Synthetic Vision Systems Overview

for

Commercial & Business Aircraft ConOps Workshop

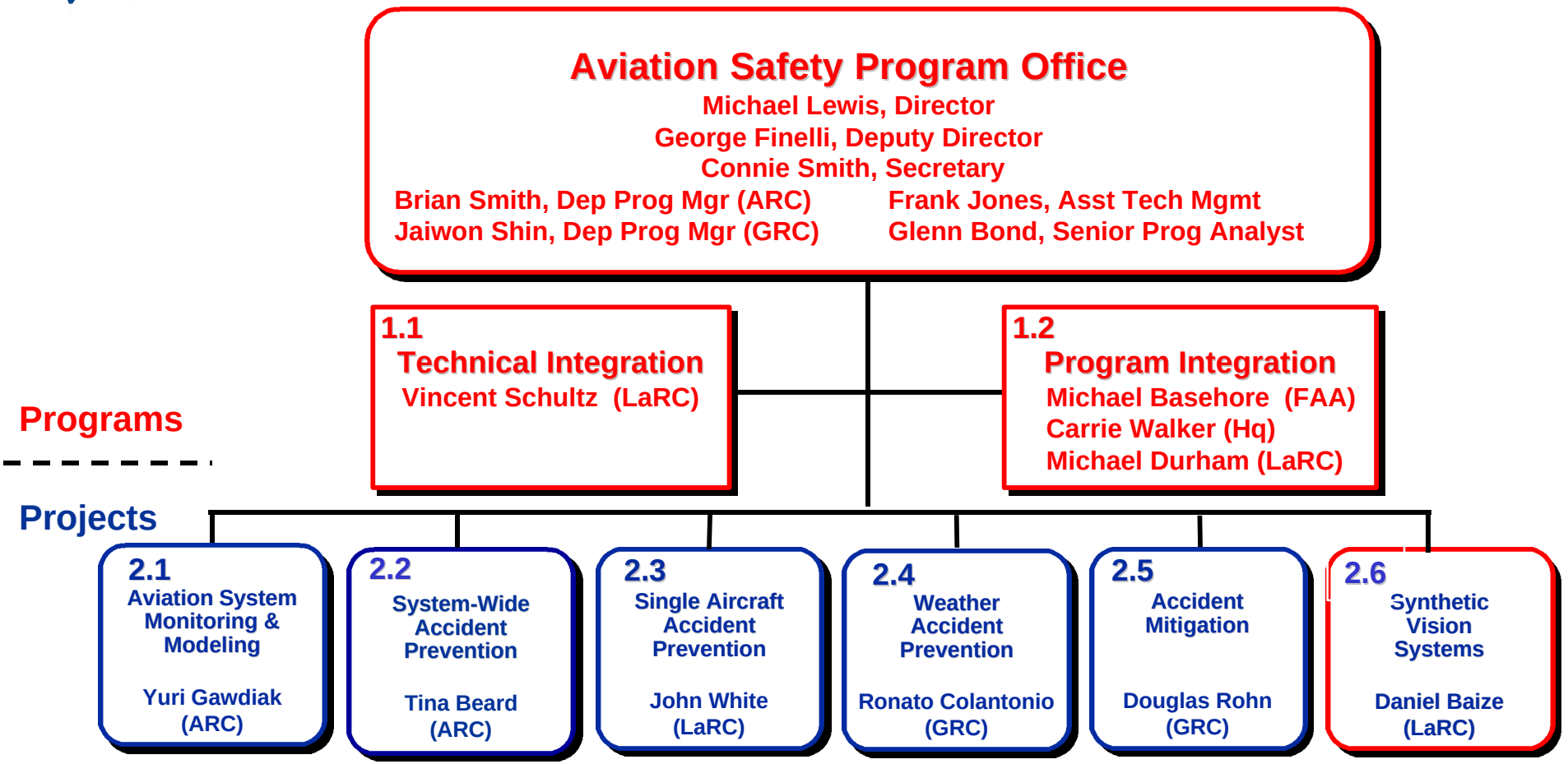
February 23, 2000

Dan Baize, Project Manager

Aviation Safety Program Office
NASA Langley Research Center

AvSP- Committed to Aviation Safety

Aviation Safety Program: Synthetic Vision Systems



Elements

- System Monitoring
- Data Sharing
- Data Analysis

- Human Error Modeling
- Maintenance Human Factors
- Training

- Health Management & Flt Crit Sys Design
- Control Upset Mgmt
- Engine Containment

- Wx Info Distribution & Presentation
- Weather Information Communication
- Turbulence Detection & Mitigation

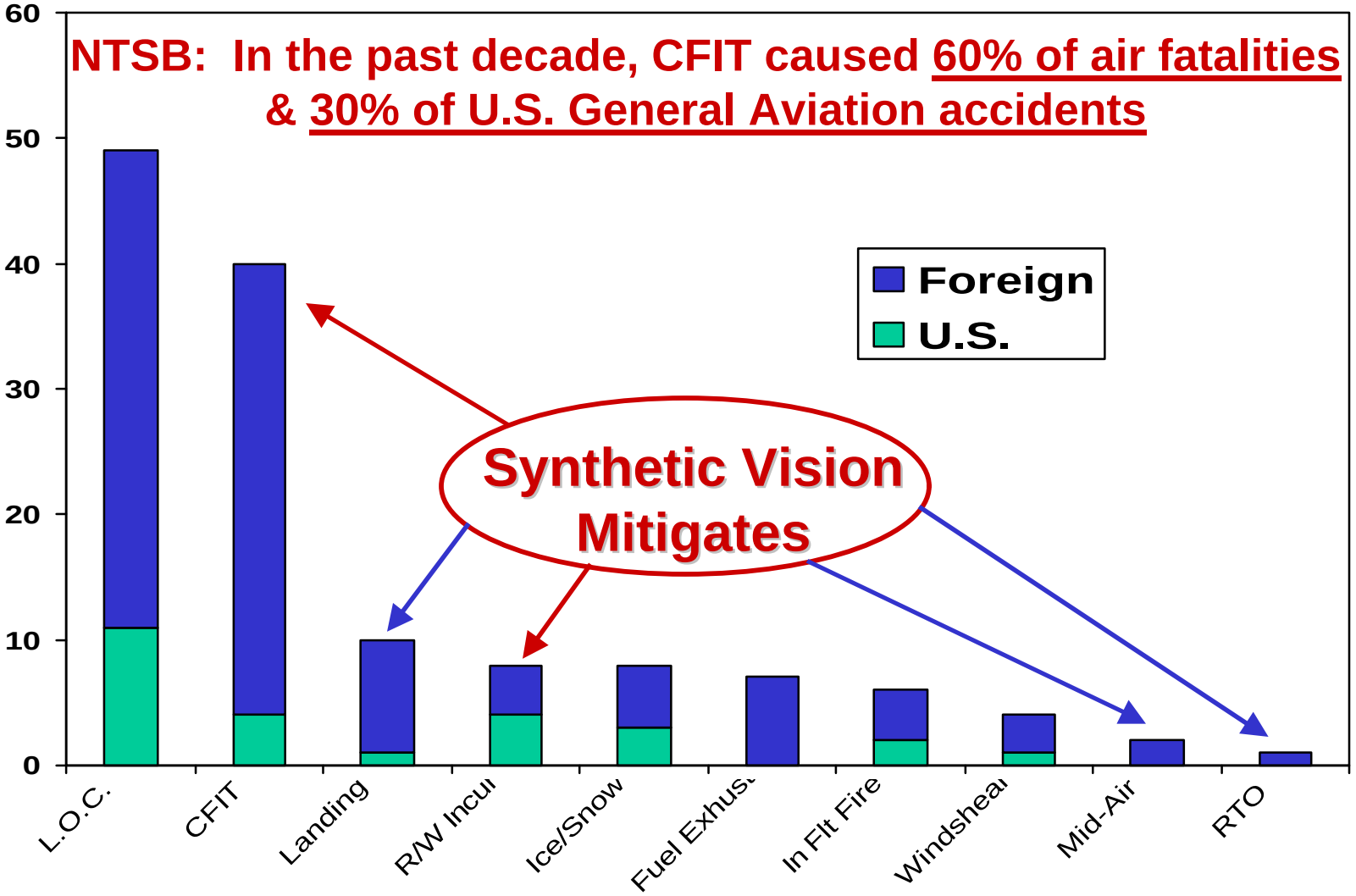
- Systems Approach to Crashworthiness
- Fire Prevention

