Future Enhancements to the U.S. Federal Aviation Administration's (FAA) En Route Automation Modernization (ERAM) Program and the Next Generation Air Transportation (NextGen) System

Federal Aviation Administration

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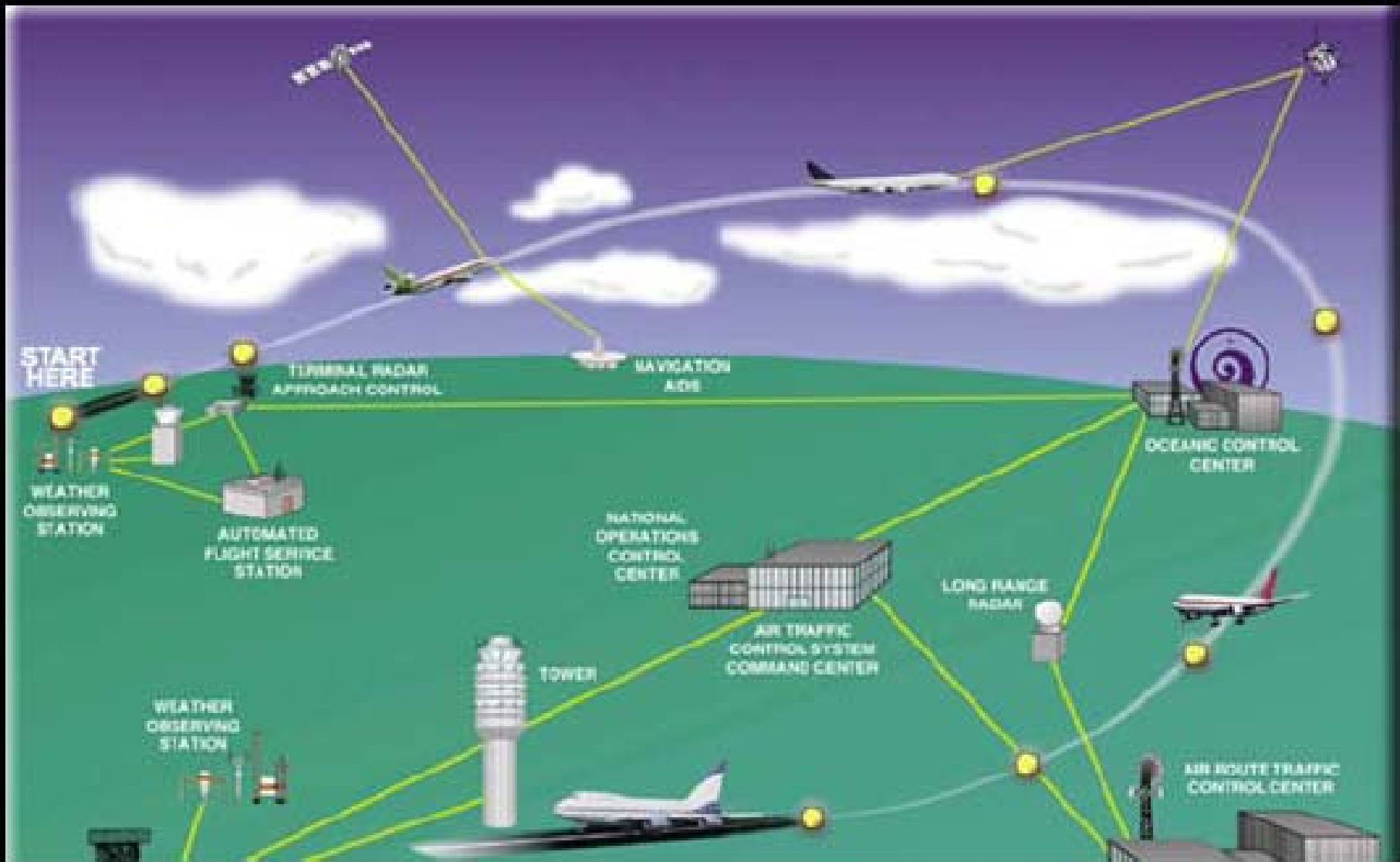
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FAA Runs the Largest and Safest ATC System in the World

New Enhancements & the Advanced Capabilities to ERAM

Route Tracking in 4-D An end-to-end, 4-dimensional trajectory model that predicts the path of each aircraft in time and space. Ground-based radar to much more accurate satellite-based automatic dependent surveillance-broadcast (ADS-B) technology.

