

Overview

Aviation Safety Program

**Electromagnetics and Sensors Branch, LaRC
Peer Review, 2013**



Robert Neece
Technical Lead for
Atmospheric Hazards Sensing and Mitigation,
Atmospheric Environment Safety Technologies,
Aviation Safety Program

Overview

Aviation Safety Program

Atmospheric Hazards Sensing and Mitigation (AHSM), 2013



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Outline – ESB Peer Review

- Introduction
- Aviation Safety Program
 - Projects
 - Technical Challenges
 - Project work in Aero
- Vehicle System Safety Technologies (VSST)
 - Safe Flight Deck Systems & Operations
 - Validation Methods for High-Confidence Technologies
- Atmospheric Environment Safety Technologies (AEST)
 - Atmospheric Hazards Sensing and Mitigation (AHSM)
 - AHSM Organization
 - General Approach
 - AHSM Elements
- Summary

Outline – Aviation Safety Overview

- Introduction
- Aviation Safety Program
 - Projects
 - Technical Challenges
- Atmospheric Environment Safety Technologies (AEST)
 - Atmospheric Hazards Sensing and Mitigation (AHSM)
 - AHSM Organization
 - General Approach
 - AHSM Elements
- Summary

NASA Aeronautics Programs



Fundamental Aeronautics Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

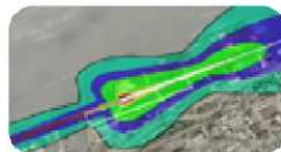
Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment



Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.



Aviation Safety Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.



Aeronautics Test Program

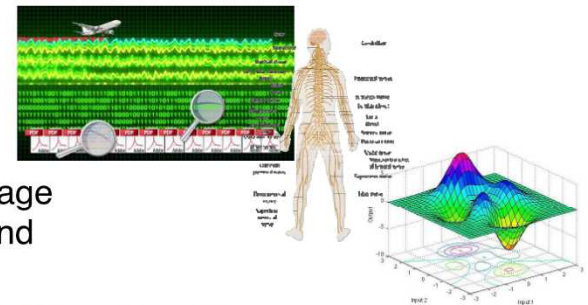
Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.

Aviation Safety Program

Program Goal: Proactively identify, develop, and mature tools, methods, and technologies for improving overall aircraft safety of new and legacy vehicles operating in NextGen

Projects

- *System-Wide Safety and Assurance Technologies (SSAT)*
 - Provide knowledge, concepts, and methods to proactively manage increasing complexity in the design and operation of vehicles and the air transportation systems
- *Vehicle Systems Safety Technologies (VSST)*
 - Identify risks and provide knowledge needed to avoid, detect, mitigate, and recover from hazardous flight conditions, and to maintain vehicle airworthiness and health
- *Atmospheric Environment Safety Technologies (AEST)*
 - Investigate sources of risk and provide technology needed to help ensure safe flight in and around atmospheric hazards



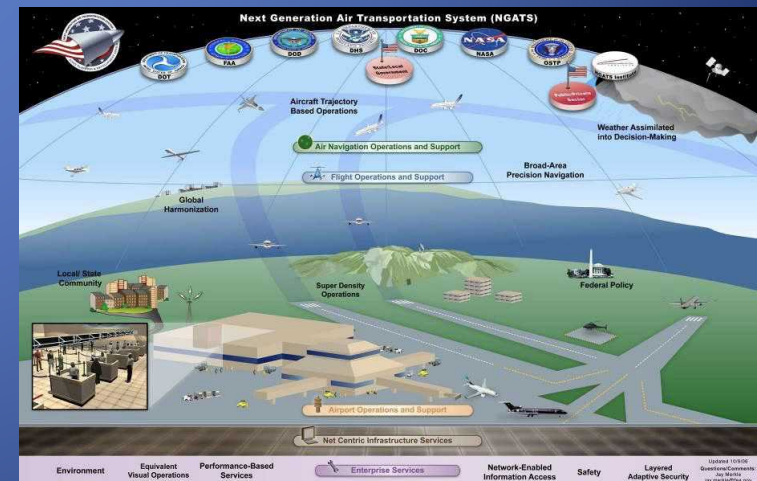
Project Work Environment

- Projects and subprojects are scoped by resource allocations
- Work is proposed and incorporated to meet technical challenges based on available resources
- Performance is measured by milestones
- Project content and milestones are shaped by the requirement to provide concrete, measureable results

System-Wide Safety and Assurance Technologies, SSAT (Aviation Safety Program)

- **Primary Goal:** Develop validated multidisciplinary tools and techniques to ensure system safety in NextGen to enable proactive management of safety risk through predictive methods.
- **Technical Challenges:**
 - Assurance of Flight Critical Systems: Development of safe, rapid, and cost effective NextGen Systems using a unified safety assurance process for ground based and airborne systems.
 - Automated Discovery of Precursors to Safety Incidents: Automated discovery of previously unknown precursors to aviation safety incidents in massive(>10 TB) heterogeneous data sets.
 - Automation Design Tools: Increase safety of human – automation interaction by incorporating human performance considerations throughout the design lifecycle in NextGen technologies.
 - Prognostic Algorithm Design for Safety Assurance: Development of verifiable prognostic algorithms to help remove obstacles to certification.
- **Workforce:** 21 full-time equivalent (FTE) civil servants

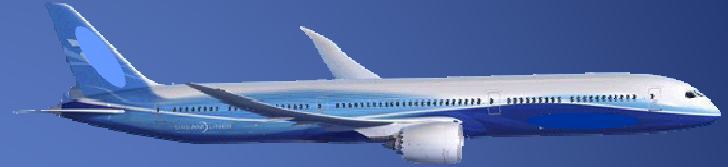
Objective Physiological Measurements



Vehicle Systems Safety Technologies, VSST

(Aviation Safety Program)

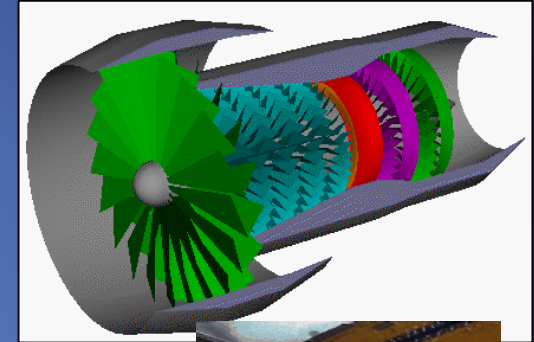
- **Primary Goal:** Develop technologies to reduce accidents and incidents through enhanced vehicle design, structure, systems, and operating concepts
- **Technical Challenges:**
 - Improved Crew Decision Making & Response in Complex Situations
 - Advanced displays and decision support
 - Robust interfaces to trajectory automation
 - Integrated Information Management System
 - Pilot Proficiency Standards
 - Maintain Vehicle Safety Between Major Inspections
 - Sensor & Diagnostic Tools
 - High Temperature Propulsion Health
 - Airframe and Engine Material & Coating
 - Safe & Effective Aircraft Control Under Hazardous Conditions
 - Vehicle Dynamics Modeling for Multiple Hazards
 - Guidance, Control, and System Technologies
- **Workforce:** 65 civil servants



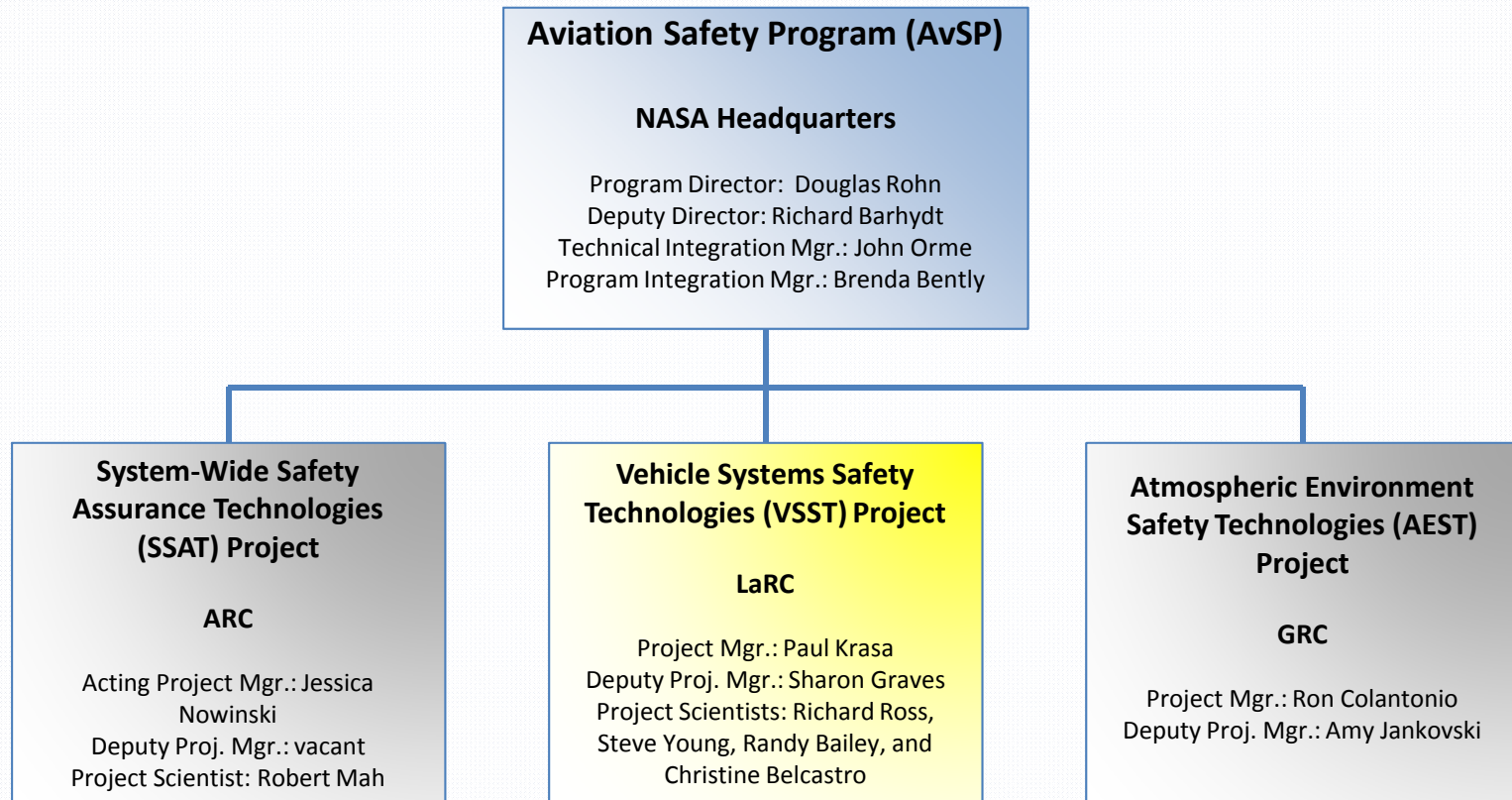
Atmospheric Environment Safety Technologies, AEST