- Commercial & Business Aircraft
- GA & Rotorcraft
- Enhanced Vision Sensors & Enabling Technologies


SVS
Synthetic Vision Systems

CFIT - # 1 Cause of Aviation Fatalities

FAA Data: U.S. and Foreign Carrier Fatal Accidents (1987-1996)



Synthetic Vision: A Visibility Solution to CFIT & RI

- **SV among top recommendations from multiple Joint Safety Analyst Team (JSAT) activities initiated by Commercial Aviation Safety Team**
  - Transport CFIT: "The aviation industry should develop and implement SV capability".
  - GA CFIT: "Promote development and use of low cost terrain clearance and/or look ahead device"

- **Flight Safety Foundation Approach & Landing Study recommendation:** "The industry should pursue the development of SV systems to determine their potential for providing precision-approach-path guidance overlaid on either an enhanced image or completely synthetic reproduction of the external environment"

- **Synthetic Vision Runway Incursion Prevention**:
  - Joint Test with FAA's Runway Incursion Reduction Program
  - Need for RIP ranked 3rd among NTSB's 1999 "10 Most Wanted List"

Synthetic Vision is a Visibility Solution to what are fundamentally low visibility/ inadequate SA accidents/ incidents, CFIT & Runway Incursions

SVS Project Goals & Objectives

Goal

Eliminate Low Visibility Induced Accidents

Objectives

- In all Weather Conditions, Replicate the SAFETY and Operational Benefits of Clear-Day Flight Operations
- Address Commercial, Business, GA, and Rotorcraft Applications for both Existing & Future Cockpits

Challenges

- Database Development, Certification, Maintenance, & Liability Issues
- Certification and NAS Integration of Flight Critical Synthetic Vision Systems
- Affordable & Retrofitable Systems

Approach

- Accelerate Development of Certifiable SVS Database & Enhanced Vision Sensors
- Cooperative Partnerships with Industry and the FAA
- Iterative Development, Assessment, & Validation of Candidate Concepts

Thrusts

- Enhanced Vision Sensors & Enabling Technologies for SVS
- Commercial & Business Aircraft Synthetic Vision Systems
- GA & Rotorcraft Synthetic Vision Systems

Synthetic Vision Systems Project Organization

Aviation Safety Program: Synthetic Vision Systems

Synthetic Vision Systems

Dan Baize, Project Manager
Russ Parrish, Project Chief Scientist

Commercial & Business Aircraft

Lynda Kramer
Dan Williams

- Crew-Centered Display Concepts
- Operational Concepts, Requirements & Integration
- Crew Response Evaluation Methodologies

General Aviation & Rotorcraft

Mary Kaiser
Marc Buntin

- General Aviation Concept Development
- Rotorcraft Concept Development
- Human Centered Methodologies (Single Pilot)

Enhanced Vision Sensors & Enabling Technologies

Dave Eckhardt
Denise Jones

- Flight Critical System Architecture
- Terrain, Obstacle & Airport Databases
- Enhanced Vision & SVS Integrity

Example Synthetic Vision Equipped Flight Deck

Photo-Realistic Synthetic Vision Demonstration

Flight Test Facts

- Flight test conducted 10/11-15, & 11/2-4 1999
- USAF Total In-Flight Simulator (TIFS) Convair 580 with research Flight Deck
- 3 evaluation pilots flown during 4 research flights
- Over 60 approaches flown, 3 to final touchdown
- Nested database of Asheville Airport with photo-realistic overlay

