NextGen 101

John Brandt / Nazanin Bonds

UC Davis Aviation Noise & Emissions Symposium 2019

March 3, 2019

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Agenda

- Introduction
- Air Traffic Control (ATC) Overview
- NextGen Overview
- Environmental Perspective
- Summary
- Q & A

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Introduction

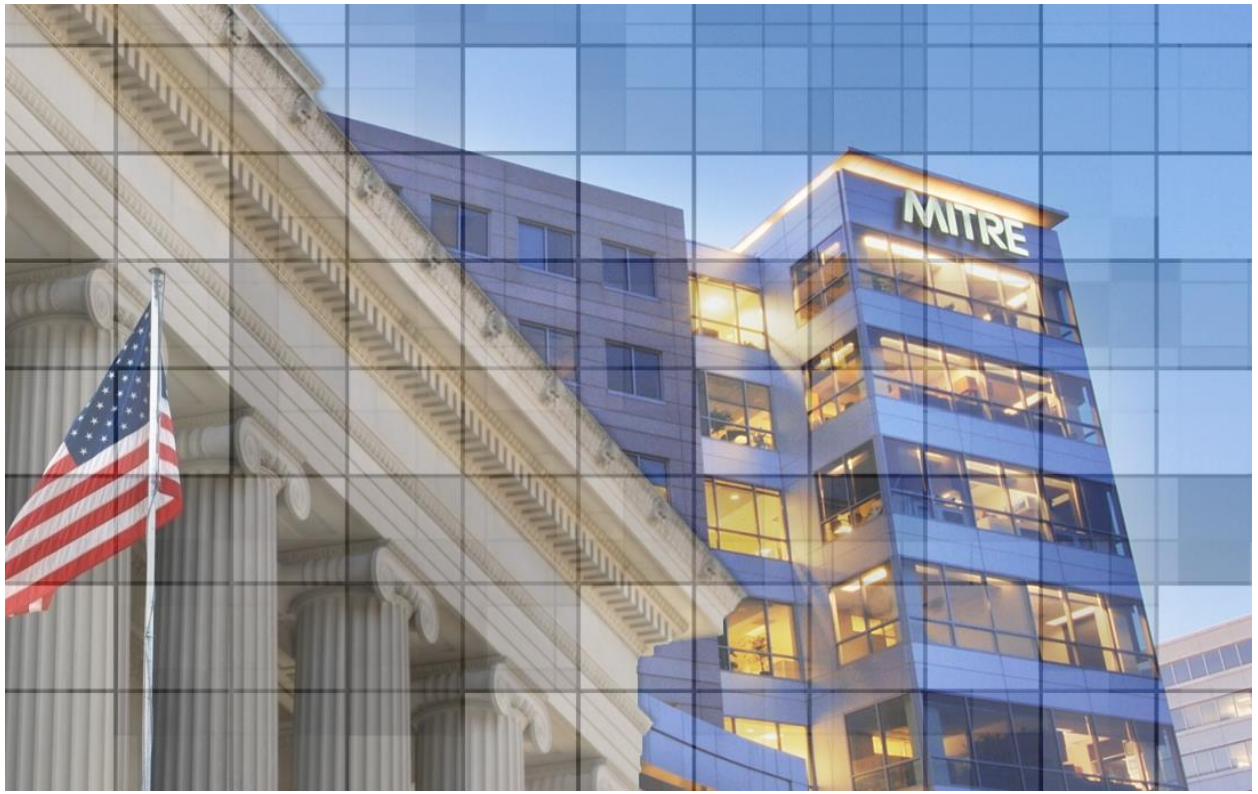
MITRE is Unique

objectivity & **independence**

public interest

long-term relationship

strategic partner



established **1958**

not-for-profit

conflict-free environment

science & **technology**

7 centers since 1958

1958 1990 1998 2009 2010 2012 2014

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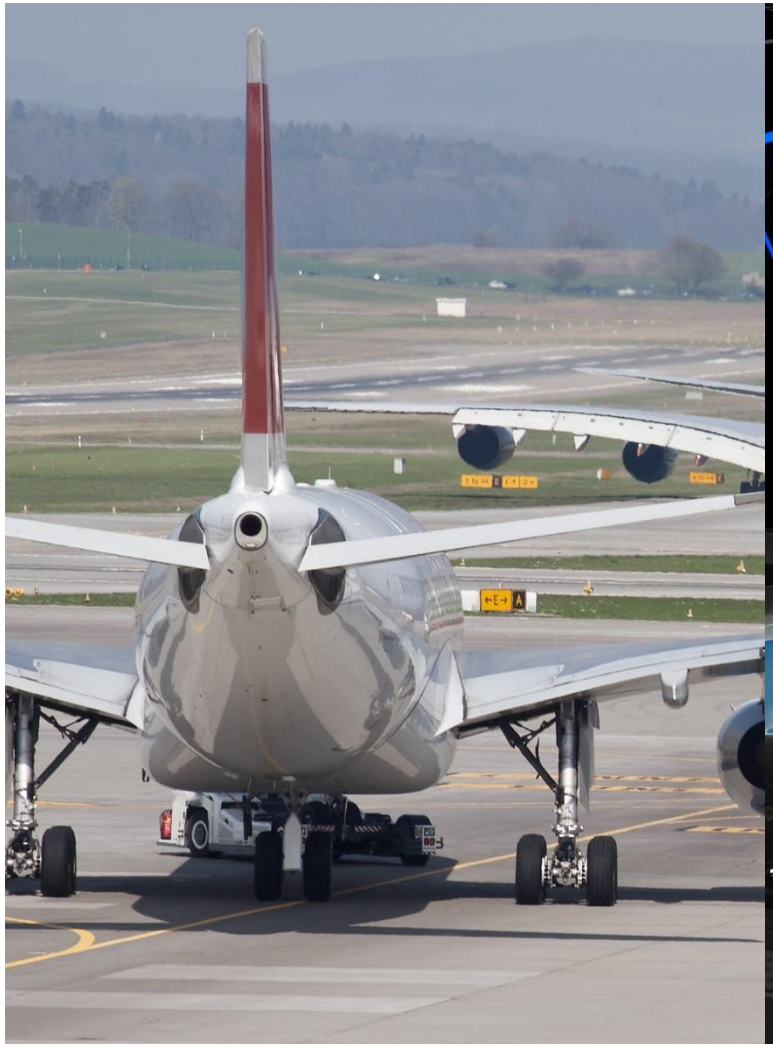
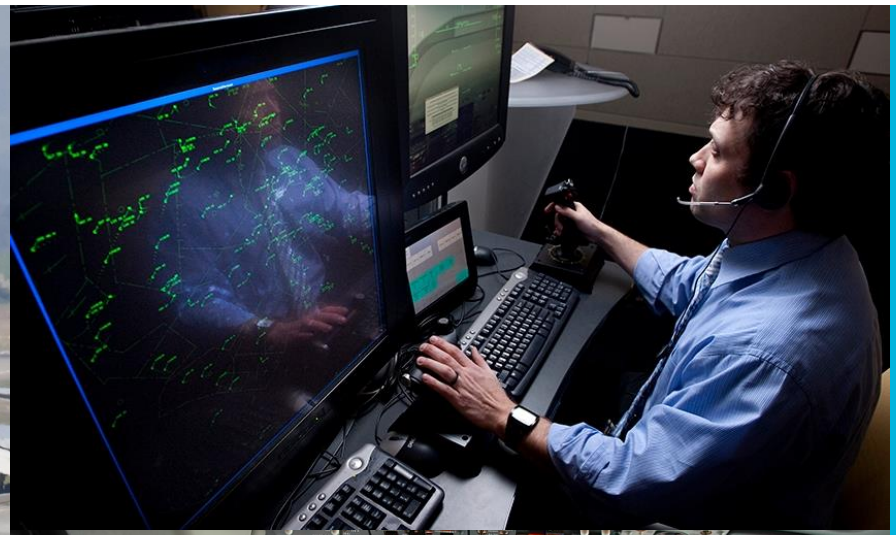
Center for Advanced Aviation System Development (CAASD) Federally Funded Research and Development Center (FFRDC)





OUR MISSION:

To serve the public interest by advancing the **safety, security, effectiveness, and efficiency** of aviation in the **United States and around the world** by conducting a continuing program of research, development, and engineering **in collaboration with the aviation community**

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NextGen 101 Training

- **Objective: Provide a broad overview of the National Airspace System (NAS) and FAA's Next Generation Air Transportation System (NextGen) modernization efforts**

- **Key messages:**
  - What is NextGen?
  - Why is it needed?
  - What are the implications and opportunities?

Approach to Training

- **Ask questions throughout**
- **If we don’t know the answers, we will try to get them**
- **Briefing materials will be made available afterwards so no need to write things down**

Air Traffic Control (ATC) Overview

What is the National Airspace System (NAS)?

The NAS is:

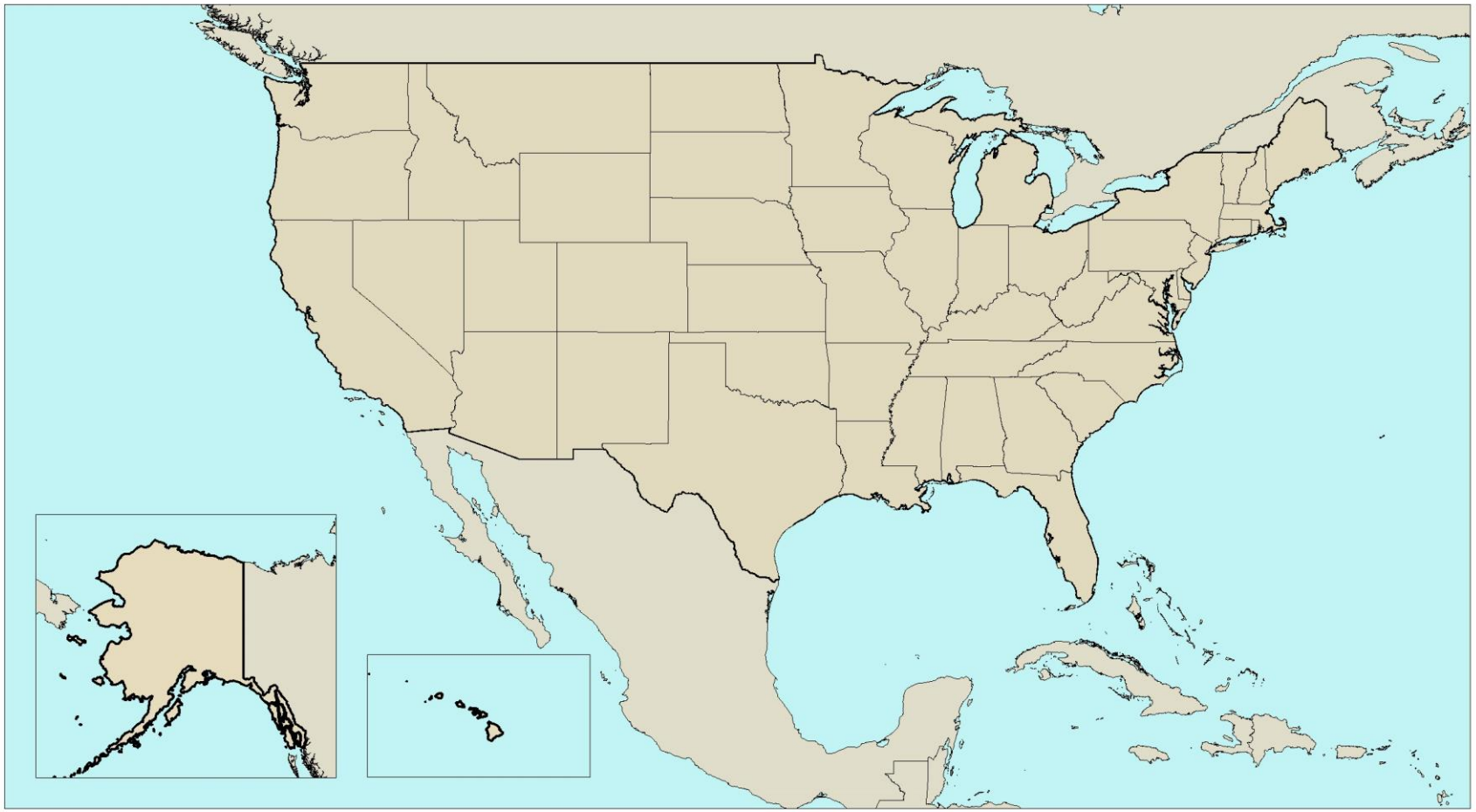
- The airspace, navigation facilities, and airports of the United States
- The associated information, services, rules, regulations, policies, procedures, personnel, and equipment

Image Source: FAA

How Big is the NAS?

Image Source: FAA

What Types of Facilities are in the NAS?



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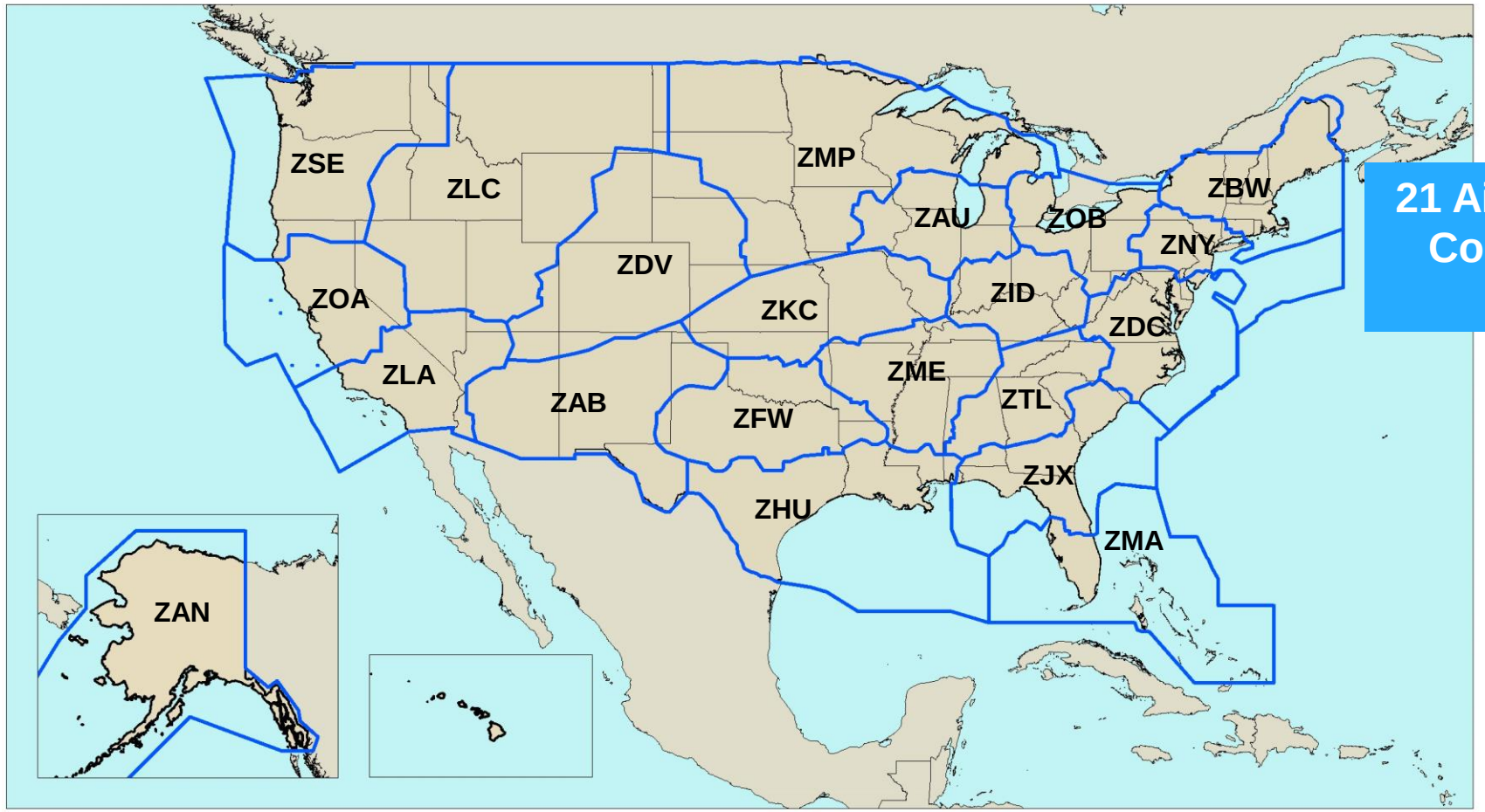

21 Air Route Traffic Control Centers (ARTCCs)

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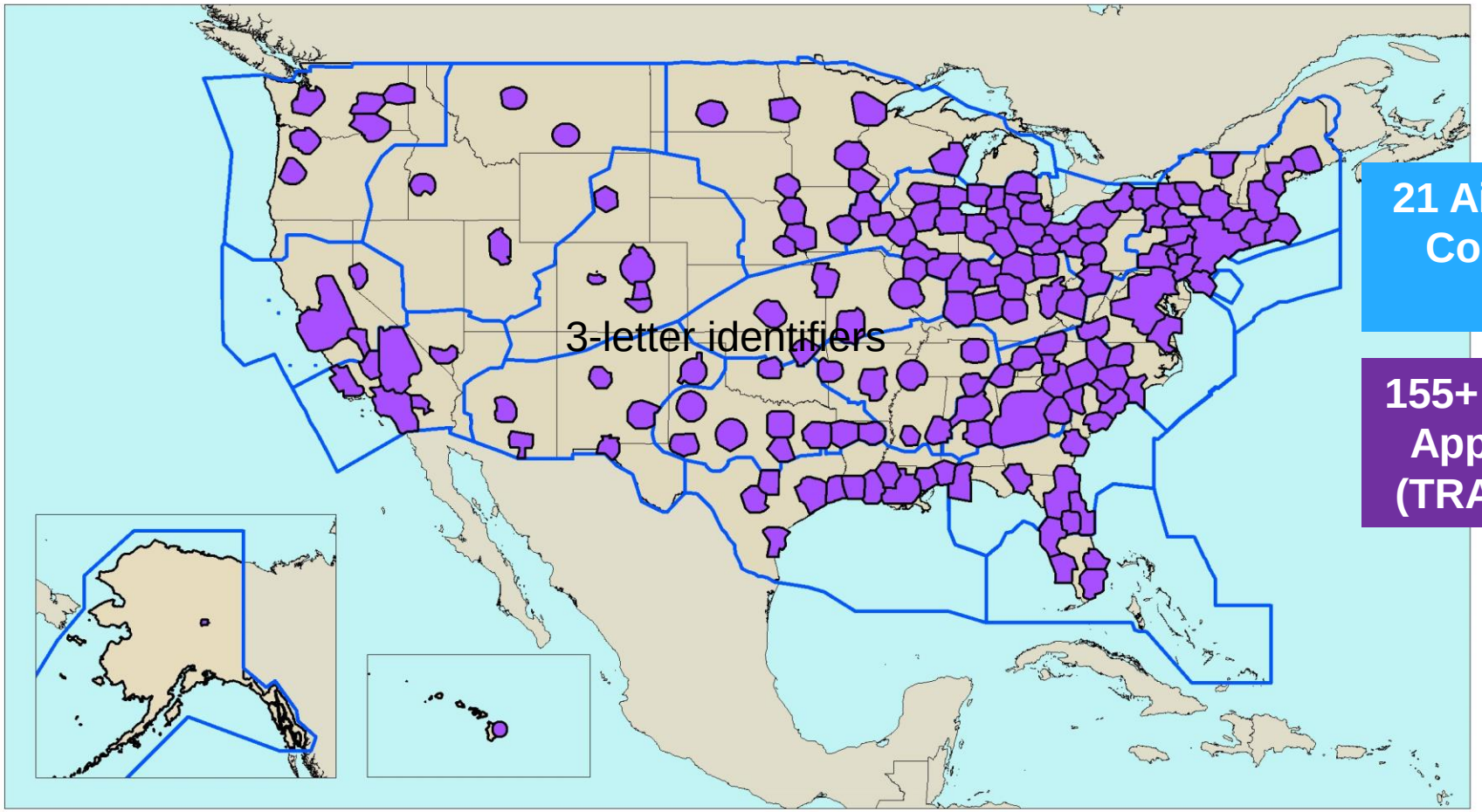
What Types of Facilities are in the NAS?



