

Weather Radar The Next 10 Years NBAA 2012, Orlando Florida

Craig Peterson
Director of Avionics Marketing

**Rockwell
Collins**

Rockwell Collins Radar (Historical Perspective)

1956 First Rockwell Collins Airborne Weather Radar

1980 First Rockwell Collins Solid State Weather Radar (Air Transport)

1987 First Rockwell Collins Solid State Weather Radar (Corporate and Gen Av)

1995 Predictive Windshear Systems Certified (Air Transport)

2002 Multiscan Radar Certifies (Auto-tilt, Auto Ground Clutter Suppression, Global Geographic Correlation)

2009 Multiscan Radar Certifies (Corporate and Regional Jet Platforms)

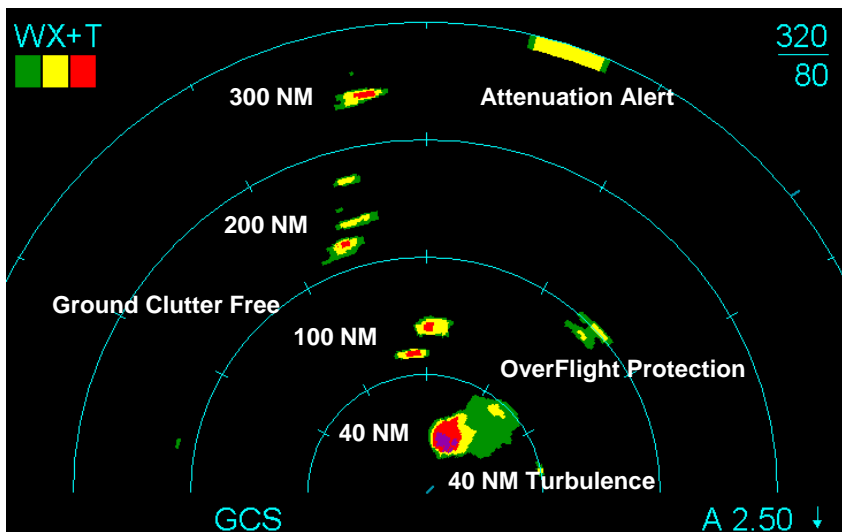
2013 Multiscan "Version 2" Enters the Air Transport Market Segment

2013 Predictive Windshear Enters Corporate and Regional Market Segment

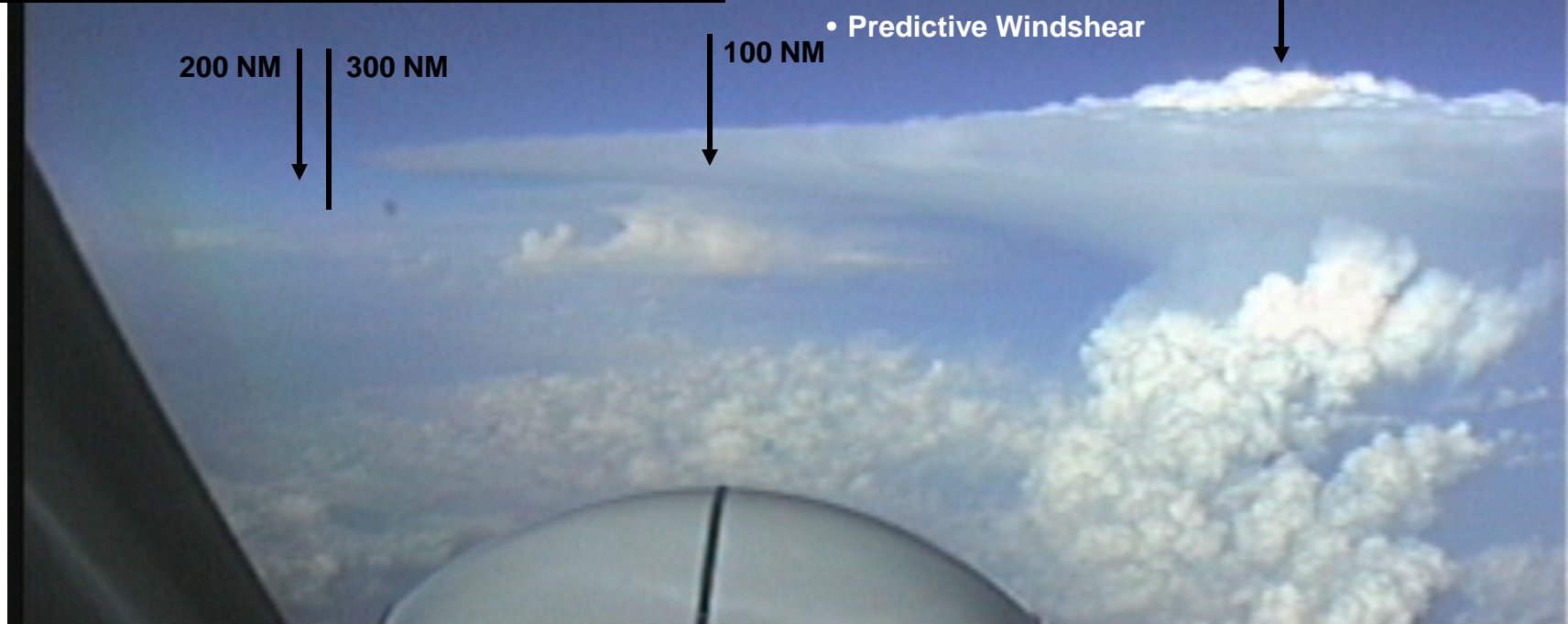
50+ Years and 40K Units of Airborne Radar at Rockwell Collins

What Is MultiScan?

MultiScan Baseline Functionality



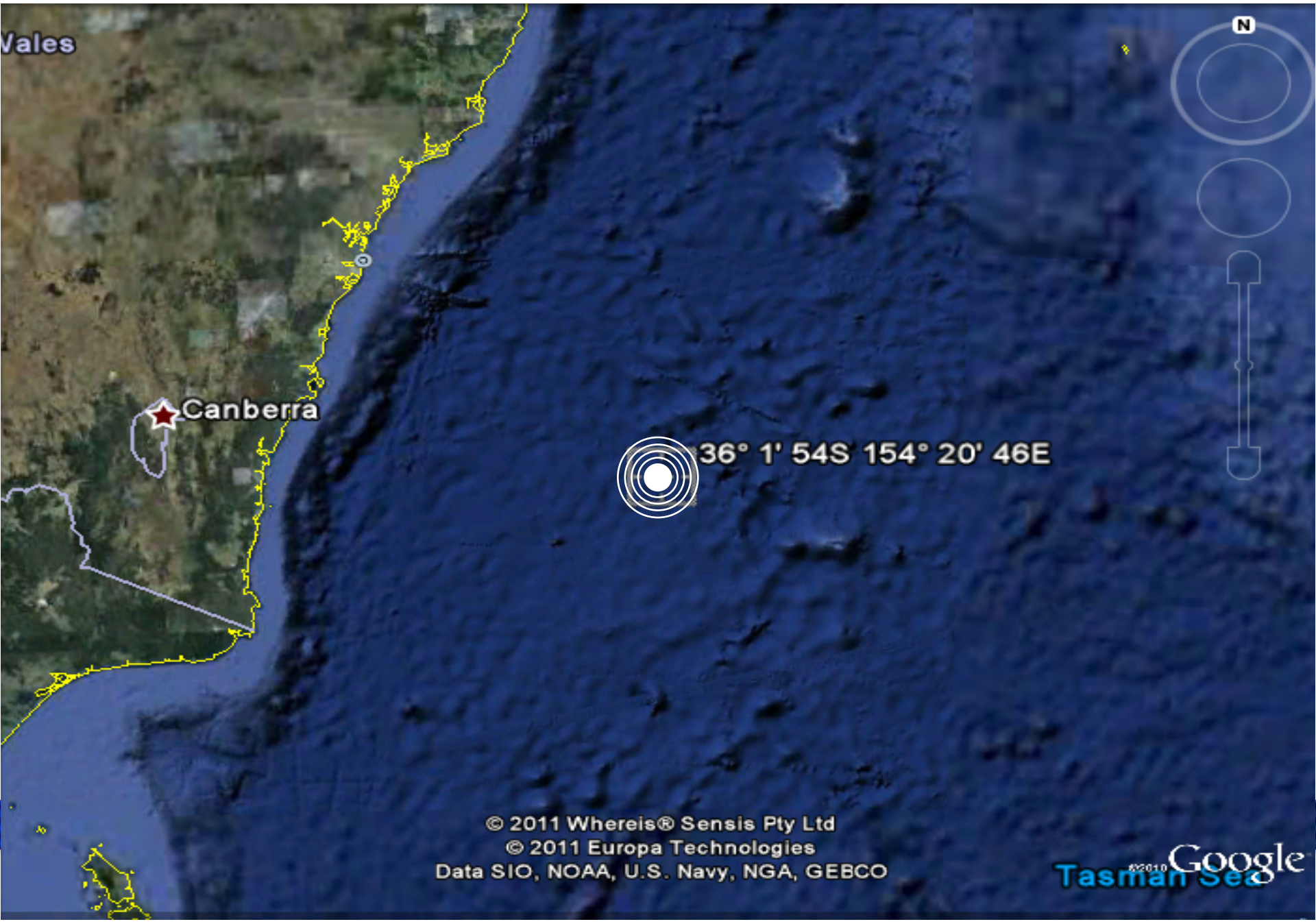
- Accurate Weather that affects the aircraft flight path from the nose of the aircraft to 320 NM
- 1st Generation Threat Analysis based on region and time of year
- Ground Clutter Free Display
- Attenuation Alert
- Certified Turbulence to 40 NM
- OverFlight™ Protection
- Predictive Windshear