Asheville Airport Database Nested Architecture

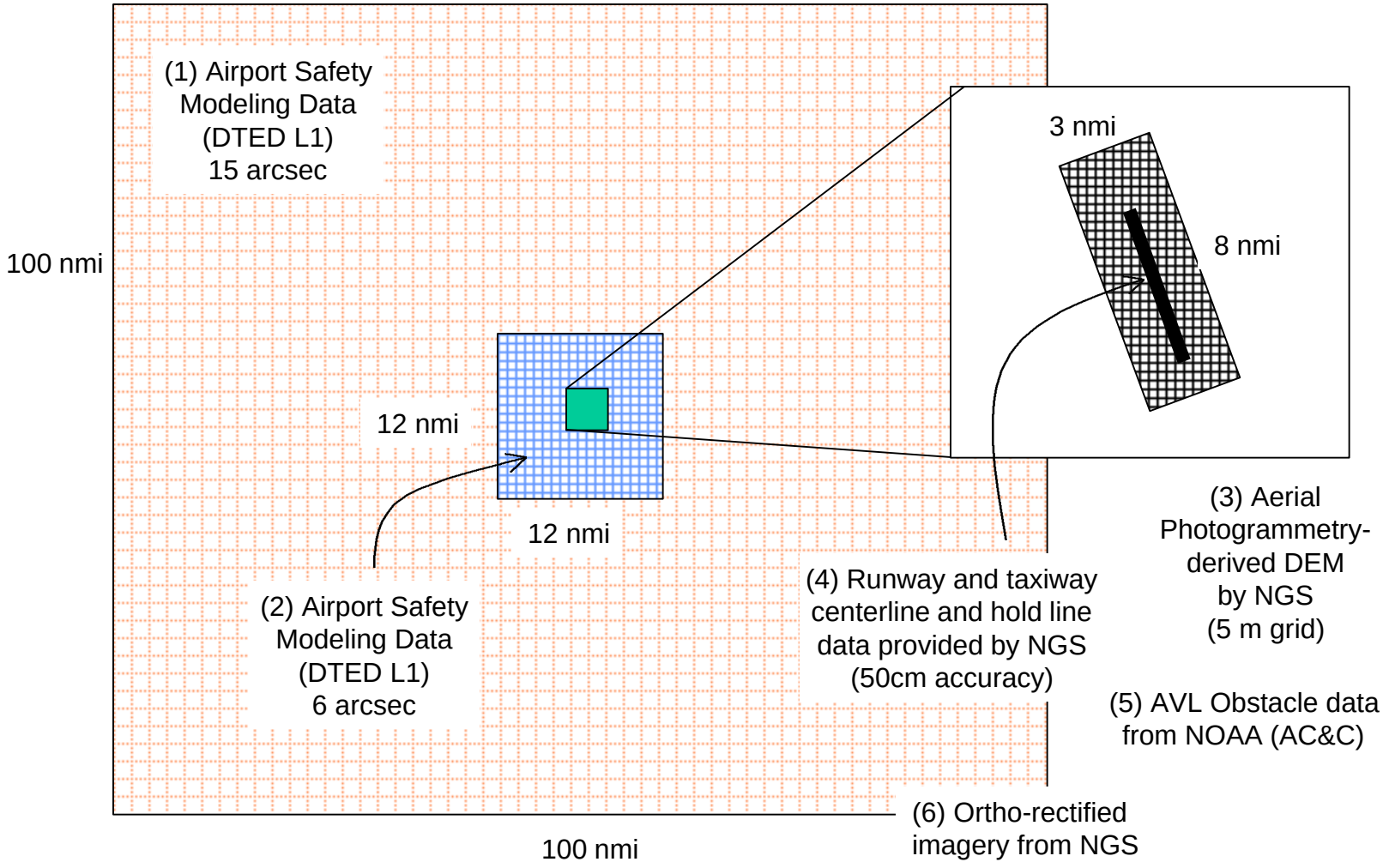


Photo-Realistic SVS Flight Test Video

Photo-Realistic Synthetic Vision Demonstration

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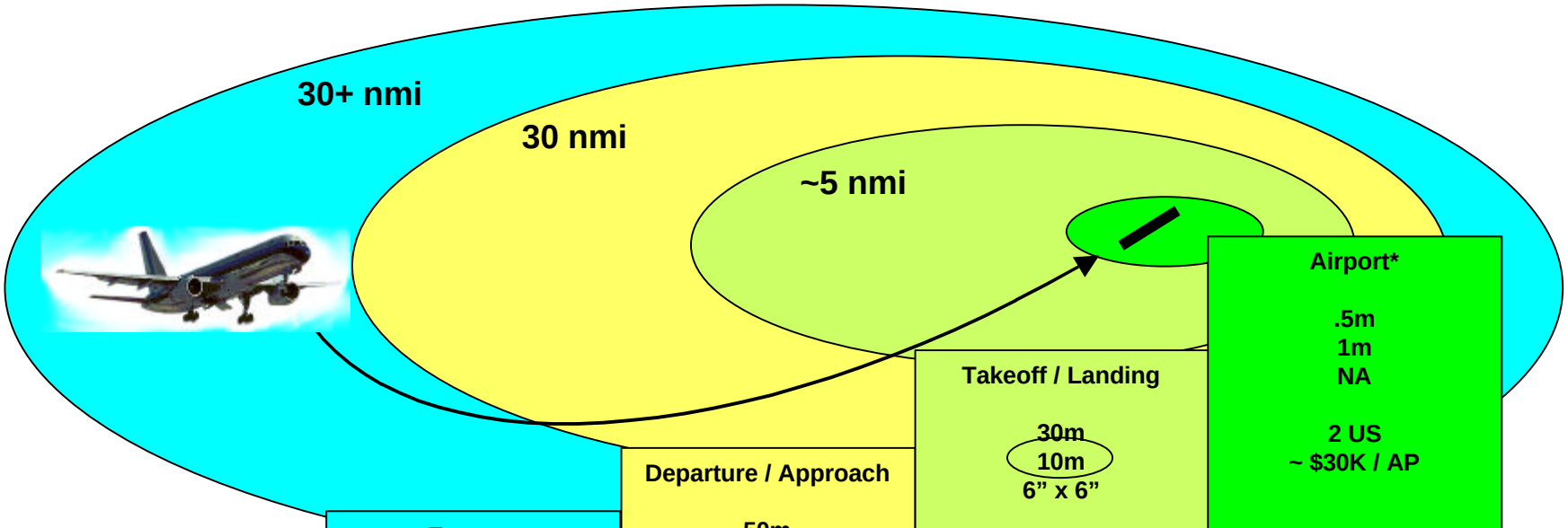
Initial Research Conclusions

- State-of-the-art terrain, obstacle, and airport databases work extremely well in actual flight
  - Tactical control of the aircraft through the use of Synthetic Vision is intuitive & low-workload
  - Data gathered on transitioning from lower to higher resolution nested databases
  - Data collected for grid size requirements eval
- Photo-realistic terrain overlay compared with computer-textured terrain technologies

Conceptual Terrain Database Requirements



*Required airport data is primarily feature data
**Obstacle requirements not shown