Weather data integration Air traffic controllers will use information from weather systems to help pilots route away from storms, avoid turbulence, and give passengers smoother flights.

Conflict resolution Automated tools will help controllers detect potential conflicts and resolve them optimally. ERAM will let them see a bigger picture, beyond their area of responsibility, and choose the safest, most fuel-efficient resolutions.

Cockpit communication Data links will let controllers and pilots share flight information. Seeing from the cockpit perspective, controllers will be better able to issue flight plan adjustments that help pilots avoid separation hazards, weather disruptions, and other complications in the most efficient manner. The ultimate objective is to share the 4-D trajectory between the cockpit and the ground automation system.

Information sharing A System Wide Information Management (SWIM) system will allow ERAM, traffic flow management and other FAA systems to share data with each other, and share information with airline, military and other airspace users.

Airspace flexibility In case of weather disturbances that affect more than one sector, the system will allow airspace boundaries to be adjusted so the workload is better balanced across controllers.

Strategic flow management The system will provide an overall view of traffic flow nationwide. Controllers will be able to re-route aircraft, whether in flight or on the ground, for optimum efficiency and keep airports operating at capacity.

ERAM Lessons Learned in Using SW Components

Positive

- Factoring out common behavior saved code overall
  - Reuse of Proxy/mirror code in many clients saved all those clients from developing similar code many times over, saved those clients from debugging that code many times over
- Clean one-way dependency rules between components help build the system in an orderly fashion

Challenges

- Interfaces between components (APIs) are still volatile, still changing as features are added; learning what should be in the API vs. internal to a component is ongoing; structuring a component such that the minimum sufficient information is in the API is still ongoing (should have set up stricter controls/rules up-front to facilitate better decision-making)

- When there is a problem it's no longer one-stop shopping to find someone who can debug – you need each component involved in the thread for the most complicated problems.

- Having the same code (component mirrors, generally) in many apps (multiple instances of apps) increases opportunity for common mode failure

ERAM Lessons Learned in Developing Systems in Ada

Positive

- ASIS interface is very useful and we're utilizing it heavily for data exchange
  - Operational software (recording data) and Support software (interpreting recorded data)
  - Support software (generating adaptation data in compact, binary data) and operational software (reading in the adaptation data)
  - Ada software exchanging data with C++ software (crossing language boundary and passing data along)
- Ada results in code that is easier to debug due to strong typing / range checking. Much easier to debug an index which is out of range when an exception is raised on the first attempt to use it as opposed to stomping on random areas of memory.

Challenges

- Ada Reuse
- The perception of that Junior personnel are working with "old" technology and that the skill acquired are not transferable/marketable
- There is a related issue about "Calling" languages (like C) that do not support exceptions

What is NextGen?

• NextGen is a wide ranging transformation of the entire national air transportation system —not just certain pieces of it - to meet future demands and to avoid gridlock in the sky and in the airports while improving safety and protecting the environment.

• NextGen moves away from ground-based surveillance and navigation to new, more dynamic satellite-based systems. These changes are well beyond our legacy modernization programs.

• NextGen will change the way the system operates, reduce congestion, expand capacity, reduce noise and emissions and improve the passenger experience.

What Changes Improve Services?

