Development of Pulsed Coherent Doppler Wind Lidar Systems for Two Aircraft

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Acknowledgments

Name	Program	Office	POC	Airplane
DAWN-AIR1	AITT-07	SMD ESD	Ramesh Kakar	DC-8
DAWN-AIR2	IIP-07	SMD ESTO	George Komar	WB-57

DAWN – Doppler Aerosol WiNd lidar

AIR - AIRborne

SMD - Science Mission Directorate (NASA)

ESD - Earth Science Division (SMD)

ESTO - Earth Science Technology Office (SMD)

ROSES - Research Opportunities in Space and Earth Sciences (SMD)

AITT - Airborne Instrument Technology Transition (ROSES)

IIP - Instrument Incubator Program (ROSES)

DC – Douglas Commercial

WB – Weather (Bomber) [formerly RB – Reconnaissance (Bomber)]

Acknowledgments

Dr. Grady J. Koch	NASA LaRC	Co-I, overall lidar system lead, field demonstration, receiver
Dr. Jirong Yu	NASA LaRC	Co-I, pulsed transmitter laser lead
Bo. C. Trieu	NASA LaRC	Co-I, mechanical and thermal engineering
Dr. Jeffrey Y. Beyon	NASA LaRC	Data acquisition HW & SW
Dr. Upendra N. Singh	NASA LaRC	Co-I, pulsed transmitter laser
Carl S. Mills/Paul J. Petzar	NASA LaRC/NIA	Electronic design & fabrication
Dr. G. David Emmitt	SWA	Airborne Doppler lidar, pointing knowledge
Dr. Michael J. Kavaya	NASA LaRC	Principal Investigator
Garfield A. Creary	NASA LaRC	Project manager
John Cox	SSAI	Management consultant

Projects Comparison

	DAWN-AIR1	DAWN-AIR2
Approved Length	3 yr	3 yr
Start Date	~4/1/08 – 3/31/11	12/1/08 – 11/30/11
Airplane	DC-8	WB-57
Flights in Proposal	No	Yes
Lidar Operation	1-2 Operators	Autonomous
Environment	Aircraft Controlled T & P Ranges	Low T & Low P
Additional Hard Time Deadline	Ready by Summer 2010	No
Science Requirement in Addition to Preparing for Space?	Yes, Hurricane Science (GRIP)	No
Fly with GSFC Lidar	Goal	Goal

Projects Approach

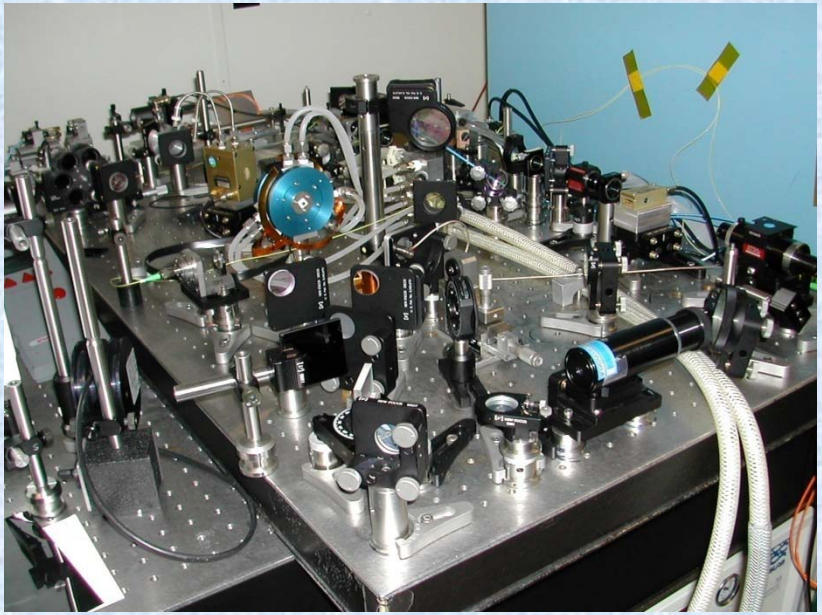
- Use the DAWN compact transceiver for both airplanes
- Add a rugged 15-cm telescope
- Add a rotating wedge scanner; 30 deg nadir (DC-8), 45 deg nadir (WB-57)
- Design one packaged transceiver/telescope/scanner for both airplanes

