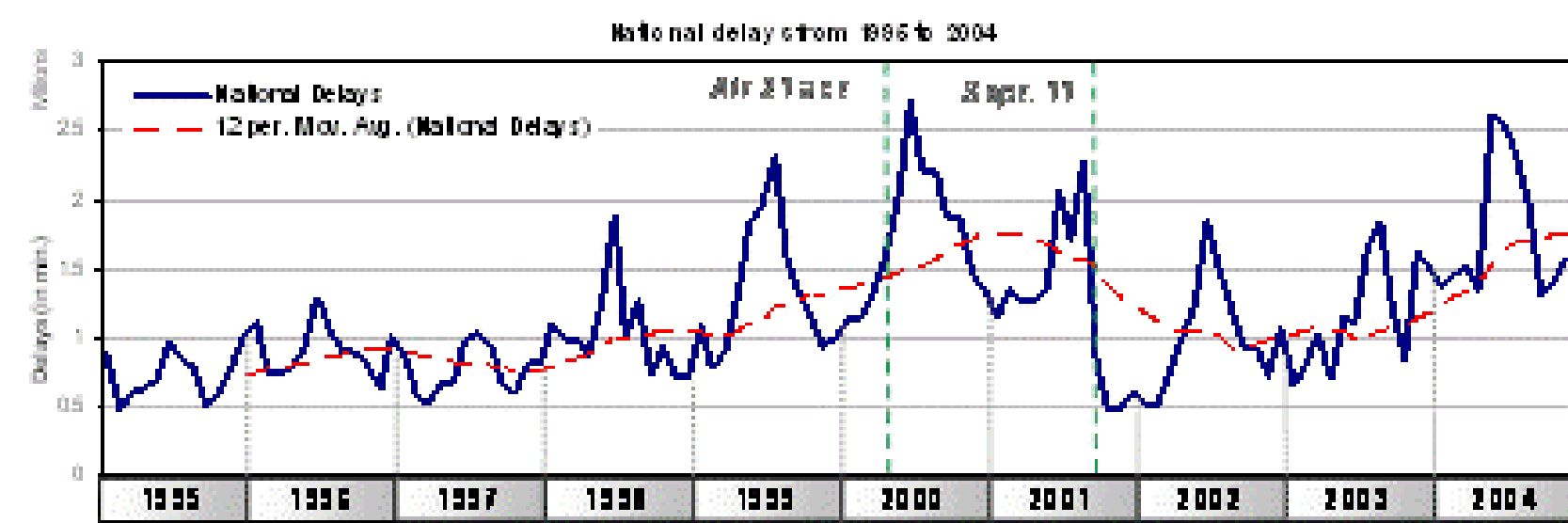


## Air Transportation Crisis



- Rapid growth in demand but system not scalable
- US economy and quality of life highly dependent on air transportation
- Exacerbated by environmental, fuel, and security concerns