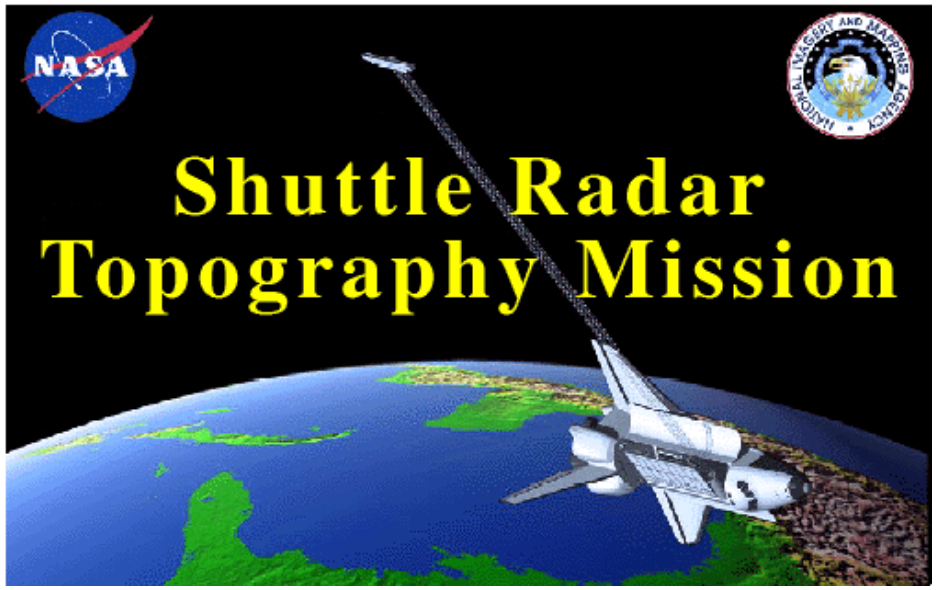
RTCA/EUROCAE Committee Participation

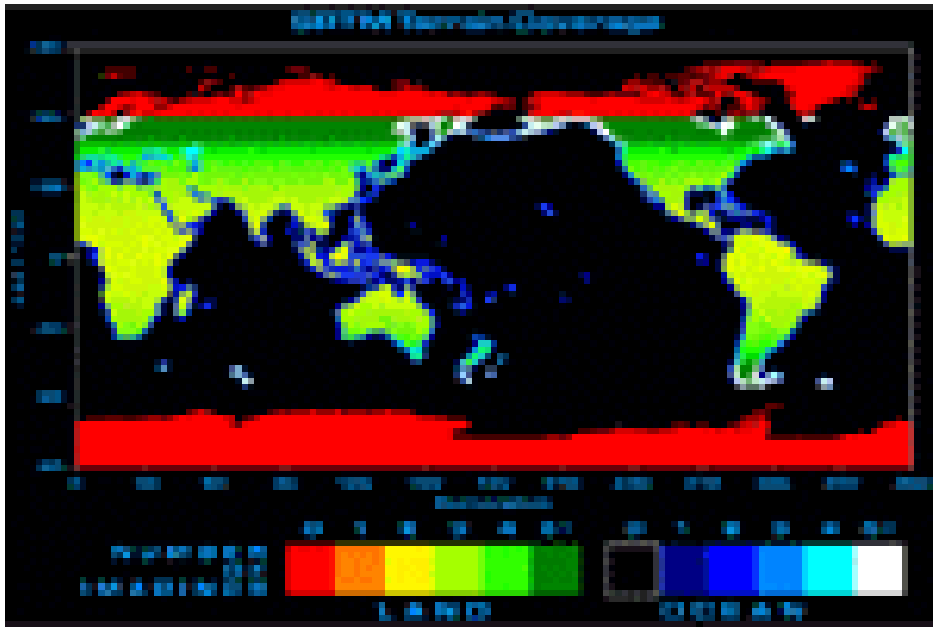
User Requirements for Terrain, Obstacle & Airport Databases

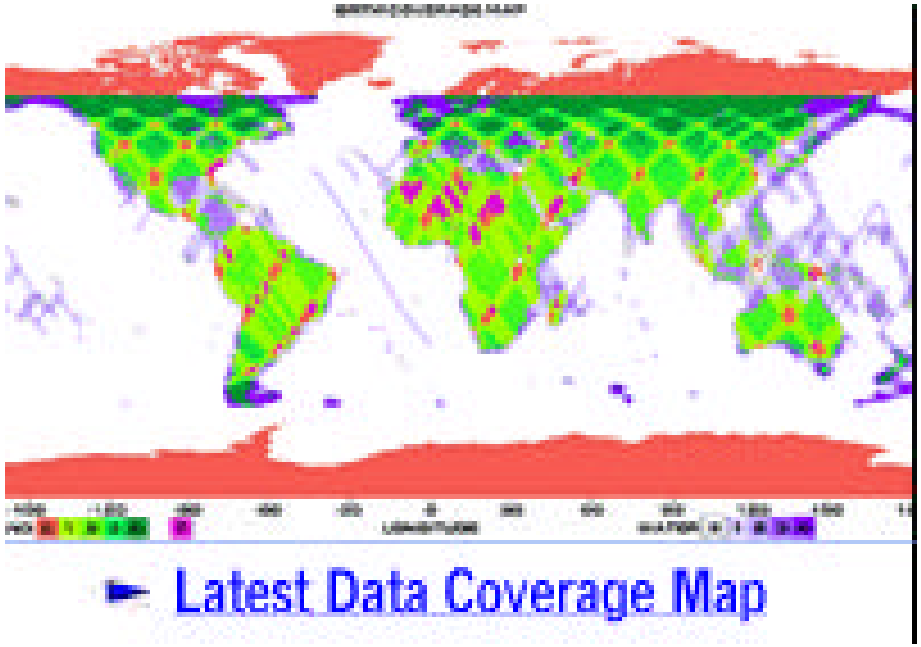
- International committee formed to develop requirements for terrain, obstacle, and airport mapping data to be used in aviation
- Includes requirements for content, accuracy, integrity, format, acquisition, integration, distribution, and maintenance of these data
- These standards needed for certification on a worldwide basis of many proposed applications:
  - Proactive CFIT-avoidance using Synthetic Vision Systems; Runway Incursion Prevention Systems; Terrain Awareness Warning Systems; Minimum Safe Altitude Warning Systems; Airport Surface Navigation Systems; Procedure design; High-fidelity flight simulation
- SVS Project actively contributing both in reviewing proposed requirements and in developing requirements through analytical and flight test activities
  - NASA Chair of subgroup 3 “User Requirements for Airport Mapping Databases”
  - Committee documents are scheduled to be released for ballot in March 2000.

SVS Key Enabling Activity: SRTM Mission

- 80 % of the Earth's land surface (99.96% of land between 60° N. & 56° S. latitude) mapped sufficiently for SVS enroute requirements
- STS-99 launched 2/11/2000: 10-day mission; 18 month data processing time
- $700 Million investment by NASA/ NIMA