(Aviation Safety Program)

- **Primary Goal:** Investigate sources of risk and provide technology needed to help ensure safe flight in and around atmospheric hazards.
- **Technical Challenges:**
 - Engine Icing: Characterization and Simulation Capability: Develop knowledge bases, analysis methods, and simulation tools needed to address the problem of engine icing; in particular, ice-crystal icing.
 - Airframe Icing Simulation and Engineering To Capability: Develop and demonstrate 3-D capability to simulate and model airframe ice accretion and related aerodynamic performance degradation for current and future aircraft configurations in an expanded icing environment that includes freezing drizzle/rain
 - Atmospheric Hazard Sensing and Mitigation (AHSM) Technology Capability: Improve and expand remote sensing and mitigation of hazardous atmospheric environments and phenomena
- **Workforce:** 14 civil servants



Aviation Safety Organization – Highlight VSST



VSST Technical Challenge - 1

ESB supported

Improve Crew Decision-Making and Response in Complex Situations

Increase pilots' ability to avoid, detect, and recover from adverse events that could otherwise result in accidents/incidents.

Goal: Demonstrate new capabilities that enable pilots to better understand and respond safely to complex situations.

Products: For terminal area operations

- Revised pilot proficiency standards for skills associated with manual handling, automation interactions, and reverting from automated to manual handling
- **Demonstrations of innovative flight deck systems** that include:
 - Advanced displays that improve situation awareness and hazard protection during low altitude runway operations and on the surface
 - Systems that assure pilot engagement with arrival/departure 4D trajectory management automation, and that provide a robust interface when responding to unexpected events
 - Integrated information management systems that assure the information needed by flight crews to make critical decisions is complete and not misleading

Benefits:

- Identify and remove barriers to safe piloting in the presence of the new complexities brought on by NextGen;
- Eliminate key contributing factors to accidents/incidents such as: inappropriate crew response, lack of situation awareness, distraction, overload, and confusion

TC-1: Improve Crew Decision-Making and Response in Complex Situations

Current

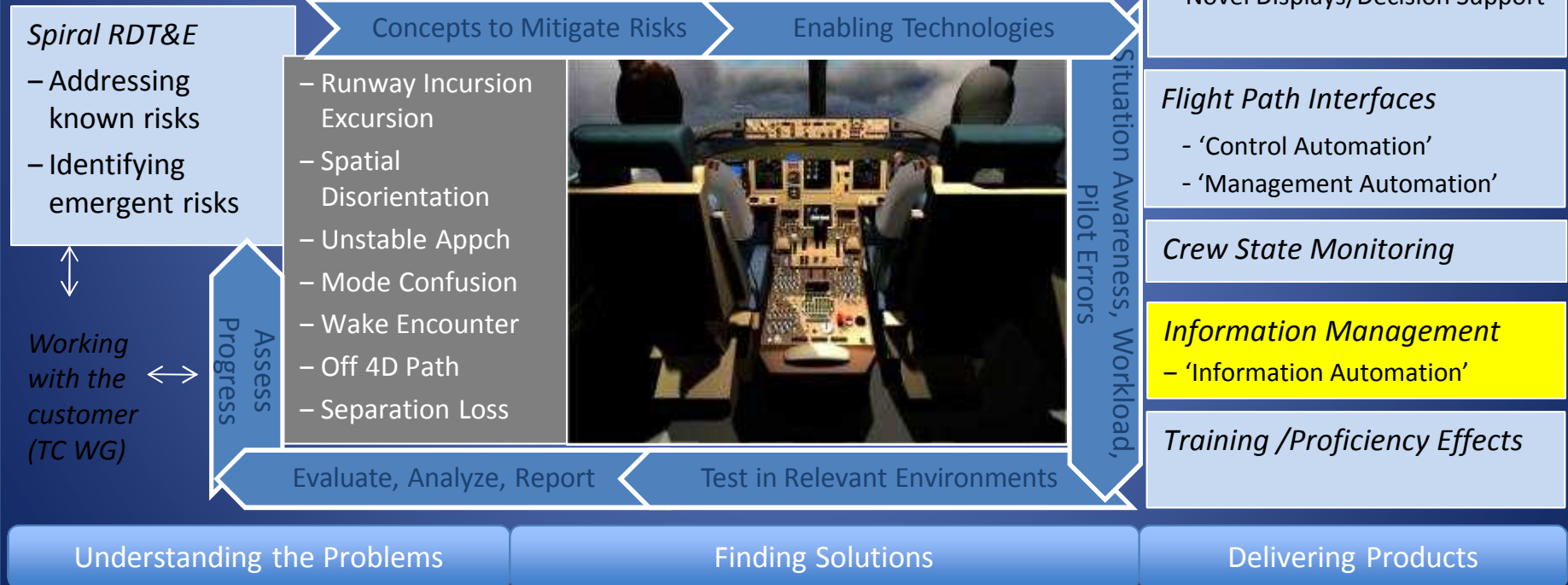
- Crew primary causal factor in 68% of accidents
- 74% of accidents are in the terminal area
- Why? Gaps in awareness, high workload, complexity/uncertainty, time and traffic compression

Future Trends

New roles, responsibilities, automation, and operational complexities for pilots and ATM

- New automation agents and operational challenges
- Expansion of available information via data link
- Dense operations that increase exposure to hazards
- Assumption that reverting to “old way” is fail-safe

Approach and Objectives (Terminal Area Focus)



VSST Technical Challenge - 2

“Maintain Vehicle Safety Between Major Inspections”

Goal:

Develop and demonstrate new integrated health management and failure prevention technologies to assure the integrity of vehicle systems between major inspection intervals and maintain vehicle state awareness during flight

Products (FY12-16):

Evaluate and demonstrate:

- Innovative sensors and diagnostic tools to anticipate and prevent potential critical failures.
- High temperature engine sensor systems that directly monitor compressors and turbines for reliable engine health monitoring;
- Airframe and engine materials and coatings that detect damage and minimize premature failures from fatigue, fracture, delamination, and corrosion

Benefits:

- Safe operation between major inspections.
- Reduced in-flight safety risks due to engine, airframe, and avionics related faults and failures,
- Individual vehicle health-state awareness supports better in-flight decisions and targeted ground based maintenance.

TC-2: Maintain Vehicle Safety Between Major Inspections

Today

- Vehicle failures: 2nd leading factor in aircraft fatalities
- Vehicle failures are often the first factor in the sequence of events leading to fatal accidents
- Faults/failures not always detected during inspections

Tomorrow

- Potential increase in vehicle related accidents resulting from increased air transportation demand
- Advanced airframe engine materials and components introduce new failure modes

Airframe /engine materials and coatings that detect damage and minimize premature failures



Structural health management tools that combine ground inspections with in-flight health assessments

Use working group of industry, academia, and OGA to evaluate risks and establish priorities

High temperature engine sensor systems for reliable health monitoring

*1 in 4 fatal accidents caused by vehicle systems failures and malfunctions**

VSST Technical Challenge - 3

ESB supported

“Assure Safe and Effective Aircraft Control under Hazardous Conditions”

Goal:

Develop and evaluate integrated guidance, control, and system technologies that enable safe and effective crew/system aircraft control under hazardous conditions, and demonstrate success for realistic high-risk LOC scenarios

Products (FY12-16):

Evaluate and demonstrate:

- Vehicle dynamics modeling and simulation technologies for characterizing multiple hazards effects,
- Onboard systems technologies that include:
 - Methods for upset onset detection and prevention under crew spatial disorientation and/or loss of energy state awareness,
 - Prediction methods that provide anticipatory guidance on maneuverability limitations and potential LOC risk,
 - Methods for upset prevention and control mitigation under failures, icing, and wakes

Benefits: Technologies that enable prevention and safe recovery from abnormal flight conditions for normal and impaired aircraft

- Enhanced simulation models for improved crew training under LOC conditions,
- Real time envelope prediction methods and trajectory guidance to avoid onset of LOC
- Methods that enable safe and effective aircraft control under multiple hazards, as determined by current and potential future LOC risks.

