NASA Ames Research Center
Air Traffic Management Research Overview

Sandy Lozito
Chief, Aviation Systems Division
July 18, 2017

- Who's ever been delayed at the airport waiting to depart for what appears to be no reason whatsoever?
- Who's ever landed and had to wait for a gate for 20+ minutes?
- Who's ever wanted to fly their sweet new UAV over their massive oil pipeline without slamming into all sorts of other UAVs?

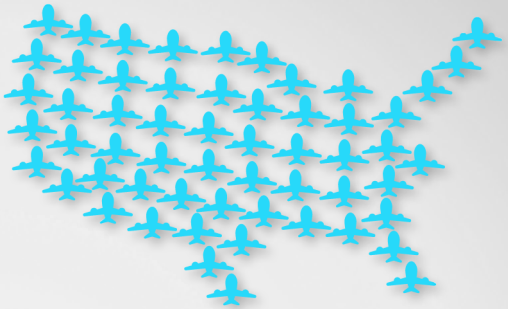
Why is aviation so important?

The air transportation system is critical to U.S. economic vitality.

$1.5 TRILLION

TOTAL U.S. ECONOMIC ACTIVITY

(civil aviation-related goods and services, 2012)



$76.1 BILLION

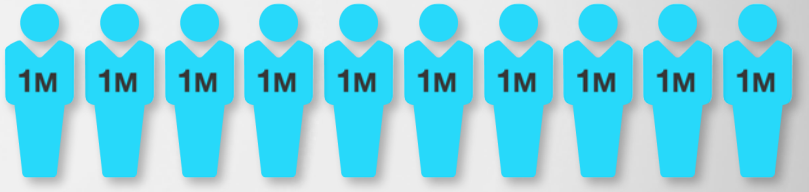
POSITIVE TRADE BALANCE

(aerospace industry, 2012)

11.5 MILLION

DIRECT AND INDIRECT JOBS

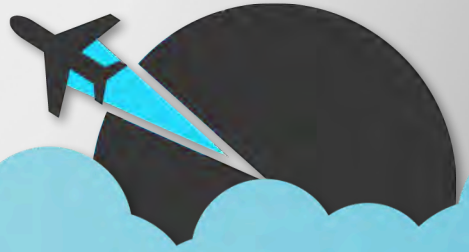
(civil and general aviation, 2012)



5.4% ($847.1 BILLION)

OF TOTAL U.S. GROSS DOMESTIC PRODUCT (GDP)

(civil and general aviation, 2012)



Why should I care?

Take the system view. You may not have flown today but something you needed did.

17.7 BILLION

TONS OF FREIGHT TRANSPORTED BY AIR

(all U.S. carriers, 2013)

$670.8 BILLION

SPENT BY AIR TRAVELERS IN U.S. ECONOMY

(domestic and foreign travelers, 2012)

741 MILLION

PASSENGERS ON U.S. CARRIERS

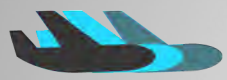
(domestic and foreign, 2013)

What are the challenges?

Challenges are driven by emerging global trends.

16 BILLION

GALLONS OF JET FUEL BURNED IN 2013
(U.S. airlines)



$8.1 BILLION

COST OF DELAYS TO U.S. AIRLINES IN 2013

$9.3 BILLION

SPENT BY AIRPORTS ON NOISE ABATEMENT SINCE 1982

3%

OF GLOBAL CO_2

AND

5%

WARMING EFFECTS PROJECTED FROM AVIATION BY 2050

360 MILLION

PASSENGERS BEING ADDED IN ASIA PACIFIC FROM 2009 TO 2014
(market is growing and moving East)

Why is "Aeronautics" the first "A" in NASA?

The nation's early aeronautics research led to creation of NASA.

National Advisory Committee for Aeronautics
March 3, 1915

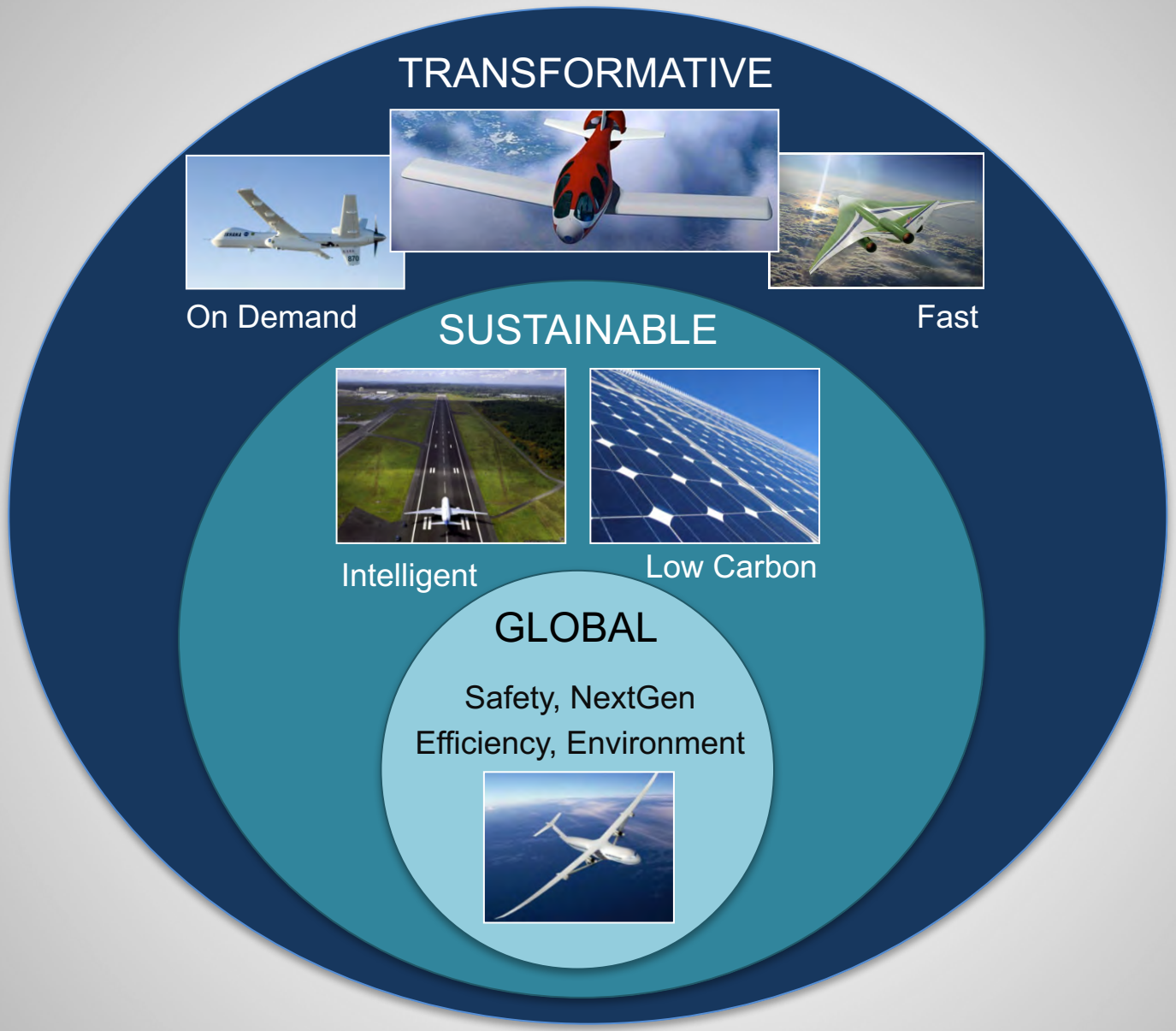
National Aeronautics and Space Administration
October 1, 1958

What does NASA Aeronautics do?

NASA is with you when you fly.

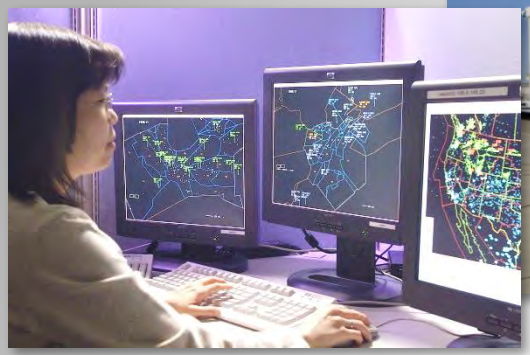
What vision has NASA set for aviation?

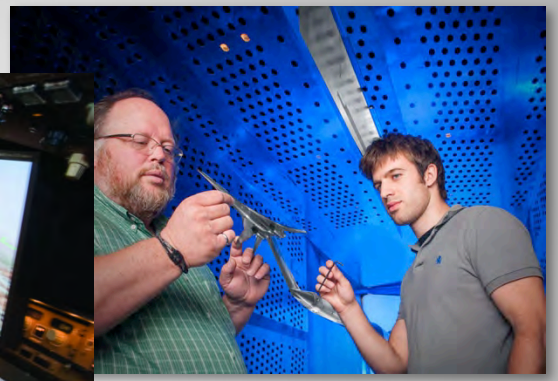
A revolution in sustainable global air mobility.



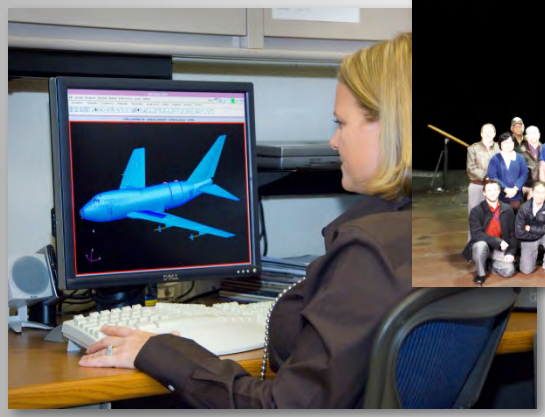
Who is NASA Aeronautics?

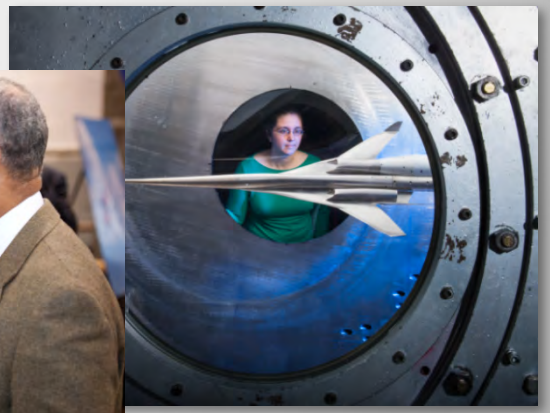
Engineers, pilots, managers, programmers -- we are proud of our legacy of technology contributions to aviation.