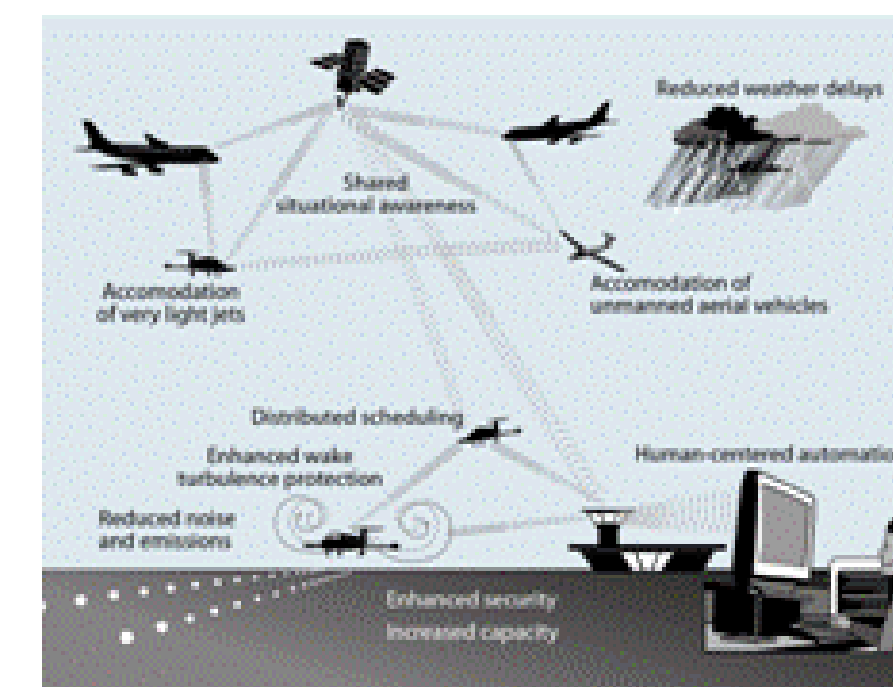
## Air Transportation Vision

### A distributed air transportation system with

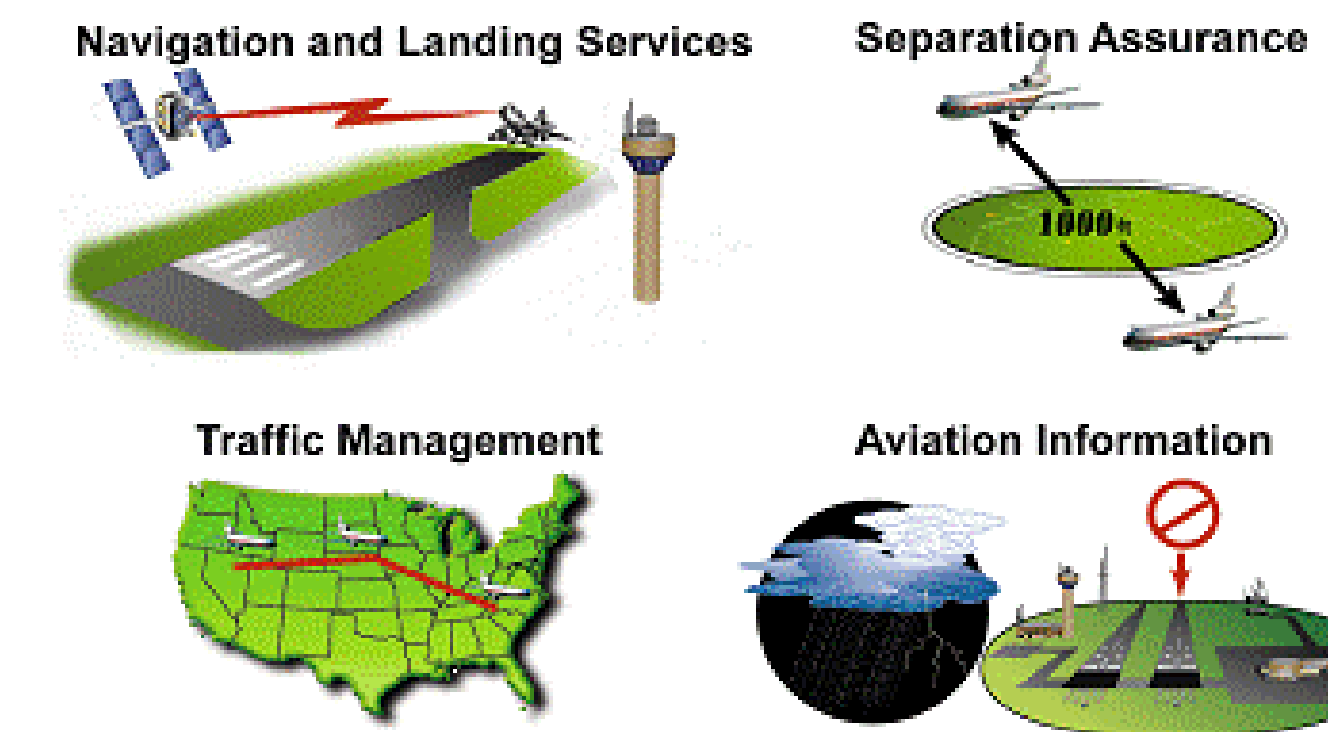
- Information-rich airspace
- Scalable/increased capacity
- Safe, secure operation
- Reduced environmental impact

### That incorporates

- Human-centered automation
- Accommodation for new vehicles
- Shared situational awareness
- Distributed vehicle state and health, traffic, weather, and airport information
- Agile systems for safety, security, capacity, and environment



## Air Transportation Services



Complex collection of systems, operating procedures, facilities, aircraft, and people

Manage 30,000 commercial flights to safely move 2,000,000 passengers daily

- ~ 500 FAA Managed Air Traffic Control Towers
- ~ 180 Terminal Radar Control Centers
- 20 Enroute Centers
- ~ 60 Flight Service Stations
- ~ 40,000 Radars, NAVAIDS, Radios, etc.

