

Distributed On-Demand Air Transportation Using Small Airplanes and Small and Underutilized Community Airports



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Outline

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- Vision
- Small Aircraft Transportation Systems Project
- Status
- Next Steps
- Conclusions

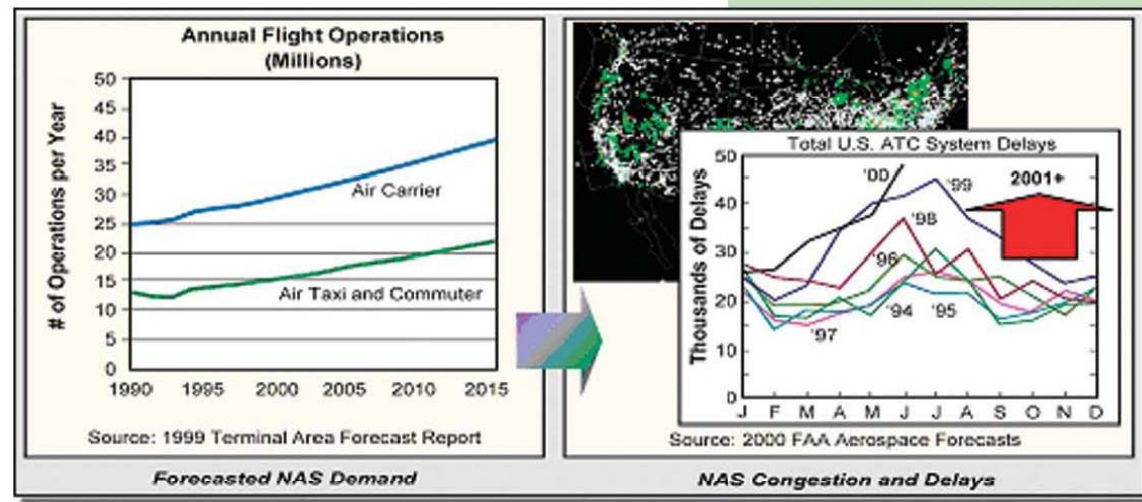


AIR TRAVEL GRIDLOCK



- **Current System Cannot Meet Future Needs**
- **Hub Airports Are Approaching Gridlock During Primary Operating Hours**
- **Demand at Hub Airports Will Grow by 200M Passengers Over the Next Decade**

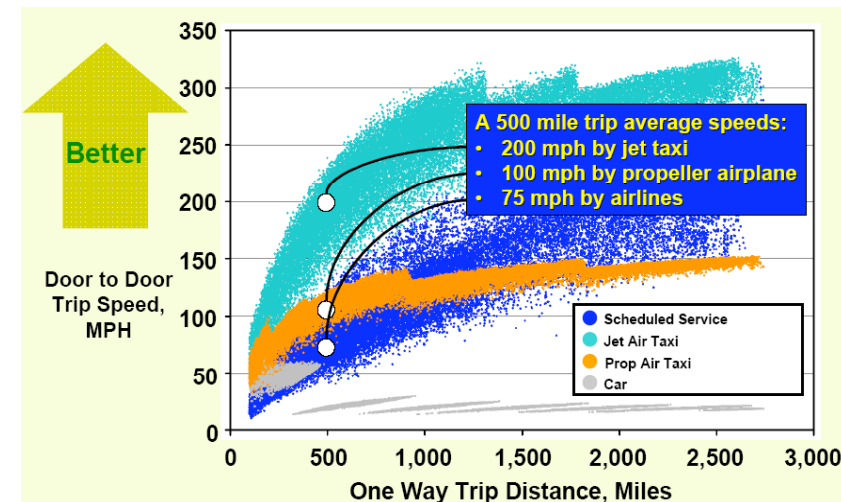
NAS Gridlock Projections



TRAVEL TIME



- **Air Travel is Becoming Increasingly Inefficient**
 - Travel time by Car is Essentially the Same for Travel Distances of 500 Miles or Less
- **After September 11, Hub Delays Have Caused Business Travelers to Seek Alternative Means of Conducting Business, Especially for Short Trips**
 - Increased Business & Corporate Jet Travel
 - Teleconferencing
 - Automobile



SMALL AIRCRAFT TRANSPORTATION SYSTEM (SATS)

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Nearly 98% of all Americans Live Within 30 Minutes of a Community Airport

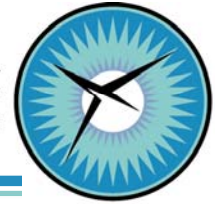
What if They Could

- **Travel at 3 Times the Speed of an Automobile Using These Available Landing Facilities**
- **Travel When You Choose**
- **Use Safe, Comfortable, and Reliable Piston Engine and Small Jet Aircraft**
- **Travel in Near All Weather Conditions?**

And What if the Prices Were Affordable?

Small Aircraft Transportation System Vision

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To Bring Attractive, Affordable Air Transportation Service to Every Community in America.



ECONOMIC IMPACT OF SATS

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Attractive Alternative for Transportation of People and Cargo for Distances Between 200 and 800 Miles

Viable Transportation System for Citizens Living in Rural Areas Not Served by Commercial Air Service

Essential Transportation for Disaster Relief Efforts

New Service and Manufacturing Opportunities in a Community

New Jobs in Markets Such as Car Rental, Hotels, Restaurants, etc.

SATS Project:

Develop/Demonstrate Feasibility of Four Important Operating Capabilities



- **Lower Landing Minimums (LLM) at Minimally Equipped Landing Facilities**



- **Higher Volume Operations (HVO) in Non-Radar Airspace and at Non-Towered Airports**

- **Increase Single-Pilot Performance (SPP) Crew Safety & Mission Reliability**



- **En Route Procedures & Systems for Integrated (ERI) Fleet Operations**

Government/Industry Partnership

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National Consortium for Aviation
Mobility (NCAM)

SATS Leveraged Other Programs

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AATT DAG-TM

- Airborne technologies
- En route and terminal ops
- Formal methods



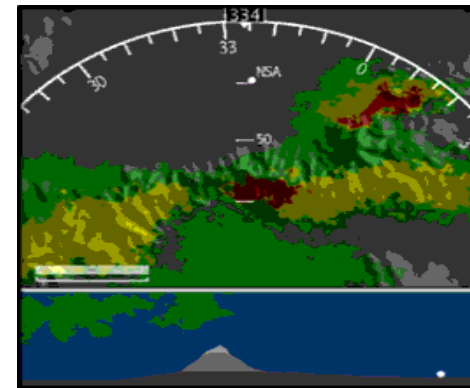
Quiet Aircraft Technologies

- Curved approaches
- Approach energy management



SafeFlight 21

- Cockpit Display of Traffic Info
- Datalink communications
- In-trail self-spacing



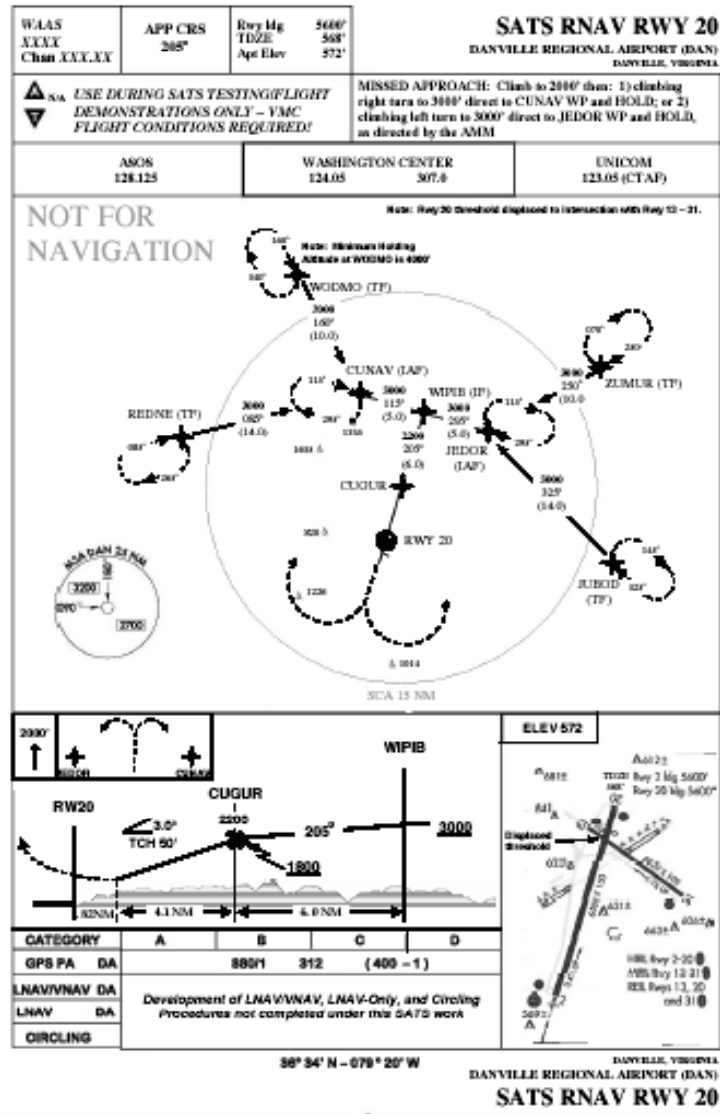
Aviation Safety Program

- Weather data distribution
- Hazardous weather avoidance
- Synthetic vision systems