TC-3: Assure Safe and Effective Aircraft Control under Hazardous Conditions

Today

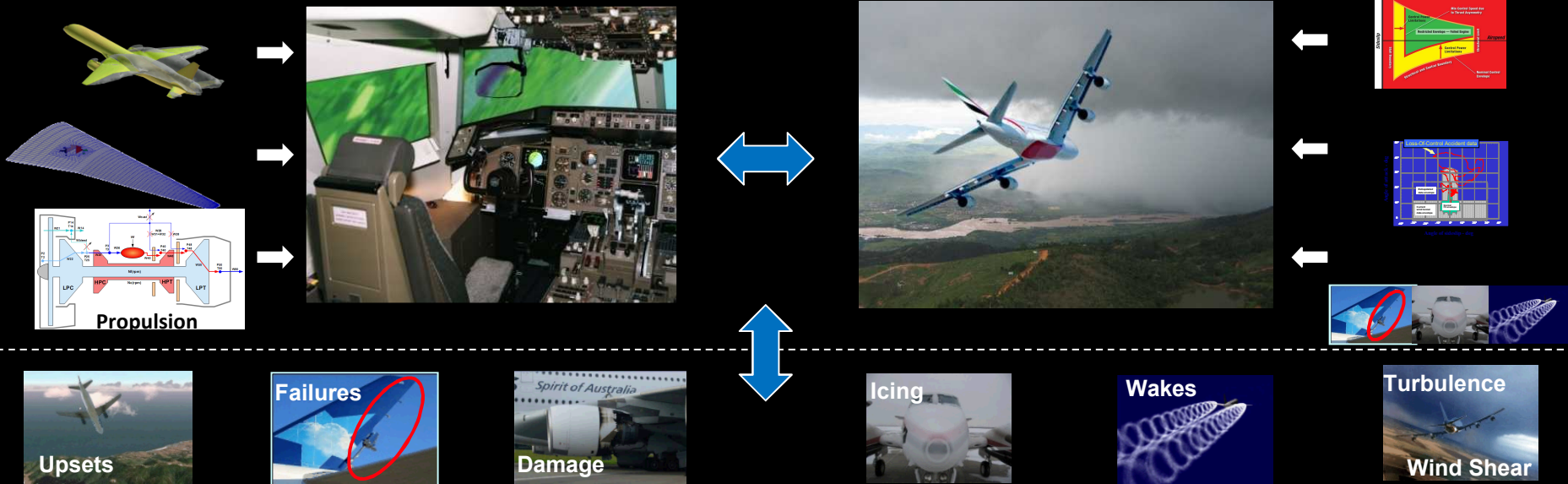
Aircraft Dynamics and Control Limitations under Hazardous Conditions can lead to Loss of Control (LOC)

- Current crew training under LOC conditions is limited due to model limitations for full stall conditions, failures and damage, and environmental hazards
- Information currently provided to the crew does not clearly inform of impending LOC
- Current autopilot systems are designed for nominal operations and often disengage under off-nominal conditions
- Current envelope protection systems provide limited capabilities

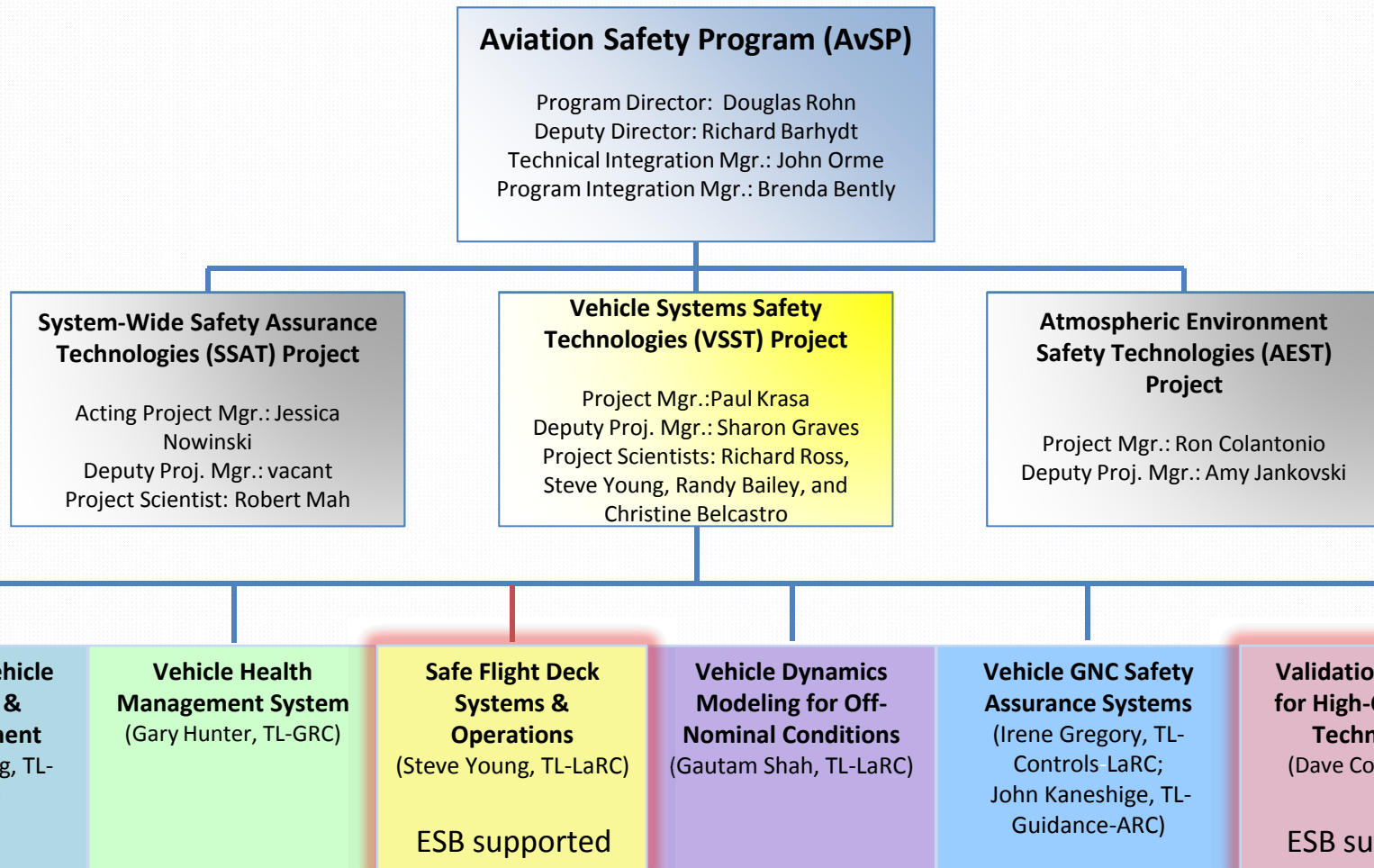
Tomorrow

Potential Increase in LOC Accidents Resulting from

- Increasing demand on the National airspace requiring high-density operations
- Increased demand on crew & automated systems
- Increased external hazard encounters (wakes, weather)
- New materials and vehicle configurations



