Air Transportation is a Complex Adaptive System not an Aircraft Design:

Innovation at the Interface of Disciplines

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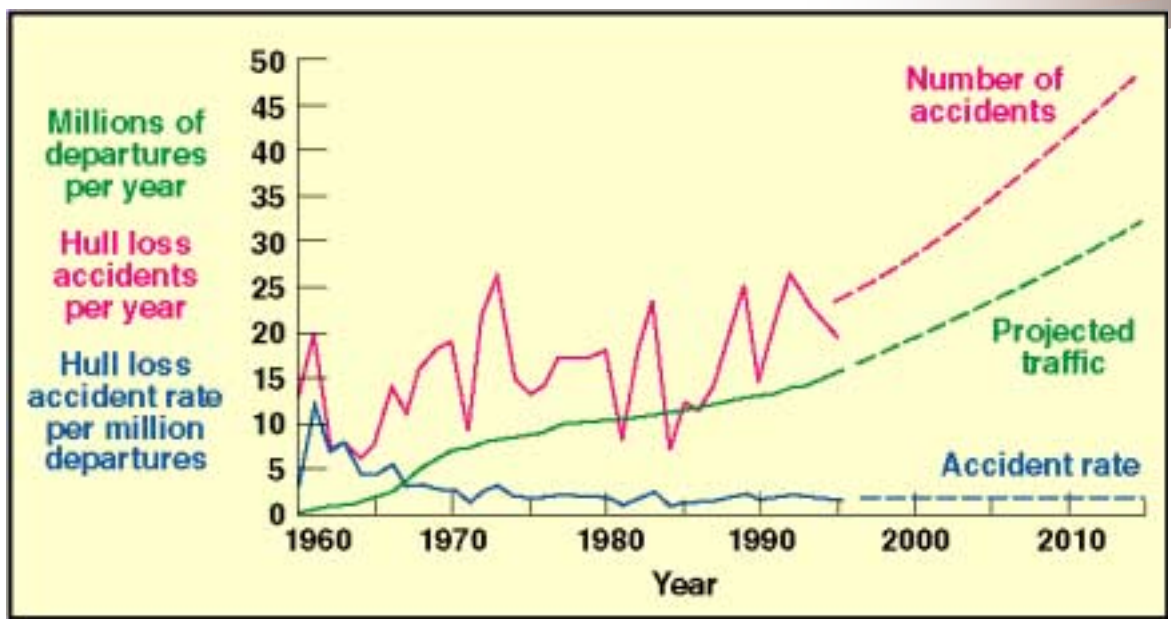
Problem

- > 11 % of US Disposable Personal Income goes to Transportation
- Highways and Airways are Approaching Gridlock and Hub lock
- Traditional Engineering Approaches are Failing to Find Solutions
- New and Innovative Systems Approach is required to overcome Traditional Stovepipe solution shortfalls and Political/Economic Barriers

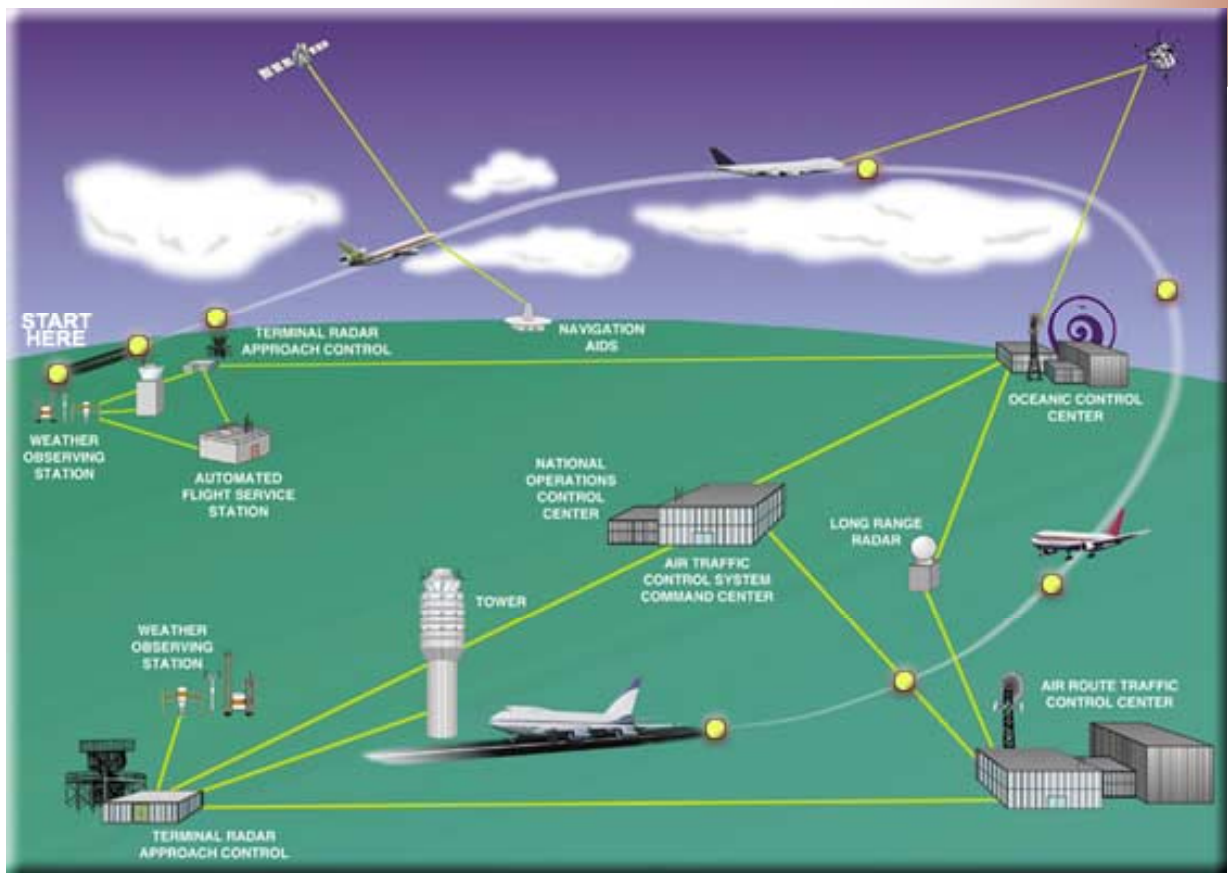
The Aviation Capacity and Safety Challenge