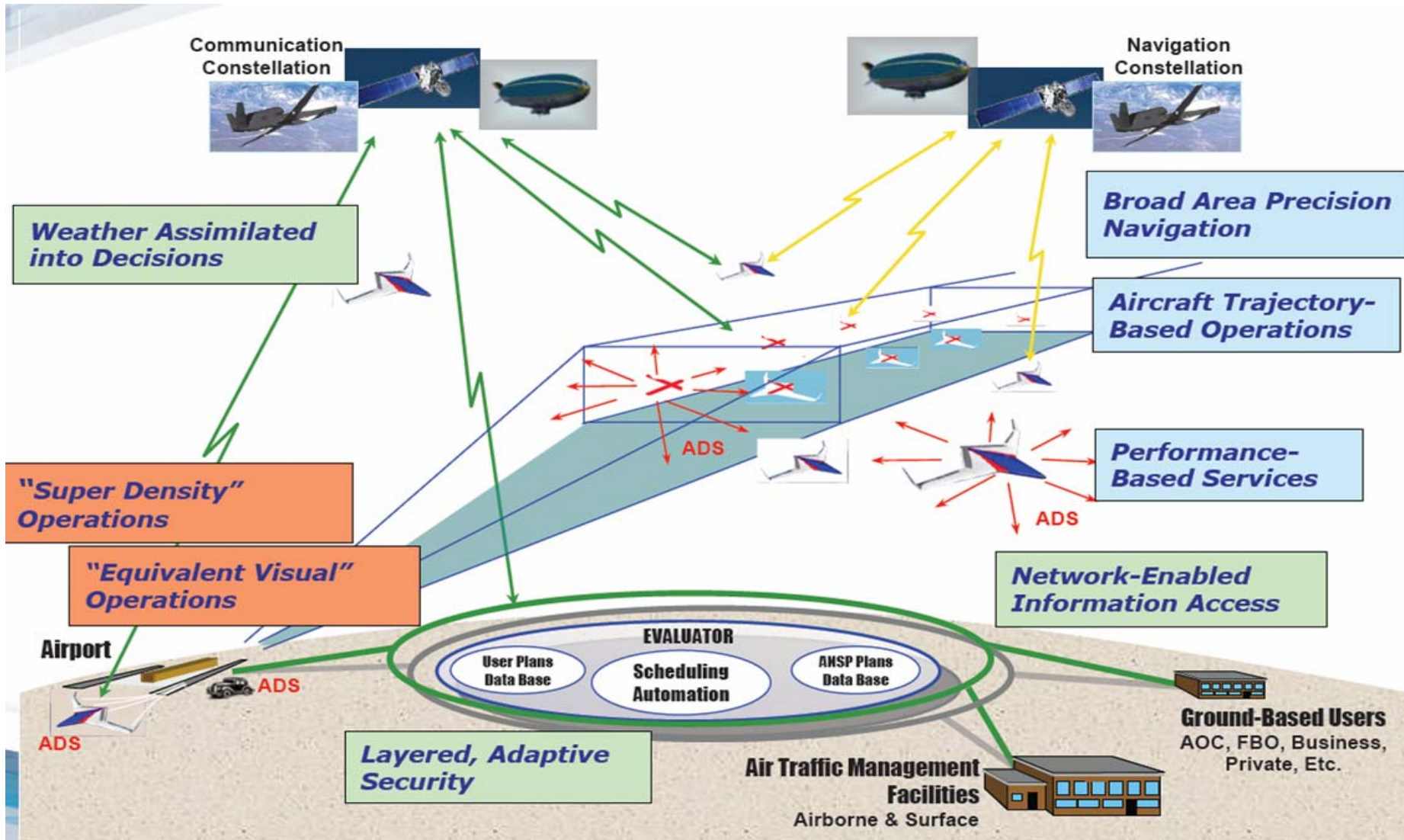| Today		NextGen
Ground-based navigation and surveillance	→	Satellite-based navigation and surveillance
Air Traffic Control communications by voice	→	Routine information sent digitally
Disconnected information systems	→	Networked Information systems
Air traffic "control"	→	Air traffic "management"
Fragmented weather forecasts	→	Forecasts embedded into decisions
Airport operations limited by visibility conditions	→	Operations continue into lower visibility conditions

Besides, airports facilities improvement, NextGen aircraft will have more onboard capabilities to perform airborne self-separation, precisely navigate and execute four-dimensional trajectories and improved surveillance technologies. Unmanned aircraft systems will operate among regular aircraft and domestic supersonic cruise operations will be more prevalent.

NextGen offers tremendous opportunities to the Ada vendors. Lockheed and Boeing (major Ada Users) have joined hands to pursue the ATC business.

Article in Aviation Week magazine, the web link for the subscribers is
http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=awst&id=news/aw012907p3.xml

Next Generation Air Transportation System

NextGen: "What It Isn't…"

• NextGen is not a single project. NextGen integrates many projects, concepts and technologies.

• NextGen is not a program plan. NextGen integrates many program plans to deliver new service capabilities to meet new demands.

• NextGen is not simply a new system. NextGen integrates new systems, new procedures, new aircraft capabilities, new supporting infrastructure and a new way to do business as the Air Transportation System.

NextGen… "What is it ?"