## Capacity Limit Factors

### Airport Capacity

- Runways (Landing/Takeoff)
- Gates
- Landside Limits (including Security)
- Weather



### Airspace Capacity

- Airspace Design
- Controller Workload
- Balkanization

### Spectrum

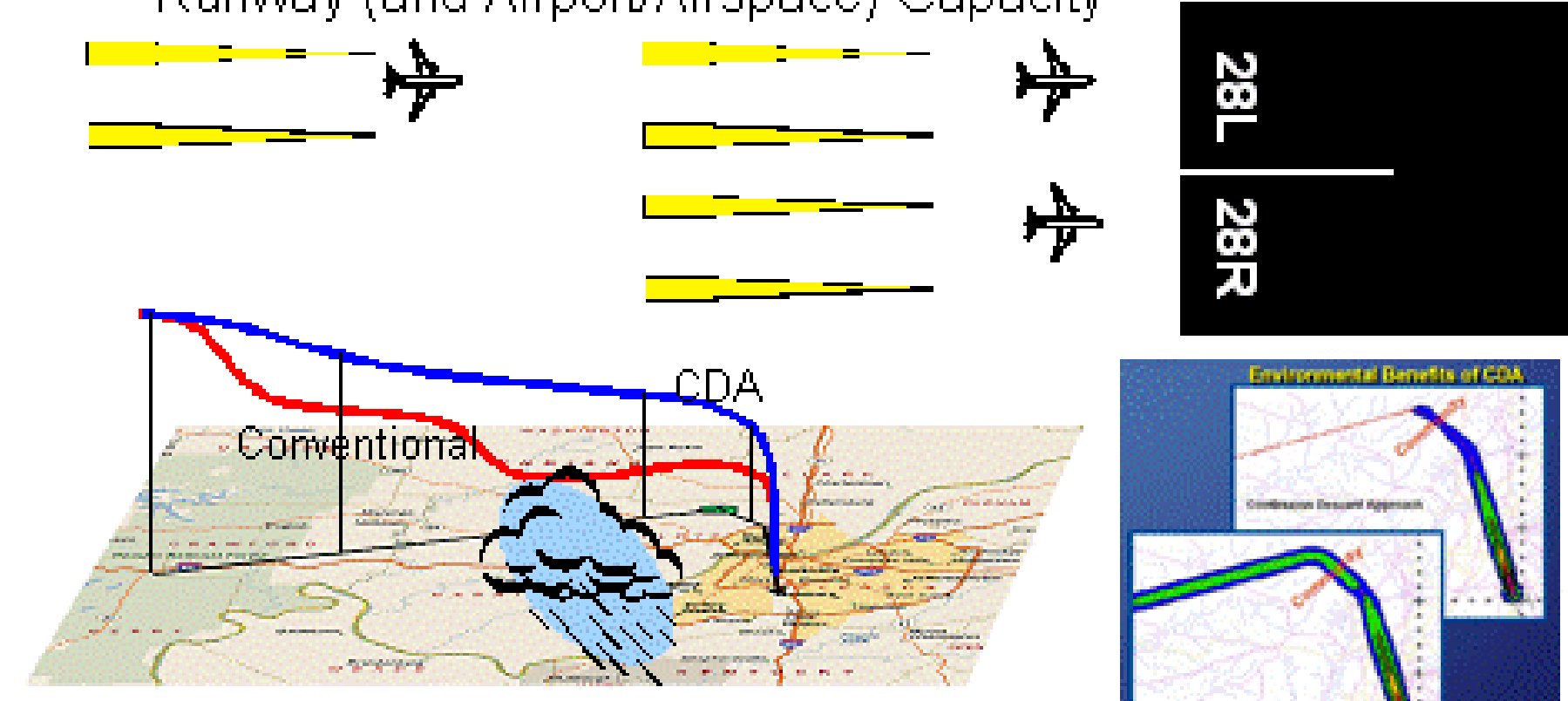
- Communications
- Navigation
- Surveillance

### Separation Between Adjacent Landing Aircraft

	Heavy	Large	Small
Heavy	4	5	5
B757	4	4	5
Large	3(2.5)	3(2.5)	4
Small	3(2.5)	3(2.5)	3(2.5)

## NextGen Con-Op Example

- Formation Landings with Adaptive Minimal Noise Trajectories Robust to Weather Perturbation to Increase Runway (and Airport/Airspace) Capacity