Air Traffic Could Triple in Next 20 Years

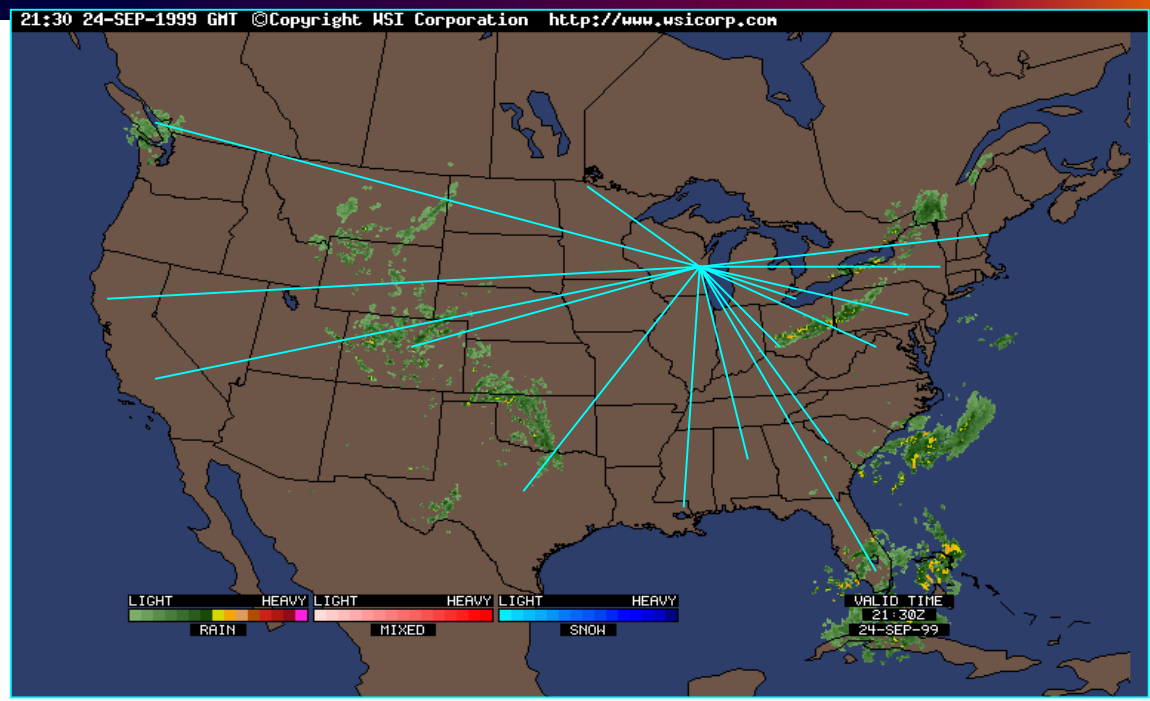


"The current air traffic management system is near its capacity limits with extensive system delays and inefficiencies resulting in annual losses to users estimated at over $3.5B."