  (i.e., overdesign for DC-8)
- Perform some hardening of laboratory electronics for DC-8; mount in racks
- Repackage all electronics for WB-57
- Upgrade to autonomous operation for WB-57
- Utilize Emmitt technique of obtaining attitude knowledge of each lidar shot
- Attempt to co-fly with GSFC direct detection Doppler lidar on WB-57
- Propose to NASA GRIP to fly on DC-8 during hurricane mission
- Propose in future to do science flights for various applications

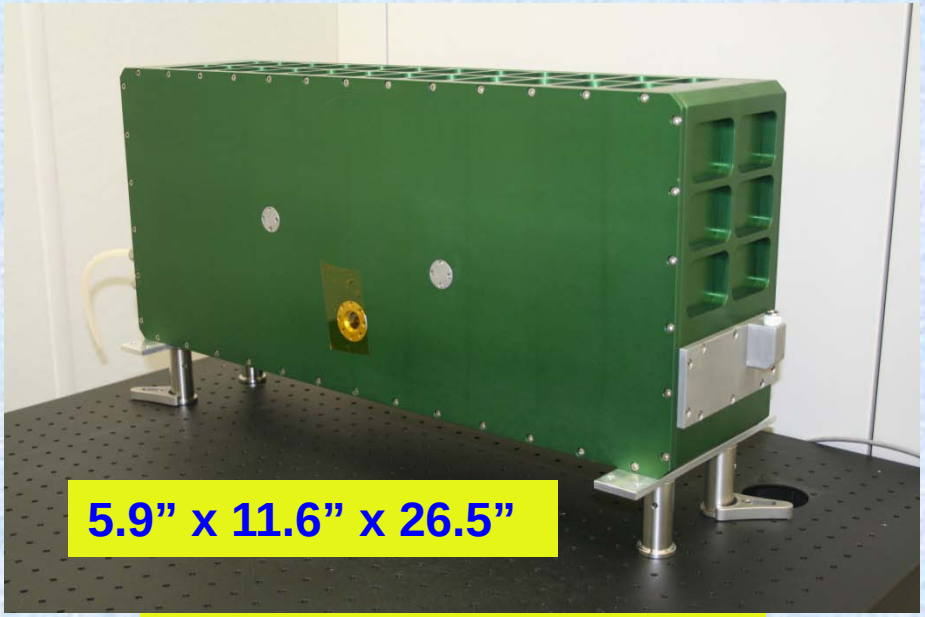
DAWN
Doppler Aerosol WiNd lidar

1. Compact laboratory laser
2. Add receiver components
3. Provide cooling

DAWN Transceiver (Transmitter + Receiver)
250 mJ/pulse, 10 pulses/sec.
5.9” x 11.6” x 26.5”, 75 lbs.; 15 x 29 x 67 cm, 34 kg
(no telescope or scanner)



