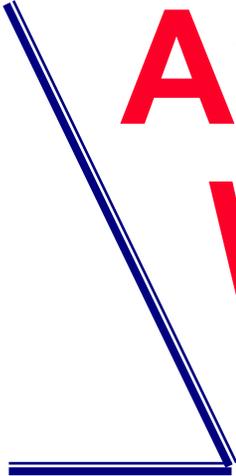


AWIN

<http://awin.larc.nasa.gov>



Aviation
Weather
INformation

Weather Accident Prevention Annual Project Review
May 23 - 25, 2000

Paul Stough
NASA Langley Research Center
Hampton, VA

Aviation Weather Information

AWIN

- **Background**
- **Enhanced Weather Products**
- **Operator Support**

Background

AWIN

- **Feb. 1997, President Clinton established national goal: Reduce fatal accident rate by 80% in 10 years**
- **NASA Aviation Safety Investment Strategy Team (ASIST) prioritized research needs**
- **NASA created Aviation Safety Program (AvSP)**
- **Weather is a major contributing factor in accidents**
 - 33% Commercial Carrier**
 - 27% General Aviation**
- **AvSP created Weather Accident Prevention Project**

Weather Information System Goals

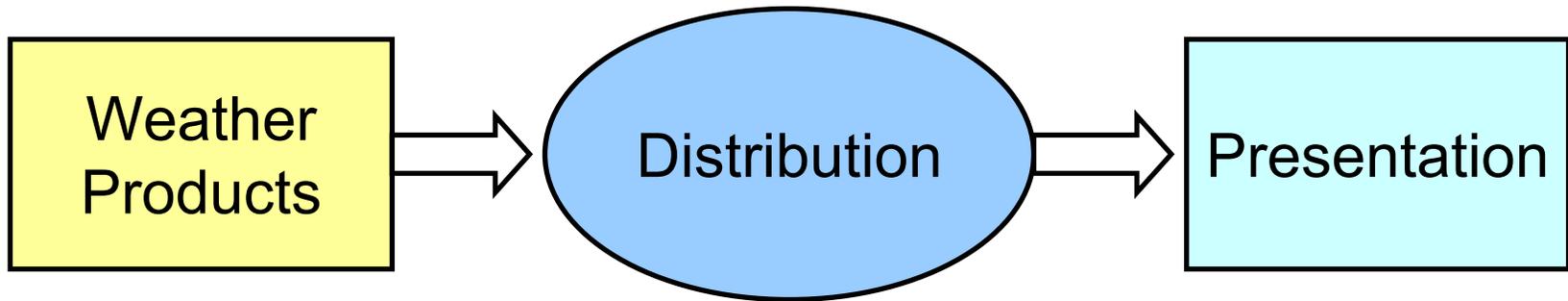
AWIN

- **Data dissemination** - Implement **data link** capabilities for Flight Information Services (FIS)
- **Crew/dispatch/ATC monitoring, presentation, and decision aids** - develop and implement multifunctional **color cockpit displays** incorporating FIS products
- **Weather product generation** - expand and institutionalize the generation, dissemination, and use of **automated PIREPS** to the full spectrum of the aviation community, including general aviation
- **Advanced aviation meteorology** - improve underlying weather **forecasting** services
- **Near term tactical sensors/systems** - incorporate **satellite-based and ground-based sensor technologies** and develop **aircraft-mounted forward-looking technologies** for detecting weather hazards

- **Better forecasts need better data**
- **Graphic presentations need more bandwidth**
- **Current data communication capability limits availability & presentation**
- **Presentation should not increase workload**
- **Existing aircraft need retrofit capability**

System Elements

AWIN



AWIN
Enhanced
Weather
Products

WINCOMM
Communications
Networks and
Data Links

AWIN
Operator
Support

Aviation Weather Information (AWIN)

AWIN

Goal

Develop technologies and methods to provide sufficiently accurate, timely and intuitive information to pilots, dispatchers, and air traffic controllers which, if implemented, will enable a 50% reduction in aircraft accidents attributable to weather situation awareness