Lower Landing Minima



Reduce lower landing minima at minimally equipped landing facilities to 200-ft ceiling and 1/2-mile visibility



Synthetic Vision With HiTS And FD Guidance

Enabling technologies:

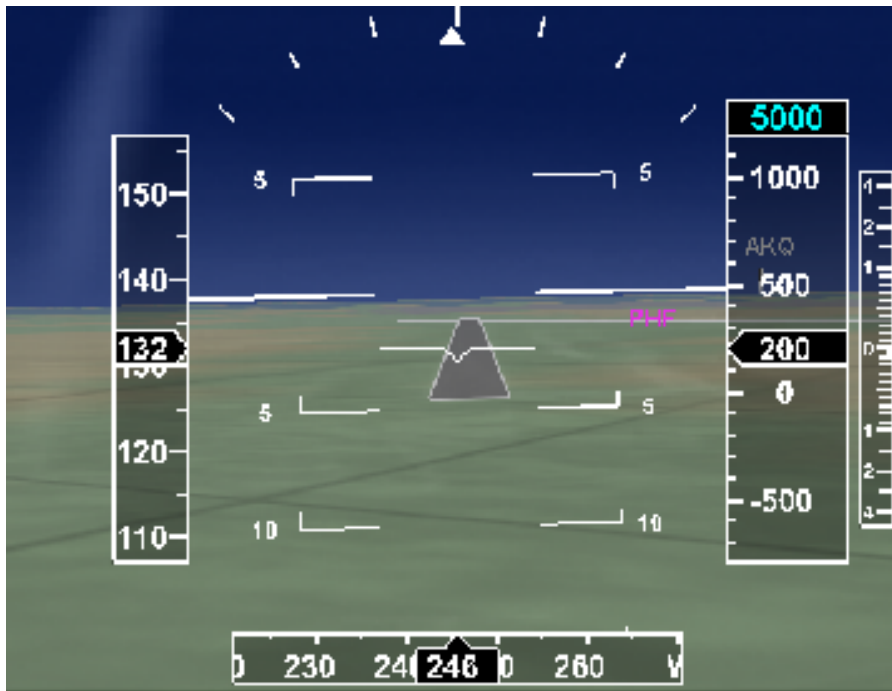
- GPS/WAAS
- RNP Approaches
- Synthetic Vision System
- Highway in the Sky
- Enhanced Vision
- Combined Vision



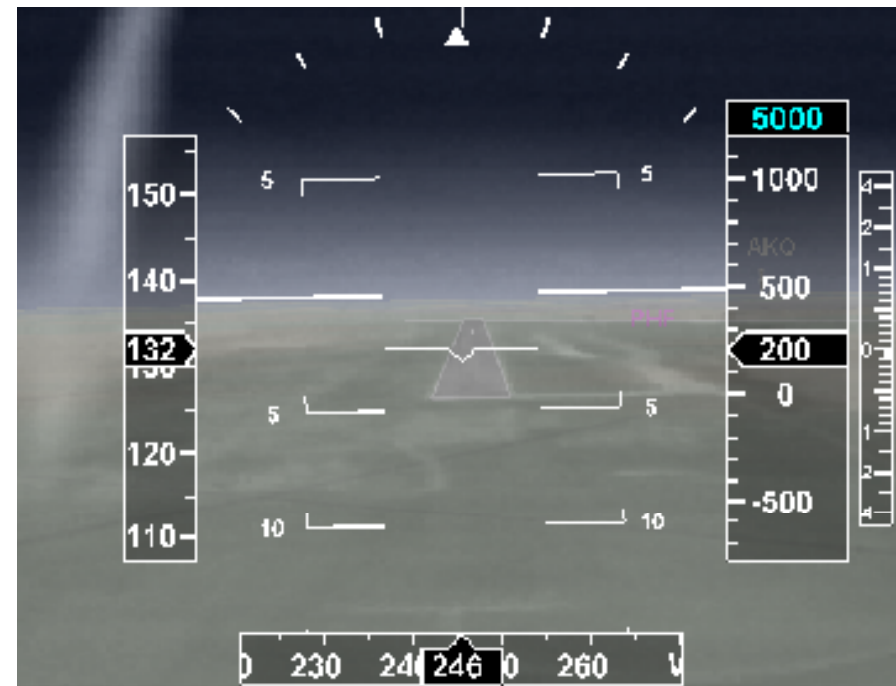
SVS/FLIR Blending



- Developed computer software to blend imagery on PFD
 - Blend IR and SVS images using adaptive weighted average
 - Proportion of FLIR imagery increases as aircraft approaches runway
- Successful operation demonstrated on recorded FLIR video



70% SV and 30% IR



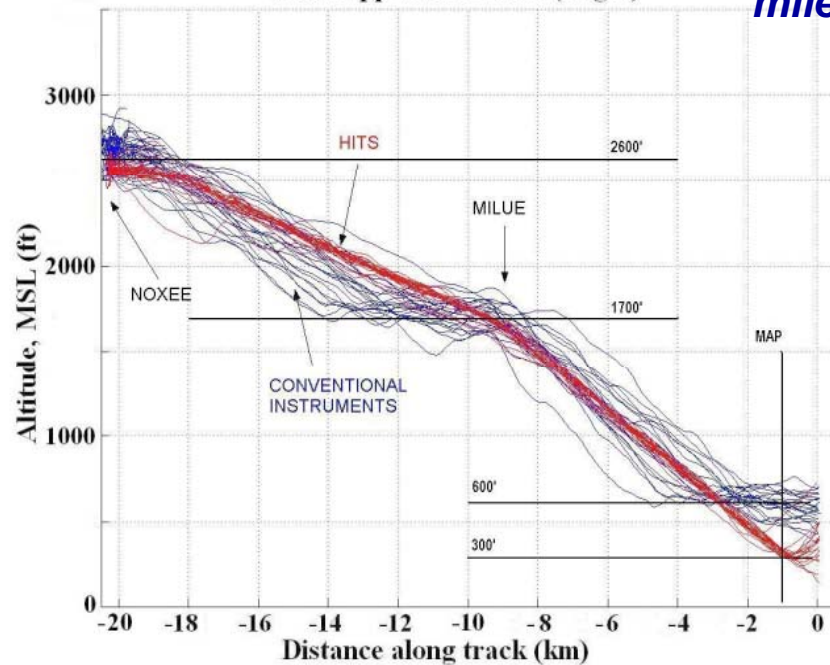
20% SV and 80% IR

LLM Flight Experiment

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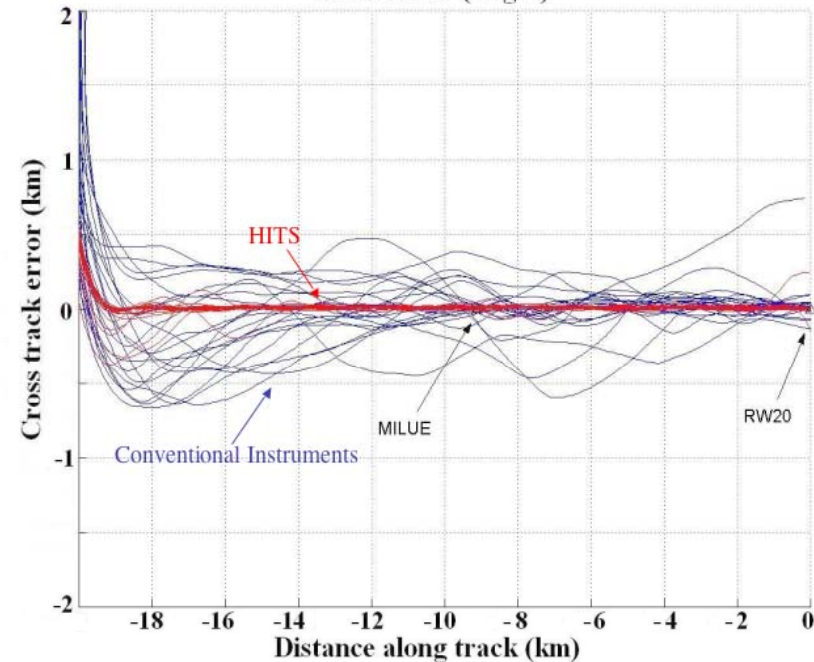
Final Approach Profile (Flight)



