An Overview, Current Status and Future Transformation Direction of NASA's Communications, Navigation & Surveillance (CNS) Research & Technology Activities

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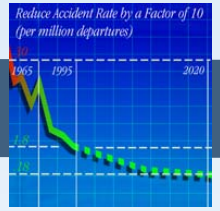
NASA's Aeronautics Research Mission

Objectives

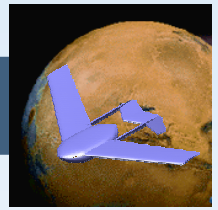


Protect Air Travelers and the Public

Protect the Environment

Increase Mobility

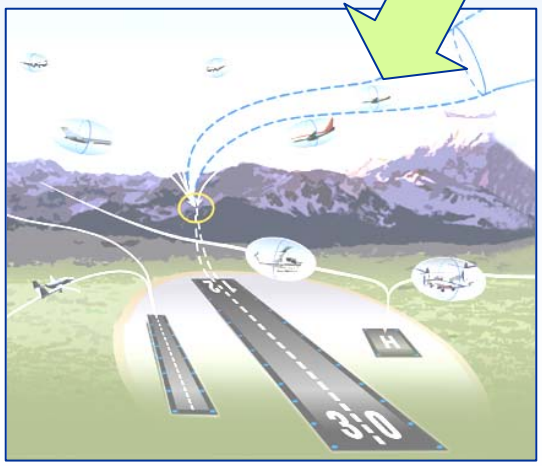
Protect the Nation



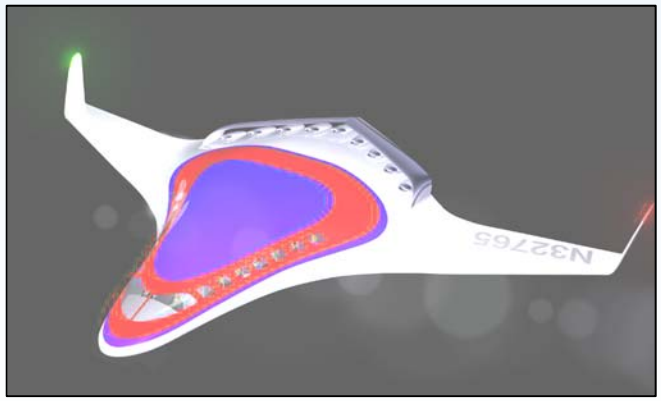
Explore New Aeronautical Missions

Programs

Aviation Safety & Security



Airspace Systems



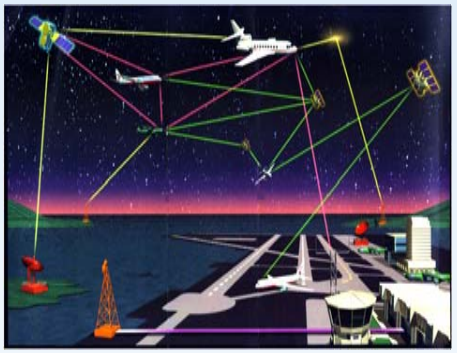
Vehicle Systems

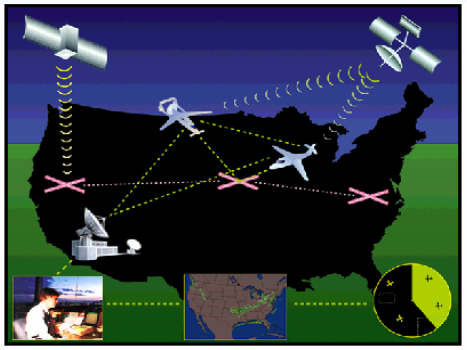
CNS: Enabling the 21st Century Digital Airspace System

Civil Aviation CNS: Present & Future States

Today's Challenges

- Analog, voice-based ATC cannot support future complex ATM concepts
- Inadequate surveillance and communications coverage in remote and oceanic regions
- Insufficient security and integrity
- Insufficient communications capacity to support future ATM
- Congested frequency spectrum limiting air traffic growth





Future

Secure Global Integrated CNS Network

- Digital, robust CNS system reliable under severe weather or other hazardous conditions
- Active and passive surveillance
- High integrity satellite navigation
- Remote and autonomous flight command and control
- Virtual security presence throughout aircraft & airspace
- New integrated CNS architecture enabled by spectrum-efficient and network-centric technologies

Aviation Safety & Security CNS Research & Technology

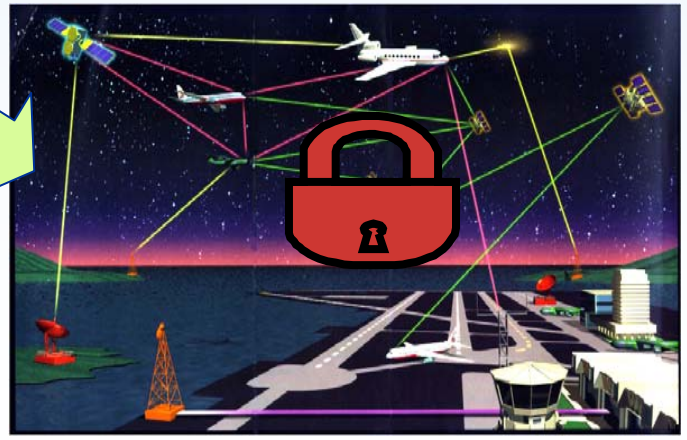
Decrease the aircraft fatal accident rate, reduce the vulnerability of the air transportation system to hostile threats, and mitigate the consequences of accidents and hostile acts.

Program

Aviation Safety & Security

R&T Activity

•Weather safety communications



•Secure communications

•Protected airspace surveillance

Aviation Safety: Weather Safety Communications
(PM: Michael Jarrell)

Goal:

Develop advanced communications technologies to enable high quality and timely dissemination of:

- strategic weather information between flight deck and ground users/providers
- tactical airborne turbulence hazard information

Objective:

- Develop advanced weather communication data links and networks

Technical Challenges:

- Establish weather information requirements
- Reduce cost of aviation weather data links
- Integrate solutions into the NAS infrastructure

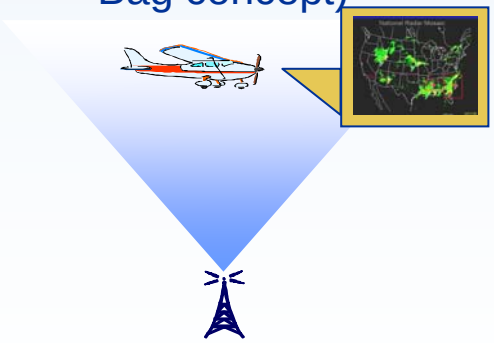
Approach:

Select and validate data link candidates for weather dissemination meeting the near-term needs of:

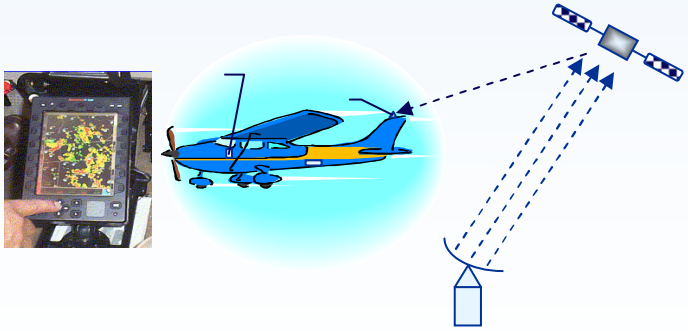
- Commercial transport aircraft in the national airspace
- General Aviation / Regional aircraft in the national airspace
- Global coverage (including oceanic)