National Airspace System

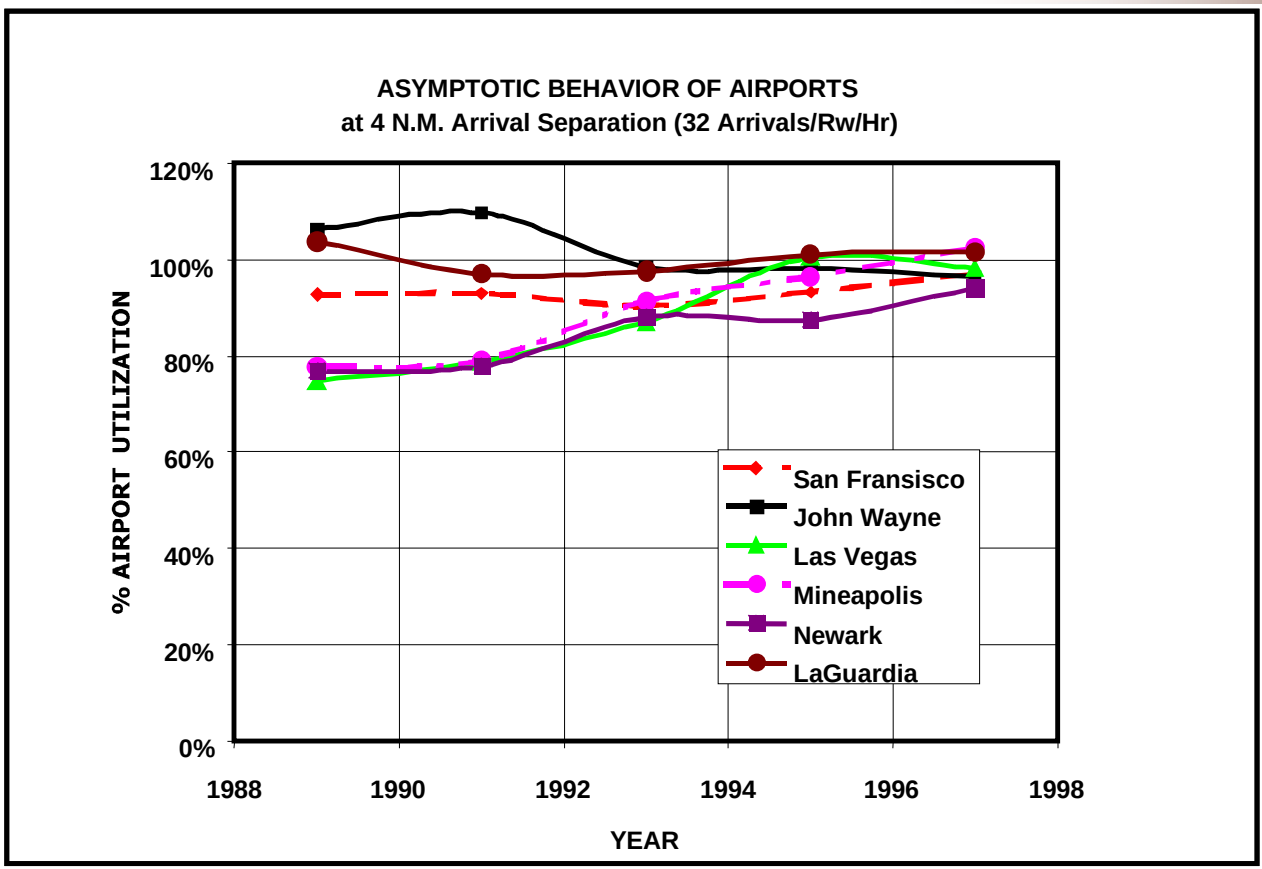


Hub and Spoke Network

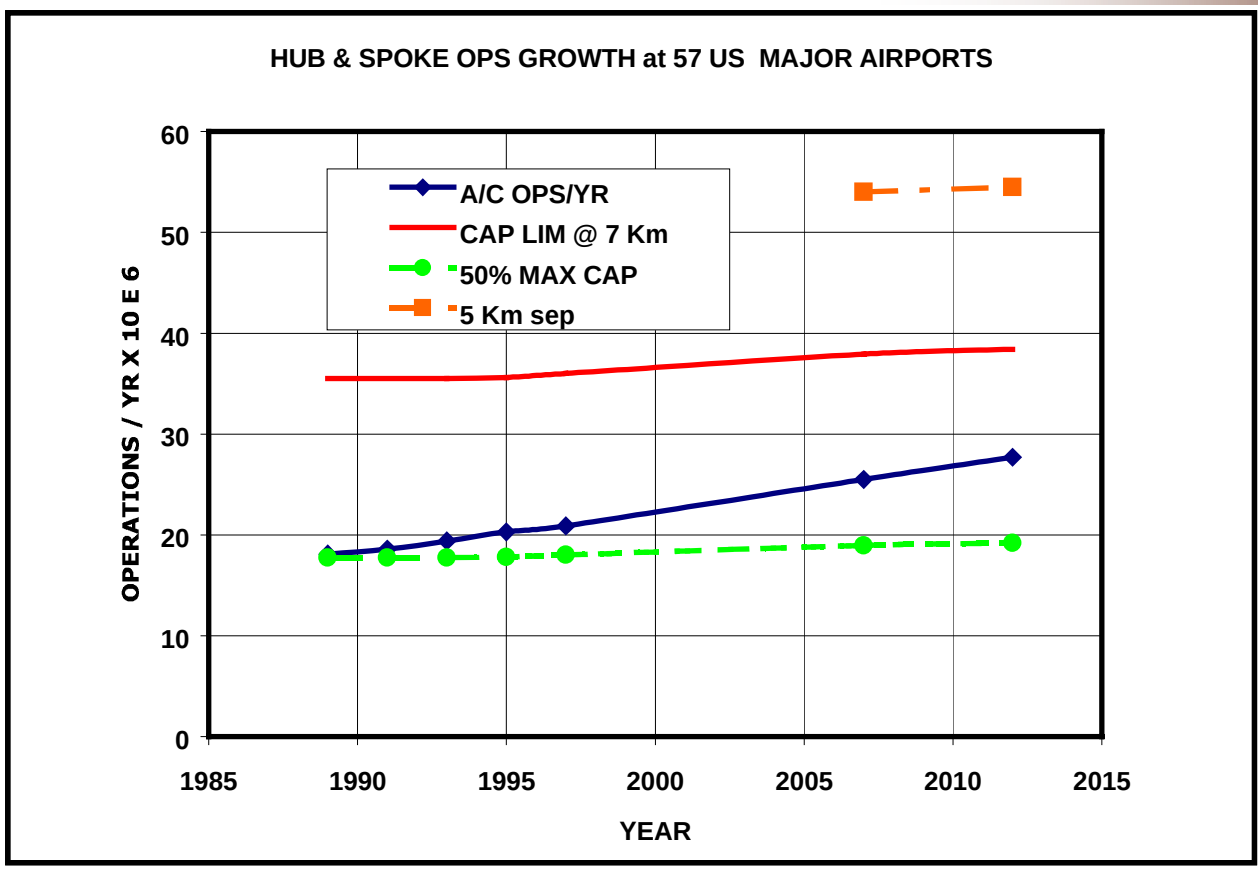


Completely Connected Network = 2(N-1) Flights
(eg., 50 Airports, 98 Flights)
Ref: J. Hansman, MIT