Objectives

Develop Needed Weather Products and Sensing Capabilities

Develop Enhanced Weather Presentations and Decision Aids

Challenges

Improved Forecast Models and Remote Area Weather Sensing

Multi-Purpose Sensor Systems

Weather Display Systems for Retrofit Applications

Diverse Aviation User Groups

Approaches

Improve Wx Forecast/ Nowcast Capabilities

Use Aircraft as Airborne Wx Data Collectors

Develop Installed and Portable Systems

Provide Decision Aids

Elements

Cooperative Agreements

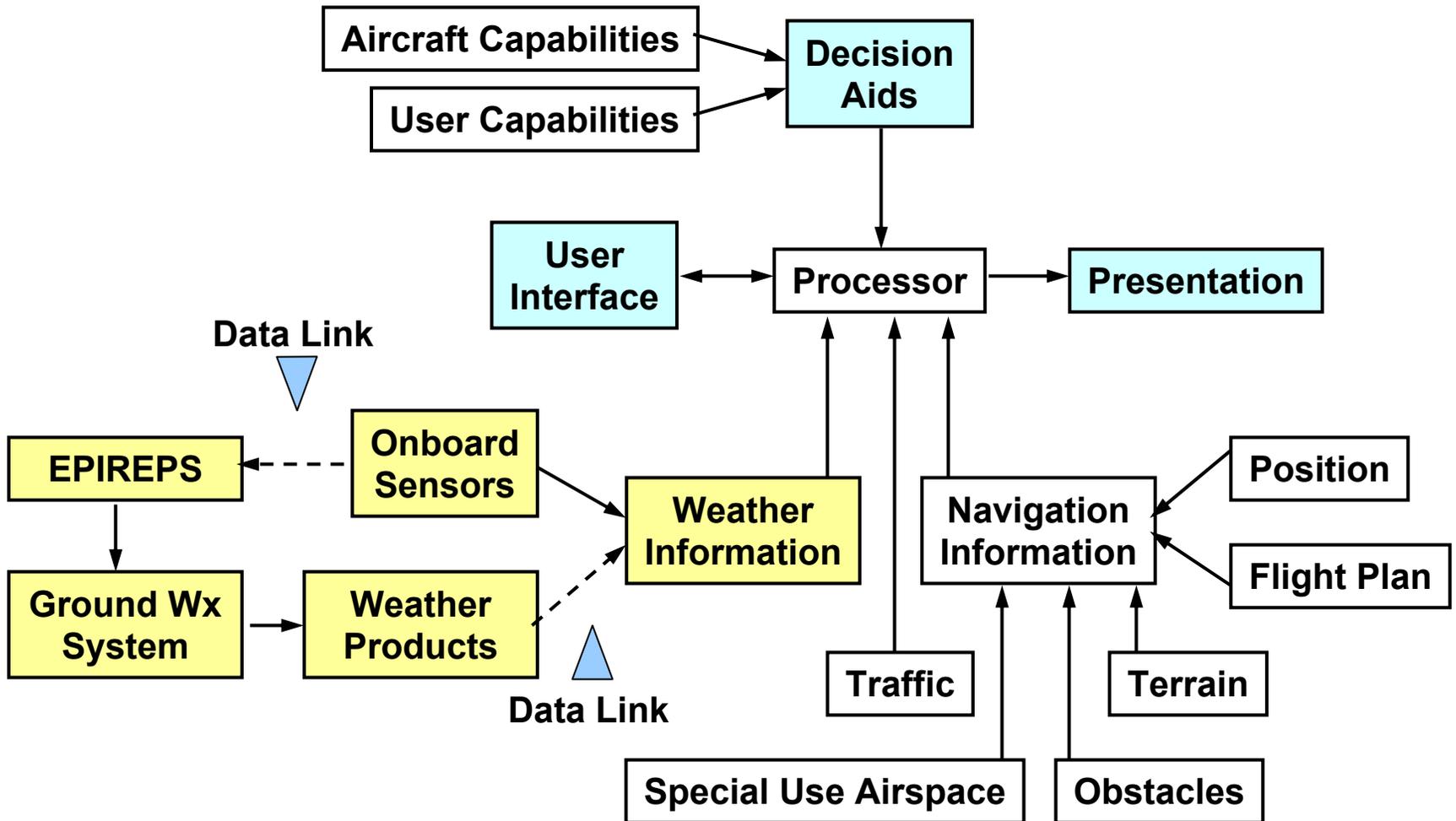
Enhanced Weather Products

Operator Support

Systems Engineering

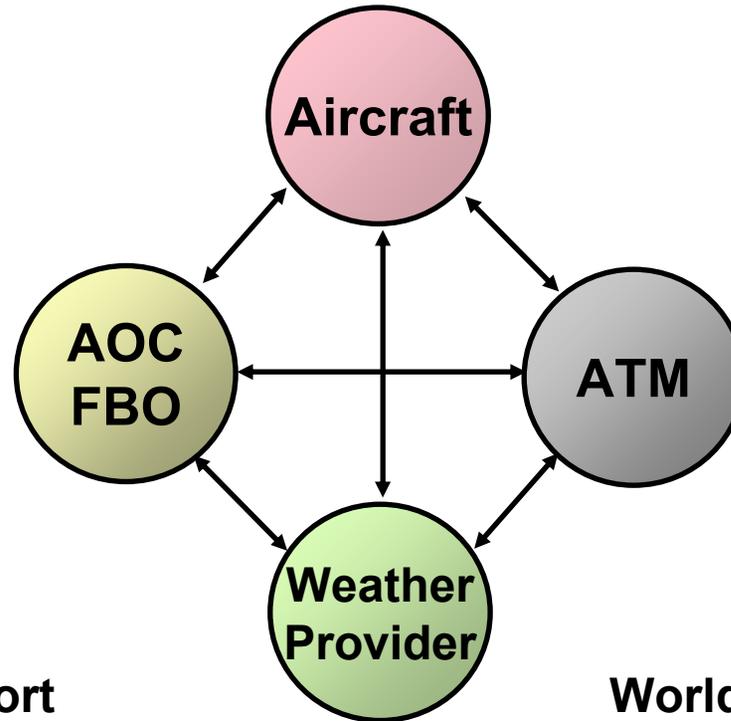
AWIN System

AWIN



Weather Information Exchange

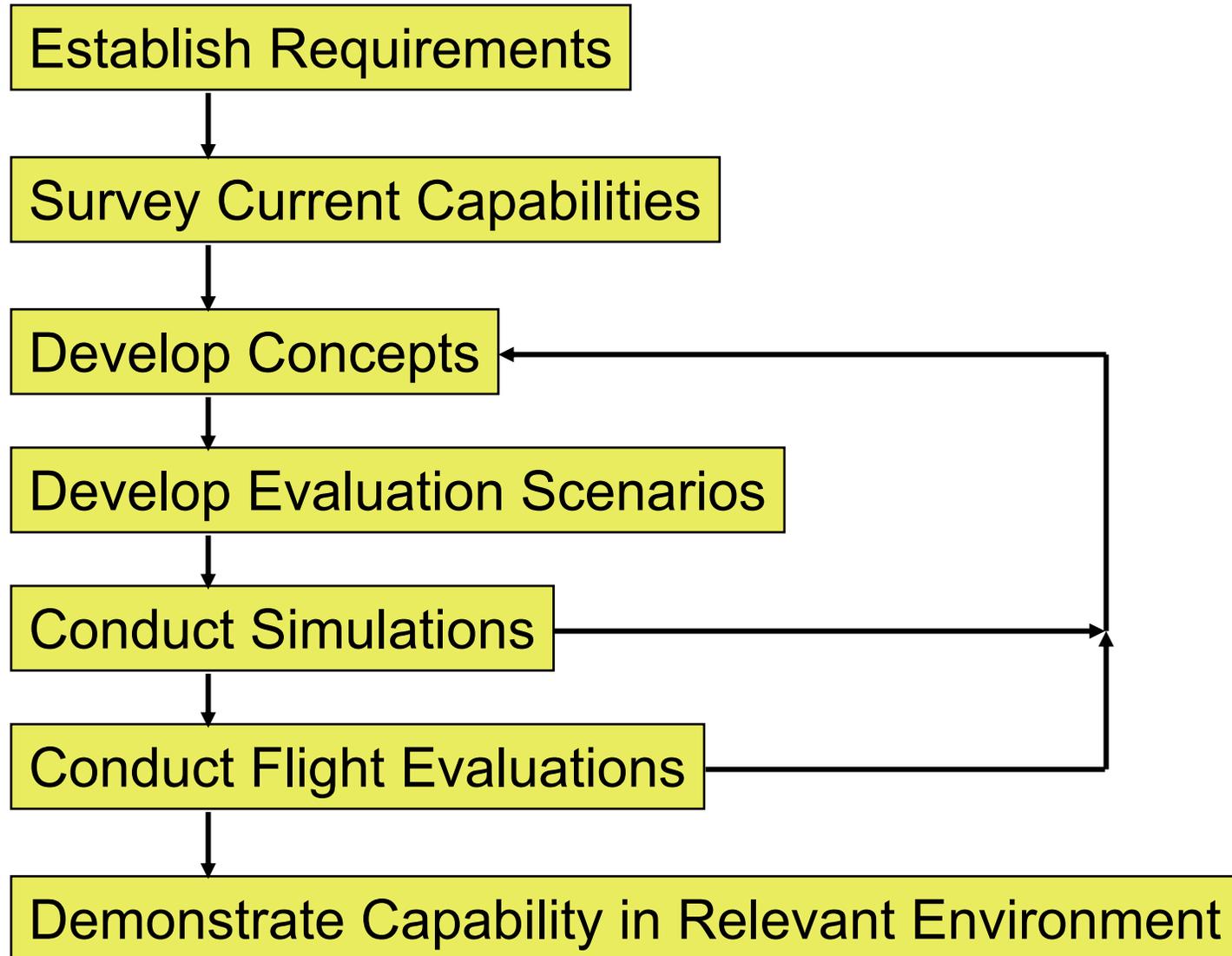
AWIN



- **Transport** **Worldwide**
- **Commuter** **United States**
- **General Aviation** **United States**
- **Air Traffic Management (ATM)** **United States +**
- **Airline Operations Center (AOC)** **Worldwide**
- **Fixed Base Operator (FBO)** **United States**

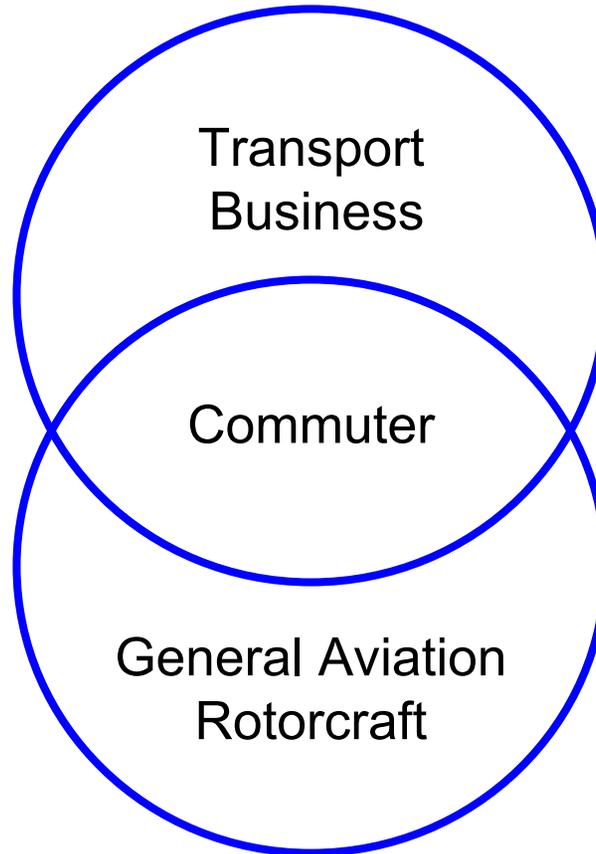
Technology Development Process

AWIN



Market Segments

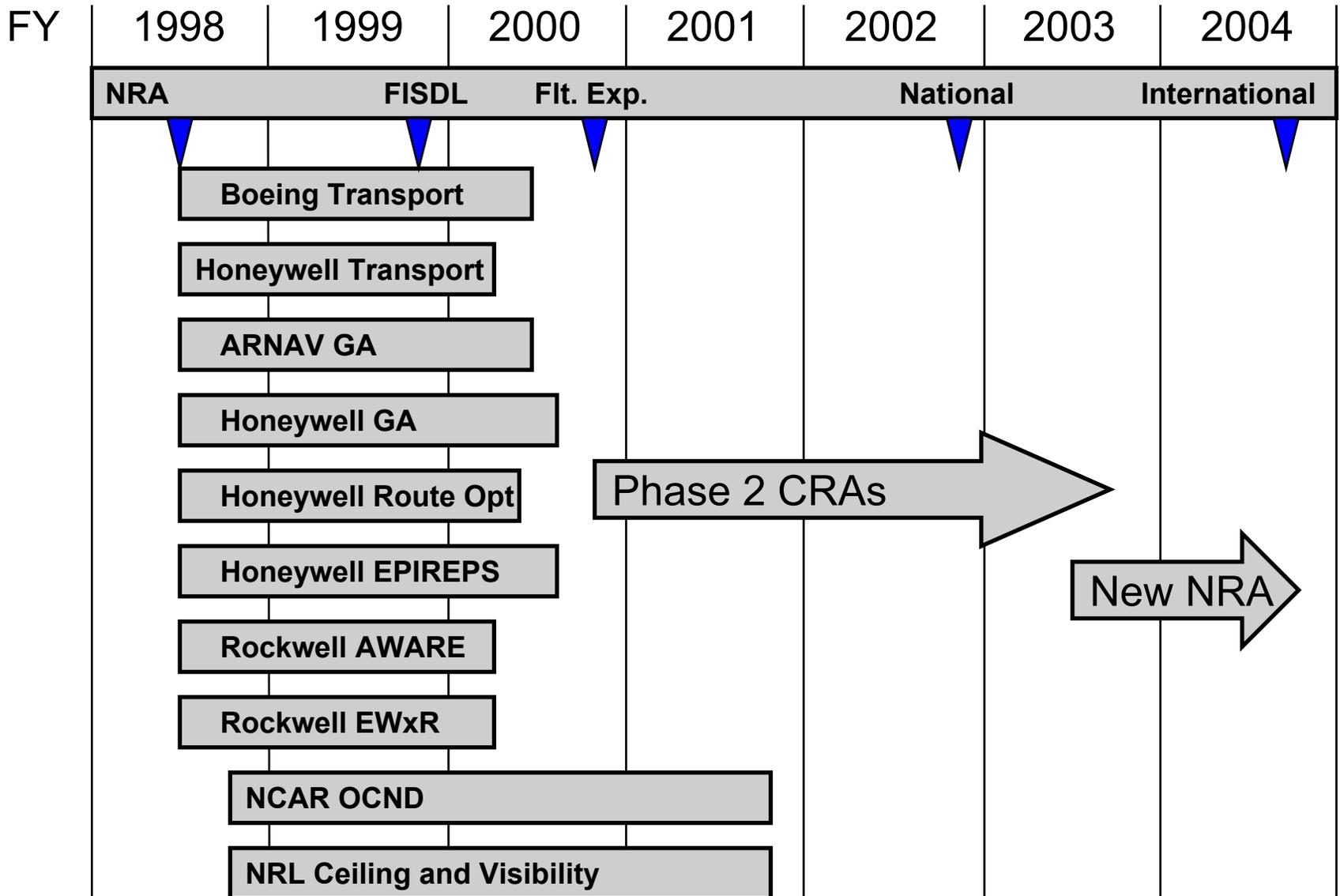
AWIN



SAE 2000-01-1662 Kauffmann, "Estimating the Adoption Rate for Cockpit Weather Information Systems"