A Complete Threat Picture



Complete Threat Picture at a Glance



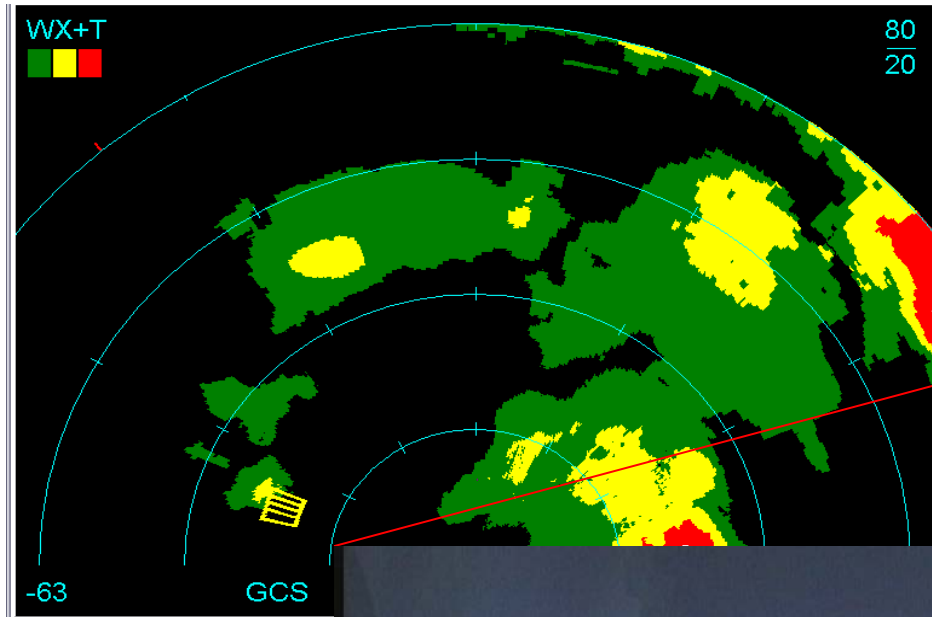
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO

MultiScan Version 2

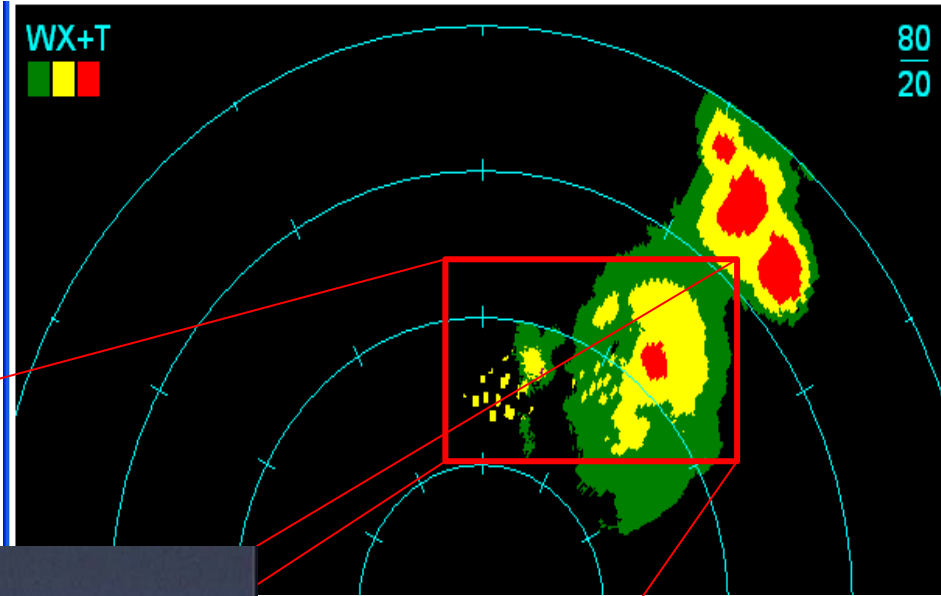
Summary of V2 Features

- Version 2.0 Threat Assessment Features
 - Track-While-Scan Cell Analysis
 - Inferential Lightning, Hail and Convective Assessments
 - Predictive Overflight Protection
 - Flight Path Threat Assessment
 - Two-Level Enhanced Turbulence Detection

