Solid-State Cloud Radar System (CRS) Upgrade and Deployment

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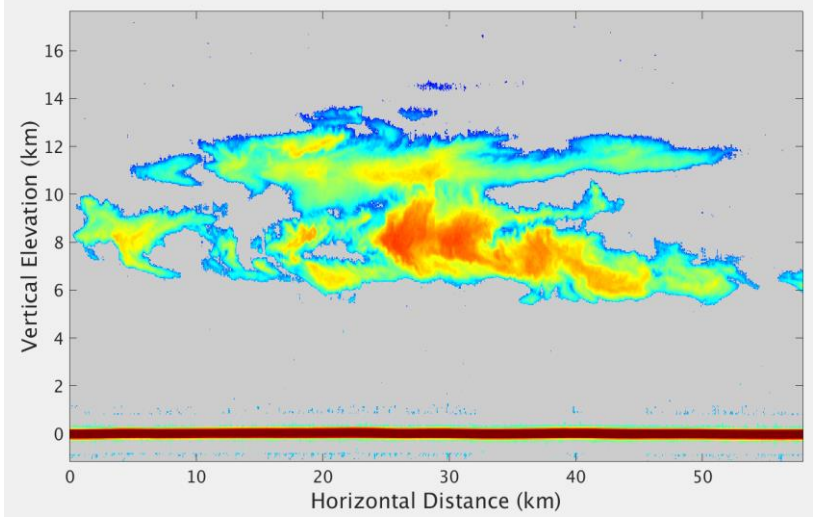
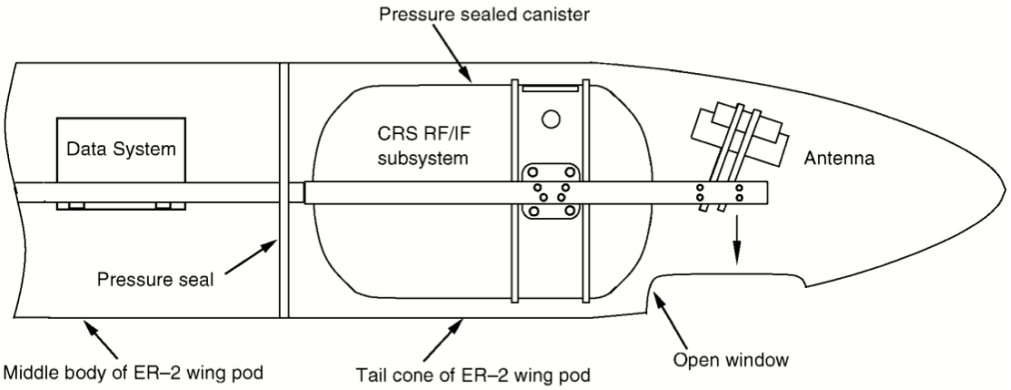
CRS – Airborne Cloud Measurements Since 2002

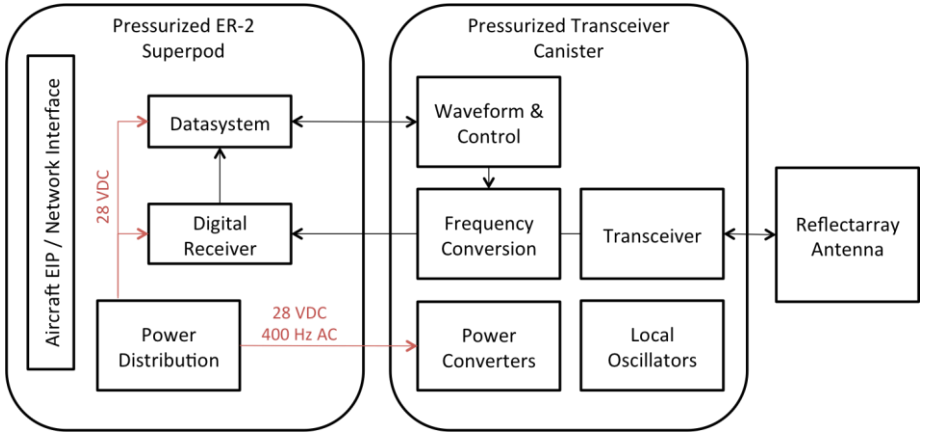
1993	CRS Initiated
2001	CRS Completed
2002	First Science Flights: CRYSTAL-FACE experiment
2006	CCVEx (CloudSat) experiment
2006	CR-AVE experiment
2007	TC4 experiment
2010	TCSP experiment
2012	Upgrade Started
2014	Upgrade Completed
2014	IPHEX experiment
2015	Upcoming RADEX-OLYMPEX experiment