21 Air Route Traffic Control Centers (ARTCCs)

155+ Terminal Radar Approach Control (TRACON) facilities

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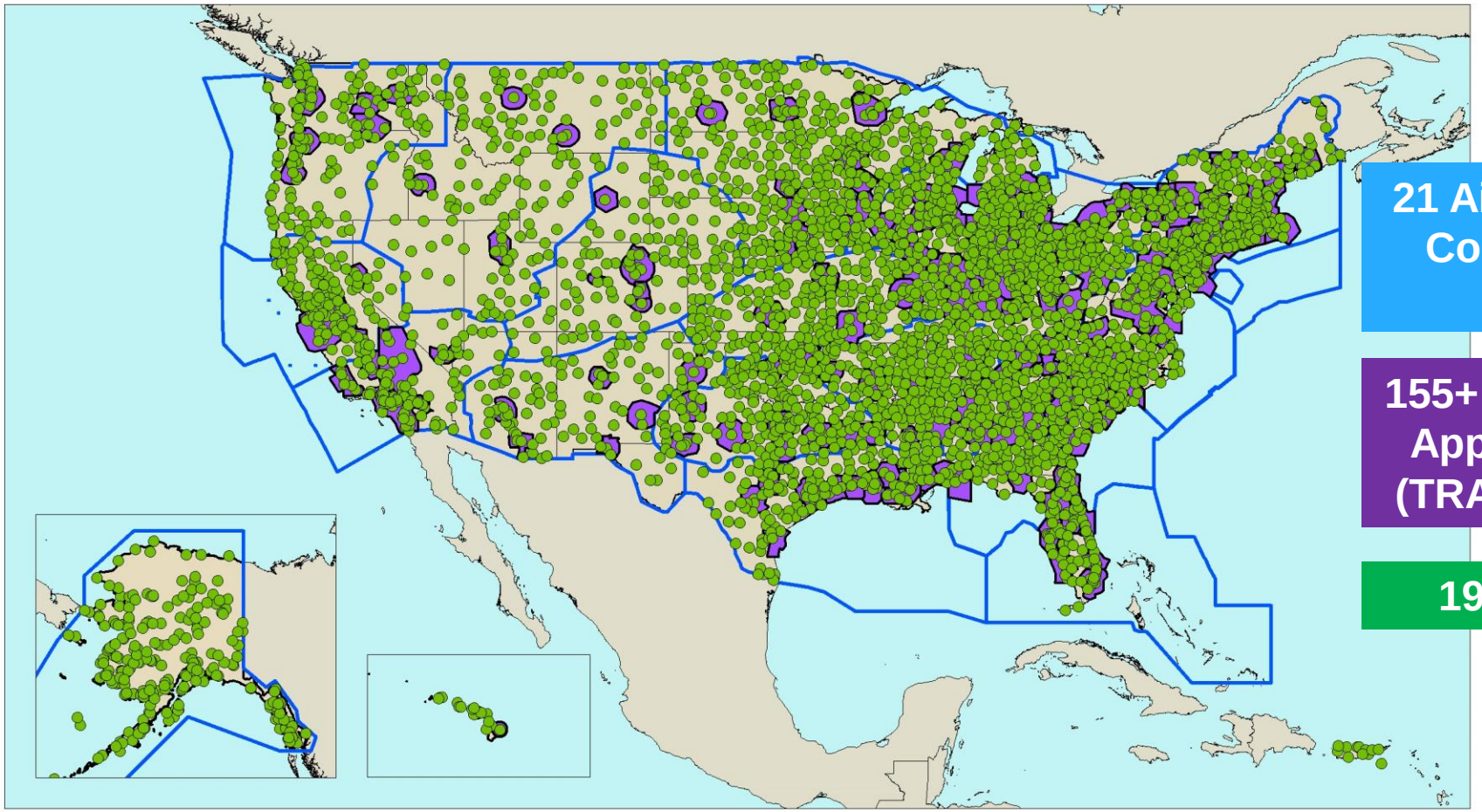
What Types of Facilities are in the NAS?



21 Air Route Traffic Control Centers (ARTCCs)

155+ Terminal Radar Approach Control (TRACON) facilities

19,000 Airports

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Who Operates the NAS Using What Equipment?

Image Source: FAA

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How Many Operations Are in the NAS?

Image Source: FAA

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Who are the NAS Consumers / Users?

Image Source: FAA

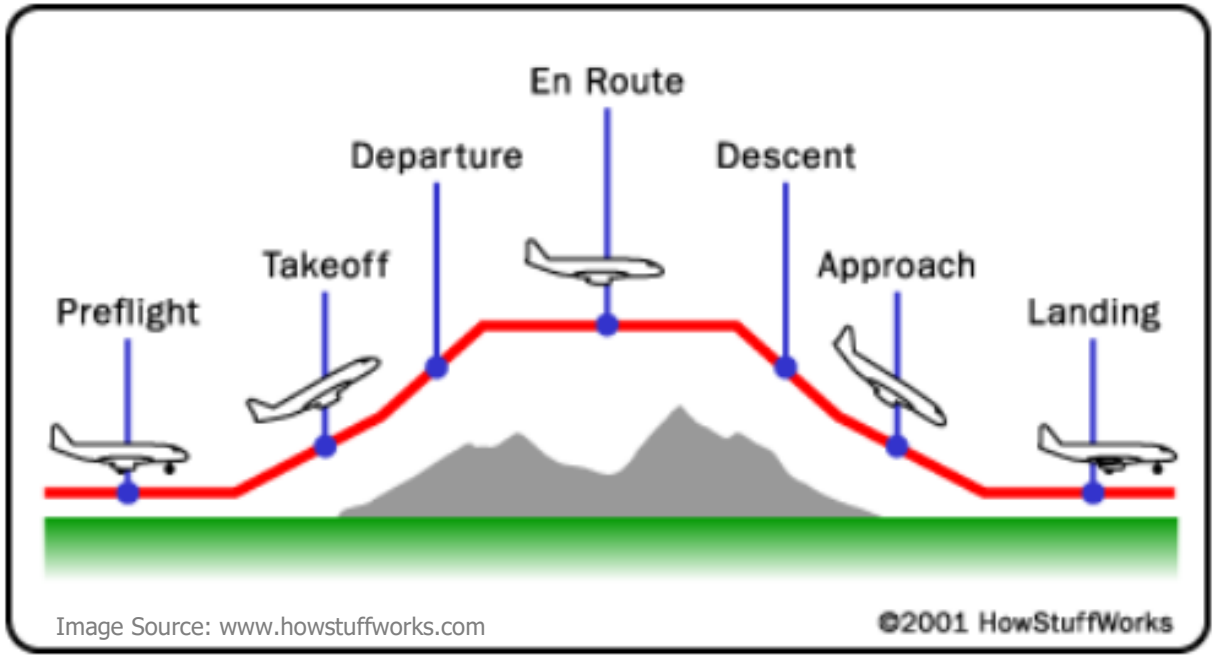
Additional Facts

- The NAS is comprised of several types of airspace that govern the rules and regulations that controllers and pilots must follow
- The National Air Traffic Controller's Association (NATCA) is the exclusive bargaining unit representative for FAA air traffic controllers, including traffic management coordinators and some support staff
- Most U.S. airports are not managed by air traffic controllers and are considered "uncontrolled"
- Air traffic control facilities take many forms and often have unique operational needs

Air Traffic Facilities

Phases of Flight

Typical profile of a commercial airline flight:



- **Preflight:** Starts on the ground and includes flight checks, push-back from the gate and taxi to the runway
- **Takeoff:** The pilot powers up the aircraft and speeds down the runway
- **Departure:** The plane lifts off the ground and climbs to a cruising altitude
- **En route:** The aircraft travels through one or more center airspaces and nears the destination airport
- **Descent**: The pilot descends and maneuvers the aircraft to the destination airport
- **Approach**: The pilot aligns the aircraft with the designated landing runway
- **Landing**: The aircraft lands on the designated runway, taxis to the destination gate and parks at the terminal

Air Traffic Facilities

Tower (Departure)

- Controls aircraft on the ground
- Gives departure clearance
- Controls aircraft in the air within 5 miles

TRACON

- Controls aircraft in the terminal airspace
- 5 to 40 miles from the airport or until an altitude of above ~10,000 feet

ARTCC(s)

- Controls aircraft in its specific airspace
- Airspace is divided into sectors
- The control of aircraft is handed from one sector to another and from one ARTCC to another when a boundary is crossed

TRACON

- Controls aircraft in the terminal airspace
- 5 to 40 miles from the airport or until handed off to Tower

Tower (Arrival)

- Controls aircraft on the final approach to the airport
- Gives clearance to land
- Controls aircraft on the ground

Image Source: FAA

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Air Traffic Control Towers (ATCTs)

- **Tower with Radar**
  - Located at an airport (not all airports have ATCTs)
  - Provides advisories, spacing, sequencing, and separation services to Visual Flight Rule (VFR) and Instrument Flight Rule (IFR) aircraft operating in the vicinity of the airport
  - Uses a combination of radar and direct observations
- **Combination Tower with Radar and Radar Approach Control**
  - Two functional areas that are located within the same facility or in close proximity to one another
    - Tower positions
    - Radar approach control positions
  - Provides radar-control service to aircraft arriving or departing the primary airport and adjacent airports, and to aircraft transitioning the terminal's airspace
- **Other**
  - Tower without radar
  - Combination non-radar approach control and tower without radar

Tower

Combined Tower and TRACON

Image Source: FAA

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Terminal Radar Approach Control Facilities (TRACONs)

- **Provide radar-control service to aircraft arriving or departing the primary airport and adjacent airports and to aircraft transitioning the TRACON's airspace**
- **Responsible for airborne aircraft ~5-40 miles from origin/destination**
- **FAA TRACON Types:**
  - Standalone TRACON
  - Combined TRACON and Tower with Radar
  - Combined Control Facility
  - Combined TRACON

Combined TRACON

Combined Tower and TRACON

Air Route Traffic Control Centers (ARTCCs or Centers)

- **Provide air traffic control service to aircraft operating under Instrument Flight Rules (IFR) flight plans within controlled airspace and principally during the en route phase of flight**

Indianapolis ARTCC (ZID)
Image Source: FAA

- **Area of Operation:**
  - The control room is divided into areas of operation
  - Each area consists of a group of sectors (basic unit in each area of operation)
    - Classified as radar, non-radar, or oceanic
    - Subclassified by altitude strata
  - Number of areas is based on ARTCC's requirements and staffing needs

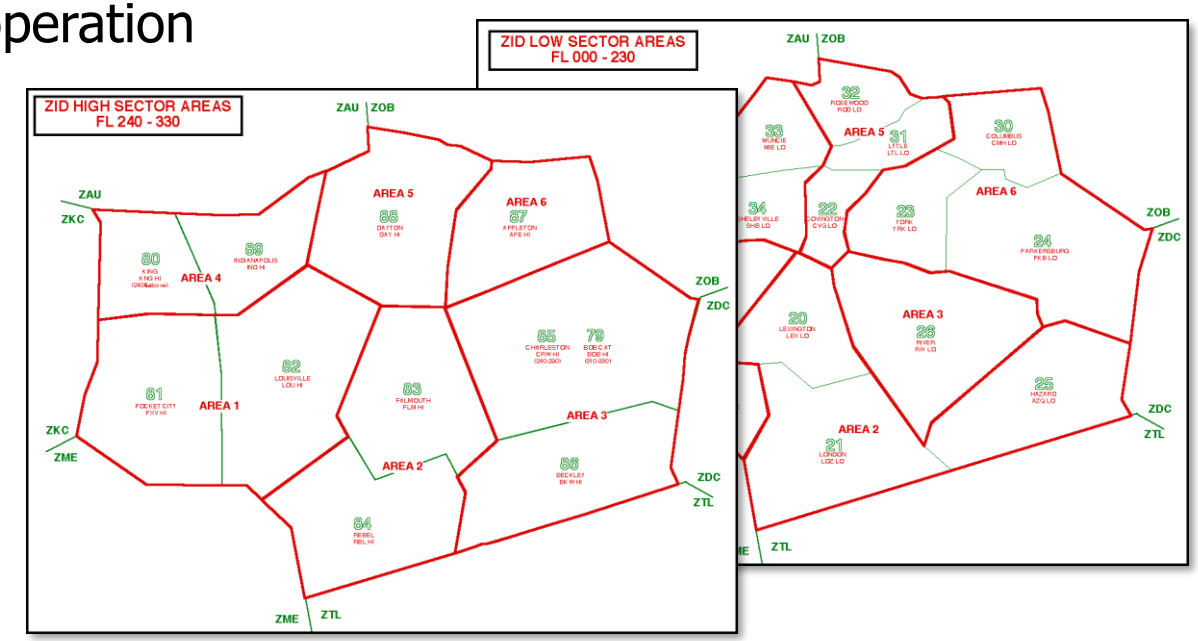

Image Source: www.pointsixtyfive.com

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Air Traffic Control System Command Center (ATCSCC) (aka Command Center)

- **Located in Warrenton, VA**
- **Became operational in May 1994 and is the largest, most sophisticated facility of its kind in the world**
- **Works in collaboration with ARTCCs, TRACONs, ATCTs, and Aviation Industry Partners**
- **Responsible for the strategic aspects of the NAS**
- **Balances air traffic demand with system capacity**

Image Source: AviationWeek.com

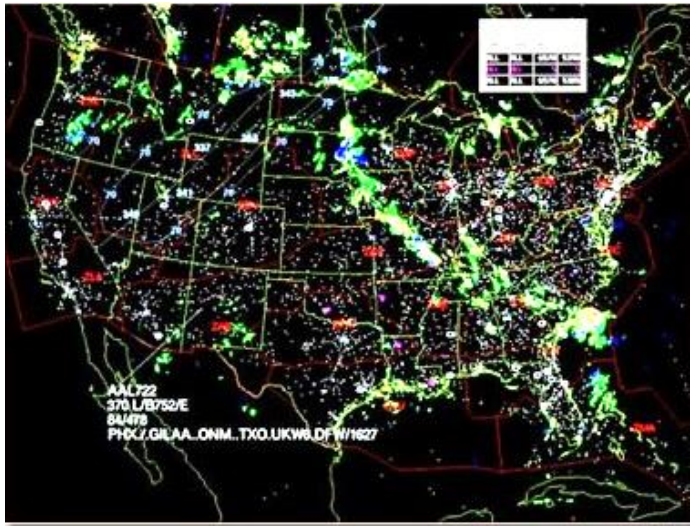

Image Source: FAA

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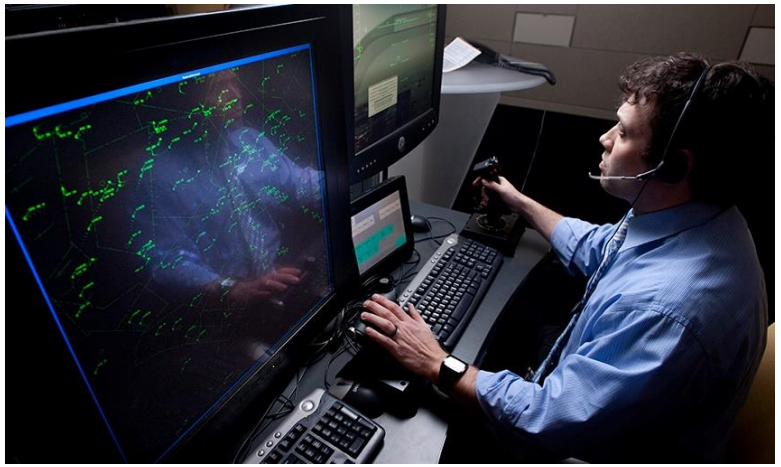
Air Traffic Management (ATM)

Air Traffic Management (ATM)



