NASA's Request for Comments on the Global Air Space System Requirements

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NASA's Collaborative Effort

- Airspace Systems Program
  - Enable major increases in the capacity and mobility of the air transportation system.
  - The Advanced CNS Architectures and Systems Technologies Project (ACAST) Project
    - Developing technologies intended to improve the performance of the CNS infrastructure
- Aviation Safety Program (AvSP)
  - Secure Aircraft System for Information Flow (SASIF) project
    - Established 2004.
    - Concerned with hardening the radio data links and network communications, mainly directed at hostile act intervention and protection
- Acccess5
  - National project to introduce High Altitude Long Endurance (HALE) Remotely Operated Aircraft (ROA) in the National Airspace System (NAS)
  - NASA, Industry, DoD and FAA

Current View of the Global Airspace System

- Current Global and National Airspace System
  - Stove-piped communication systems
  - Disjoint set of networks
    - Currently not globally network centric
  - Evolved over time with limited concern for network security
    - Security by obscurity
    - Closed systems
    - Insufficient bandwidth to support security measures
  - Safe and Secure
    - Air Traffic Control methods have evolved in reaction to changes in technology, capacity and use
    - Current methods are reaching limit of scalability
- FAA - Bringing Safety to America's Skies
  - Mission is to provide the safest, most efficient aerospace system in the world.
  - Responsible National Airspace System, not funded to address global issues.
- Movement toward Network Centric Operations
  - Cross network security
  - Authentication, Authorization, Accounting and Encryption
  - Required changes in Policy!

Motivation

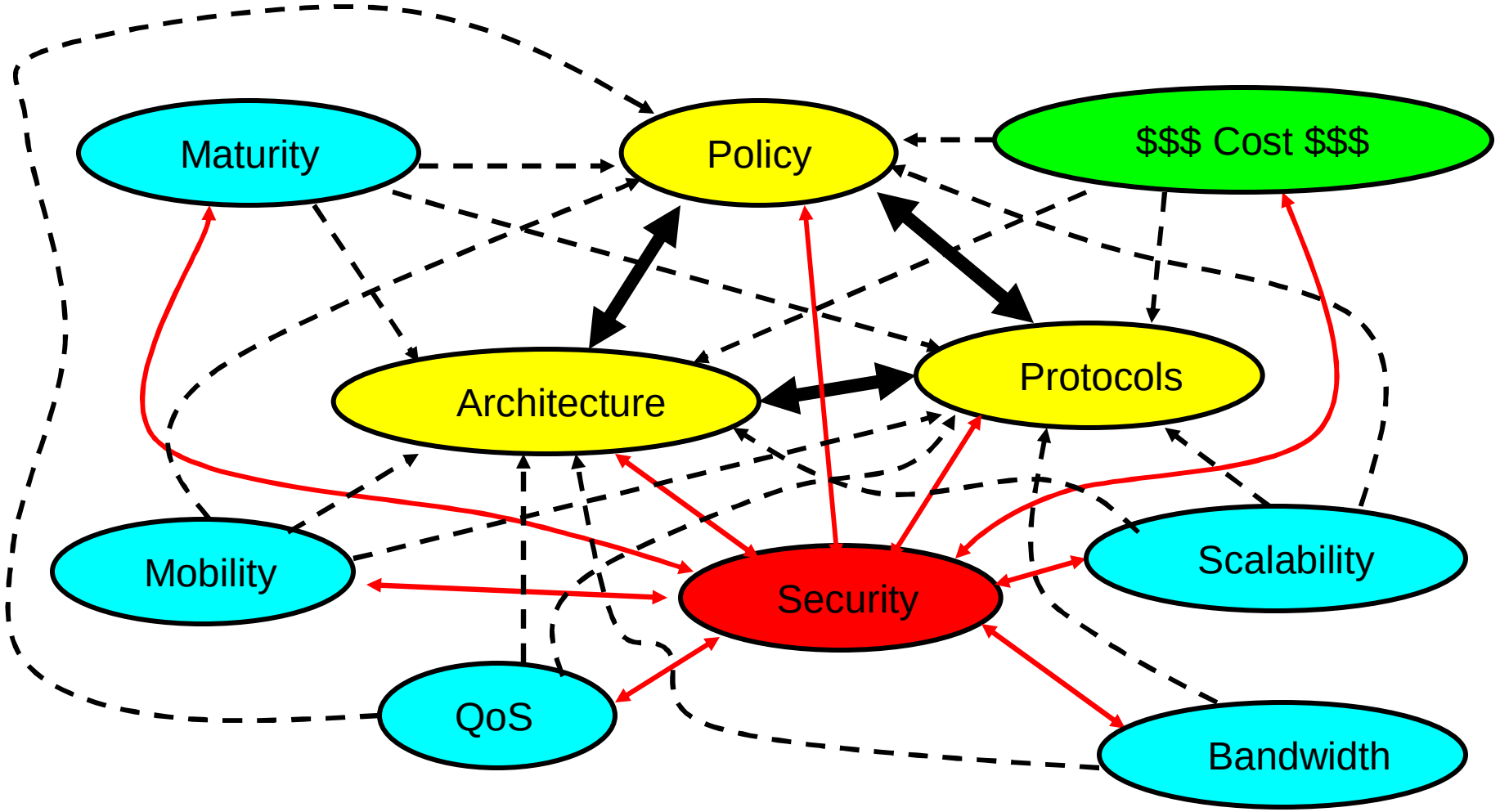
- Systems and solutions being proposed for National System only
  - Global Security issues being ignored or at least not emphasized.
- Divided and conquer design approach being performed prior to understanding of global issues
  - Global system has not been a requirement (An important issue when considering security implications)
- It takes more effort to design and build an incorrect solution than to build a correct solution
  - The incorrect solution is very complex albeit perhaps not as complex as the correct solution
  - Once built, one either has to fix the incorrect solution OR…
  - Scrap the incorrect solution and start over.
- Ultimately Who Pays?
  - Airlines and stock holders
  - End users via a combination of taxes and airfare