CRS Installation

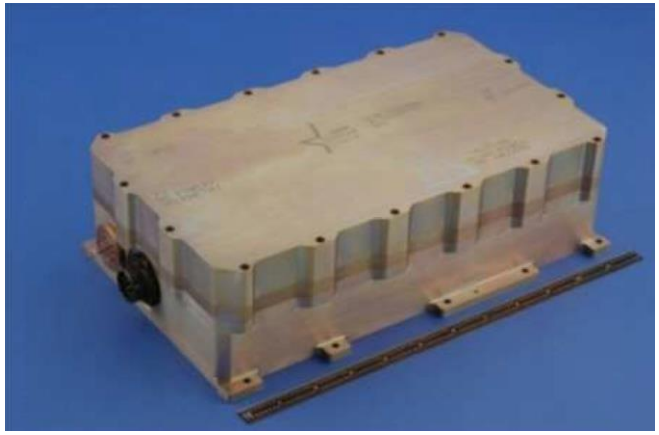
Image Credit: NASA / Carla Thomas





2014 CRS Upgrade - Modern Radar Technologies

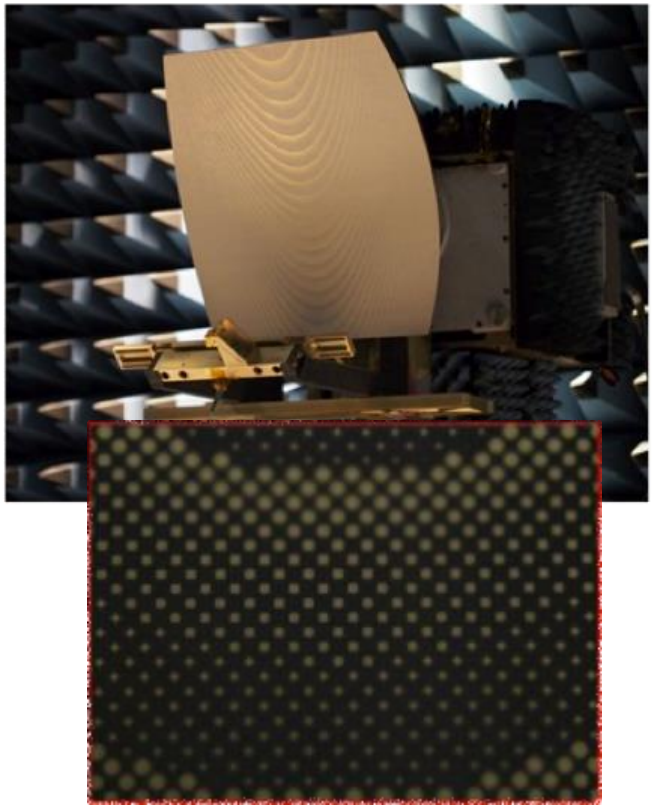
- Pulse Compression.
- Frequency Diversity.
- Low-noise receiver.
- Solid-State Power Amplifier (Also EIK compatible).
- Large reflectarray antenna.
- Internal Loopback Calibration