Demonstrated flight-path accuracy and situation awareness required for approach operations to 200-foot ceiling and 1/2-mile visibility



Path Error (Flight)



Higher Volume Operations

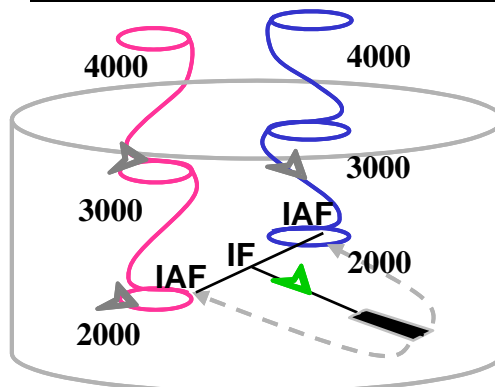
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Increase rate of operations at non-radar, non-towered airports by enabling concurrent flights in poor weather conditions.

Enabling Technologies:

Self Controlled Area (SCA)



Pilots maintain separation between themselves and other aircraft using procedures and on-board automation. HVO concept works for many different approach geometries.

Airport Management Module (AMM)

Ground-based AMM assigns sequence to arriving aircraft; seamlessly supports traffic flow generated by ATC controller.



Pilots operating in the SCA use:

- Multi-Function Display,
- Automatic Dependent Surveillance-Broadcast,
- two-way data link,
- on board software, and
- sequence information from ground automation (AMM)

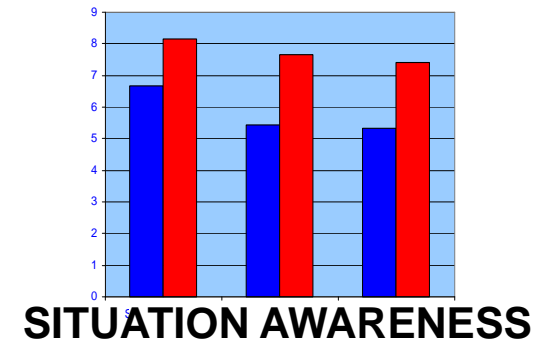
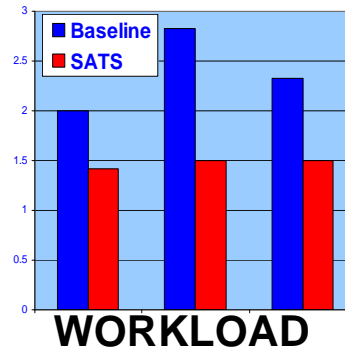
Higher Volume Operations

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NASA Langley Flight Experiment

Shown pilots can fly these procedures safely, proficiently and with acceptable levels of workload and situation awareness



Results

- Simulation and Flight Experiments of pilots and controllers show a four-fold increase in number of operations without an increase in workload or complexity.
- Flights into non-radar, non-towered airports predictable and efficient; air taxi and charter operations become economical.

Single-Pilot Performance

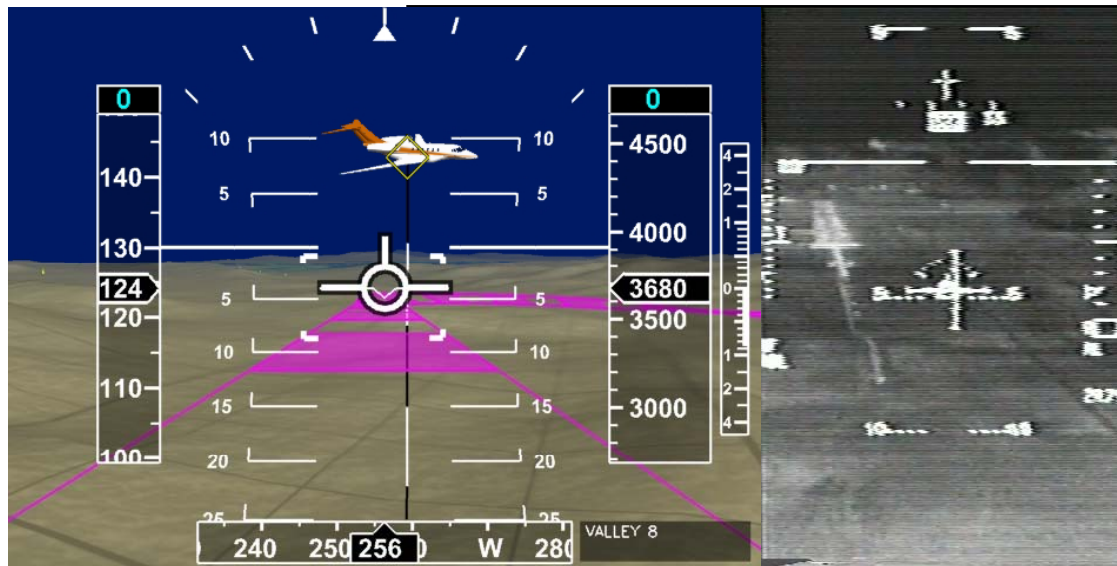
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Enhanced single pilot safety, precision, and mission reliability

Enabling technologies:

- “Highway in the Sky” (HITS)
- Enhanced Vision System
- Head-Up Displays
- Advanced displays
- Decision-aiding automation
- Combined Vision System



Single-Pilot Performance

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Low-cost Electronic Flight Instrument System for general aviation; “Electronic Flight Bag”

- Navigation, performance, and safety information
- Flight planning capabilities
- Weather monitoring
- HVO functionality to the pilot



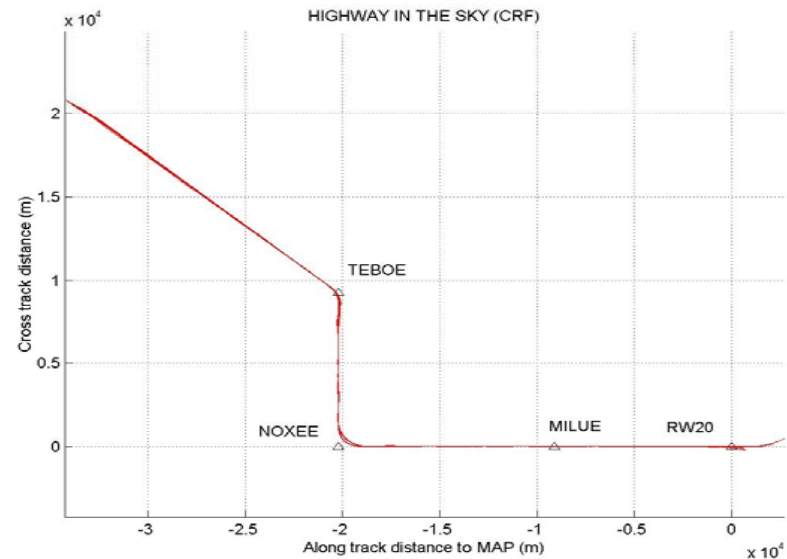
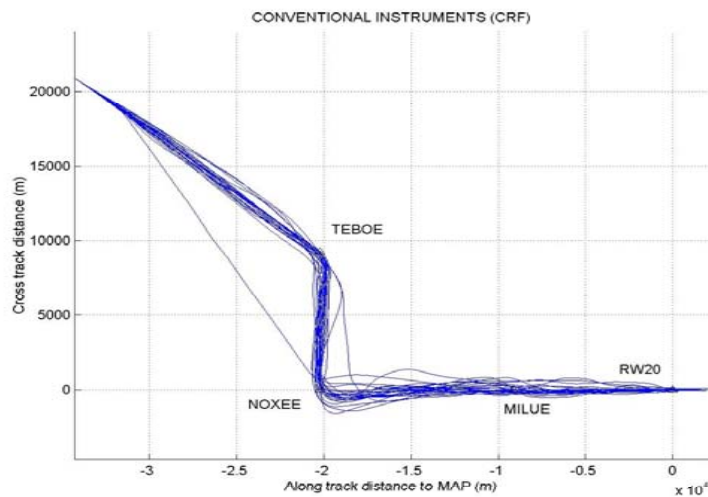
Pilot “Cockpit Associate”