Aviation Safety Organization – Highlight VSST

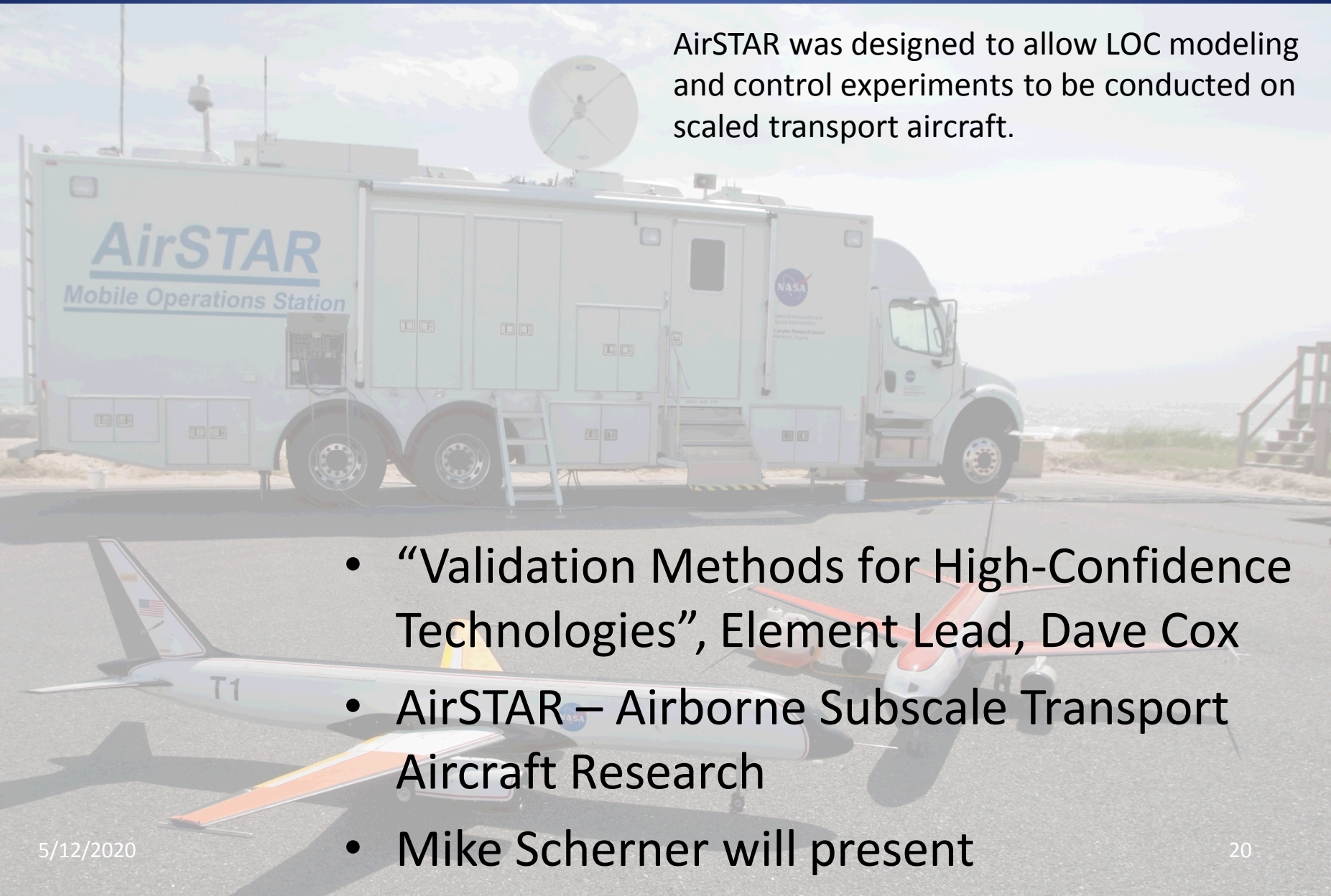


ESB Support for VSST TC-1

- “Safe Flight Deck Systems & Operations”
- Development of a flight deck simulation including realistic weather
- Evaluate methods for utilizing weather information for safer operations
- Information management
- New weather information sources
- User interfaces
- New operational procedures
- Presented by Taumi Daniels

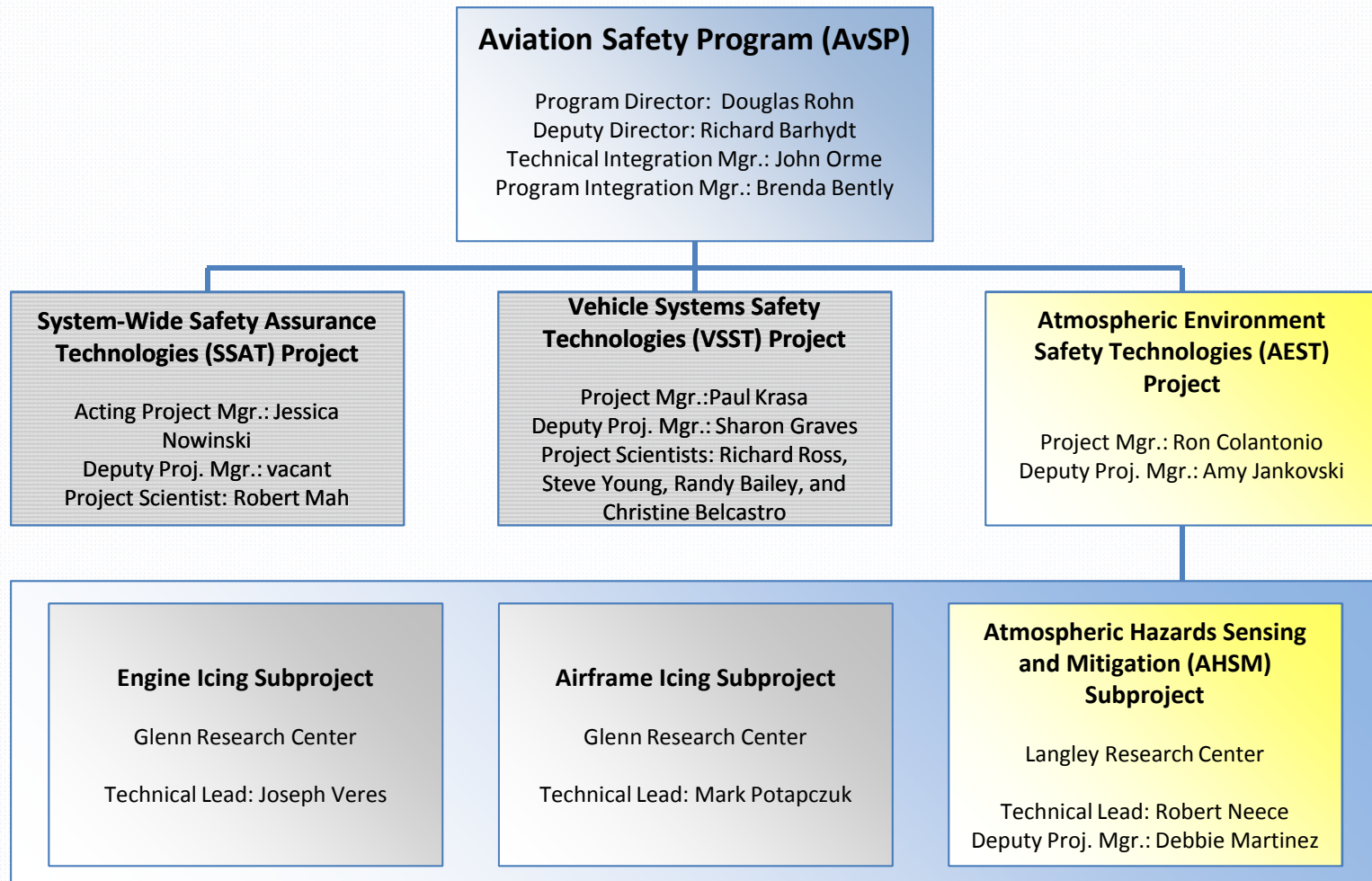
ESB Support for VSST TC-3

AirSTAR was designed to allow LOC modeling and control experiments to be conducted on scaled transport aircraft.



- “Validation Methods for High-Confidence Technologies”, Element Lead, Dave Cox
- AirSTAR – Airborne Subscale Transport Aircraft Research
- Mike Scherner will present

Aviation Safety Organization – Highlight AEST AHSM



AEST Project Description

Objective: The Atmospheric Environment Safety Technologies (AEST) project will investigate sources of risk and provide technology needed to help **ensure safe flight in and around atmospheric hazards.**

Focus: In-flight icing, both engine and airframe. Research will also include investigations of other high priority atmospheric hazards and sensor technologies required for their detection.

Relevance to National Needs

1. Engine icing incidents are occurring on a frequent basis with the aviation community calling for action.
2. New aviation regulatory requirements necessitate the development of new and enhanced icing simulation tools
3. Operations in the Next Generation Air Transportation System environment demand precise information about the atmosphere and awareness of weather hazards



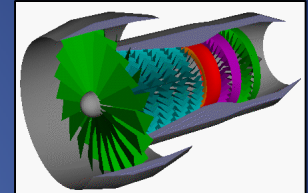
Linkages to Program Goal

“By 2016, identify and develop tools, methods, and technologies for improving overall aircraft safety of new and legacy vehicles operating in the Next Generation Air Transportation System.”

AEST Sub Project Technical Challenges

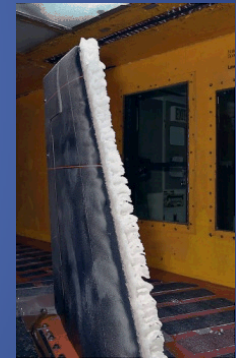
Engine Icing: Characterization and Simulation Capability:

Develop knowledge bases, analysis methods, and simulation tools needed to address the problem of engine icing; in particular, ice-crystal icing



Airframe Icing Simulation and Engineering Tool Capability:

Develop and demonstrate 3-D capability to simulate and model airframe ice accretion and related aerodynamic performance degradation for current and future aircraft configurations in an expanded icing environment that includes freezing drizzle/rain



Atmospheric Hazard Sensing and Mitigation Technology

Capability: Improve and expand remote sensing and mitigation of hazardous atmospheric environments and phenomena



AHSM Technical Challenge / Organization

Improve and expand remote sensing and mitigation of hazardous atmospheric environments and phenomena

Goal: *Mature technologies for sensing and measurement of icing, turbulence, and wake vortex hazards for real-time information to the pilot and operators in the NAS and to address low visibility conditions for safer runway operations; develop technologies for a lightning immune composite aircraft*

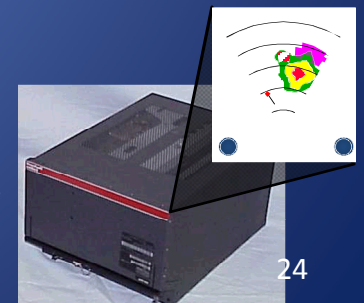
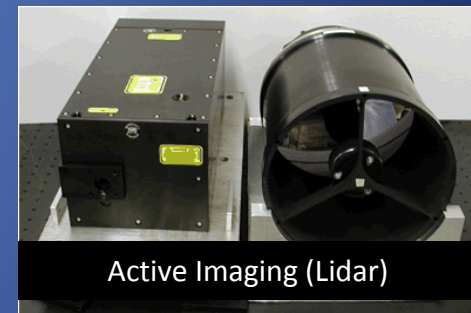
Benefit: *Greater ability for aircraft to avoid hazards; hazard information available for sharing with other aircraft and ground-based systems; reduced vulnerability to lightning and other hazards*