What is NASA Aeronautics working on?

Research activities reflect NASA's vision to ultimately transform aviation.

Air traffic management tools that reduce delays and save fuel

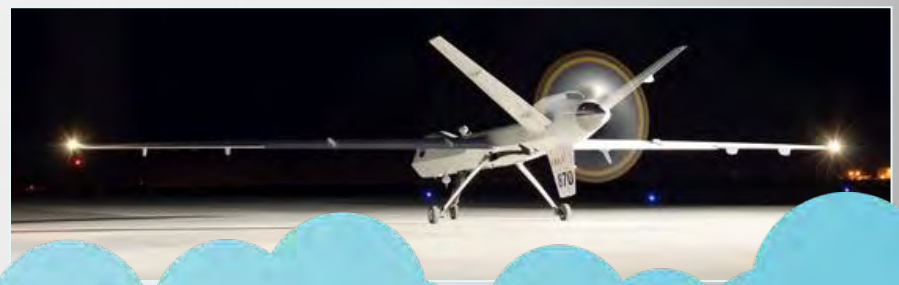
Aircraft shapes that reduce aviation's impact on the environment

Data that reveals the real impacts of alternative jet fuels

Tests of new technologies that increase autonomy in the aviation system

Technologies that lower the volume on sonic booms

Ground tests on ways to detect and prevent engine icing in jet engines



Test your knowledge!

- NASA is a:
  A. Privately-owned company
  B. Federal government agency
  C. Part of the Department of Defense
  D. Federally-funded research and development corporation (FFRDC)
  E. A non-profit organization

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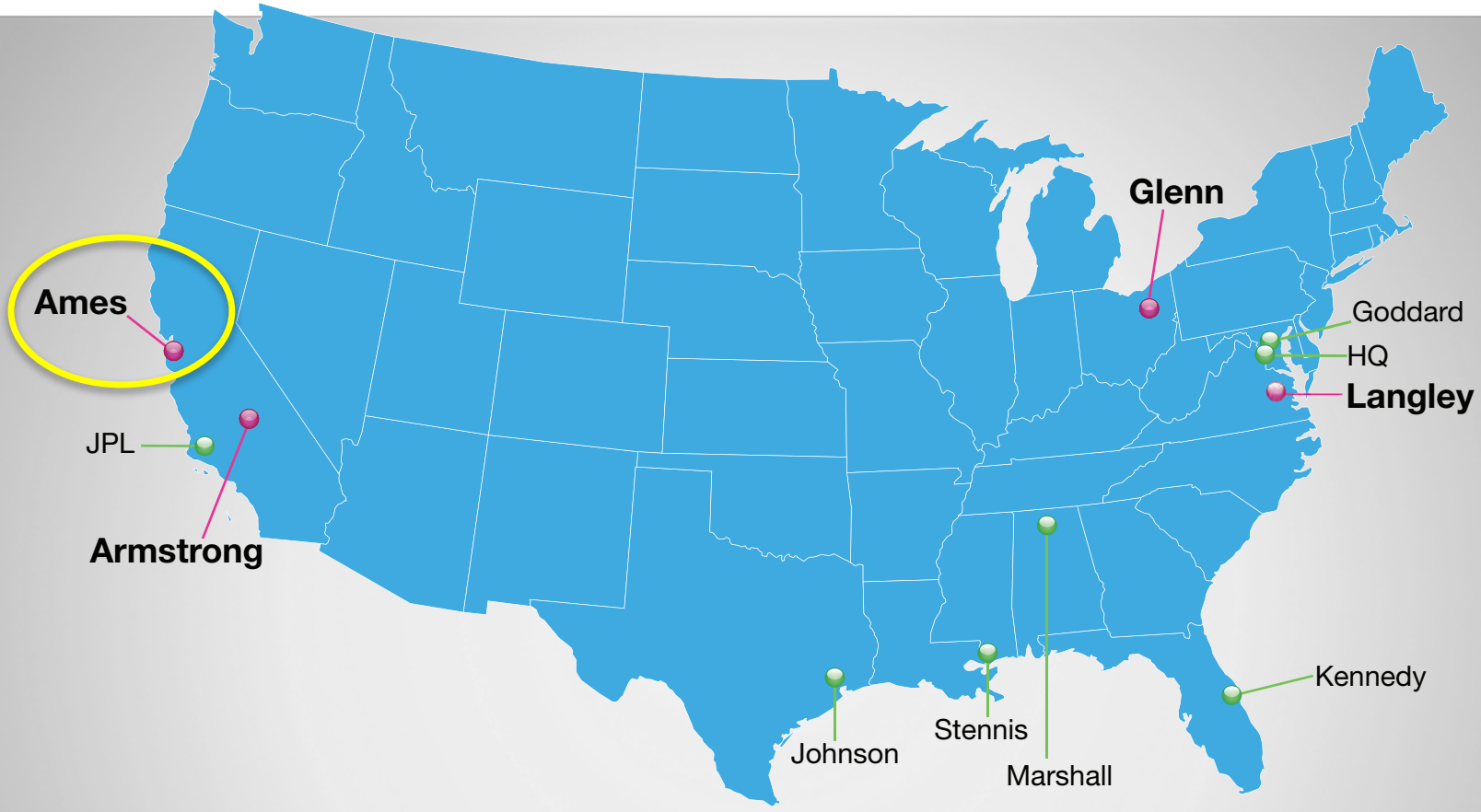
Test your knowledge!

- How many NASA field centers are there, not including HQ?
  A. Three
  B. Four
  C. Five
  D. Seven
  E. Ten

Test your knowledge!

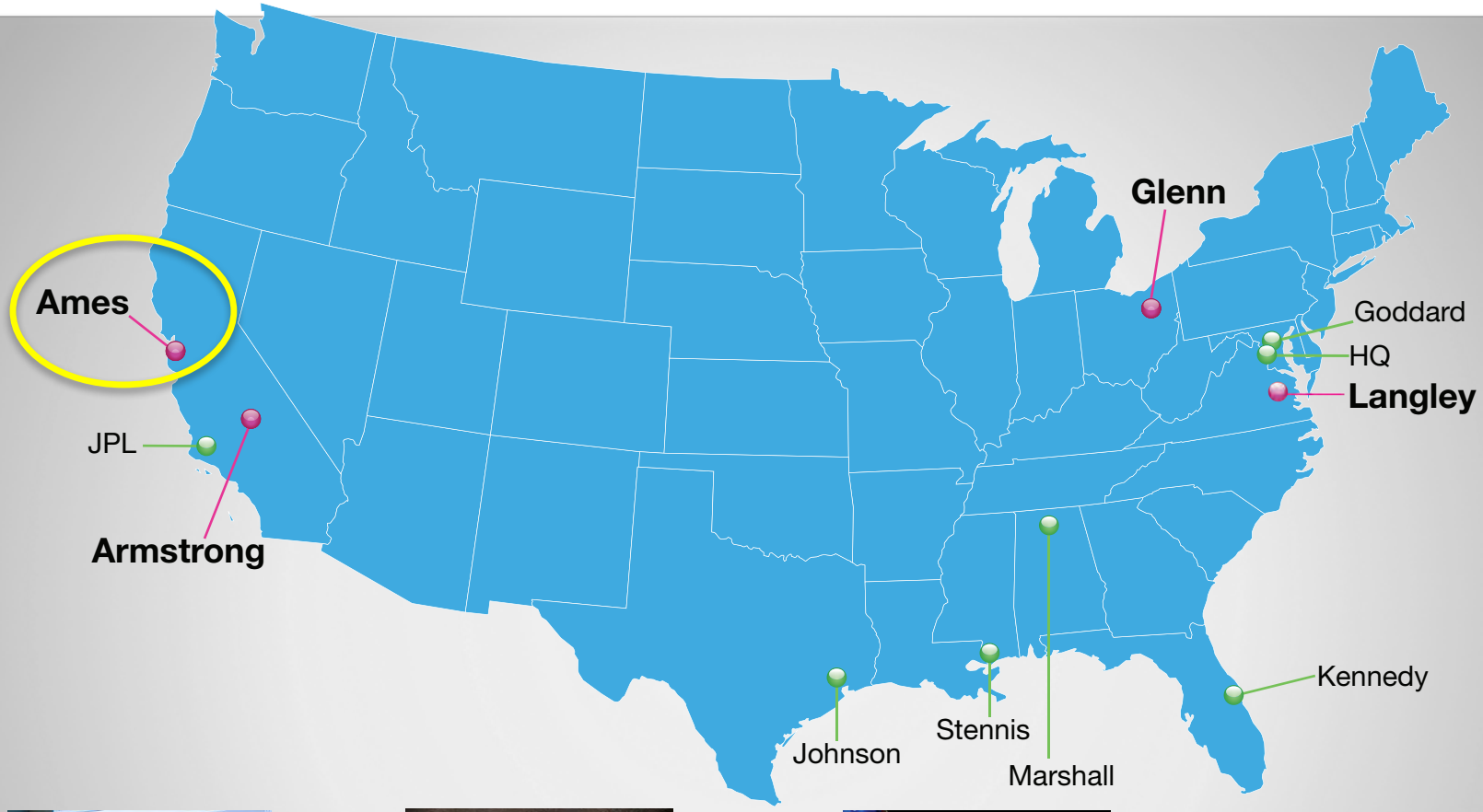
- How many NASA field centers are there, not including HQ?
  A. Three
  B. Four
  C. Five
  D. Seven
  E. Ten; how many can you name?

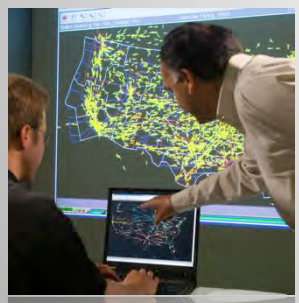
You are here


Glenn
Ames
Goddard
HQ
Langley
JPL
Armstrong
Kennedy
Johnson
Stennis
Marshall

Where does NASA aeronautics research happen?

Aeronautics research takes place at four of NASA's centers.





AMES

ARMSTRONG

GLENN

LANGLEY

March 3, 2015 was the 100th anniversary of what?