- HVO Conflict Alerting
- Weather monitoring
- Approach procedures
- Aircraft health through audio system and MFD

Single Pilot Performance



Flight-Path Accuracy Results



En Route Integration

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En Route Procedures & Systems for Integrated Fleet Operations

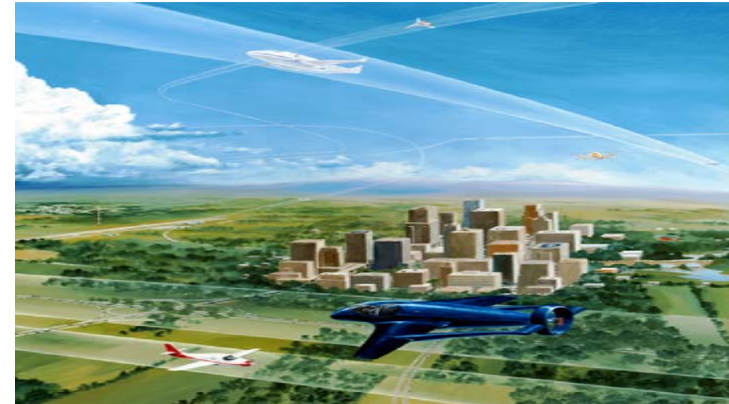
Focused on two areas:

- **Impact Mitigation:**

- Develop technologies/procedures to facilitate NAS implementation and interaction
 - » Transfer of separation responsibility to aircraft once inside the SCA
- Work with FAA to assess operational effectiveness of SATS concepts, technologies, and required airspace/procedures

- **Traffic Modeling:**

- Modeling to assess the impact on NAS traffic density and flow
- Project future point-to-point traffic demand triggered by SATS
- Model impact of increased point-to-point traffic on NAS traffic density and flow
- Assess ability of NAS infrastructure to absorb increased traffic



En Route Integration

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En Route Procedures & Systems for Integrated Fleet Operations

- **Proof of Concept simulation experiments:**

- Danville Regional Airport
- Philadelphia TRACON
- Joint FAATC/LaRC Simulation

- **Simulation Results:**

- **SATS likely to have little or no impact on ATC workload transitioning aircraft into and out of SCA.**
- **Potential to ease future airport congestion and delays.**
- **Procedures viable for non-towered airports.**
- **Tailor size of SCA to specific airport sites.**
- **Refine clearance procedures and phraseology.**
- **Further research with mixed equipage.**



Transportation Systems Assessments



- Developed new and/or upgraded existing transportation systems analytical models and simulation tools
 - to address key transportation model variables (being used by JPDO)
 - For case studies and simulations for:
 - North Carolina
 - Ohio
 - Upper Great Plains
 - Virginia
 - Michigan
 - Northeast Corridor & the Southeast
- Results (validated by providers)
 - If operators could charge \$1.50 - \$2.00/seat-mile they can make a 20% profit
 - There is a significant demand at that rate



2025 Demand Growth

relative to 2005 level



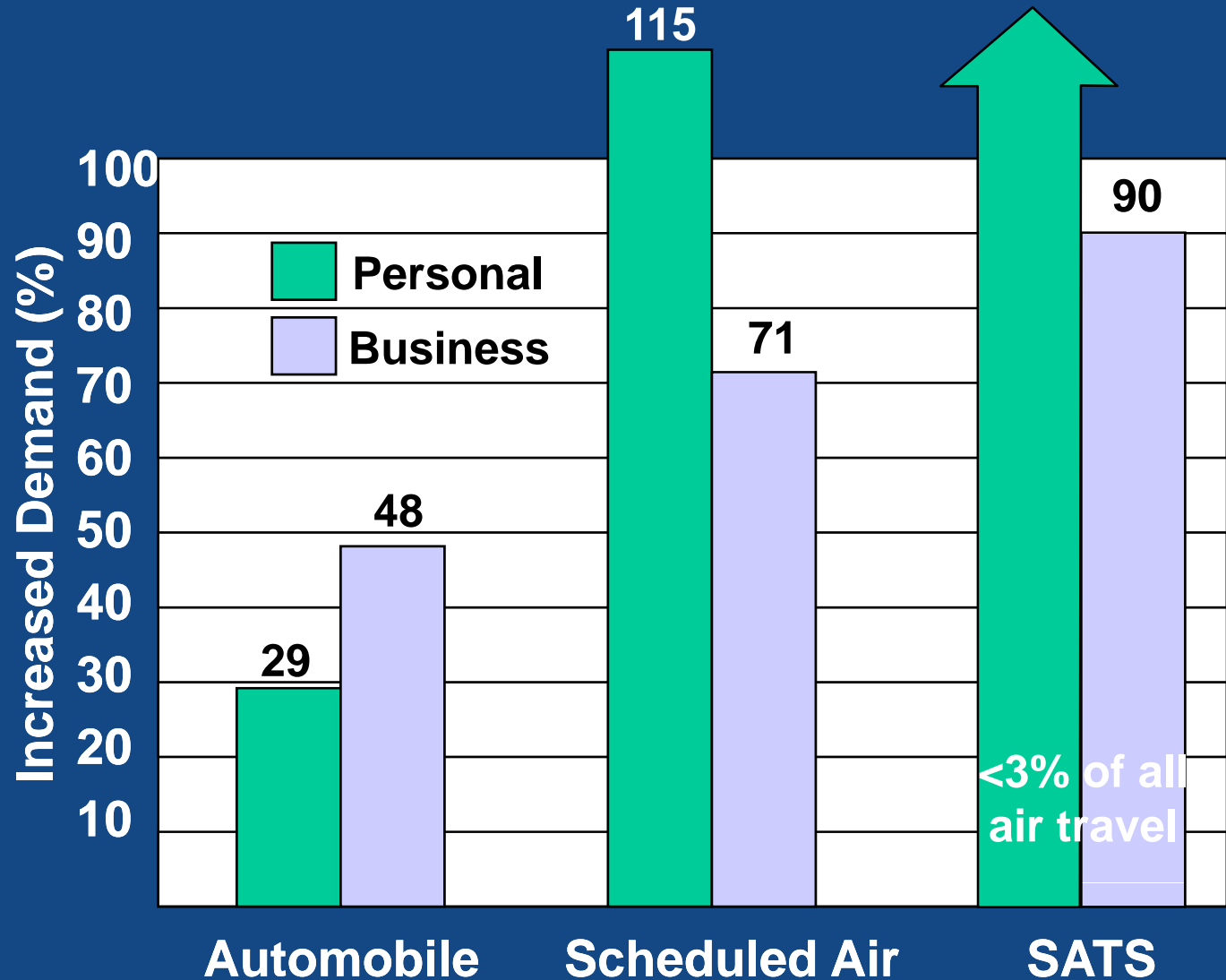
One-Way SATS trips in 2025:

58,400 passengers/day

25,800 flights/day

6,000 - 7,000 VLJs

Trips greater than 100 miles



SATS Project Accomplishments

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- **Demonstrated feasibility of enhanced operating capabilities to permit more reliable access to community airports including:**
 - **Increased traffic capacity for small airports without the need for expensive radar, control towers, or ground navigation systems**
 - **Guidance system for safe, reliable aircraft operation to/from small airports in low visibility conditions**
 - **Flight control and guidance displays for safe, easy-to-fly, single pilot aircraft operation with enhanced situation awareness**
- **Acknowledged as the first step toward the Next Generation Air Transportation System - Capabilities directly contribute to Roadmap strategies**

What is Status of SATS Today?



