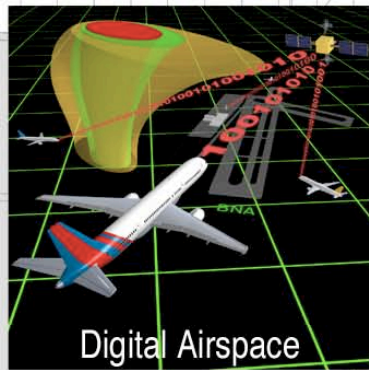


The NASA Aeronautics Blueprint - Toward a Bold New Era of Aviation





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Towards a Bold new Era of Aviation**

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- 4.1 Summary
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- Aviation is crucial to U.S. economic health, national security, and overall quality of life.
- Our Nation is facing serious challenges in aviation.
- NASA's Aeronautics Blueprint outlines the advanced technologies that can help solve today's problems and create a new level of performance and capability in aviation:
 - Advanced concepts for the airspace system
 - Revolutionary vehicles with significantly greater performance
 - New paradigm for safety and security
 - Assured development of the capable workforce of the future
- **The cost of inaction is gridlock, constrained mobility, unrealized economic growth, and loss of U.S. aviation leadership.**



Aeronautics
Blueprint

Toward A Bold New Era of Aviation 2002 2005 2008 2009 2012 2018 2025

The Imperative



Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

Economic Growth

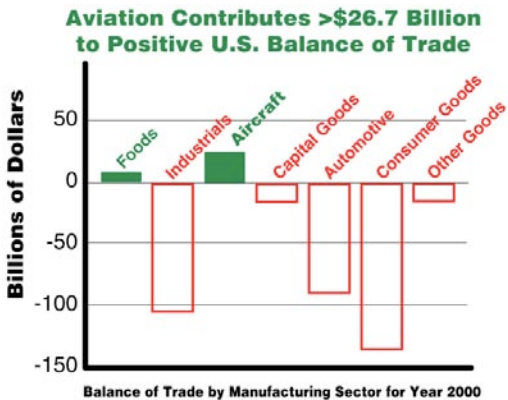
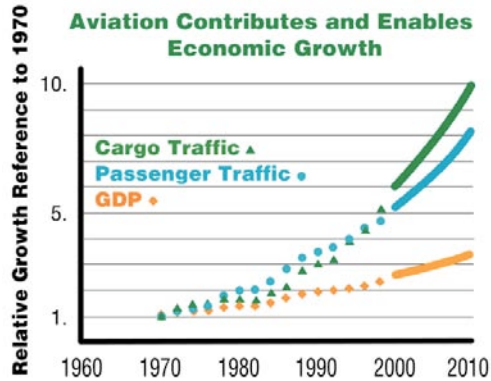
- Productivity
- Global Competition
- Fullest Commercial Use

National Security

- Air Superiority !!!!
- Global Mobility

Quality of Life

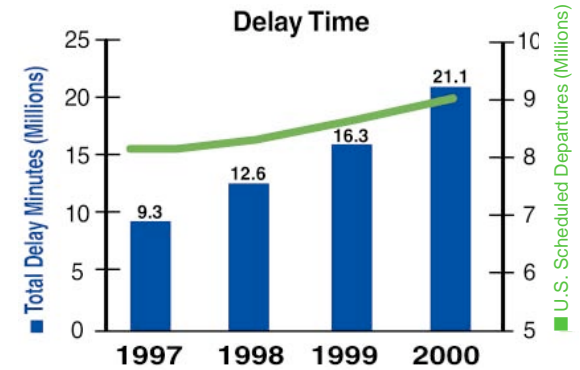
- Freedom of Movement
- General Welfare



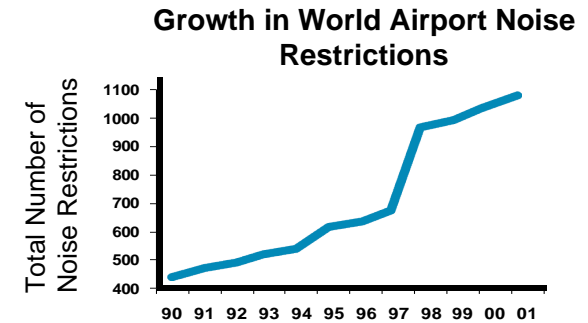


Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

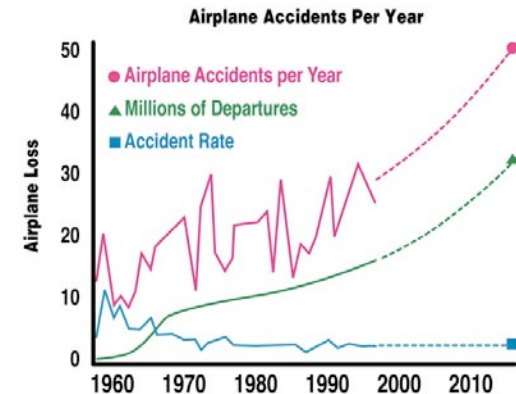
- Limits to capacity - U.S. aviation system is approaching gridlock.



- Noise and emissions are constraints on aviation growth.



- Security and safety must be maintained.





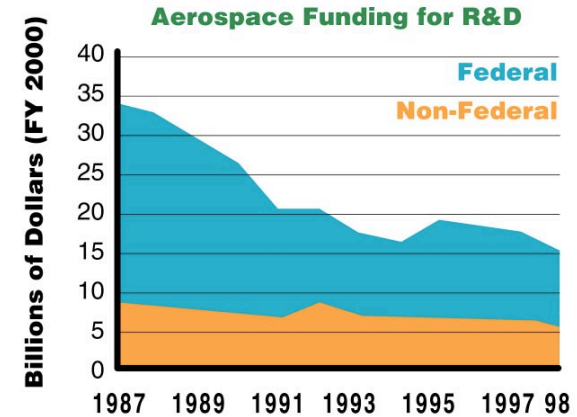
Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

- The changing national security threat demands technical superiority.