Predictive OverFlight icon

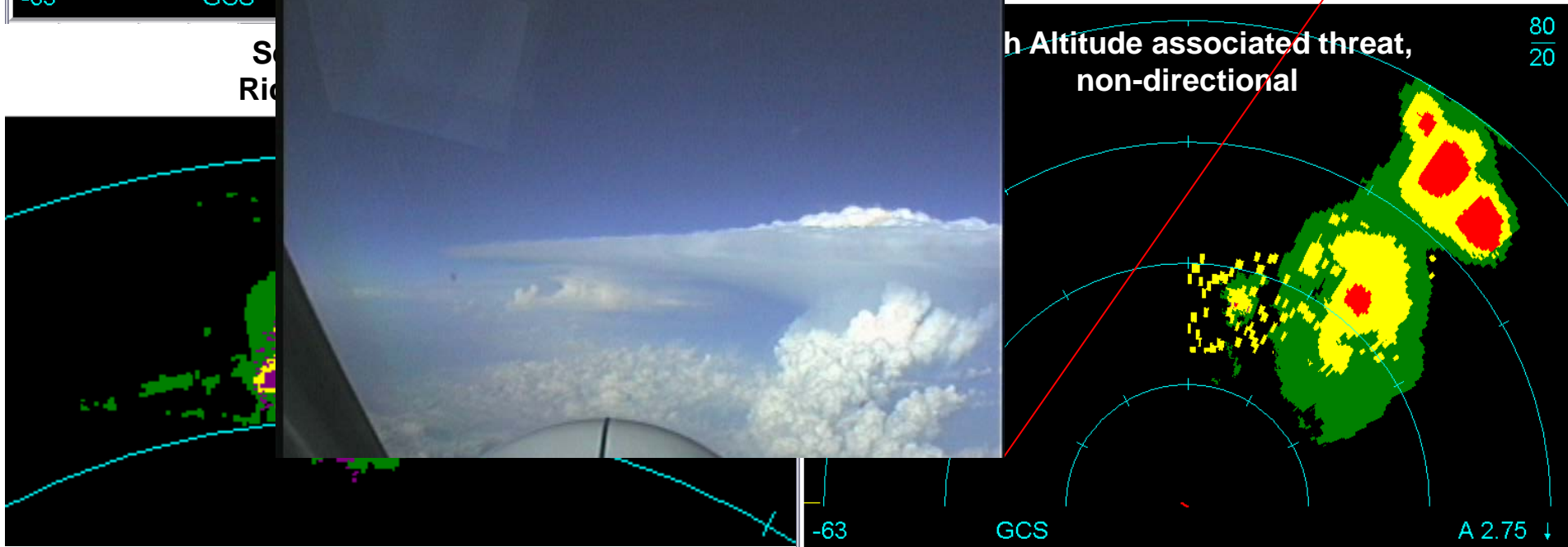


High Altitude associated threat,
directional wind vector



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High Altitude associated threat,
non-directional



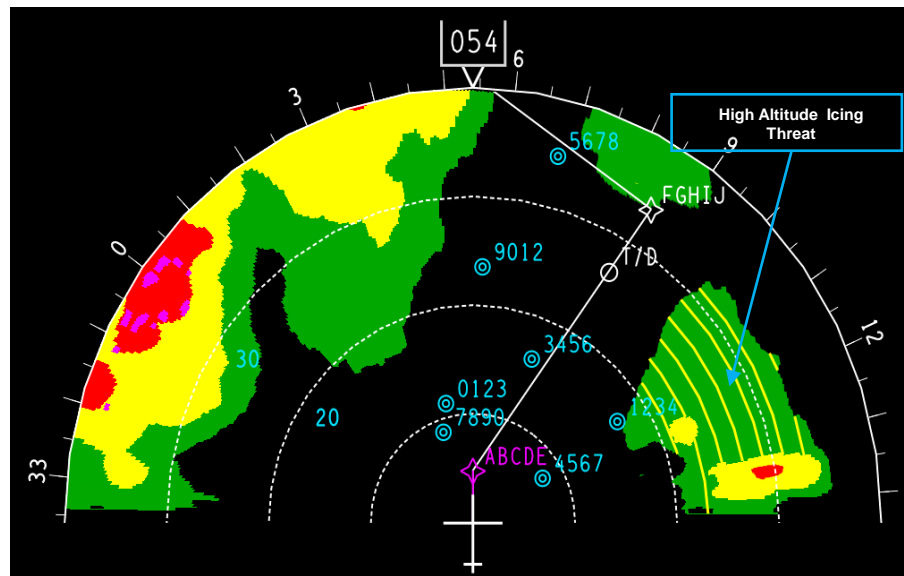
Potential Future Features & Functions

High Altitude Ice Crystal Detection

What Is It?

- Ice Crystals that form at high altitudes
- Ice particles can adhere to compressors turbofan engines and lead to flame-outs
- Radar would directly or indirectly detect the existence of HAIC and provide indications to crew for avoidance

Note: Early discussions suggest that the current MultiScan radar may provide HAIC warning if used and interpreted properly in AUTO



Value Propositions;

- **Enhanced Situational Awareness**
 - Strategic Route Planning
- **Enhanced Safety (Hazard Avoidance)**
 - Enhance Aircraft and Flight Safety
 - Prevent engine flame outs
- **Life Cycle Cost Reductions**
 - Prevent / reduce engine maintenance cost

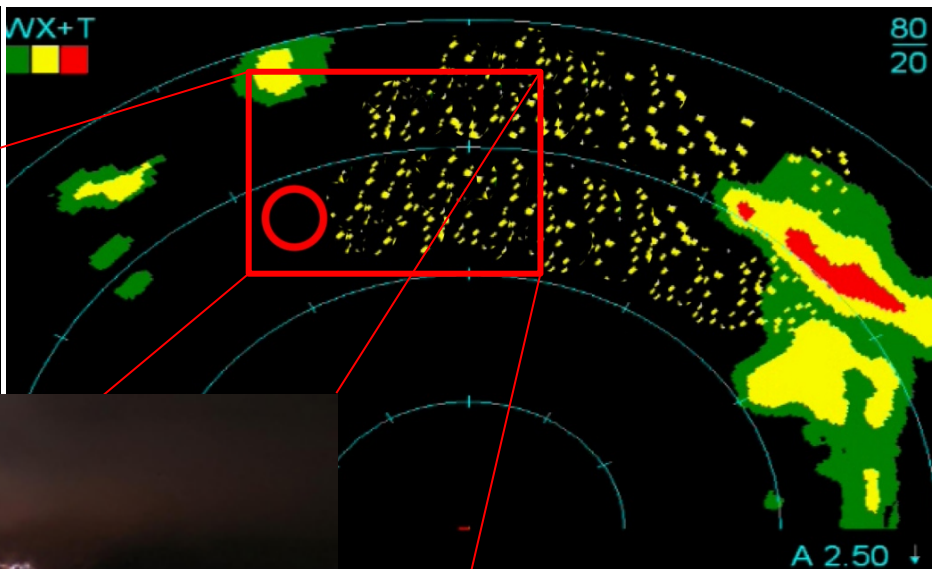
Implementation Issues;

- **May Require Graphical HMI Changes**
 - Colors or Symbols
 - A708A Definition Changes
 - Display Changes
- **Will Require Weather Radar Changes**
 - Possible Hardware (Processing, Antenna, etc...)
 - Software Algorithms
- **Retrofit vs Forward Fit Considerations**

Direct Lightning Detection (Volcanic Ash Correlation)

What Is It?

- The Addition of a direct lightning detection system to the weather radar pedestal
- The addition of a "Volcano" Database
- Indications on the map of directly detected lightning



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Graphical HMI Changes
r Symbols
definition Changes
Changes

Additional Sensor Hardware,
connectors

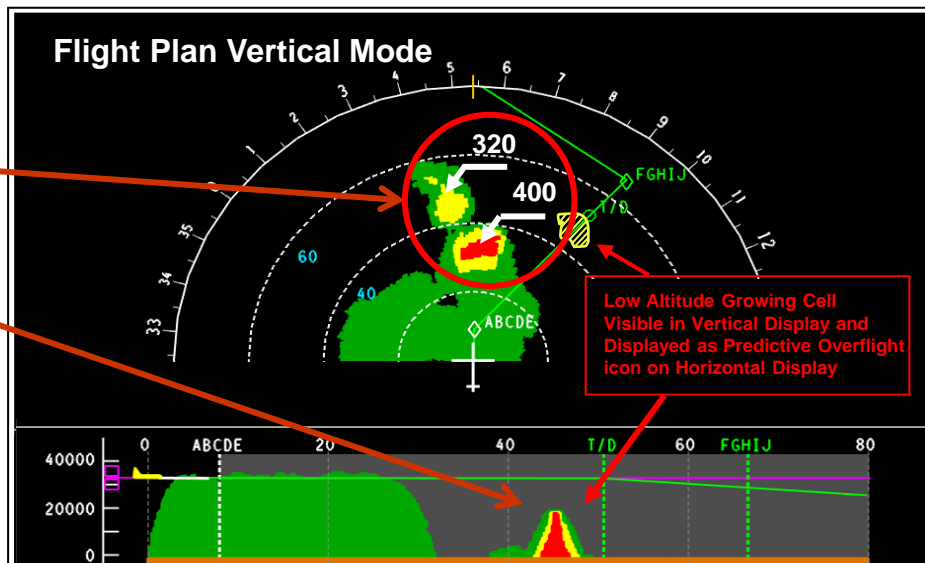
cy Interference if implemented
cloud detector.

orward Fit Considerations

Vertical Weather Depictions

What Is It?