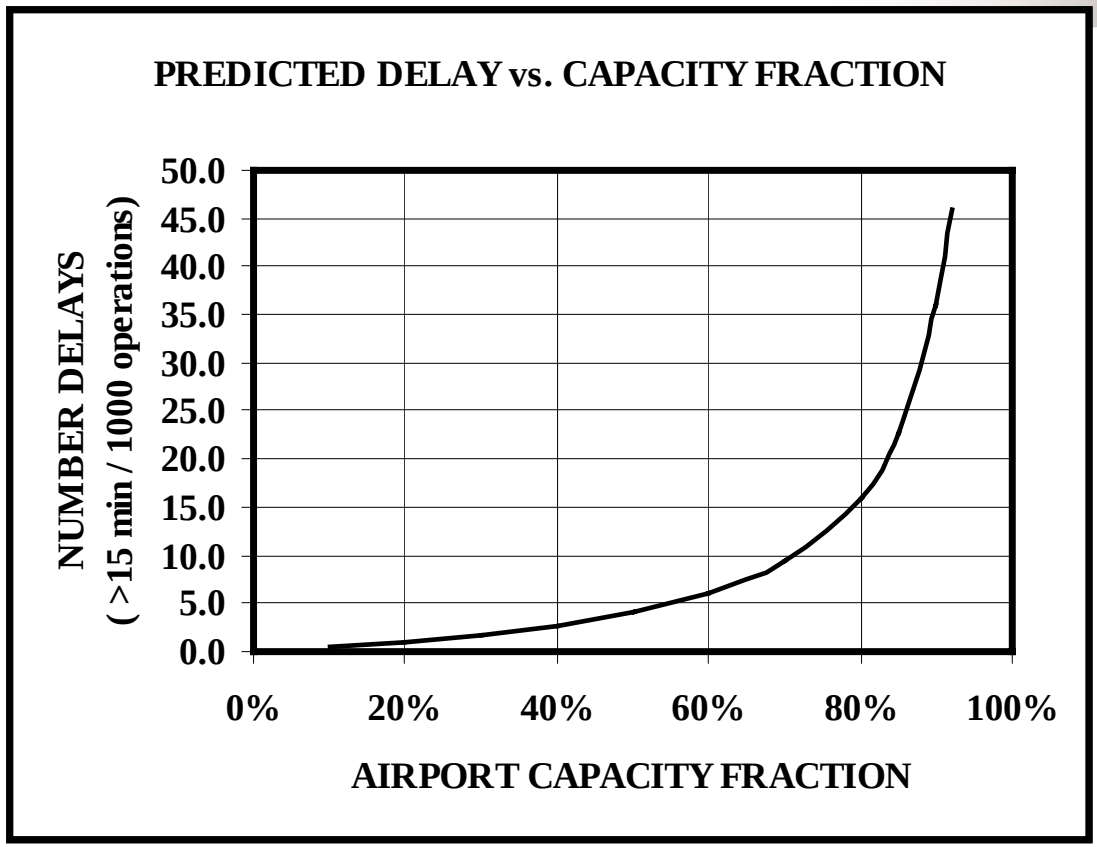
Hub Airports Becoming Saturated



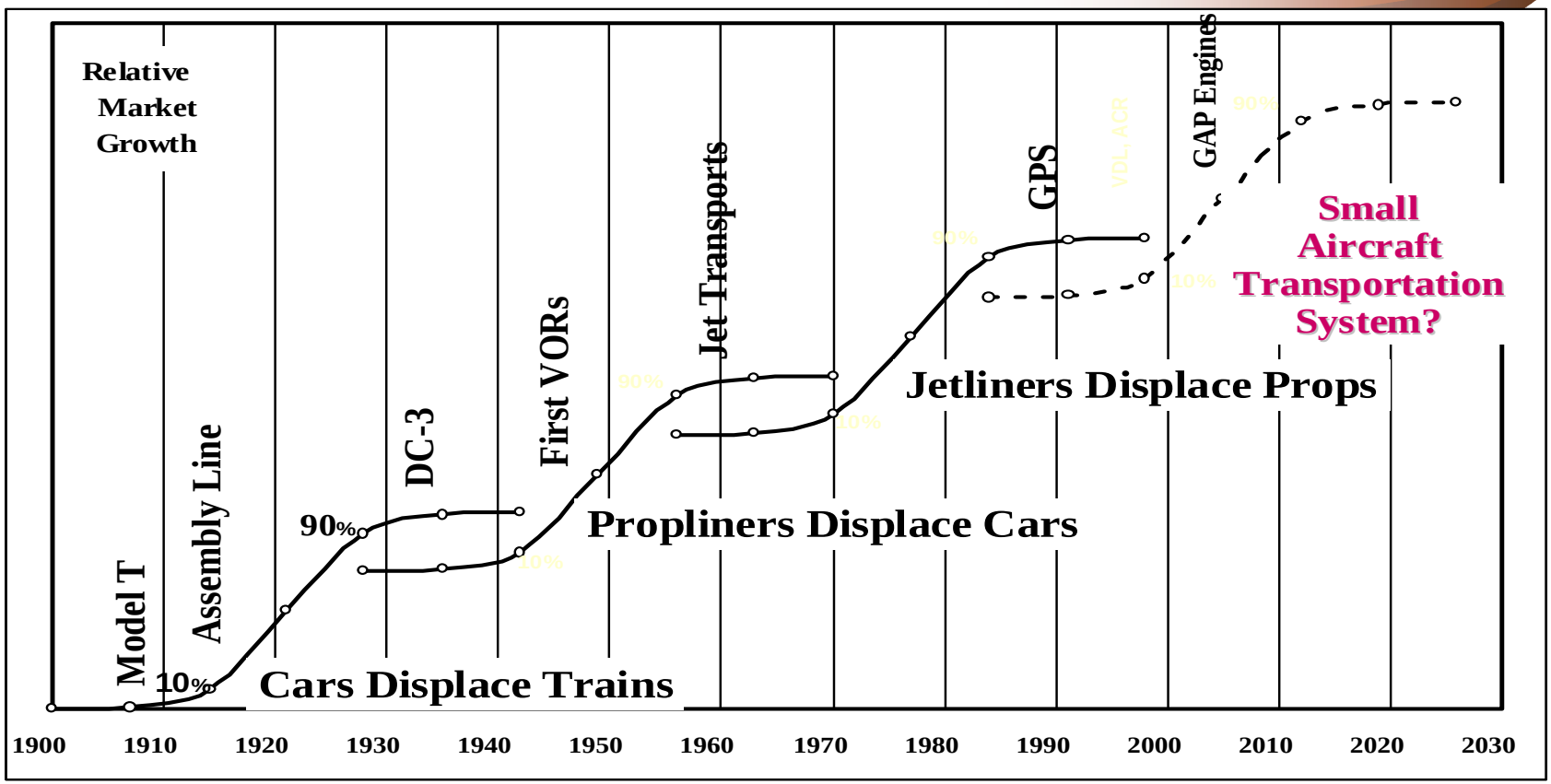
Air Transportation System at 58% Max Capacity



ATS Delays will Grow Exponentially

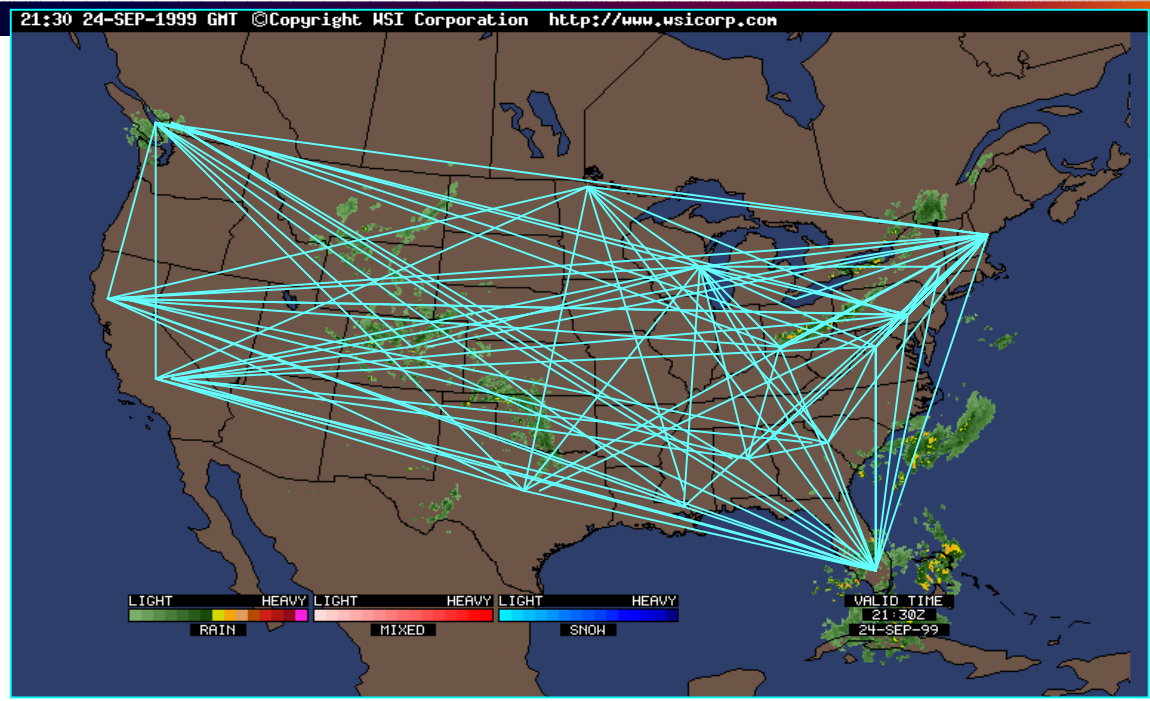


Inter City Transportation: Time for a Paradigm Shift ?