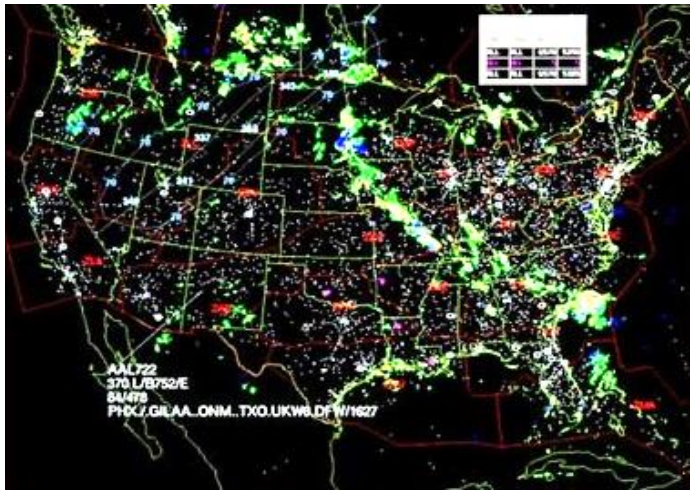
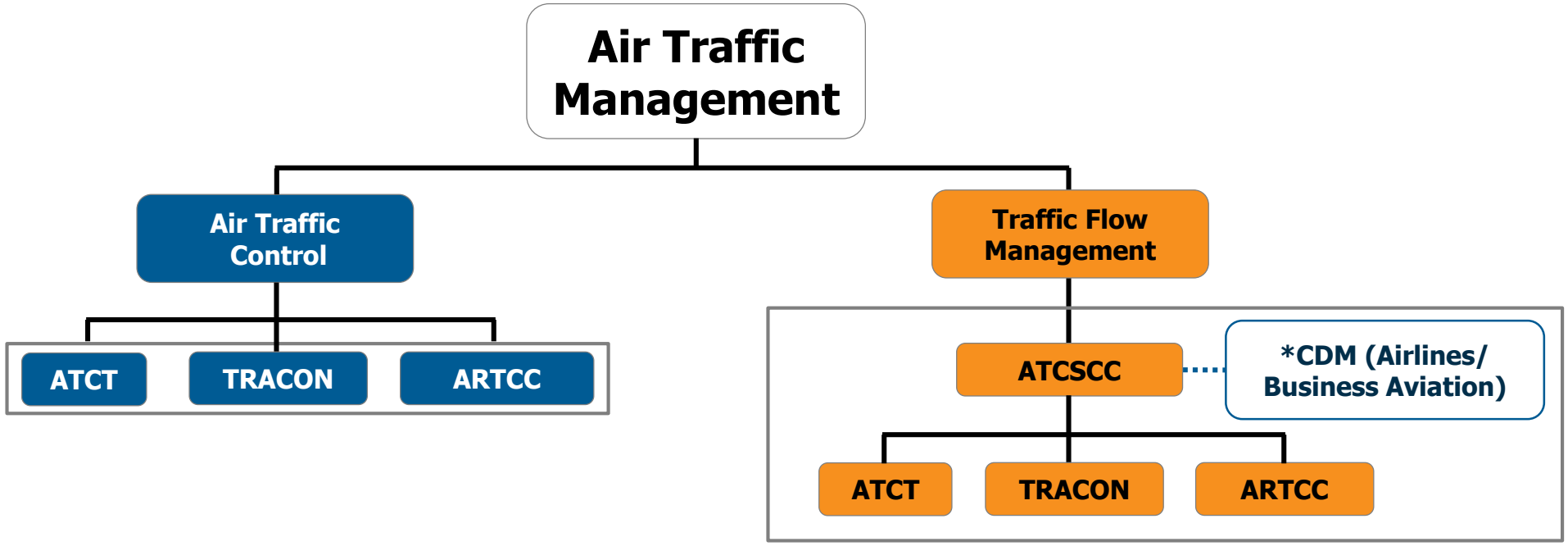


Image Source: FAA

- **Air Traffic Control (ATC)**
  - Provides for safe separation of aircraft for each phase of flight
  - Controllers speak directly with pilots
- **Traffic Flow Management (TFM)**
  - Develops and implements strategies to address situations where demand exceeds capacity
  - "System approach" to managing traffic

Facilities Involved in ATM



* Collaborative Decision Making (CDM) – a joint government / industry initiative aimed at improving air traffic flow management through increased information exchange among aviation community stakeholders

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Tactical vs Strategic Traffic Flow Management

Tactical traffic flow management typically refers to the tasks or procedures that are carried out in a relatively short amount of time (< 2 hours) in a localized area

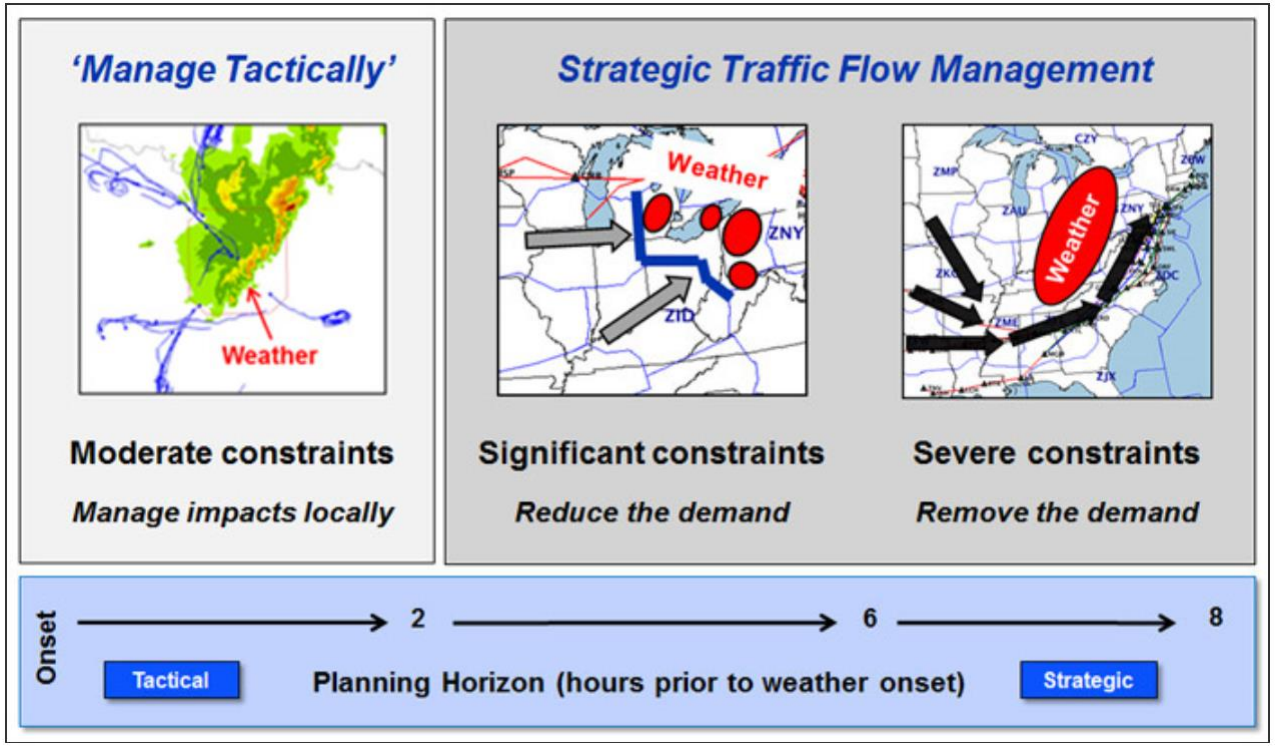

Image Source: FAA

Strategic traffic flow management refers to a longer-range planning effort (2-8 hours) at a larger, perhaps regional or national scale

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Traffic Management Initiatives (TMIs)

- **Traffic managers impose TMIs to account for congestion, weather, special activity airspace, or other constraints**

- **Examples of TMIs:**
  - Ground Delay Program (GDP)
  - Airspace Flow Program (AFP)
  - Ground Stop (GS)
  - Miles-in-Trail (MIT)
  - Holding
  - Vectoring
  - Rerouting
  - Fix Balancing
  - …

On Ramp Management

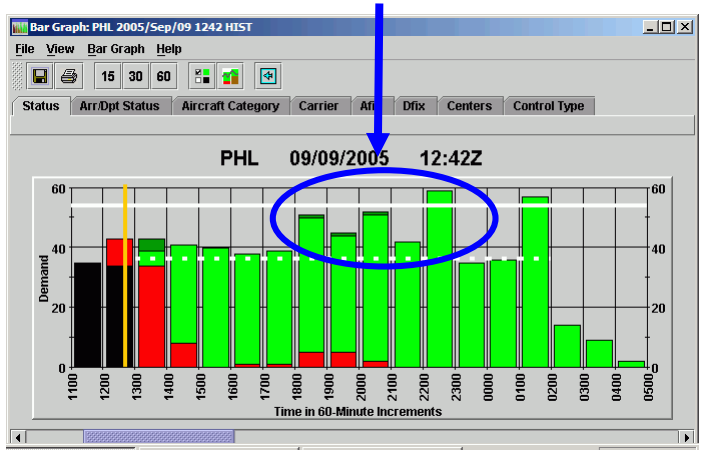
Speed Control

Image Source: Washington DoT

Ground Delay Program (GDP)

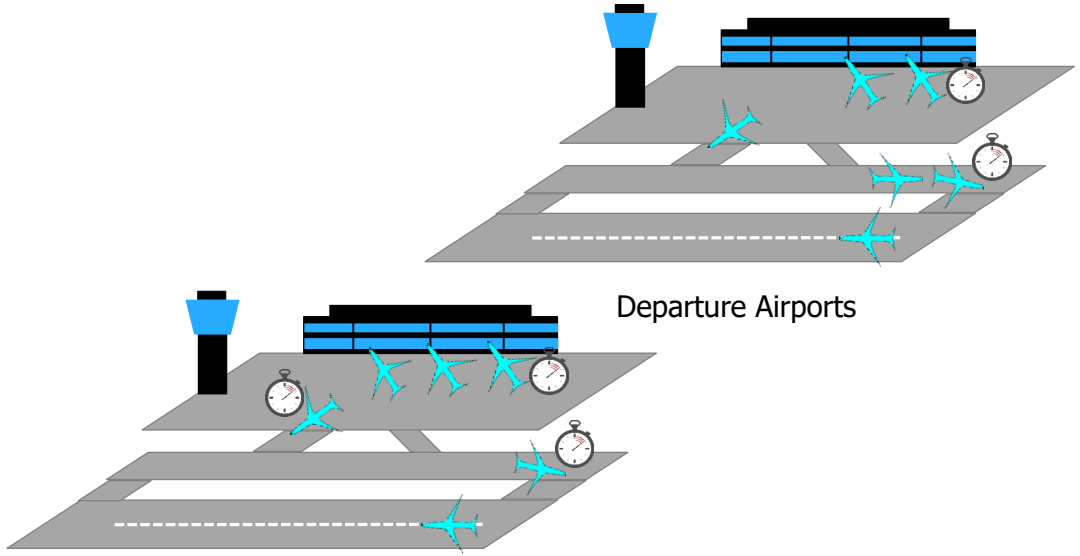
- **Used to control excess arrival demand to an airport**
  - Traffic demand is expected to exceed the airport's acceptance rate for a lengthy period of time
- **Aircraft are delayed at their departure airport in order to reconcile demand with capacity at the arrival airport**
  - Flights are assigned expect departure clearance times (EDCTs), which ensure that they arrive at the affected airport when they can be accommodated

Excess demand …



Arrival Airport

Image Source: FAA



Departure Airports

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Miles-in-Trail (MITs)

- **Used to manage arrival flows**
  - Often used to manage reduced capacity or high volume
- **Involves slowing down or speeding up traffic to maintain a certain amount of space between aircraft**
  - Allows room for tactical deviations
  - Reduces sector loading

FRFAC	TOFAC	AIRPORT	ENTRY_TIME	RSTN_START	RSTN_STOP	MITVAL	DURATION	REASON_TXT
ZHU	ZFW	HOU	06/09/2018 21:32	06/10/2018 00:15	06/10/2018 01:15	20	60	WX:THUNDERSTORMS

Flights destined to HOU from ZFW will have 20 miles-in-trial for 60 minutes, beginning 06/10/18 00:15 Zulu, due to thunderstorms. ZHU is the requesting facility and entered the request at 06/09/18 21:32 Zulu

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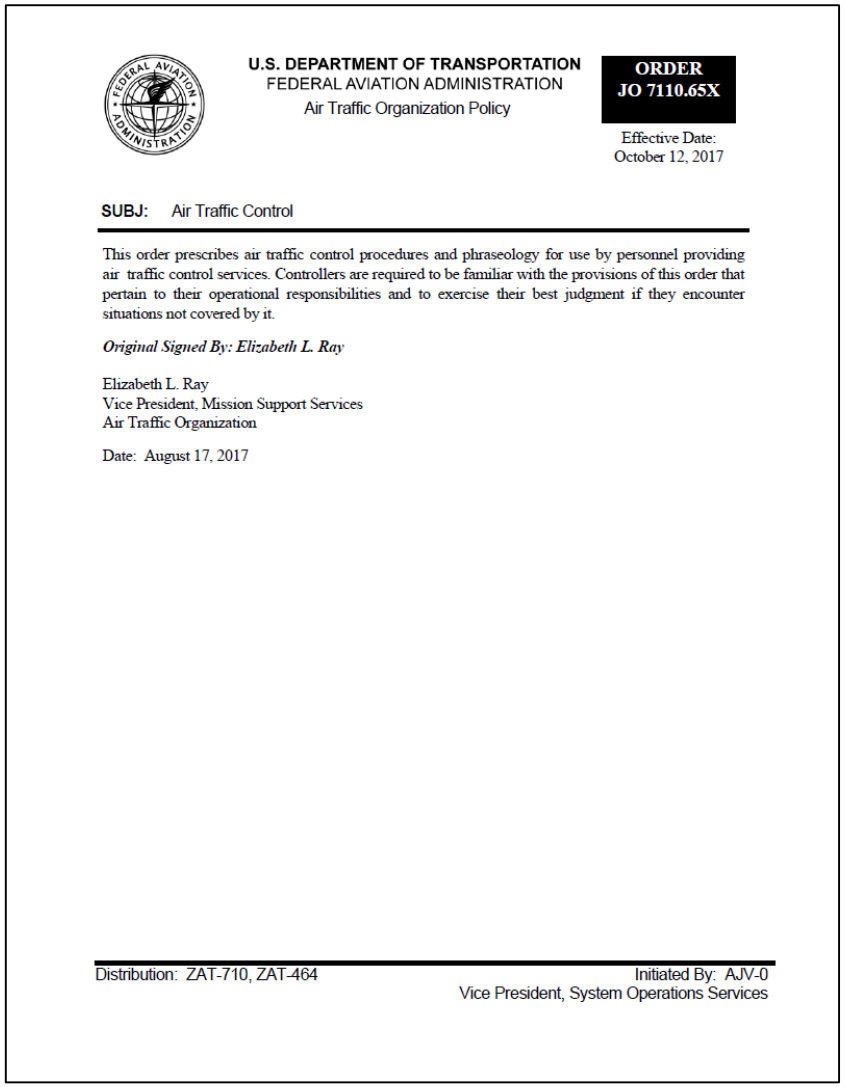
Separation Rules

- **VFR vs IFR**
- **Radar vs Non-Radar**
- **Wake Turbulence**
- **Departure Rules**
- **Arrival Rules**



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Air Traffic Organization Policy

ORDER JO 7110.65X

Effective Date:
October 12, 2017

SUBJ: Air Traffic Control

This order prescribes air traffic control procedures and phraseology for use by personnel providing air traffic control services. Controllers are required to be familiar with the provisions of this order that pertain to their operational responsibilities and to exercise their best judgment if they encounter situations not covered by it.

Original Signed By: Elizabeth L. Ray

Elizabeth L. Ray
Vice President, Mission Support Services
Air Traffic Organization

Date: August 17, 2017

Distribution: ZAT-710, ZAT-464

Initiated By: AJV-0
Vice President, System Operations Services

Image Source: FAA

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Meteorological Conditions

Visual Meteorological Conditions (VMC)


Source: iStockphoto_000010749447

A lot hinges on the weather in which we operate:

- Equipment
- Training
- Airport Capacity

Instrument Meteorological Conditions (IMC)


Source: iStockphoto_000003476627

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Visual Flight Rules (VFR) | Instrument Flight Rules (IFR)

VFR

- ATC contact not always required
- See and avoid (other aircraft, clouds, terrain)
- Pilots generally control and navigate by visual reference
- May or may not have a flight plan

IFR

- ATC contact required
- ATC provides separation services
- Pilots control and navigate by reference to instruments
- Must have a flight plan

Image Source: FAA

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Basics of Oceanic ATC

- **FAA is allocated the majority of the worlds oceanic controlled airspace**
- **Oceanic air traffic control differs from domestic air traffic control largely because**
  - There is little radar tracking of aircraft
  - Direct radio communication between pilot and controller is rare
- **Oceanic air traffic controllers must rely on other sources of aircraft position information to ensure separation**
  - Relay of aircraft position reports via High Frequency/Radio Operator
  - Satellite-derived position reports via Automatic Dependent Surveillance-Contract (ADS-C) or Controller-Pilot Data Link Communications (CPDLC)
- **Oceanic airspace is managed collaboratively through International Civil Aviation Organization (ICAO) regional working groups**

U.S. Airspace Classes at a Glance

- Class A, B, C, D, E is controlled airspace where ATC service is provided
- Class A is controlled airspace where traffic is Instrument Flight Rules (IFR)
- Class B separates VFR traffic from IFR traffic and around busy towered airports
- Class C and D is controlled airspace at an airport with a tower
- Class E is controlled airspace that is not Class A, B, C, or D
- Class G is uncontrolled airspace where no ATC services are provided

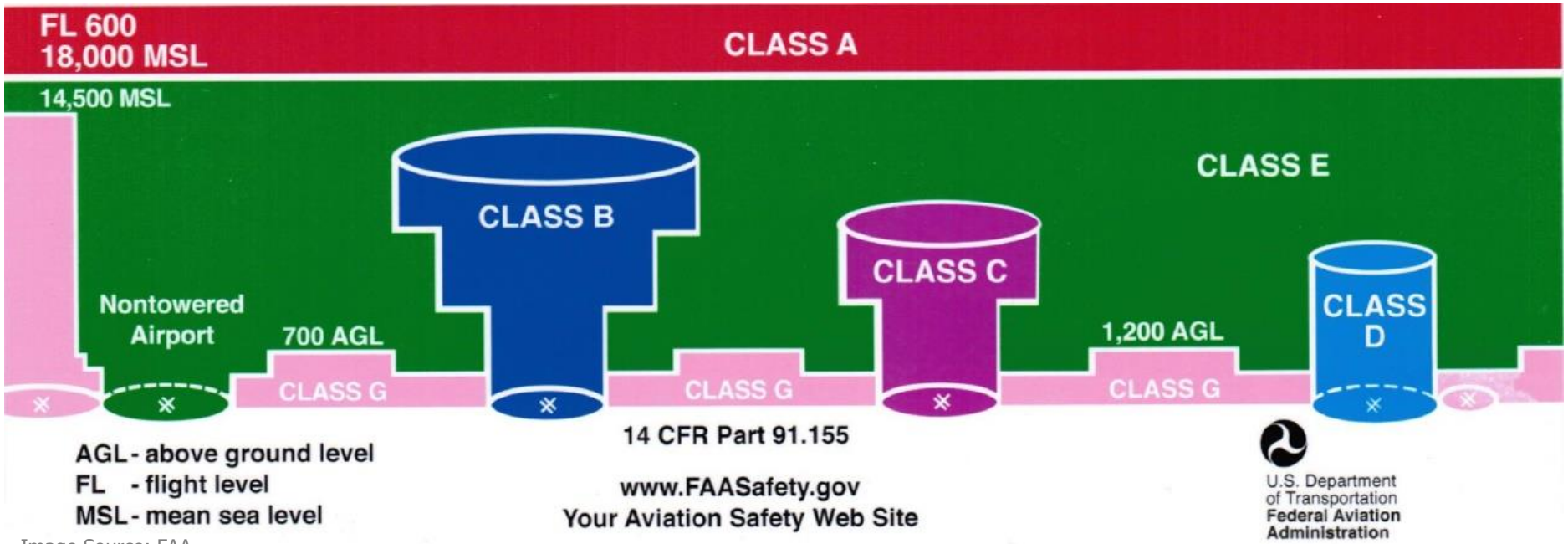

Image Source: FAA

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Next Generation Air Transportation System (NextGen) Overview

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What is the Next Generation Air Transportation System (NextGen)?

