The NASA Aeronautics Blueprint - Toward 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.
The Imperative
Aviation is Critical to the U.S.

- Economic Growth
- Productivity
- Global Competition
- Fullest Commercial Use

- National Security
- Air Superiority
- Global Mobility

- Quality of Life
- Freedom of Movement
- General Welfare

Aviation Contributes and Enables Economic Growth

Aviation Contributes >$26.7 Billion to Positive U.S. Balance of Trade
- Limits to capacity - U.S. aviation system is approaching gridlock.

- Noise and emissions are constraints on aviation growth.

- Security and safety must be maintained.
The changing national security threat demands technical superiority.

Aerospace R&D investments and skilled workforce are declining.

The U.S. is losing global market share and leadership.
Government Responsible to Provide:

<table>
<thead>
<tr>
<th>Air Traffic Operations</th>
<th>Enabling Technology in the National Interest</th>
<th>National Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe and secure</td>
<td>Basic research</td>
<td>Air superiority</td>
</tr>
<tr>
<td>Environmentally compatible</td>
<td>High-risk technology</td>
<td>Technical superiority</td>
</tr>
<tr>
<td>Meet growing demand</td>
<td>Unique facilities</td>
<td>Full-spectrum dominance</td>
</tr>
<tr>
<td></td>
<td>Educated workforce</td>
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- 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
  - Quadrennial Defense Review Report
  - Safety of flight
  - Affordability
  - Reduced noise and emissions
  - Lightweight, high-strength adaptable structures
  - Adaptive controls
  - Situational awareness

- **Aging Aircraft**
- **High-Performance Propulsion**
- **Autonomous Operations**
- **Revolutionary Vehicles**
- **Reduce Design Cycle Time & Development Tools**
NASA is currently supporting FAA Operational Evolutionary Plan (OEP):

- 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
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

DoD  Aero Industry  DOT

Toward a Bold New Era of Aviation
Technology advances have enabled today’s world of aviation . . .

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>1900</td>
<td>Wright Flyer</td>
</tr>
<tr>
<td>1950</td>
<td>DC-3, Riveted Metal Structure, Retractable Gear</td>
</tr>
<tr>
<td>2000</td>
<td>777, Supercritical Wing, Highly Reliable Engines</td>
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</tbody>
</table>

First Century of Aviation Progress
Aviation’s Future is Driven by Technology

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

1st Century of Flight

2nd Century
A Bold New Era is Possible
A Bold New Era of Aviation is Possible

- 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:

1. The Airspace System
2. Revolutionary Vehicles
3. Security and Safety
4. An Educated Workforce
### 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

### NASA Research Centers:

- Ames
- Langley
- Glenn
- Dryden

### National Goals

**Economic Growth**
- Productivity
- Global Competition
- Fullest Commercial Use

**National Security**
- Air Superiority
- Global Mobility

**Quality of Life**
- Freedom of Mobility
- General Welfare
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

* Statistic: 64 major airports handle 85 percent of air traffic in the U.S.
The Airspace System—Weather

**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:

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

![Image](example.jpg)
### 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
- Secure networked communications
- Remote surveillance of all airspace
- Satellite communications and surveillance
  - Global surveillance and communications
  - Real-time cockpit weather and other hazard awareness
- Secure digital communications
- Digital broadband communication

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*Communication, Navigation, and Surveillance*
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:

- 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:

- 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:

- 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.

Advanced Acoustic Design

Acoustic Properties of Landing Gear (CFD)

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

Airport Boundary

Acoustic “Footprint” of Chicago O’Hare

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.”
Revolutionary Vehicles—Emissions

**Today’s Challenges:**

- **Improve local air quality; reduce NOₓ**
  - 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:

- 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:

- 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

CIA  FBI  INS  IRS  Interpol

National Information System for Transportation Security
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.
Educated Workforce—Accomplishing the Enterprise Mission

**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.
NASA’s First Steps to Achieve the Vision

- 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.