Courtesy of IKONOS

- Aerospace R&D investments and skilled workforce are declining.



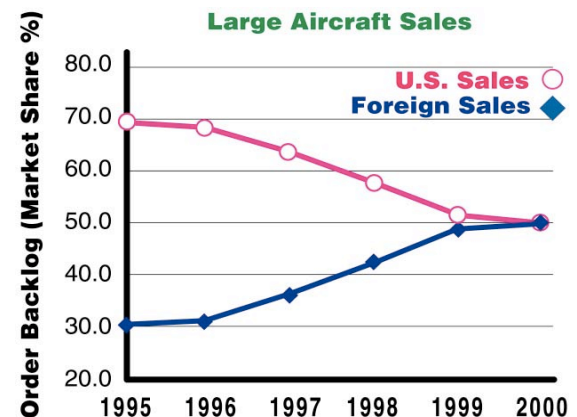
- The U.S. is losing global market share and leadership.

EUROPEAN AERONAUTICS: A VISION FOR 2020

Meeting society's needs and winning global leadership



European Aeronautics Strategic Plan for Winning Global Leadership





Government Responsible to Provide:



Air Traffic Operations

- Safe and secure
- Environmentally compatible
- Meet growing demand

Enabling Technology in the National Interest

- Basic research
- High-risk technology
- Unique facilities
- Educated workforce

National Security

- Air superiority
- Technical superiority
- Full-spectrum dominance

■ **Technologies flow between civil, military, and commercial applications**

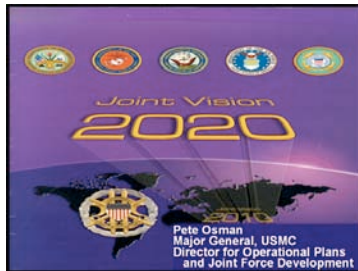
■ **Need for Government role in aeronautics technology**



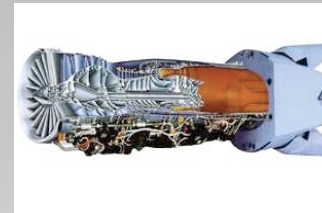
NASA is collaborating in strategic planning and is providing technical solutions to DoD:

Programs

■ DoD Joint Vision 2020



Aging Aircraft



High-Performance Propulsion



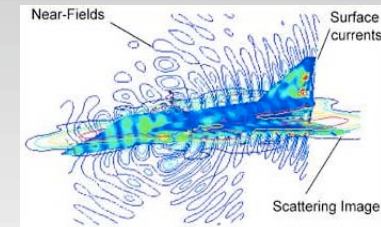
Autonomous Operations

■ Quadrennial Defense Review Report



Revolutionary Vehicles

- Safety of flight
- Affordability
- Reduced noise and emissions
- Lightweight, high-strength adaptable structures
- Adaptive controls
- Situational awareness



Reduce Design Cycle Time & Development Tools



NASA is currently supporting FAA Operational Evolutionary Plan (OEP):

Programs

- NASA participated in planning
- NASA is in partnership on critical path



Organization of challenges addressed by OEP



NASA's technology is prominent in the FAA's roadmaps



Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

NASA provides enabling technologies, expertise, state-of-the-art facilities, and technology solutions:

Economic Growth

- Productivity
- Global Competition
- Fullest Commercial Use

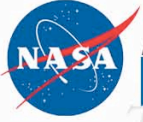
National Security

- Air Superiority !!!!
- Global Mobility

Quality of Life

- Freedom of Movement
- General Welfare





Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

Technology advances have enabled today's world of aviation . . .