Previous implementation
90 mJ per pulse



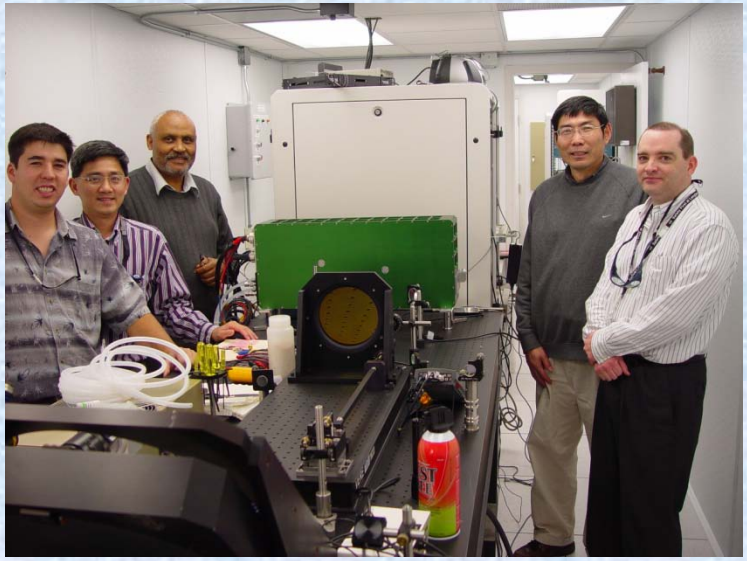
Completed DAWN package
Small, Robust, **250 mJ per pulse**