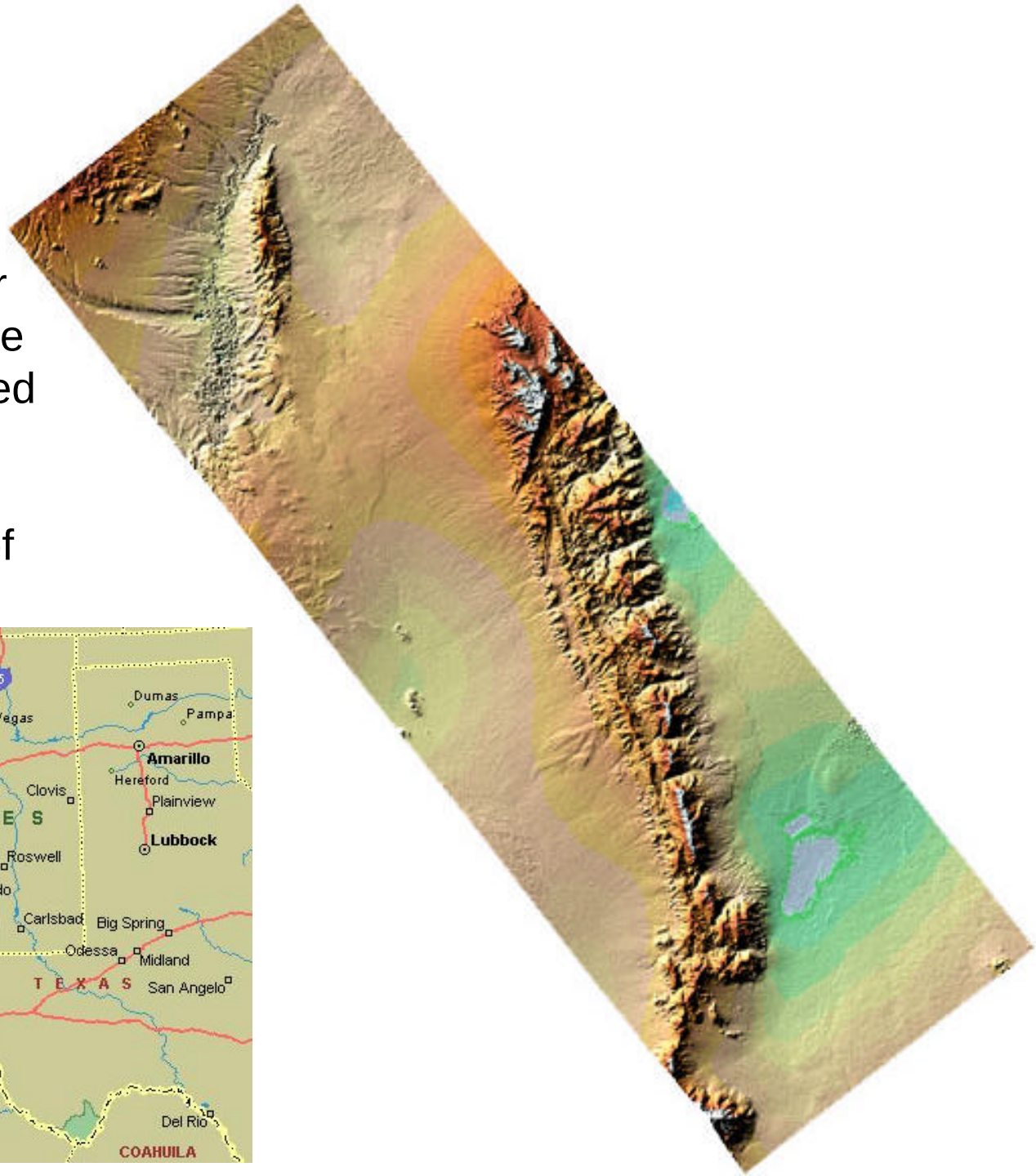


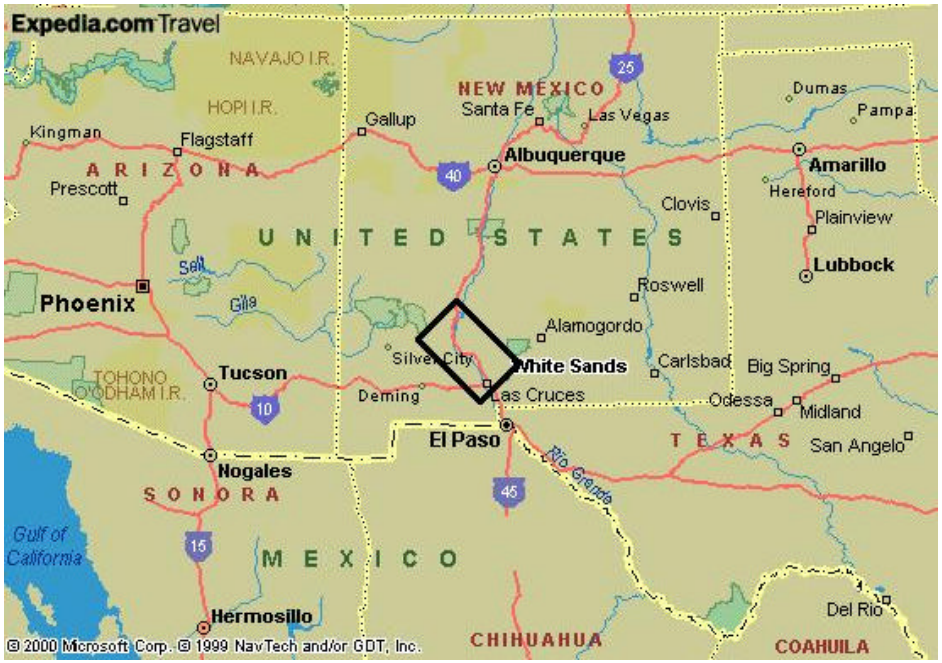




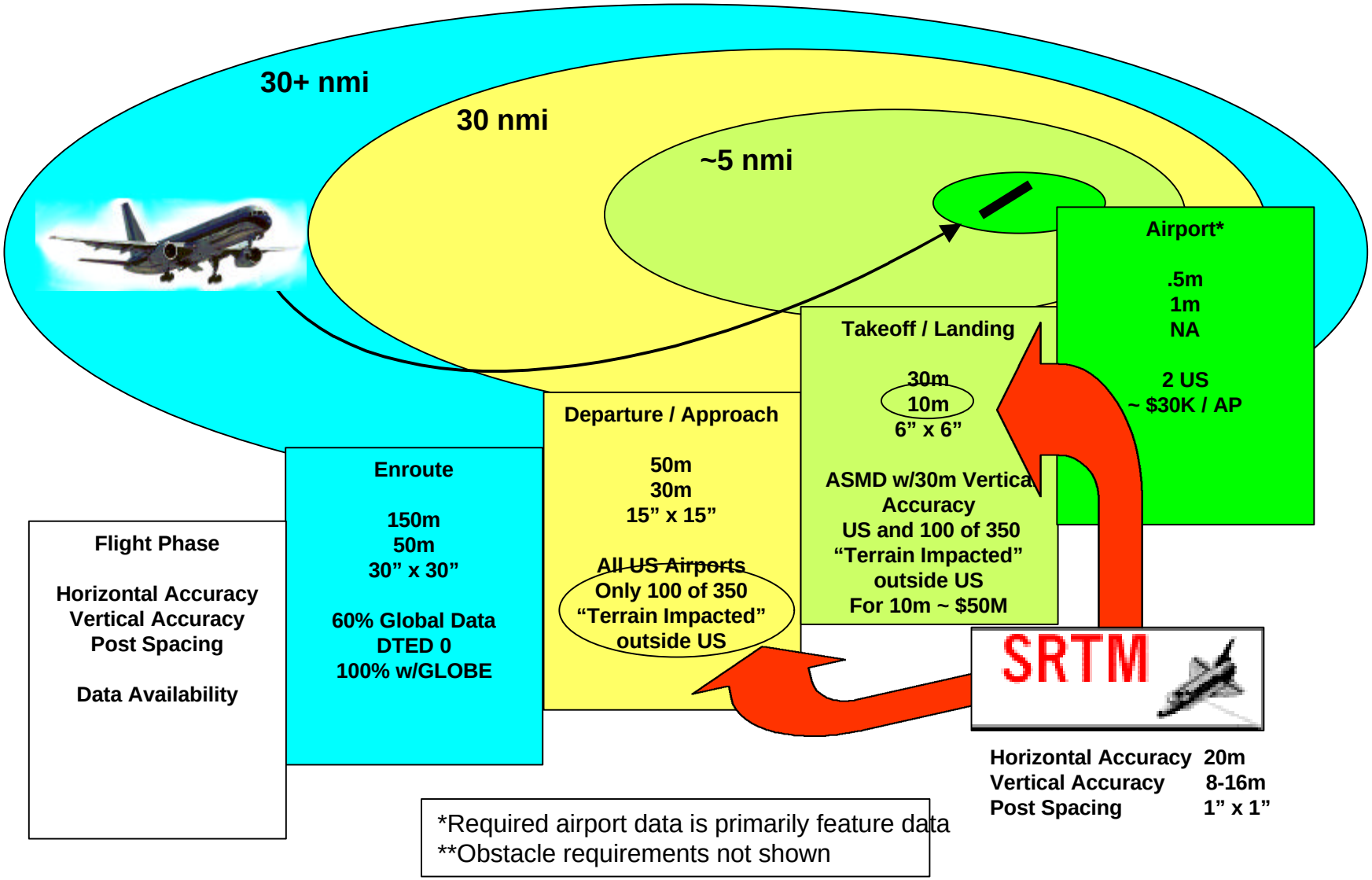
SRTM Data: White Sands

- Shown is a pseudo-color shaded relief of the White Sands, NM area extracted from 30 meter resolution terrain data taken by the SRTM from an altitude of about 150 miles