Timeline

AWIN



- **Expanded collection and dissemination of weather observations**
 - Remote areas (oceanic)
 - Lower atmosphere
 - Off established airways
- **Easier access to aviation weather information**
- **More intuitive presentation of information to flight crew**
 - Graphic format
 - Flight path relevant
- **Better situation awareness**
- **Faster, more informed decisions**
 - Decision aiding

Summary

AWIN

- **Addressing strategic and tactical weather information needs and presentation**
 - Weather Product Generation
 - Presentation and Decision Aids
- **Excellent coordination with FAA**
 - FAA Aviation Weather Research Program
 - FAA Flight Information Services
- **Strong industry commitment shown by significant cost sharing**
 - Positive implementation potential

Aviation Safety Program

Weather Accident Prevention Aviation Weather Information Enhanced Weather Products (EWxP) Level IV Overview

Phil Schaffner, EWxP Manager
NASA Langley Research Center
P.R.Schaffner@LaRC.NASA.gov
(757)864-1809

NASA AvSP Organizational Structure



**Aviation Safety
Program Office
1.0**

**Government/Industry
Program Leadership
Team**

**Technical Integration
1.1
Vince Schultz (LaRC)**

Level 1- Program

**Aviation System
Monitoring &
Modeling
2.1
Yuri Gawdiak (ARC)**

**System-Wide
Accident
Prevention
2.2
Dave Foyle (ARC)**

**Single Aircraft
Accident
Prevention
2.3
John White (LaRC)**

**Weather Accident
Prevention
2.4
Ron Colantonio (GRC)**

**Accident
Mitigation
2.5
Doug Rohn (GRC)**

**Synthetic
Vision
2.6
Dan Baize (LaRC)**

Level 2- Elements

**Aircraft Icing
(Base Program)**

**Aviation Weather
Information
(AWIN)
2.4.1
Paul Stough (LaRC)**

**Weather Information
Communication
(WINCOMM)
2.4.2
Gus Martzaklis (GRC)**

**Turbulence
Detection &
Mitigation
2.4.3
Rod Bogue (DFRC)**

Level 3- Projects

**Enhanced
Weather Products
2.4.1.1
Phil Schaffner (LaRC)**

**Operator Support
2.4.1.2
Dan Shafer (LaRC)**

**Cooperative Research
Agreements
2.4.1.3
Paul Stough (LaRC)**

**Systems Engineering
2.4.1.4
Ed Johnson (LaRC)**

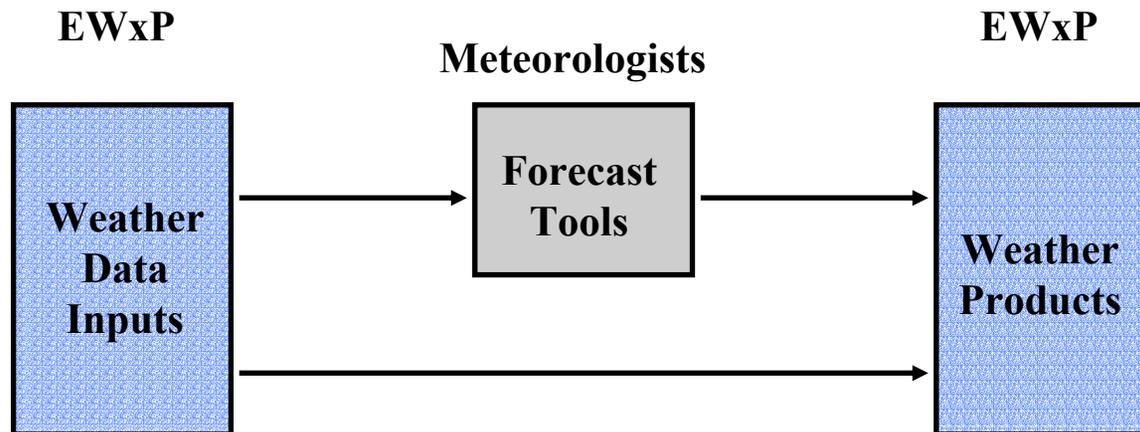
Level 4

EWxP Project Goals/Objectives/Products

AWIN

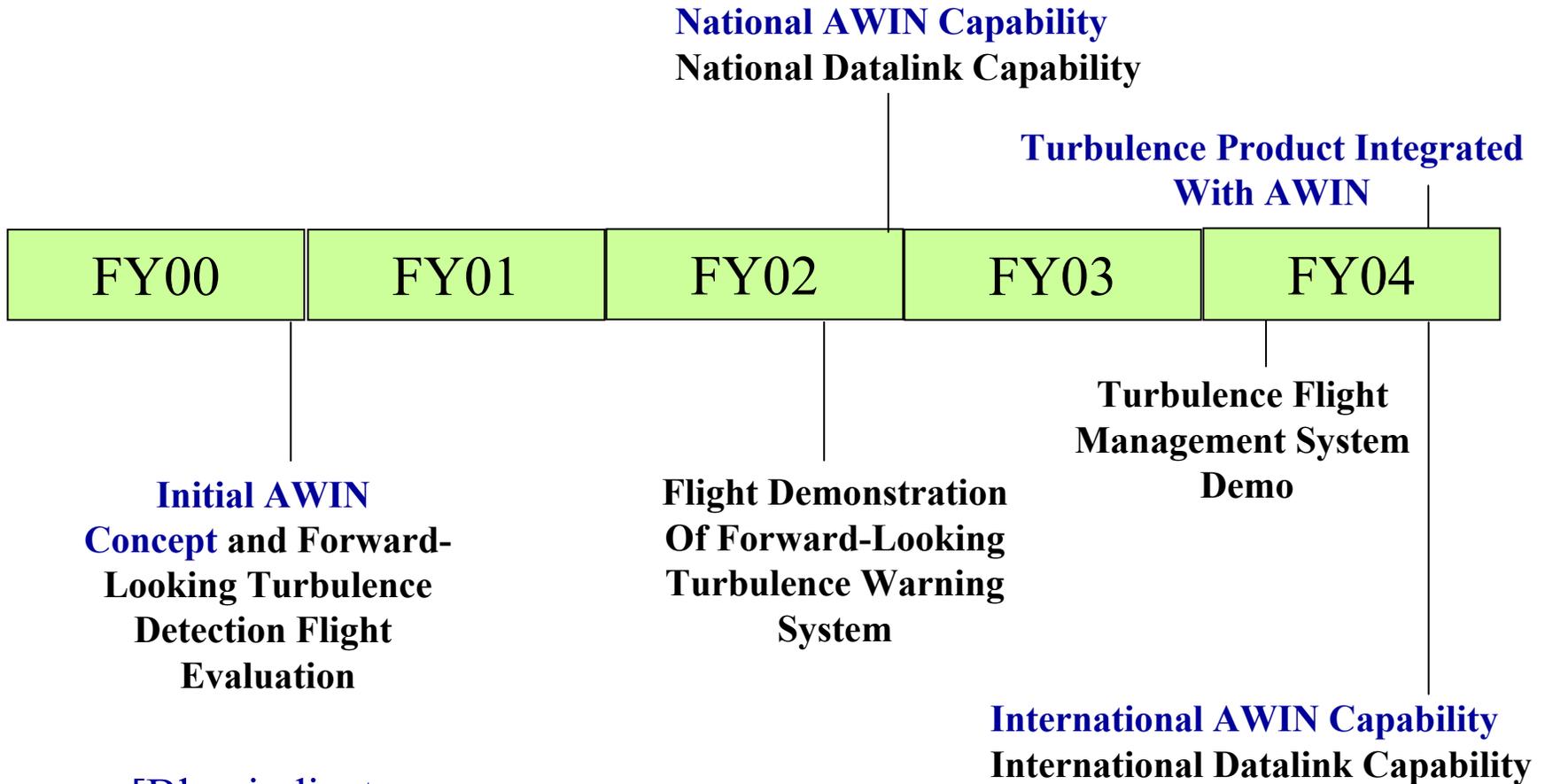
Goal: Develop technologies that will provide accurate, timely and intuitive information to pilots, dispatchers, and air traffic controllers to enable the detection and avoidance of atmospheric hazards.

