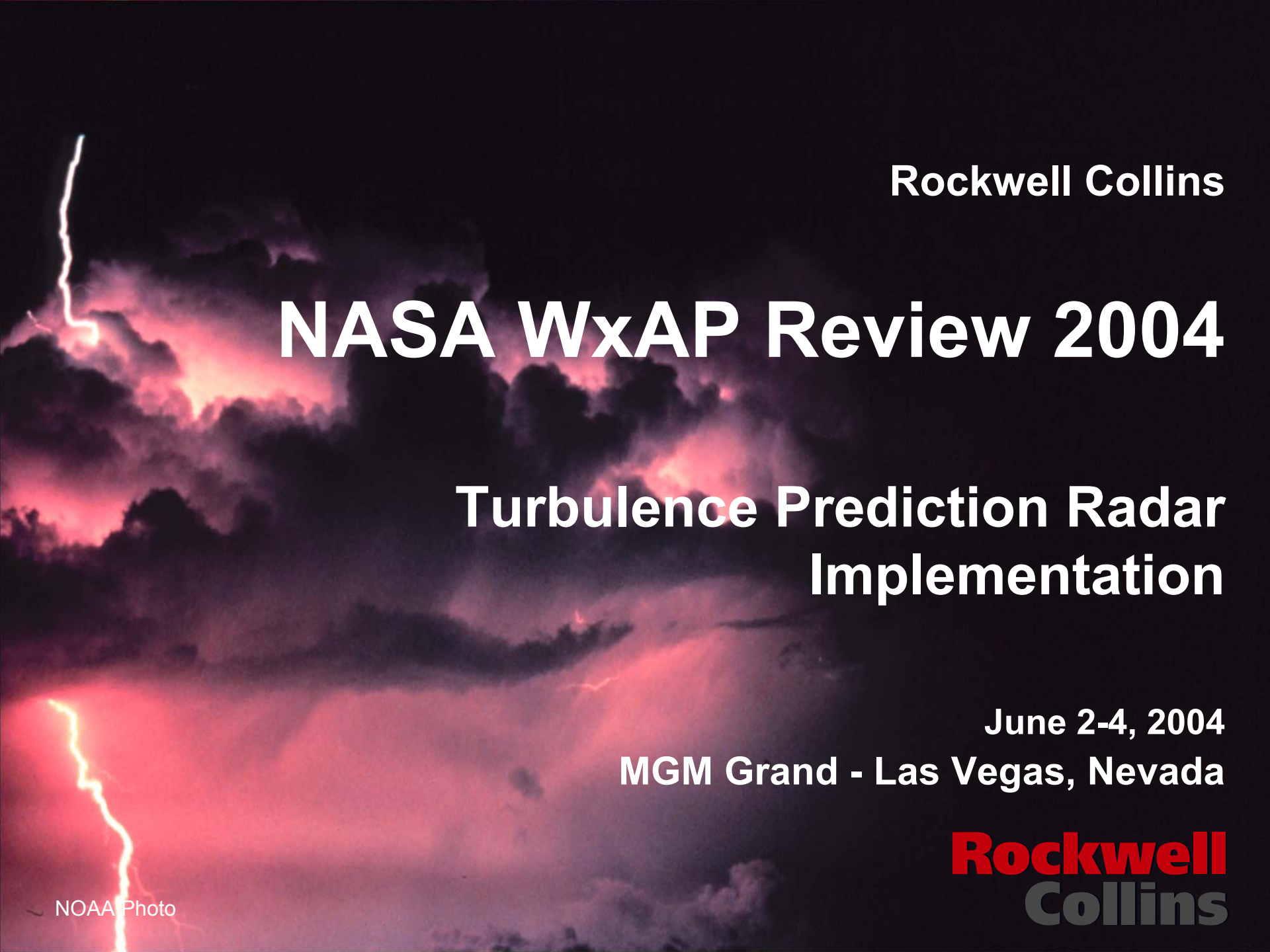


Rockwell Collins

NASA WxAP Review 2004

Turbulence Prediction Radar Implementation

June 2-4, 2004

MGM Grand - Las Vegas, Nevada

Rockwell Collins

NOAA Photo

Topics

- Operational Evaluation Program Overview
- Enhanced Turbulence Radar Implementation
- Delta B737-800 Aircraft Installation
- NASA Role In Safety Technology Development