Benefit Domain: *All aircraft flying in the NAS; pilots, operators, and controllers*

Leadership: *Debbie Martinez (DPMF), Robert Neece (Technical Lead)*

Elements:

- *Advanced Radar (AdvR)*
- *Lightning and Electromagnetic Effects Mitigation (LEEM)*
- *Icing Weather Systems (IWS) Development*
- *Lidar and Electro-Optical (LEO) Sensor Development*
- *Smart Visual Awareness (SVA) Sensor Systems*



Modern WX Radar
- Severe WX
- Windshear
- Turbulence

Elements at a Glance

- **AdvR – Advanced Radar**
 - Icing Conditions and Severe Weather Information
 - Steve Harrah, LaRC
- **LEEM – Lightning and Electromagnetic Effects Mitigation**
 - Lightning Strike Mitigation
 - George Szatkowski, LaRC
- **LEO – Lidar/Electro-Optical**
 - Kinetic Air Hazards, Air-worthy Lidar
 - Ivan Clark & Taumi Daniels, LaRC
- **IWS – Icing Weather Systems**
 - Remote Detection of Icing Conditions, Multi-sensor Detection
 - Andy Reehorst, GRC
- **SVA – Smart Visual Awareness**
 - Low Visibility, Image Enhancement, Scene Analysis for Hazard Detection
 - Dan Jobson, Glenn Woodell, Andrew Moore, LaRC

AHSM Approach – Hazard Priorities

Hazard priorities are set by consideration of several factors:

- Ranking versus NextGen needs for safety and capacity
- NextGen sensor technology needs
- Available technologies for detection and measurements and the level of maturity
- Available resources and expertise
- Interest and concern from the private sector
- Interest and support from NASA and the FAA

Icing Conditions – remote detection

Lightning – mitigation and damage measurement for strikes to composite aircraft, investigating lightning strike characteristics

Kinetic Air Hazards – detection and avoidance; turbulence, wake vortices, wind shear, etc.

Low Visibility Conditions – mitigation by imagery analysis and enhancement

5/12/2020

Phenomena Identification and Ranking Table (PIRT)																				
LEGEND		AIRBORNE SENSORS																		
		ACTIVE SENSORS							PASSIVE SENSORS											
		X-Band Radar	Millimeter Wave Radar	Opportunistic Bi-Static Radar (GPS & ADS-B)	Other Radar (frequency, polarimetric, multi-wave length, multi-polarization, etc.)	Lidar	Near-IR Ranged-Gated Imaging Lidar	Cooperative (ADS-B / TCAS)	Lightning Detector	Other Passive RF/Microwave	Forward-Looking Infrared (FLIR) Imaging	Forward-Looking Interferometry (FLI) Imaging	Visible Imaging	Other Passive Optical	SVS & TAWS	Off-Board Derived (gnd, sat, other aircraft)				
Applicability/Research Level																				
U = Unknown (some potential)																				
0 = Not Recommended																				
1 = Limited/Fundamental																				
2 = Moderate/Sensor Development																				
3 = Significant/System Integration																				
4 = NextGen-Ready																				
Values represent min. safety perf. under low visibility conditions																				
EXTERNAL HAZARDS	Atmospheric	Natural																		
		Convective Weather	4	2	0	2	2	1	0	1	1	2	U	2	1	0	3		H	
		Dry Microburst	4	3	0	2	3	U	0	0	0	0	1	0	0	0	3		H	
		Wind Shear	4	3	0	2	3	U	0	0	0	U	0	1	0	0	0	3		H
		Wind Gusts	2	2	0	1	2	U	0	0	0	0	1	0	0	0	3		H	
		Turbulence	3	1	0	1	2	U	0	0	0	1	2	1	1	0	3		M	
		Icing Conditions	1	2	0	2	1	1	0	0	1	1	1	1	1	0	3		H	
		Hail	2	2	0	2	1	U	0	1	U	U	1	U	U	0	3		L	
		Volcanic Ash	1	1	0	1	1	1	0	0	1	0	2	0	1	0	3		M	
		Orographic Vortices	1	1	0	1	2	U	0	0	0	U	1	0	U	0	3		M	
		Low Visibility	2	2	0	1	1	2	0	0	0	2	1	2	1	0	3		H	
		Lightning	U	U	0	U	U	U	0	3	0	1	U	2	U	0	3		L	
	Terrain	Man-Made																		
		Wake Vortices	1	1	0	1	2	U	0	0	0	U	1	U	U	0	3		M	
		Natural																		
		Topography	3	3	2	2	3	2	0	0	1	3	3	3	U	4	3		H	
		Wet/Icy Runways	0	0	0	U	U	1	0	0	1	1	1	1	U	0	3		L	
	Traffic	Man-Made Structures																		
		Buildings	3	3	0	2	3	2	0	0	1	3	2	3	U	4	3		M	
		Towers	3	3	0	2	3	2	0	0	1	3	2	3	U	4	3		M	
		Wires	1	3	0	2	2	1	0	0	1	1	1	1	U	2	3		M	
		Airborne (ownship)																	H	
		Cooperative Aircraft	3	2	3	2	1	1	4	0	0	2	2	2	U	0	4		H	
		Non-Cooperative																		
		Commercial Aviation	3	2	3	2	1	1	0	0	0	2	2	2	U	0	3		H	
		General Aviation	3	2	3	2	1	1	0	0	0	2	2	2	U	0	3		H	
		Ultra-Lights	2	2	2	2	1	1	0	0	0	1	1	1	U	0	3		L	
		Weather Balloons	U	1	0	1	1	1	0	0	0	1	1	1	U	0	3		L	
		Birds	2	2	0	2	1	1	0	0	0	0	U	0	U	0	3		L	
		Ground (ownship)																		
		Aircraft	3	2	2	1	1	1	4	0	1	2	1	2	U	0	4		H	
		Ground Vehicles	3	2	2	1	1	1	4	0	1	2	1	2	U	0	4		H	
		Animals	1	1	1	1	1	1	0	0	U	2	1	1	U	0	3		L	
NextGen Technology Ranking		H	H	M	H	H	H	L	L	MH	M	MH	M	L	H					

Systems Perspective

Inclusion of a sensor depends on utility, effectiveness, and affordability.

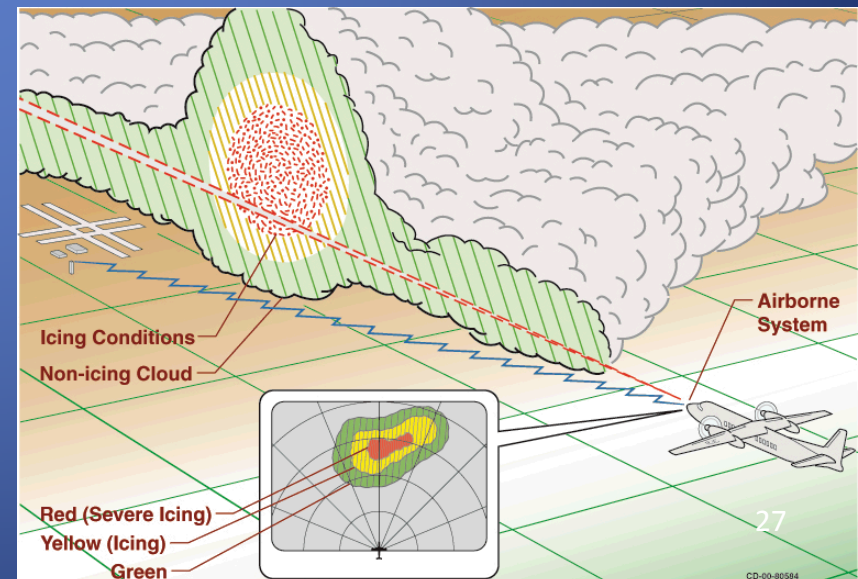
- Sensors as part of the cockpit system
- High-utility, multipurpose sensors
- Multi-sensor detection, characterization, and cross verification
- Net-enabled hazard information
- Airborne sensors as an information source

FLIR Technologies
and
SVA Processes



Provides Vision in IMC

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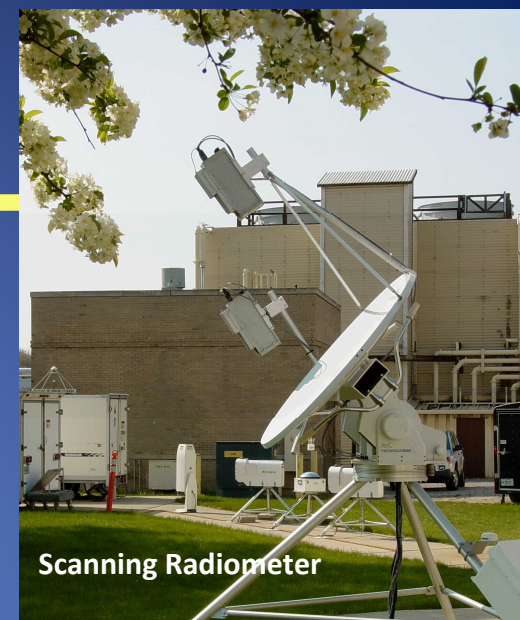
AHSM Approach – Contracting

- SBIRs, Small Business Innovative Research
 - Phase 1 starts, 2 or more per year
 - Phase 2 starts, 1 or more per year
 - Primarily supporting Lidar Electro-optical Element
- NRAs, NASA Research Announcements
 - Typically start 1 per year with a two or three year term
 - Most recent subtopics associated with
 - Airborne detection of wake vortices
 - Multi-frequency radar
- These are proposed efforts – we do not start with a Statement of Work