1940 – Ames Aeronautical Laboratory

NASA 1915-2015

Moffett Field

1943

* National Advisory Committee on Aeronautics (predecessor to NASA)

USS Macon

February 1934

Navy Squadrons VF-6, VB-2, VS-2, & VT-2

July 1934

First Ames Test Plane – O-47A

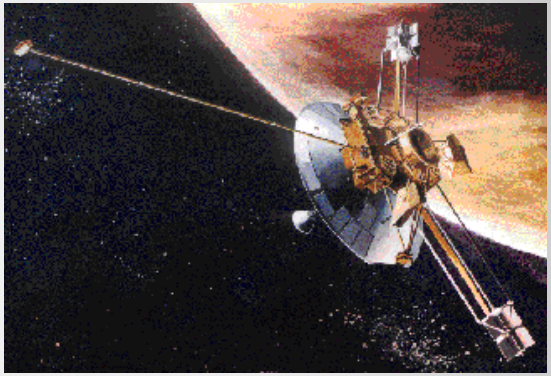
October 1940

Aerial View of Ames Research Center

Ames Contributions

Has conducted pioneering aeronautics research since WWII

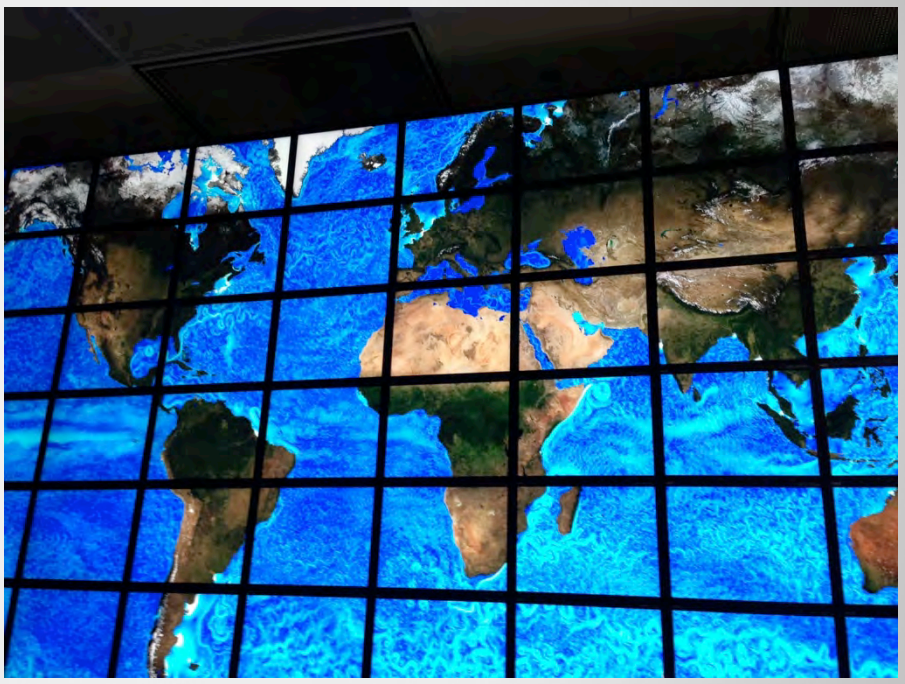
Designed and developed the Pioneer spacecraft, including Pioneer 10, the first spacecraft to encounter Jupiter and the first spacecraft to leave the solar system (1983)

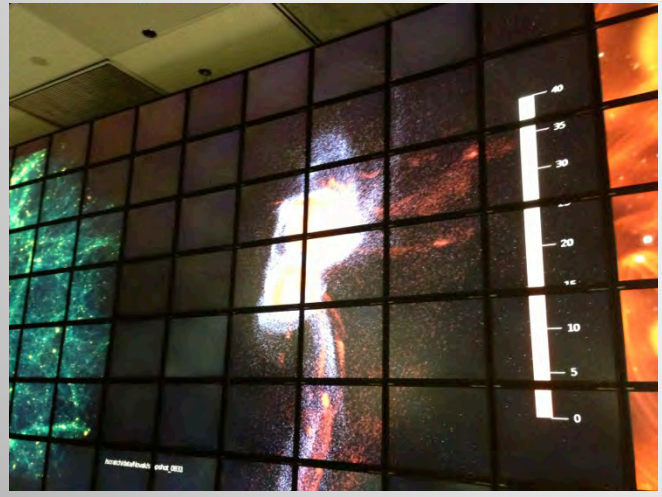


Designed the heat shield for the Stardust comet sample return mission

Ames Contributions, cont.

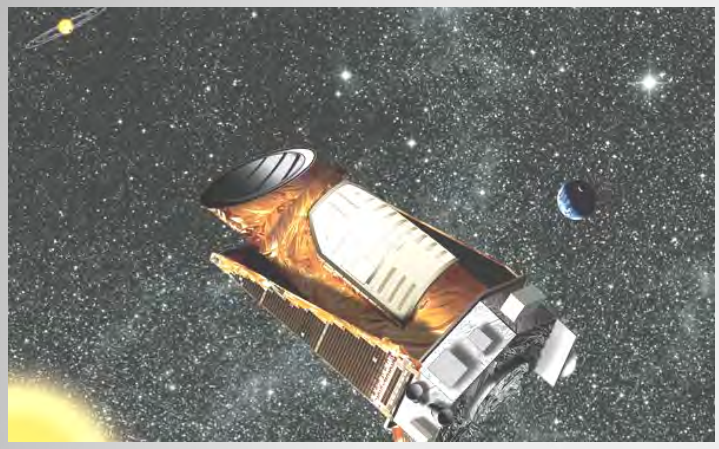
Home to the Pleiades supercomputer, one of the fastest in the world





Ames Contributions, cont.

Leads the Kepler mission to detect earth-like planets in other solar systems



Made major contributions to heat shield development, parachute testing, and scientific instruments aboard the Mars Science Laboratory (Curiosity)

Led the LCROSS mission that has discovered water on the moon

Four NASA Mission Directorates

- Aeronautics Research Mission Directorate (ARMD)
  (Dr. Jaiwon Shin)
- Human Exploration and Operations Mission Directorate (HEOMD)
  (William Gerstenmaier)
- Science Mission Directorate (SMD)
  (Dr. John Grunsfeld)
- Space Technology Mission Directorate (STMD)
  (Dr. Michael Gazarik)

NASA Aeronautics Research

We have aligned our research efforts with these six research thrusts.

3 Mega-Drivers

6 Strategic Research & Technology Thrusts

Safe, Efficient Growth in Global Operations

- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft

- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles

- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion

- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance

- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation

- Develop high impact aviation autonomy applications

NASA's Aeronautics Programs

Mission Programs

Airspace Operations and Safety Program

- Airspace Technology Demonstrations Project (ATD)
- Shadow Mode Assessment Using Realistic Technologies for the National Airspace System Project (SMART-NAS)
- Safe Autonomous Systems Operations Project (SASO)

Advanced Air Vehicles Program

- Advanced Air Transport Technology Project (AATT)
- Revolutionary Vertical Lift Technology Project (RVLT)
- Commercial Supersonic Technology Project (CST)
- Advanced Composites Project (AC)
- Aeronautics Evaluation and Test Capabilities Project (AETC)

Integrated Aviation Systems Program

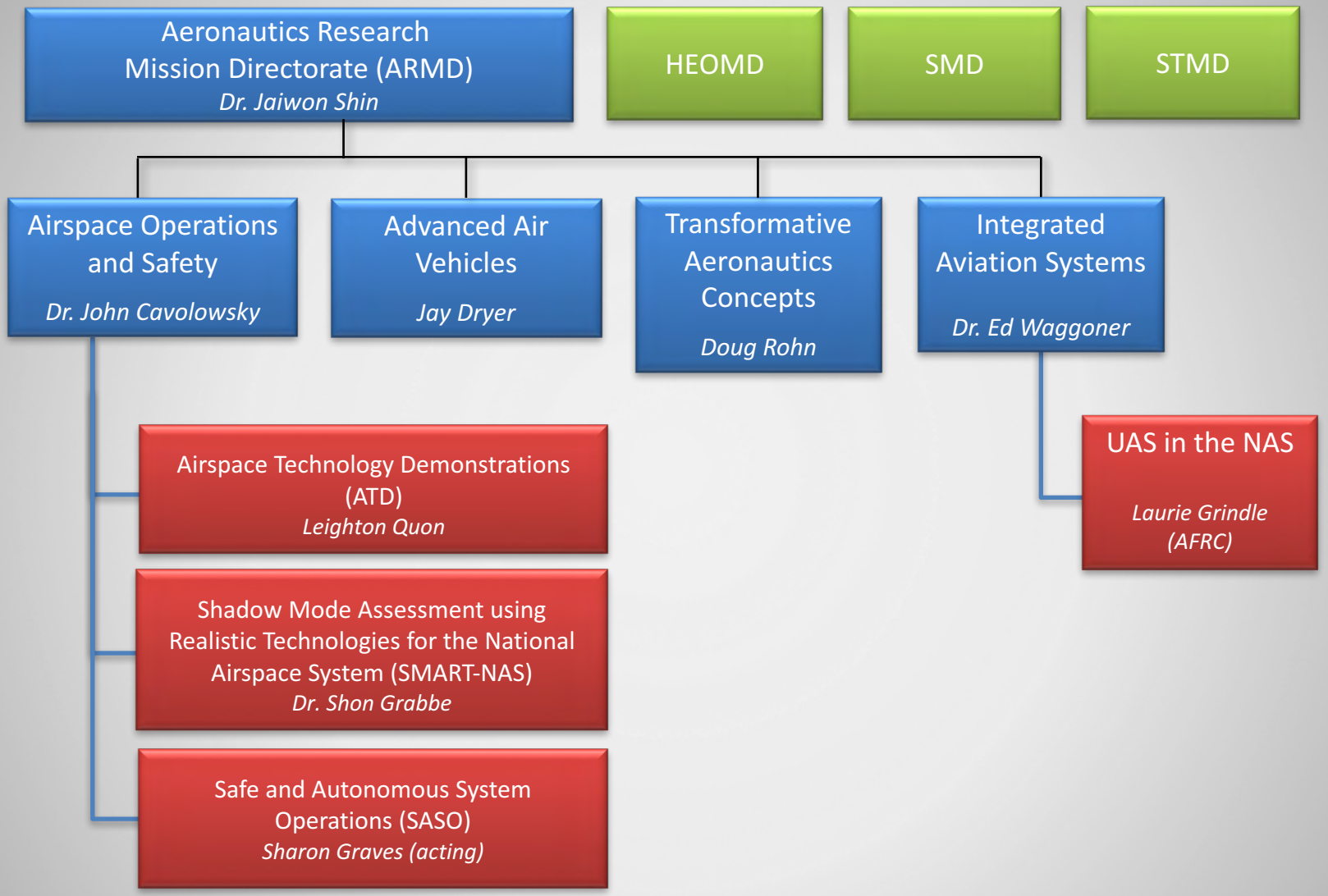
- Environmentally Responsible Aviation Project (ERA)
- Unmanned Aircraft Systems Integration in the National Airspace System Project (UAS in the NAS)
- Flight Demonstrations and Capabilities Project (FDC)