- The Addition of “Tops” Indication for Convective Cells on the Navigation Display
- The Addition of weather on the vertical situation display
 - Along the A/C track
 - Along the FMS Path
 - Along a Pilot Selectable Azimuth



Value Propositions;

- **Enhanced Situational Awareness**
 - Provides Granularity and Understanding of vertical threat (when and how to deviate)
- **Enhanced Safety (Hazard Avoidance)**
 - Can Enhance diversion decision making
- **Life Cycle Cost Reductions**
 - Fuel and Time Savings by reducing unnecessary diversions.

Implementation Issues;

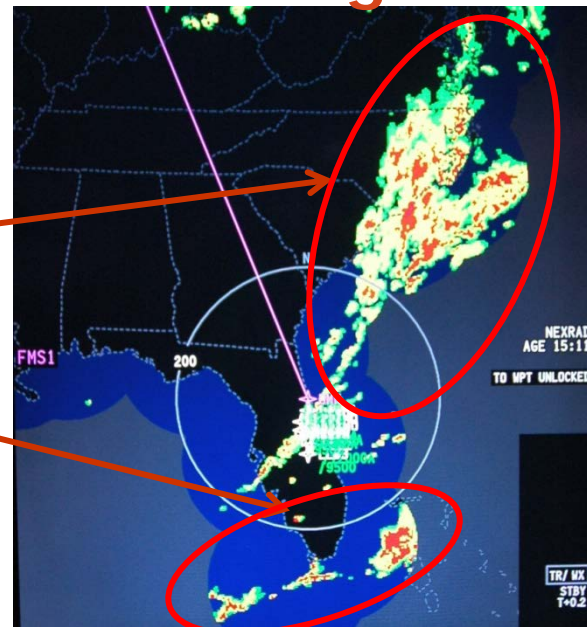
- **Will Require Graphical HMI Changes**
 - Format and Symbology Changes to Display
 - A708A Definition Changes
 - Interface and control changes
 - Potential FMS changes (I/O) to support
 - Display Changes
- **Tops Precision for displays realistically only achieved at short ranges.**
- **Retrofit vs Forward Fit Considerations**

Uplink Weather with Airborne Weather Merge

What Is It?

- Datalink transmission, storage, and retrieval ground based weather products for display on the primary displays
 - Ground Based Radar
 - Satellite Imagery
 - Other Products

- The merging of these uplink products with airborne weather radar



Value Propositions;

- **Enhanced Situational Awareness**
 - Strategic Depiction of Weather
 - Products and Capabilities not provided by airborne weather radar (see next slide)

- **Enhanced Safety (Hazard Avoidance)**
 - Can Enhance diversion decision making

- **Life Cycle Cost Reductions**
 - Fuel and Time Savings by enhancing strategic route planning.

Implementation Issues;

- Will Require Graphical & HMI Changes
 - Control Mechanisms must be implemented
 - Display Changes

- Uplink weather products have limitations
 - Latency of the displayed product
 - Geographic Coverage
 - Presentation (color) differences vs airborne weather
 - High bandwidth requirements
 - Disparate Content providers

- Commercial Alternatives (i-Pad, laptops, etc..)

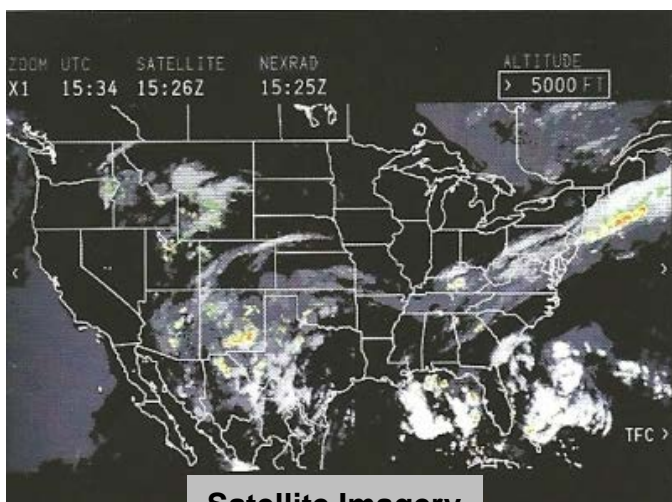
Uplink Weather Product Examples



Ground Based Radar Imagery



**Merged Ground Based Radar and Satellite Imagery
Rockwell Collins Pro-Line Fusion**

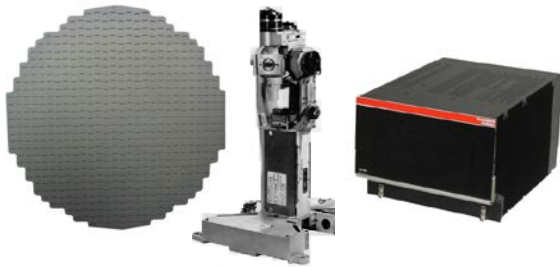
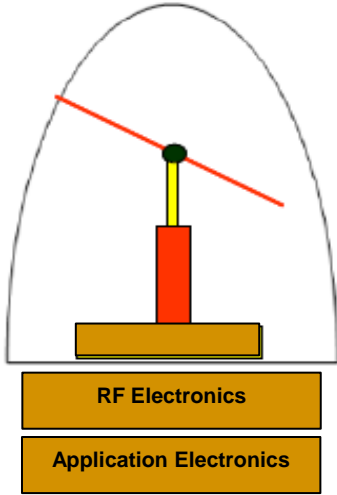


Satellite Imagery

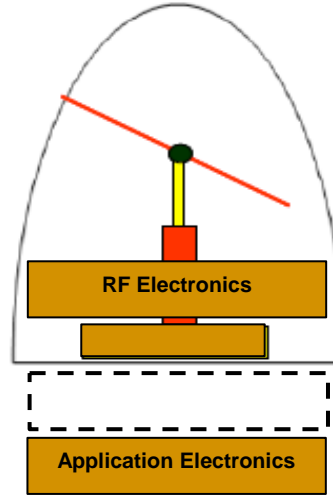
Next Generation Architectures & Technology

Radars Architecture Trends

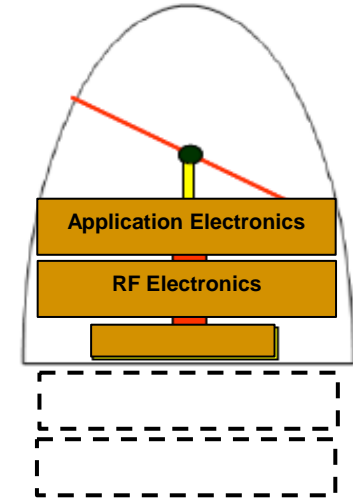
**Current WRT-2100
Federated Air Transport Radar**



**Current Rockwell Collins
Integrated Air Transport Radar**



**Current Rockwell Collins
RTA-40XX Corporate / RJ Radar**



Considerations;

- Environmental Ramifications Outside Pressure Vessel (MTBF,MTBUR)
- Access to Radome
- Redundancy on Aircraft (one or two radars)
- Manufacturing Complexity (Waveguide)

Questions?