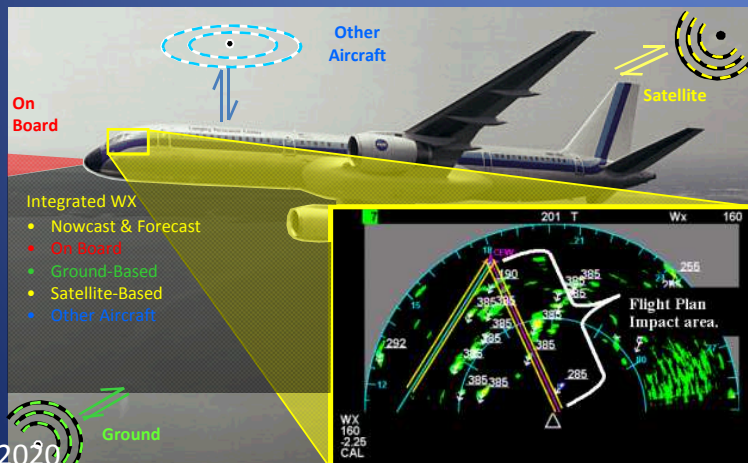
AHSM Summary

- Investigating atmospheric hazard detection and mitigation
- Five elements represent both technology and hazard foci
- Applying a systems perspective

Icing conditions
remote sensing
experiments



More & Improved Information
through Integration



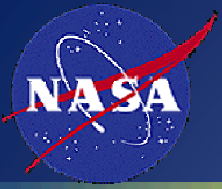
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- Allow aircraft to avoid hazards
- Reduce vulnerability to lightning and other hazards
- Provide hazard information to the cockpit and for sharing through net-enabled operations in NextGen

Questions?

Backup and alternate slides

-



Advanced Radar – Technical Challenges

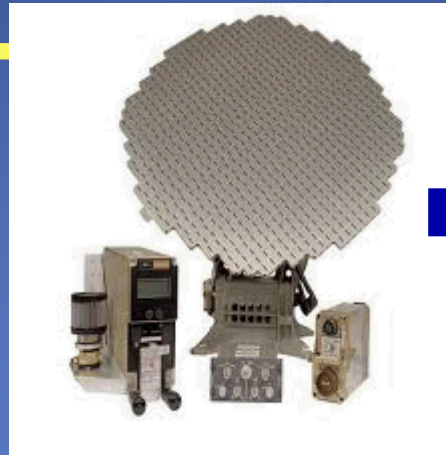
Current WXR Capabilities

- Severe WX < 300Nmi
- Enhanced Turb < 10-20Nmi
- Windshear < 5-10Nmi
- Cloud Tops < 1-5Nmi
- TAWS < 1-5Nmi
- NCAT < 1-5Nmi
- RID < 2-5Nmi
- R/W! < 2-5Nmi

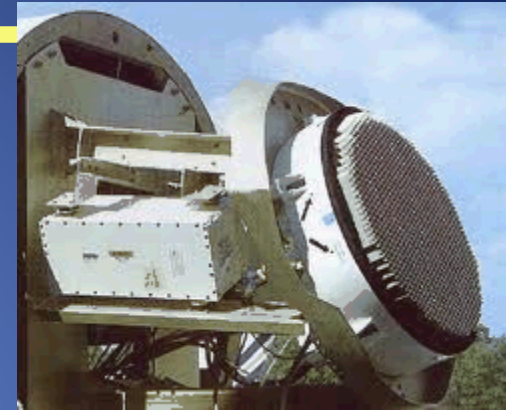


Desired WXR Capabilities

- Predictive Icing (fuselage/engine)
- Volcanic Ash
- Predictive IMC (Low Vis)

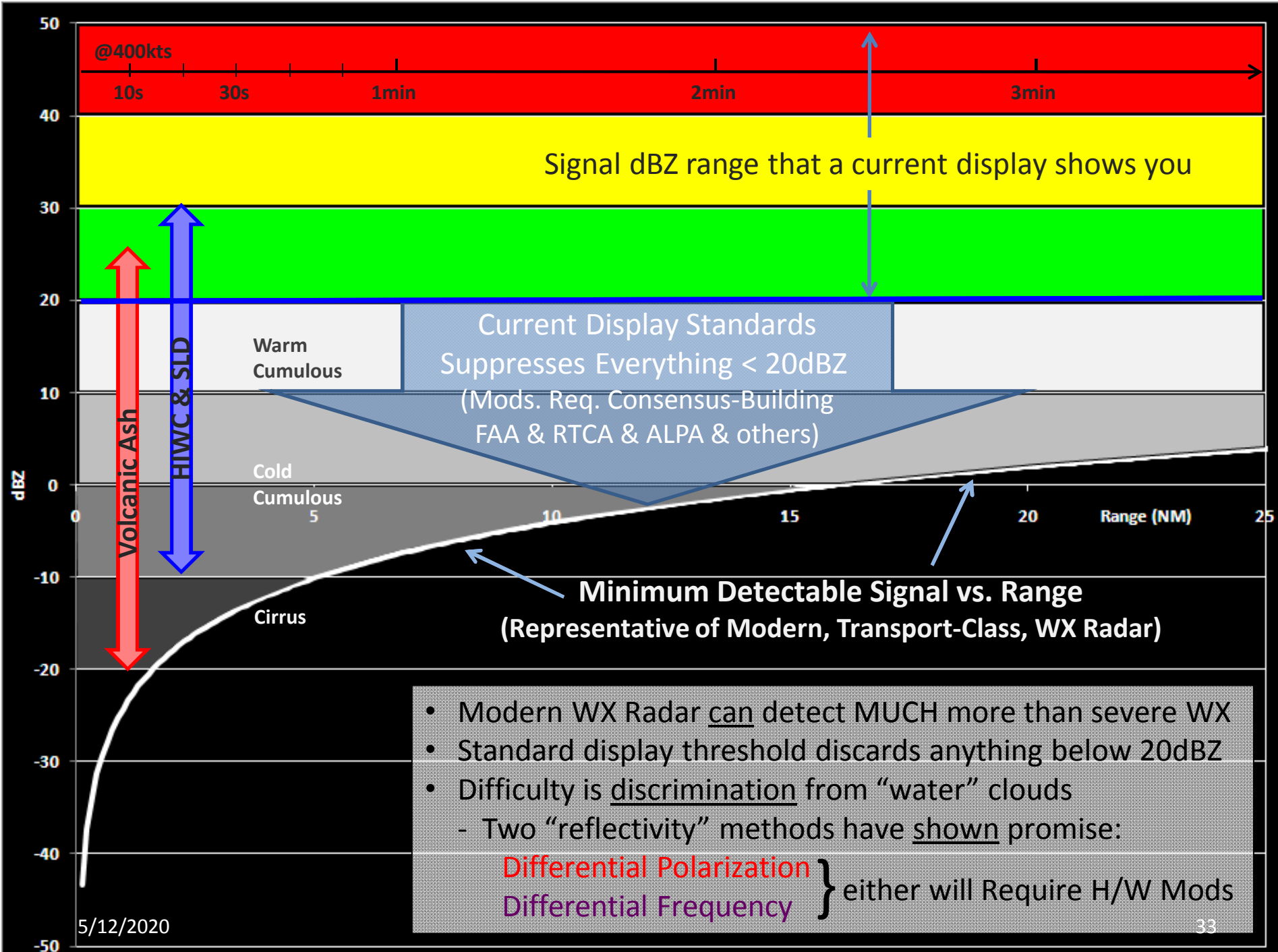


2015?



Desired WXR Enhancements

- **Electronically-scanned antenna (Low Cost)**
 - enable more functions w/n same time/scan
 - rapid, non-sequential, scan operation (haz-based)
 - distributed trans/rec (graceful degrade)
 - adaptive pattern capability
- **Increased Main/Sidelobe Isolation**
 - reduce fundamental performance limitation
- **Polarimetric capability**
 - shape/orientation discriminator (volcanic ash / hail)
- **Simultaneous Multi-Frequency**
 - size/permittivity discriminator (fuselage/wing icing)
- **Regional-Transport Application**
 - target largest class of aircraft (sig. safety impact)



LEEM

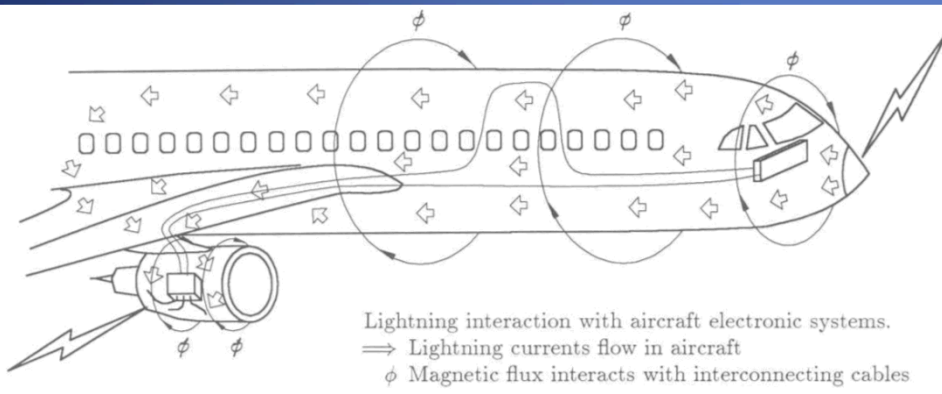
Lightning and Electromagnetic Effects and Mitigation

