# Communication Support for NASA Enterprises: A Satellite-Based Aeronautical Communications Network

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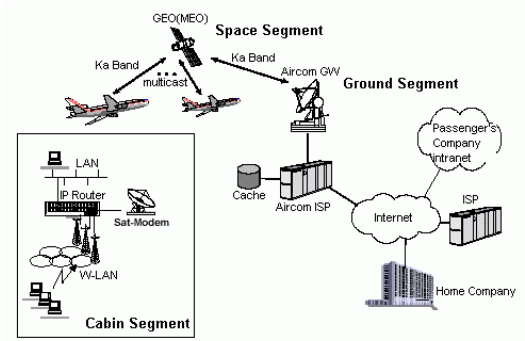



Network Architecture for Aeronautical Communication

## Objectives

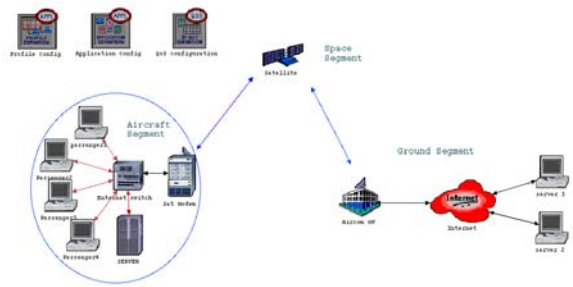
- ❖ Study the current NAS communication system and FAA modernization program and define the communication requirements for a satellite-based solution to broadband aeronautical communications
- ❖ Design an efficient and reliable transport layer protocol for aeronautical satellite networks
- ❖ Maintain high utilization of the satellite link and improve fairness among competing TCP connections

## Background

- ❑ The National Airspace System (NAS) is quickly becoming overburdened by increases in air traffic coupled with the use of old technologies and legacy systems.
- ❑ The use of satellite technology for aeronautical communications provides improvements in over-ocean coverage, high communication capacity, suitability to free flight concepts, and economic benefits.
- ❑ The Internet protocols (TCP/IP) provide most of the required features necessary to support aeronautical communications and represent a much more cost effective solution.
- ❑ TCP problems in satellite hybrid network: Long propagation delay, Large bandwidth-delay product, High bit error rate, Bandwidth asymmetry.
- ❑ The proposed TCP solutions for satellite environment: End-to-end enhancements, TCP connection splitting, Rate based solution, and link layer solution.

## Approaches

- ❑ End-to-end enhancements
  - large initial window, byte counting, delayed ACKs after slow start, TCP for transaction, SACK, and Forward acknowledgement.
  - Does not involve large changes in the network and still allow end-users to get good performance.
  - Not all computer operating systems support these special options. Some options are not good for hybrid satellite networks.
- ❑ TCP connection splitting
  - Deploy intelligent gateways to locally optimize data transfers over satellite links. Transparent to end-users.
  - Use specific congestion control, error control and flow control for satellite link. Isolation of satellite specific enhancements from the rest of the networks.
  - Use one duplicate ACKs to trigger the retransmission and use a fixed window size for the satellite TCP connection.
  - End-users use standard TCP. Achieve high utilization of the satellite link and fairness among the competing connections.




Simulation scenarios in OPNET

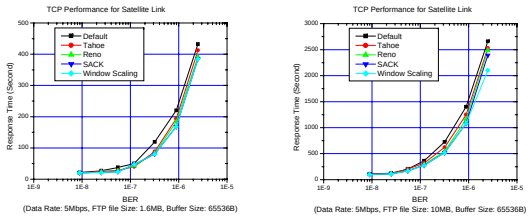
## Network Architecture

- ➢ Aircraft segment: consists of satellite antennas, aircraft gateway, and on-board network. On-board network may include several wired or wireless access segments for users in the aircraft cabin.
- ➢ Space Segment: Space segment for interconnection of the aircraft cabin with the terrestrial networks.
- ➢ Ground Segment: provides the interconnection to the terrestrial personal and data networks as well as the Internet backbone.

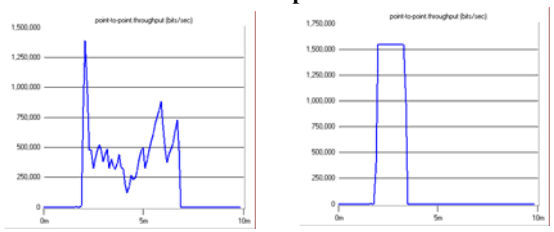
## Accomplishments

- ✓ Defined traffic model for new and emerging applications and services that need to be supported.
- ✓ Defined basic operational scenarios and simulation platform that includes the GEO satellite (Ka-Band), the aircraft (with on-board LAN), and the ground network.
- ✓ Studied the performance of modified TCP protocols (Tahoe, Reno, SACK, Window Scaling).
- ✓ Proposed a TCP splitting protocol , which for the satellite connection uses fixed window for flow control and one duplicated ACK for fast retransmission.
- ✓ Completed the simulation model of TCP splitting protocol. Compared its performance with the end-to-end TCP solutions.

## Simulation Results




End-to-end TCP performance



TCP splitting performance

## Conclusions

- o Some modifications of the TCP protocol stacks would be necessary to achieve better performance if TCP/IP protocols are going to be adopted.
- o Our TCP splitting protocol can maintain high utilization of the satellite link and improve fairness among the competing connections.