Aviation Progress Benefits Society



Glass Cockpit



KC-135/707, Jet Age



Wright Flyer



DC-3, Riveted Metal Structure,
Retractable Gear



Air Traffic Radar



777, Supercritical Wing,
Highly Reliable Engines



B-47, Swept Wing, Jet
Propulsion

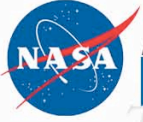


Constellation, Pressurized Cabin, Limit on
Piston Propulsion

1900

1950

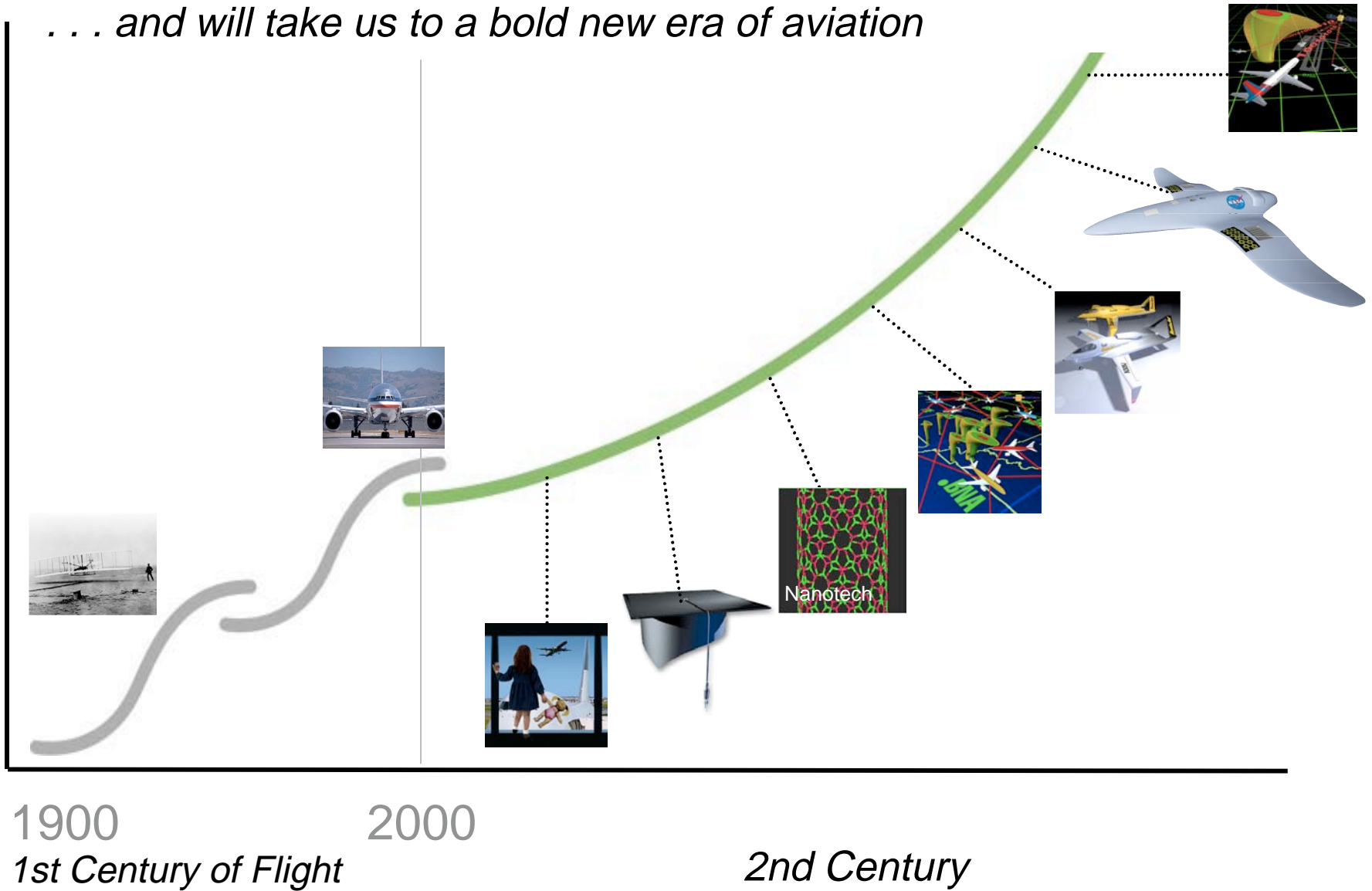
2000



Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

... and will take us to a bold new era of aviation

Aviation Progress Benefits Society





Aeronautics
Blueprint

Toward A Bold New Era of Aviation 2002 2005 2008 2009 2012 2018 2025

A Bold New Era is Possible



Aeronautics Blueprint

A Bold New Era of Aviation is Possible

Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

Arrivals						
Airline	Flight	City	Time	Gate	Remarks	
Continental	1006	Key West	10:15am	B1A	On Time	
TWA	5335	Miami	11:48am	A1A	On Time	
UNITED	59	New York JFK	1:25	A2	On Time	
UNITED	670	Cleveland	11:50am	B5	On Time	
Delta Air Lines	263	Newark	10:49	B1	On Time	
Delta Air Lines	9280	Tampa	12:53pm	B1A	On Time	
NORTHWEST	401	Albany	11:03am	B9	On Time	
NORTHWEST	2015	Atlanta	10:14am	B2	On Time	
US AIRWAYS	2439	Boston	10:40am	B4	On Time	
US AIRWAYS	401	Cincinnati	11:03am	B9	On Time	

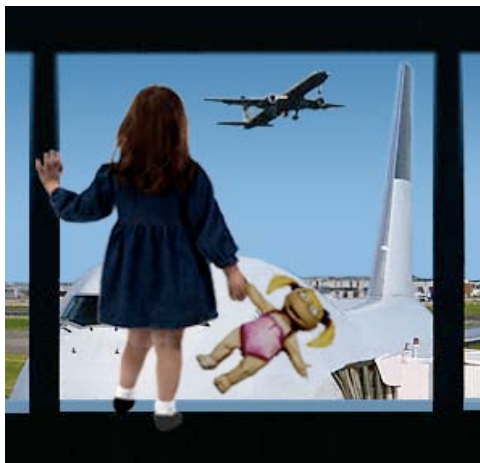
■ On-Time—All the Time



■ Freedom of Mobility, Access to Communities Large and Small



■ Clean, Quiet, Good-Neighbor Airports



■ Aviation Security and Safety



■ Meeting the Changing Threat



■ New Choices in Personal Air Transportation



The Blueprint has four major elements:

Economic Growth

- Productivity
- Global Competition
- Fullest Commercial Use

National Security

- Air Superiority !!!!
- Global Mobility

Quality of Life

- Freedom of Movement
- General Welfare



DoD **Aero Industry** **DOT**

1. The Airspace System

2. Revolutionary Vehicles



Toward a Bold New Era of Aviation

Digital Airspace Security & Safety State of the Art Educated Workforce

Revolutionary Vehicles

Revolutionary National Security and Neighbor

Security Safety

An Educated Workforce

3. Security and Safety

4. An Educated Workforce



Aeronautics Blueprint

A Strategy Based on System Analysis

Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

Collaborative Partners



Investment Strategy

Aeronautics Blueprint

Toward a Bold New Era of Aviation



Research and Systems Engineering

- Government, Industry, and Academia collaborations
- Systems engineering
- Defining requirements
- Research & technology development