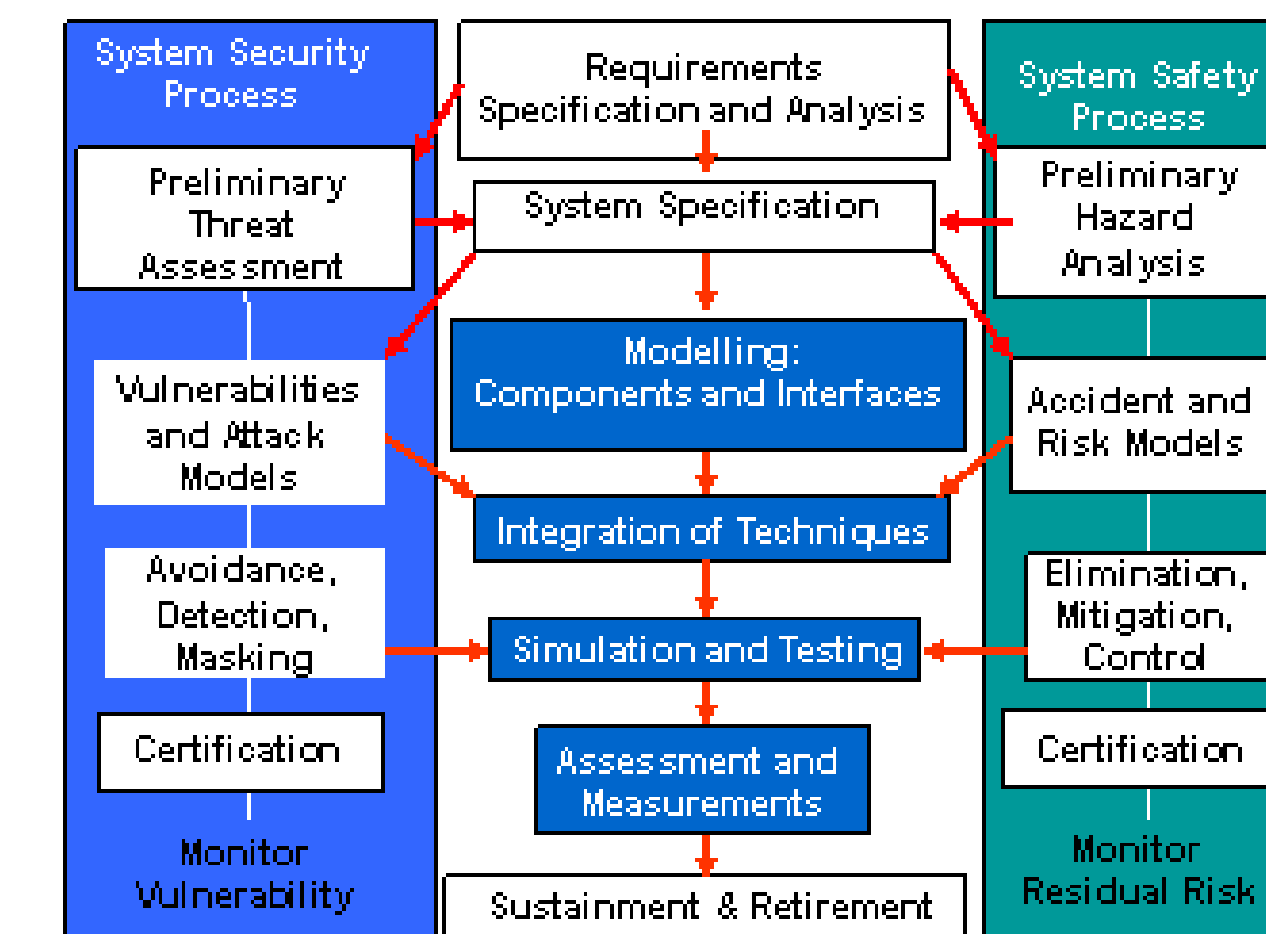


## Quality Assurance

### Approach:

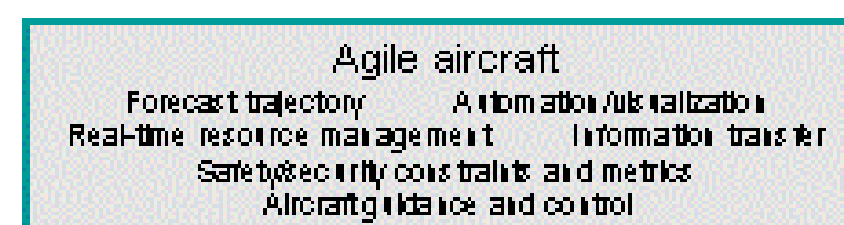
- Build in Safety/Security from system inception
- Engineer software, hardware, operational procedures concurrently

- Broader Context: Methodology applies to safety critical high confidence critical infrastructure systems
- Can be used for mobile, real-time systems