Image Source: FAA

- **FAA-led modernization of our nation's air transportation system**
  - Focused on increasing safety, efficiency, capacity, predictability, and resiliency
- **<u>Not</u> a single technology, product, or goal**
  - Collection of innovative technologies, capabilities, and procedures
- **Better information and tools for airlines, general aviation operators, pilots, and air traffic controllers**
  - Help passengers and cargo arrive at their destinations more quickly
  - Help aircraft consume less fuel and produce fewer emissions

NextGen Overview

- **NextGen is transforming the NAS through a number of operational improvements that are being achieved through an ongoing rollout**
- **Each improvement is implemented through a series of capabilities, or increments, that provide individual benefits**
- **Combined, these improvements are transforming the way the NAS is operated**
- **This transformation began in 2007, and all major components should be in place by 2025**

Image Source: FAA

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Evolution of NextGen

Video Source: https://www.faa.gov/nextgen/faqs/#q5

Where is NextGen?

- **NextGen technologies and procedures are in place across the country:**
  - In the skies and on the ground
  - In air traffic control facilities
  - In aircraft cockpits

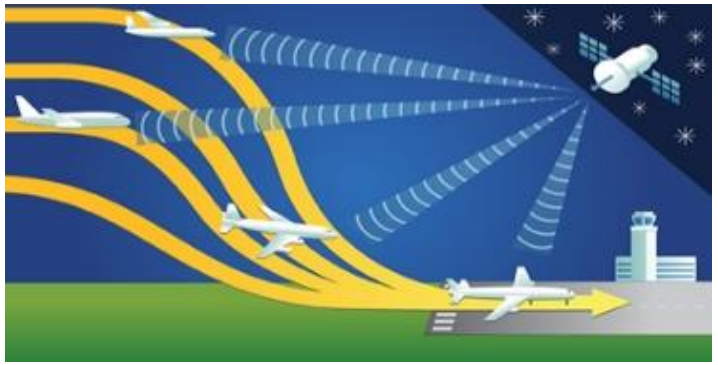

Image Source: FAA

- **Through research, innovation, and collaboration, NextGen is setting standards around the world and further establishing the FAA's global leadership in aviation**

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NextGen as a Whole: See, Navigate, Communicate

Video Source: https://www.faa.gov/nextgen/how_nextgen_works/

NextGen Programs and Portfolios

- **The FAA uses a comprehensive, cross-agency portfolio approach to implement NextGen capabilities**
- **This approach recognizes NextGen as an integrated effort, rather than a series of independent programs**

Image Source: FAA/MITRE

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NextGen Benefits

(1 of 2)

Improvements within each portfolio provide different benefits in ICAO defined *Key Performance Areas (KPAs)*

- **Access:** Ensures all airspace users have access to the air traffic resources they need to meet their specific operational requirements, and that shared use of airspace by different users can be achieved safely
- **Capacity:** Provides capacity to meet airspace user demands while minimizing restrictions on traffic flow, increasing to respond to future growth along with efficiency, flexibility, and predictability, while ensuring that there are no adverse impacts on safety and giving due consideration to the environment
- **Environment:** Contributes to environmental protection by considering noise, emissions, and other environmental issues in the implementation and operation of the aviation system

Image Source: FAA

NextGen Benefits

(2 of 2)

- **Efficiency:** Addresses the operational and economic cost-effectiveness of gate-to-gate flight operations so airspace users can depart and arrive at the times they select and fly optimal trajectories
- **Flexibility:** Ensures all airspace users can dynamically modify flight trajectories and adjust departure and arrival times, thereby permitting them to take advantage of operational opportunities as they occur
- **Predictability:** Enables airspace users and air traffic service providers to deliver consistent and dependable levels of performance, essential to users as they develop and operate their schedules
- **Safety:** Systematically provides uniform safety standards and risk / safety management practices, ensuring implementations are assessed against proper criteria, and according to appropriate and globally standardized safety management processes

Image Source: FAA

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NextGen Priorities
(1 of 2)

- **Collaboration between FAA and aviation stakeholders**
  - Identify high-benefit, high-readiness NextGen capabilities for implementation in the near term
  - Implement specific capabilities at certain locations by specific dates to increase safety, reduce impact on the environment, enhance controller productivity, and increase predictability, airspace capacity and efficiency
  - Documented in the FAA's NextGen Priorities Joint Implementation Plan
- **Began in 2014**

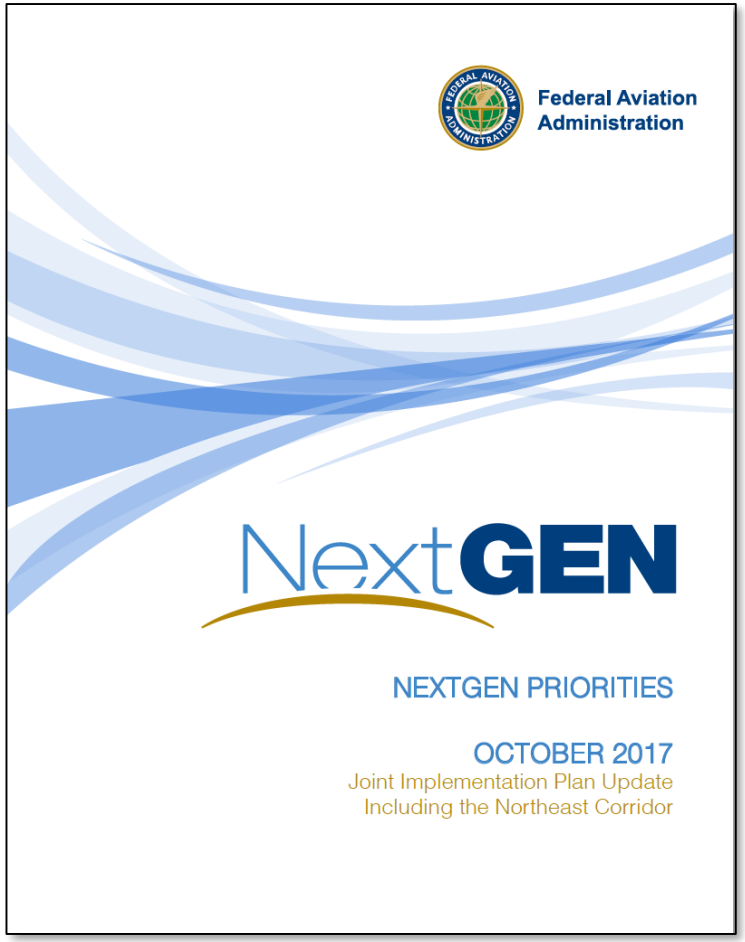
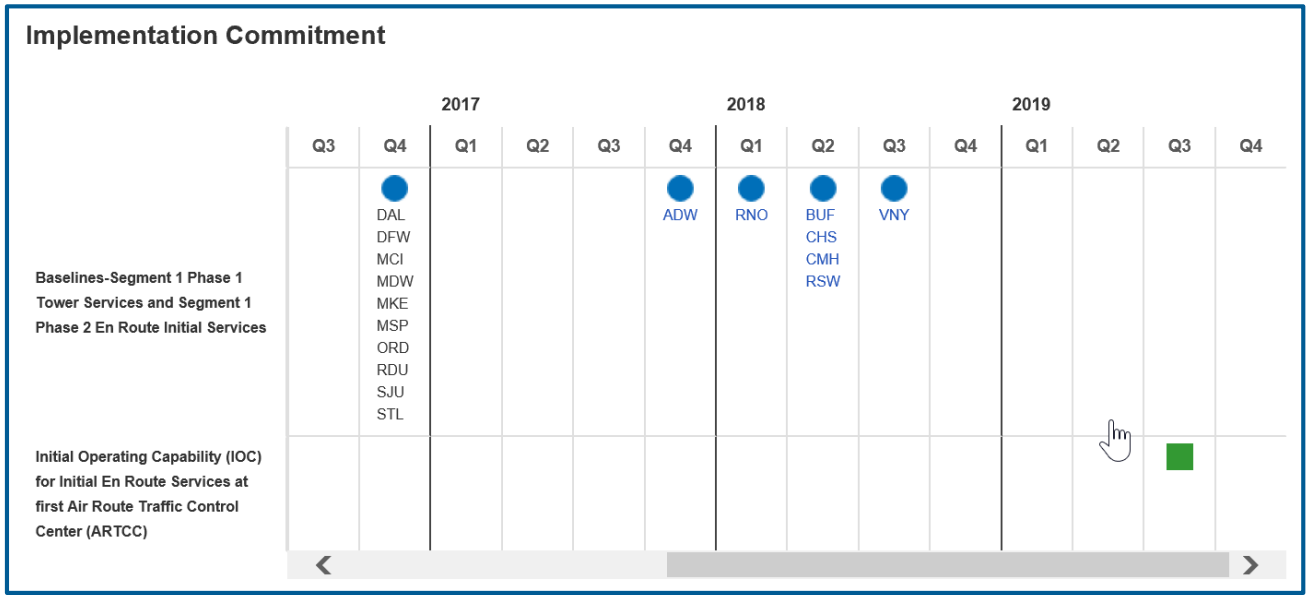


Image Source: FAA

NextGen Priorities
(2 of 2)

5 NextGen Priority Focus Areas

- **Multiple Runway Operations**
- **Performance Based Navigation**
- **Northeast Corridor**
- **Surface Operations and Data Sharing**
- **Data Communications**



Industry, Pre-Implementation, and Implementation Commitments are tracked on the NextGen Performance Snapshots website (https://www.faa.gov/nextgen/snapshots/)

Image Source: FAA

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NextGen Programs

- Automatic Dependent Surveillance-Broadcast (ADS-B)
- Automation
- Data Communications (Data Comm)
- Decision Support Systems (DSS)
- NAS Voice System (NVS)
- Performance Based Navigation (PBN)
- System Wide Information Management (SWIM)
- Weather

Automatic Dependent Surveillance-Broadcast (ADS-B) Program

- **ADS-B provides real-time precision, shared situational awareness, and advanced applications for pilots and controllers**
- **Functions with satellite rather than radar technology to more accurately observe and track air traffic**
- **Improves safety and efficiency in the air and on runways, reduces costs, and lessens harmful effects on the environment**

Video Source: https://www.faa.gov/tv/?mediaId=1793

- **Aircraft equipped with an ADS-B Out transmitter send their position, altitude, heading, ground speed, vertical speed, call sign, and ICAO identifier to a network of ground stations that relays the information to air traffic control displays**

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Automation Program

- **New, state-of-the-art computer systems have been deployed to FAA air traffic control facilities across the country**
- **The Standard Terminal Automation Replacement System (STARS) and En Route Automation Modernization (ERAM) are enabling NextGen capabilities at all phases of flight**

Video Source: https://www.faa.gov/tv/?mediaId=1520

- **STARS and ERAM enable NextGen capabilities such as ADS-B and Data Comm**
  - STARS is a digital automation system capable of tracking all aircraft within the defined airspace using information from available surveillance systems
  - ERAM enables controllers to track, direct, and separate aircraft within their area of responsibility. It also has an improved conflict detection capability and helps reduce aircraft separation from 5 nautical miles to 3 nautical miles under certain conditions
- **These platforms will play a key role in the transition to Trajectory Based Operations (TBO), a time-based form of air traffic management**

Data Communications (Data Comm) Program

Video Source: https://www.faa.gov/tv/?mediaId=1526

Data Communications departure clearances are available at 62 airports

Decision Support Systems (DSS) Program

- **DSS programs and products help manage strategic flow, en route flow, terminal flow and airport surface movement**
- **The primary tools, often referred to as the "3Ts" are:**

Traffic Flow Management System (TFMS)
Decision support system for planning and mitigating demand-capacity imbalances in the NAS.

Terminal Flight Data Management (TFDM)
A new decision support system for airport surface management and ATC tower functions.

Time-Based Flow Management (TBFM)
Decision support system for metering based on time to optimize the flow of aircraft.

- **DSS tools combine modeling and analysis with traditional data access and retrieval to enable traffic managers to make decisions in rapidly changing environments**
- **The tools alert operators to conditions that require a decision and help to develop and analyze possible courses of action**

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Terminal Flight Data Manager (TFDM)

Image Source: FAA; Video Source: https://www.faa.gov/tv/?mediaId=1714

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NAS Voice System (NVS) Program

- **NVS is a digital telecommunications network that will**
  - Provide state-of-the-art digital voice communication services to ATC facilities
  - Replace and standardize the FAA's aging analog voice communication system
  - Enable voice communication with operators of Unmanned Aircraft Systems
- **Benefits:**
  - Air-to-ground voice communication is no longer limited by geographical facility boundaries
  - Provides greater flexibility for developing and using airspace/traffic assignments
- **NVS software is in the development and testing phase**

Image Source: FAA

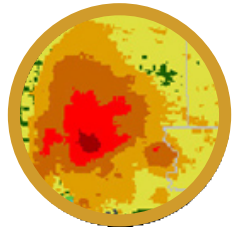
MITRE

System Wide Information Management (SWIM) Program

- **SWIM is the digital data delivery platform that turns raw NAS data into meaningful information for aviation stakeholders**
  - Replaces outdated system of multiple dedicated computer interfaces
  - Creates a single connection through a secure FAA telecommunications system where consumers can retrieve data from producers
- **Users gain access to data products with improved bandwidth and security**

Video Source: https://www.faa.gov/tv/?mediaId=1528

Weather Program



- **Collaboration between FAA, National Oceanic and Atmospheric Administration (NOAA), and National Aeronautics and Space Administration (NASA)**
- **Help reduce the impact of weather on aviation, resulting in safer, more efficient and more predictable day-to-day NAS operations**
- **Provides tailored aviation weather products, helping controllers and operators develop reliable flight plans, make better decisions, and improve on-time performance**

Image Source: FAA

NextGen Portfolios

- **There are eleven portfolios**
  - Eight implementation portfolios
  - Three supporting activities portfolios

Collaborative Air Traffic Management (CATM)

Improved Approaches and Low-Visibility Operations

Improved Multiple Runway Operations

Separation Management

Improved Surface Operations

On-Demand NAS Information

Supporting activities portfolios →

NAS Infrastructure

System Safety Management

Environment and Energy

Performance Based Navigation

Time Based Flow Management

MITRE

Collaborative Air Traffic Management (CATM) Portfolio

- **Improvements designed to:**
  - Coordinate flight and flow decision-making by flight planners and FAA traffic managers to improve overall efficiency of the NAS
  - Provide greater flexibility to flight planners
  - Make the best use of available airspace and airport capacity

- **Targeted to deliver a combination of:**
  - Increased information on the users' preferred alternative routes
  - Enhanced tools for assessing the impact of rerouting decisions
  - Improved communications and display of instructions to air traffic controllers

- **Main benefit areas: Capacity, Efficiency, Flexibility, Predictability**

Improved Approaches and Low-Visibility Operations Portfolio

- **Improvements are designed to increase:**
  - Airport approach and arrival access
  - Flexibility
- **Accomplished through a combination of:**
  - Procedural changes
  - Improved aircraft capabilities
  - Improved precision approach guidance

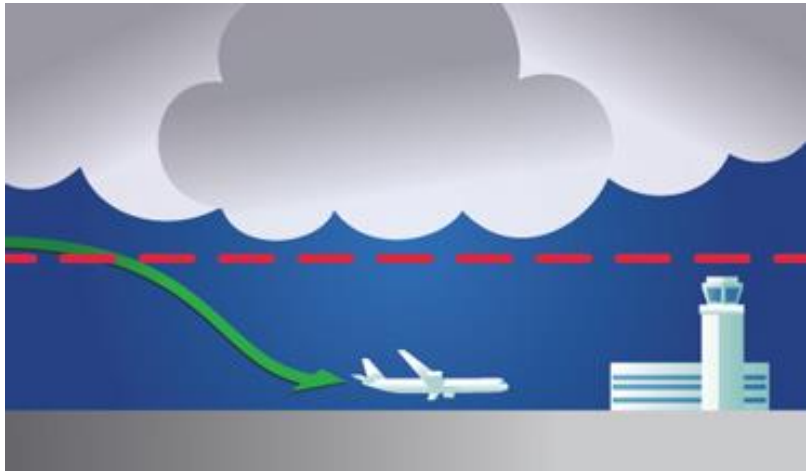


Image Source: FAA

- **Vertical navigation and other flight deck capabilities provide access to more runways when visibility is low, leading to increased throughput and reduced delay**
- **Main benefit areas: Access, Capacity**
- **Example of portfolio improvements:**
  - Expanded Low-Visibility Operations Using Lower Runway Visual Range Minima

Improved Multiple Runway Operations Portfolio

- **Improvements are designed to improve access to closely spaced parallel runways by:**
  - Enabling the use of simultaneous approaches (two aircraft arriving side-by-side) during periods of reduced visibility
  - Decreasing the required separation between aircraft on dependent approaches (staggered aircraft arrivals on parallel runways)
  - Alleviating the effects of wake turbulence that normally require increased separation between aircraft in terminal airspace (airspace surrounding airports)
- **Main benefit areas: Capacity, Efficiency**
- **Example of portfolio improvements:**
  - Amend Standards for Simultaneous Independent Approaches — Triple

Chicago O'Hare International Airport (ORD)