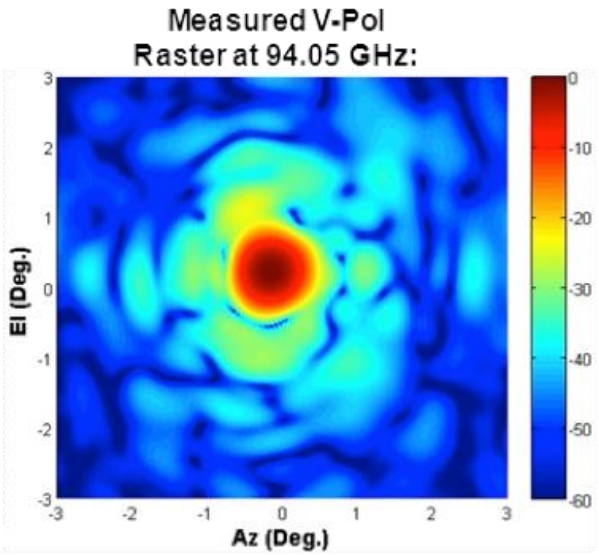


Parameter	Original System	Solid-State System
Frequency (GHz)	94.15	94.00
Peak Power (W)	1700	30
Pulse Width (us)	1	1, 30, 1
Pulse Repetition Time (us)	200 / 250	224 / 280
Noise Figure (dB)	10	8
Antenna Beamwidth (deg)	0.6 x 0.8	0.45
Antenna Gain (dB)	46.4	51
Effective Pulse Length (m)	150	150, 100, 150
Vertical Gate Spacing (m)	150	37.5

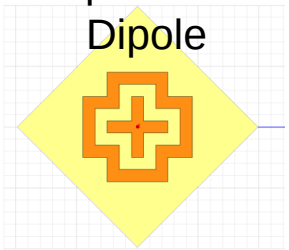
Reflectarray Antenna

The dual-frequency (Ka/W) reflectarray antenna designed by Northrop Grumman Electrical Systems (NGES) and NASA/GSFC for a 2010 IIP “Antenna Technologies for 3D Imaging, Wide Swatch Radar Supporting ACE (PI: Paul Racette) is a technology demonstrator for the ACE or CAPPM missions.