National Goals

- Economic Growth**
 - Productivity
 - Global Competition
 - Fullest Commercial Use
- National Security**
 - Air Superiority
 - Global Mobility
- Quality of Life**
 - Freedom of Mobility
 - General Welfare

NASA Research Centers:

Ames



Langley



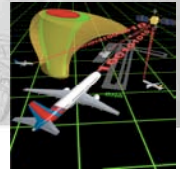
Glenn



Dryden



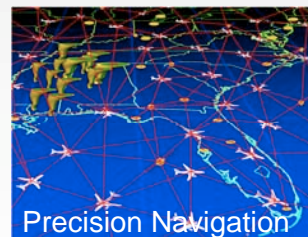
- Information Technology
- Flight Path Monitoring
- Simultaneous Operations
- High-resolution Weather
- Nanotechnology
- Morphing Airframe
- General Aviation
- Precision Navigation
- Advanced Sensors
- Propulsion
- High-Flow Airports
- Streaming Flight Recorder
- Refuse-to-Crash
- Synthetic Vision
- Aging Aircraft



Today's Challenges:

- **Overcome reduced throughput in bad weather**
- **Eliminate en route congestion and the "domino effect" throughout the system**
- **Keep pace with demand for arrival and departures at benchmark airports***
- **Increase situational awareness in the system**

Technology Solutions:



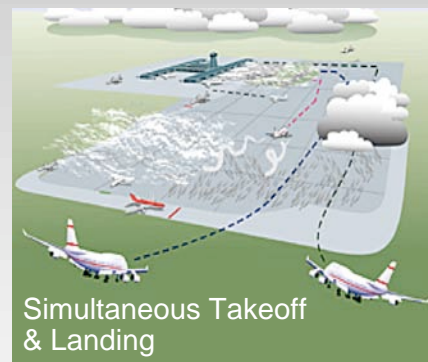
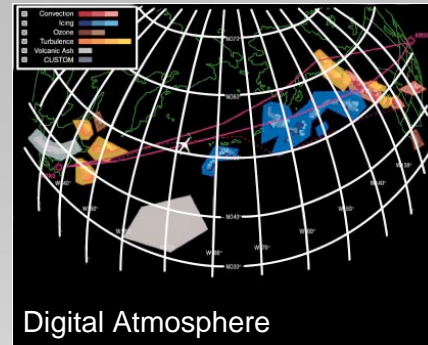
- **High-resolution weather**
 - Precise forecasts
 - Precise wake vortex knowledge
- **System-level traffic flows optimization**
 - Separation assurance for complex traffic flows
- **High-flow airports**
 - No gaps in arrival and departure streams
 - Efficient surface movement and rapid reconfiguration
- **Communication, navigation, and surveillance**
 - High-bandwidth and reliable data transmission
 - Precision navigation
 - System wide coverage



Today's Challenges:

- **Reduce disruptions of en route traffic due to bad weather**
- **Eliminate delays in terminal area airspace**
 - Efficiently manage terminal area traffic flow
 - Understand wake vortex movement and dissipation

Technology Solutions:



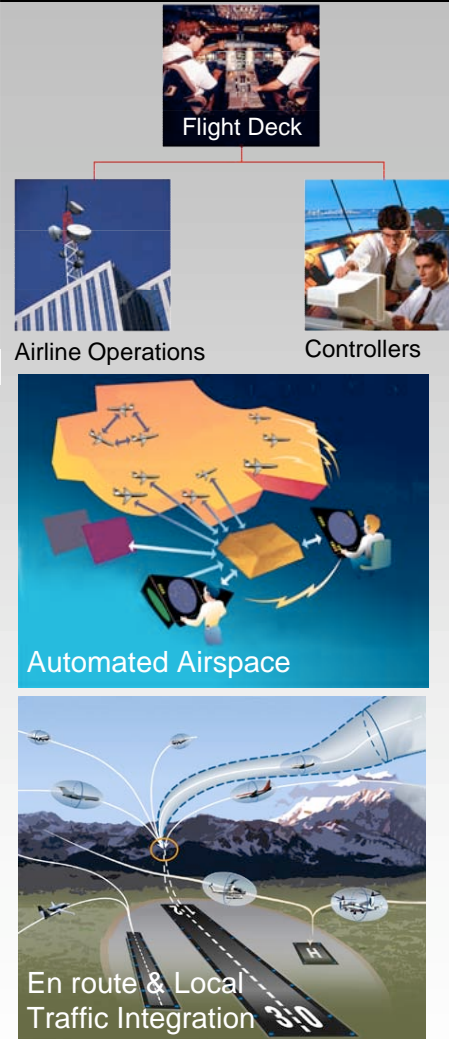
- **Complete digital knowledge of the en route atmosphere**
 - Precision forecasts
 - Sensors
 - Worldwide measurements
 - Data processing
 - Information dissemination
- **Precise local weather forecasts integrated with airport operations**
 - Reliable prediction and conformation of wake vortices integrated with atmospheric conditions



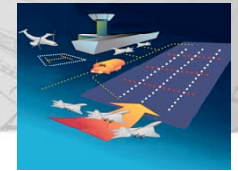
Today's Challenges:

- **Eliminate the air traffic “domino effect” across the National Airspace System**
 - Geographic “choke points”
 - Limited airspace/sector flexibility
- **Increase airline flexibility to manage contingencies**
- **Minimize congestion in complex traffic situations**

Technology Solutions:



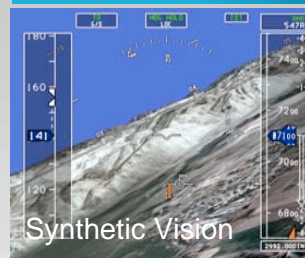
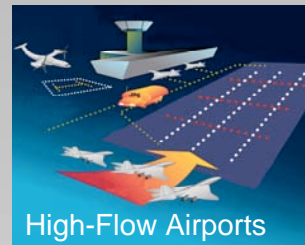
- **National airspace management**
 - Remove restrictions across facilities and sectors
 - Distributed air-ground traffic management
 - Assured safe and efficient flight path
 - Use of precision weather and aircraft position
- **Interactive monitoring and goal setting**
- **System-level (en route and local) traffic flow planning and decision making**



Today's Challenges:

- Eliminate gaps in arrival/departure streams.
- Increase airport operations in bad weather.
 - Single-runway use limits
 - Parallel-runway use limits
- Enable rapid reconfiguration of runways.
- Integrate short-haul aircraft into airport operations.
- Exploit 5,000 underutilized public airports.