Objective: Develop new and derivative weather products, complementing existing weather sources with in situ and remote sensing capability where necessary, to provide necessary information at appropriate temporal and spatial resolution for both tactical and strategic decision making for aviation users.



WxAP Project Schedule and Milestones

AWIN



[Blue indicates EWxP Emphasis]

EWxP Product Implementation Strategy

AWIN

- Utilize Cost/Market studies to guide product development.
- Work with and complement efforts under Cooperative Research Agreements (CRAs).
- Work with FAA PDTs and NWS/AWC to adapt existing and experimental, guidance, and operational weather products for cockpit use.
- Cooperate with FAA PDTs and NWS to enhance weather products by providing additional information. (e.g. E-PiReps)
- Partner with industry to develop and demonstrate technologies.

EWxP Areas of Emphasis

AWIN

- Airborne Hazard Avoidance System
- Electronic Pilot Reports (E-PiReps)
- FAA, FAA PDTs, NOAA, and other interfaces
 - Cooperate in ongoing research activities
- Ground and space based sensor development/exploitation
 - Low Cost Terminal Area Weather Radar (& Airport Services?)
 - Adaptation of GIFTS and other Atmospheric Sciences Satellites
- Adaptation of Weather Products for Cockpit use

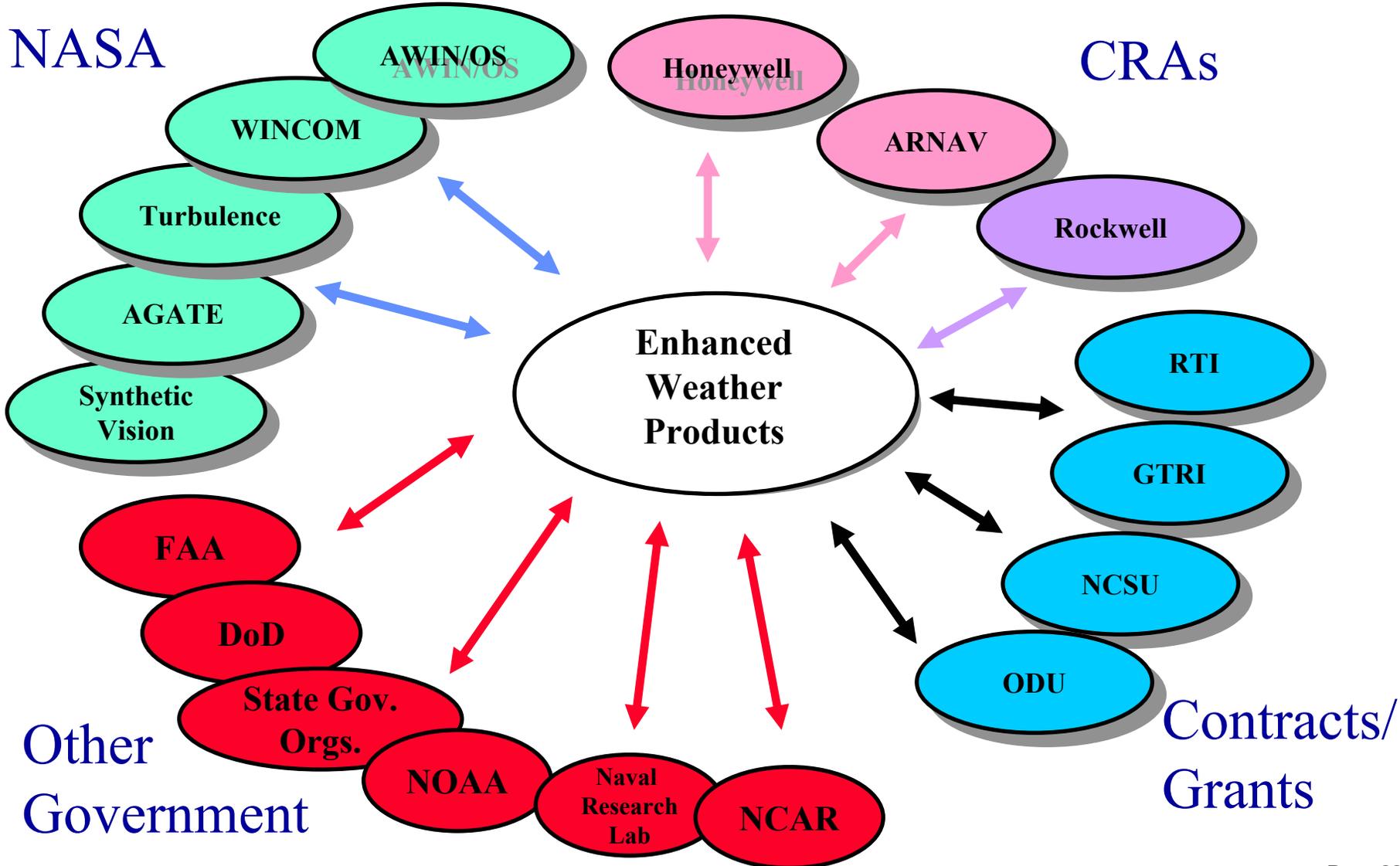
EWxP Accomplishments

AWIN

- Completed AWIN requirements study.
- Supporting NCSU Icing Accident Characterization.
- Jointly Supporting NRL Ceiling and Visibility Improvement Experiment with Navy and FAA.
- Supporting NWS/AWC Visiting Scholar Program.
- Supporting Enhanced Weather Radar data collection and merging of airborne radar data with uplinked NEXRAD data on Summer 2000 flight experiments.
- ATLAS Total Lightning Sensor Testing
- Investigated sensor simulation environments to support sensor and system development.
- Developing architecture for AWIN hazard detection and avoidance systems.

EWxP Interfaces

AWIN



EWxP CRA Connections

AWIN

- **Transport World-Wide Weather Information Systems**
 - Boeing Aviation Weather Information (AWIN)
 - Honeywell Weather Information Network (WINN)
- **General Aviation Weather Information Systems**
 - ARNAV Weather Hazard Information System: Reducing GA Fatal Weather-Related Accidents
 - Honeywell GA-Oriented VHF DataLink (VDL) Mode 2-Based Weather and Flight Information Services (FIS) Broadcast, Reception, and Display System
- **Topical Category - Elements of Weather Information Systems**
 - Honeywell Weather Avoidance Using Route Optimization as a Decision Aid
 - Honeywell General Aviation Oriented Electronic Pilot Report (EPIREP) Generation and Datalink System
 - Rockwell Aviation Weather Awareness and Reporting Enhancements (AWARE)
 - Rockwell Enhanced On-Board Weather Information System (EWxR)
 - NCAR A Demonstration of an End-to-end Oceanic Weather Hazard Information Dissemination System
 - NRL Ceiling and Visibility Forecast/Nowcast Improvements

Legend:

Managing

Close Connection

Electronic Pilot Reports (E-PiReps)

AWIN

Intent is to develop low cost sensor and communications infrastructure, and to complement and enhance current ACARS/MDCRS information.

- **Industry Partners**

- Honeywell International E-PiReps, GA, and Transport System CRAs
- ARNAV GA System CRA
- ???

- **Other Agency Partners**

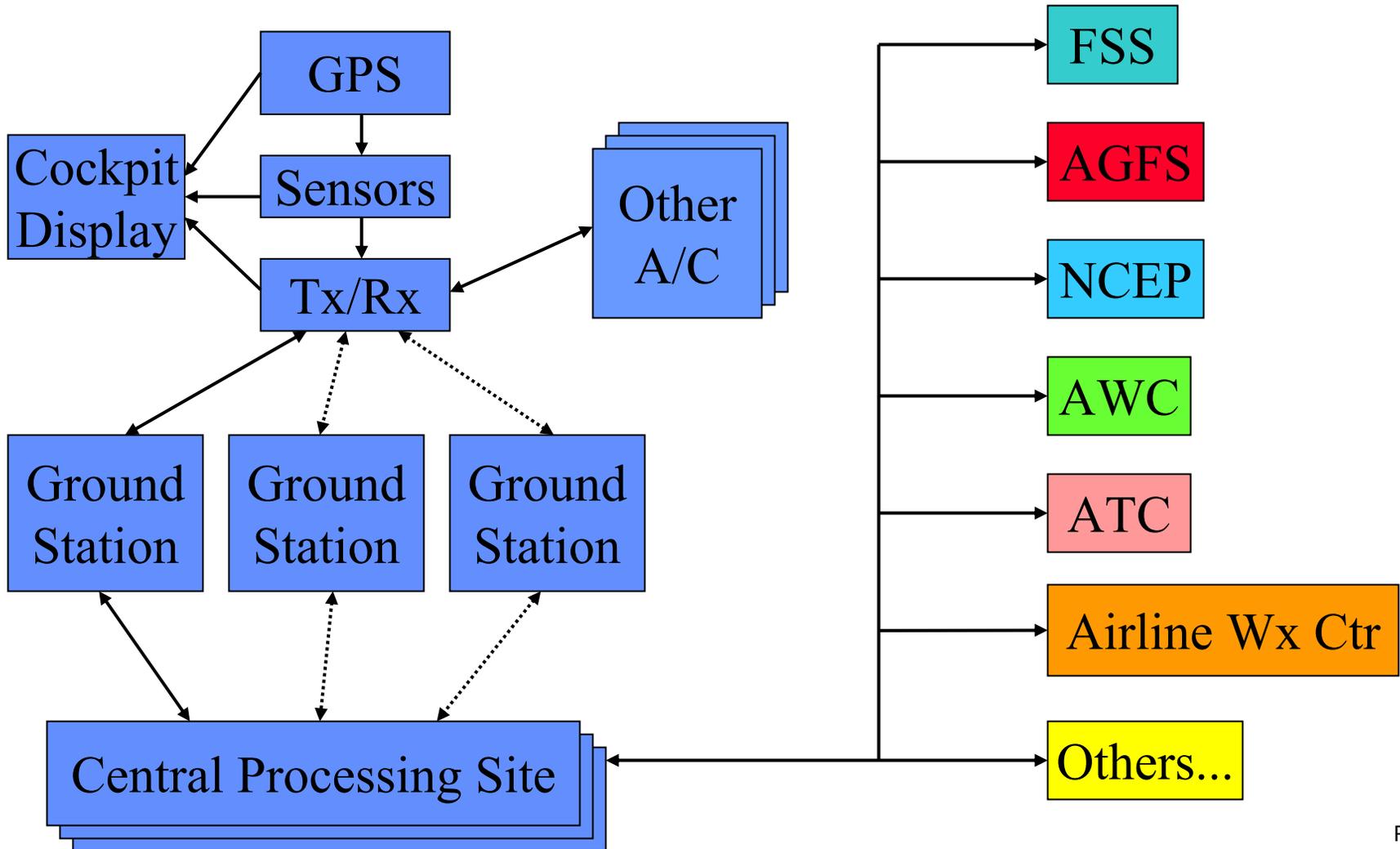
- FAA and PDTs
- NOAA (NCEP, FSL, AWC)