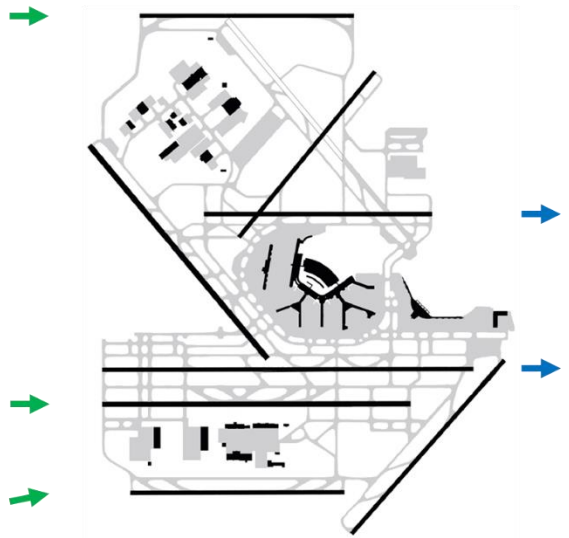
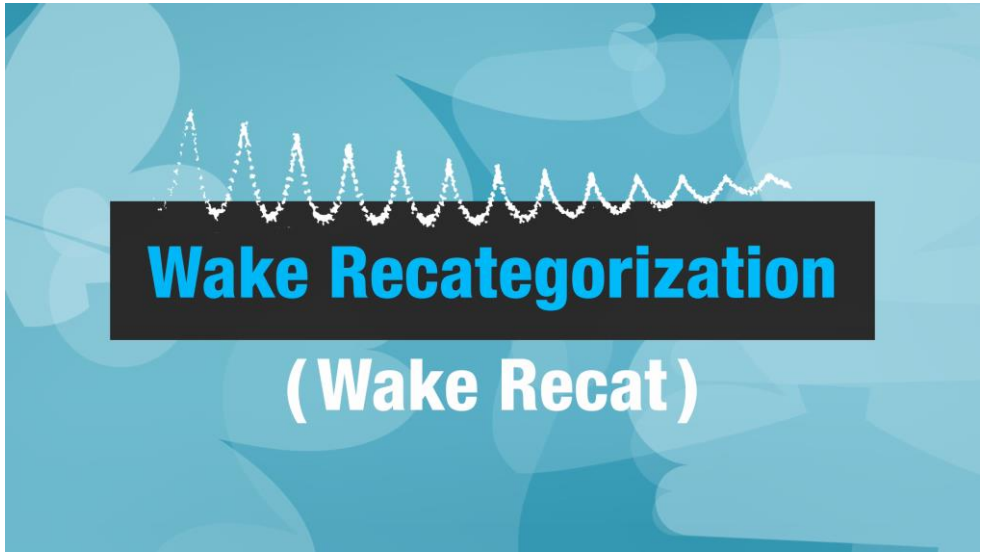


Image Source: FAA

Separation Management Portfolio

- **Improvements will enhance aircraft separation assurance by safely reducing separation between aircraft**
- **Capabilities in this portfolio will provide air traffic controllers with tools and procedures to separate aircraft in a mixed environment with various types of navigation equipment and wake performance capabilities**
- **Main benefit areas: Access, Capacity, Efficiency, Safety**
- **Example of portfolio improvements:**
  - Wake Recategorization



Video Source: https://www.faa.gov/tv/?mediaId=1689

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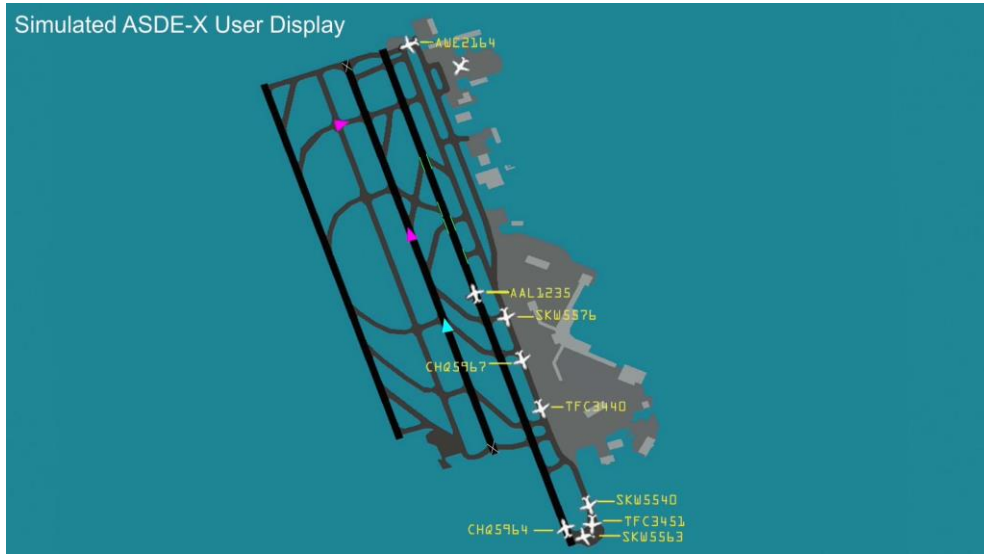
Improved Surface Operations Portfolio

- **Improvements are designed to:**
  - Track the movement of surface vehicles and aircraft, incorporating the movement data into the airport surveillance infrastructure, and sharing the information with air traffic controllers, pilots and airline operations managers
  - Support the exchange of information that occurs from before the aircraft pushes back from the gate up to departure and after landing from exiting the runway to arriving at the terminal gate

- **Main benefit areas: Capacity, Efficiency, Environment, Flexibility, Predictability, Safety**

- **Example of portfolio improvements:**
  - Airport Surface Detection Equipment-Model X (ASDE-X)



Video Source:
https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/asdex.html

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On-Demand NAS Information Portfolio

- **Improvements provide flight planners, air traffic controllers, air traffic managers, and flight crews consistent and complete information related to changes in the airspace system**
- **The capabilities in this portfolio will be realized through access to and exchange of aeronautical and flight information using common data formatting and information exchange standards**
- **Main benefit areas: Environment, Flexibility, Safety**

NAS Infrastructure Portfolio

- **Supporting activity portfolio**
- **Contains key transformational and infrastructure sustainment capabilities that are critical to the success of NextGen across multiple portfolios**
- **Includes technical refreshes of current infrastructure**
- **Capabilities fall into the following infrastructure categories:**
  - Communications
  - Oceanic
  - Information Management
  - Weather

System Safety Management Portfolio

- **Supporting activity portfolio**
- **Aims to develop and implement the policies, processes, and analytical tools that the FAA and industry will use to ensure the safety and security of the NAS**
  - Ensure that new capabilities either improve or maintain current safety levels while simultaneously improving capacity and efficiency in the NAS
- **This portfolio contains two projects that will define emerging safety requirements**
  1) Aviation Safety Information Analysis and Sharing (ASIAS)
  2) System Safety Management Transformation (SSMT)
- **Main benefit area: Safety**

Environment and Energy Portfolio

- **Supporting activity portfolio**
- **Overcome the environmental constraints facing aviation**


NOISE


AIR QUALITY


CLIMATE


ENERGY

- **Five-pillar approach**

- **Main Benefit Area: Environment**

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NextGen Environmental Goals

NOISE

Reduce the number of people exposed to significant noise around US airports in absolute terms, notwithstanding aviation growth, and provide additional measures to protect public health and welfare and national resources

AIR QUALITY

Achieve an absolute reduction of significant air quality health and welfare impacts attributable to aviation

CLIMATE

Limit the impact of aircraft carbon dioxide (CO2) emissions on the global climate by achieving carbon-neutral growth by 2020 compared to 2005, and net reductions of the climate impact from all aviation emissions over the longer term (by 2050)

ENERGY

Improve National Airspace System (NAS) energy efficiency and develop and deploy alternative jet fuels for commercial aviation

Summary of Current Improvements and Increments

Science and Tools

Integrated Environmental Modeling
- Aviation Environmental Tools Suite

Technology

NextGen Environmental Engine and Aircraft Technologies
- Explore and Demonstrate New Technologies Under CLEEN

Alternative Fuels

Sustainable Alternative Jet Fuels
- Other Advanced Drop-In Aviation Alternative Jet Fuels
- Generic Methodology for Alternative Jet Fuel Approval
- Support Qualification and Deployment of Drop-In Alternative Jet Fuels

Policy

Environmental Policies, Standards, and Measures
- Environmental Performance and Targets
- EMS Data Management
- Analysis to Support International Environmental Standard-Setting

CLEEN — Continuous Lower Energy, Emissions & Noise — Federal Aviation Administration

http://www.faa.gov/go/cleen

CAAFI — FUELING SOLUTIONS FOR SECURE & SUSTAINABLE AVIATION

http://www.caafi.org

ASCENT — AVIATION SUSTAINABILITY CENTER

http://ascent.aero

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Performance Based Navigation Portfolio

- **Improvements are designed to:**
  - Address ways to leverage emerging technologies, such as Area Navigation (RNAV) and Required Navigation Performance (RNP), to improve access and flexibility for point-to-point operations
  - Help air traffic managers conduct Trajectory Based Operations (TBO)
  - Save time and fuel while reducing emissions
- **The FAA has already published more than 9,300 Performance Based Navigation (PBN) procedures and routes**
- **Main Benefit Areas: Access, Efficiency, Flexibility, Predictability**
- **Example of portfolio implementations:**
  - RNAV/RNP Procedures
  - Metroplex

Image Source: FAA

What is PBN?

PBN is comprised of RNAV and RNP and describes an aircraft's capability to navigate using performance standards

- RNAV enables aircraft to **fly on any desired flight path**
  - Paths are limited by the coverage of ground or spaced-based navigation aids and/or the limits of the aircraft's self-contained systems
  - RNAV aircraft have better access and flexibility for point-to-point operations

- RNP is RNAV with the addition of an **onboard performance monitoring and alerting capability**
  - The aircraft navigation system can monitor navigation performance and inform the crew if the requirement is not met during an operation
  - This onboard monitoring and alerting capability enhances the pilot's situation awareness and can enable reduced obstacle clearance

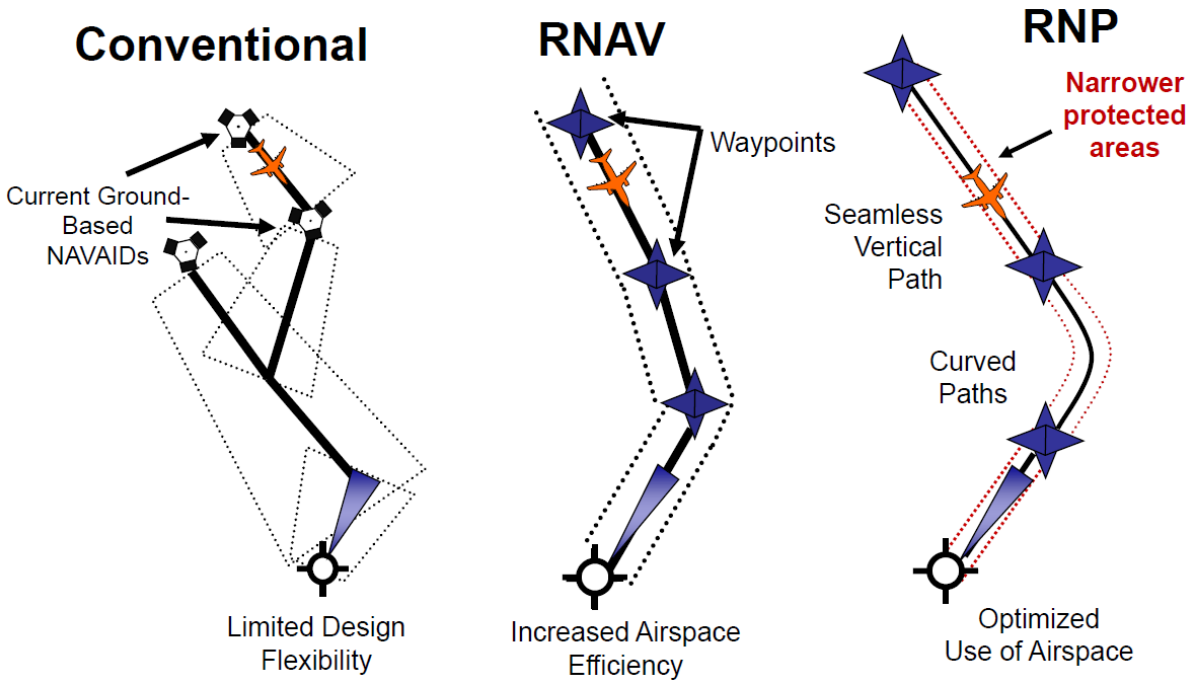
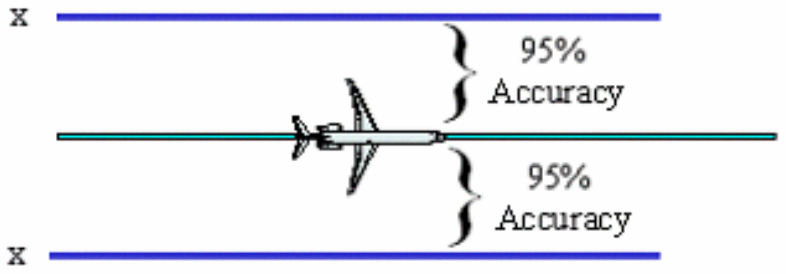


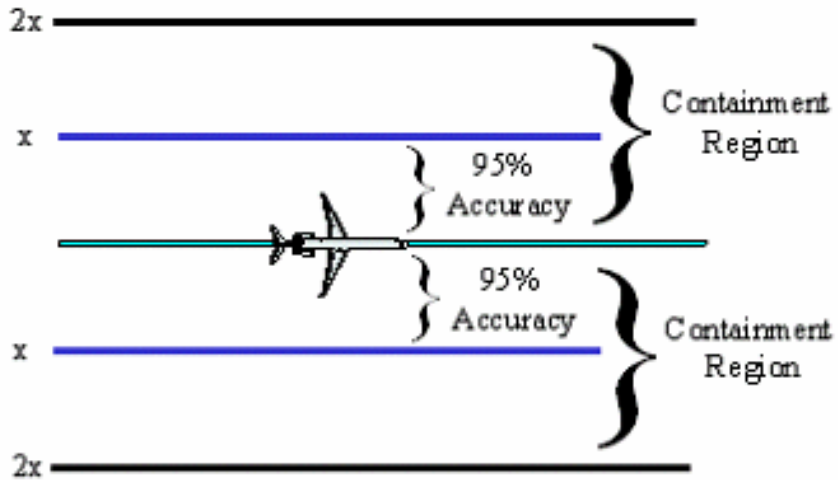
Image Source: FAA

RNAV and RNP Accuracy and Containment

RNAV-X



RNP-X
(w/Containment)



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Takeoff-to-Touchdown PBN NAS

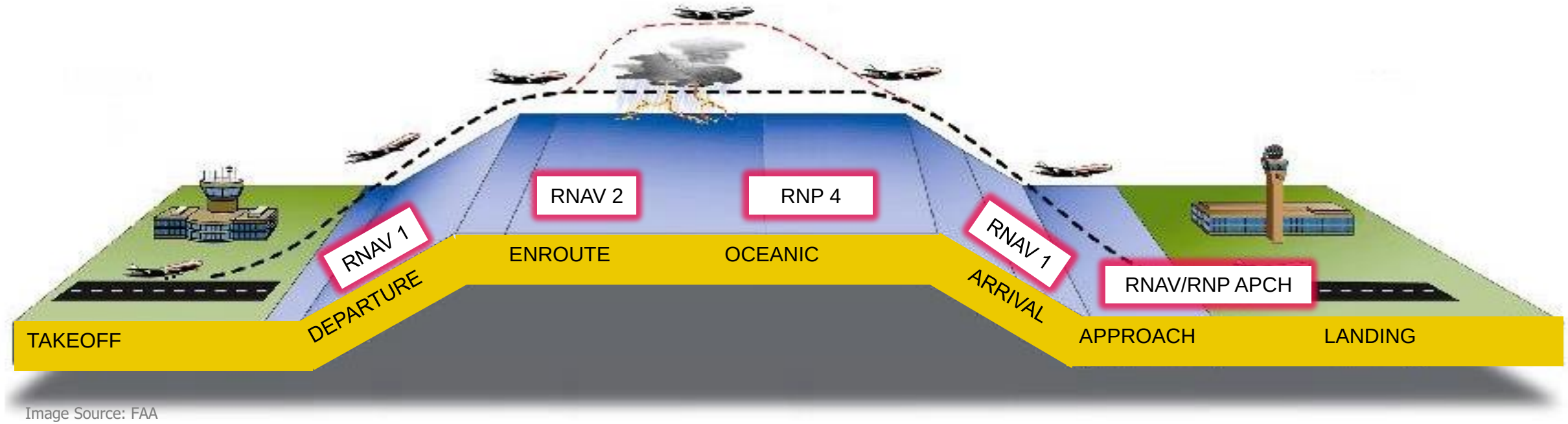

Image Source: FAA

- Departure: RNAV (and RNP) SIDs
- En-route: Q-routes, T-routes, TK-routes
- Arrival: RNAV STARs (RNP?)
- Approach: RNAV and RNP approaches