Rockwell Collins Radar Product Timeline

1956-1966

WP-101, 102
Collins First
Airborne
WXR
Manufacture
d in Dallas



1969

WX-80
15KW Mag
300 nm
Range

1976-1982

General Aviation
Radar Product
Family Introduction
WXR-150, 200 Series
WXR-300 Series
2 Box Magnetron
Digital Color Displays

1980

WXR-700X/C
Air Transport
Product
Introduction
First All Solid State
Transmitter
Digital Processing
Digital Aircraft
Interfaces
Coherent Frequency
Plan

1983

WXR-
700X/C
Doppler
Turbulence
Detection
Industry
First

1987

TWR-850
First Fully
Integrated
Solid State
BRS Radar
System for
Beech
Starship

1989-1993

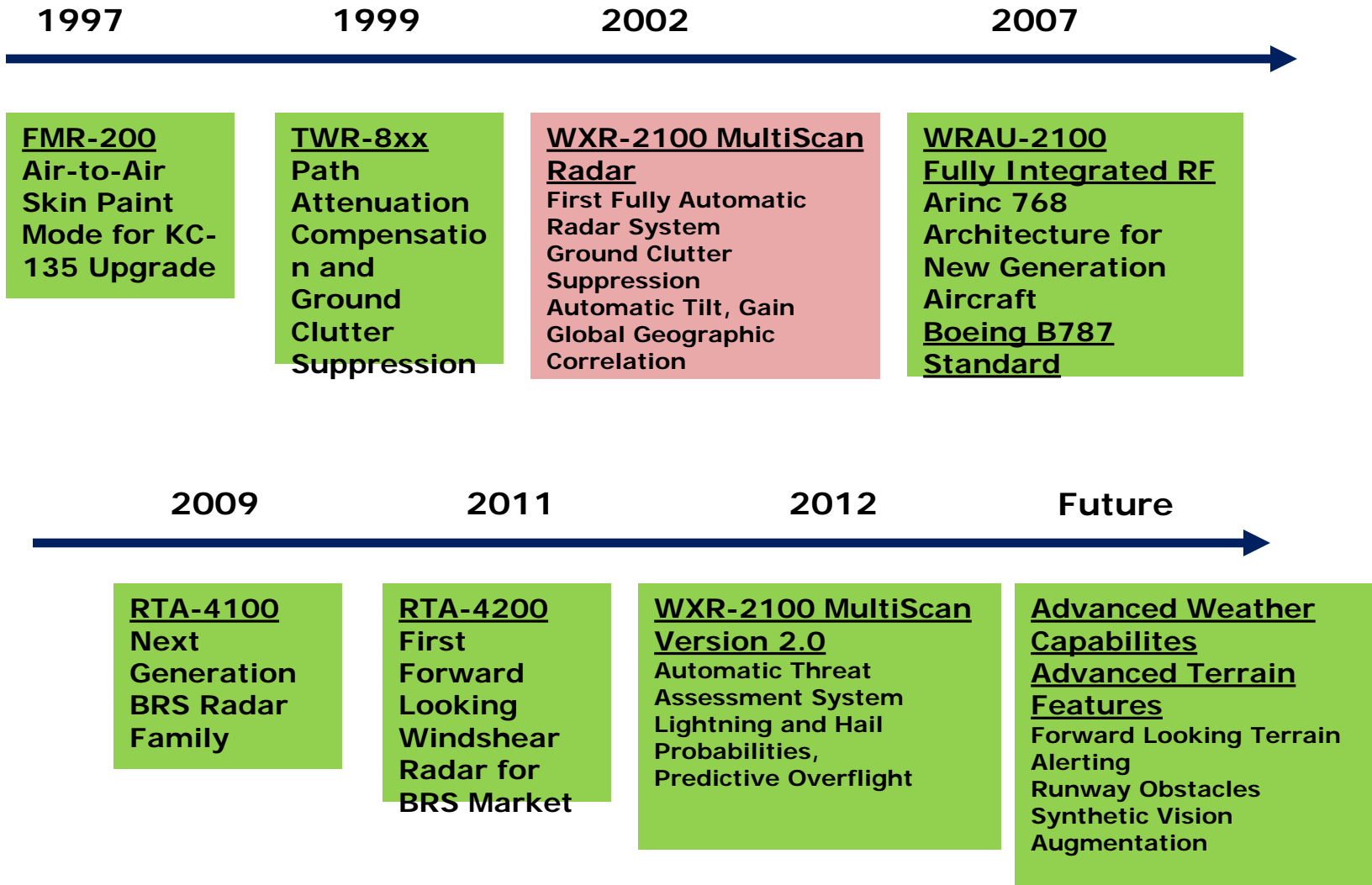
NASA Experimental
Research Radar
Forward Looking
Windshear Research
Platform
B737 Flight Test
Aircraft

1995

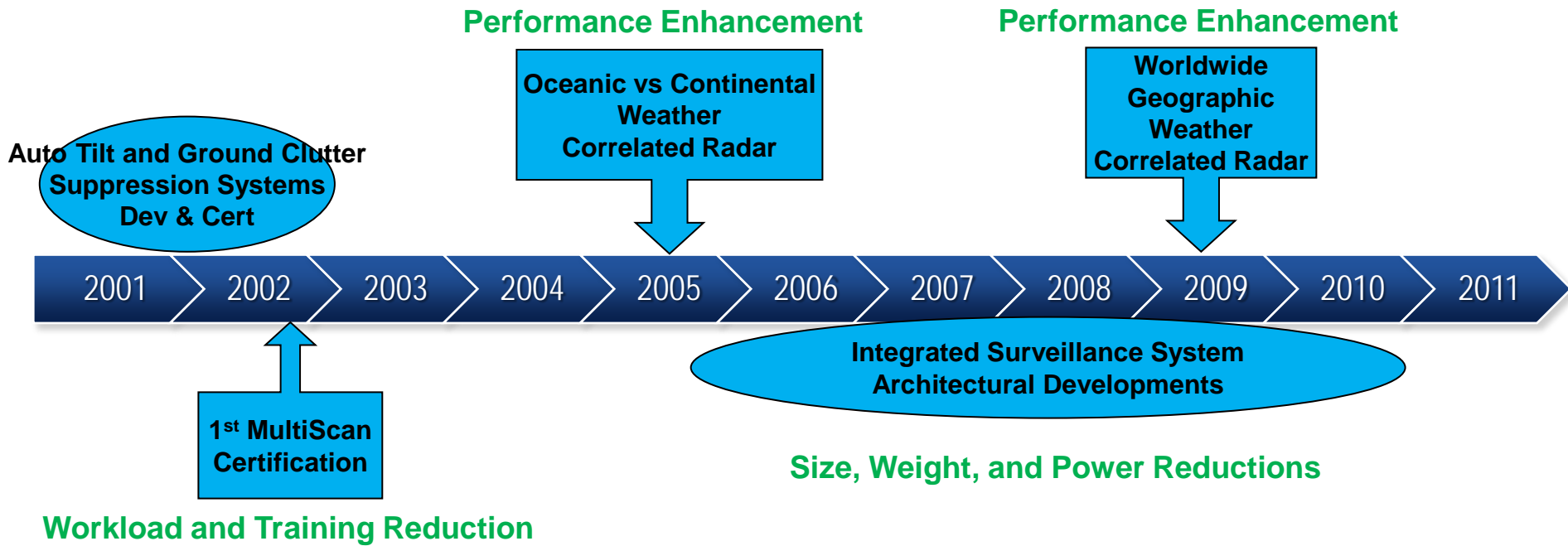
WXR-700X
Forward Looking
Windshear
Detection
Certification



Rockwell Collins Radar Product Timeline









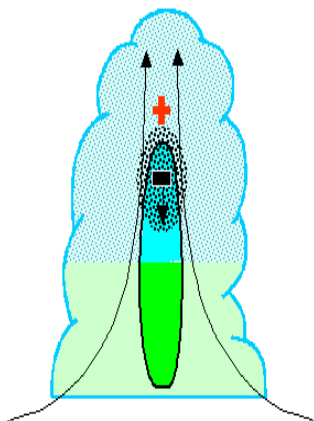
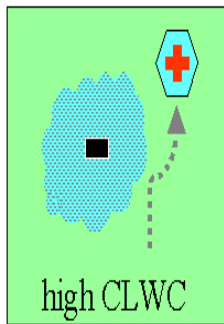
Radar Product Capabilities (Historical Perspective)