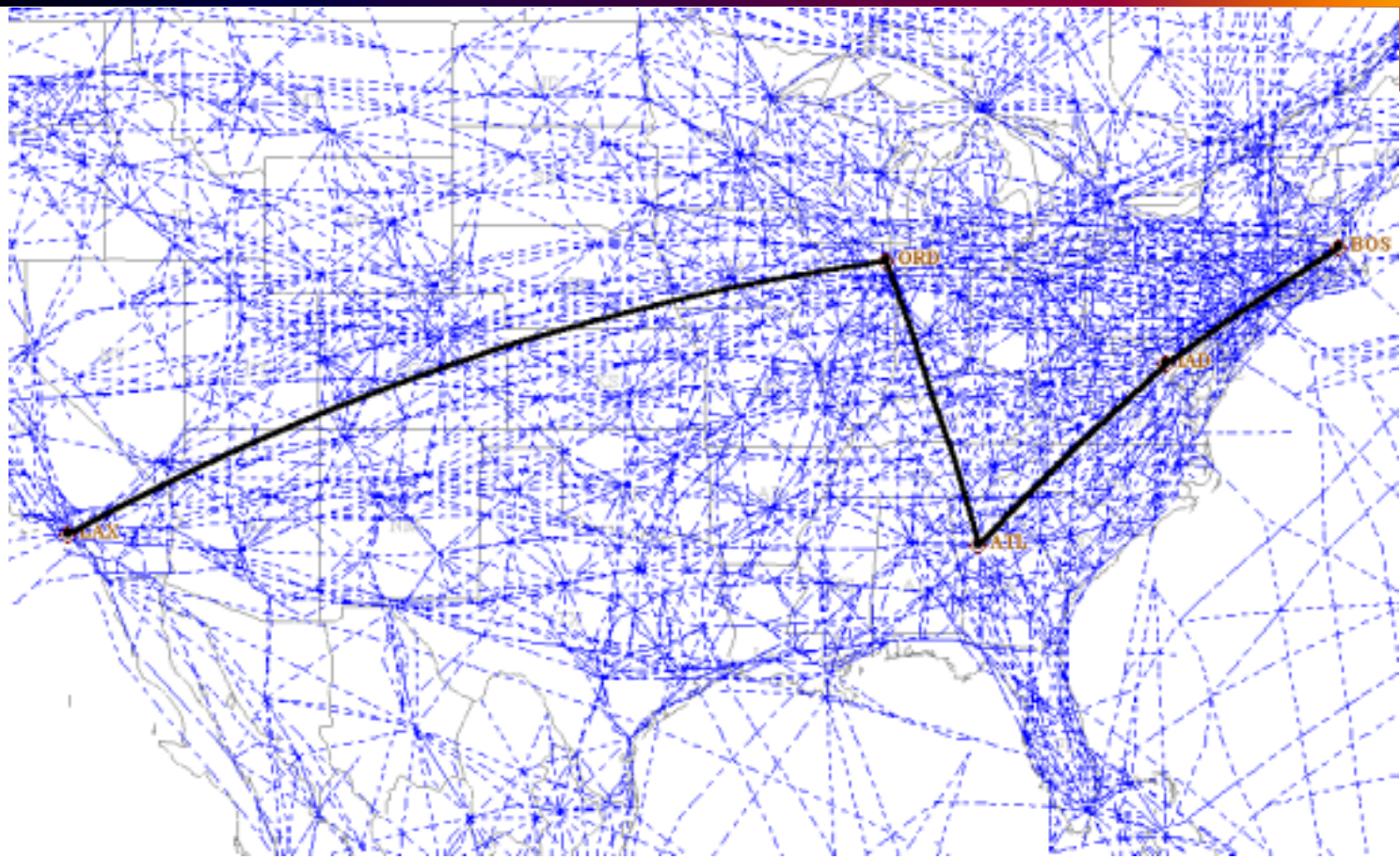
Vision of the Future for Inter-Modal Transportation