- Small airplanes are utilizing small airports
 - Fractional ownership
 - Air charters
 - Air taxis
- The number of small advanced piston and VLJ aircraft manufacturers is growing.
- FAA is now embracing ideas for small aircraft using small airports.
- SATS Project did not complete needed research.
- Both implementation and additional R&D is required



Next Steps



- Certification of Developed Systems

- SVS/EVS/CVS
- HUD
- HitS
- EFB/CA
- Laser Horizon
- Low-Cost Wx/Lighting
- Manufacturing Methods

- Evaluation Trial

- Air Taxi HVO/LLM Operations

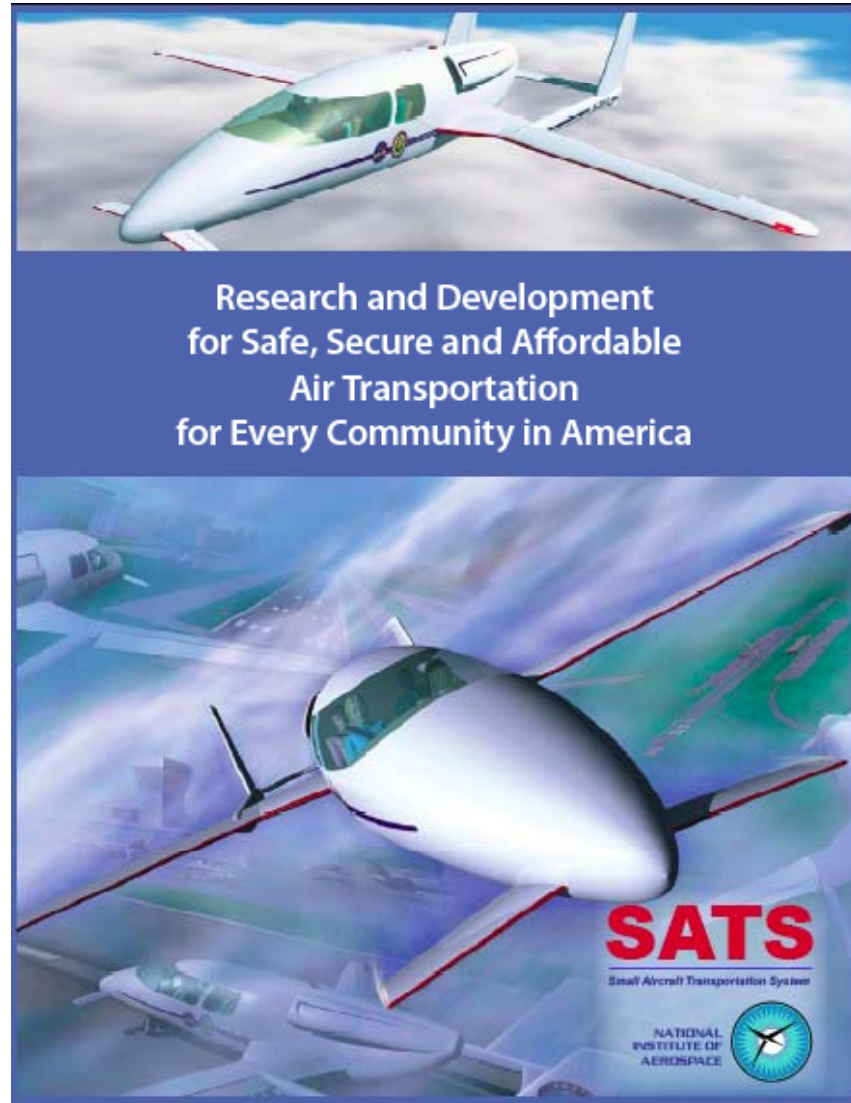


Identification of Next Steps in R&D

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- **NASA requested NIA to provide Independent Assessment and Guidance for Federal R&D Investments in Aeronautics**
 - Report published in April 2005, but did not include SATS vision
- **NIA conducted a supplemental assessment in Fall of 2005 of next steps for SATS**
- **The Supplemental NIA report**
 - Provided a National Directive to Implement SATS
 - Identified Required R&D
 - Published January 2006

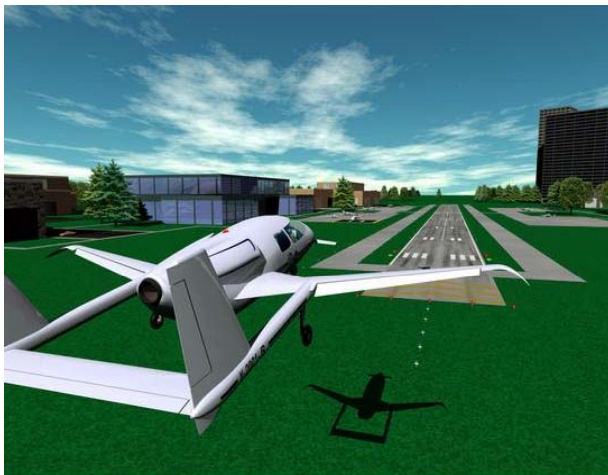


http://www.nianet.org/nianews/community_air_transport.php

Technology Areas for Next Steps in SATS R&D



- **Service Reliability**
- **Weather Safety**
- **Ease of Operation**
- **Community Compatibility**



 SATS aircraft - takeoff to landing
NASA Langley Research Center 2/3/2000 Image # EL-2000-00003



Service Reliability

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- **Integration into the Airspace**
- **Self-controlled airspace**
- **Performance Based Operational Capability**
- **Combined Vision**

Service Reliability



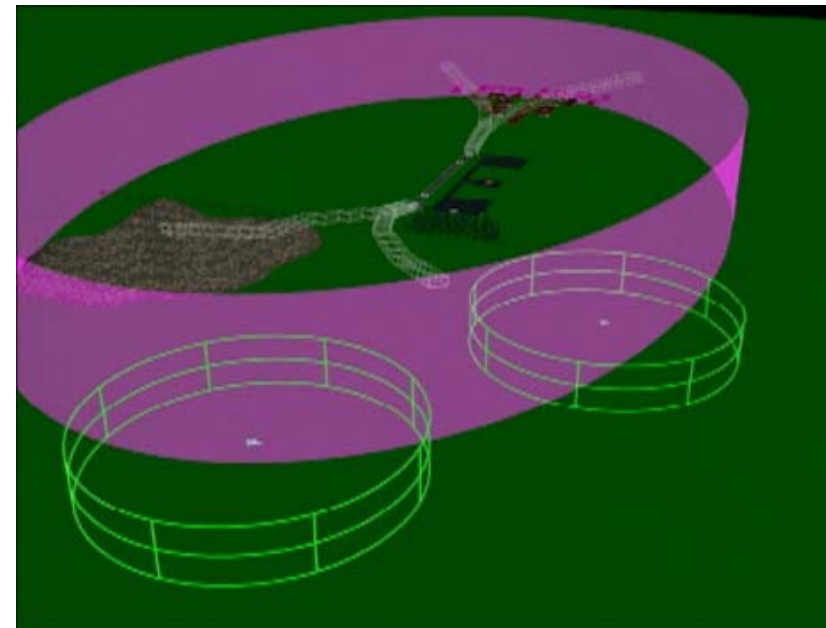
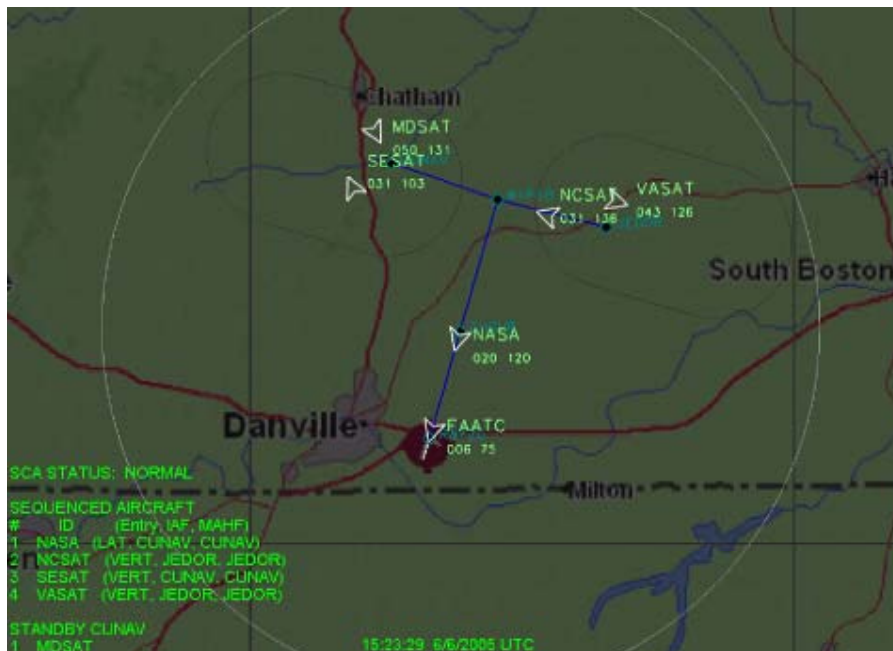
- Integration Into NAS
 - Evaluate ADS-B/Radar surveillance at non-towered airports
 - Define network centric operation & data link communication requirements
 - Evaluate operational efficiencies obtained with advanced avionics
 - Assess technology to alleviate capacity constraints and controller workload



Service Reliability (Cont.)