Develop innovative lightning strike sensing & mitigation technologies to minimize flight safety risks from electromagnetic environmental hazards (Lightning & HIRF)



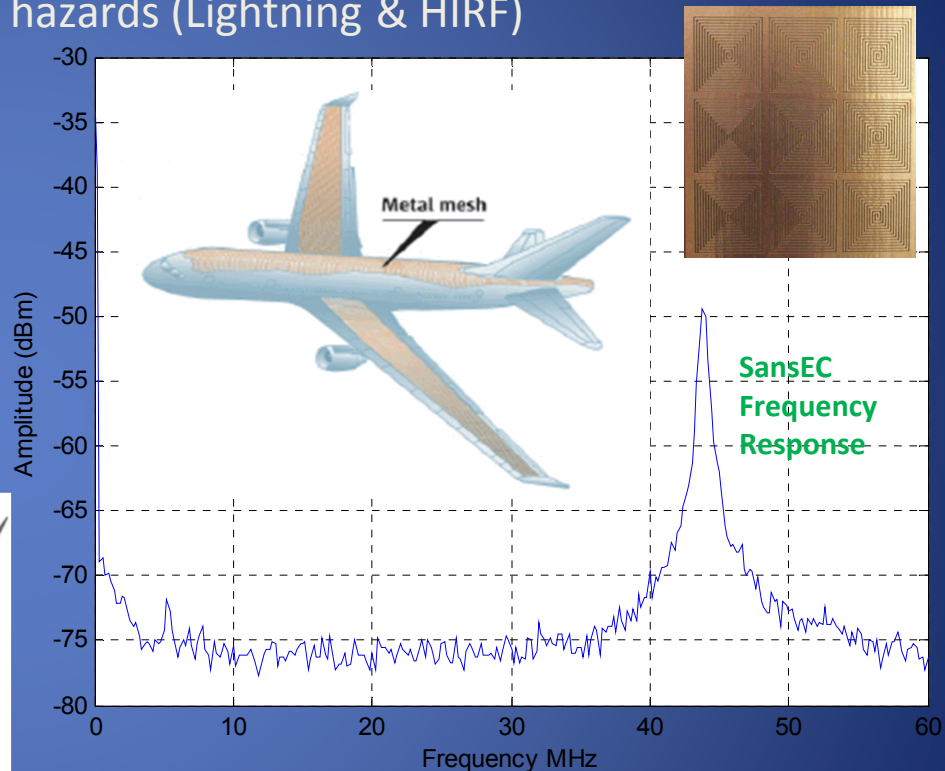
Lightning Mitigation

Develop mitigation strategies to improve aircraft lightning protection designs through passive or active methods.



Lightning Environment

Develop in-flight lightning measurement sensors to capture & record lightning waveforms which pose risk to flight safety.)



Lightning SansEC Sensors

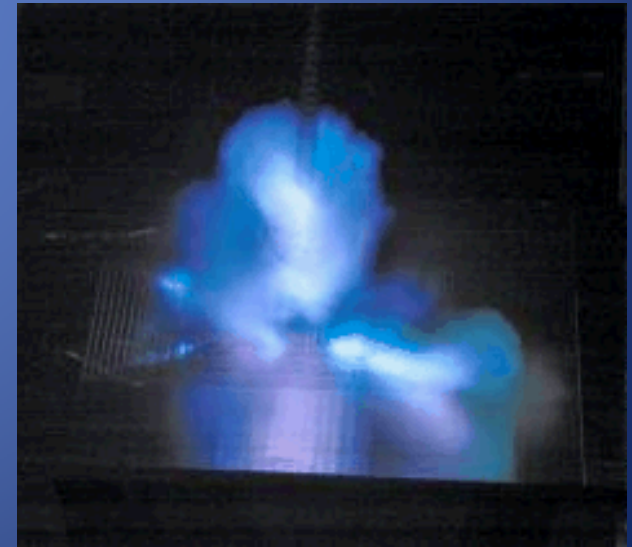
Robust, multifunctional sensors to protect & diagnose composites

SansEC – Without Wires

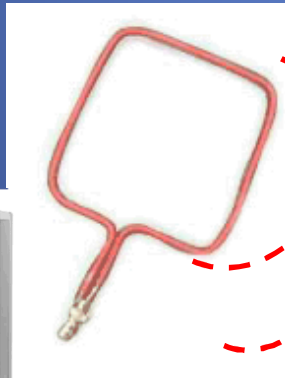
- Sensor resonant response is dependant on sensor geometry and impedance of coupled material.
- Abrupt change in resonate response is indicative of damage to the sensor or underlying material.
- Measurable parameters; frequency, amplitude, bandwidth, phase, harmonics



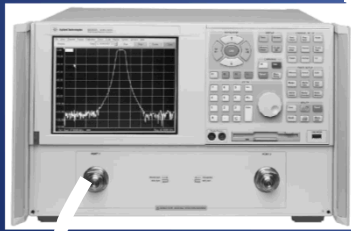
Lightning Test on 6" Sensor



Square Loop
Antenna



Network Analyzer



SansEC Sensor

Faraday Sensor for Lightning Current



- Loops illustrates fiber optic (Faraday) sensors that directly measure total current on the structures
- Existing Technology: Dots represent existing sensors that only measure the local magnetic fields – *An inverse problem, to be solved numerically, is to approximate the total current and strike location.*

Approach

- Apply evolving technologies to address prioritized aviation hazards
 - Evaluate state of sensor technology versus aviation hazards
 - Down select a Hazard-Sensor matrix for further effort based on:
 - hazard priority
 - sensor suitability (including probable airworthiness)
 - budget constraints
- Current efforts include:
 - Passive hyper-spectral imaging for:
 - terminal area wake vortices
 - surface runway state
 - reduced visibility operation
 - Active imaging for:
 - reduced visibility operation
 - Lidar for:
 - kinetic air hazards
 - optical air data systems
 - volcanic ash

	HAZARDS							
Sensors								
Passive Imaging								
Active Imaging								
LIDAR								
Other								

Goal:

*compact, low power consumption,
multi-function sensor capability
for enhanced situation awareness*

LEO Contractual Efforts

NASA Research Announcement (NRA) Funded

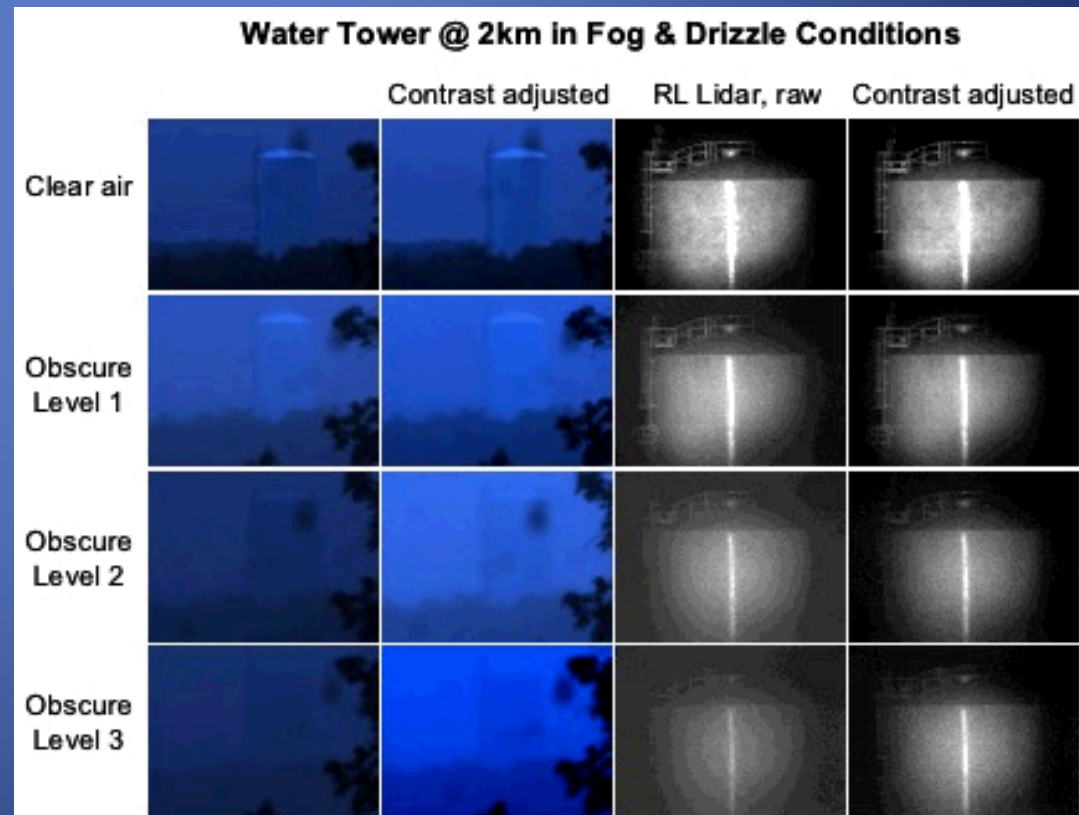
- Forward Looking Interferometry (FLI) – Georgia Tech Research Institute (GTRI) (lead)
- Wake Vortex Hazard Investigation (WV) – AI <selected, pending award>