Technology Solutions:



- Integrated arrival, departure, and surface decision-support tools
 - Precision spacing and merging
 - Optimized surface operations
- All-weather situational awareness and response
 - Synthetic vision
 - Computer-assisted air and ground coordination
- New airport design and operation models
 - Intelligent runways and taxiways
 - Simultaneous landings and departures
- Smart non-towered airports
 - Autonomous sequencing and scheduling



Today's Challenges:

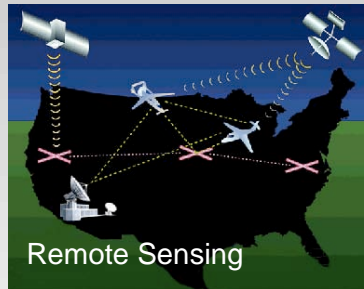
- Congested frequency spectrum limiting air traffic growth
- Voice-based air traffic control cannot support complex air traffic management concepts
- System provides insufficient security & integrity
- Communications capacity cannot support future air traffic management
- Coverage is lacking in remote and oceanic regions



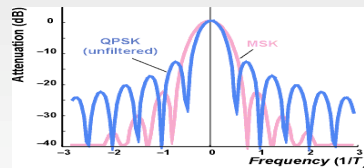
Technology Solutions:



Airborne Internet



Remote Sensing



Secure digital communications

- Airborne internet
- Secure networked communications
- Remote surveillance of all airspace
- Satellite communications and surveillance
 - Global surveillance and communications
 - Real-time cockpit weather and other hazard awareness
- Digital broadband communication

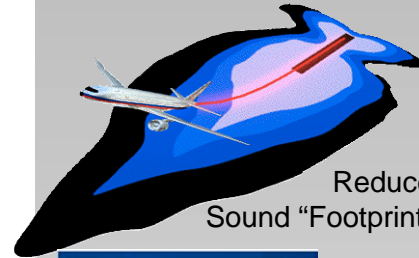


Today's Challenges:

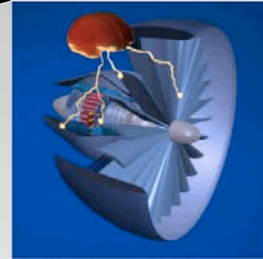
- **Reduce noise**
 - Eliminate airport restrictions
- **Lower emissions**
 - Reduce greenhouse gases
 - Improve local air quality
- **Improve safety**
 - Reduce the accident rate
- **Enhance capabilities—advance technology**
 - Autonomous operation
 - Supersonic overland flight
 - Runway independence



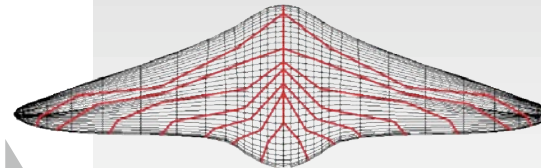
Technology Solutions:



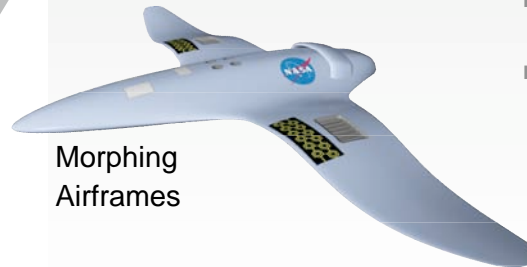
Reduce Sound "Footprint"



Intelligent Propulsion System



Intelligent Sensors



Morphing Airframes

- **Integrated airframe and propulsion systems**
- **Active flow and noise control**
- **Intelligent propulsion systems**
- **Fuel-efficient vehicles**
- **Robust flight control**
 - Reconfigurable control laws
- **Integrated vehicle health monitoring**
- **Automated decision aids**
- **Advanced vehicle concepts**



Today's Challenges:

- Long-duration and large, long-haul transportation
- High-speed commercial transportation
- Quiet and efficient runway-independent aircraft
- Autonomous operations capability

Future Possibilities:



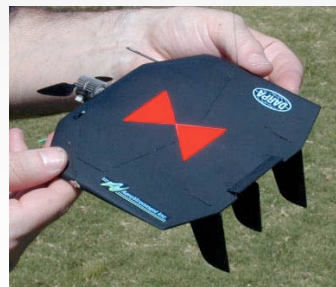
- Months aloft at high-altitudes and long distances



- Quiet, efficient, affordable supersonic flight

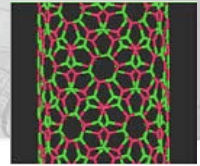


- Extremely short takeoff and landing—doorstep-to-doorstep



- Intelligent flight controls, micro-vehicles to transports





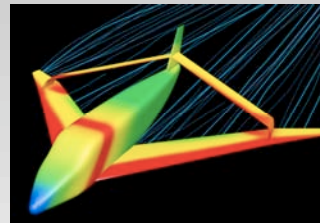
Today's Challenges:

- Develop light, strong, and structurally efficient air vehicles.
- Improved aerodynamic efficiency.
- Design fuel-efficient, low-emission propulsion systems.
- Develop safe, fault-tolerant vehicle systems.