Past Accomplishments

- **General Aviation/Regional En-Route:**
  - CRAs with ARNAV and Honeywell led to rollout of national broadcast network for weather (FISDL)
  - SBIR with Vigyan produced a low cost satellite-based graphical weather to the cockpit service (WSI).
  - Cooperative Agreement with Rockwell Collins proved S-DARS for weather product delivery over AfriStar; catalyst for XM Satellite Radio, HeadsUp and Baron Aviation teaming for a GA national weather service
- **Commercial Transport En-Route:**
  - Cooperative Agreements with Boeing & Honeywell leveraged off-the-shelf communications for rapid implementation (air phone, VHF/ACARS, Inmarsat)
  - Conceptual and human factors emphasis; system implementation utilized non-optimal datalinks
  - In-Service Evaluations of the Honeywell system by United Airlines (Electronic Flight Bag concept)



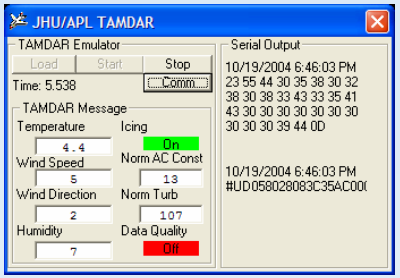
Terrestrial Broadcast FISDL



SATCOM Broadcast Pilot Weather Advisor

Honeywell

GA/Regional Weather Information Dissemination



TAMDAR Data Emulator (JHU-APL)

Cockpit Display Unit

Modified UAT Avionics (Garmin)

NASA GRC Learjet

Air-to-Air Link

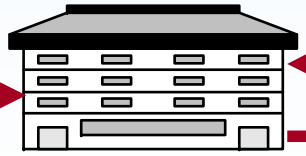
Weather Hazard Information

NASA GRC Learjet

Ground-to-Air Link
Weather Information

Air-to-Ground Link
Airborne Weather Reports

Modified UAT Ground Based Terminal (Sensis) & Router (MITRE)



Weather Information Service

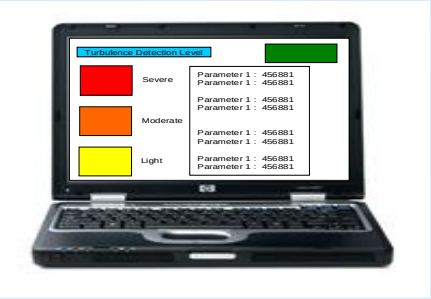
TAMDAR Data Collection

FAA Technical Center, Atlantic City, NJ
UAT HUB

UAT ADS-B System utilized in cooperation with the FAA Safe Flight 21 office

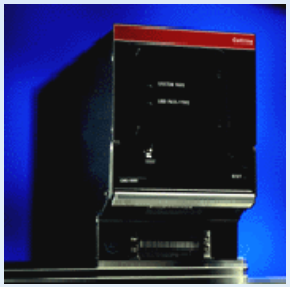
Air Transport Weather Information Dissemination

Turbulence Emulator



Cockpit Display

Modified* VDLM3 Avionics (Rockwell Collins)



Air-to-Air Link (1090ES)

Turbulence Information
(Honeywell/Sensis)

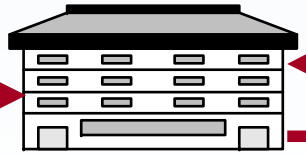
NASA GRC Learjet

NASA GRC Learjet

Ground-to-Air Link
- **Weather Information**
- ***Broadcast***

Air-to-Ground Link
- **Turbulence Reports**
- **Pilot Requested Value Added Weather Products**

Modified* VDLM3 Ground Terminal



Weather Information Service

Turbulence Data Collection

FAA Technical Center, Atlantic City, NJ

VDLM3 Data Link utilized in cooperation with the FAA NEXCOMM office

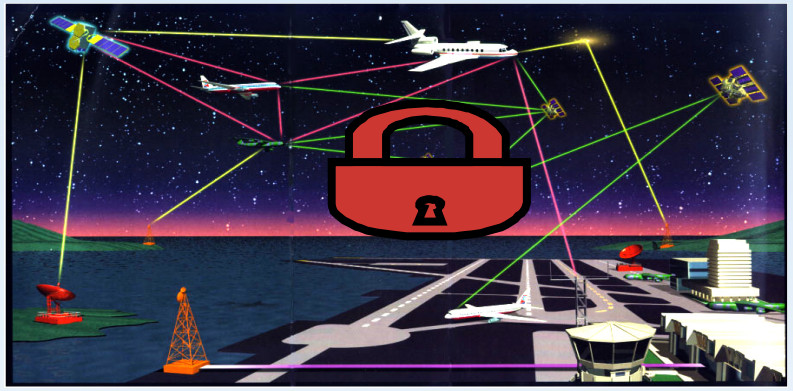
*Internet Protocol (IP) over VDLM3

Aviation Security: Secure Communications
(PM: Gus Martzaklis)

Goal:
- Secure aircraft networks and communications links from intentional threats, enable surveillance of aircraft, and minimize protected airspace intrusions.

Objectives:
- Develop protected airspace surveillance system concepts and technologies
- Develop technologies for remote monitoring of onboard systems and the aircraft environment
- Develop technologies to secure and harden aircraft datalinks and onboard networks

Technical Challenges:
- Security solutions within an acceptable level of overhead
- Secure onboard wireless comm for Air Marshals and crew
- Hardening of air/ground comm links without significant changes to existing infrastructure
- Viable, affordable uplink of TFR info
- Additional spectrum or datalink utilization to accommodate new security comm reqt's
- Secure authorization/key distribution across diverse NAS mobile/fixed and international/domestic networks

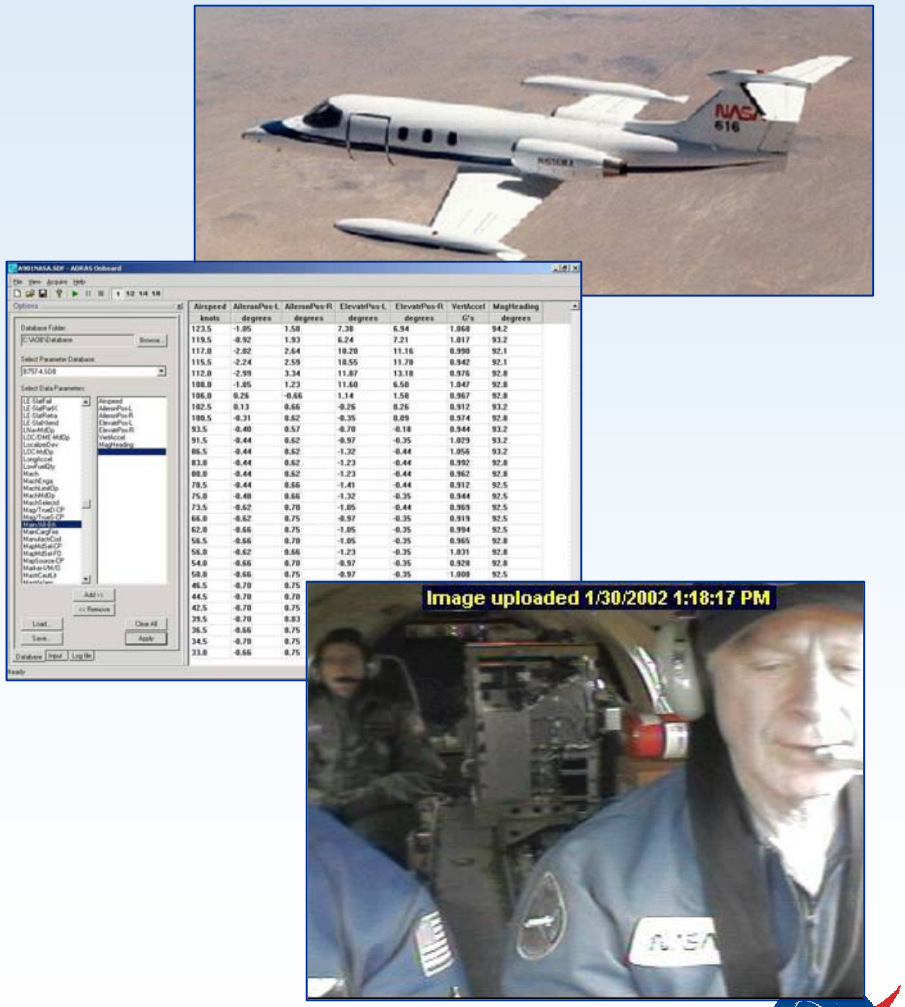


Approach:
- Partner with OGAs, industry and academia to leverage external research capabilities and enhance implementation
- Conduct in-house research in unique areas
- Develop necessary facilities to enable users & developers to evaluate technologies and identify improvements
- Perform studies to assess technical impact of security technologies, trade-offs and cost benefits