Turbulence Operational Evaluation Program Overview

- **NASA Enabled Collaborative Program to Bring TPAWS Technology Into Airline Operational Environment**
- Team Partners:
  - **NASA**
  - **Aero-Tech Research**
  - **Delta Airlines**
  - **Rockwell Collins**

Enhanced Turbulence Definition

- Initial Industry TPAWS definition oriented toward short range alerting system
  - 5-10 Mile Detection Range
  - Cockpit Effects (Aural, Visual Alerts)
- Airlines desire performance characteristics and safety benefits Demonstrated by NASA TPAWS system but universally desire longer ranges – Situational Awareness for Maneuvering

Collins Turbulence Direction

- Tradeoff Studies Between Alerting and Advisory Systems
  - Operational Utilization, Radar Implementation, Aircraft Implementation, Certification Implications, Costs
- Collins Decision to Develop Longer Range Advisory System
  - 25-40 Mile Capabilities, Lower Reflectivity
  - Cockpit Alerts Possible In Future

Program Goals

- Evaluate Operational Utilization and Effectiveness of Enhanced Turbulence Product In Revenue Service
- Evaluate Airline Operational Needs From The Pilot's Perspective
- Establish Meaningful Thresholds / Avoidance Guidelines
- Refine Requirements for Production System

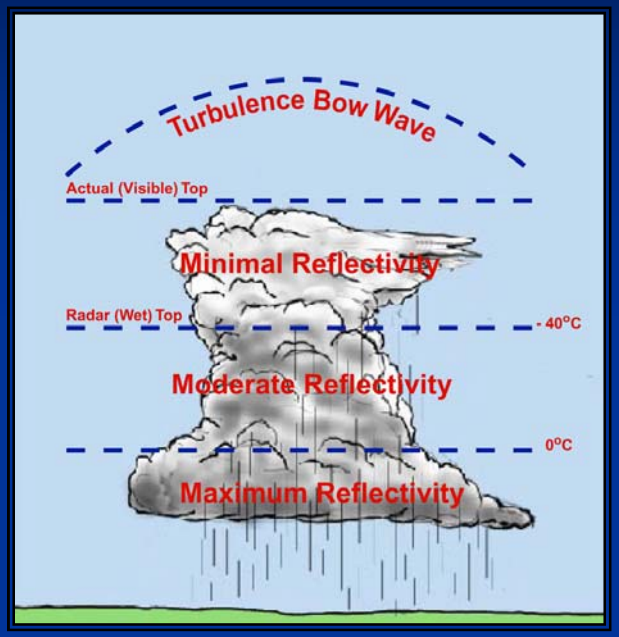
Enhanced Turbulence Radar Implementation