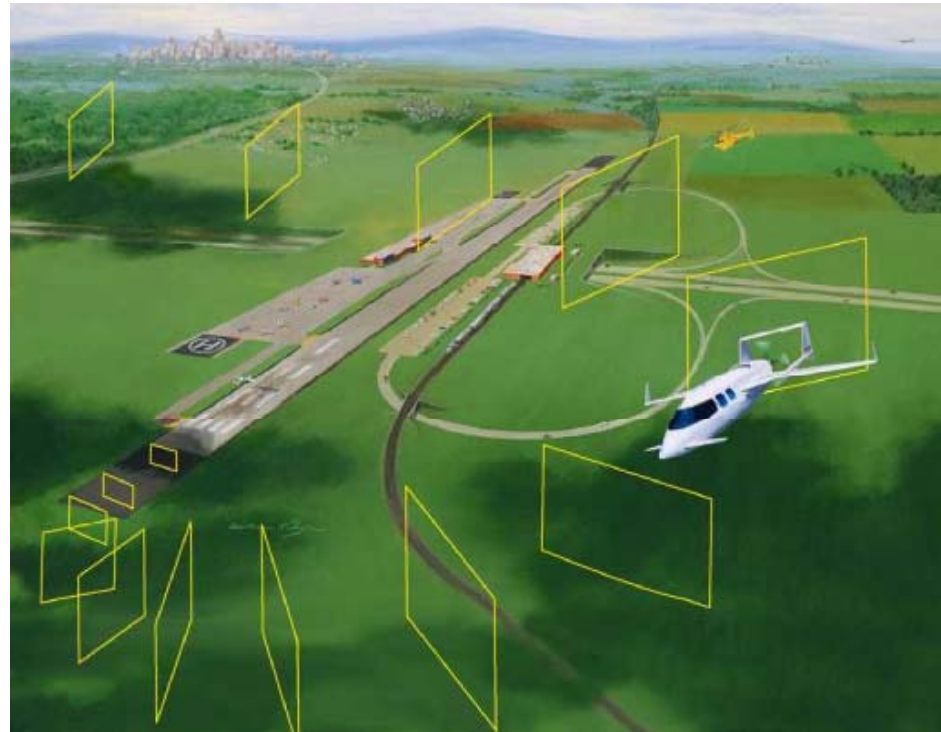
- Self Controlled Airspace
 - Modeling of Alternative SCA Concepts
 - SCA Automation System Development
 - SCA System Validation



Service Reliability (Cont.)



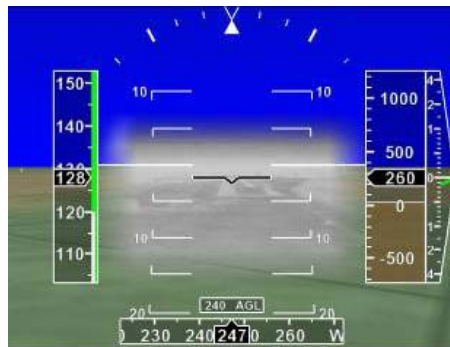
- **Performance Based Operational Capability**
 - Real-Time ANP and RNP
 - Determine Recommended Credits



Service Reliability (Cont.)



- **Combined Vision System**
 - **Simulation and Flight Test Evaluation**



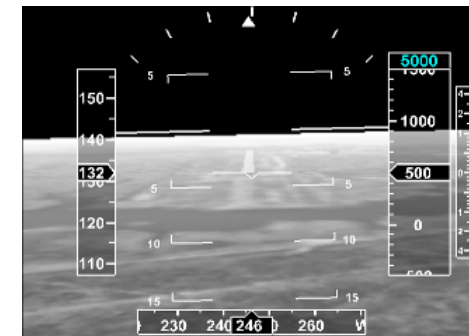
Combined Vision:

=



Synthetic Vision

+



Enhanced Vision

Weather Safety

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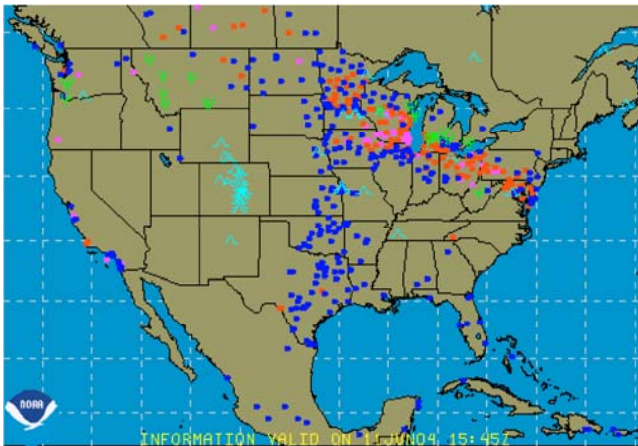


- **Real time cockpit intelligence**
- **Enhanced weather forecasting**
- **Airport weather sensors**
- **Enhanced icing safety**

Weather Safety



- Real-Time Cockpit Weather Intelligence
 - Intuitive Weather Data Interpretation



Weather Safety (Cont.)



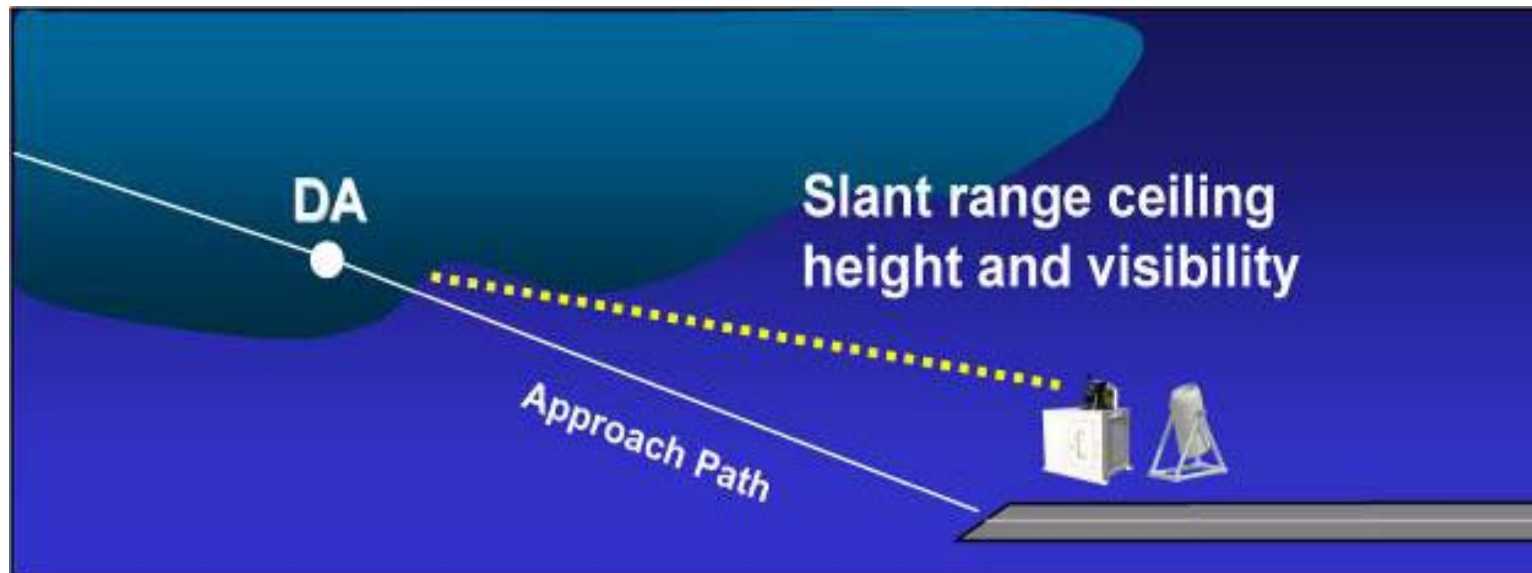
- **Enhanced Weather Forecasting**
 - **Fine-grid Forecast Models**
 - **Sensor Requirements**
 - **Prototype Model Assessment**



Weather Safety (Cont.)