Fully Connected Network

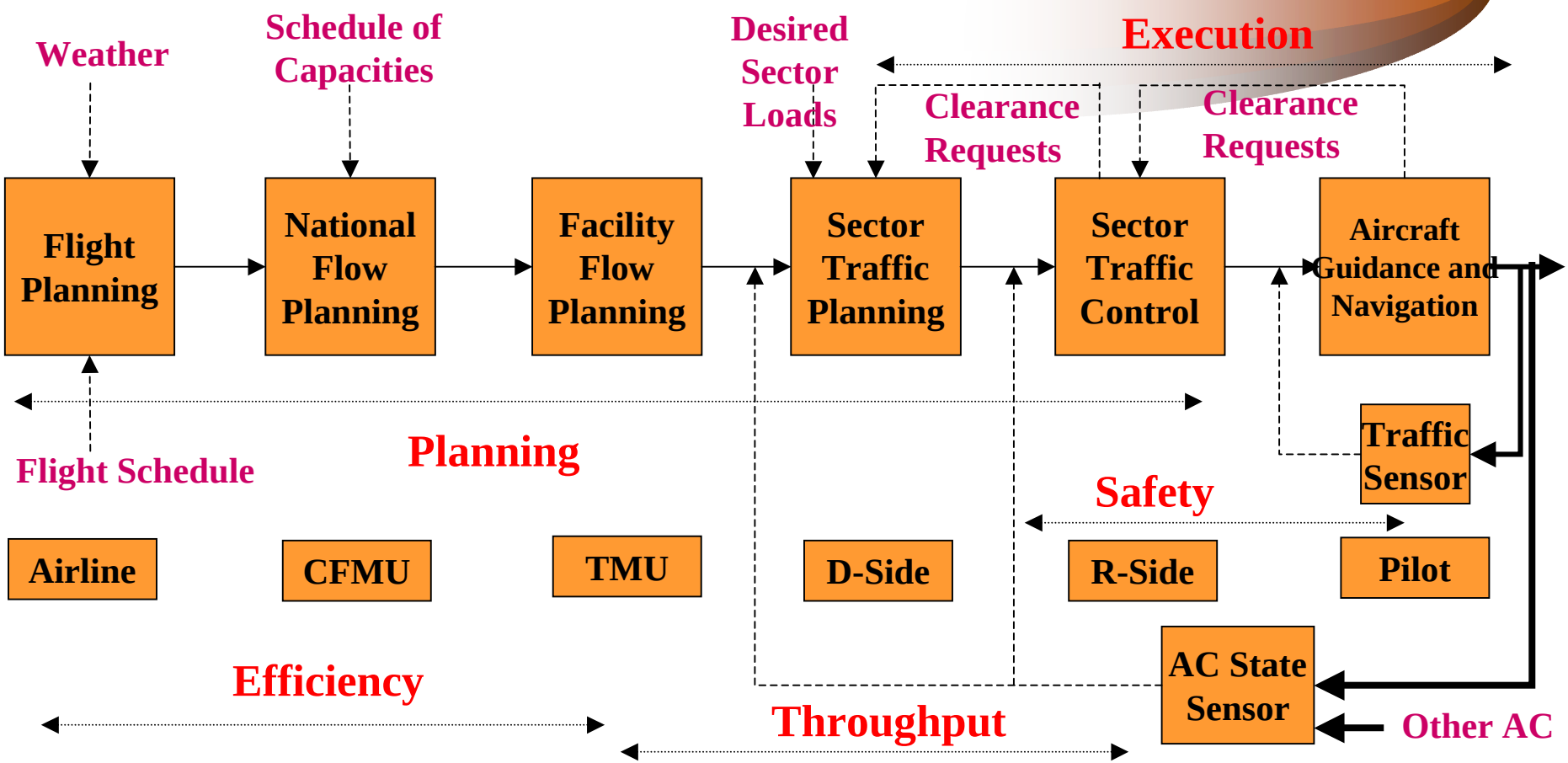


Completely Connected Network = N(N-1)
(eg., 50 Airports, 2450 Flights)
Ref: J. Hansman, MIT