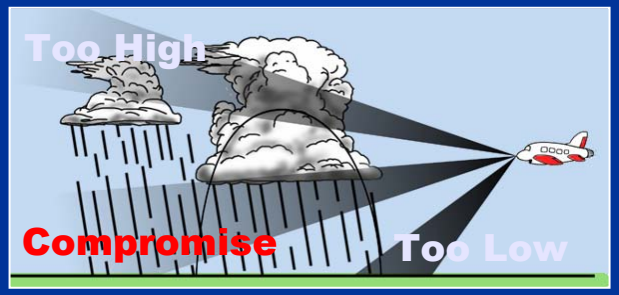
Rockwell Collins

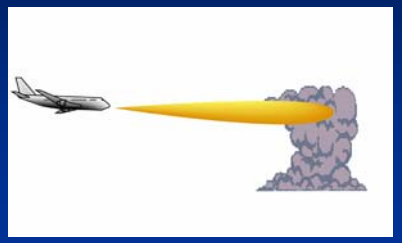
WXR-2100 MultiScan™ Radar

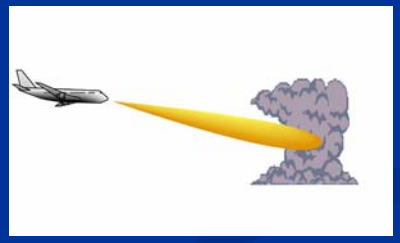
- **WXR-2100 MultiScan™ Radar Platform**
  - **Fully Automatic World-Wide Operation**
  - **Automatic Compensation for Atmospheric and Geographic Characteristics**
  - **Removes Ground Clutter for Clean Weather Display**
  - **Contains Several Features Designed for Turbulence Avoidance at Longer Ranges**