System Reliability ?

- Air-ground ATS application are low bandwidth voice or data application with stringent requirements in terms QoS (low latency for voice & CPDLC) and higher availability (99.999% availability.)
  - Tuesday, September 14, 2004: Failure to purge the radio communication system at the Los Angeles Enroute Air Traffic Control Center in Palmdale caused Tuesday's nearly four-hour communication breakdown with hundreds of airplanes throughout Southern California, according to a preliminary investigation by the Federal Aviation Administration.
- October 27, 2003 Sweeping fires across southern California prompted major delays in US air traffic for the second straight day on Monday, as carriers canceled hundreds of flights after the evacuation of an air traffic control center.

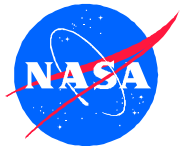
What is next – natural or otherwise?

Network Design Triangle



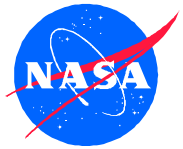
How Can We Obtain Input and Participation?

- Ask and keep asking!
  - U.S. Department of Commerce published an RFC (Request for Comments) on IPv6 January 21, 2004 http://www.ntia.doc.gov/ntiahome/frnotices/2004/IPv6RFCFinal.htm
  - NASA Network Research Group borrowed the idea
    - http://roland.grc.nasa.gov/~ivancic/RFI/rfi.html
    - Additional solicitation and advertisement
      - 6sense newsletter
      - Ipv6 Forum
      - Pilots Association
      - Automotive Manufacturers
    - Approximately 13 responses to date (tax day 2005)
    - Mix of boilerplate capabilities to actual point-by-point critique
    - Attempting to send letter of response directly to national and international airlines – still working issue as of May 2, 2005



Hoping for Multi-Disciplinary Response

- Industries, Academia and Government Agencies throughout the world
  - Hoping to get some response from telecommunication and electronic appliance industry
- Challenge
  - Organization needs to be aware RFC
    - Most do not watch for Federal Solicitation
    - Finding and getting the right person(s) to respond is difficult
    - Response must be valued added to the organization
- Disappointments to date
  - No response from airlines, electronics industry, telecommunication industry or automotive industry



Letter to Airlines – Why it is worth while to respond

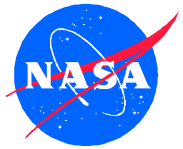
- Application of commercial off the shelf technologies and techniques
  - Potential to make network centric operations *economically and technically realizable throughout the Global Airspace System*
- Network Centric Operations
  - Enhance system capacity
  - Enhance system throughput
  - Providing airlines with new revenue generating services
    - Entertainment services, Internet access, directed advertising
  - Improve Operations
    - Engine and aircraft monitoring, security, electronic flight bag, baggage handling, flight safety, and passenger scheduling and rescheduling
- Desire for Airlines to address Return On Investment.

Airline Distribution

- Air Canada
- Airborne Express
- AirTran Holdings, Inc
- Alaska Air Group Inc
- AMR Corp
- Continental Airlines Inc
- Delta Air Lines Inc
- Fedex Corp
- Northwest Airlines Corp
- Ryanair Holdings PLC
- Southwest Airlines Inc
- British Airways PLC
- AIR France-KLM
- United Airlines
- United Parcel Service Inc
- China Eastern Airlines Corporation Ltd
- China Southern Airlines Company
- Deutsche Lufthansa AG
- British Airways
- Air New Zealand Limited
- JALways Co. Ltd.
- Indian Airlines
- Qantas Airways Ltd.
- Korean Air Lines Co. Ltd.
- Malaysia Airline System Berhad
- Phuket Airlines Co., Ltd.
- Egyptair
- Israir Airlines and Tourism Ltd.
- El Al Israel Airlines Ltd.
- Kuwait Airways
- Pakistan International Airlines
- Saudi Arabian Airlines
- Alitalia - Linee Aeree Italiane
- Scandinavian Airlines System