- **NASA Langley Efforts**

- Surveys of User Requirements
- Laboratory, Wind Tunnel, Flight Testing and Validation

E-PiReps Concept

AWIN



E-PIREPS as Wx Information

AWIN

E-PiReps information may include: position, heading, airspeed, winds aloft, temperature, water vapor/humidity, ice detection, ice depth, accelerations, A/C independent turbulence, measurements or alerts from forward-looking sensors

Potential Users:

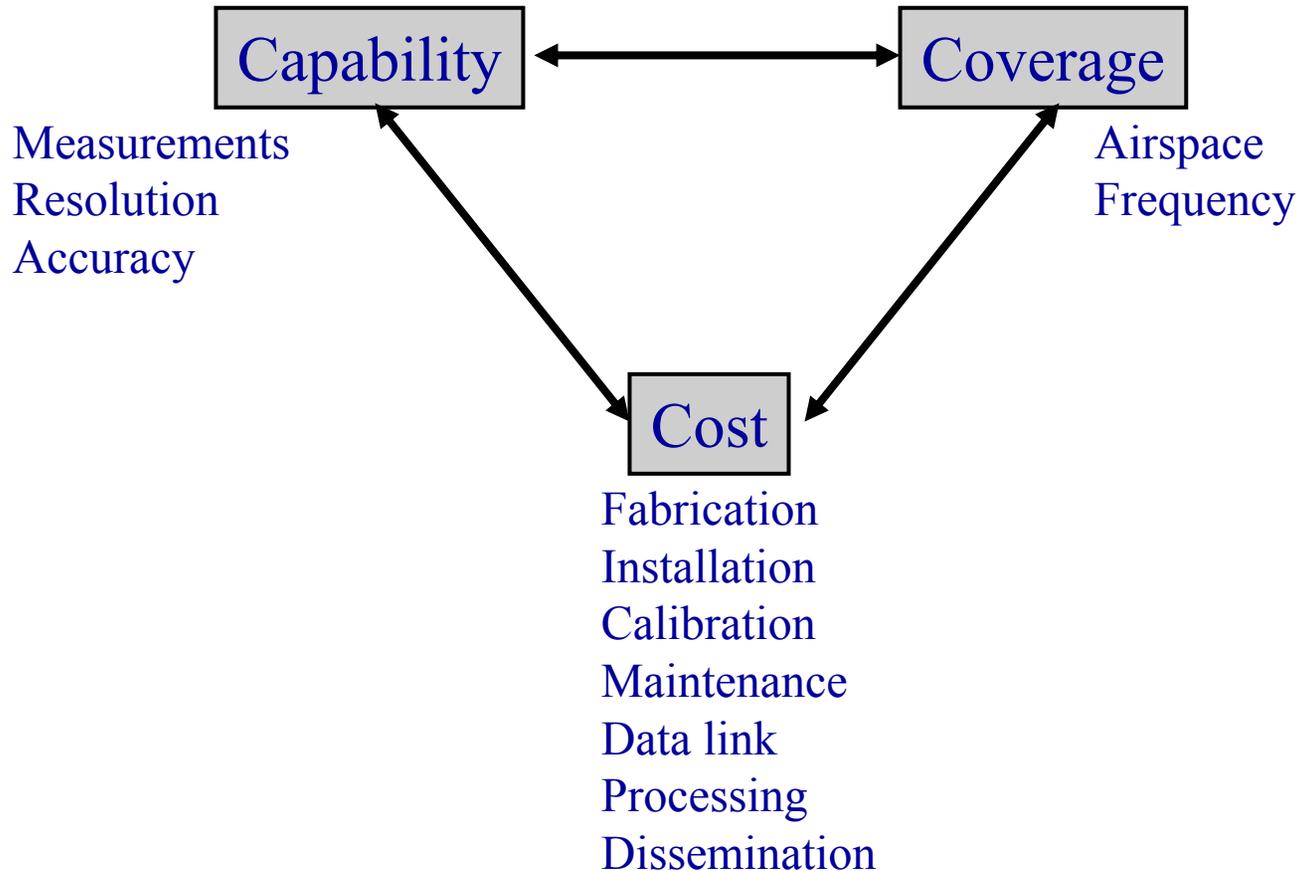
- Pilots (Tactical, Strategic)
- ATC and NAS Traffic Planners (Strategic, Tactical)
- NCEP (Strategic)
- AWC/RTVS (Strategic)
- Airline Wx Centers (Tactical, Strategic)

EPIREPS System Issues

AWIN

What sensors do you use?

What aircraft do you equip?



“GA” E-PiReps Costs and Benefits

AWIN

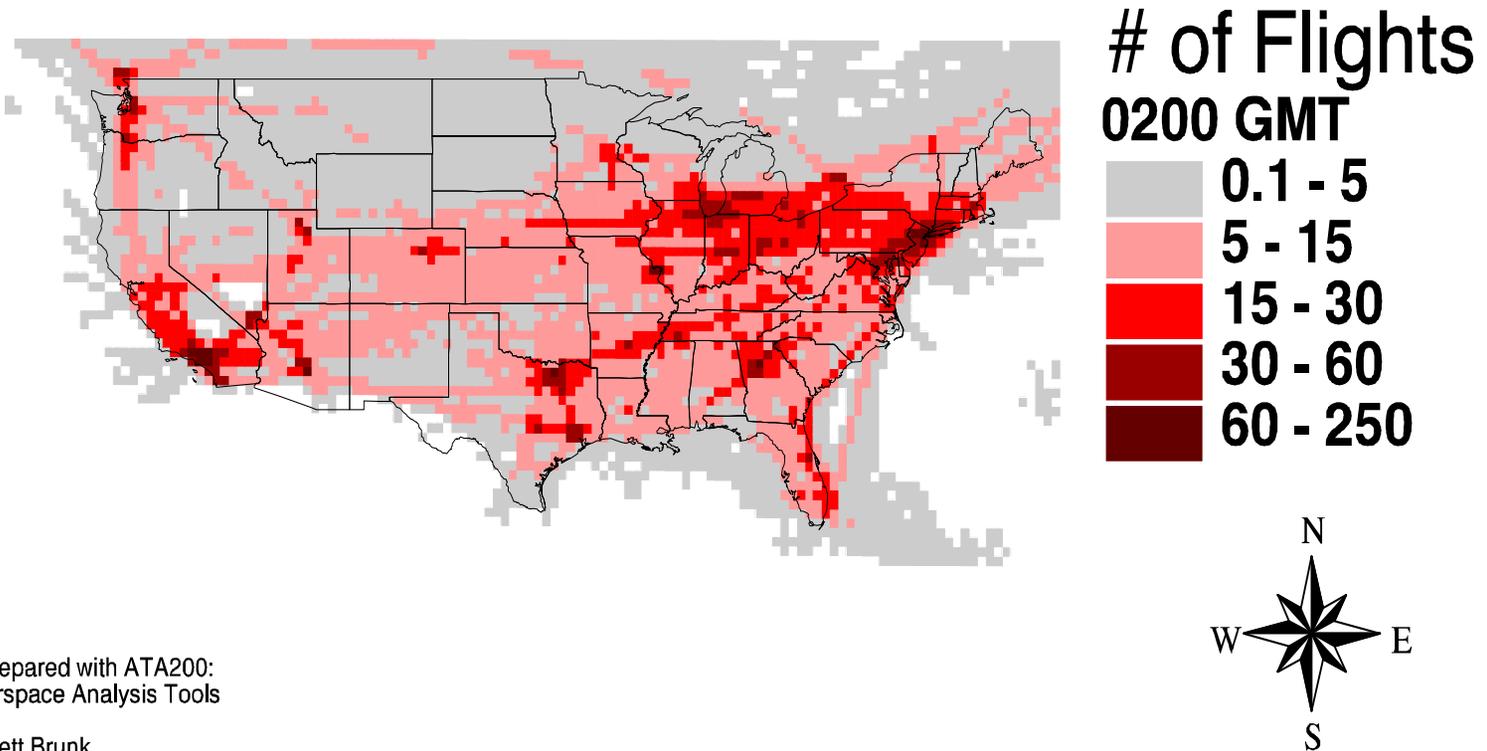
- Incentives to Equip
 - Regional Airlines
 - General Aviation FBOs, Individual Owners
- Sensor/Communications Package Price
 - Rebates, Tax Incentives, Sale of data
- Weather Data Cost
 - Users share cost of data
 - Value added to FIS

- FAA ATA-200 Airspace Planning and Analysis Division
 - Archives IFR flight data into the ETMS database
 - Will share data and provide analysis to help answer the coverage issue

E-PiReps Coverage Study



Expected Results from ATA-200



Prepared with ATA200:
Airspace Analysis Tools

Brett Brunk
CNA Corporation
October 7, 1997

E-PiReps Sensor Calibration

AWIN

- Factory Calibration
- Internal self-checks
- Periodic calibration
 - Performed by?
 - How often?
 - To what standards?