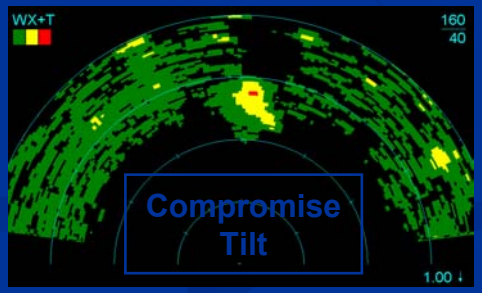
MultiScan™
Ground Clutter Suppression

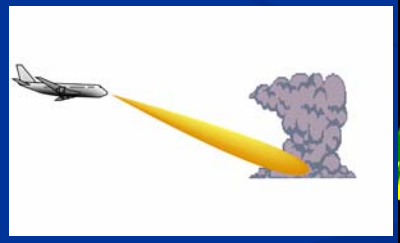


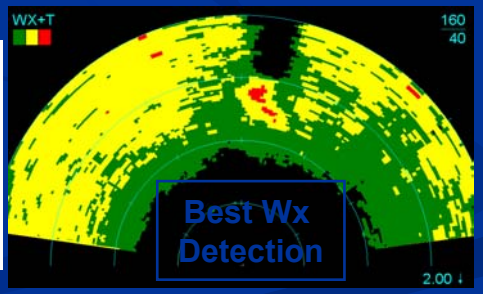






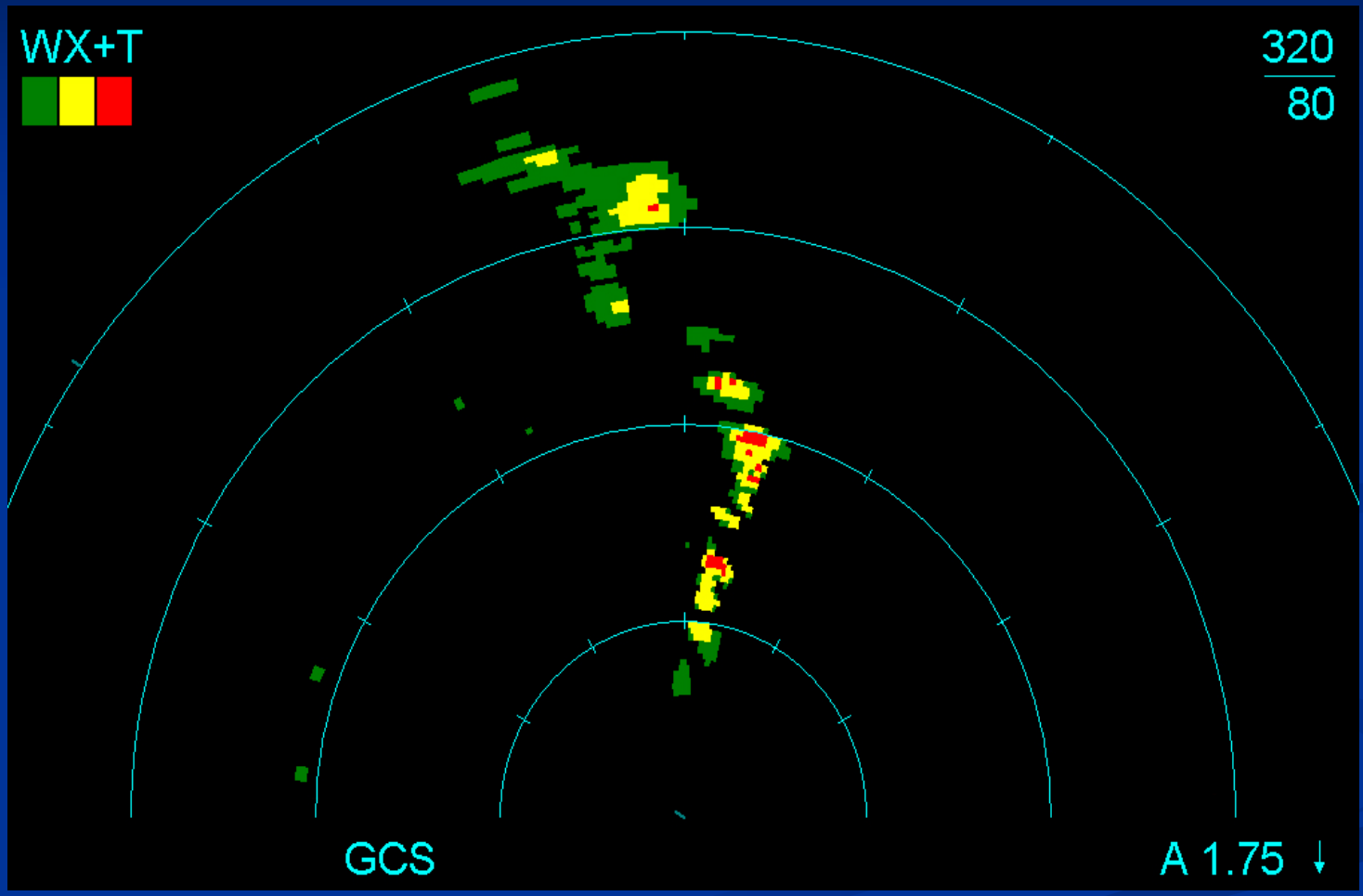






As the radar beam moves higher in the thunderstorm reflectivity decreases

MultiScan™ Clutter Free Strategic Weather Detection



MultiScan - 320 nm Strategic Weather

Rockwell Collins

Enhanced Turbulence Operational Evaluation

- Advanced Autocorrelation Turbulence Algorithm
  - Integrated Turbulence With MultiScan
  - 25 Mile Range, Low Reflectivity Capability
- Aircraft “G” Load Prediction Hazard Tables
  - Custom Table for B737-800
  - Additional “Weight” Parameter From FMC Bus
- Two Level Turbulence Advisory Display
  - Ride Quality, Safety

Enhanced Turbulence Display

Rockwell Collins

B737-800 Aircraft Installation

- Aircraft STC for Standard WXR-2100 MultiScan™ Completed March 28, 2004
  - Additional Weight Parameter from FMC Bus
  - System Flying In Revenue Service
- Enhanced Turbulence Evaluation System Installation – Late July 2004
- In-Service Operational Evaluation
  - August 2004 – September 2005

Delta B737-800
MultiScan™ Installation

Rockwell Collins

NASA Role In Technology Development

- NASA Provides Resources and Is A Catalyst For Technology Development Beyond Individual Company's Capabilities
- Collaboration of a Wide Variety of Team Members: Research, Government, Scientific, Manufacturing, Air Carriers
- Focal Point for Industry / Government Coordination – FAA Involvement Merges Science With Real World Safety / Regulatory Requirements

Results of NASA Initiatives

- NASA Sponsorship Fosters Safety Technology Growth in Fiscally Limited Industry
- NASA Sponsorship Leverages Larger Expenditures Within Industry And Breaks Down Roadblocks To Realize Benefits To The Flying Public