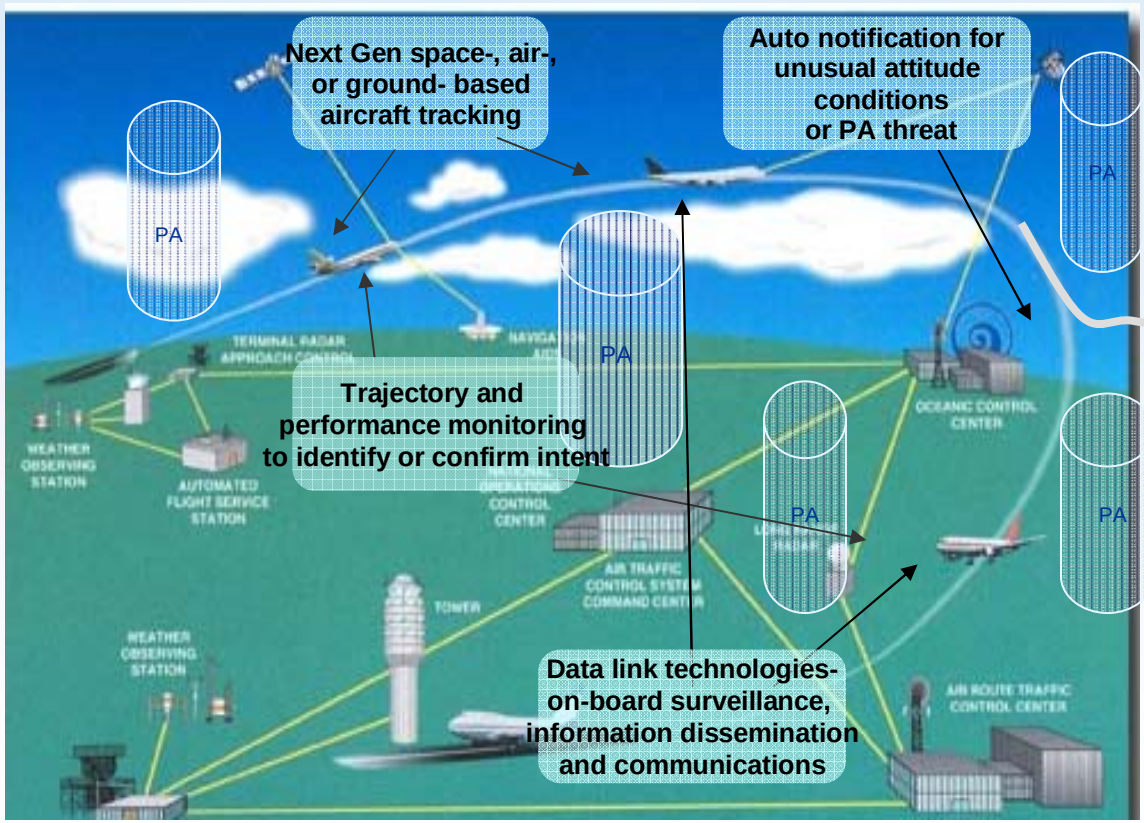
Deliverables:
- Protected Airspace Surveillance Technologies
- Aviation Security Communications
  - Air marshal, bio/chem, biometric, secure landing encrypted datalink
- Cabin, cockpit & aircraft systems surveillance
- Intrusion-proof networks & datalinks
- Secure key delivery systems

Past Accomplishment: Remote Monitoring of Aircraft Environment

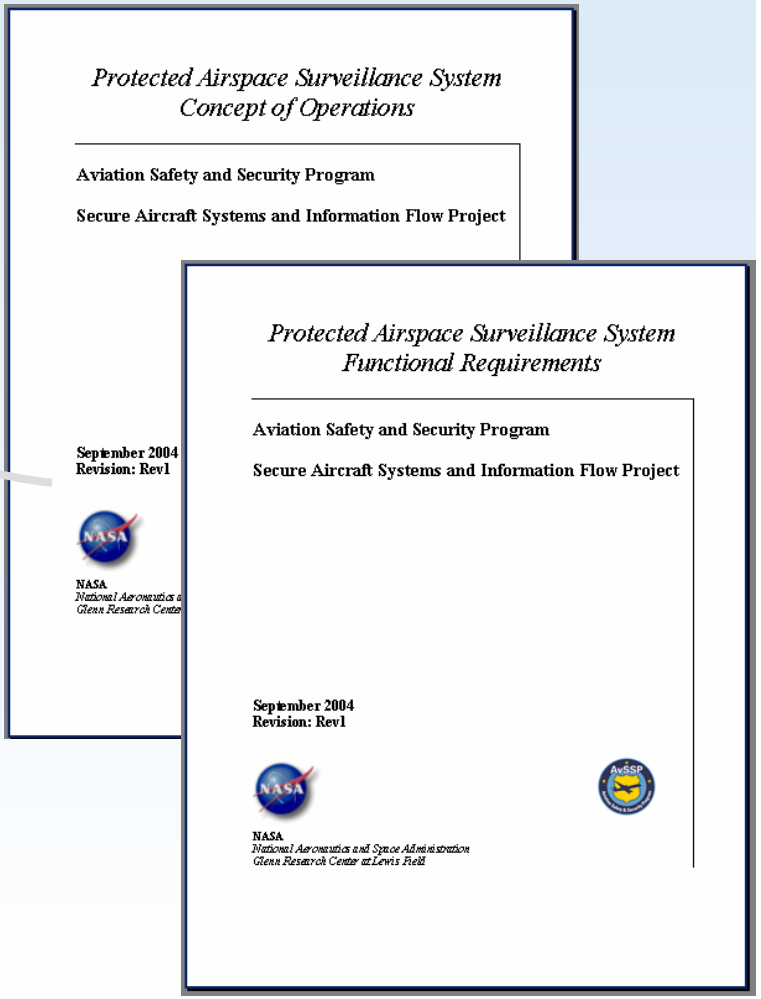
In response to the events of September 11, NASA Glenn Research Center and its industry partners conducted demonstration flights in December 2001 and January 2002 downlinking aircraft cockpit/cabin imagery, audio and “black box” data for ground-based monitoring of the aircraft environment by law enforcement officials.



Past Accomplishment: Initial Definition of Protected Area Surveillance System Concepts



Protected Airspace Surveillance System Concept

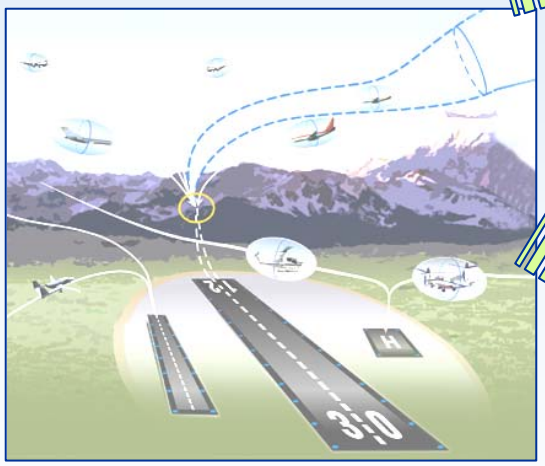


Protected Airspace Surveillance System ConOps and FRD Documents

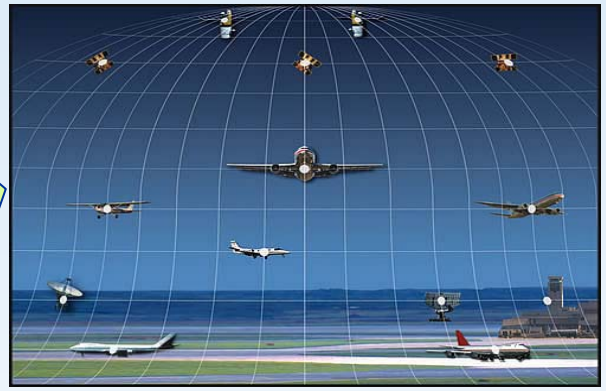
Aviation Mobility CNS Research & Technology

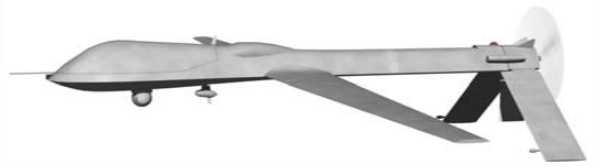
Enable more people and goods to travel faster and farther, with fewer delays.

