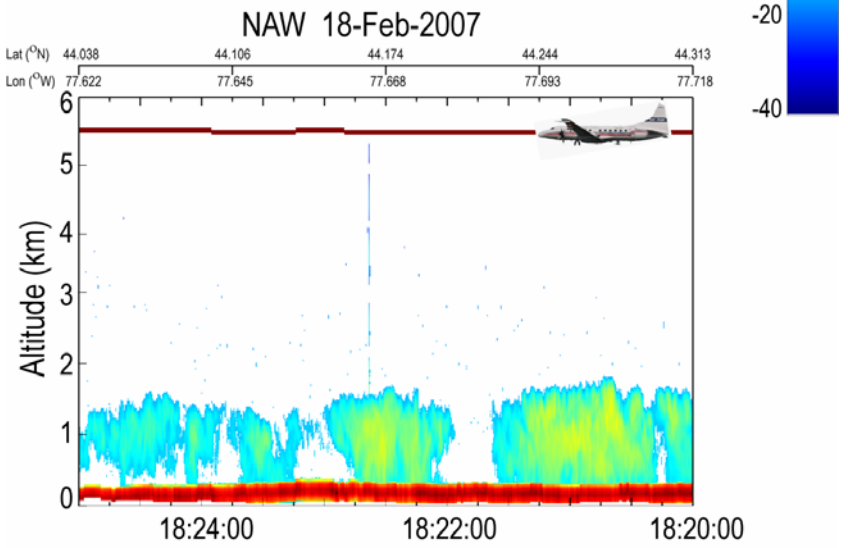
More details/updates: **http://www.nawx.nrc.gc.ca**

NAWX / CloudSat 18-Feb-2007

Feb 18-2007: Boundary layer Cu Clouds

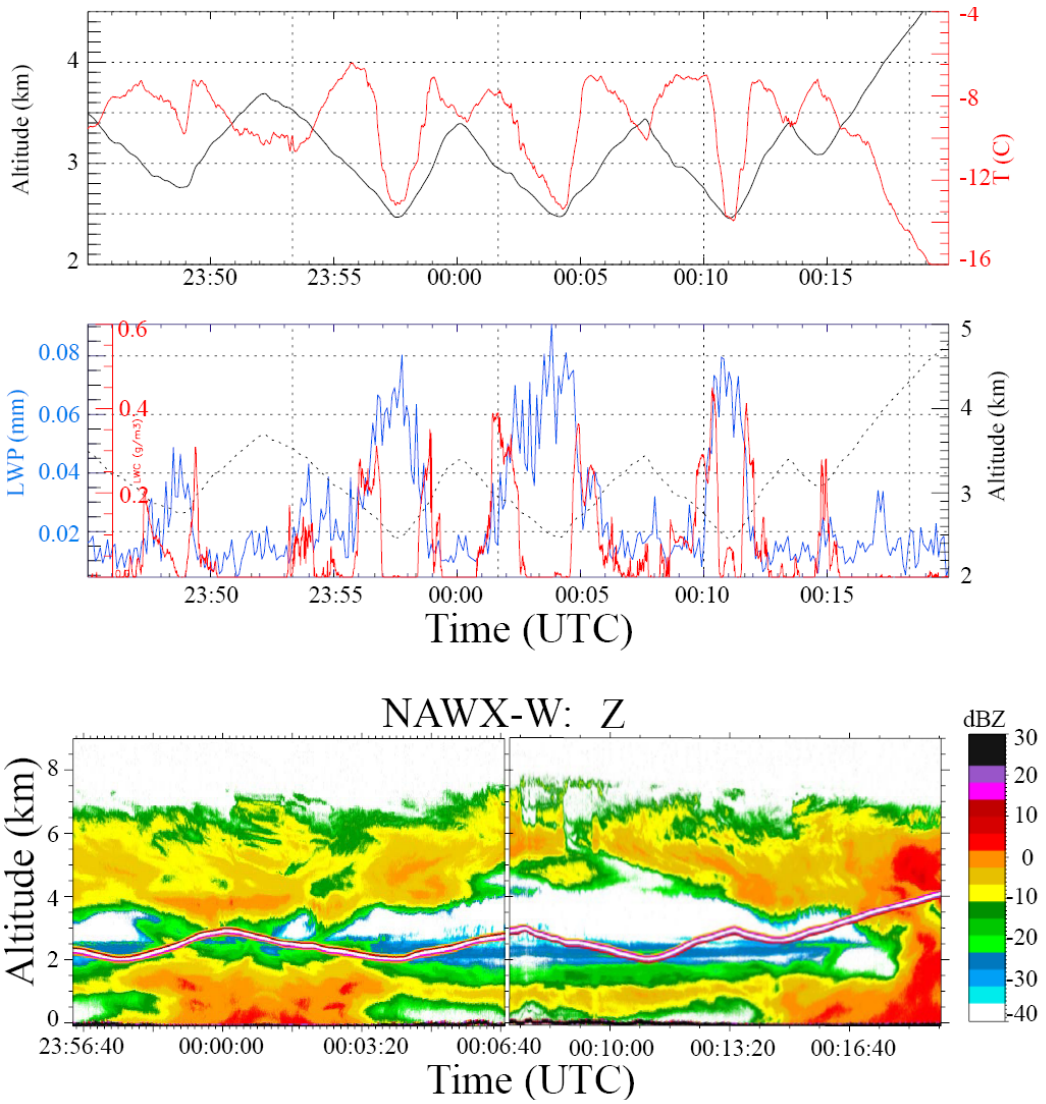
- ✈ A/C at ~ 6 km at the time of the CloudSat pass
- ✈ Good agreement of cloud top boundaries by CloudSat and NAWX
- ✈ Difference b/n CPR and NAWX near the surface





GVR / NAWX – 26-Jan-2007

- Multiple layers- Upper layer: All ice and shallow layer of supercooled drops at the top of the lower layer at T of ~ -10C°
- Convair made repeated porpoise maneuver in the liquid layer
- Good correlation between GVR and in-situ LWC measurement



- Preliminary work on retrievals of r_{eff} and N form combined GVR and NAWX data show good agreement with in-situ data (Wolde, Pazmaney, Hudak – 33rd AMS radar conference, Cairns, Australia, 2007)

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Fleet Review

- *FRL Committee – 2009 ($2M NRC)*
  - *Review existing aircraft assets (aging, research need, long term maintenance / supportability..)*
  - *Develop a plan for future acquisition Fleet Review*
    - *Inputs from FRL staff, collaborators and clients*
    - *Categories: Small UAV, Cabin Class Jet/Falcon replacement*
    - *High Altitude Research Aircraft*
    - *Non-cabin Class Jet*
    - *Convair replacement*
  - *Reported to IAR with recommendation (*LTR-FR-307 November 2009 L. Auriti and R. Erdos)