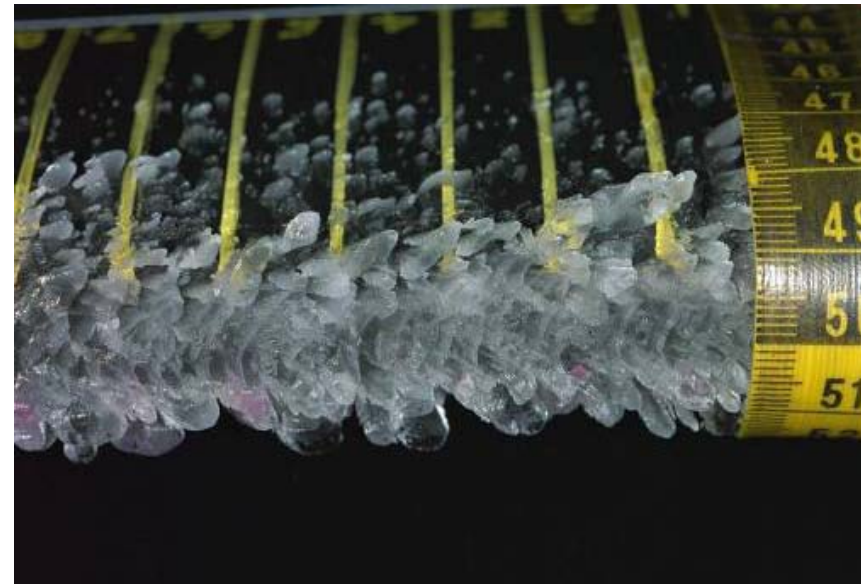
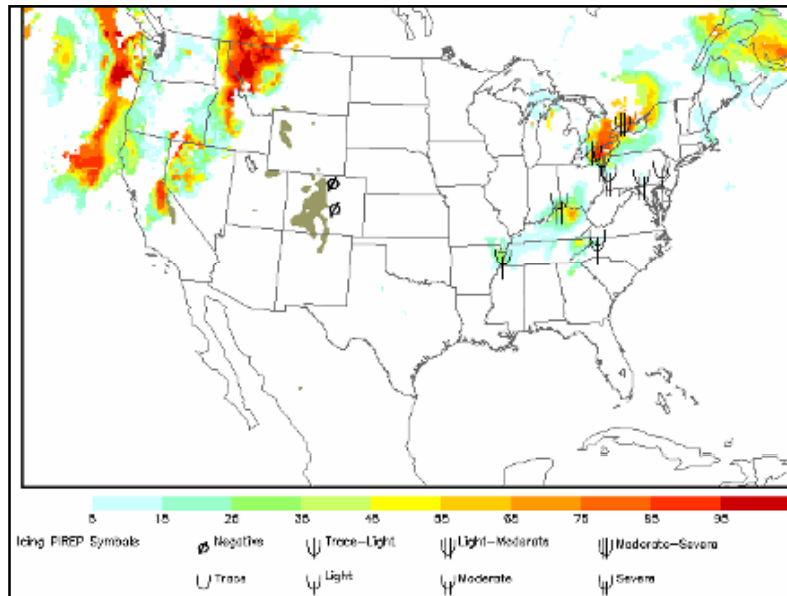
- Airport Weather Sensors
 - Microelectronic Sensor R&D
 - Airport Weather Dissemination
 - Slant Range Visibility Sensor R&D



Weather Safety (Cont.)



- **Enhanced Icing Safety**
 - Icing Forecasting and Avoidance
 - Icing Detection, Prevention, and Removal




Ease of Operation



- enhanced single pilot performance
- single pilot operation
- aircraft automation
- open architecture
- virtual co-pilot, intelligent
- auto-flight systems
- envelop protection and automation
- autopilot with auto-throttle
- emergency auto-land
- real time WAAS non-precision approach procedure design



 SATS-Cockpit Concept
NASA Langley Research Center

2/3/2000

Image # EL-2000-00008

Community Compatibility

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- **Small aircraft safety improvement**
- **Small aircraft and airport security**
- **Community noise reduction**
- **Small aircraft emissions**
- **Real time health safety monitoring**
- **Small aircraft ride quality improvement**

Community Compatibility



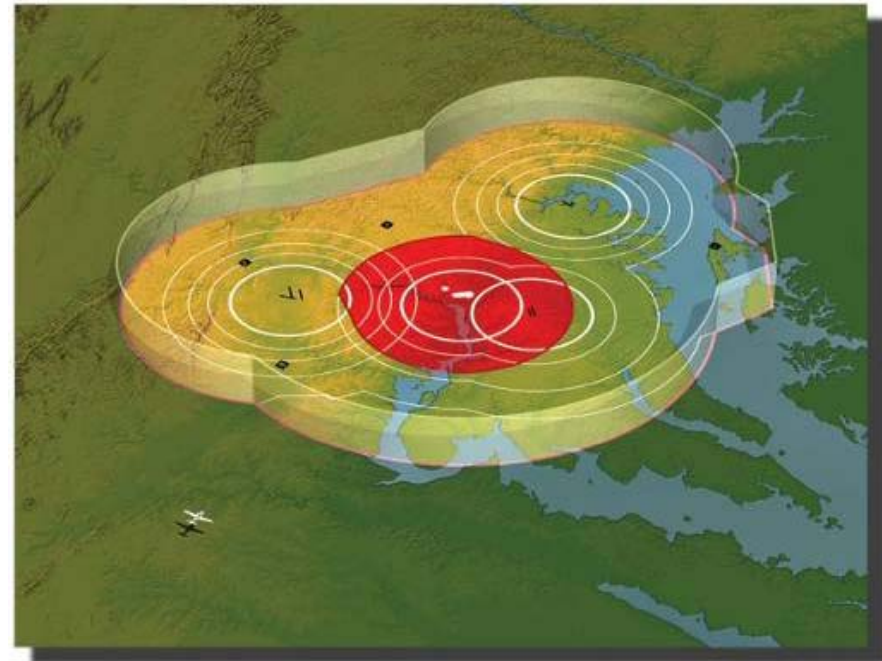
- **Small Aircraft Safety Improvement**
 - **Safety Enhancements from Health Monitoring Systems**
 - **Safety Enhancements from Pilot Training**
 - **Total System Safety Assessment**



Community Compatibility (Cont.)



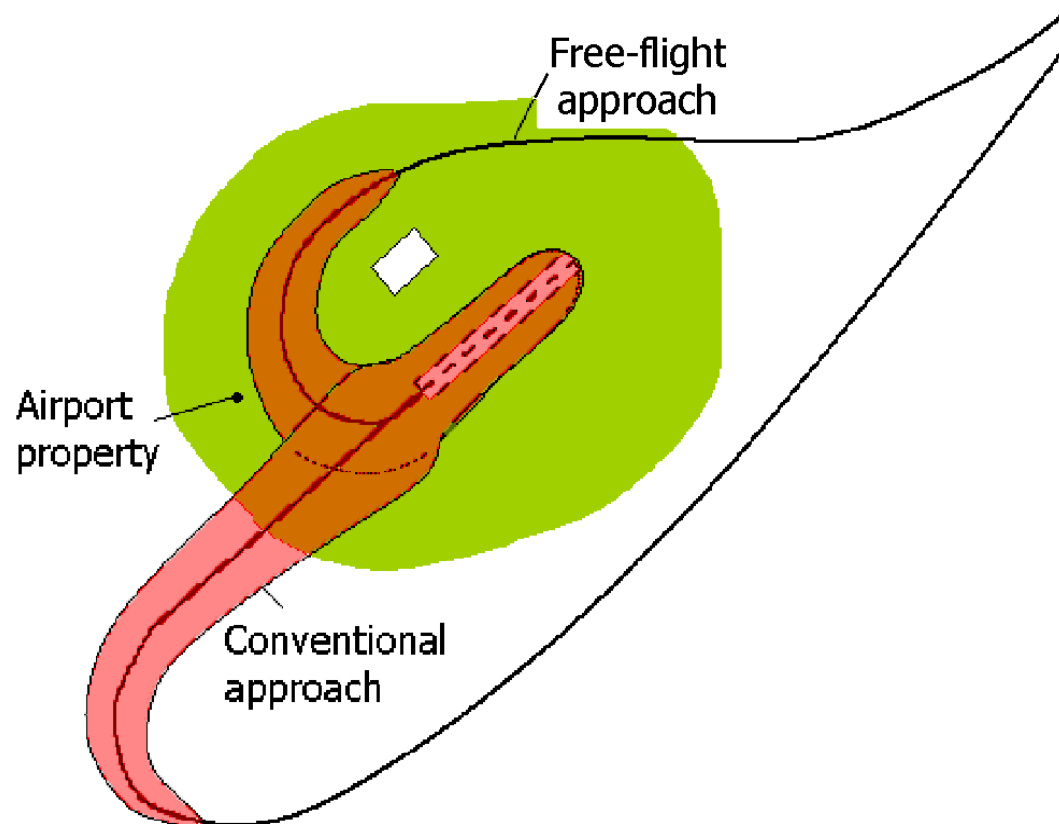
- **Small Aircraft and Airport Security**
 - Evaluate Small Aircraft and Small Airport Security Infrastructure Requirements
 - Developed Encrypted ADS-B Based Security Identification System for Small Aircraft
 - Conduct Testing and Develop Standards for Airborne Small Aircraft Identification Procedures



Community Compatibility (Cont.)