Program



Airspace Systems





Focus on increased capacity, mobility, efficiency & access.

R&T Activity

- **Network-centric digital CNS for future ATM**
- **CNS system modeling for virtual airspace system simulation**
- **High Altitude Long Endurance, Remotely Operated Aircraft Command, Control, Communications**

Advanced CNS Architectures and System Technologies (PM: Robert Kerczewski)

Goal

Initiate the transition of today's CNS systems into a high-performance network-centric digital infrastructure to support future ATM concepts in the National Airspace System.

Objectives

- Identify the transitional architecture to achieve the transformational high-performance integrated CNS (ICNS) system and define the global air/ground network architecture
- Develop efficient aviation spectrum utilization and support global spectrum allocations
- Enable efficient oceanic/remote operations through improved communications and surveillance
- Increase air-ground communications performance and capacity for terminal and en-route operations
- Improve airport surface operations via an integrated wireless CNS network
- Develop high-payoff advanced CNS technologies

Technical Challenges

1. Developing technology solutions that can be certified for safe operation in the NAS
2. Developing technologies that provide acceptable cost/benefit to users.

Approach

Develop and demonstrate key technologies:

1. Mobile Communications Network
2. Multi-mode Multi-function Avionics
3. Surface ICNS Network
4. Oceanic/Remote Comm & Surveillance

Progress

- Future Communications Study – Technical support to FAA and Eurocontrol
  - Phase I technology prescreening completed Dec 2004 (ITT). Phase II technical studies to be started (ITT).
- Aviation Spectrum Technical Support
  - Analysis and field testing focused on 5091-5150 MHz band – supporting aviation spectrum advocacy at WRC-07. Two working papers were submitted to the ICAO Aeronautical Communications Panel Working Group F meeting.
- Multi-mode Multi-Function Avionics
  - Initial phase of effort to define a business case analysis and certification roadmap for multi-mode, multi-function avionics is completed (CNS Inc., AMA)

Progress (2)

- Airport Surface Integrated CNS Network and Terminal Area Communications
  - Detailed analysis of airport surface communications requirements is complete (Trios).
  - The first set of channel sounding and propagation measurements for 5091-5150 MHz band have been completed at Cleveland Hopkins International Airport and Cleveland Burke Lakefront Airport (Ohio University, FAA). Analysis of results is underway.
  - In-house efforts to define airport surface applications are nearing completion.
  - In-house efforts to define characteristics and applicability of various COTS network standards are on-going.
  - Terminal area communications requirements analysis is proceeding (CNS Inc, Raytheon).
- Mobile Communications Network Architecture (MCNA) Definition
  - The MCNA effort (Boeing task under the GCNSS-II contract) to define the mobile communications network architecture for aviation is progressing well, scheduled for completion in July, 2005.
- Oceanic Communications and Surveillance Development
  - Analysis of oceanic benefits of reduced separation in an ATOP environment for the North Atlantic Track System is underway (CSSI Inc.)
  - In-house effort to define current costs for oceanic communications systems is continuing.
- Test facility definition and design
  - Contracted effort (CNS Inc.) to survey existing test, demonstration and simulation capabilities relevant to CNS was completed.

Virtual Airspace Modeling & Simulation – CNS
(PM: Michael Zernic)

Goal

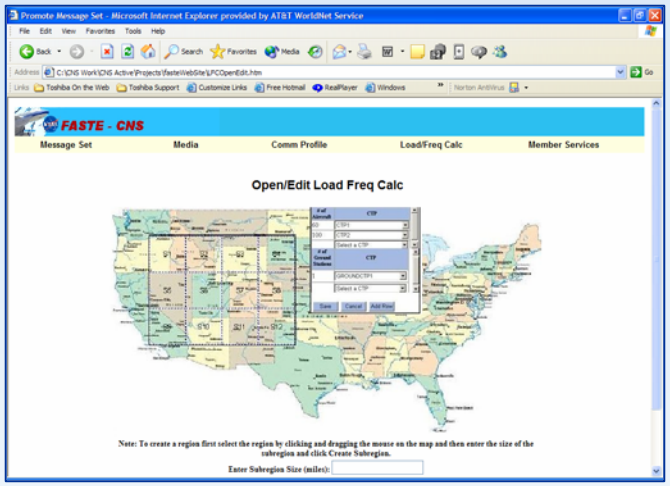
Model the imperfect behavior of CNS system behaviors in an integrated simulation environment

Objectives

- Provide simulation tool capable of representing CNS systems
- Utilize tool to realistically and comprehensively evaluate airspace concepts
- Utilize tool to evaluate individual CNS system or application effectiveness in context of a particular airspace concept

Technical Challenges

- Developing appropriate, comprehensive models
- Integration with updated Airspace Concept Evaluation System (ACES) builds and system level interactions
- Benchmark and validate complex system behaviors against real world data for confident simulations



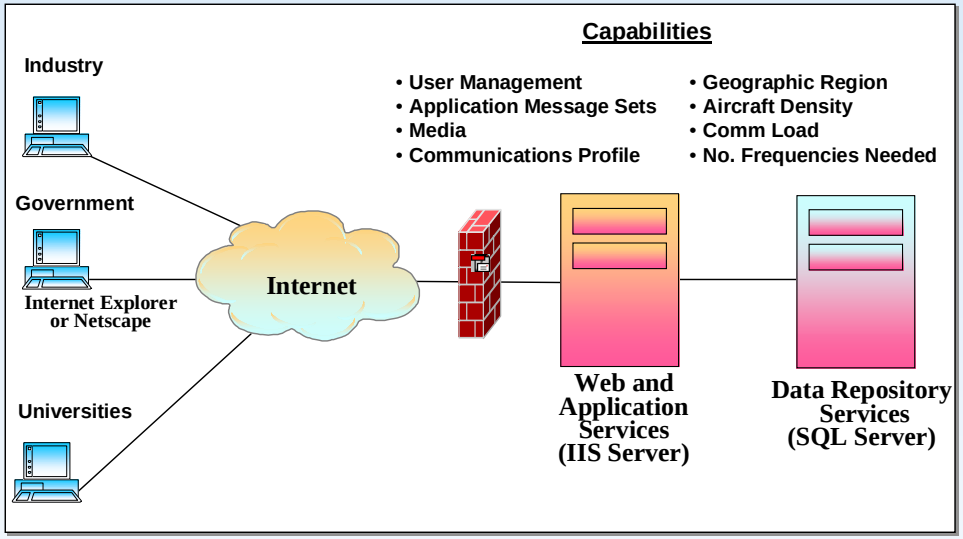
Approach

- Develop requirements for CNS modeling that supports evaluation of advanced airspace concepts
- Select and develop CNS models for
  - today's system
  - technologies currently being considered within the FAA's OEP, and
  - technologies being considered for the future
- Develop and demonstrate standard traffic model for assessing CNS model elements and architectures
- Integrate CNS into the software models toolbox of updated builds of ACES