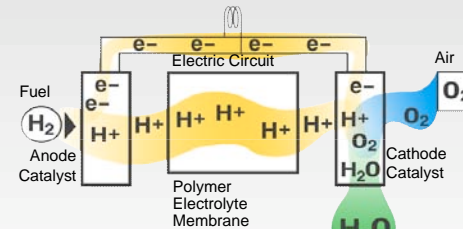
Technology Solutions:



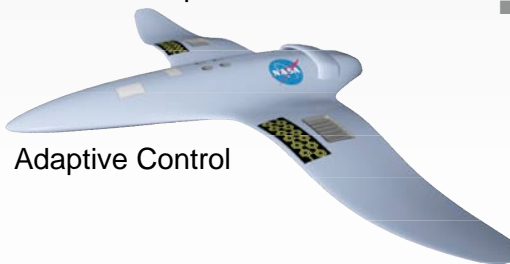
Nanotube



Active Flow Control

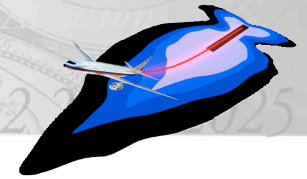


Fuel Cell Propulsion



Adaptive Control

- Nanostructures: 100 times stronger than steel at 1/6 the weight
- Active flow control
- Distributed propulsion
- Electric propulsion, advanced fuel cells, high-efficiency electric motors
- Integrated advanced control systems and information technology
- Central “nervous system” and adaptive vehicle control

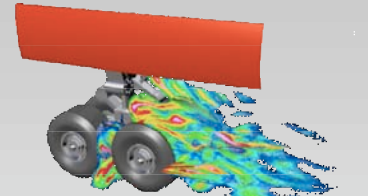
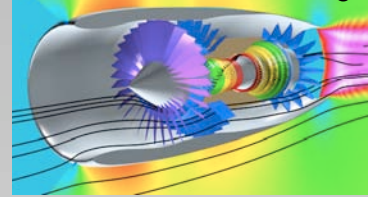


Today's Challenges:

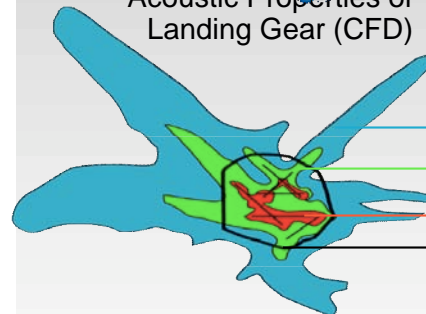
- **Keep noise inside airport boundaries.**
 - Reduce the number of restrictions from the current 825 worldwide.
 - Eliminate the need to sound-condition homes near airports.
 - Revolutionize how citizens view airports.

Technology Solutions:

Advanced Acoustic Design



Acoustic Properties of Landing Gear (CFD)



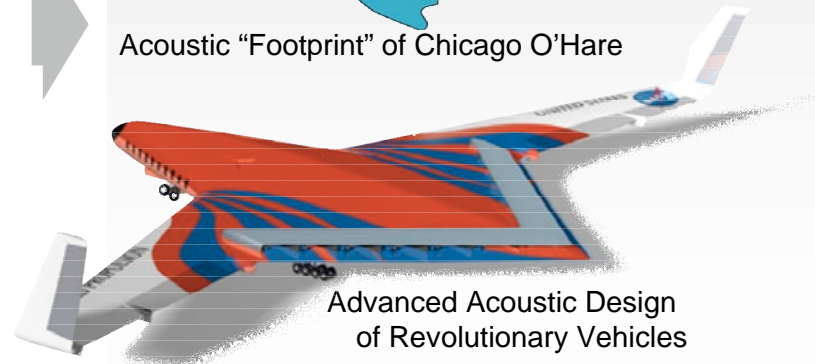
Acoustic "Footprint" of Chicago O'Hare

- **Eliminate noise by improving the design of engines, landing gear, and airframes.**

- Understand the sources! of noise.
- Integrate emerging materials, structures, and flow-control technologies.
- Develop revolutionary vehicle designs.

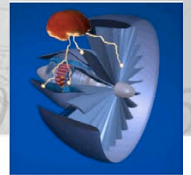
Noise Level	People Impacted
Baseline*	= 620,000
-10 dB	= 55,000
-20 dB	= 0

Airport Boundary



Advanced Acoustic Design of Revolutionary Vehicles

* DNL 55 is the EPA outdoor noise exposure level "requisite to protect the public health and welfare with an adequate margin of safety."

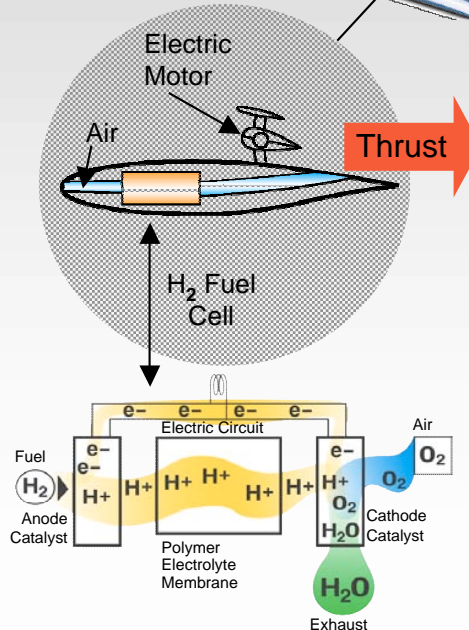
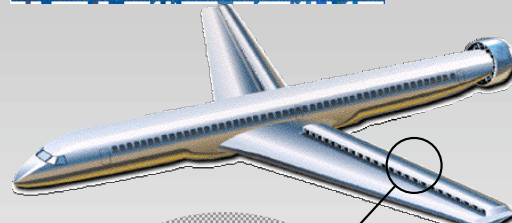
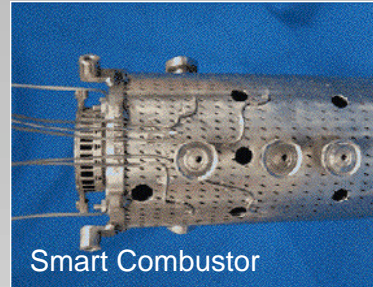