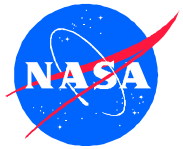
Global Airspace System Requirements

1. Must be value added
   - Cannot add cost without a return on investment that meets or exceeds those costs.
2. Must be capable of seamless global operation.
3. Must be capable of operating independently of available communications link. Must support critical Air Traffic Management (ATM) functions over low-bandwidth links with required performance.
4. Must use same security mechanisms for Air Mobile and Ground Infrastructure (surface, terminal, en router, oceanic and space)
   - Critical ATM messages must be authenticated.
   - Must be capable of encryption when deemed necessary
   - Security mechanisms must be usable globally
     - Must not violate International Traffic in Arms Regulations
5. Must operate across networks owned and operated by various entities
   - Must be able to share network infrastructure
6. Must make maximum use of standard commercial technologies (i.e. core networking hardware and protocols)
7. Must enable sharing of information with proper security, authentication, and authorization
   - Situational Awareness
   - Passenger Lists
   - Aircraft Maintenance
8. Same network must accommodate both commercial, military and general aviation.



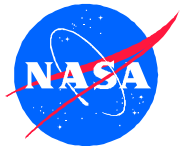
Design Concepts

- Must be IPv6 based.
- Must be capable of a prioritized mixing of traffic over a single RF link (e.g. ATM, maintenance, onboard security, weather and entertainment).
- Must utilize IPsec-based security with Security Associations (SAs) bound to permanent host identities (e.g. certificates) and not ephemeral host locators (e.g. IP addresses).
- Must be capable of accommodating mobile networks.
- Must be capable of multicasting
- Must be scalable to tens of thousands of aircraft



Consensus

- IPv6 is *the* way to go, virtually everyone agrees.
- There seems to be consensus that links should be shared, and the system should be provider-independent, and this makes QoS a requirement.
- There is a need for some type of mobile networking (mobile-IP, NEMO, ad hoc)
  - Placement of home for mobile-IP or NEMO is being addressed, but needs further study.
- Everyone agrees that some work is still to be done cleaning up IPsec multicast, envisioning the certificate architecture, and figuring out how exactly to do QoS.



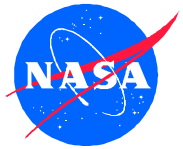
Value Added

- Lower Telecommunication Costs of IP-based networks as compared to dedicated point-to-point links
- Competition among information providers
- Economies of scale
- Lower development costs for new applications and maintenance due to standardization of interfaces

Link Independence

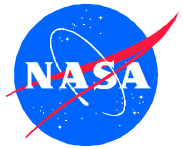
- Most important considerations for this is not technical, but related to cost, safety, and politics
- Facilitates globalization and supports positive ROI
- Requires change in policy
- Change in use of spectrum
  - World Radio Conference to allow use of other frequencies for air traffic control messages
- Air Traffic Controller is now networked.

These are some very different modes of operation from what the aeronautics community is comfortable with.



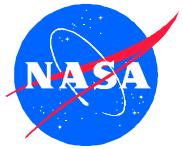
Security Mechanisms

- Encryption mechanisms should be limited to those that are free of ITAR restrictions
- Other counties also have regulations restricting the exportation of cryptography technology
  - These regulations may limit the ability to realize cost and schedule advantages that could be gained by using a single set of proven security infrastructure software throughout the world.
- Multicast and *current* IPSec implementations do not necessarily work well together.
- Support for IPSec-base security with Security Associations bound to permanent host (multicast group) identities (e.g. certificates)
  - Location, control, and responsiveness of the authentication authority servers is critical.



Significant Comments

- IPv6 improves interoperability between Civilian, Military and Homeland Security portions of the GAN
- Any future GAN will need to exceed the current network capacity, and reduce operational cost while meeting system safety and passenger needs in order to justify its cost.
- ***"So far"*** no significant advantage has been identified to providing IP over narrow-band aeronautical links.
- Message delivery costs were a contributing factor to the FAA's decision to terminate CPDLC operations at the Miami ARTCC.
- Need assurances that mixing ATM messages with general Internet traffic on public networks does not introduce unacceptable hazards.
- Scalability is an absolute requirement for a global solution



Further Studies and Investigation

- QoS related to mixing ATM traffic with other information
- Much research is needed regarding network mobility
- Networking ATM traffic for use over multiple links and service providers
- Mobile-IP, NEMO and Ad Hoc networking
  - Route Optimization
    - Placement of Location Manager (Home Agent)
    - Ping-pong routing
  - QoS and delay issues
  - Multi-homing (use of best available link)
  - To load balance or not to load balance?
  - Make before break or not?
- Application of Ad Hoc type networking for Oceanic to extend networks (MANETs or Mobile-IPv6)

Conclusions

- Input to date has been limited, but useful. Hopefully, more will come.
- Provided a sanity-check of our requirements and design concepts
- Highlighting a few research directions that still need work.

We are still interested in here from you.

Pass this message on!