Seedling Program

Transformative Aeronautics Concepts Program

- Convergent Aeronautics Solutions Project (CAS)
- Transformational Tools and Technologies Project (TTT)
- Leading Edge Aeronautics Research for NASA Project (LEARN)

Missions, Programs, Projects



Last updated 10/3/16

NASA Ames Research Center

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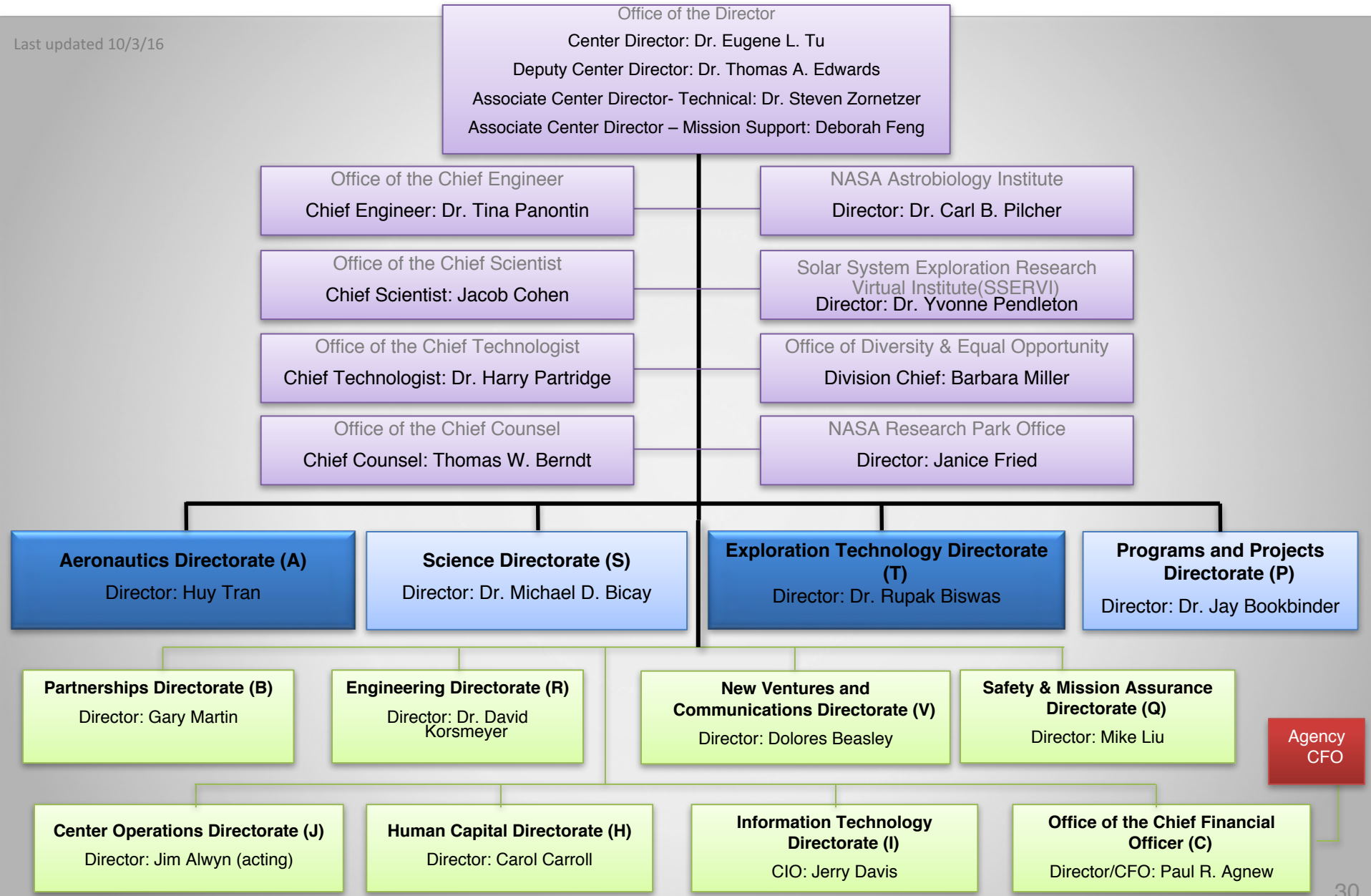
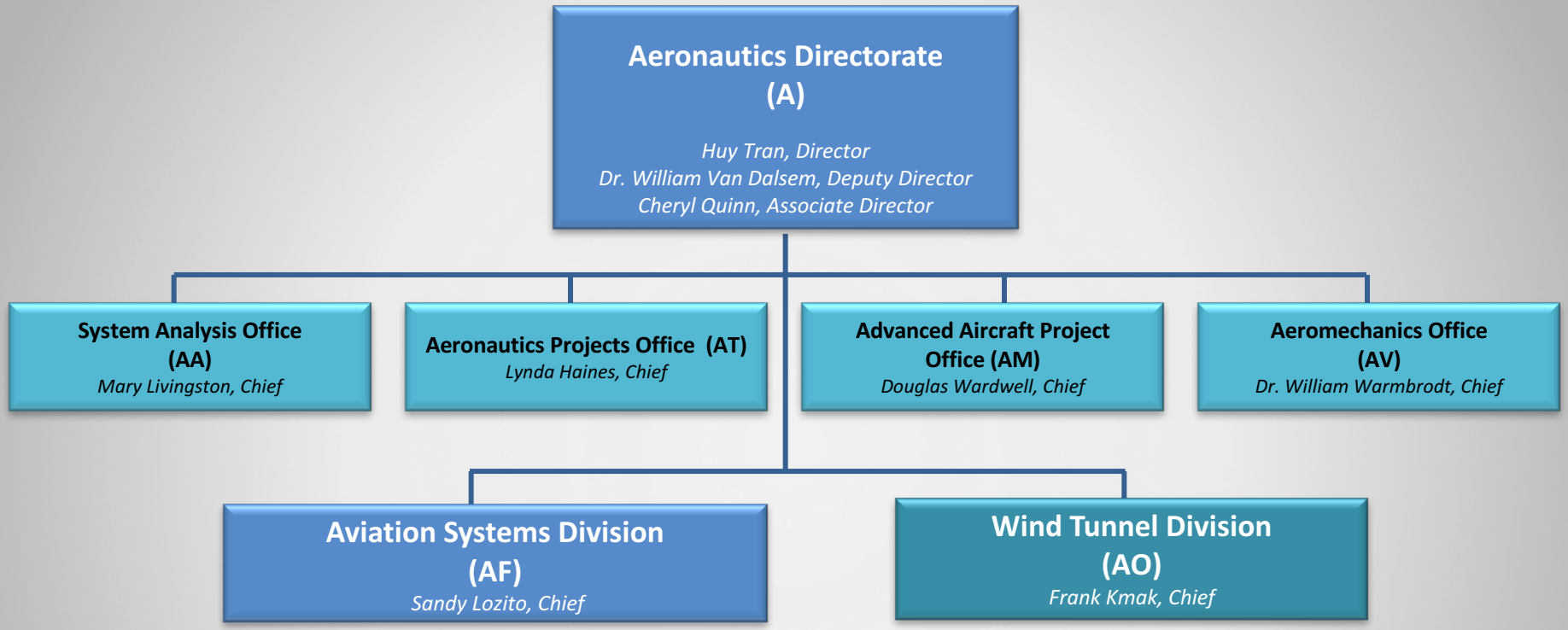
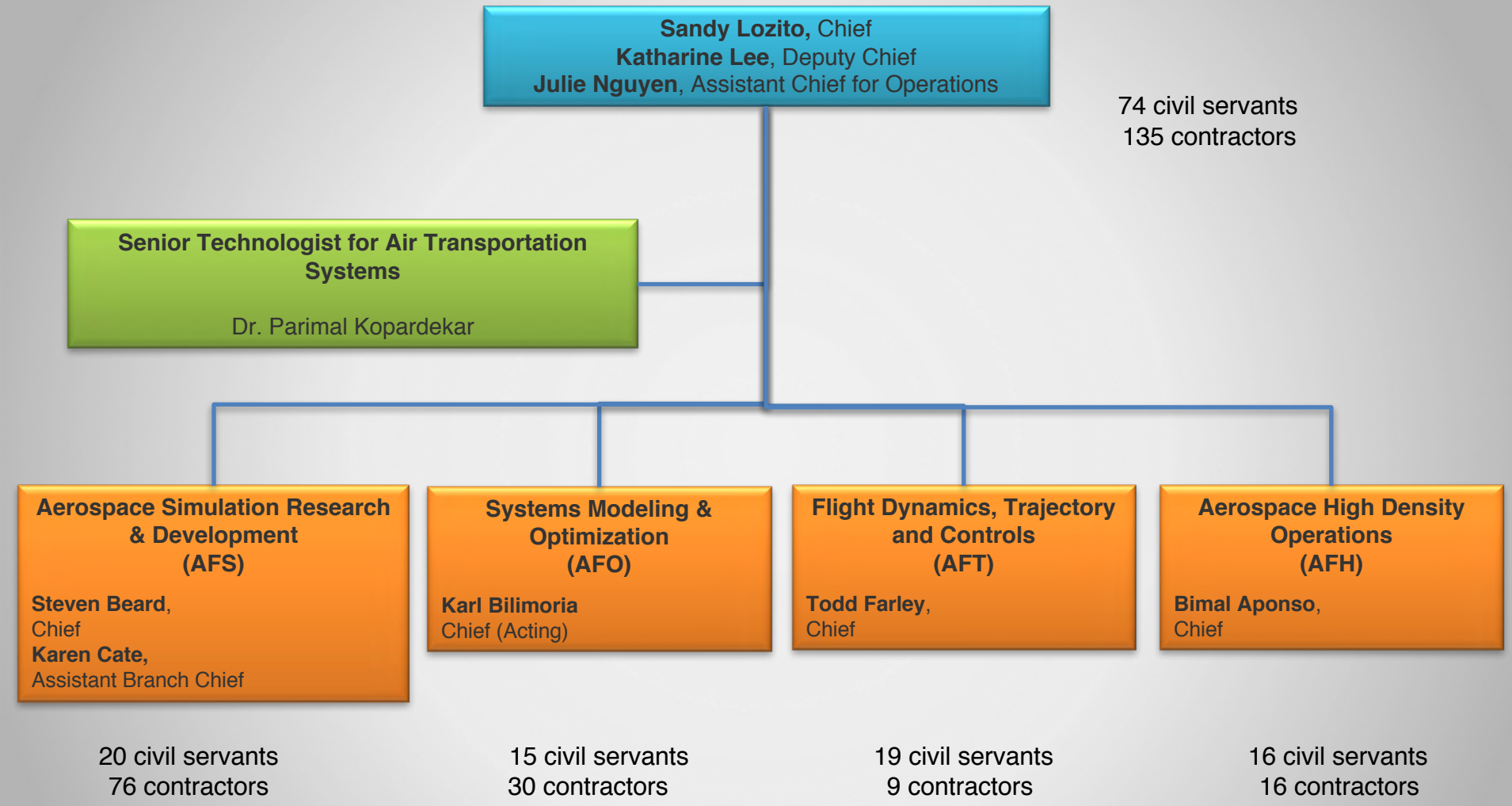