DAWN Transceiver vs. Commercial Doppler Lidar

Commercial Doppler Lidar

2 microns, 2 mJ, 500 Hz, 10 cm telescope
111 x 85 x 102 H inches, > $1 M

LaRC
IIP
DAWN

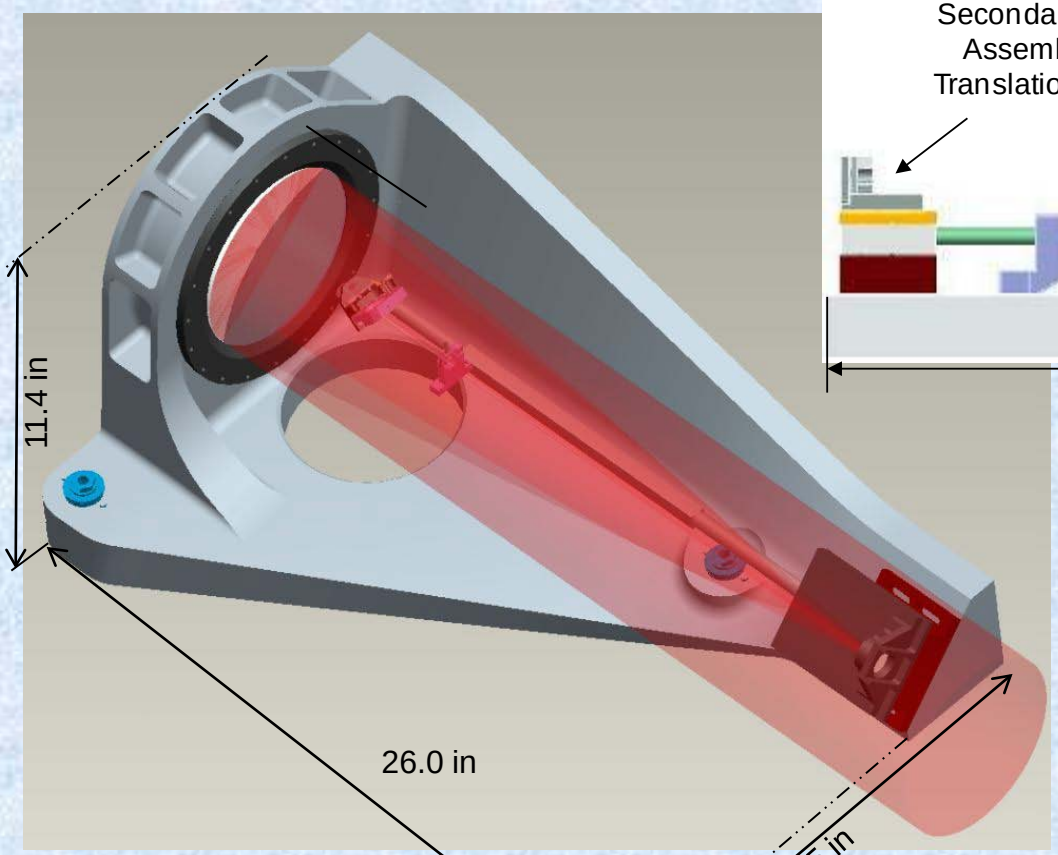


2 microns, 250 mJ, 5 Hz
15 cm telescope
Transceiver: 6 x 27 x 12 H inches

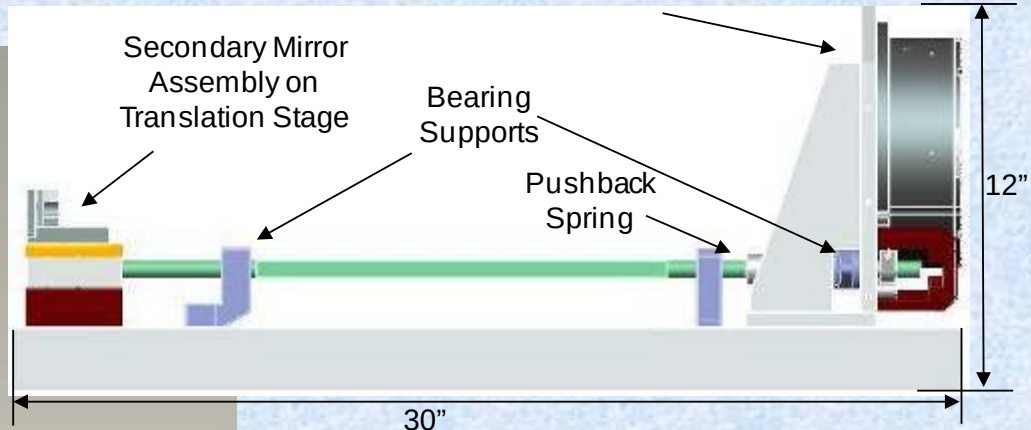
DAWN vs. COTS Unit
Wind figure of merit = E x $\sqrt{PRF}$ x D^2
Energy gain = x125
Energy-PRF gain = x13
Energy-PRF-diameter gain = x26
Either x26 in aerosol backscatter or x5 in range