Conceptual Terrain Database Requirements



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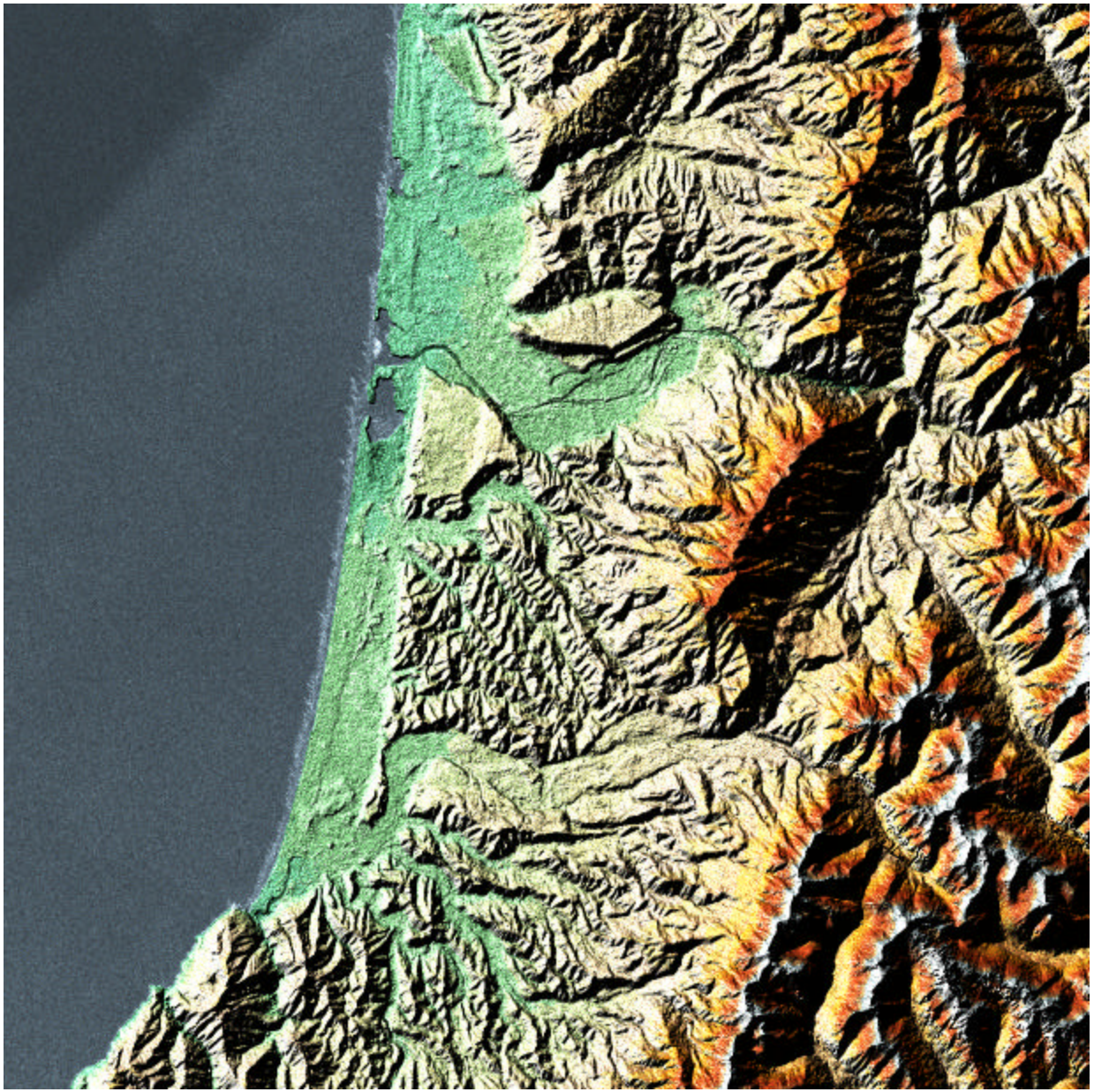
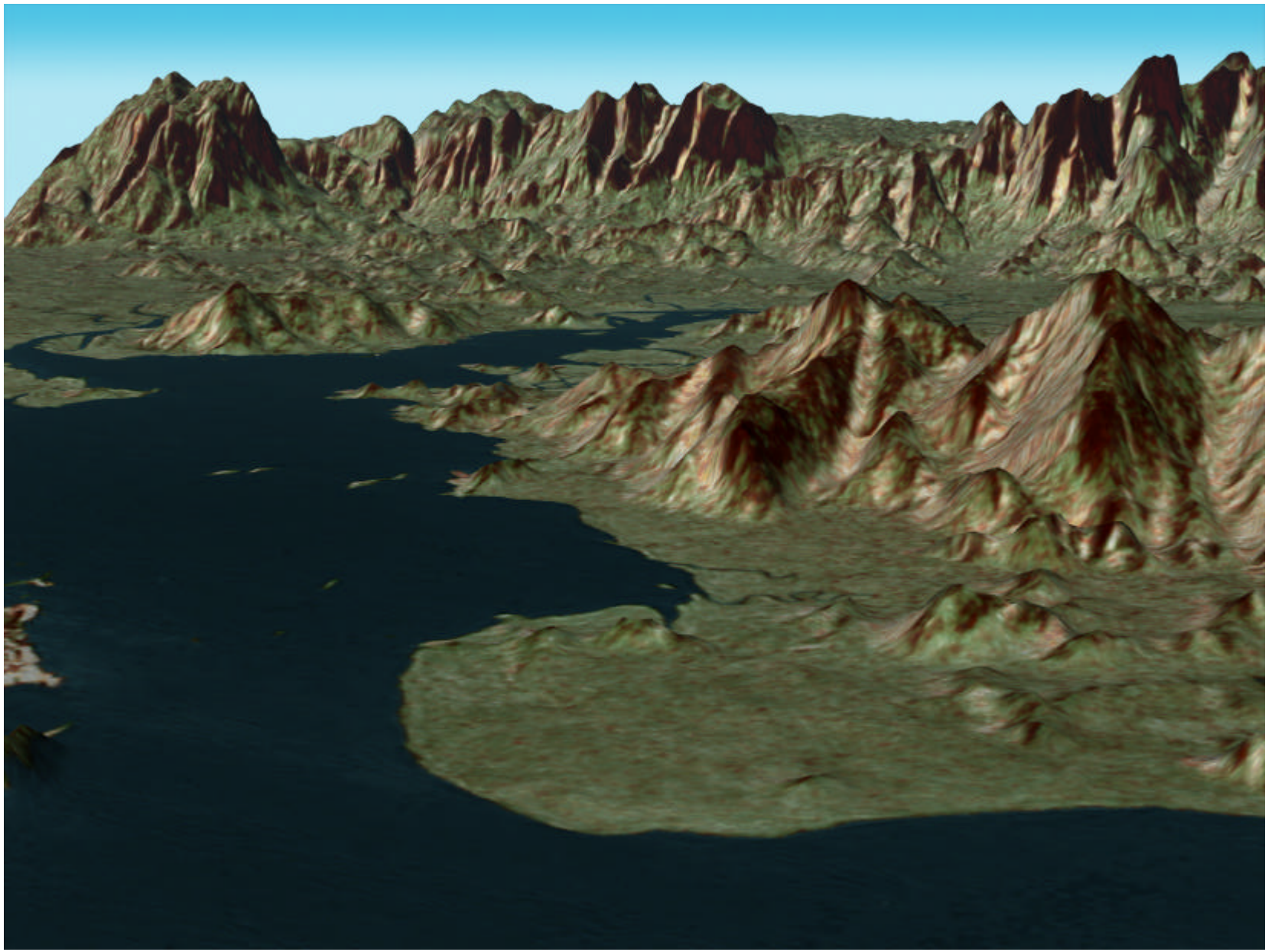
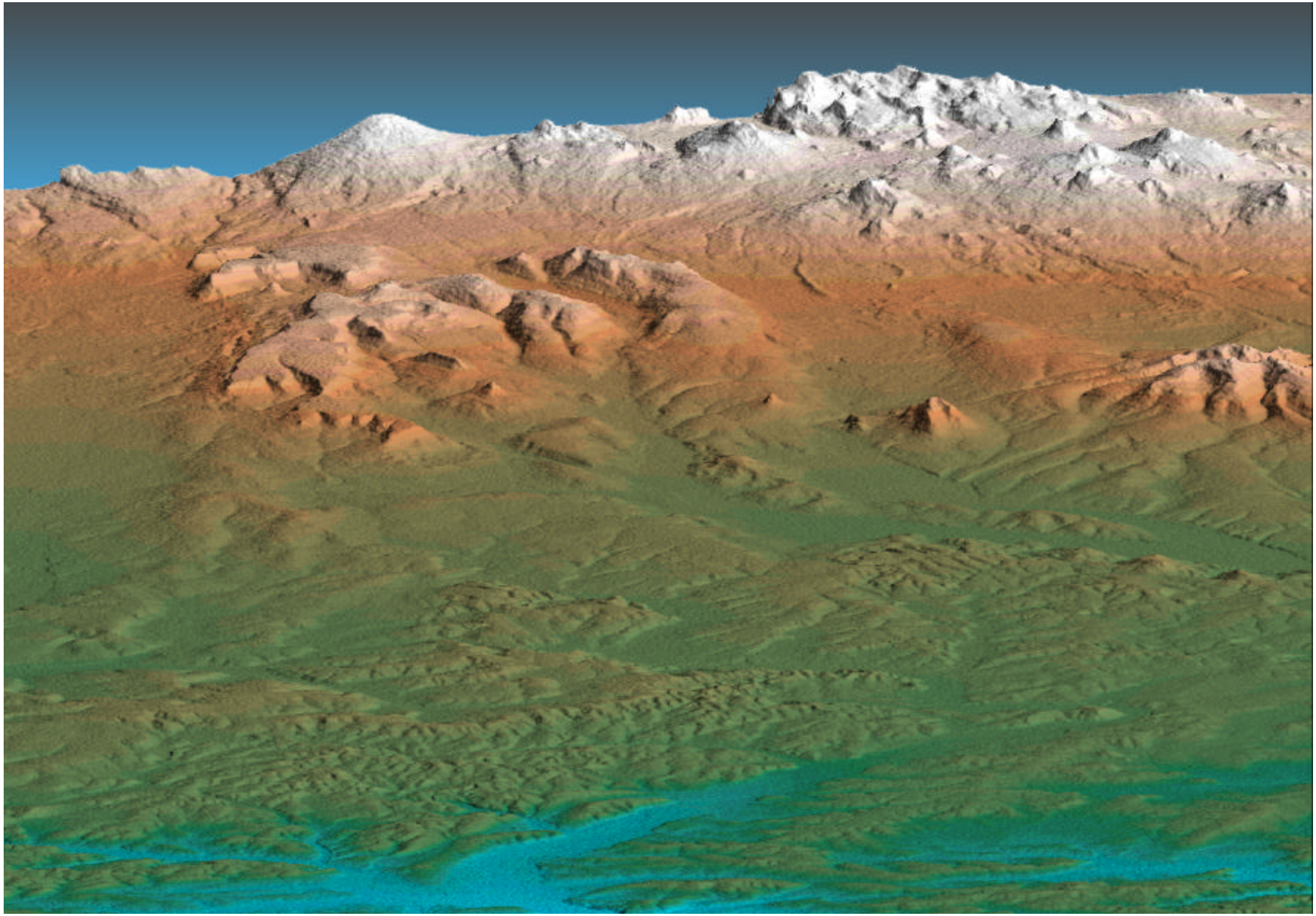
SRTM Data: Karamea Bight / New Zealand