Ames Aeronautics



Last updated 10/3/16

Aeronautics Directorate
Aviation Systems Division (AF)



http://aviationsystemsdivision.arc.nasa.gov

Last updated 6/7/17

NASA Ames

1940

Aviation Systems Division (Code AF)

March 17, 2014

Our Core Abilities

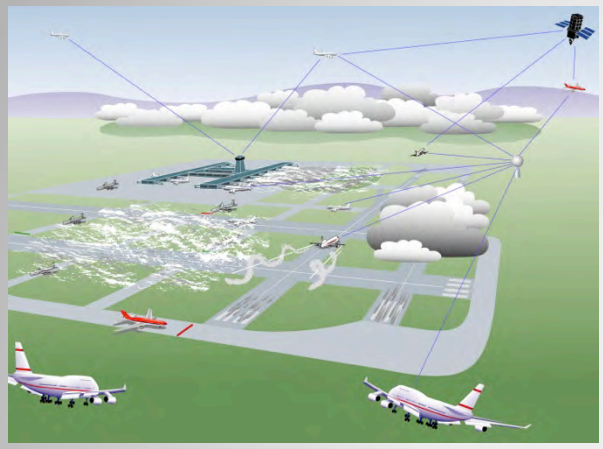
- ATM Research
  - *Airspace domains* – en route, terminal area, surface, nation-wide, regional
  - *Engineering skills* – airspace operations and procedures, optimization, scheduling, trajectory prediction and analysis, data mining, learning algorithms, human factors and automation, software development, computer and systems engineering
- Flight Simulation
  - Operating world-class, high fidelity flight simulators
  - Developing flight simulation scenarios, math models, etc.

Challenges We Confront

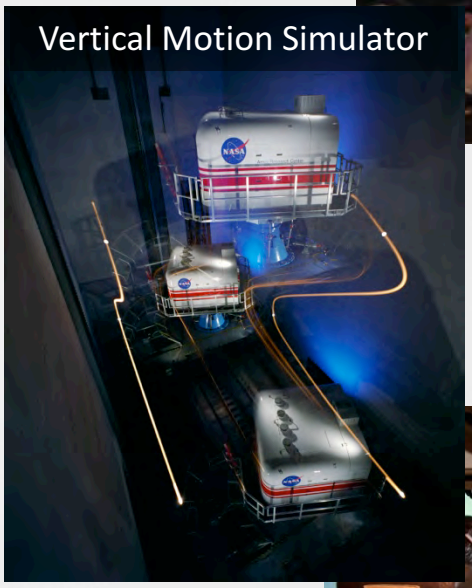
- The air transportation system of the future will need to accommodate a higher demand of commercial air traffic as well as manage a complex mixture of flying vehicles, and meet requirements for maintained safety as well as reduce environmental impact.
- Future commercial air transportation is likely to be comprised of not only the legacy aircraft seen today, but will have to operate alongside more advanced, capable aircraft, and all sizes of unmanned aerial systems (UAS) all vying for the same airspace access.
- The operators of the system increasingly rely on technology advances to make the overall system run more efficiently without compromising safety.

What is the focus of the Aviation Systems Division?

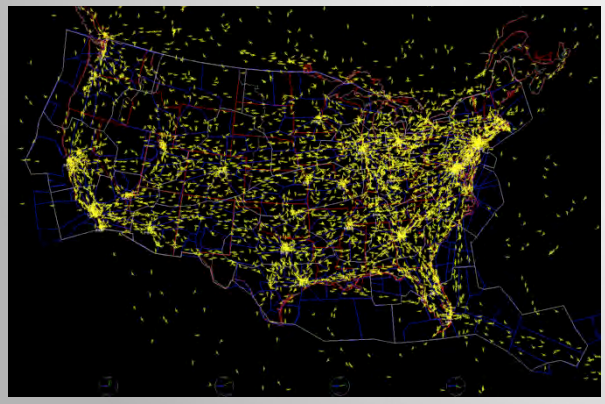
Unmanned Aerial Systems/ UAS Traffic Management



Air Traffic Management



High Fidelity Flight and Airspace Simulation



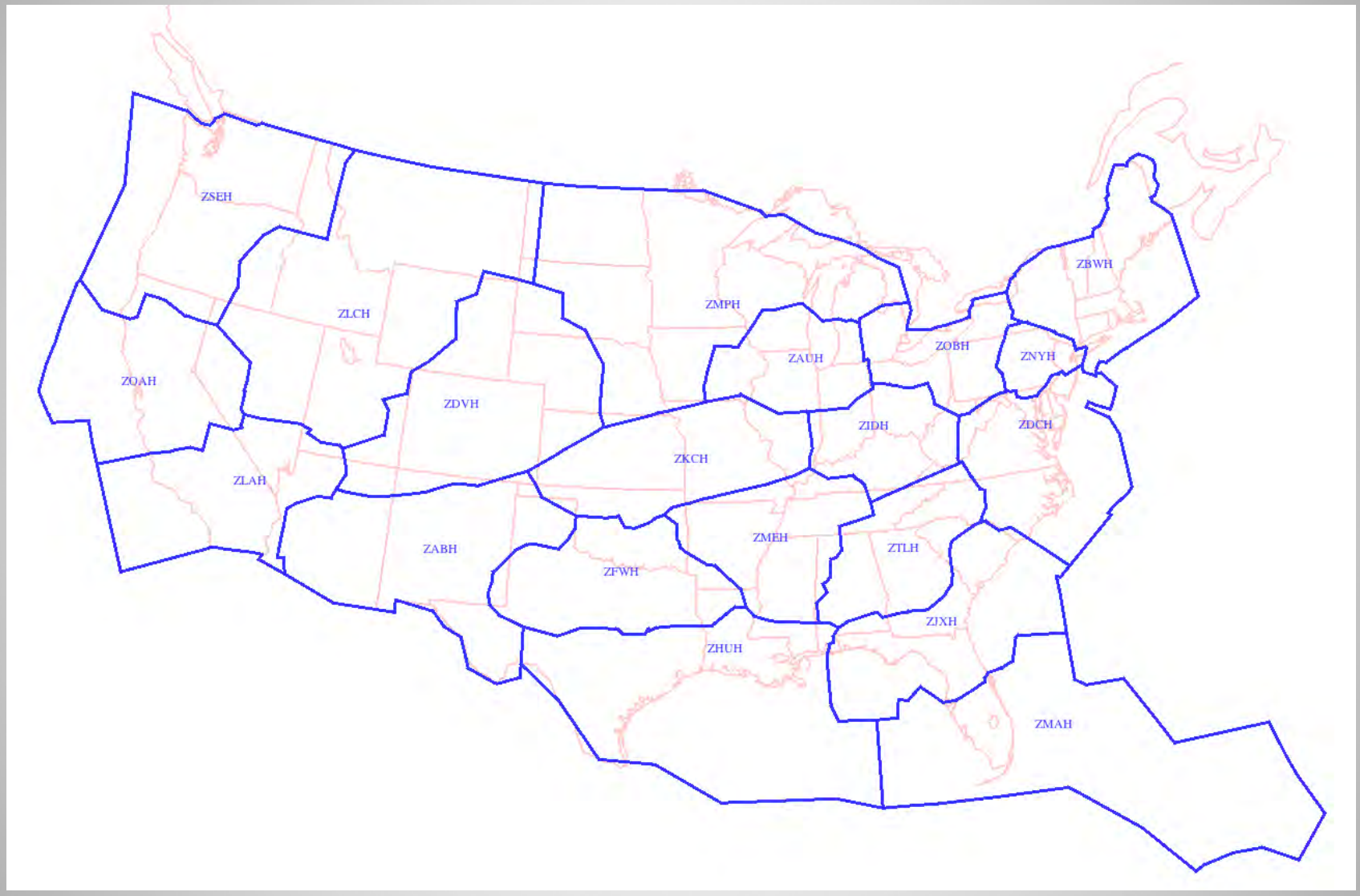
National Airspace System

The network of United States airspace: air navigation facilities, equipment, services, airports or landing areas, aeronautical charts, information/services, rules, regulations, procedures, technical information, manpower, and material.