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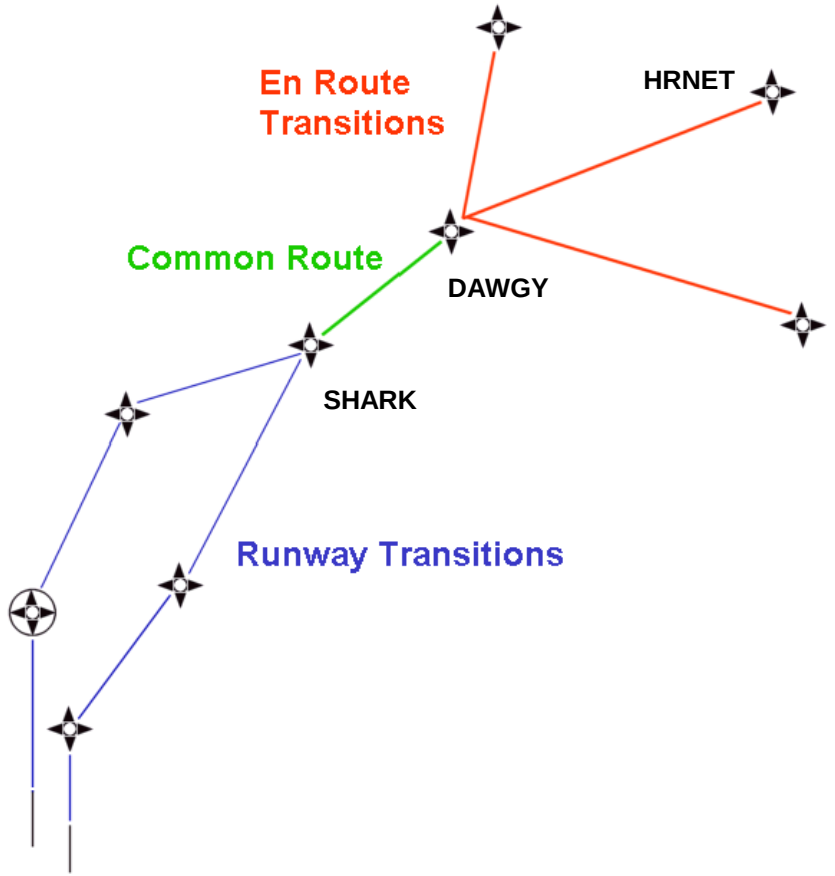
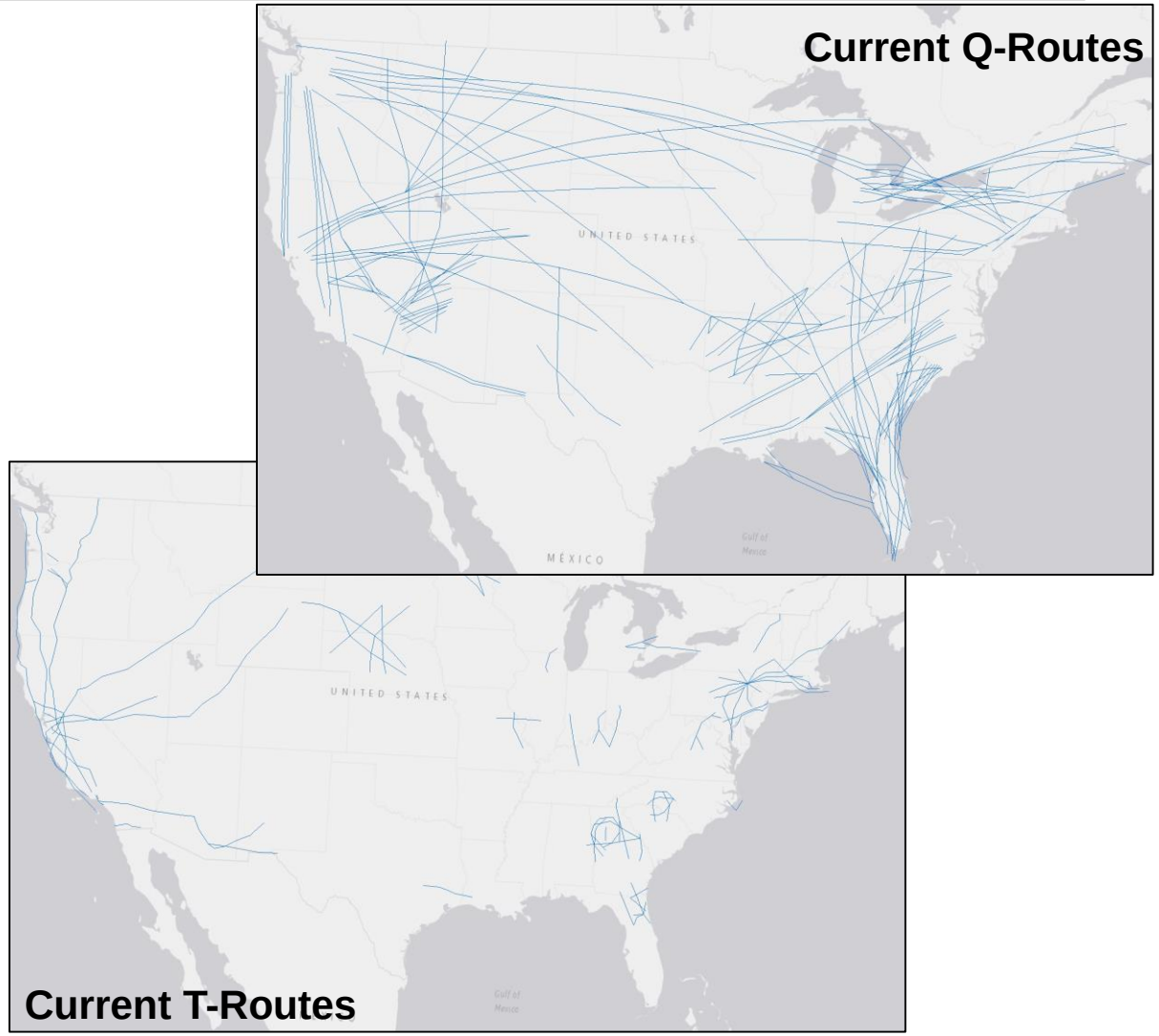
Types of PBN Procedures – RNAV Standard Instrument Departures (SIDs)

- **Fixed, precise repeatable paths for aircraft from takeoff to en route**
- **Minimal level offs to reduce fuel consumption and noise**
- **Reduced pilot and controller task complexity in all weather**
- **Deconfliction of departing and arriving traffic**
- **More than 1,200 RNAV SIDs deployed to date**



Types of PBN Procedures – Q- and T-Routes

- **Replacements for high- and low-altitude routes that rely on ground-based navigation aids**
- **T-Routes**
  - Flown primarily via satellite navigation
  - Replacing many Victor routes in airspace from 1,200 to 18,000 feet
- **Q-Routes**
  - Flown using positioning from satellite signals or distance measuring equipment (DME) in case of a GPS outage
  - Replacing many Jet routes from 18,000 to 45,000 feet
- **More than 100 T-Routes and 145 Q-Routes deployed to date**



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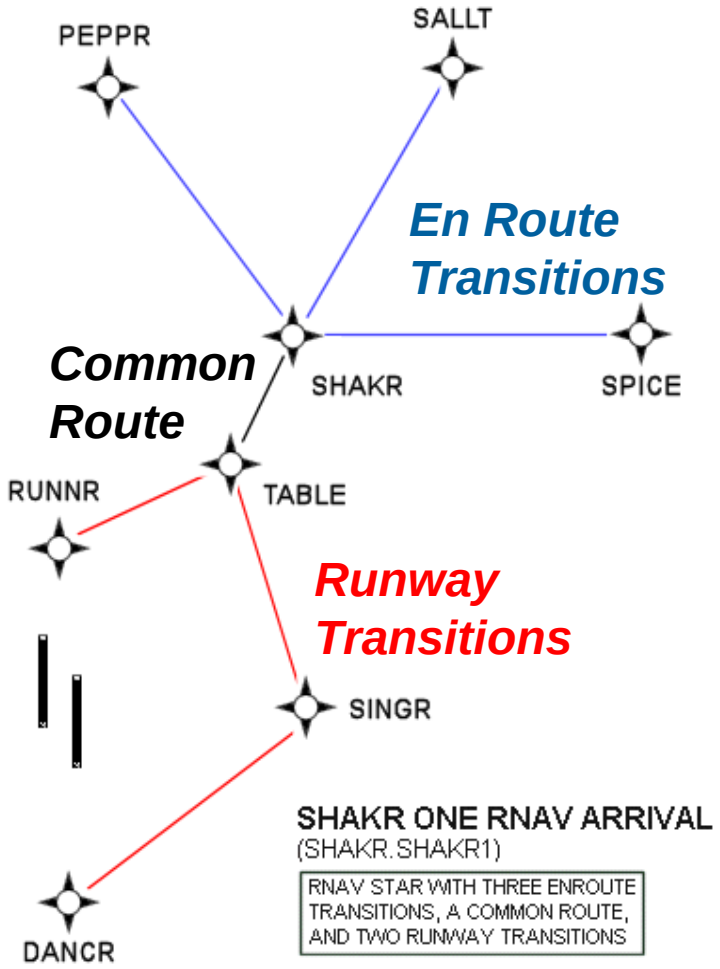
Types of PBN Procedures – RNAV Standard Terminal Arrivals (STARs)

- **Fixed, precise repeatable paths for aircraft from en route to approach**
- **Potential for continuous descent from cruise altitude using optimized profile descents (OPDs) to save fuel and reduce emissions**
- **Reduced pilot and controller task complexity in all weather**
- **Deconfliction of arriving and departing traffic**
- **More than 860 RNAV STARs deployed to date**



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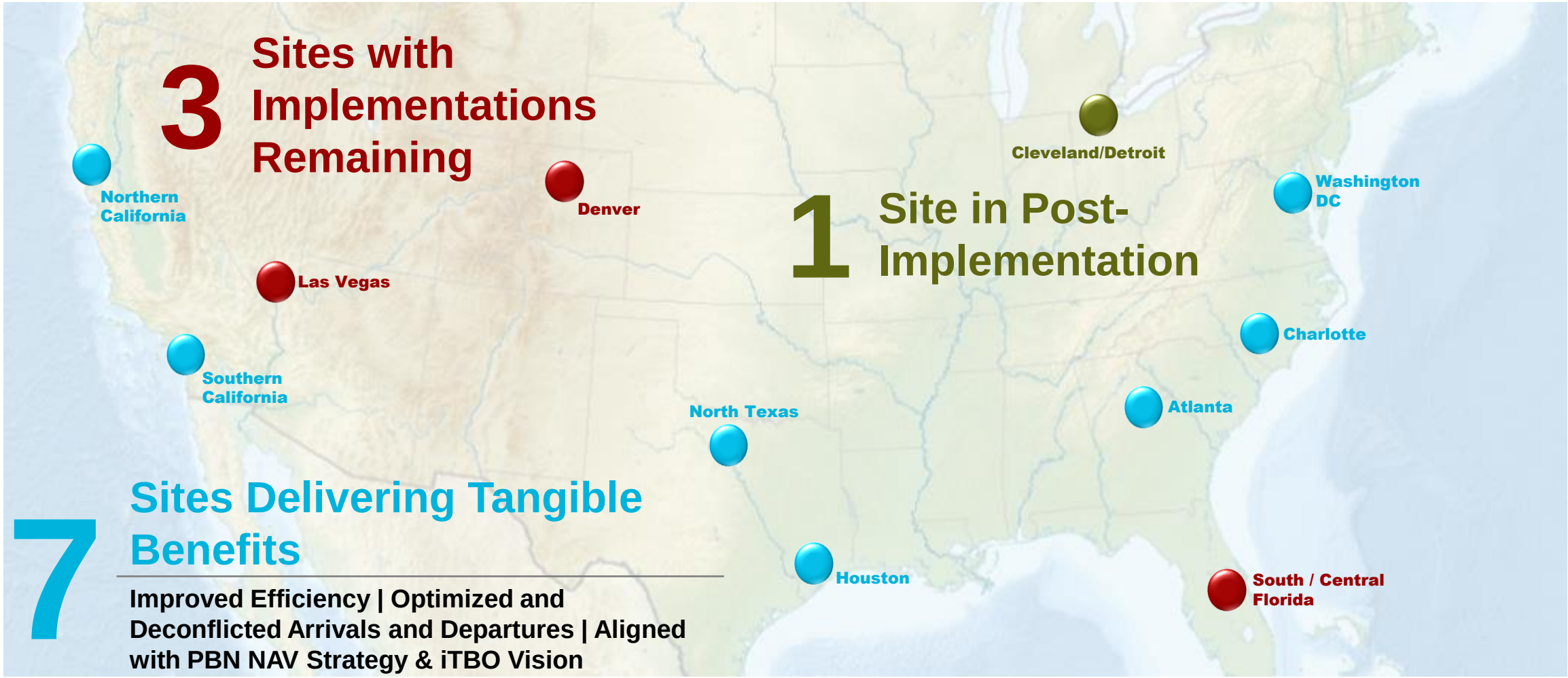
Types of PBN Procedures – Approaches

- **RNAV (GPS) Approaches**
  - ICAO nomenclature is RNP Approaches
  - Serve aircraft equipped primarily with GPS or GPS enhanced by WAAS
  - More than 7,000 RNAV (GPS) approaches deployed to date
    - More than 3,800 LPV (localizer performance with vertical guidance) approach procedures at more than 1,880 airports, most of which do not have an ILS (minimums are similar)
    - More than 650 localizer performance approach procedures without vertical guidance at more than 490 airports
- **RNP Approaches with Authorization Required (RNP AR)**
  - Highly accurate approaches requiring special training and certification
  - May enable curved paths or provide greater precision near terrain or in congested airspace
  - More than 390 RNP AR approaches deployed to date

Metroplex Program



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Recent and Ongoing PBN Single Site Projects

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PBN NAS Navigation Strategy: Focus Areas

- **Operating with PBN throughout the NAS, using the right procedure to meet the need**
- **Using navigation structure where beneficial and flexibility where possible**
- **Shifting to time- and speed-based air traffic management**
- **Delivering and using resilient navigation services**
- **Modernizing the FAA navigation service delivery to reduce implementation time**
- **Enabling lower visibility access**
- **Innovating and continuously improving**

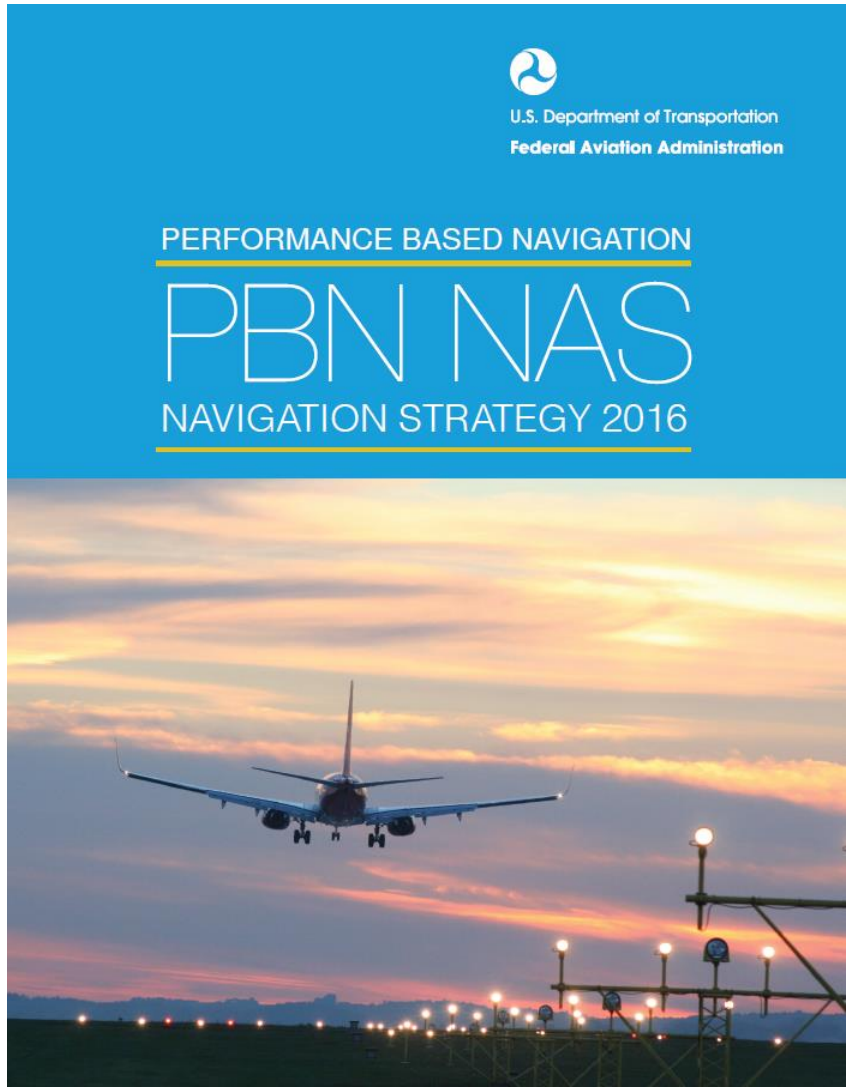

Image Source: FAA

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PBN-Related Concepts

- **Trajectory-Based Operations (TBO)**
- **Enabling new en-route and terminal separation standards**
  - Reduced Divergence Departure (ELSO)
  - Established on RNP (EoR)
  - Multiple Airport Route Separation (MARS)

Video Source: https://www.faa.gov/nextgen/how_nextgen_works/new_technology/pbn/

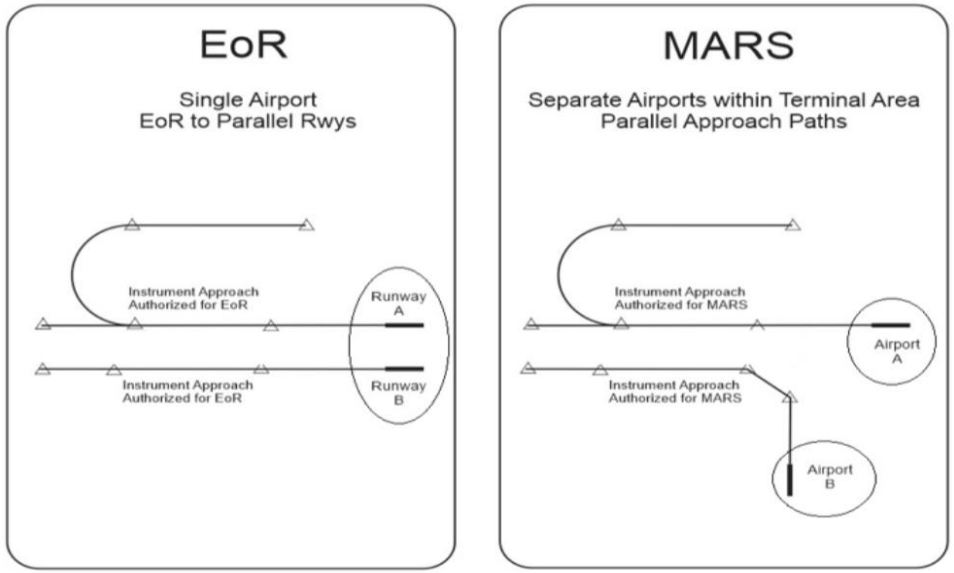

Image Source: FAA

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Time Based Flow Management Portfolio

- **Capabilities will enhance NAS efficiency by improving the capabilities of the TBFM decision-support tool, a system already deployed at all high altitude ARTCCs**
- **Capabilities will enable aircraft to maintain a spacing interval behind a preceding aircraft, further improving capacity and flight efficiency**
- **Improvements will also enable controllers to more accurately deliver aircraft to the TRACON facility while providing the opportunity for aircraft to fly optimized descents**
- **Main Benefit Areas: Capacity, Efficiency, Environment, Predictability**
- **Example of portfolio capabilities:**
  - Adjacent Center Metering (ACM)
  - Integrated Departure/Arrival Capability (IDAC)