FY03 Accomplishments

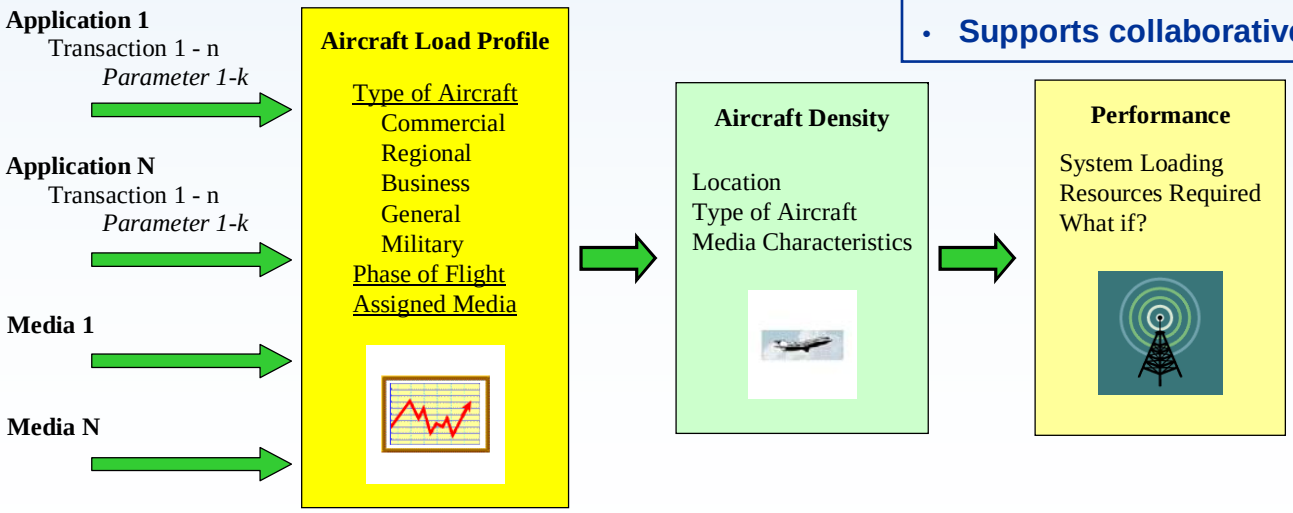
Future Aviation Subnetwork Traffic Emulator (FASTE) for CNS

FASTE CNS Architecture



- Dynamic estimating tool to define and assess the communications traffic loading
  - Media Type
  - Single aircraft
  - Multiple aircraft, geographic region with various communication profiles
  - Number of frequencies to support region profile
- Web-based, Internet accessible http://www.faste-cns.com
- Supports collaborative research

FASTE data communication loading analyses



FY04 Accomplishments

Initial CNS Models for ACES Build 3 Post-processing

Current Systems

Analog communications links

- Voice - DSB-AM, 25kHz bandwidth
- ACARS - character-oriented data messaging, 25kHz

Digital communication links

- Oceanic SATCOM

Navigation aids

- VOR; ILS
- Loran
- GPS

Surveillance radar

- Primary radar
- Secondary radar - mode A, C and S
- TCAS (collision avoidance transponder)

Emerging Systems

Analog communications links

- Voice - DSB-AM, 8.33kHz bandwidth

Digital communication links

- Voice - VDL Mode 3
- Bit-oriented data -

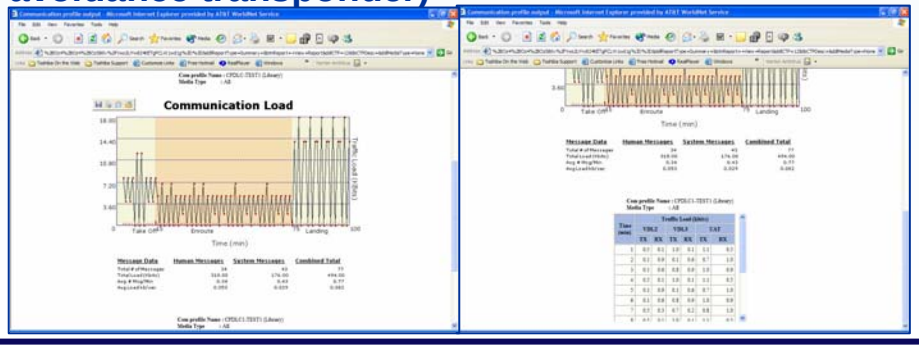
  VDL Mode 2, 3, & 4, UAT, 1090ES, SATCOM
- Communication networks - ATN

Navigation aids

- GPS with WAAS and LAAS

Surveillance radar

- ADS-B/TIS-B, UAT, 1090ES



HALE ROA in the NAS: Command, Control & Communications (PM: Gregory Follen)

Goal

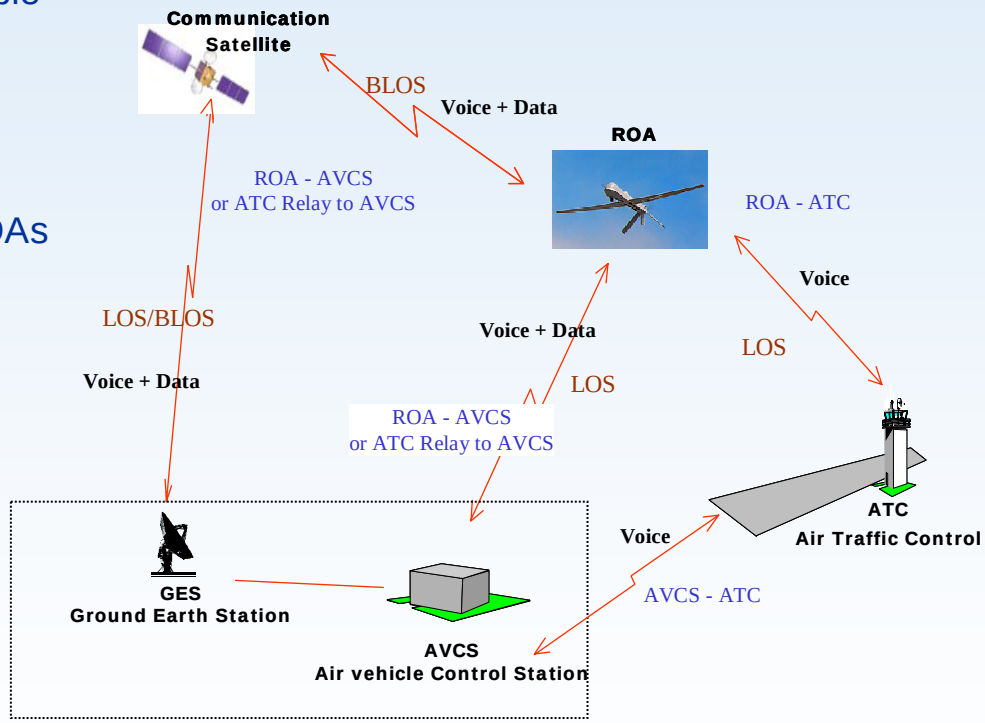
Establish the necessary requirements for a HALE ROA command, control, and communications system that are capable of maintaining a reliable voice and data link with both the ROA Control Element and Air Traffic Control