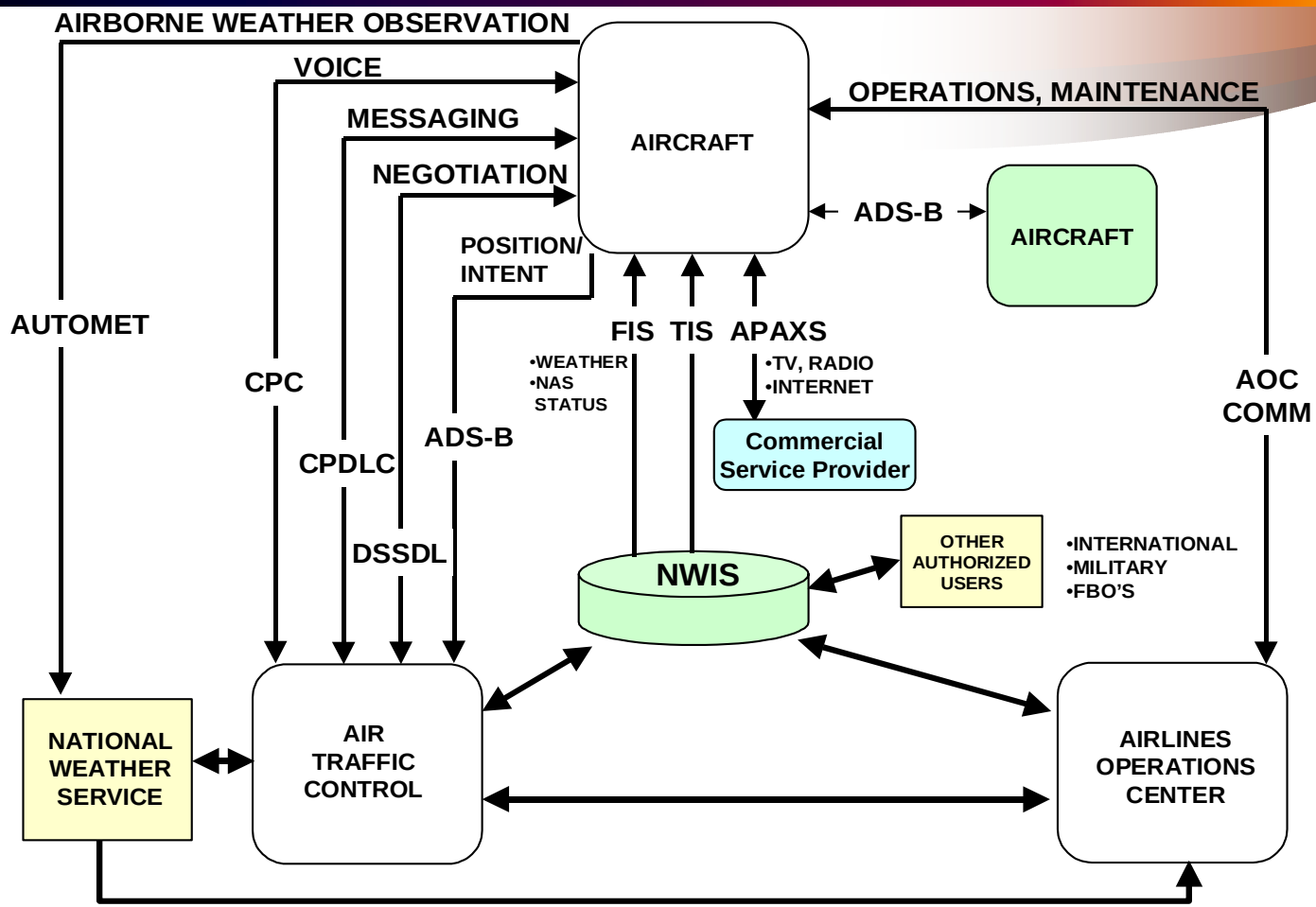
National Air Transportation Network



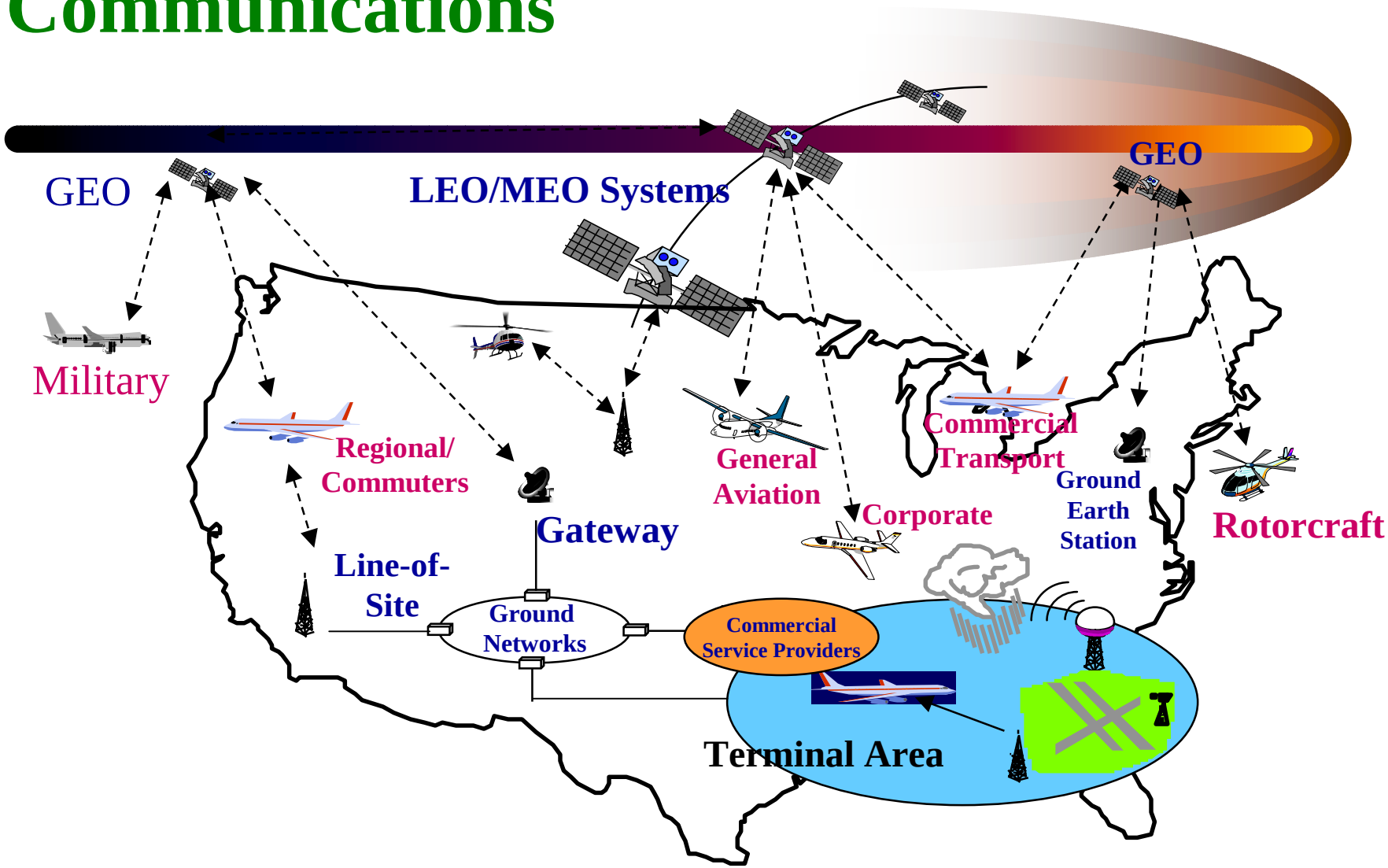
ATM System Functional Structure (Boeing Model)



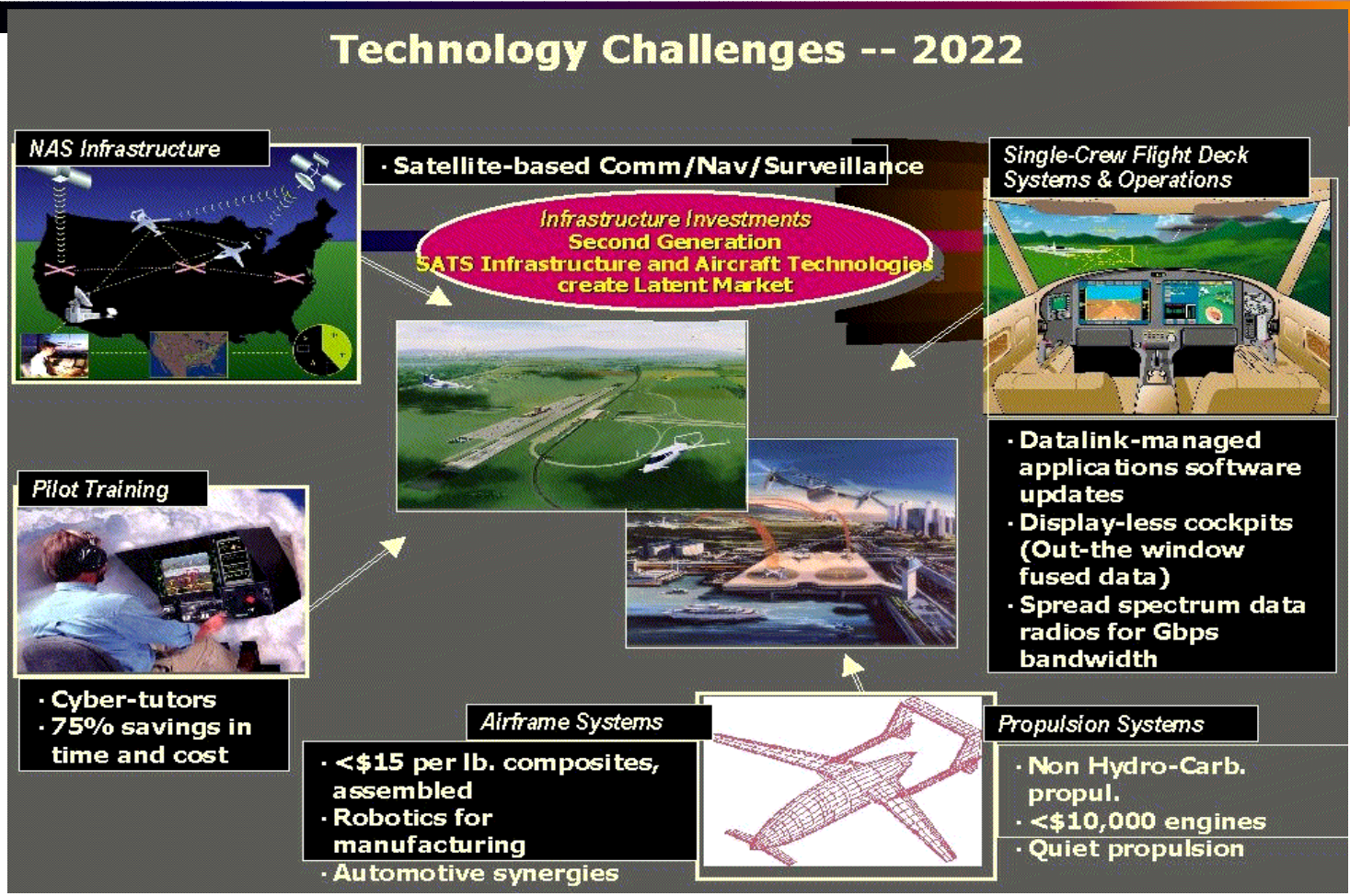
Future Air Traffic Broadband Network Requirements