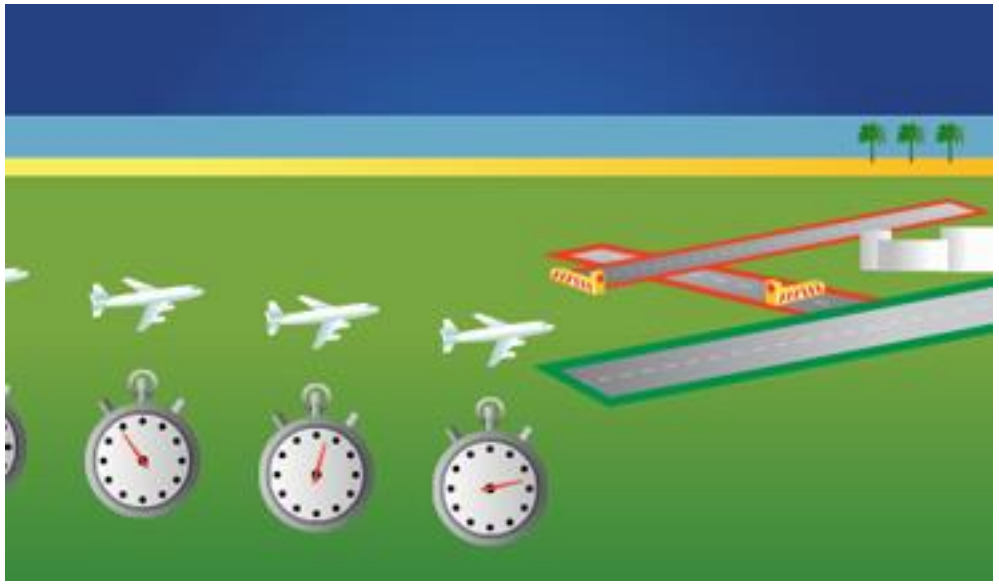

Image Source: FAA

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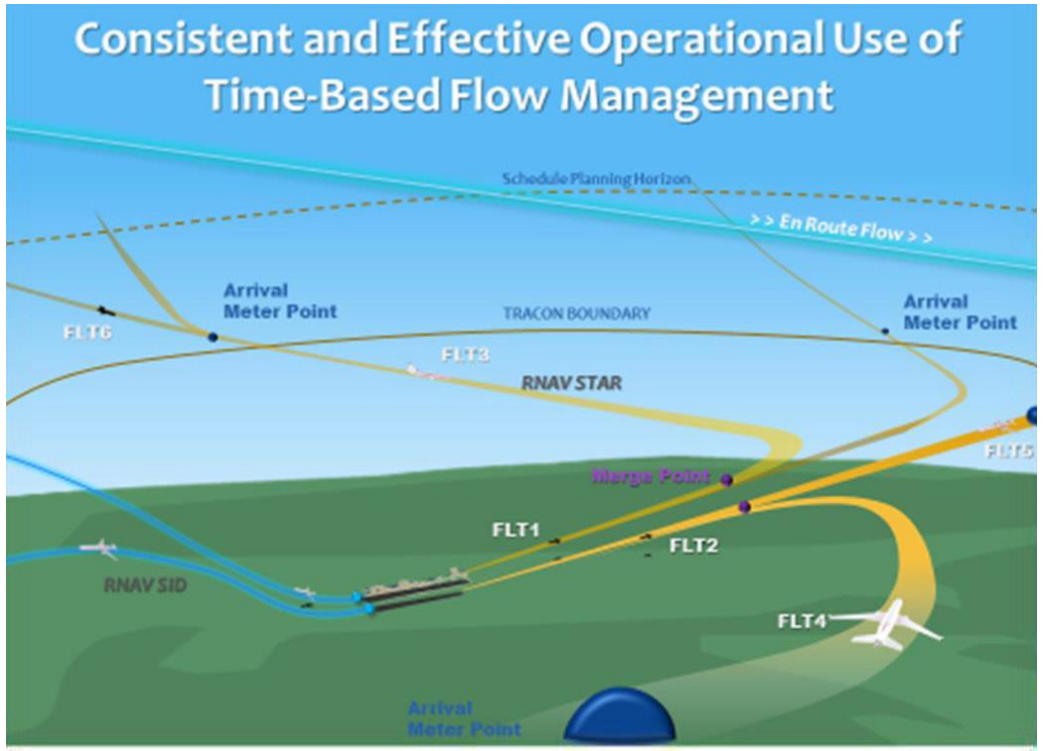
What is TBFM?

- A system that provides continuous demand vs. capacity information
- A set of processes that rapidly generate a time-ordered sequence of operations to an adapted airport or constraint point
- An advanced decision support tool designed to help ATC deliver consistent traffic flows

Benefits:

- More consistent traffic flows
- Improved operational awareness
- More accurate and dynamic than Miles-In-Trail (MIT)
- Can adapt to changing conditions and use airspace more efficiently



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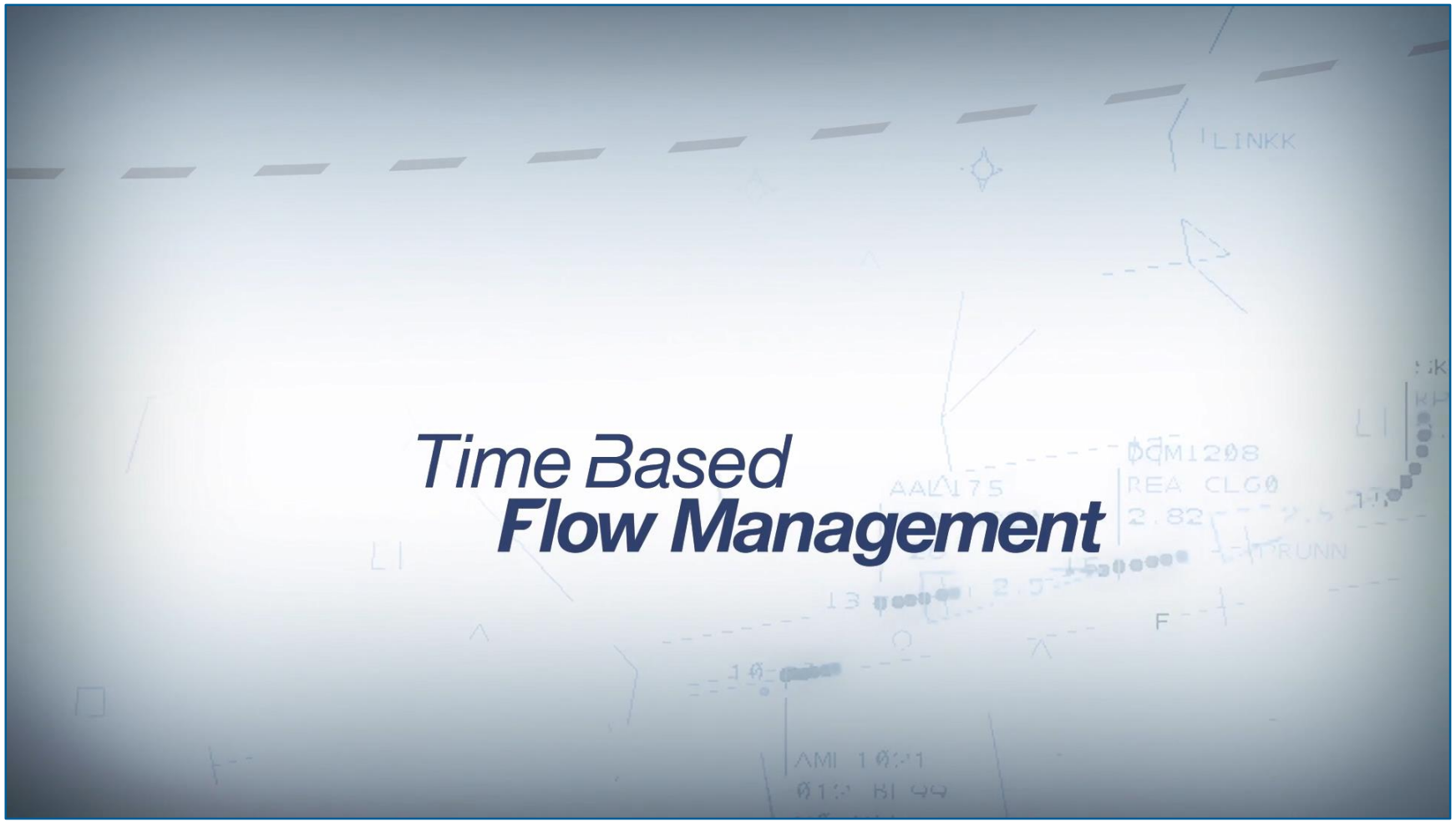
Time-Based Flow Management - TBFM



Video Source: https://www.faa.gov/tv/?mediaId=1426

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How do TBM & PBN Work Together to Support TBO?

WHEN

TBM is an air traffic management concept for using time as the common reference to coordinate operations across all phases of flight

WHERE

PBN is an advanced, satellite-enabled form of air navigation that enables flights to fly precise paths. Repeatable paths are defined with PBN procedures

What is TBO?

Trajectory Based Operations (TBO) is an air traffic management method for strategically planning, managing, and optimizing flights throughout the operation

TBO works best when TBM and PBN work together

Time-Based Management (TBM)

Arrival Metering
Surface Metering
Terminal Metering
Departure Scheduling
Ground Delay Programs
...and more

Performance Based Navigation (PBN)

Area Navigation (RNAV)
Required Navigation Performance (RNP)
Flight Management System (FMS)
Optimal Profile Descents (OPD)
...and more

Enterprise Enablers

DataComm
System-Wide Information Management (SWIM)
Enhanced Data Exchange
Advanced Weather Products
Airborne Rerouting
...and more

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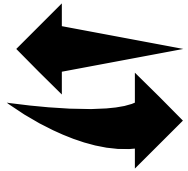
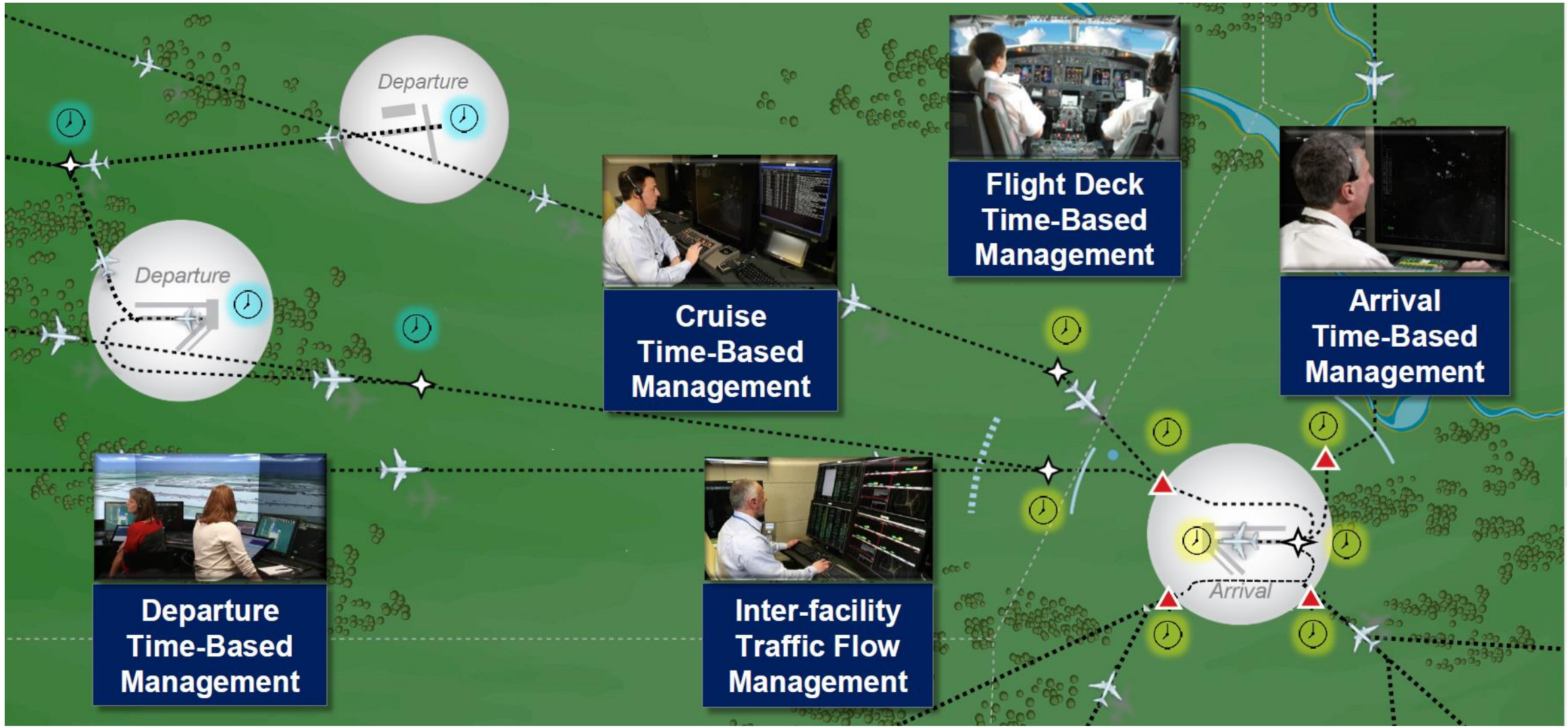
Why TBO?

	Throughput	More efficient use of system capacity by maximizing airspace and airport throughput using time-based management techniques and precise, repeatable PBN procedures
	Predictability	Improved operational predictability through more accurate and efficient end-to-end strategic planning and scheduling
	Flight Efficiency	Enhanced flight efficiency by delivering more efficient flows into and out of major metropolitan areas through integrated operations, including the continuous use of more PBN procedures
	Operator Flexibility	Increased operational flexibility through increased user collaboration regarding preferred trajectories and priorities to support business objectives

How Does TBO Work?

- **TBO is about predicting where a flight will be and at what time**
  - This forms the basis for a ‘strategic plan’
- **A trajectory is used as a reference for the flight and shared between systems and stakeholders**
- **A trajectory is defined in four dimensions**
  - Latitude, Longitude, Altitude, and Time
- **The trajectory is updated as operations evolve over time and new information becomes available**
- **TBO is a collection of systems, capabilities, processes, and people working together to achieve operational objectives**

TBO Integration



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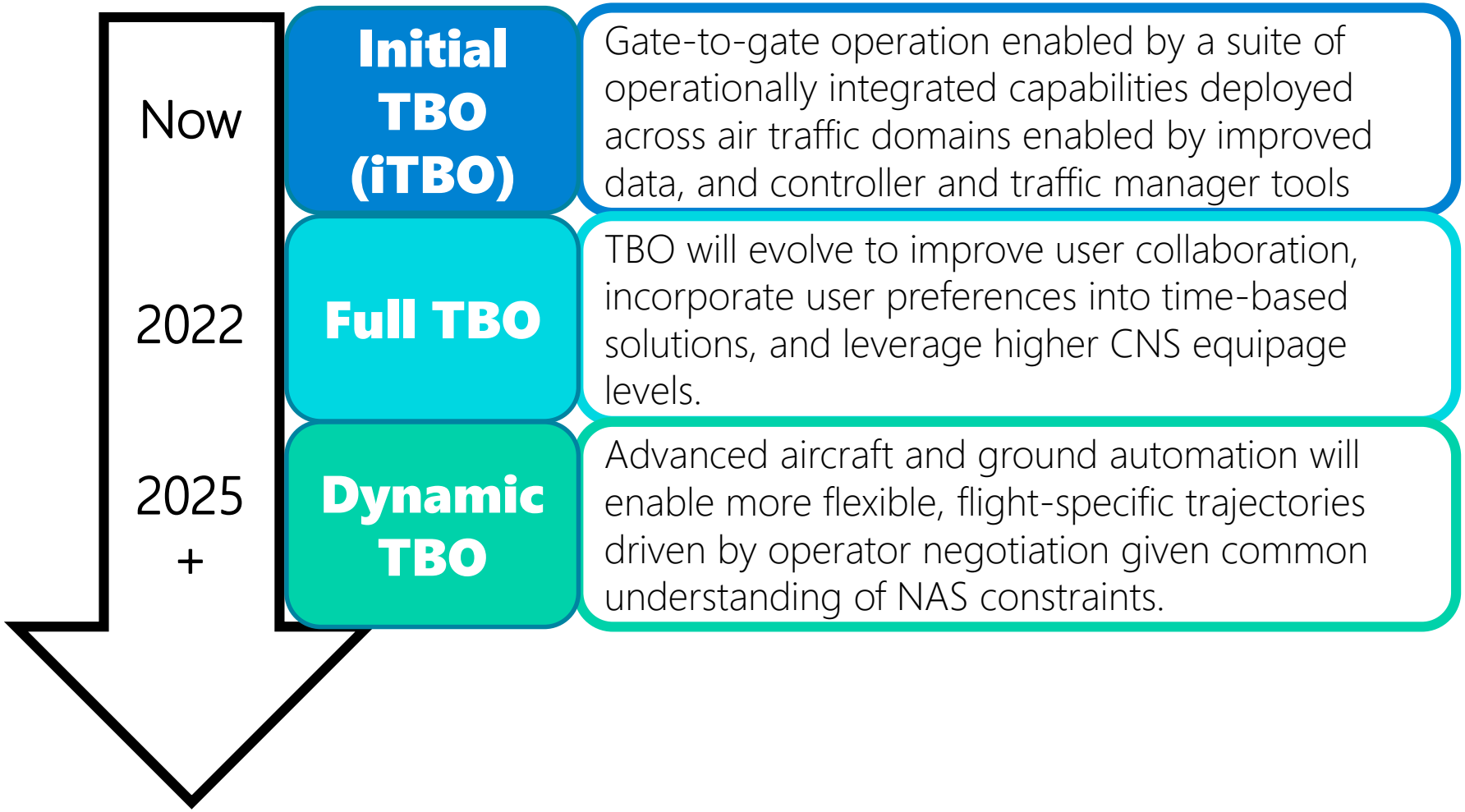
When is TBO?