Objective

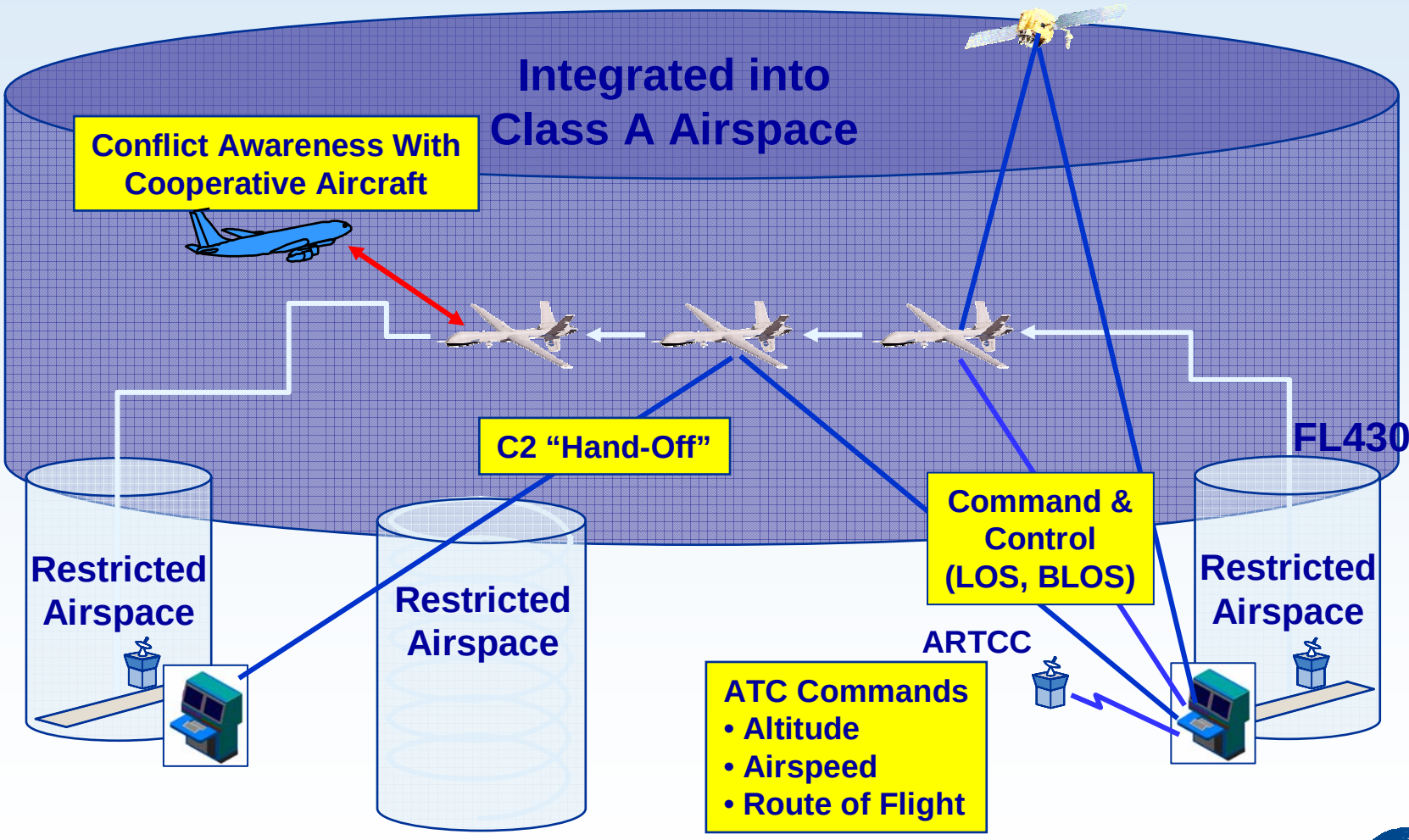
- To characterize the presence and effect of ROAs on the NAS communications infrastructure through simulation and modeling.

Approach

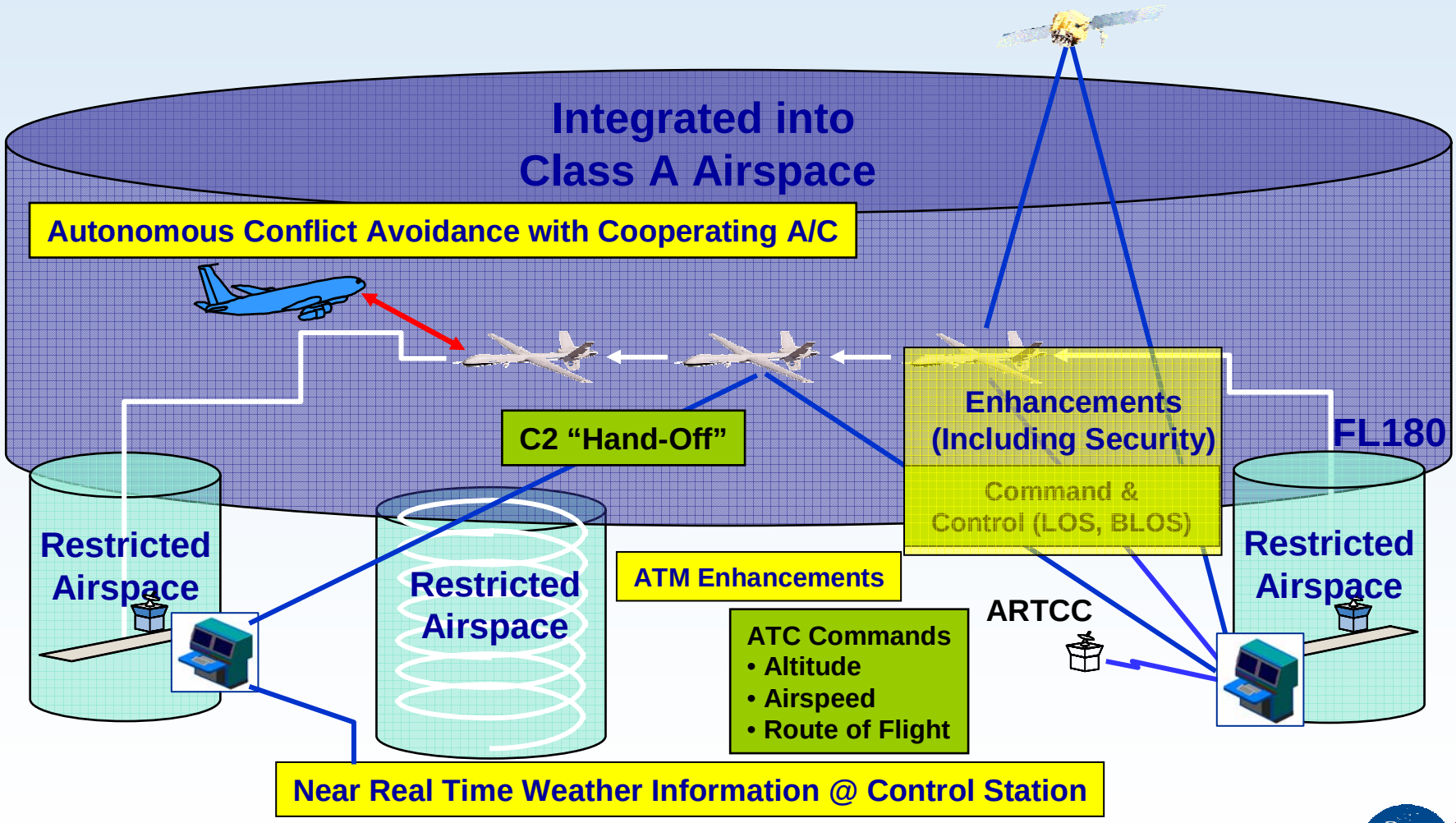
- Provide aeronautical communications system simulations for proposed ACCESS 5 (A5) Demonstration scenarios.
- Develop flexible simulations to evaluate and predict future communication systems requirements to meet A5 project objectives.
- Develop representative models of A5 ROA systems and communications system architecture components and run simulations to analyze communications system performance.