NextGen 2025 OV-1

SURFACE TRAFFIC MANAGEMENT

Automation optimizes taxi routing. Provides controllers and pilots all equipped aircraft and vehicle positions on airport. Real-time surface traffic picture visible to airlines, controllers and equipped operators. Surface movement management linked to departure and arrival sequencing. ADS-B and ASDE-X contribute to this function. Taxi times reduced and safety enhanced.
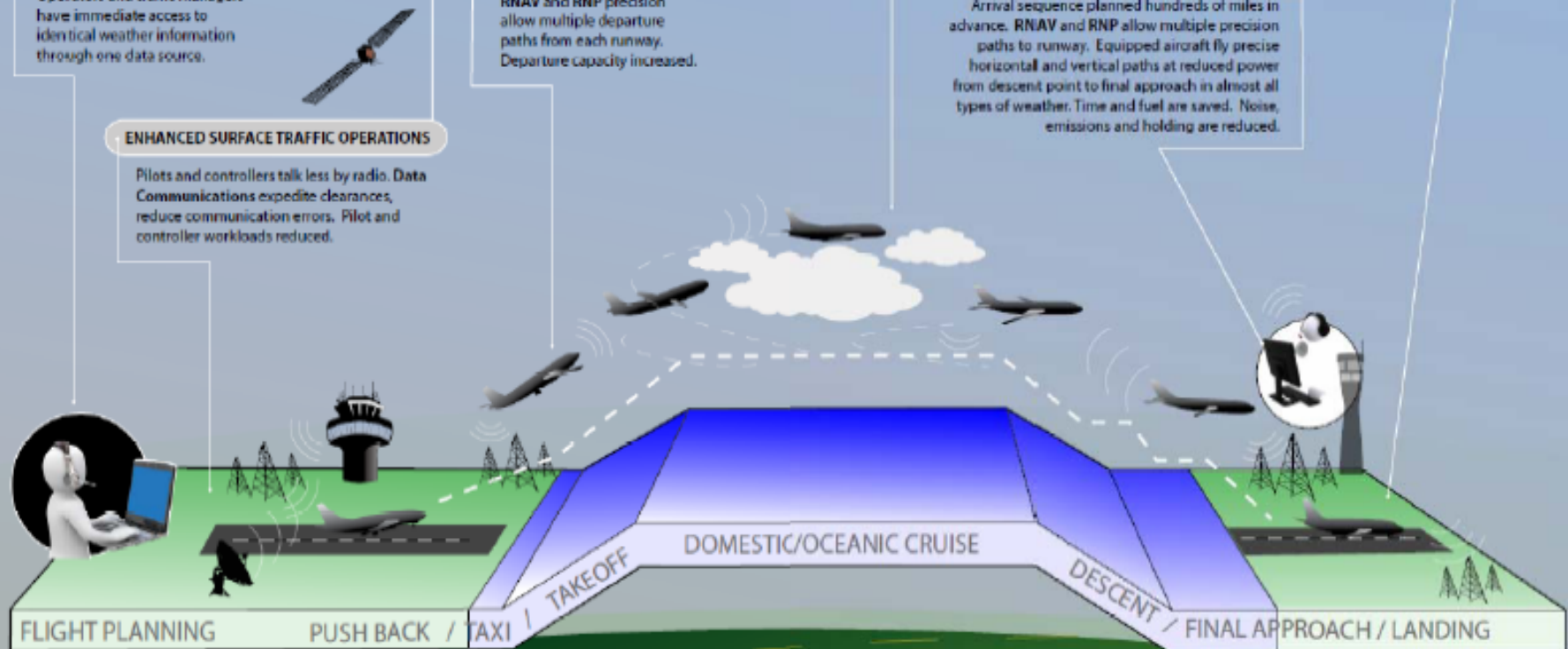
CRUISE

RNAV, RNP and RVSM utilize reduced separation requirements increasing airspace capacity. Aircraft fly most optimal path using trajectory-based operations considering wind, destination, weather, and traffic. Re-routes determined with weather fused into decision-making tools are tailored to each aircraft. Data Communications reduce frequency congestion and errors. ADS-B routes available for equipped aircraft.

SURFACE TRAFFIC MANAGEMENT

Runway exit point, assigned gate and taxi route sent by Data Communications to pilots prior to approach. Pilot and controller workload reduced and safety improved.