SRTM Data: Baia de Paranaguá - Brazil



SRTM Data: Kamchatka Peninsula, Russia

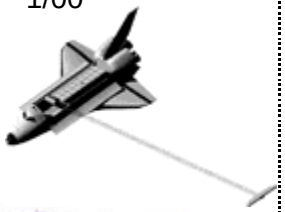


Synthetic Vision Systems Project Schedule

Aviation Safety Program: Synthetic Vision Systems

2000				2001				2002				2003				2004				2005			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
$ 13.5 M				$ 15.1 M				$ 14.1 M				$ 15.4 M				$ 15.5 M				Σ = $ 73.6 M			

★ Preliminary Integrated Program Assessment
1/00



☆ Safety-Improvement Concepts Defined
9/01

☆ Interim Integrated Program Assessment
6/02

☆ Simulations & Flight Test Evaluations of Safety-Improvement Systems within AvSP Complete
3/03

☆ Integrated Full-Mission Applications, Simulations & Flight Demonstration
6/04

☆ Final Integrated Program Assessment
9/04

TIFS Demonstration of High-Resolution SVS Database

2.6-1 Flight Evaluation of Runway Incursion Prevention Technologies △ 9/00

2.6-2 SVS Retrofit Concepts Downselect △ 9/01

NRA Round I Research and Development

2.6-3 SVS Concepts Initial Flight Evaluation △ 12/02

2.6-4 Worldwide SVS Terrain Database Infrastructure Defined △ 9/03

NRA Round II Research and Development

2.6-5 Flight Critical SVS Concepts Demonstrated △ 6/04

☆ Level I Milestone

△ Level II Milestone

Status: Cooperative Agreements Awarded

Commercial and Business Aircraft SVS:

Future Flight Deck Information Management & Display System

- Team led by **Marconi Aerospace Systems**, Inc. CNI Division, Wayne, NJ.
  - Members: Canadian Marconi Company and Marconi Astronics

Synthetic Vision Information Systems Implementation Team

- Team led by **Rockwell Collins**, Inc., Cedar Rapids, IA.
  - Members: Jeppesen-Sanderson, Inc., The Boeing Company, American Airlines, Delft University of Technology, Embry-Riddle Aeronautics University, and Flight Dynamics, Inc.