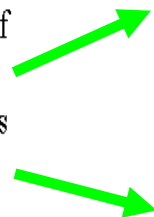
Historical Investments In Radar Have Been Value Based

Lightning Production - Convective Cell 'Growth' Stage

Low CLWC	
High CLWC	
Low SC-CLWC	
High SC-CLWC	
Small ice only	
Large & small ice	

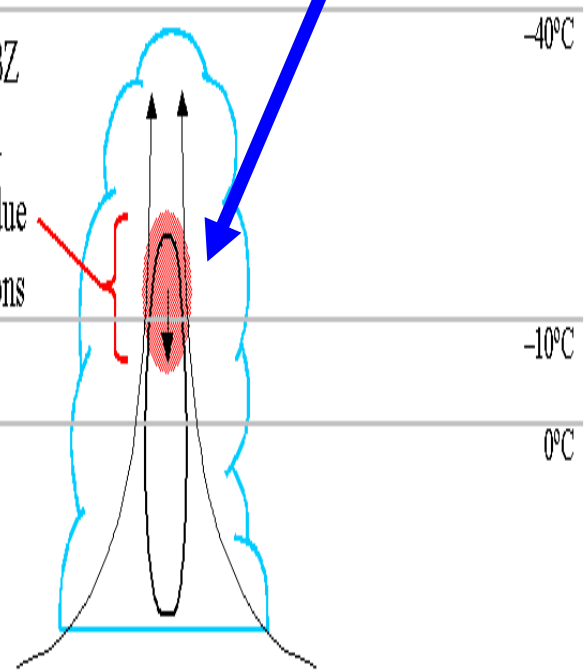


1. Electrification begins at mid-levels with the development of graupel
2. Electrification results from millions of collisions between graupel and ice crystals
3. A small amount of charge is transferred during each collision
4. Graupel charges negative, ice crystals charge positive



Radar echo > 35 dBZ first appears around $T = -10^{\circ}$ to -20°C due to high concentrations of millimeter-sized graupel

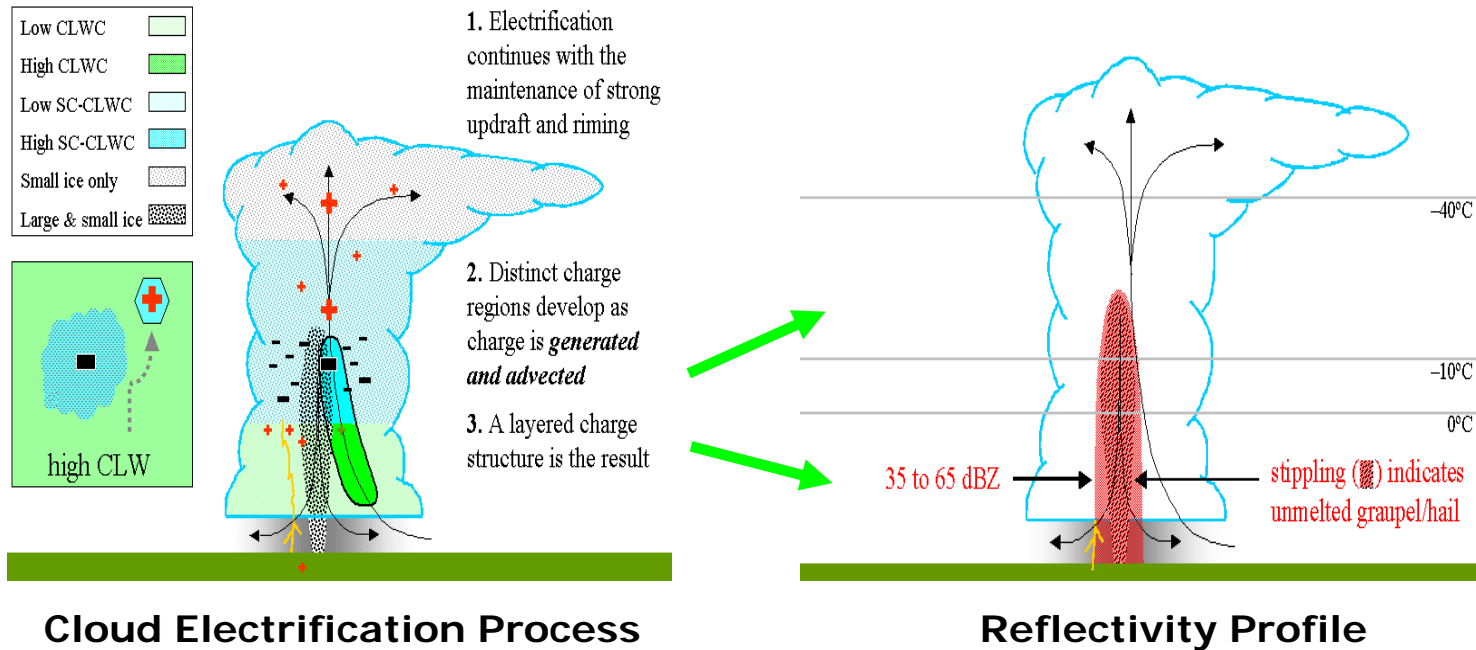
Cell Region Where Lightning Generation Begins



Reflectivity Indicator

Cloud Electrification Process

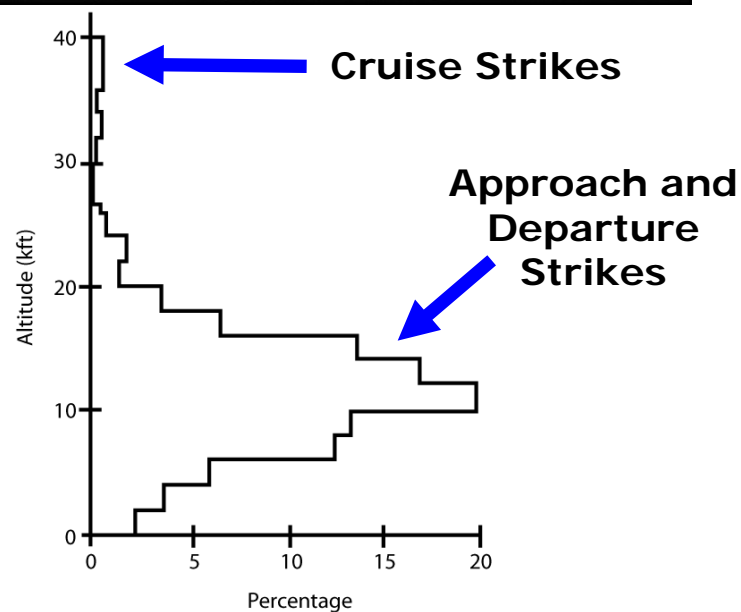
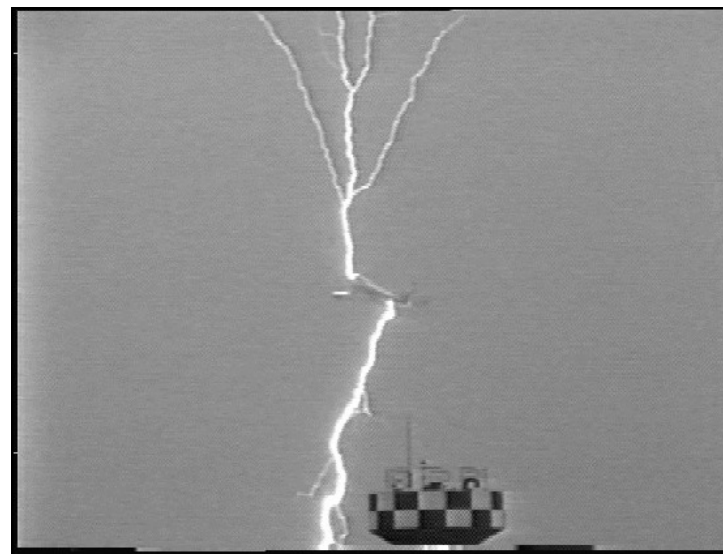
'Mature' Cell Development Stage