Access 5 Step 1: Capabilities



Access 5 Step 2: Capabilities



Summary and Future Transformation

- NASA, in partnership with other government agencies, industry and academia, is performing CNS research and technology development to enable future national and global airspace system concepts.
- NASA CNS R&T activities are in support of increased safety, security, mobility, capacity, efficiency and access of the airspace system.
- Transformation:
  - New program structure
    - New Base R&T Program focused on Foundational Research
    - Other 3 programs to focus on barrier-breaking demo projects
  - New competition model
    - 80% of all funds to be competed by FY10 (FY06-09 transition)
    - NASA will seek greater collaboration & partnerships

Supplemental

NASA's Vision

- To improve life here
- To extend life to there
- To find life beyond

NASA's Mission

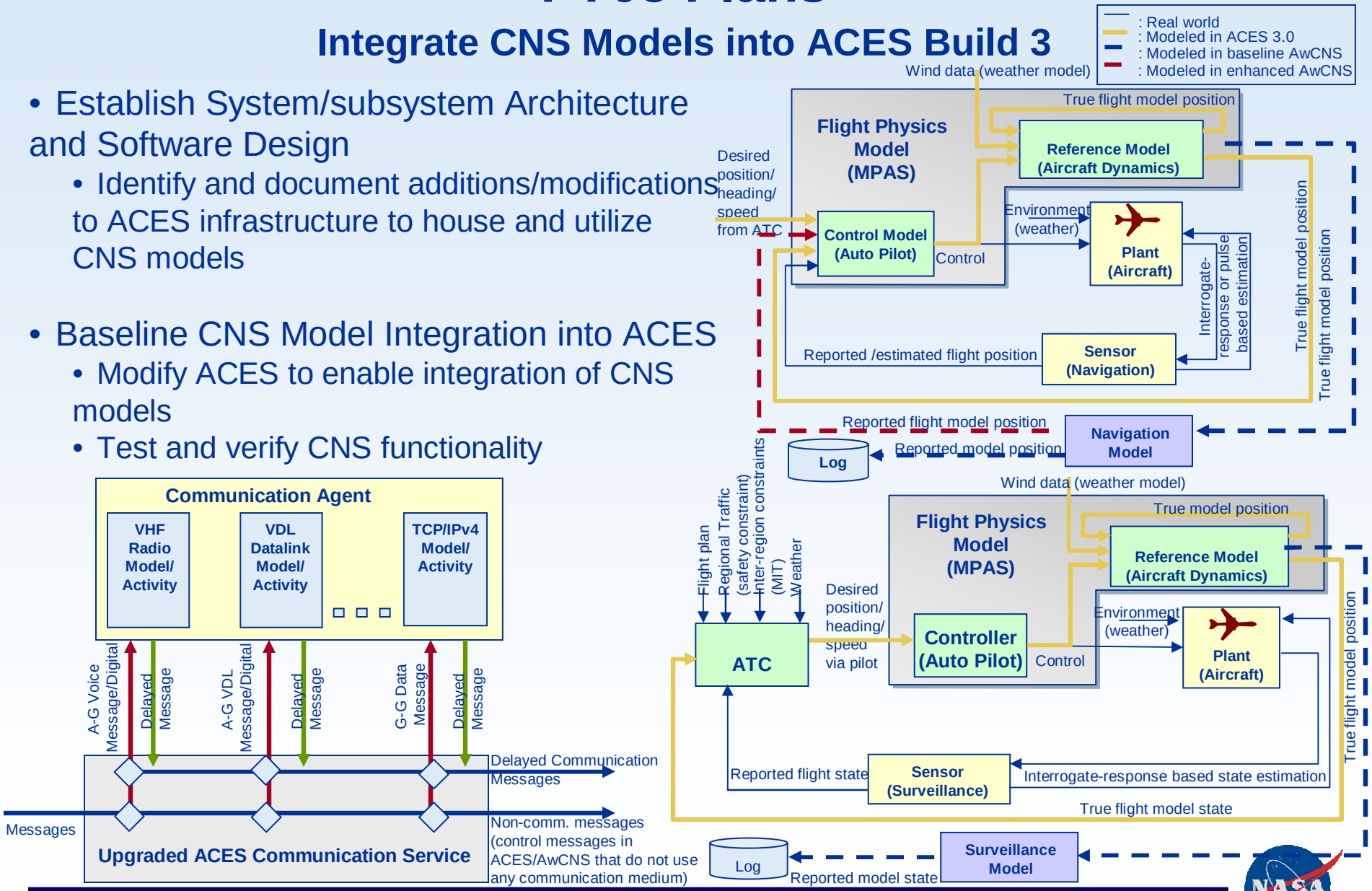
- To understand and protect our home planet
- To explore the universe and search for life
- To inspire the next generation of explorers

…as only NASA can

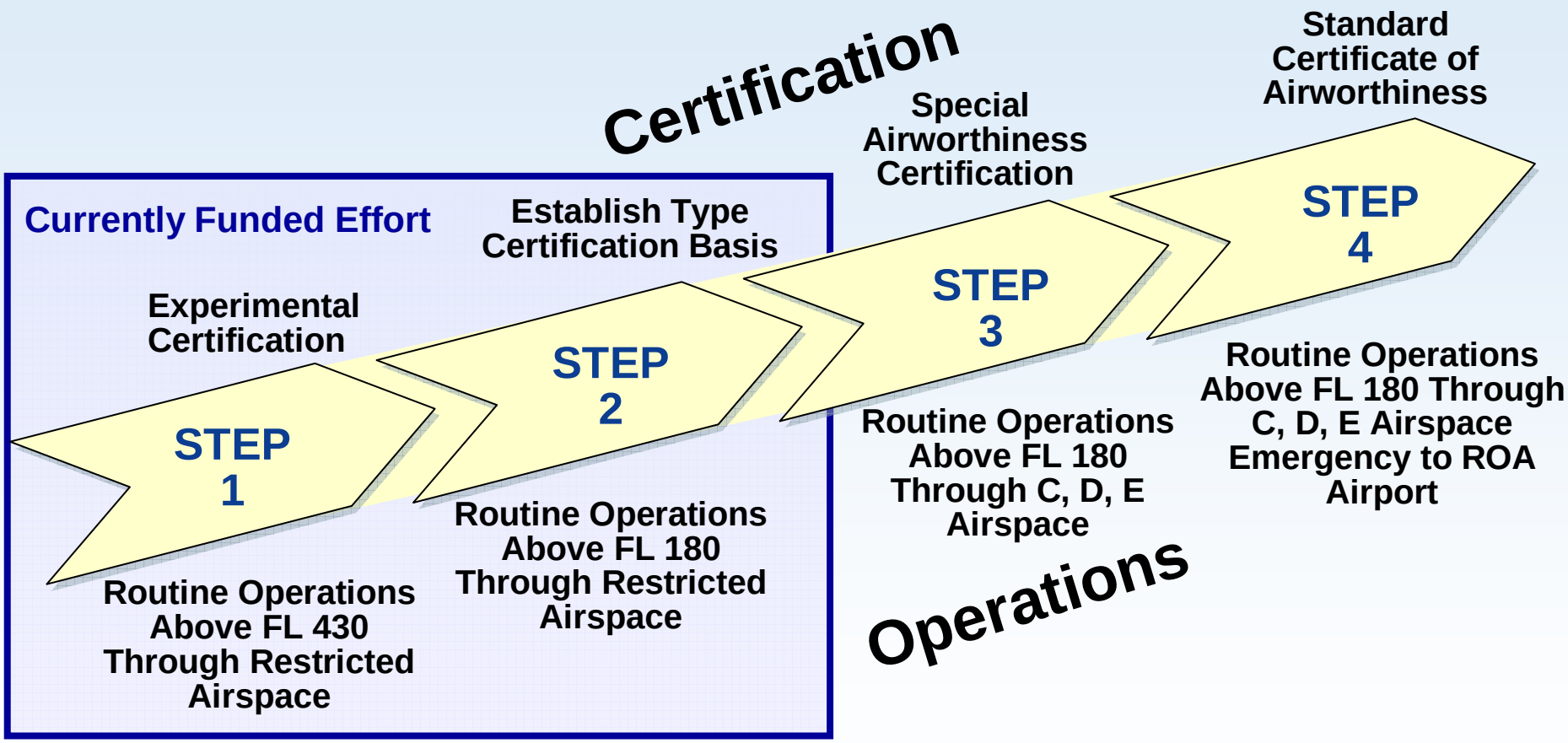
FY05 Plans

Integrate CNS Models into ACES Build 3

- Establish System/subsystem Architecture and Software Design
  - Identify and document additions/modifications to ACES infrastructure to house and utilize CNS models
- Baseline CNS Model Integration into ACES
  - Modify ACES to enable integration of CNS models
  - Test and verify CNS functionality