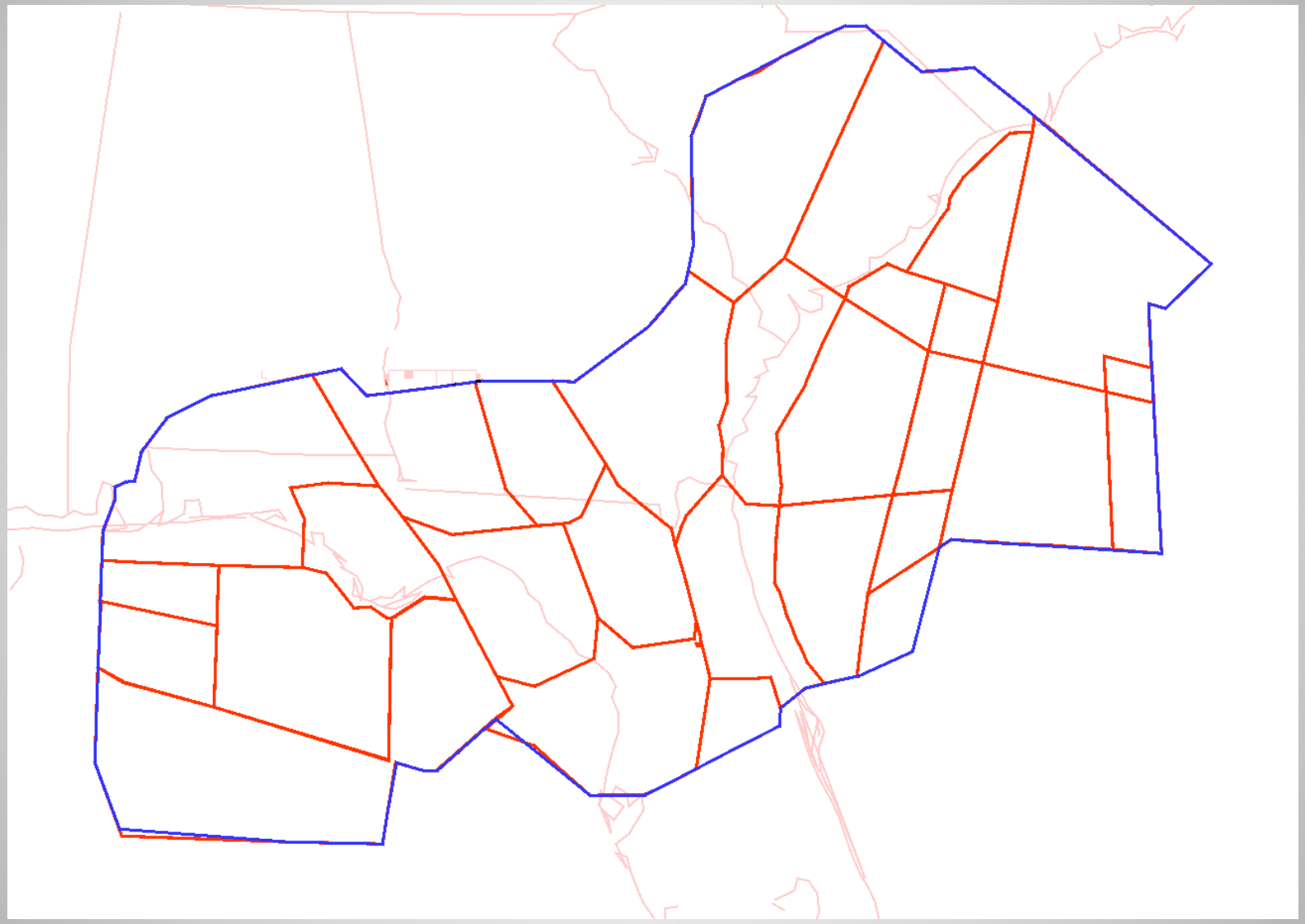
- 280,000+ aircraft
- 19,854 airports
- 16,000 air traffic controllers
- Etc…

Air Traffic Control System Command Center

Air Route Traffic Control Centers



Jacksonville Sectors

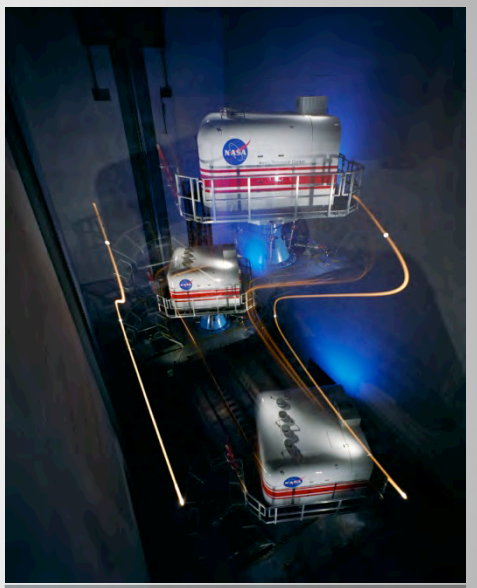


AF Simulation Facilities

Boeing 747-400

Advanced Concepts Flight Simulator

Vertical Motion Simulator



FutureFlight Central

Air Traffic Management Simulation

North Texas Research Station

Dallas/Fort Worth International
679,820 flights in 2014
***3rd** among US airports*
(per ASPM/ATADS)

NTX Research Station…

- NASA research assets embedded in a high-demand, varied operational air transport environment
- Access to ARTCC, TRACON, Towers, 3 air carrier AOCs (American, Envoy and Southwest), and 2 major airports all within 12 miles.
- Supports NASA NextGen research activities from concept development through operational field evaluation.

PARTNERSHIPS

American Airlines
More than 1.1M flights in 2014
***1st** among US air carriers*
(per BTS includes USAir)

NTX Laboratory…

- 5000 ft^2 purpose-built, dedicated, air traffic management research facility
- Re-configurable computer labs, dedicated radio tower, established data links to local operational facilities and NASA centers.
- Research engineers experienced in air traffic operations analysis, technology development, and field evaluations

Dallas Love Field
182,949 flights in 2014
***41st** among US airports*
(per ASPM/ATADS)

Southwest Airlines
More than 1.1M flights in 2014
***2nd** among US air carriers*
(per BTS)

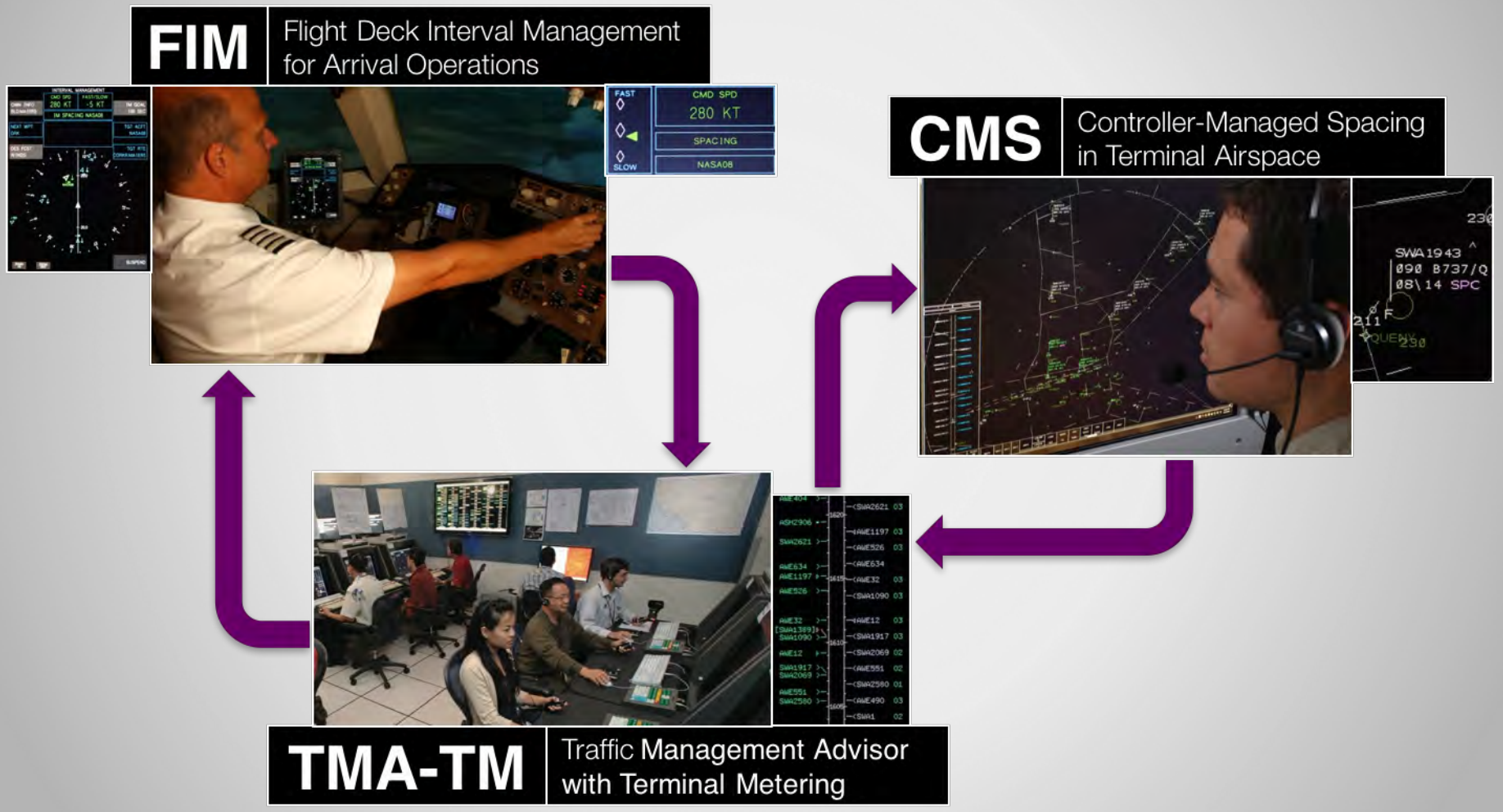
Taking NASA Technology to the Flying Public

- NASA is planning a series of “tech demos” of evolving air traffic management technologies
  - Integrated concepts where appropriate
  - Leveraging some of the most advanced infrastructure (e.g., ADS-B, RNAV/RNP precision routing, etc…)
  - “Live” air traffic evaluations, beginning in 2014
  - New technology “suites” tested every two years

- Transfer of technologies to the FAA and industry once concepts are validated in live traffic tests

ATM Technology Demonstration 1 (ATD-1)

ATD-1 is an integrated set of NextGen technologies that provides an efficient arrival solution



ATM Technology Demonstration 1 (ATD-1)

Time-Based Flow Management (TBFM)

- Generates conflict-free arrival scheduling based on airport conditions, airport capacity, and required spacing.
- Involves metering of terminal area traffic flows to avoid downstream congestion.