Testing in GRC Icing Research Tunnel

AWIN

- Support Testing of Honeywell/ODS Sensor Package
- Tunnel back online 6/2000
- Piggyback on other NASA test
- Various regimes for icing (Euro K ice detection standard)
- Test section 6' x 9' x 20'
- Must provide own data acquisition, other equipment, and cabling
- Second Shift Testing Only
- Online forms and manuals:

<http://www.grc.nasa.gov/WWW/IRT/index.html>

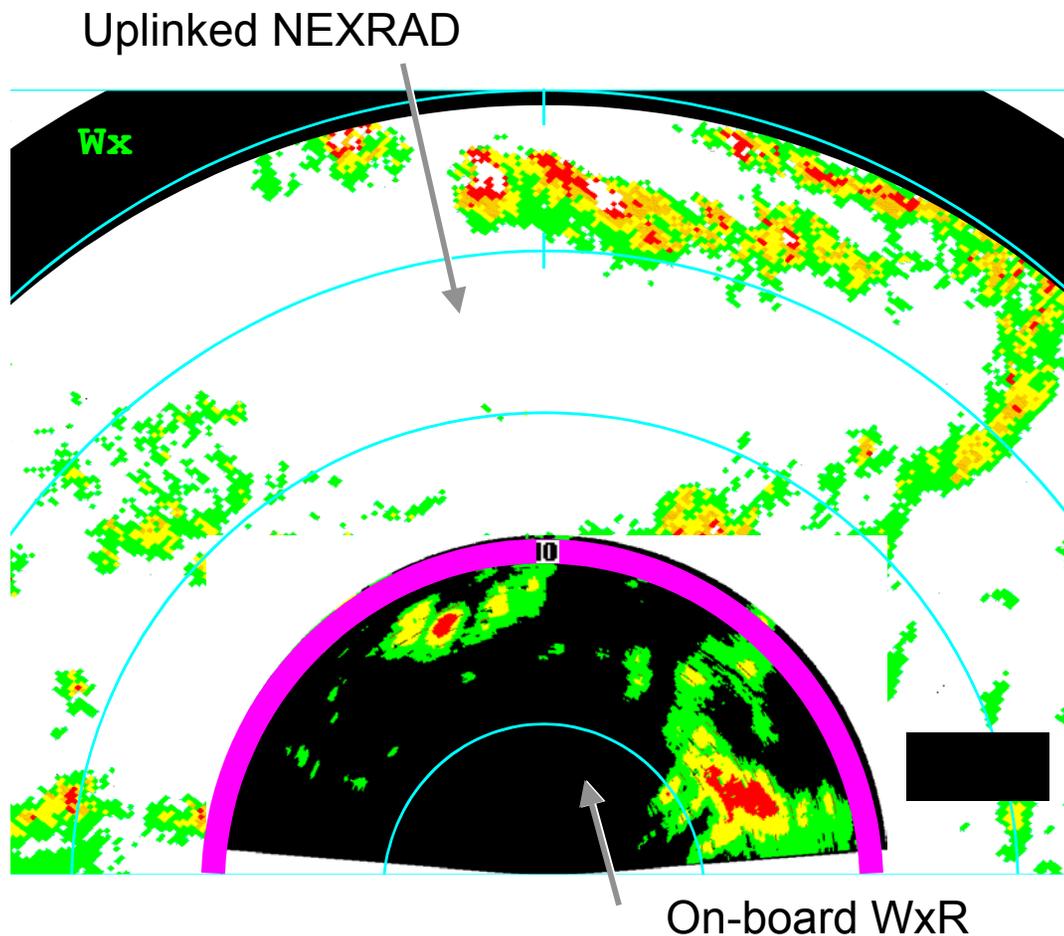
E-PiReps Summary

AWIN

- Phase II of CRAs in progress
- Interfaces established with other partners
- Coverage analysis in progress
- Testing/Costs/Calibration Issues being addressed
- Determining applications, customers, requirements

Rockwell Enhanced Weather Radar (EWxR)

AWIN



Example of WxR and NEXRAD underlay.

EWxP's Next Steps

AWIN

- Increased interaction and cooperation with FAA, NOAA, and DoD.
- Develop airborne hazard avoidance sensor-suite/information-system concepts.
- Develop low cost Terminal Area Weather Radar system design.
- Complete initial marketing studies for each product.
- Continue to seek greater participation with aviation user community.
- Develop detailed plans for FY-02 National and FY-04 International Concept Demonstrations

Potential Future Venues for Testing/Demo

AWIN

- Oshkosh 2000, 2001, ...
- Orlando Sun-N-Fun 2001,2002, ...
- Salt Lake City Winter Olympics 2002
- NE/Cleveland Corridor Experiment
- AWIN National Demo 2002
- AWIN International Demo 2004
- Other NASA and FAA activities...

Oceanic Lightning is a Potential Wx Product to be adapted for cockpit use

- **Data-sparse Areas Exist Due to:**

- Lack of sensor coverage
 - > **Oceanic Regions beyond NEXRAD coverage**
- Limited Observations/Sensors
- Limited Resolution (models)
- Limited Comms
- Satellite imagery doesn't always relate convection

But a 'Gapfiller' to augment satellite imagery for such data-sparse areas exists!

- **Long Range** or Oceanic Lightning Data
 - > We only have to 'turn on the spigot'

Oceanic Lightning Experiment

AWIN

- **WHO:**

- **Sponsors: AWC, GAI & FAA.**

- **Networks: NLDN/CLDN, France, Germany & Japan.**

- **PARTICIPATION:**

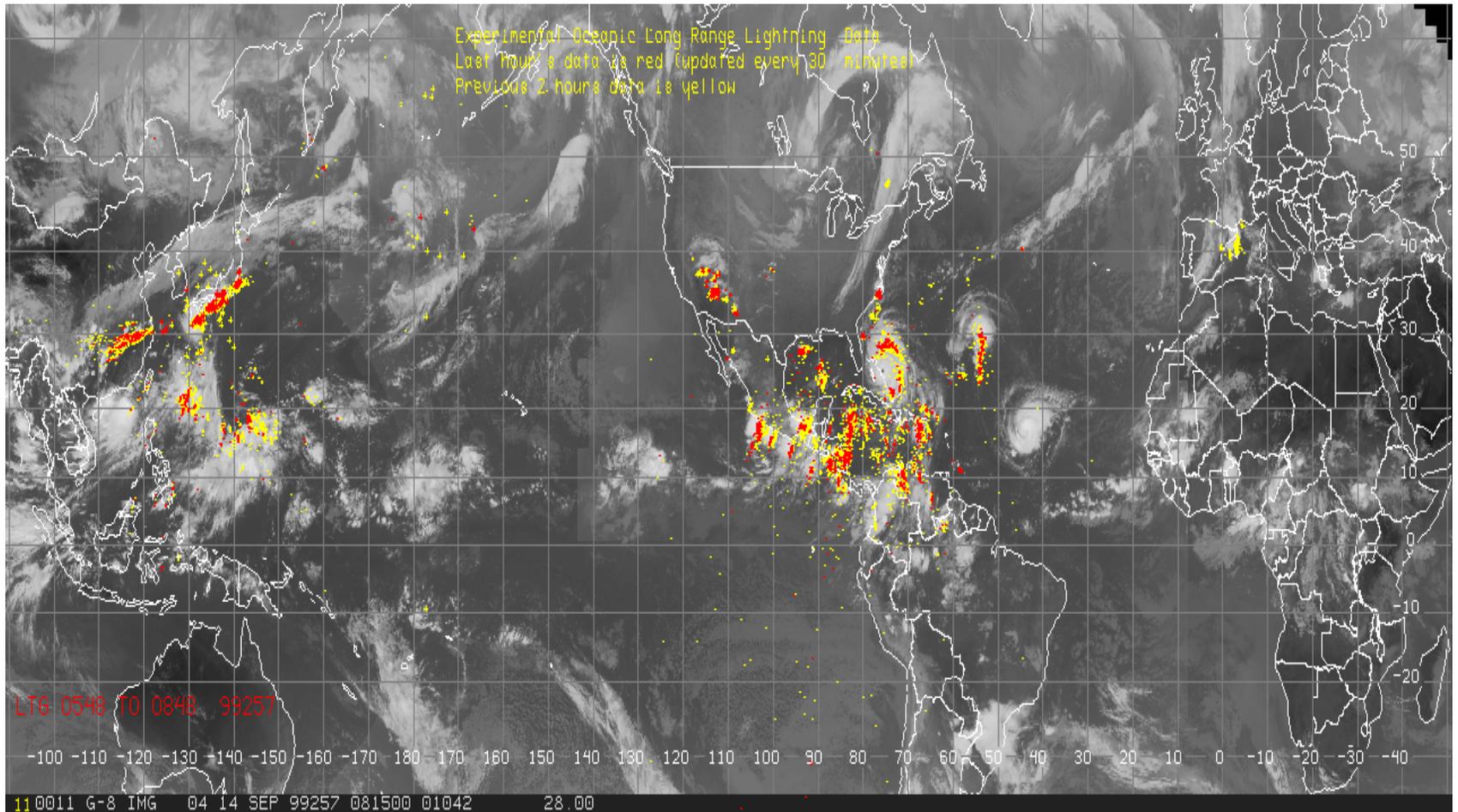
- FAA → Oceanic ARTCCs (OAK, NYC) + MIA/HOU**
>CWSUs & TMUs