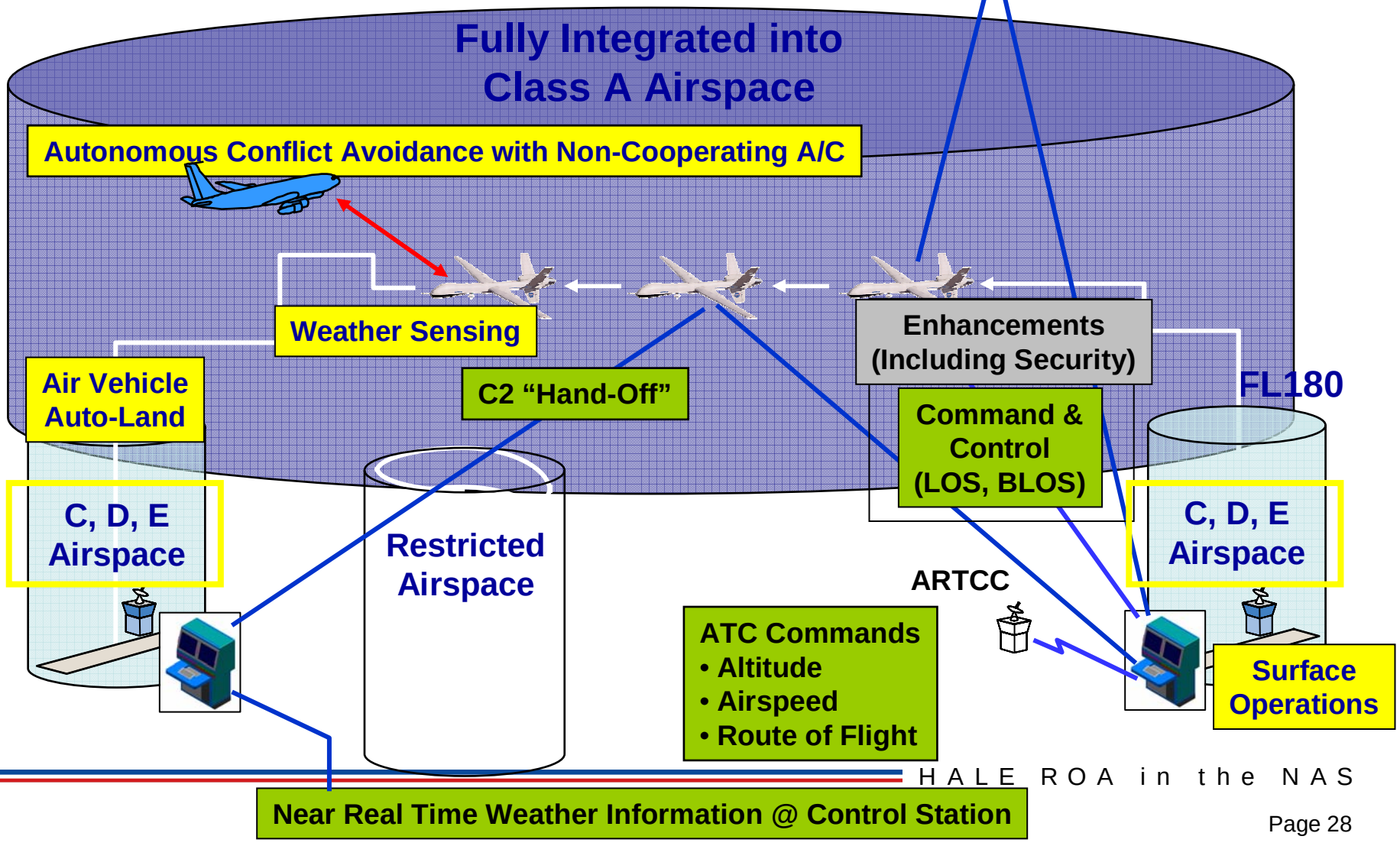


Access 5 Project Focus: Steps 1 and 2 (funded)

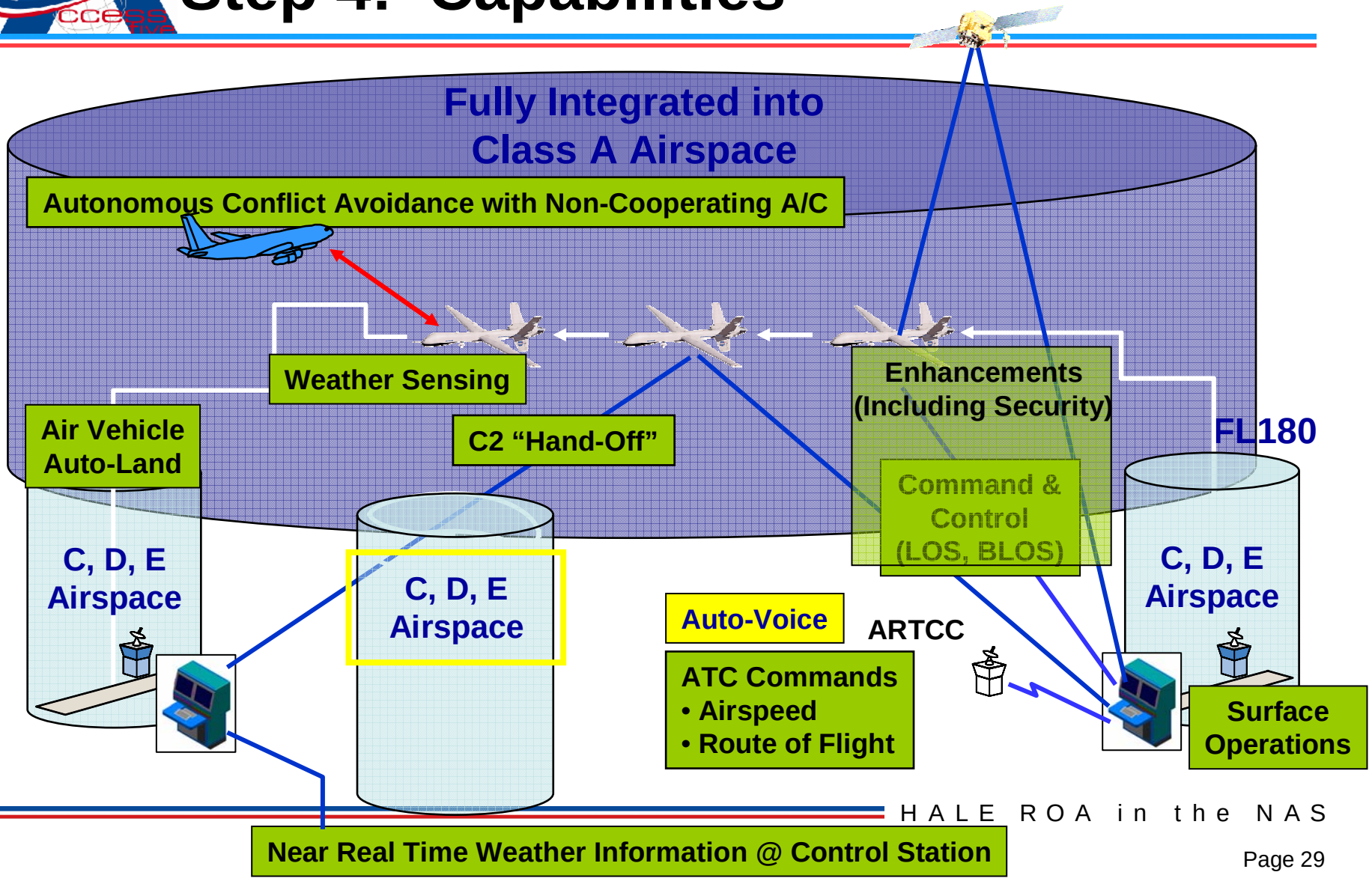


Achieve Routine Access in the NAS for HALE ROA

Step 3: Capabilities



Step 4: Capabilities



HALE ROA Physical Architecture