Next-Generation Data link Communications



System Integration



Auto Flight Issues

- **Large Number of Aircraft will require High degree of GA Flight Deck Automation to Increase Safety**
- **Control and Communication aspects of Distributed Multi Aircraft environments, evaluation of control laws as a function of Airspace Dynamic Density**
- **Cooperating Auto Pilots and Collision Avoidance Systems will stress Wireless Communications Bandwidth**
  - **Loads and Protocols need to be evaluated**
- **Human - Computer Interaction requires a Cognitive Workload Experimental Evaluation**

- **BACKUP MATERIAL**

Telcom System Issues

Utilization
- Civil Transport
- General Aviation
- Military

Service Provider
- FAA
- Other Government
- Public / Private Commercial

Avionics Issues
- Equipage / Avionics Cost
- Applicability Across Platforms
- Mandatory/Primary/Optional
- Architecture - OSA / Proprietary
- Level of Integration

Link Characteristics
- Spectrum / Frequency
- Bandwidth
- Modulation
- Access Technique

Quality-of-Service
- Timeliness/Latency
- Priority
- Availability
- Redundancy
- Robustness

Delivery
- Voice/Data
- Simplex/Duplex
- Broadcast
- Line-of-sight
- Over-the-Horizon

Phase-of-Flight
- Planning
- Surface Movement
- Terminal Operations
- En Route / Oceanic

Coverage
- Global
- Regional
- Oceanic
- Line-of-Sight

Perceived Barriers to Paradigm Shift

- There is not enough Airspace
- Aircraft are Too Hard to Fly
- Aircraft are Too Expensive
- Flying is Not Safe
- Airports are Too Noisy

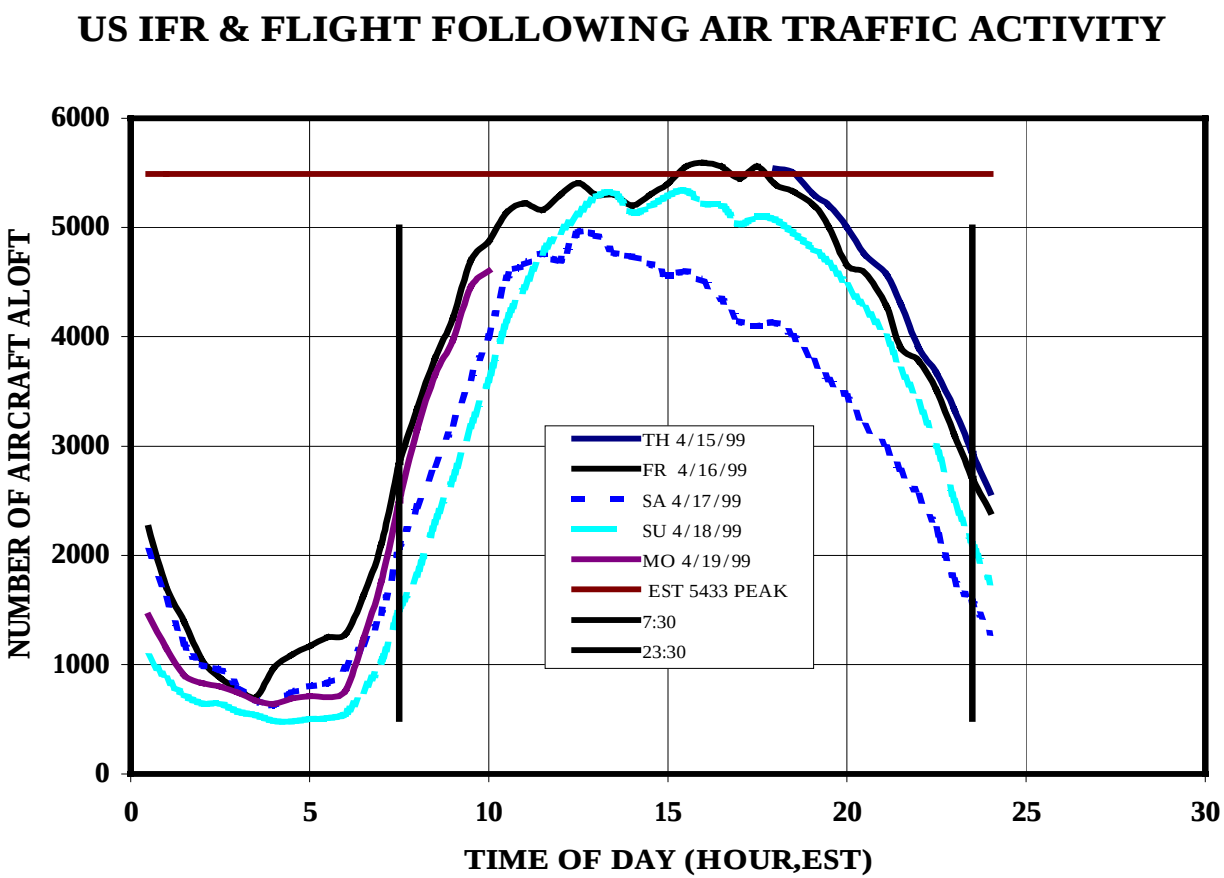
Airspace & Airports

- Free Flight Paradigm should allow more aircraft in the enroute airspace
  - **(> X 20 ?)**
- **> 5,000** Airports in US within 30 minutes of population – **Direct Flight Opportunities**
- **However: SATS** Operations will Grow like **N(N-1) vs. 2(N-1)** for Hub and Spoke

Aircraft Human Factors

- Large commercial aircraft now have:
  - 3 axis auto-pilots & auto-landing modes
  - 3 D GPS
  - Moving Map Displays
  - Terrain and Aircraft Collision Avoidance
- Non-Recurring costs have been Amortized
- Recurring costs for new GA should be small

Air Transportation Activity - ETMS Data



A/P Growth Req'd to Avoid Hub Delay Increase (DPAT model)