SINGLE AUTHORITATIVE SOURCE

Operators and traffic managers have immediate access to identical weather information through one data source.

DEPARTURE MANAGEMENT

RNAV and RNP precision allow multiple departure paths from each runway. Departure capacity increased.

ARRIVAL MANAGEMENT

Arrival sequence planned hundreds of miles in advance. RNAV and RNP allow multiple precision paths to runway. Equipped aircraft fly precise horizontal and vertical paths at reduced power from descent point to final approach in almost all types of weather. Time and fuel are saved. Noise, emissions and holding are reduced.

ENHANCED SURFACE TRAFFIC OPERATIONS

Pilots and controllers talk less by radio. Data Communications expedite clearances, reduce communication errors. Pilot and controller workloads reduced.

FLIGHT PLANNING   PUSH BACK / TAXI / TAKEOFF   DOMESTIC/OCEANIC CRUISE   DESCENT / FINAL APPROACH / LANDING

PHASES OF FLIGHT *Mid-Term* **2018**

NextGen is Already Underway !

Five (5) NextGen Transformational Programs

- **Automatic Dependent Surveillance Broadcast (ADS-B)**

- **System Wide Information Management (SWIM)**

- **Data Communications**

- **NextGen Network Enabled Weather (NNEW)**

- **NAS Voice System (NVS)**

Other

- **NextGen Goal: Performance - Based Navigation**

- **Runway Safety**

- **Airport Surface Detection Equipment, Model X (ASDE-X)**

- **Wide Area Augmentation System (WAAS)**

What Quality Attributes Will Software Need to Support the Roadmap and Development of NextGen?

- Reliability (Detect/Contain/Recover from Errors)

- Integrity (e.g. never lose a data update or TTA deadline)

- Secure Data Exchange

- Fault Tolerance (Hot Swap Redundant – Never out of service)

- Deterministic Response Time Performance

- High Availability (We Operate 24 x 7 x 365)

- Upgrade-ability (no shutdowns / cutover new functionality)

- Continuous system monitoring of all resources and applications

- Scalable – Air Traffic Growth Averages 5% per year

- Extensive Recording of All Relevant System/Application Data

- Maintainability (replace or repair hardware and software independent of and invisible to current operations)

- Extensibility and Evolvability

- Correctness (Provably or testably free from major errors)

What Does Ada Offer to Support These Qualities?

- Strong Typing to improve integrity and security at compile time
- Predictability: able to prohibit polymorphism and eliminate side effects
- Packaging abstraction for Information Hiding and Modularity to manage complexity and contain errors
- Strong Error Handling / Low Overhead – quick recovery
- Concurrency and scheduling support for performance and scalability
- Standardized syntax and semantics that supports software engineering principles
- Portability essential for long-lived systems
- Initialization support and mechanisms for controlling memory and I/O
- Complete model of mathematics (precision integer/floating point operations) for algorithms (expressive power with efficiency, flexibility, and accuracy)

FAA Monitor's Ada Viability

FAA has developed a technology forecasting process for monitoring the long-term supportability of Ada in order to make informed investment decisions in these systems. This process includes:

- Availability of Ada Compiler and Tools Vendors
- Availability of Ada Programmers and Ada Training
- Vendors support to the academic institutions
- Use of Ada in new projects/areas
- Ada Events
- Technology Refresh Activities
- Use of version Ada 2005
- Evolution and features in incoming version Ada 2012

So far no indications of any significant reasons for concern with the Ada Software Engineering.

What else is there to do?

- Improved Compilers / Optimizers
- Enhanced analysis tools – especially at compile time
- Improved interface specification with compiler validation
- Enhanced support for certification of assurance standards
- Improved integration of design models to code - execute the design specification and constrain the implementation to the design
- Improved productivity support: reuse, port, automated code generation
- Enhanced cross language support in compilers and tools (not everything needs or should be in Ada even in mission critical applications

Acknowledgements:

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References:

FAA's NextGen Initiative Website
http://www.faa.gov/about/initiatives/nextgen/

Lockheed Martin's Products ERAM
http://www.lockheedmartin.com/products/eram/index.html

Jeff O'Leary's Keynote talk at ACM SIGAda2007 International Conference, Washington DC (USA)

Questions ?

Thank you for the invitation & the opportunity.