- Other → NWS/DoD/Airlines for EVALUATION**

- **WHERE: Atlantic, Pacific & GULFMEX regions**

- **DURATION: April 1999 - January 2000**

NOTE: NASA AvSP/WxAP/AWIN program investigating feasibility of getting lightning data into cockpit



World View

Results of the AWC Evaluation

AWIN

- **Lightning data found useful for producing International SIGMETs.**
 - Provides AWC forecasters means of detecting convection in satellite imagery
- **FAA personnel/Airlines found it useful for flight planning over GulfMex, West Atlantic, and Caribbean.**
- **CWSUs issued CWAs based upon this data.**
- **DoD personnel used data to**
 - Delineate turbulence and windshear;
 - Assist in pre-flight briefings over Caribbean and CENTAM
- **Tropical/Mid Pacific & Eastern Atlantic: Accuracy & detection efficiency needs to be improved.**
 - Lack of Sensors

Lightning Summary

AWIN

- **Collaborative Decision Making/Situational Awareness**

- Improved awareness of hazardous weather
- Earlier track adjustment-minimal route deviation
- ↻ enhancing safety and fuel savings*

- **Enhanced TS detection in data-sparse regions**

- Capability to determine which storm cells are developing to significant intensity

- **Discussion:**

- Satellite imagery & LR lightning data in GOM Project
- OCND Product
- Possible operational/experimental product onto Internet, WARP (TMU)/cockpit

* **Note: MIT/LL study: \$16M potential savings for more efficient flight routing & reduction from injury due to turbulence.**

EWxP Summary

AWIN

- Significant opportunities exist to fill gaps in Aviation Wx Information
 - Improve Airborne Sensors
 - Use Sensor-suite Approach to Address New Hazards
 - Adapt Existing Weather Products for Cockpit Use
 - Provide Improved Information for Forecasts/Models via E-PiREPS, Ground & Space Based, and Airborne Forward-Looking Sensor Systems
- Partner With Others and Support Key Cooperative Activities to Achieve Safety Goals
 - Federal Agencies
 - Industry
 - Academia

Operator Support

Dan Shafer

Operator Support Lead
NASA Langley Research Center
d.b.shafer@larc.nasa.gov
(757) 864-2651

- Overview
- Accomplishments
- Plans

Operator Support Objectives

AWIN

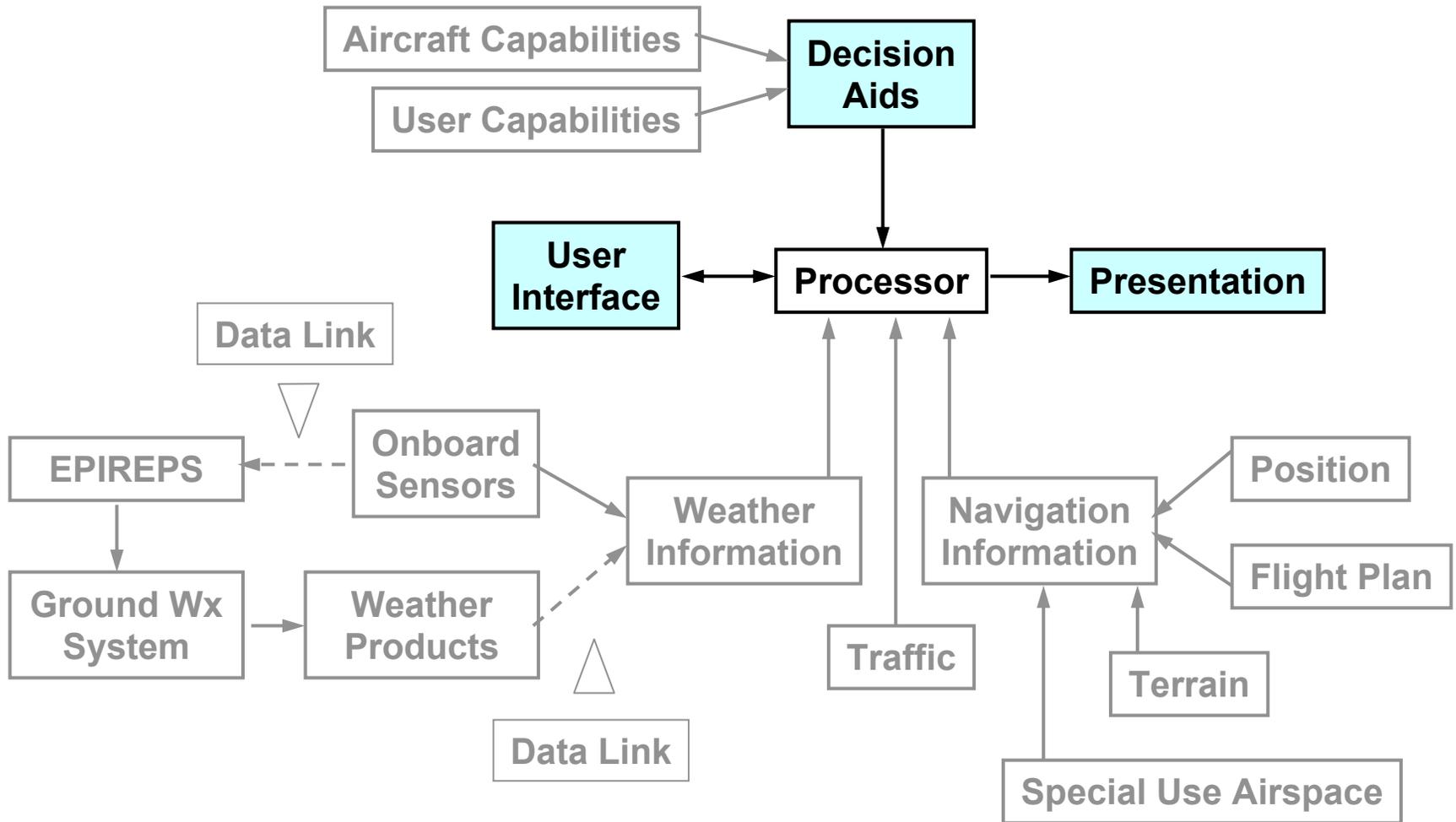
VISION

Create innovative weather information solutions that significantly increase aviation safety

- Develop enhanced weather presentations that minimize interpretation and provide enhanced situation awareness
- Develop decision-making aids which facilitate monitoring and collaboration