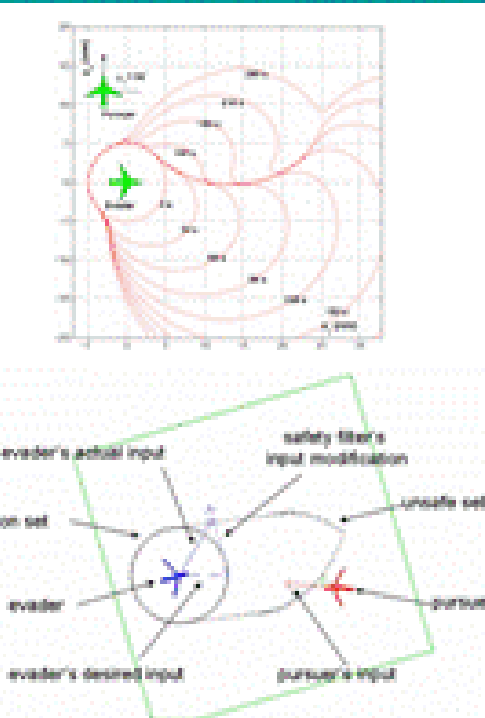
## Agile Aircraft

- Provide capability for individual aircraft to effectively respond to changes in the environment and tactical situations



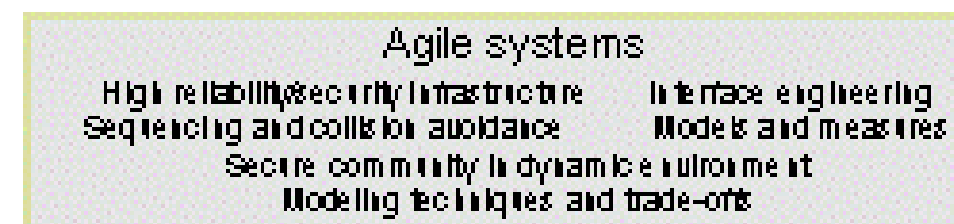
### Challenges

- Trajectory field interaction
- Multi-attribute optimization in the presence of stochastic uncertainty
- Real-time control loops over wireless



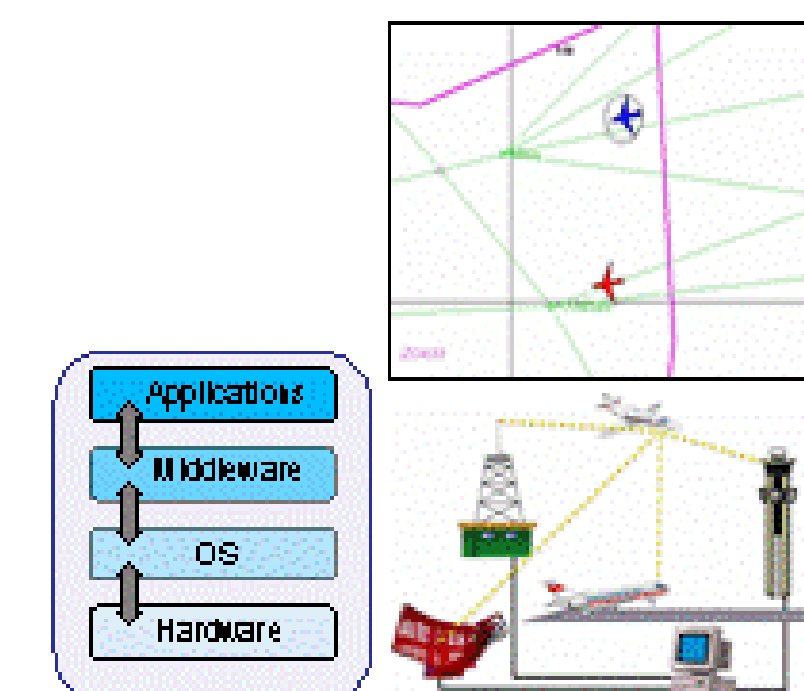
## Agile Systems

- Provide capability for distributed system to adapt and accommodate a wide range of aircraft and system disruptions



### Challenges

- High integrity-driven computation architecture
- Ensuring the accuracy, security and safety of distributed information
- Multiple vehicle and multiple objective optimization with safety constraints
- Overall system robustness to perturbations



## Scaled/UAV Testbed

- Inject/Insert Errors to cause misbehaviour
  - Evaluate detection coverage
  - Measure Performance and Latency
- Verify timing assumptions under varying operational/environmental conditions
  - Error rate and type
  - Communications
  - Power consumption
  - Malicious events
- Evaluate:
  - Operational Concepts
  - Metrics
- Discover incorrect/missing requirements that have not been traced to implementation