NASA Small Business Innovative Research (SBIR) Funded

- Phase III
 - Laser Imaging Through Obscurants (LITO)
RL Associates, Inc. (RLA)
- Phase II
 - Fiber Laser Coherent LIDAR for Wake-Vortex Hazard Detection
Fibertek, Inc. <also selected for Phase II-E – pending award of II-E & III contracts>
 - Molecular Air Data CAT Sensor (MADCAT)
Michigan Aerospace Corporation (MAC)
 - Multi-Function Lidar for Air Data and Kinetic Air Hazard Measurement
Ophir Corporation <Phase I complete, Phase II selected – pending award>
- Phase I
 - Solid State Multi-Wavelength LIDAR for Volcanic Ash Monitoring
Physical Sciences, Inc. (PSI) <Phase I complete, Phase II not selected>
 - Multi-function Fiber Laser Kinetic Aviation Hazard Sensor
Fibertek, Inc. <selected, pending award>
 - Low-Cost Lidar for Wake-Vortex and Other Hazard Detection
Q-Peak, Inc. <selected, pending award>

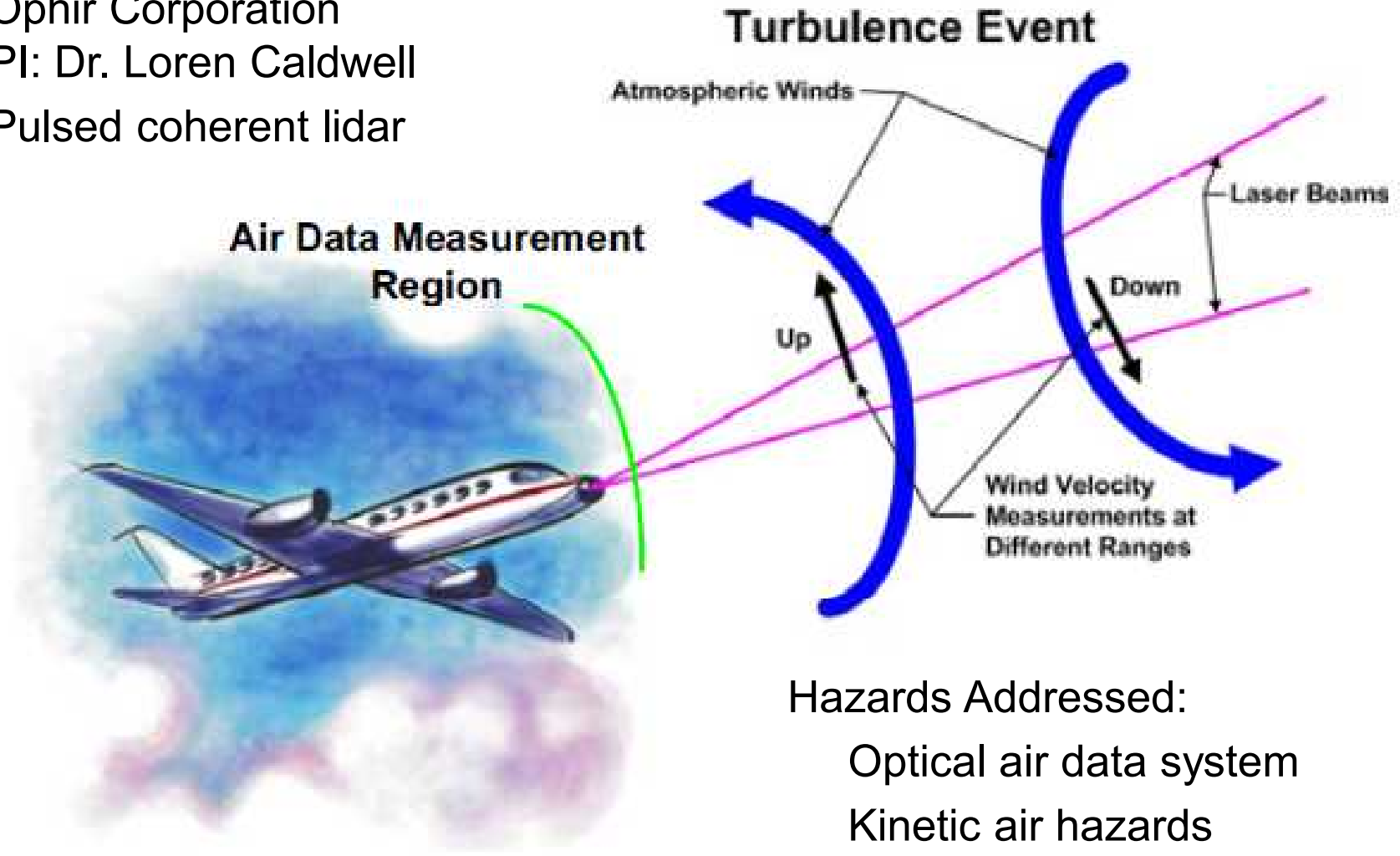
Laser Imaging Through Obscurants (LITO)

- Company & PI:
RL Associates, Inc. (RLA)
PI: Mary Ludwig
- Sensor Technology:
 - Monochromatic active imaging using laser illumination
- Hazards Addressed:
 - Reduced visibility operations



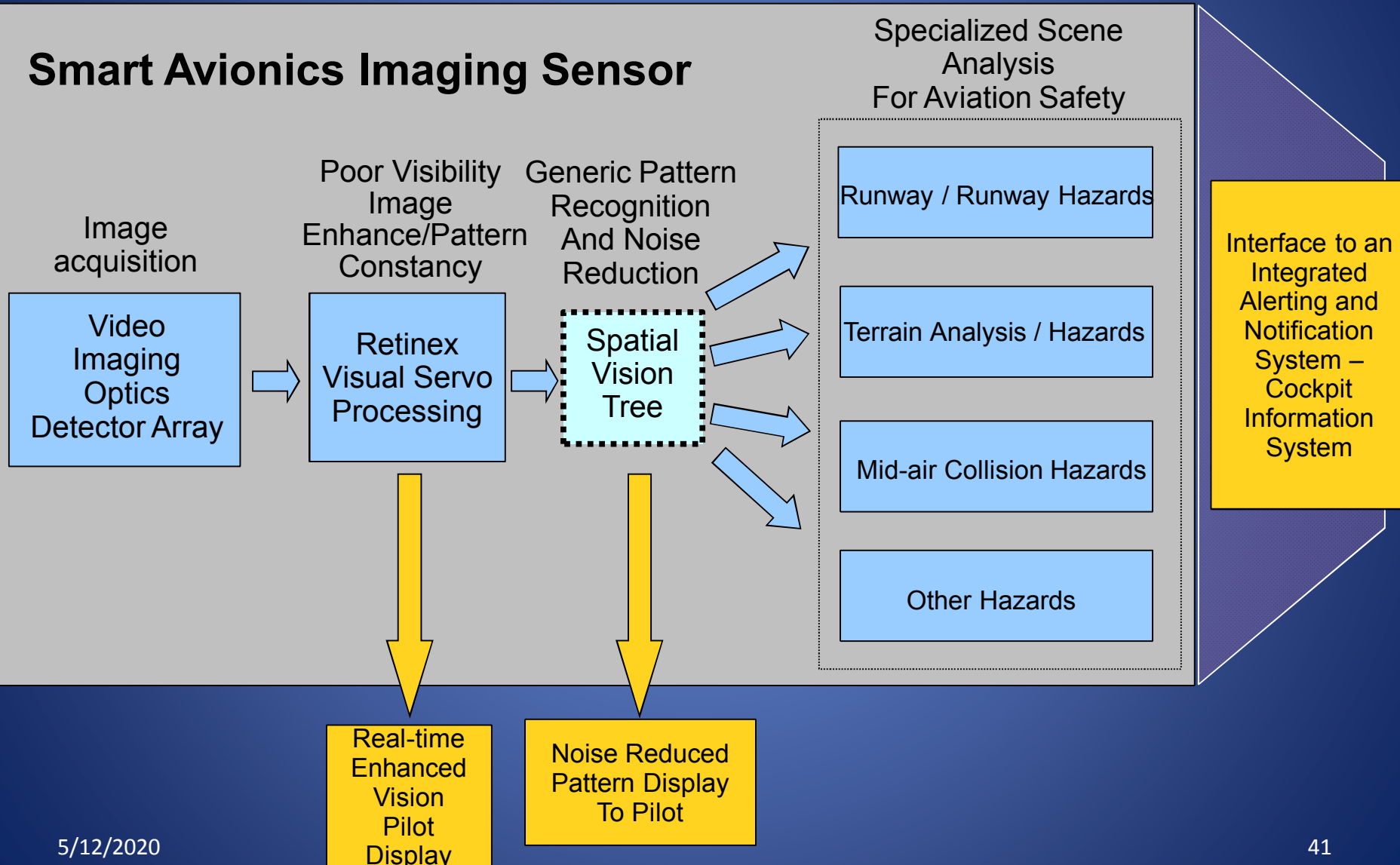
Multi-Function Lidar for Air Data and Air Hazard Measurement

Ophir Corporation
PI: Dr. Loren Caldwell
Pulsed coherent lidar



SVA – Smart Avionics Imaging Sensor

Smart Avionics Imaging Sensor



First Step – Retinex Visual Servo



Process incoming imagery to enhance it and to provide a stable starting point for subsequent processing.

As independent as possible from lighting and visibility variations

Output in real time –
suitable for presentation to
pilots