Planned Telescope

Nu-TeK



Primary Mirror Assembly



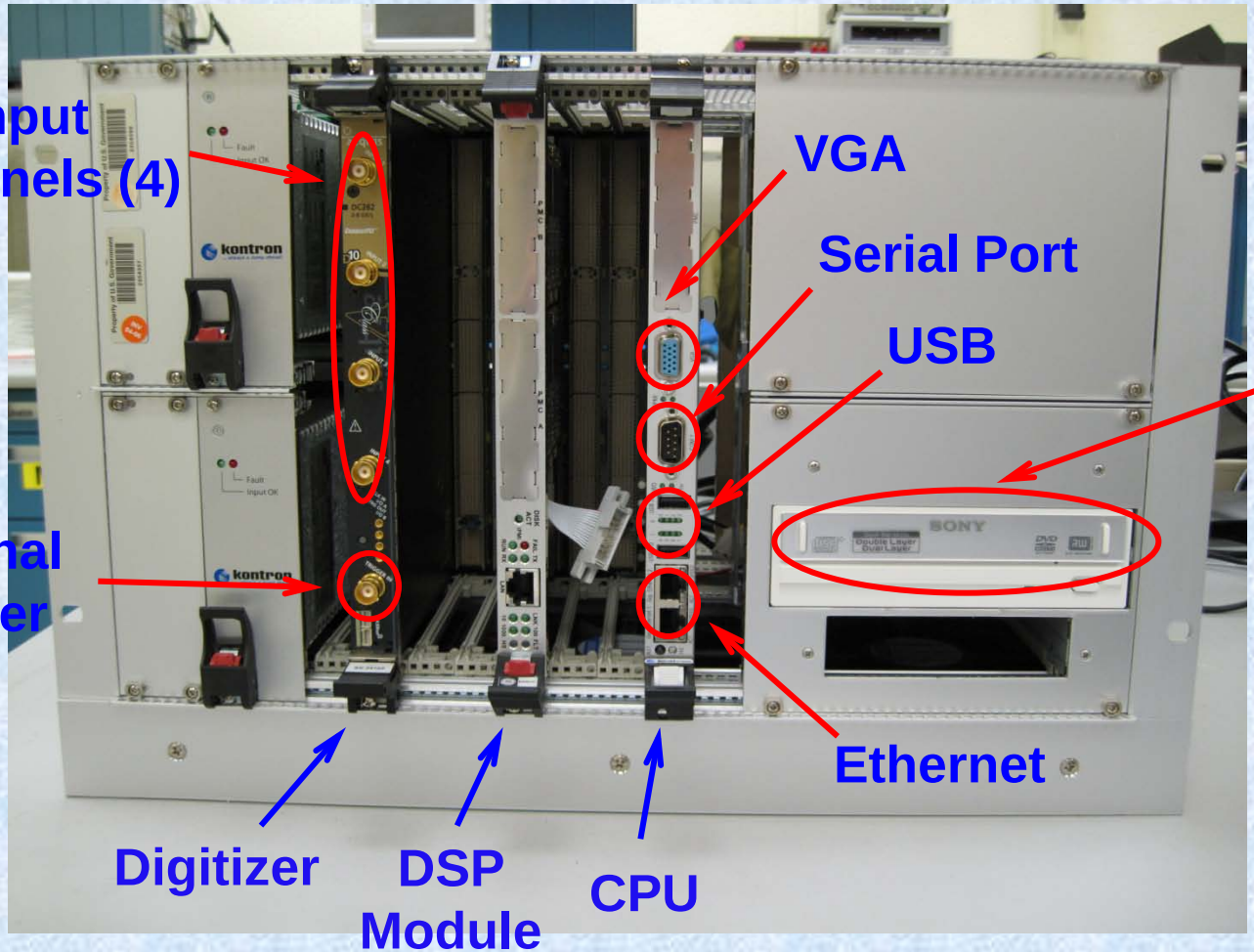
Planned Scanner

Newport's RV240CC Scanner

- Brushed DC motor (Direct & folded)
- ~ Sizes (ID: 6.89" or 175 mm):
  - Direct (11.5" x 17" x 3" H)
  - Folded (14.5" x 13.1" x 3" H)
- Bore: 175 mm (telescope aperture is 150 mm)