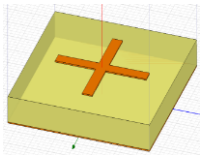




Loop/Crossed Dipole

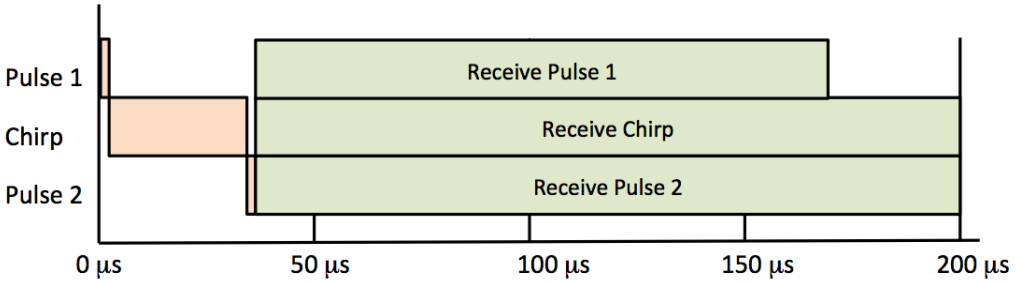


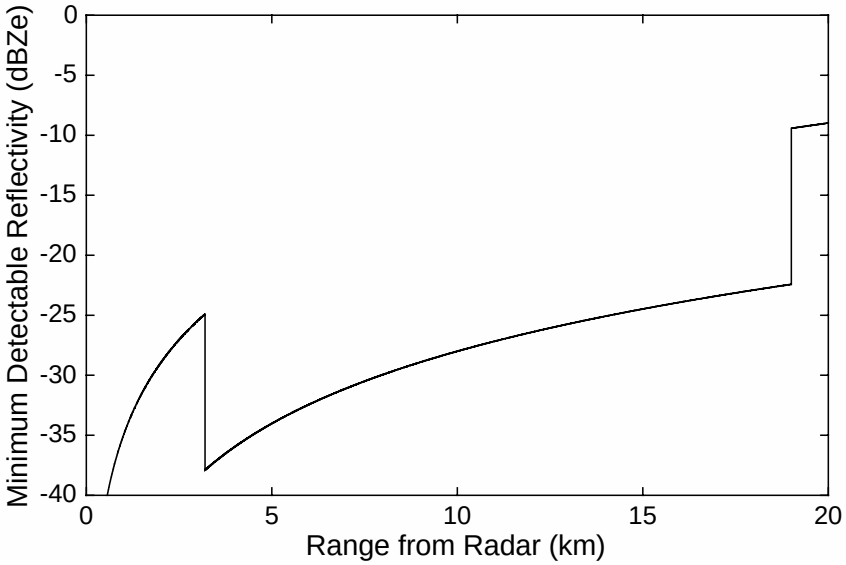
Crossed Dipole



Frequency Diversity Waveform

Frequency Diversity allows for the use of either pulsed or pulse compressed data depending on the presence of sidelobes or blind ranges

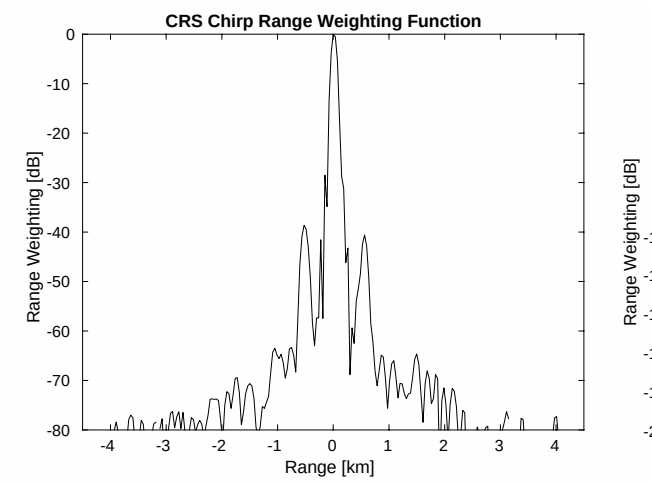


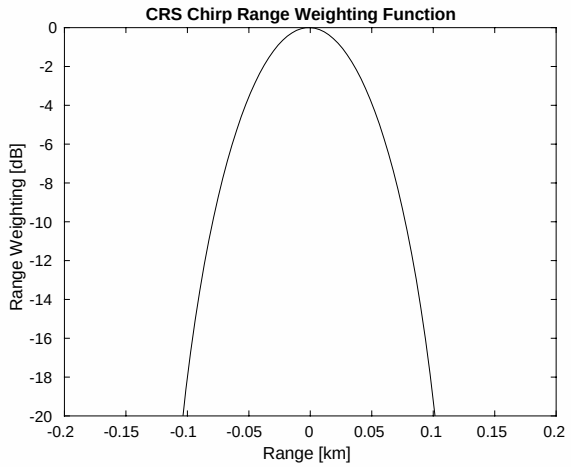


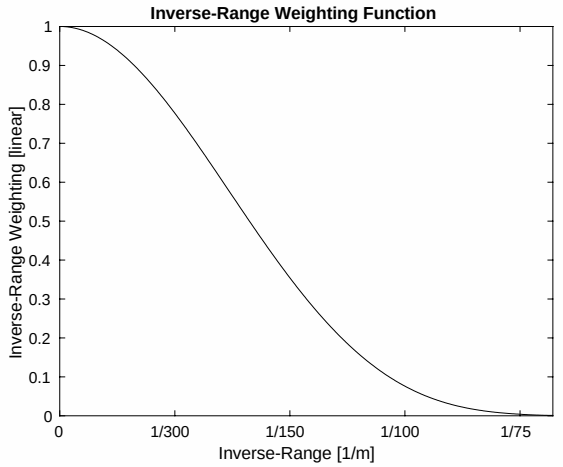
Spatial Resolution

Range Weighting Function Width (6 dB)	125 m
Range Sample Spacing	37.5 m
Horizontal Spatial Weighting (6 dB) at 10 km Range	150 m
Horizontal Sample Spacing	50 m

Using overlapping windows in range and time improves data quality by reducing image aliasing artifacts.