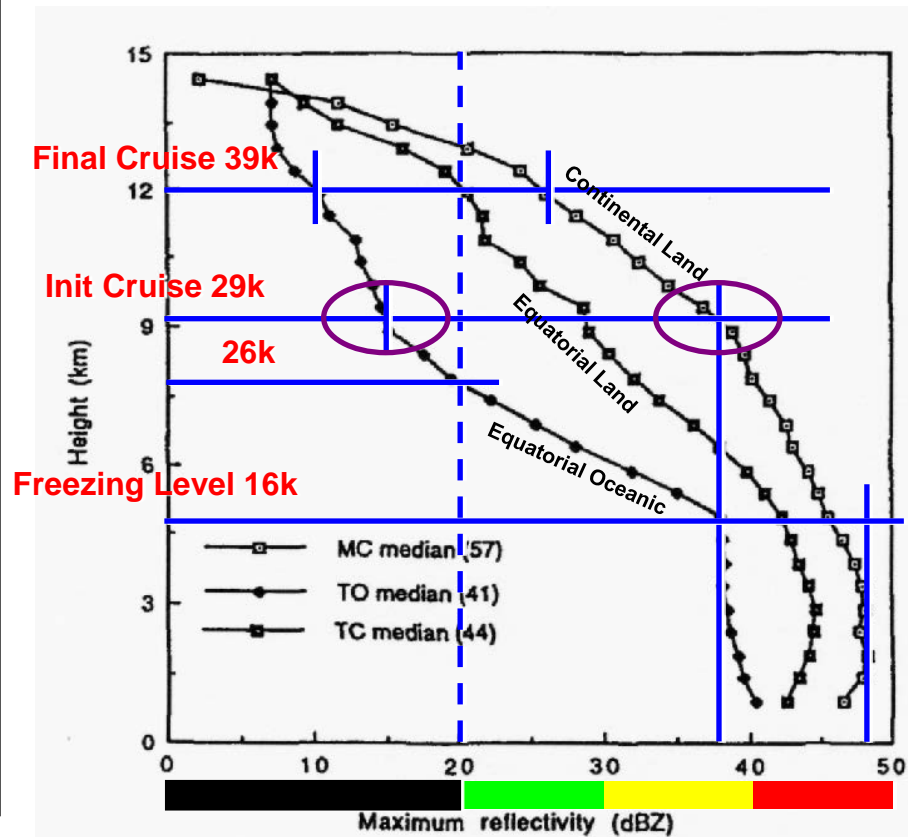
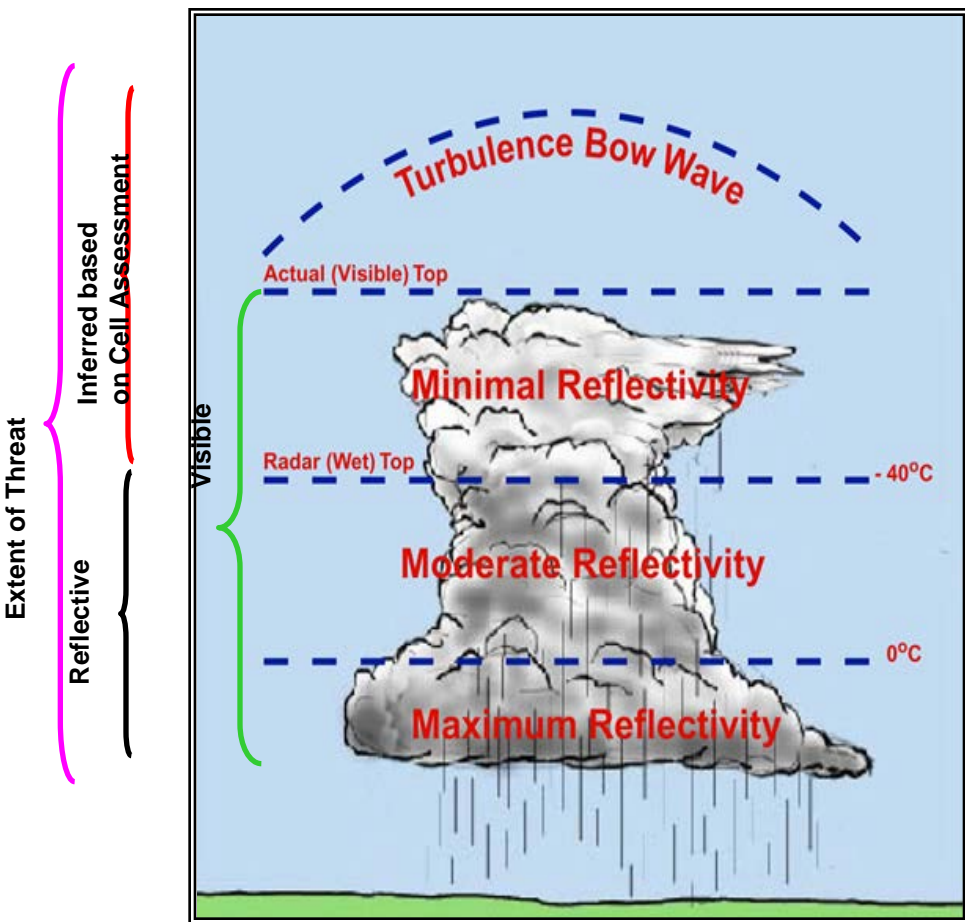
- Expanded Aircraft Threats
 - Turbulence, Up And Down Drafts
 - Lightning, Core and Anvil
 - Hail

Lightning Threat

- NASA research shows that the majority of lightning strikes occur around the freezing level at 10,000 ft. (see figure)
 - During approach and departure, close transit to cells is often required
 - Many Strikes Triggered By Aircraft Within Electrified Region
- Industry Data Indicates An Average of Several Hundred Thousand Dollars Per Strike