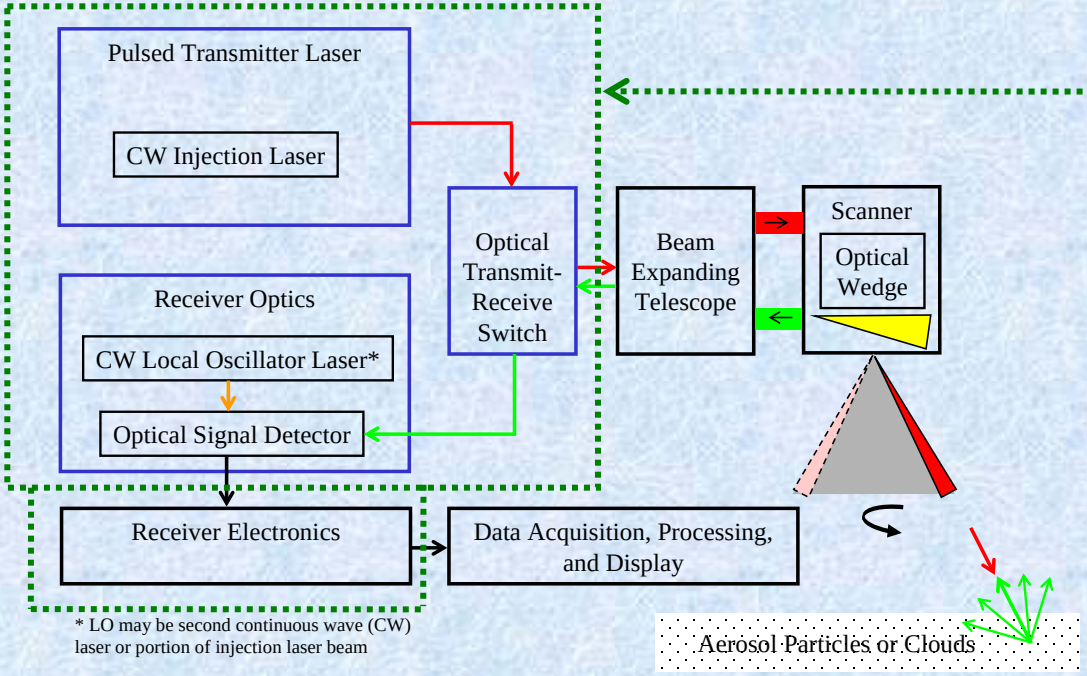
Planned Data Acquisition

500 Ms/s, 10 bit, 10 Hz, 16+ km
some real-time displays



DAWN-AIR1 Approach

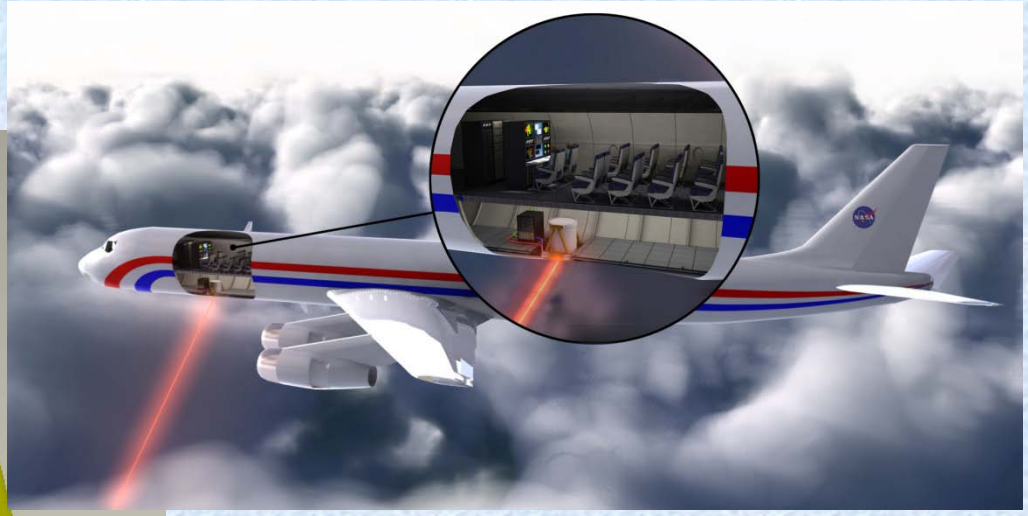
1. Add telescope and scanner to DAWN
2. Ruggedize electronics for DC-8