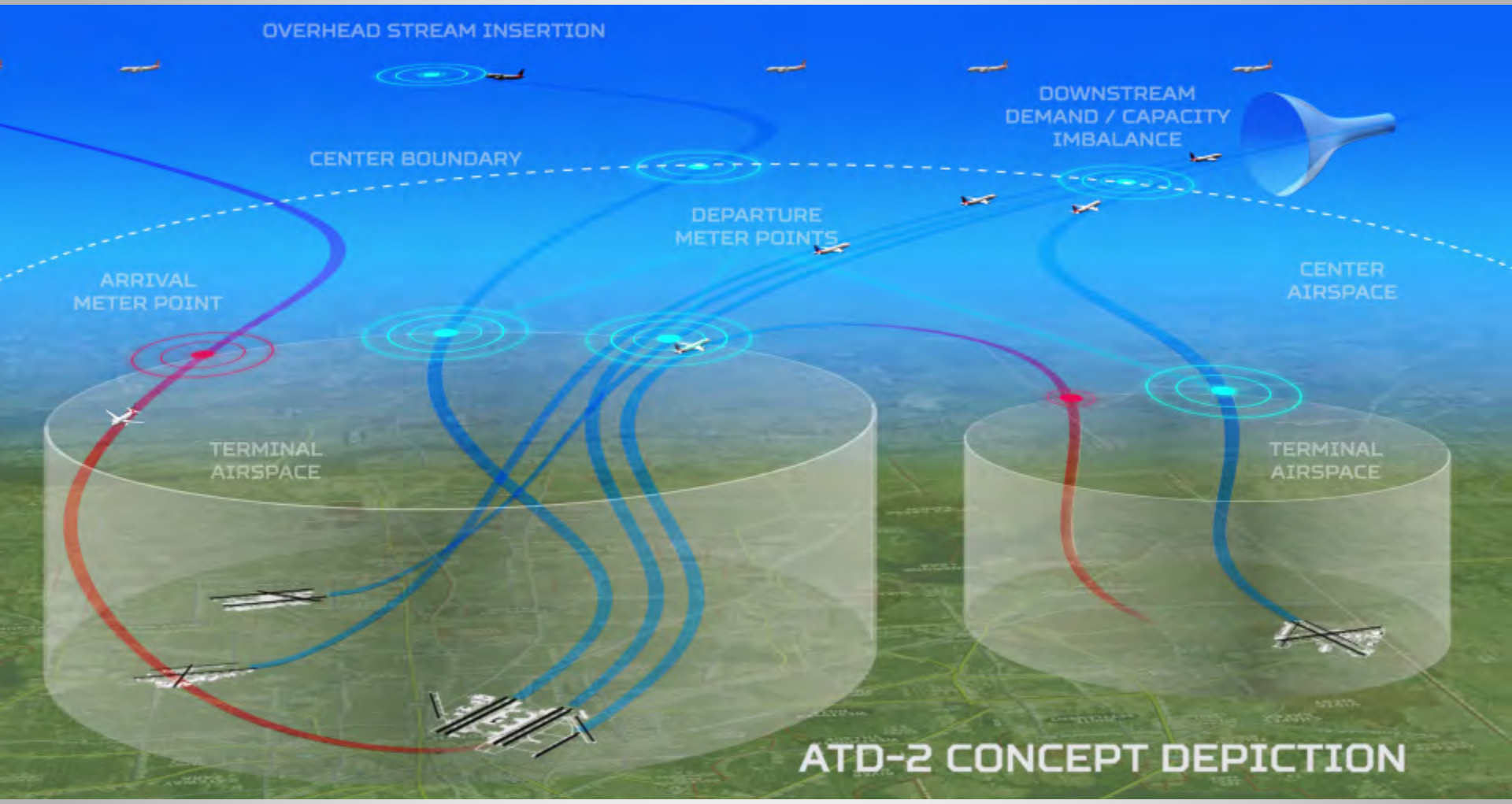
Uses speed adjustments instead of vectoring to precisely maintain aircraft spacing through:

- Controller Managed Spacing (CMS) decision support tools on controller displays.
- Flight Deck Management (FIM) guidance capabilities to pilots using ADS-B (automatic dependent surveillance – broadcast) information.

NAS Delays Due to Weather

- 24-hr delay video
- This animation shows a typical day of air traffic in the national airspace system during convective weather and the scope of the air traffic delay problem. The dots represent actual flights. The gray flights are on time. The flights with blue streaks are delayed between 15 minutes to 2 hours. The flights with red streaks are delayed 2 hours or more.

Airspace Technology Demonstration 2 (ATD-2)



Airspace Technology Demonstration 2 (ATD-2)

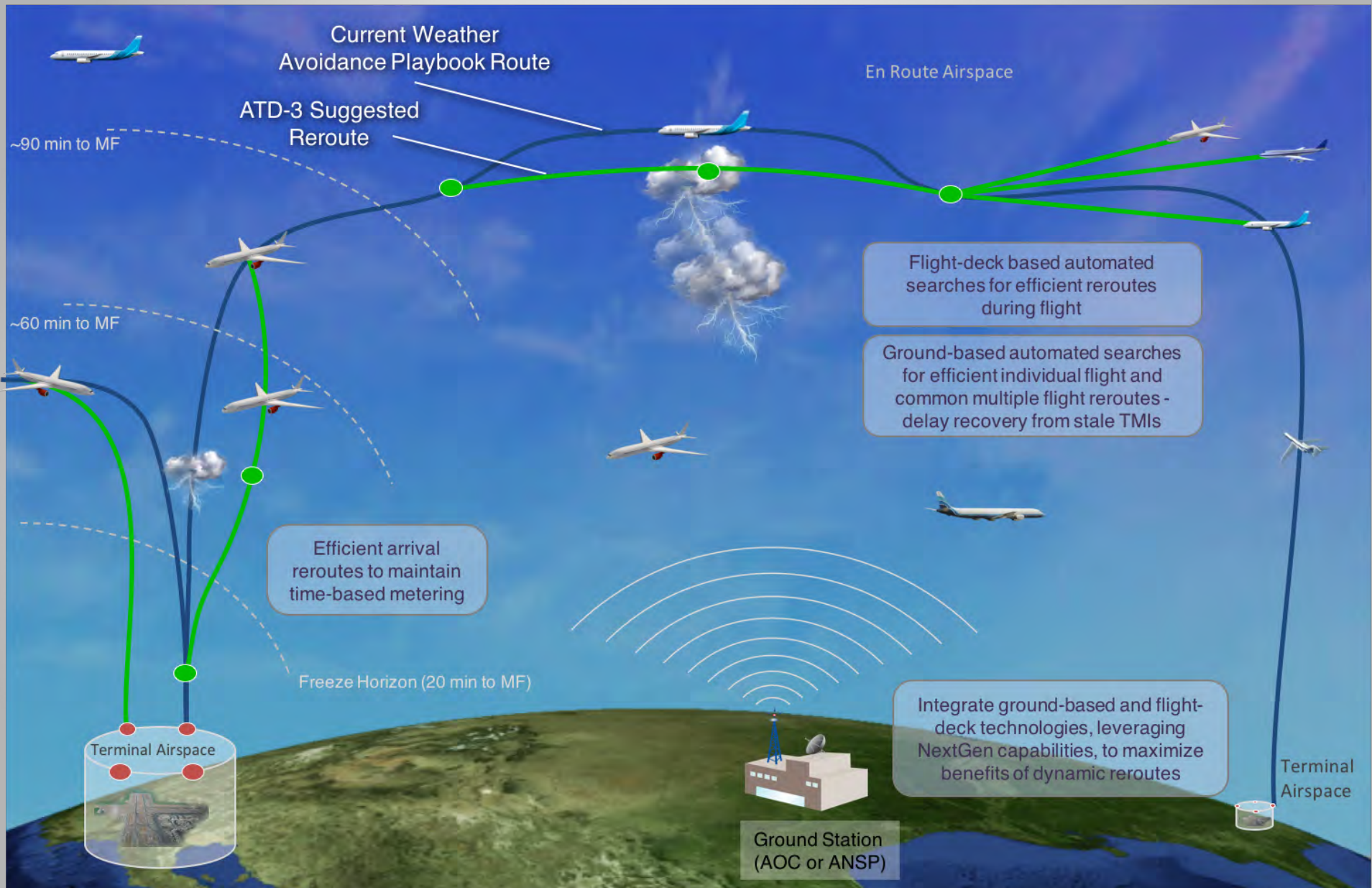
Data exchange and airport/airspace integration

- Collaborative decision making enabled by new data exchange among ATC, flight operators, and airports
- On-ramp to the overhead stream via FAA's Time Based Flow Management system

Surface modeling, scheduling, and metering

- Combines pushback estimates from flight operators with trajectory-based airport operations model to provide accurate capacity estimates
- Implements FAA's Surface Collaborative Decision Making concept for surface metering

Airspace Technology Demonstration 3 (ATD-3)



Airspace Technology Demonstration 3 (ATD-3)

NASA is developing and plans to demonstrate technologies and procedures to identify strategic, user-preferred routes and enable tactical route corrections in domestic en route and arrival airspace to:

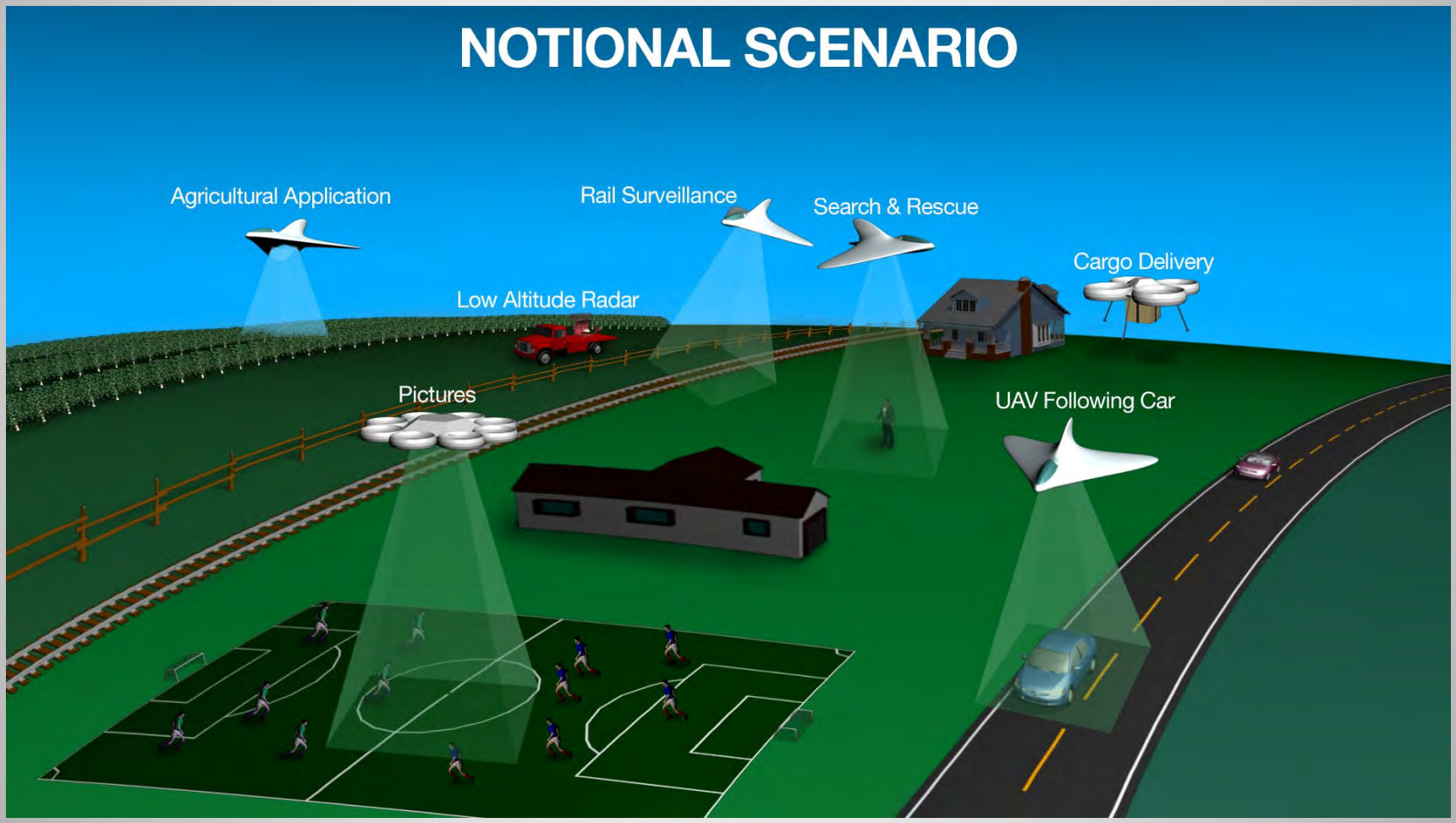
- Reduce the impact of unpredictable weather
- Enable continuous searching for more efficient routes for individual flights and groups of flights
- Efficiently share route correction options between traffic managers, controllers, pilots, and dispatchers

UAS in the NAS

- Conducted a series of experiments to measure the time to transmit aircraft state data, involving NASA Ames, Dryden, and Glenn
- Developed and delivered algorithms that provide the UAS's sense-and-avoid capabilities
- Collected more data on defining the airborne separation standard "well clear" and when to notify the pilot of potential collision situations.

UAS Traffic Management (UTM)

NASA is helping establish infrastructure to enable and safely manage the widespread use of low-altitude airspace and UAS operations.



Where do we see NASA's benefits today?

NASA's fundamental research can be traced to ongoing innovation.

Efficient Descent Advisor

NASA's work on these technologies

- Human-in-the-loop simulations
- Joint flight trials with FAA and airlines
- Automated decision support tools
  - Traffic Management Advisor
  - 3-Dimensional Path Arrival Management
- Trajectory and arrival modeling and solutions

Was transferred for use here

Transferred to the FAA in November 2011 for phased deployment starting 2014; full deployment by 2020.

Federal Aviation Administration
Source: FAA

Benefits

- Fuel-efficient continuous descents
- Potential $300 million jet fuel savings per year (savings vary per spot fuel costs)
- Reduced delays in congested airspace
- Reduced noise and emissions around airports
- Retained safety
- Reduced controller workload through increased automation

Precision Departure and Release Capability

NASA's work on these technologies

- Human-in-the-loop simulations
- Operational field trials
- Automated decision support tools

Was transferred for use here

Transferred to FAA in August 2013 for further development and implementation.

Federal Aviation Administration
Source: FAA

Benefits

- Improved precision in departure times even in bad weather and heavy traffic
- Reduced number of "missed" slots in overhead aircraft traffic stream
- More than 50% improvement in number of flights departing within release window
- Reduced congestion system-wide

Terminal Sequencing and Spacing

NASA's work on these technologies

- Human-in-the-loop simulations
- Operational field trials
- Automated decision support tools

Was transferred for use here

Transferred to FAA in February 2014 for further development and implementation.

Federal Aviation Administration
Source: FAA

Benefits

- Improved controller ability to coordinate flight paths of descending aircraft in congested airspace
- Increased capacity for aircraft in same amount of airspace
- Improved traffic flow

Where do we see NASA's benefits today?

NASA's fundamental research can be traced to ongoing innovation.

Traffic and Atmospheric Information for General Aviation

NASA's work on these technologies

- Human-in-the-loop simulations
- Operational field trials
- Automated decision support tools

Was transferred for use here →

Transferred to the State of Alaska's Department of Transportation in 2014 for implementation.

State of Alaska's DOT

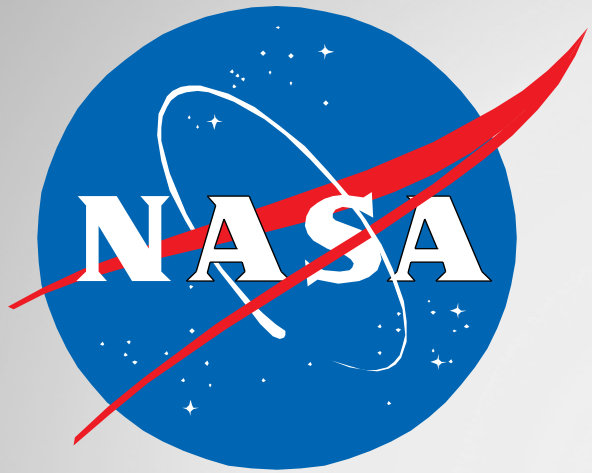
Source: Alaska DOT

Benefits →

- Improved situation awareness to general aviation and air taxi pilots
- Better access to data and better interaction with that data on a modern, off-the-shelf mobile device

How do NASA and the FAA work together?

Our roles are different but our goals to improve efficiency and safety are the same.



Conducts long-term research and development	Conducts regulation and certification
Partners with FAA to ensure new concepts and tools can be adopted into FAA's system	Partners with NASA to access expertise and testing facilities to prove viability of a new idea
Transfers data and tools to the FAA	Takes data and tools from NASA for further verification and validation, certification, and eventual deployment to aircraft and/or airports

Collaborating Partners

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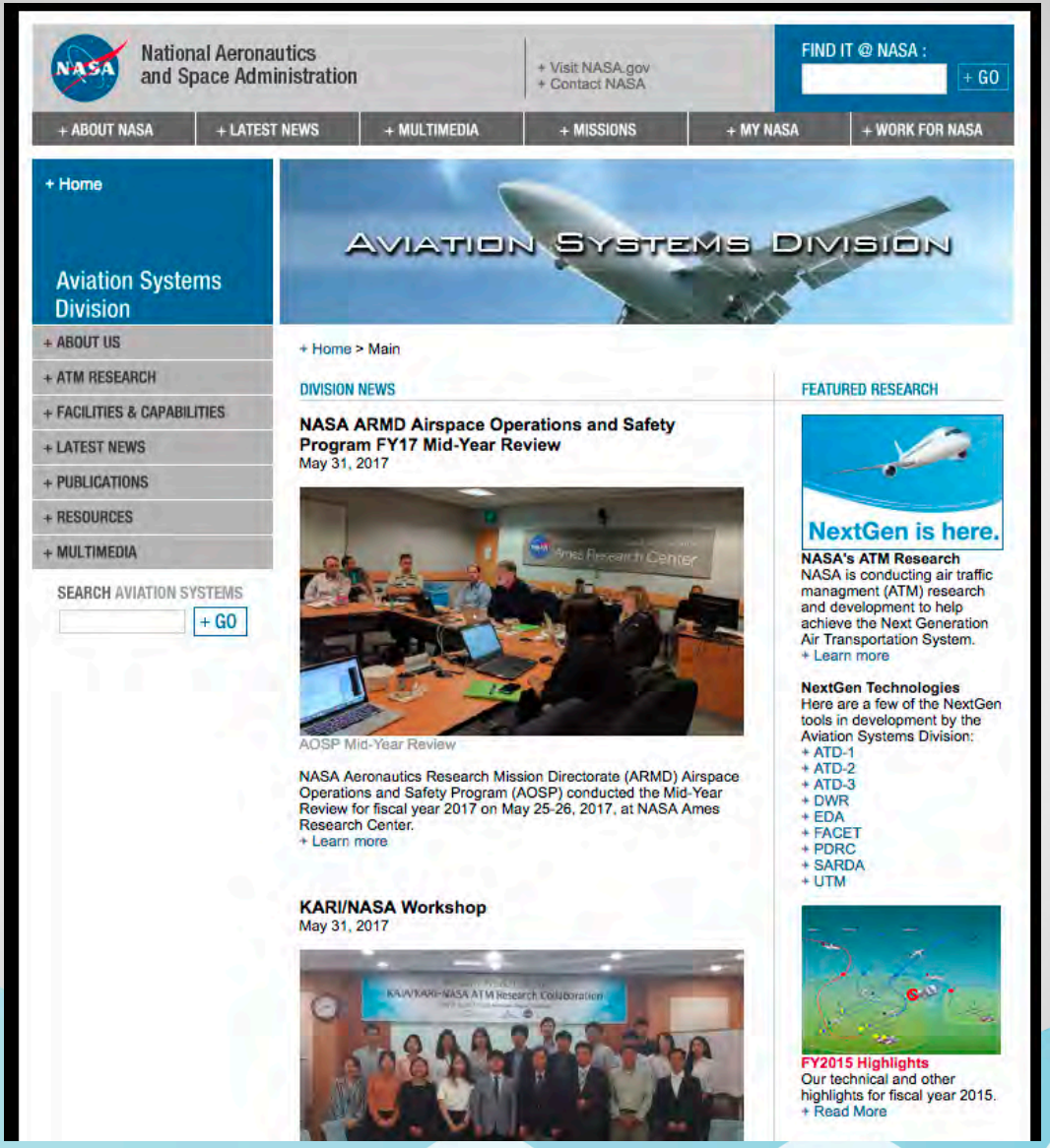
www.aviationsystems.arc.nasa.gov



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