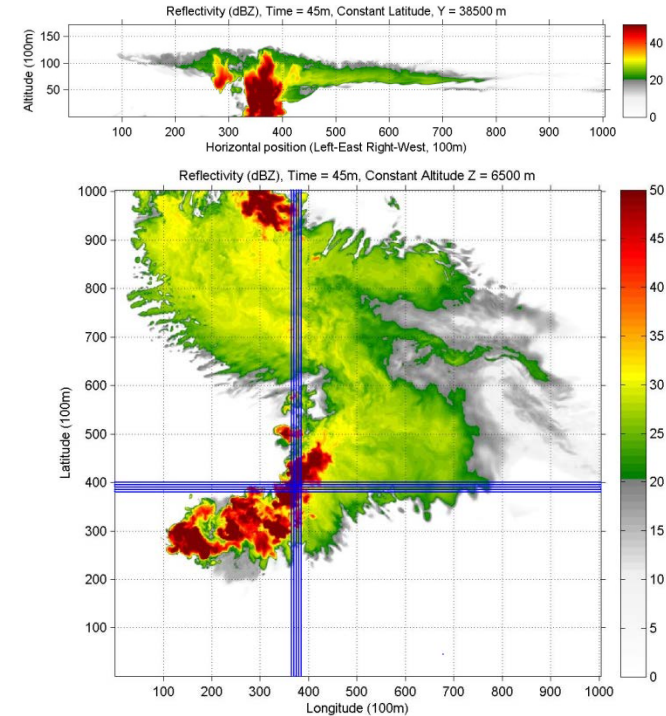
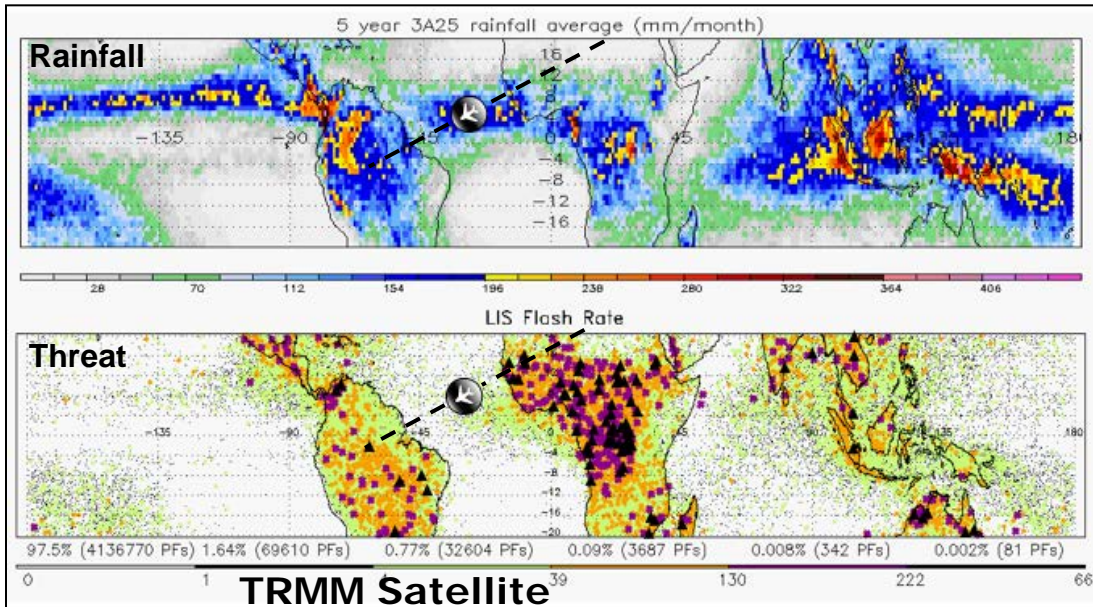


Thunderstorm Reflectivity Characteristics and Geographic Weather Variation



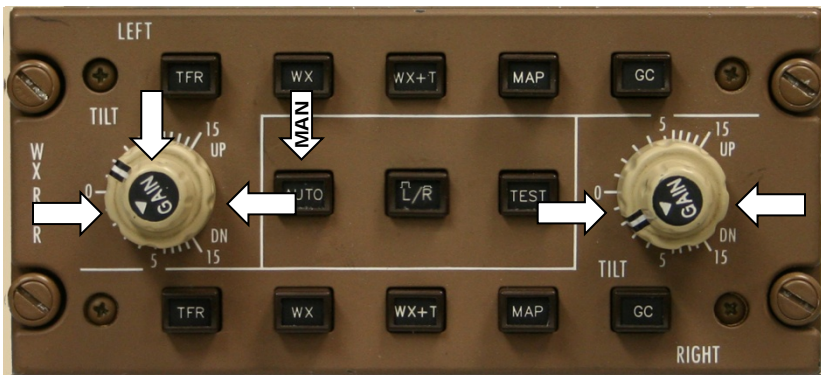
Understanding Reflectivity Characteristics Is Key To Accurately Representing Threats

Merger of Aviation Radar and Weather Science

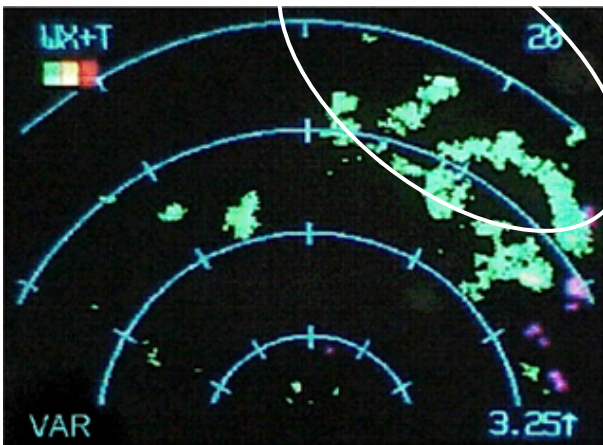
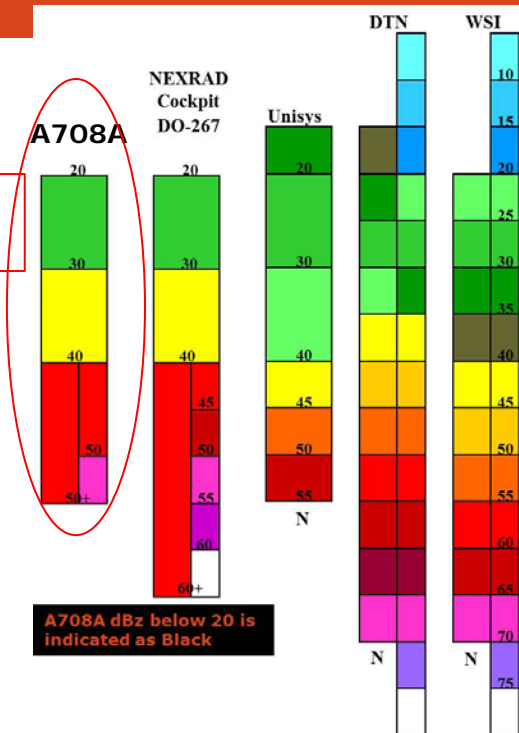
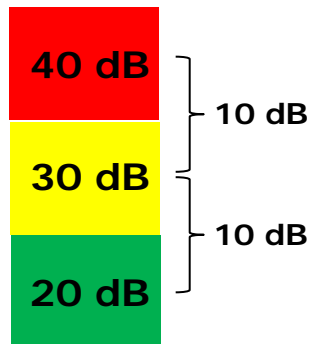


Combining Weather Science and Radar Technology to Provide *Threat* Detection

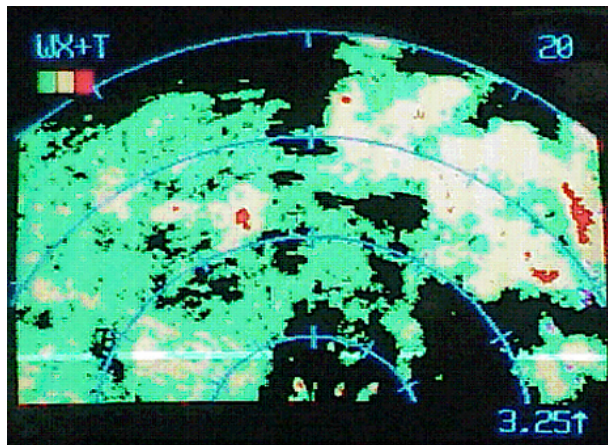
Automatic Temperature Based Gain



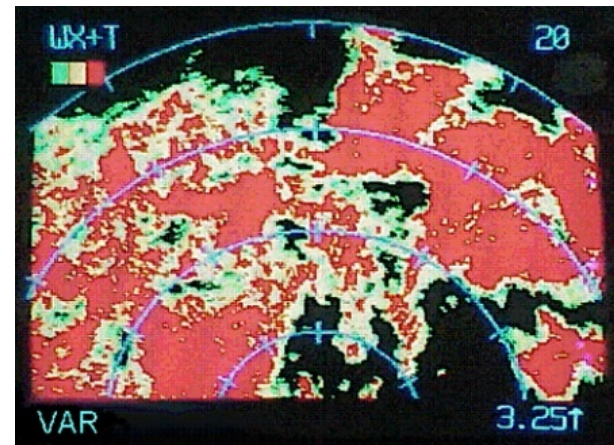
ARINC 708A
Color Limitations



Min Gain (-14 db)
One and a half color level decrease



CAL Gain (0 db)
Standard Rain Rate Reflectivity



Max Gain (+16 db)
One and a half color level increase