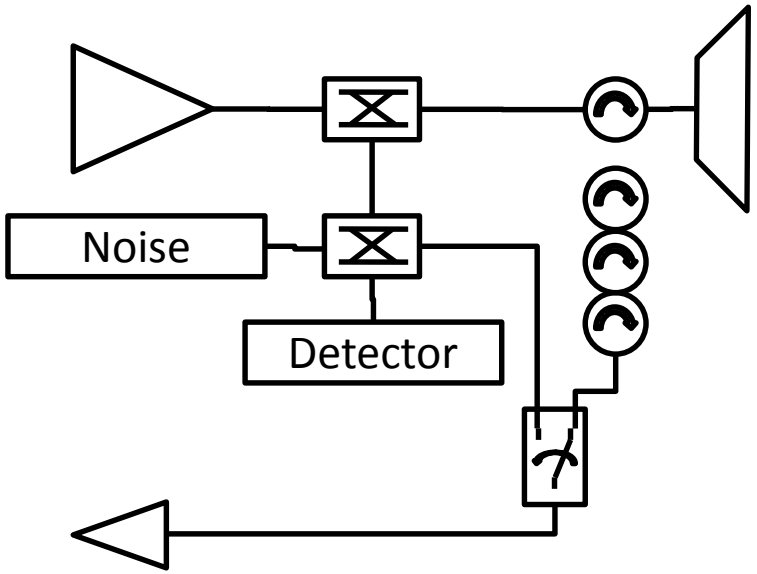






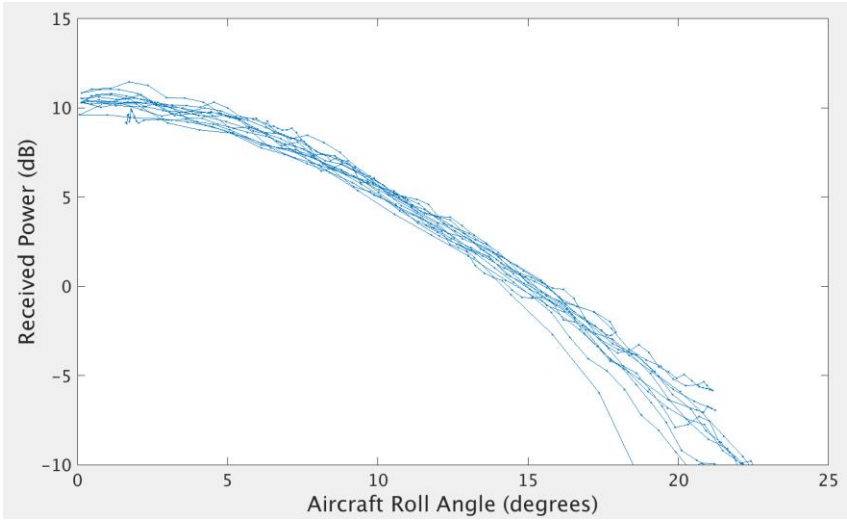
Calibration

INTERNAL



Internal calibration, using a combination of an attenuated loop-back path, a stable noise source, and a detector diode, maintains the external calibration over time.

EXTERNAL



External calibration uses the backscatter of the ocean surface over angle to provide absolute radar calibration.

Li, Lihua, et al. "Measurements of ocean surface backscattering using an airborne 94-GHz cloud radar-implication for calibration of airborne and spaceborne W-band radars." Journal of Atmospheric and Oceanic Technology 22.7 (2005): 1033-1045.

IPHEX Experiment, 2014

The GPM Integrated Precipitation and Hydrology Experiment May-June 2014

GSFC ER-2 Instruments

HIWRAP	(Radar)	13.91/13.47 GHz, 35.56/33.72 GHz
EXRAD	(Radar)	9.626 GHz (nadir); 9.596 GHz (scanning)
CRS	(Radar)	94.00 GHz
CoSMIR (Radiometer)		53 (x3), 89, 165.5, 183.3+/-1, 183.3+/-3, 183.3+/-8 GHz

CRS flights funded through IIP and RADEX

Data from IPHEX