General Aviation SVS:

An Affordable, Certifiable Low End Thrust Synthetic Vision System

- Team led by **AvroTec**, Inc., Portland, OR.
  - Members: Avidyne Corp., Lancair/PAC USA, Massachusetts Institute of Technology, Raytheon Aircraft, Seagull Technologies, Inc., and FAA-Civil Aeromedical Institute.

A Low cost Synthetic vision Display System Capability for General Aviation

- Team led by **Research Triangle Institute**, Research Triangle Park, NC.
  - Members: Archangel Systems, Inc., Flight International Inc., Seagull Technologies, Inc., Dubbs & Serverino, Inc., Crew Systems, Inc., and FLIR Systems, Inc.

Enabling Technologies for SVS:

A DTED Terrain Avoidance System Utilizing GPS and Radar Altimeter Monitoring

- Avionics Engineering Center of **Ohio University**, Athens, OH.

Aircraft Based Ground Collision Avoidance System (GCAS)

- **Rannoch** Corp., Alexandria, VA.

Other Synthetic Vision Concepts

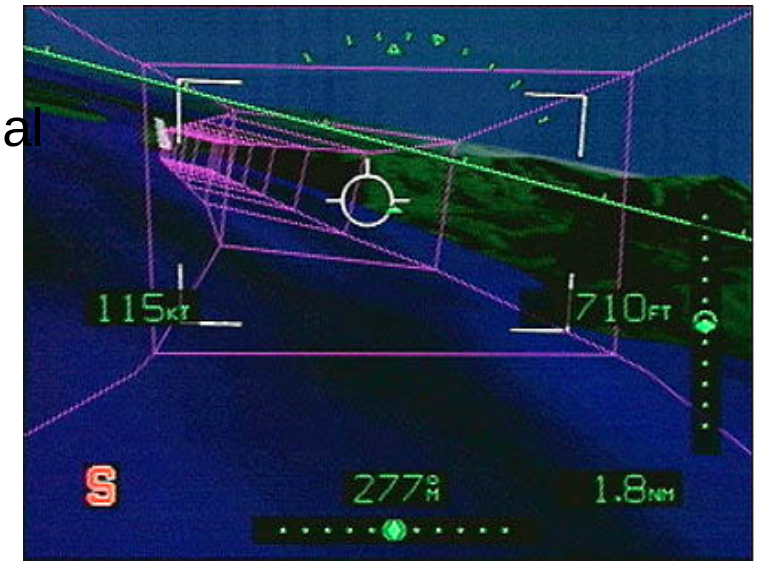
Experimental advisory, non-certified Synthetic Vision products are already on the market

"The Sierra EFIS 2000 eventually will be IFR certified…Sierra EFIS for homebuilts has seemed to have outpaced even NASA"

Sierra Flight Systems EFIS-2000

Programs with Synthetic Vision Concepts

- NASA AGATE: Highway In The Sky (HITS)
- NASA High-Speed Research Program: External Vision System (windowless cockpit)
- FAA: SafeFlight 21
- FAA/ Stanford University: Ph.D. research concepts have been developed and flown sponsored by the FAA's Satellite Navigation Program Office under the Aircraft/Avionics/ Navigation Integrated Product Team (AND-700)

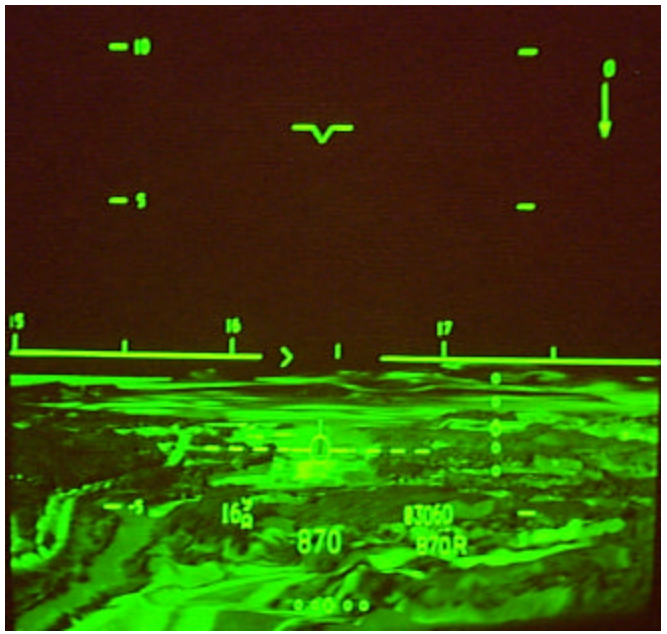


Stanford University: Tunnel-in-the-Sky-over-Terrain Display

SVS Status: SRTM Mission a Complete Success

Aviation Safety Program: Synthetic Vision Systems

- SRTM raw-data has now been collected for 47 million square miles; data processing beginning
- Interagency Agreement being worked w/ NIMA- NIMA personnel may be deployed to LaRC by 3/00
- 8 Industry teams selected for SVS Project participation via Cooperative Agreement- 6 awarded
- NASA in-house teams completing first series of SVS requirements simulation studies and preparing facilities for further experimentation
- Preparations continue for 757 flight test at DFW:
  - Runway Incursion Prevention System (RIPS) ready for final Sim and then Flight
  - Synthetic terrain data displayed on lab HUD
  - Synthetic Vision HD and on HUD
  - Enhanced Vision on HUD
  - Land & Hold-Short Operations
  - Radar Object Detection Data Collection



Synthetic Vision Summary

- Synthetic Vision technology will address visibility-induced incidents & accidents with a visibility solution, making it possible for every flight to be nearly equivalent to clear-day operation
- The availability, certificability, and liability issues associated with the required worldwide terrain and obstacle databases are key challenges
- NASA is striving to work cooperatively with the FAA, NIMA, Academia, and Industry to ensure successful implementation of Synthetic Vision Systems
- Viable commercial Synthetic Vision Systems are being made possible by significant Government investments in GPS navigation, worldwide terrain database (SRTM Mission), and the Aviation Safety Program
- The applications for- and capabilities and benefits of- Synthetic Vision technologies need to be well understood to properly focus immediate research and technology development efforts of this Project