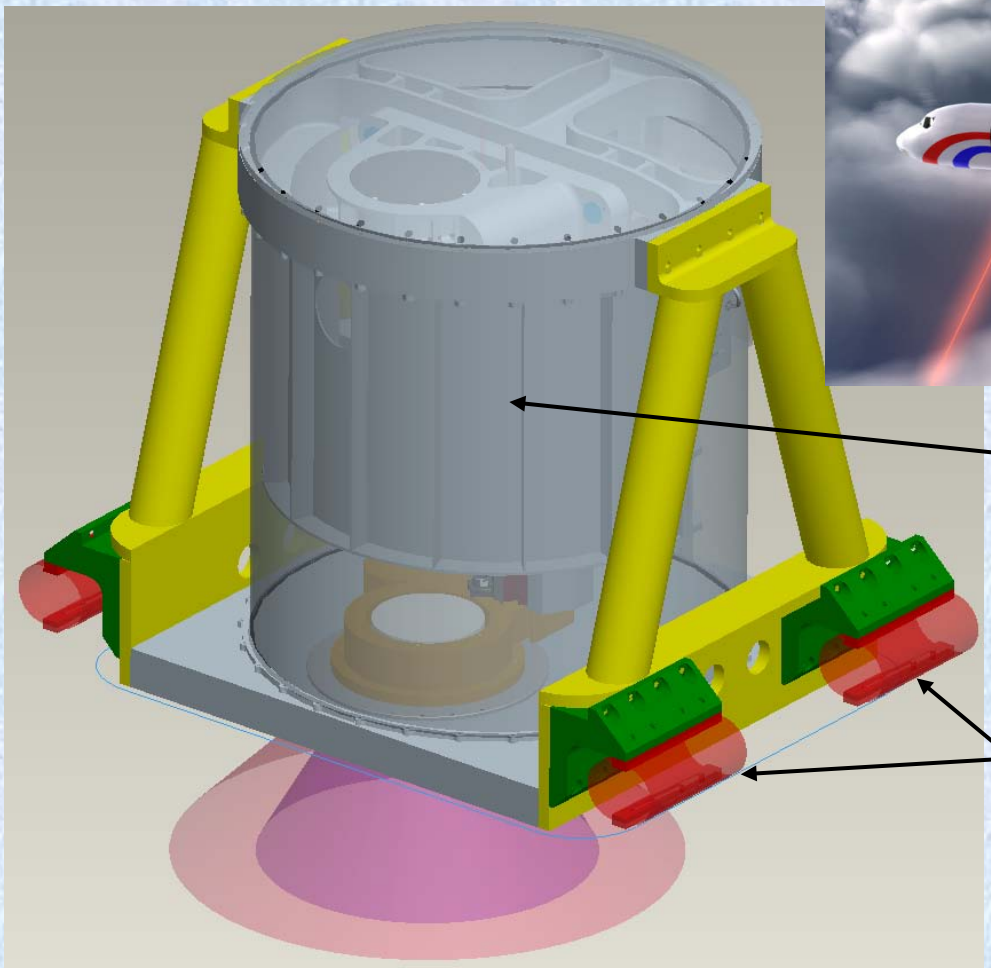


Schematic of 2-micron, pulsed, coherent-detection, Doppler wind profiling lidar system

DAWN Transceiver (Transmitter + Receiver)
250 mJ/pulse, 10 pulses/sec.
5.9” x 11.6” x 26.5”, 75 lbs.; 15 x 29 x 67 cm, 34 kg
(no telescope or scanner)