AWIN System

AWIN



Operator Support Trilogy

AWIN

- Formats
- Colors, symbology
- Architecture
- What info & When

- How access info
- Workload
- Heads-up

Presentations

Interface Technologies

Enhanced Situation Awareness

Human-Centered, Systems-Design Approach

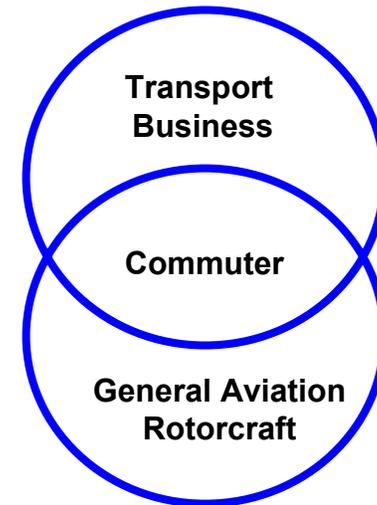
Decision Aids

- Alerting, Monitoring
- Compelling info

Focus Areas

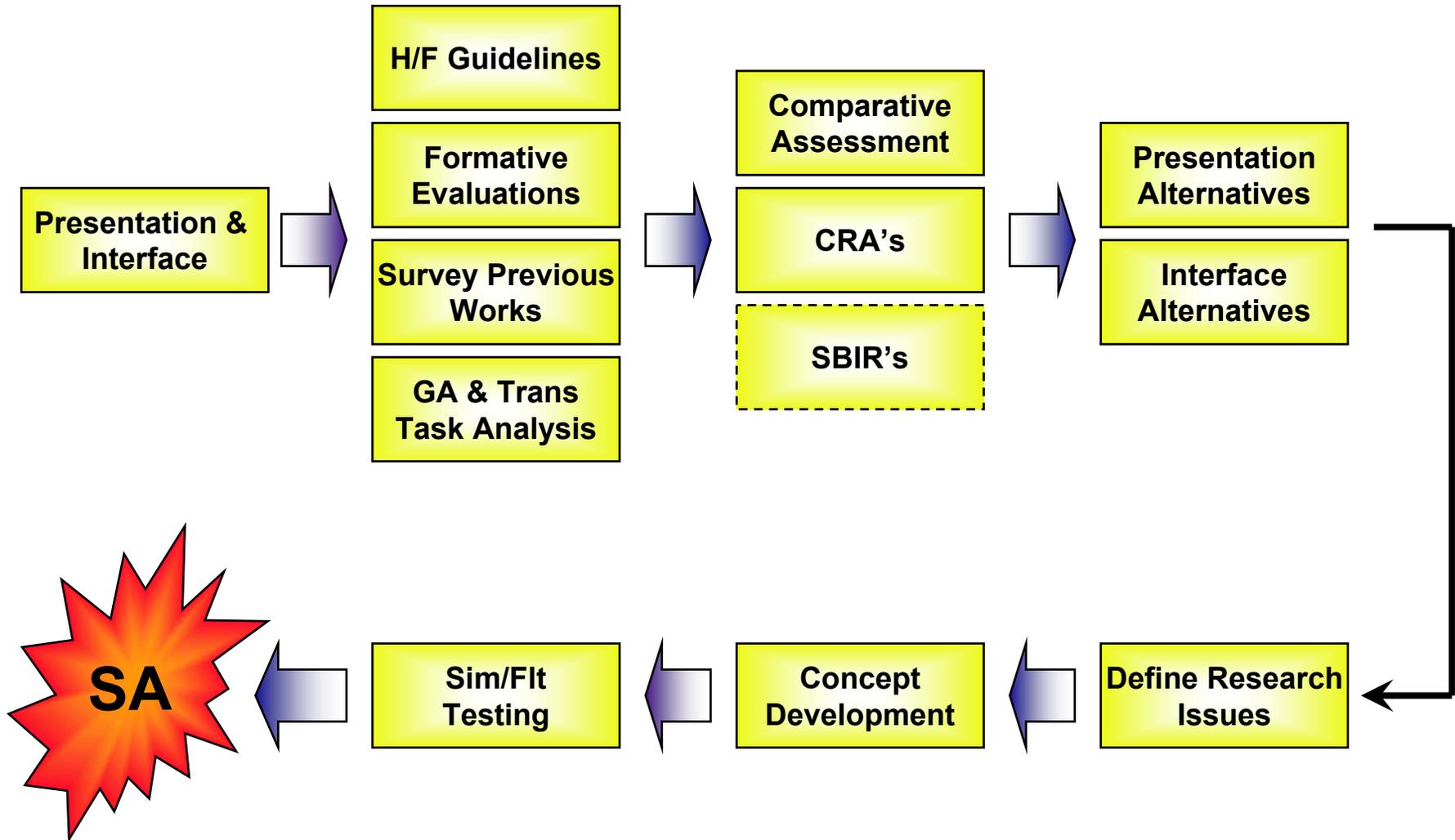
AWIN

- NASA's Role
- Cooperative Research Agreements
- Flight Deck Centric
- Strategic  Tactical
- General Aviation
- Transport



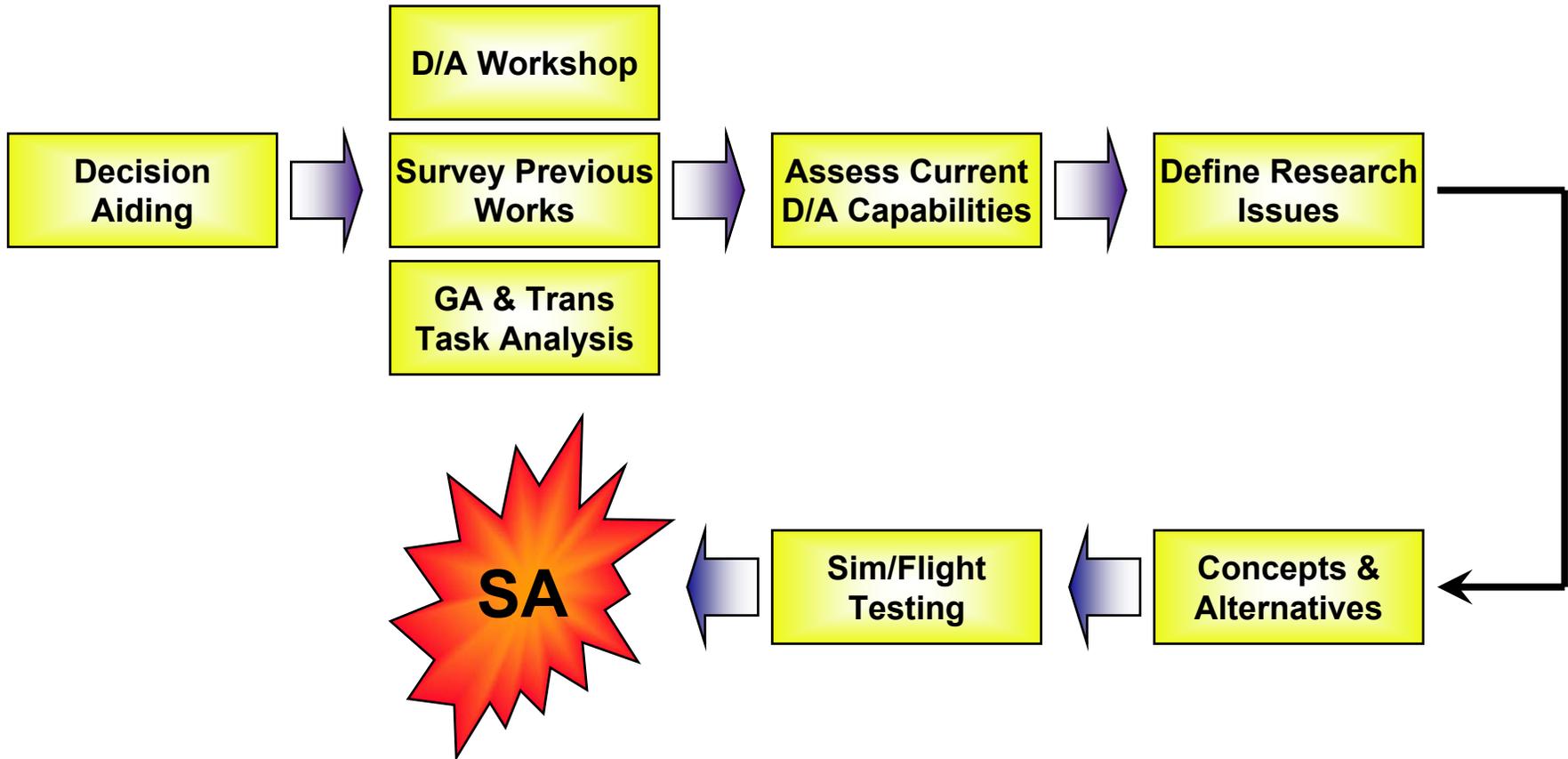
Presentation & Interface Technologies

AWIN



Decision Aiding

AWIN



Challenges

AWIN

- Retrofit
- Workload
- Human Error
- Tactical Information Presentation
- Accessibility to Technology

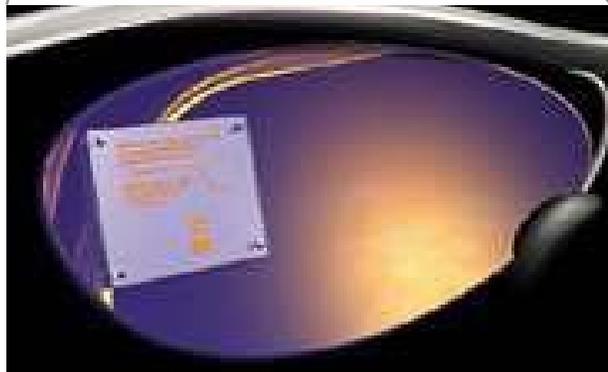
- **Presentation & Interface**
 - COTS Formative Evaluation
 - H/F Guidelines
 - Task Analysis, Accident Data Analysis
 - 757 Flight Test
 - Non-tactile Interfaces
- **Decision Aiding**
 - Naturalistic Decision Making w/ Wx Information
 - CoWS Flight Experiment
 - Task Analysis, Accident Data Analysis
 - RTI FISDL

- **Studies**
 - ERAU
 - ODU
 - GTRI
- **Facilities**
 - GA Simulator
 - Transport Simulator
 - GA Aircraft
 - King Air B200
 - 757 Transport
 - AWIN Usability Lab

Future Plans

AWIN

- Formulate Presentation Architecture
 - Adaptive, Reconfigurable, Portable/Wearable



Weather Information Overview



Future Plans

AWIN

- Develop Interface Alternatives
 - Non-tactile



Courtesy of IBM

Future Plans

AWIN

- Enhance Decision Making



Jeppesen Sanderson (1999)

- Significant opportunities
 - Sensors
 - Weather products
 - Advanced presentations
 - Decision-aids
- Commitment
 - Industry
 - Academia
 - Federal Agencies

The End

AWIN

Any Questions?