Today's Challenges:

- **Improve local air quality; reduce NO_x**
 - Projected to increase fourfold by 2050

- **Reduce impact of aviation on global air quality; reduce CO₂**
 - Projected to increase threefold by 2050

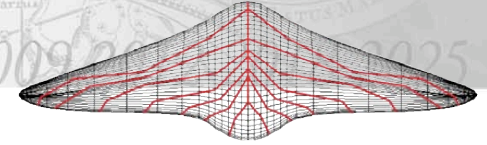
Technology Solutions:



- **Intelligent combustors**
 - Sensors and actuators to control the combustion process
 - Smart materials

- **Increased fuel efficiency**
 - Ultra-lightweight and efficient aircraft
 - Dual-fan engines
 - Distributed propulsion

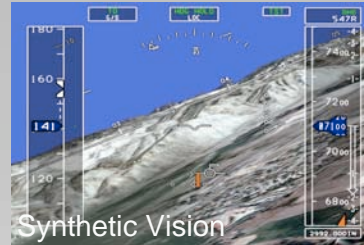
- **Electric propulsion**
 - Fuel cells
 - Global hydrogen generation and distribution



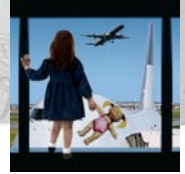
Today's Challenges:

- Provide all-weather visibility.
- Eliminate human error.
- Reduce component failures.
- Minimize the impact of weather hazards.
- Identify hidden risks.

Technology Solutions:



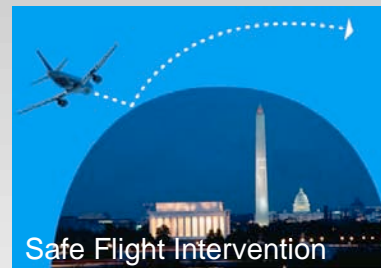
- Synthetic vision provides visibility in all conditions
- “Refuse to crash” flight controls with digital terrain technology
- Human-centered designs
- Fault detection and reconfigurable systems
- Self-healing systems
- Precise knowledge of atmospheric conditions
- Advanced modeling of air traffic to identify and minimize risk



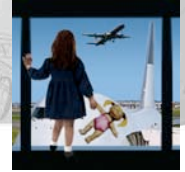
Today's Challenges:

- **Protect the public, passengers, and crew from danger or injury.**
- **Protect the airplane from threats.**
- **Prevent the aviation system from being used for malicious purposes.**
- **Develop solutions maximizing security of the Nation's aviation system while minimizing cost and unintentional consequences.**

Technology Solutions:



- **Aircraft and systems hardening**
- **Flight operations with enhanced procedures and monitoring**
- **Air traffic surveillance and intervention**
 - Onboard flight control
 - Ground control override
- **Enhance security systems through application of information technology**
 - Passenger threat assessment from reservation to boarding
 - Analysis of security data from 100's of airports and thousands of flights



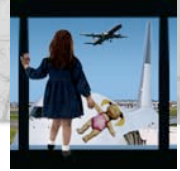
Today's Challenges:

- Design systems to tolerate failures and damage.
- Provide onboard network security and protection.
- Minimize fuel-fed fires

Technology Solutions:



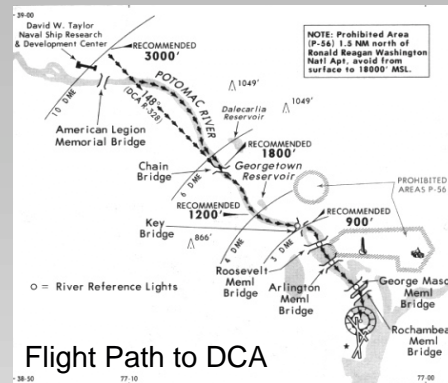
- Blast-resistance structures, which can withstand damage and land safely
- Fault detection and reconfigurable avionics
- Self-healing systems
- Recoverable computers with Software-virus protection
- Network intrusion prevention
- Secure communications
- Self-extinguishing fuel



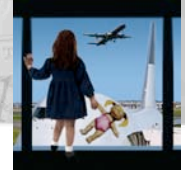
Today's Challenges:

- **Assure predictable approaches to metropolitan areas and around prohibited locations.**
- **Increase situation awareness of terrain and special airspace.**
- **Improve detection of deviations from the intended flight path.**

Technology Solutions:



- **Precise flight path management**
 - Complex curved approaches
 - Four-dimensional approaches
- **Advanced modeling and evaluation of air traffic to identify and minimize risk**
 - “Intelligent” advisor for authorities
 - Simulate scenarios for training and mitigation strategy development
- **Remote monitoring of flight path conformance**
 - Notification of deviations
 - Rapid intervention strategy



Today's Challenges:

- **Rapid detection of any state of duress on an airborne aircraft**
 - Terrorist on board
 - Hazardous materials or other on-board threats
- **Prevent intentional, destructive pilot-controlled flight.**
- **Prevent hazardous flight from non-malicious pilot actions.**

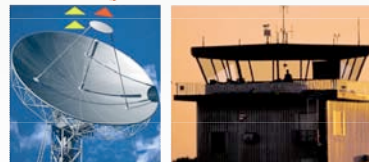
Technology Solutions:



Flight Path Monitoring

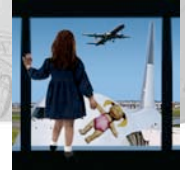


Real-Time Transmission
Cockpit Flight Recorder



Ground Control Override

- **Remote audio and visual links to cabin and cockpit**
 - Real-time cockpit and flight data transmission to a remote monitoring center
- **“Refuse to Crash” flight system can correct pilot error and prevent sabotage**
 - Real-time dynamic avoidance threshold algorithms
 - Automatic avoidance maneuvers, autonomous navigation, and landing
 - Ground control override



Today's Challenges:

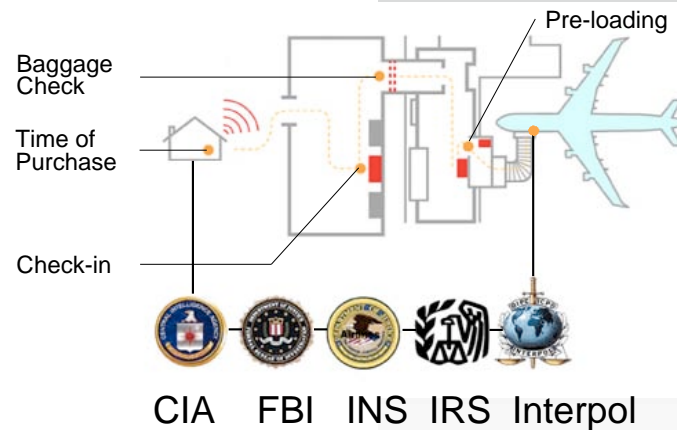
- Rapid pre-departure passenger screening and threat assessment
- Identify trends in system security status



Technology Solutions:



Threat Assessment



National Information System for
Transportation Security

- Real-time passenger threat assessment from reservation to boarding
 - Intelligent searches of distributed databases
 - Biometric identification
 - Context-sensitive threat evaluation
- Aviation Security Reporting System
 - Anonymous submission of security incidents
 - Data Mining to identify trends of concern and initiate preventative action



Aeronautics
Blueprint

Toward A Bold New Era of Aviation 2002 2005 2008 2009 2012 2018 2025

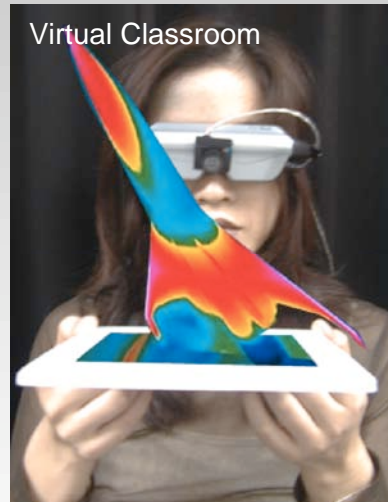
State-of-the-Art Educated Workforce



Today's Challenges:

- **Raise the interest in science and engineering in elementary, middle, and high schools.**
- **Prepare future graduates for a world of rapid technological change, complex systems, and advancements around the world.**
- **Maintain the high-tech workforce on par with the continuously advancing state of technology.**

Technology Solutions:



- **Foster interest and excitement in aerospace—establish an exciting vision for aeronautics**
- **Stimulate curriculum change and virtual and collaborative learning environments that will enhance educational relevance and scope**
- **Create life-long learning system that links classrooms to laboratories and on-the-job experiences**



Today's Challenges:

- Adjust to the rapid loss of senior scientists and engineers (baby boomer demographics and reduced interest)
- Ensure seamless access to specialized talents and geographically dispersed teams.
- Keep pace with the rapid change of technology.
- Fill-in the knowledge gaps of aerospace research and technology to support major advances for the next generation of aerospace products.

Technology Solutions:



- Develop long-term partnerships between government, universities, and industry research entities
- Create virtual collaborative research laboratories working on multi-discipline projects
- Workplace virtual classrooms support life-long and advanced distributed learning
- Adaptive learning computer systems for access to global scientific and technology knowledge



Summary and Actions



- Driven by technology advances, aviation has progressed remarkably over the past century.
- Today's air transport system is facing severe constraints on further growth and service to the Nation.
- New technologies and operational concepts, nearly in hand and in early development, offer the potential to far surpass those constraints and create a new level of performance and capability in aviation.
- NASA, academia, FAA, DOT, DoD, and industry are needed in order to realize this vision.
- Now is the time to aggressively pursue
 - advanced concepts for the airspace system;
 - revolutionary vehicles with significantly greater performance;
 - new paradigms for safety and security; and
 - the development of a capable, flexible workforce of the future.
- **The cost of inaction is gridlock, constrained mobility, unrealized !!!economic growth, and loss of U.S. aviation leadership.**

- Structure investments and performance metrics based on systems analysis and public good.
 - Evaluate, realign, and strengthen our workforce, facilities, partnerships, and ways of doing business.
 - Renew our focus on innovation in engineering tools and capabilities for complex aerospace systems:
 - Act in partnership with industry
 - Act as a catalyst for the future workforce
 - Restructure approach and portfolio for long-term research:
 - New national technology competencies
 - New, expanded approach to University Research Center partnerships
 - Continue to strengthen interagency partnerships to meet national needs.
- NASA is embarking on technological changes for the 21st century.**