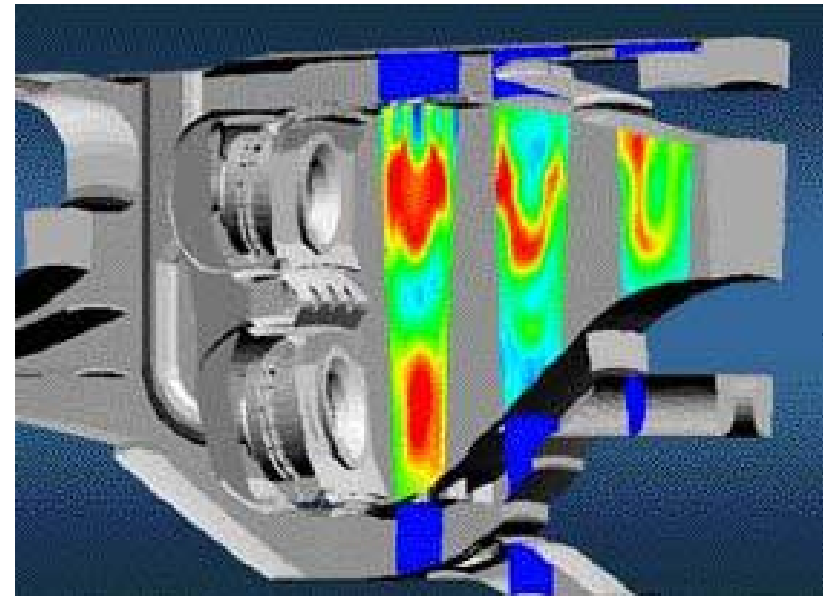
- **Community Noise Reduction**
 - **Flight Trajectory & Aircraft Systems Noise Reduction**



Community Compatibility (Cont.)



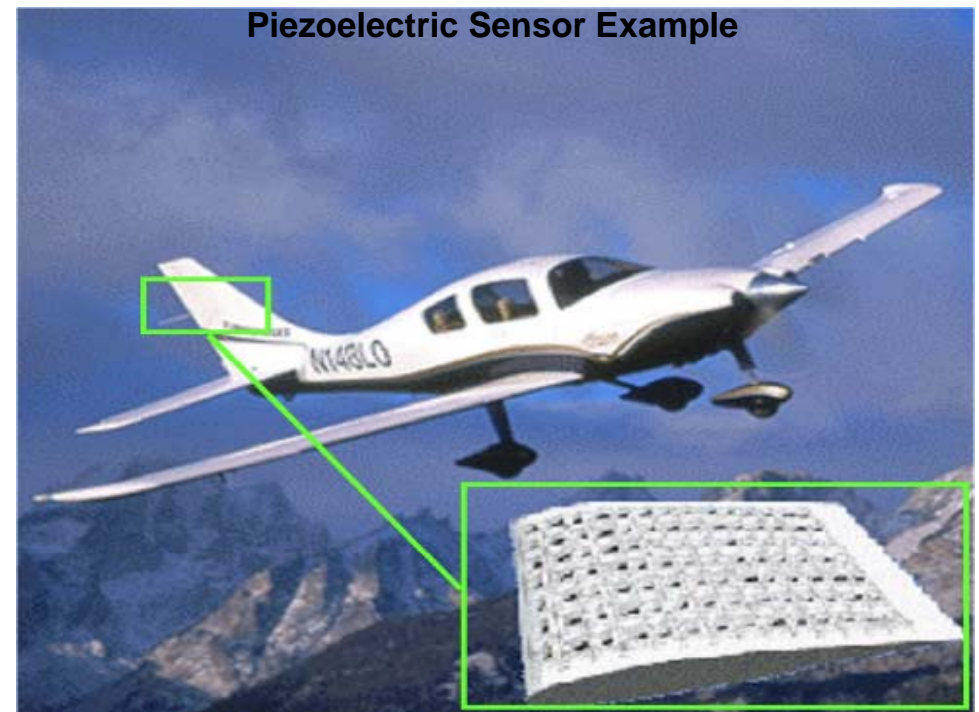
- **Small Aircraft Emissions**
 - **New Small Aircraft Emission Modeling**
 - **Non-traditional Aircraft Trajectories to Minimize Emission Impacts to the Community**
 - **Reduction of Airport Emission Impacts and Community Feedback**



Community Compatibility (Cont.)



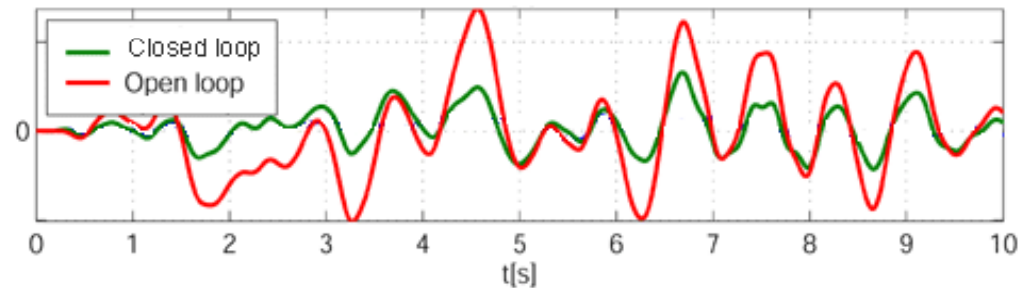
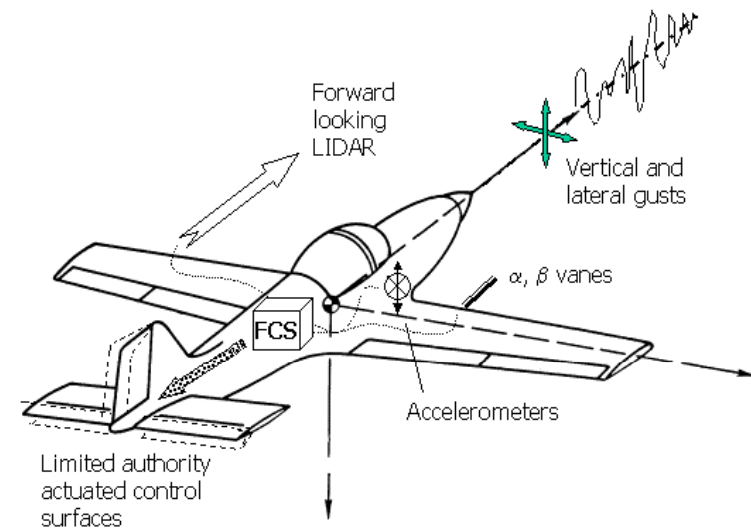
- **Real-Time Safety Health Monitoring**
 - Develop Structural Stress Sensors
 - Aviation Industry Collaboration
 - Develop Integrated Health Monitoring Systems



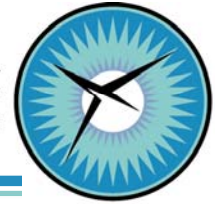
Community Compatibility (Cont.)



- **Small Aircraft Ride Quality Improvement**
 - **Dynamic Modeling**
 - **Sensor & Actuator Package Definition**
 - **RCS Algorithms & Flight Validation**



Conclusions



- **Development and Implementation of the SATS Vision provides an important step toward the Next Generation Transportation System**
- **Operating Capabilities have been demonstrated that enhance the accessibility and capacity of small and underutilized community airports in low visibility conditions; single pilot performance has been enhanced**
- **General aviation is being transformed to a transportation system**
- **Additional work (implementation and R&D) required to continue pursuit of the SATS vision has been identified**