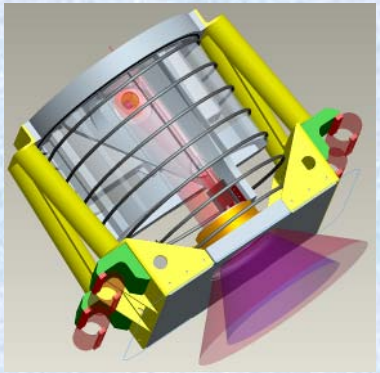
DAWN-AIR1





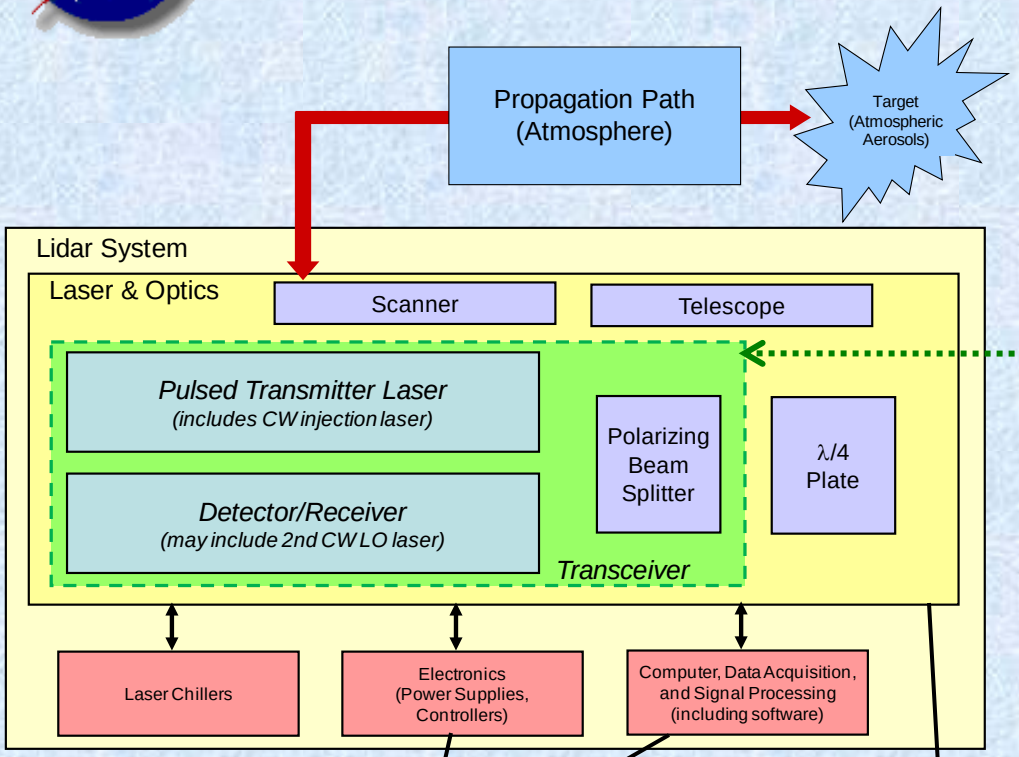
Lidar Sealed Enclosure
Contains:
DAWN Transceiver
Telescope
Scanner & Wedge

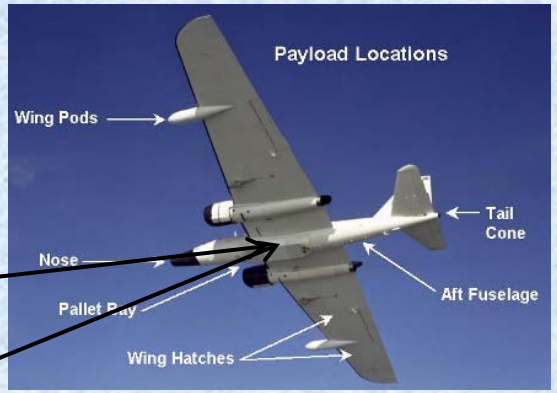
Vibration Isolation

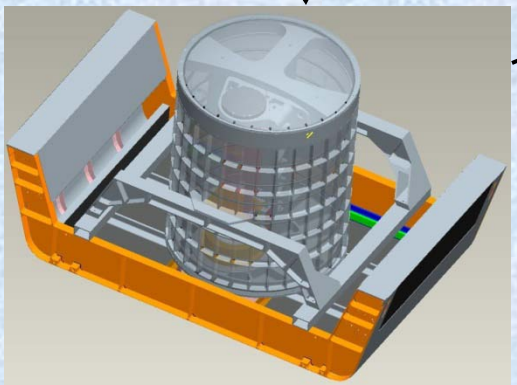


As shown with both the 30-deg and 45-deg cone

DAWN-AIR2 Approach







Conclusions

- We are grateful to SMD ESD and ESTO for the opportunity to validate the coherent Doppler lidar on two airplanes
- Wonderful team assembled at LaRC to perform these projects
- Standing on shoulders of LRRP and DAWN, etc.
- Look forward to performing science while proving this technology
- Hope to do first hybrid airborne demonstration with GSFC
- Airborne demonstration will be a large step towards confidence in a space instrument