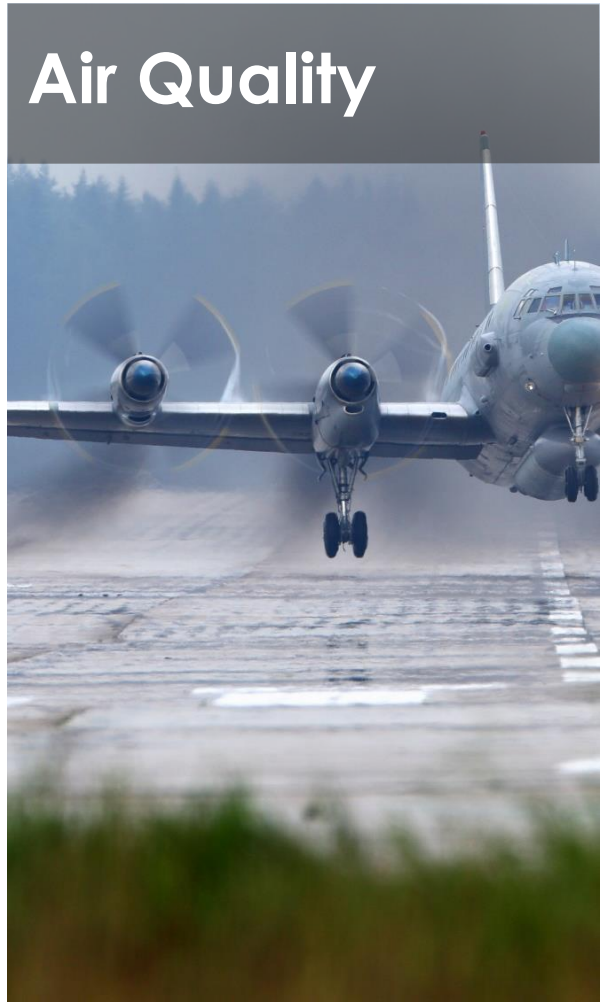


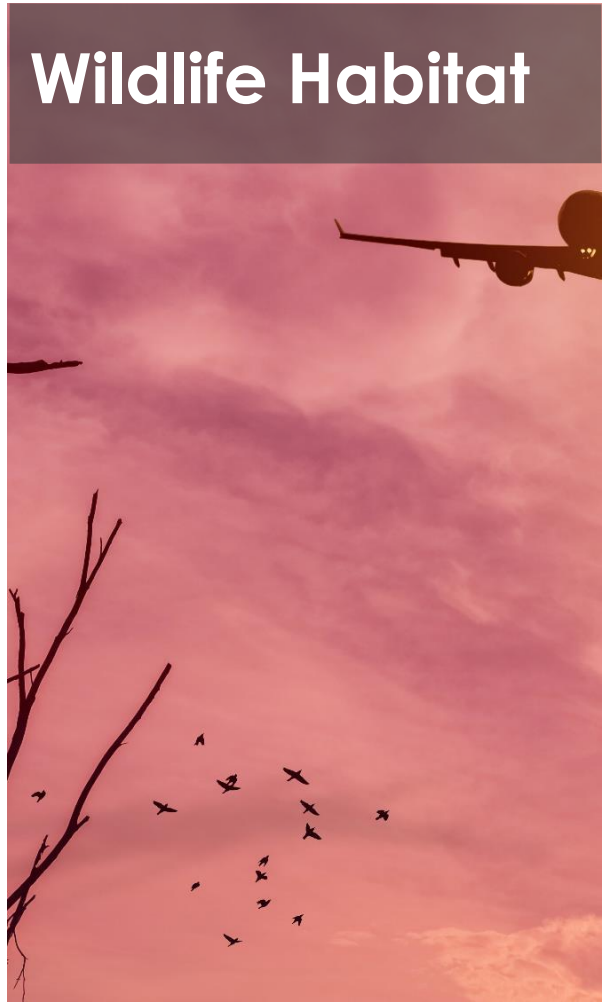
NextGen as a Whole: NextGen Flight 101

Video Source: https://www.faa.gov/tv/?mediaId=1437

Environmental Perspective

Environmental Considerations are Becoming Increasingly Important





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Climate Change is a Growing Consideration

(1 of 3)

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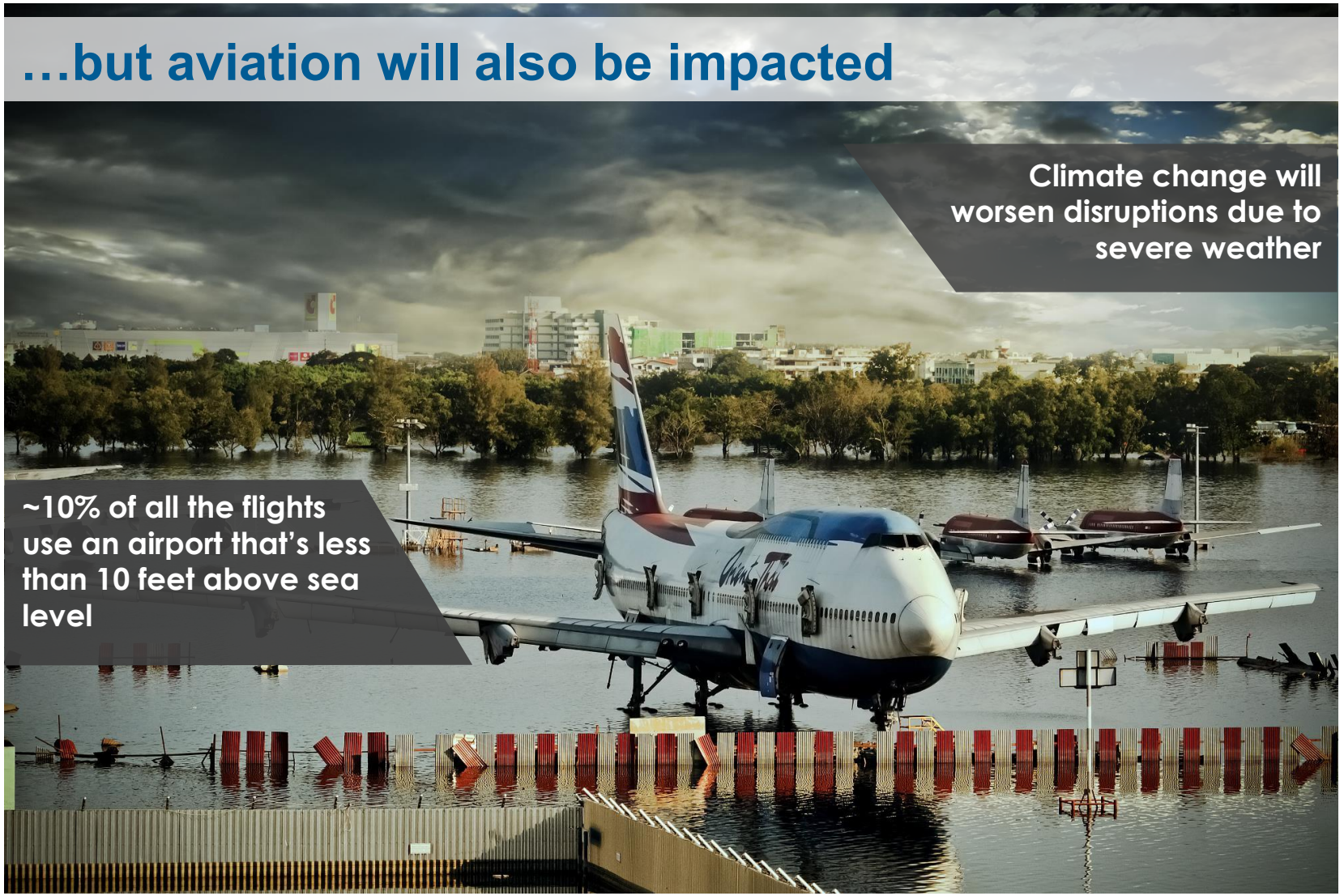
Climate Change is a Growing Consideration

(2 of 3)



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Climate Change is a Growing Consideration

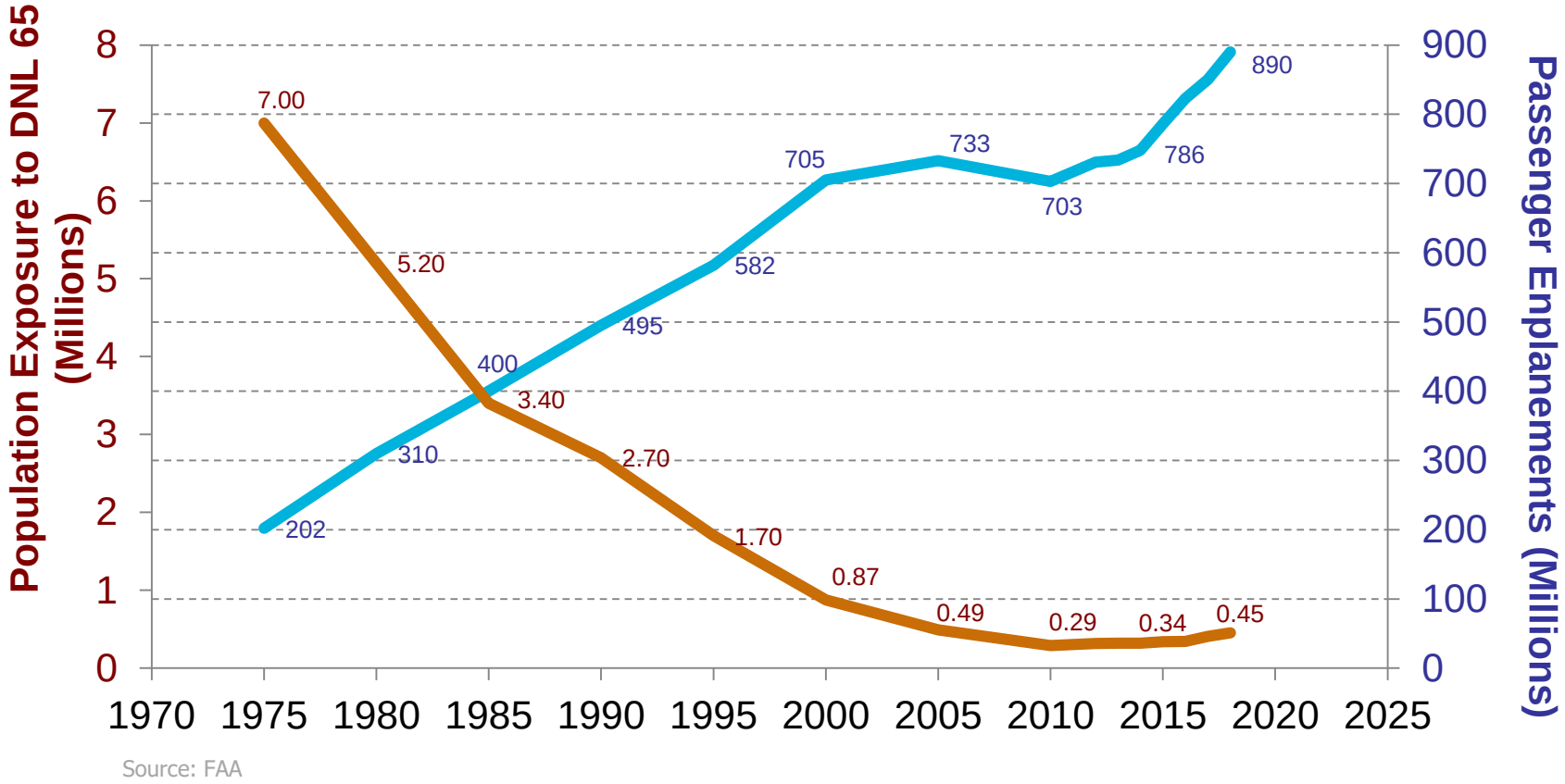
(3 of 3)

An ICAO-led effort to curb carbon emissions is underway

Image Source: ICAO

MITRE

However, Noise is Still the Biggest Concern, Despite Significant Noise Exposure Reduction in the Last 40 Years



Source: FAA

DNL

Day-Night Average Sound Level

Time-average of the total sound energy over a 24-hour period. One nighttime event is equivalent to 10 daytime events.

MITRE

Increasing Community Concerns over PBN, Metroplex, and NextGen Noise Issues

- **PBN single-site implementations:**
  - LGA TNNIS
  - PHX SIDs
- **Metroplex projects:**
  - Northern California
  - Southern California
  - Charlotte
  - Washington DC
- **Communities are making their voices heard**

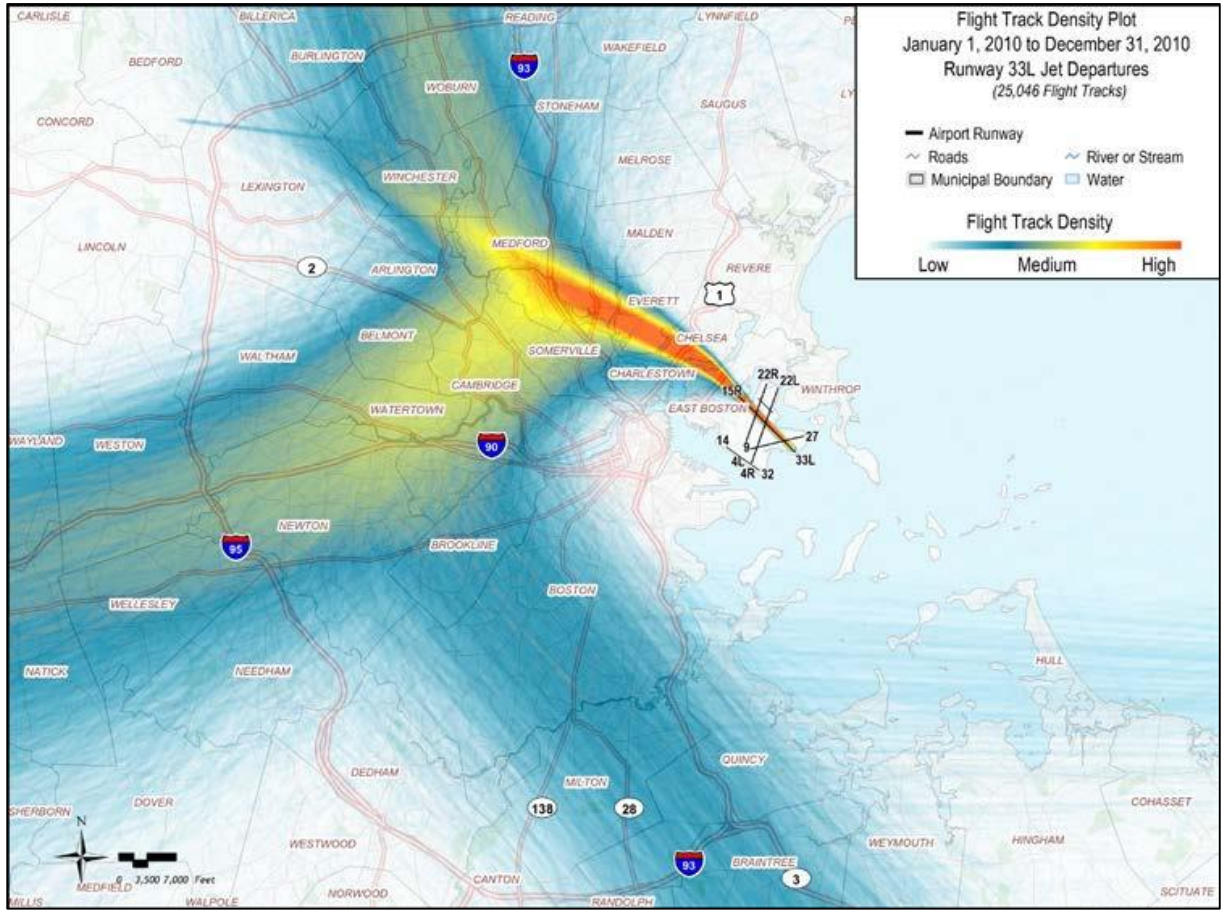
Image Source: MITRE (compiled from multiple web sites)

Image Source: https://airnoise.io/

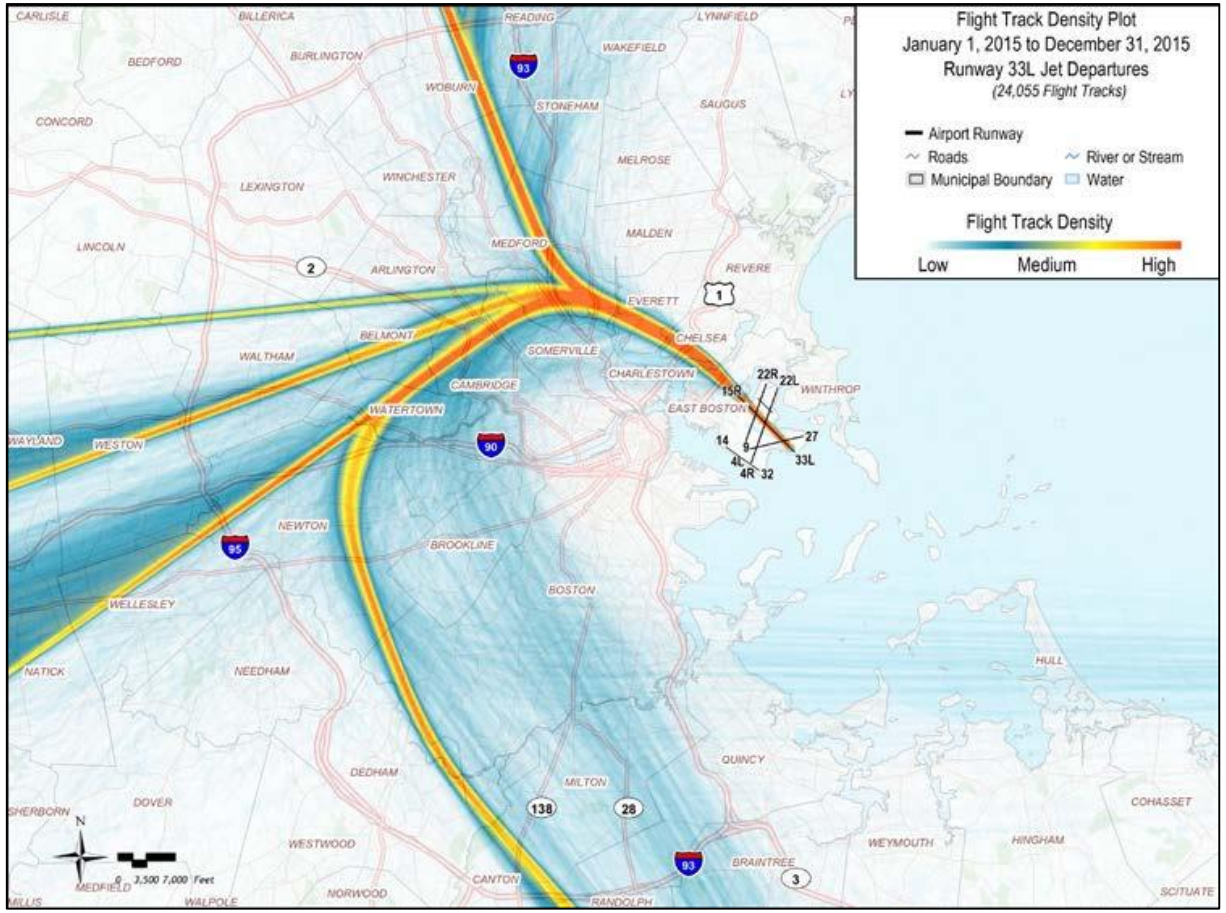
MITRE

Flight Concentration is Driving Some Community Concerns…

Before Procedure Change (2010)



After Procedure Change (2015)



Source: R. John Hansman (MIT), "Procedure Design Concepts for Logan Airport Community Noise Reduction"

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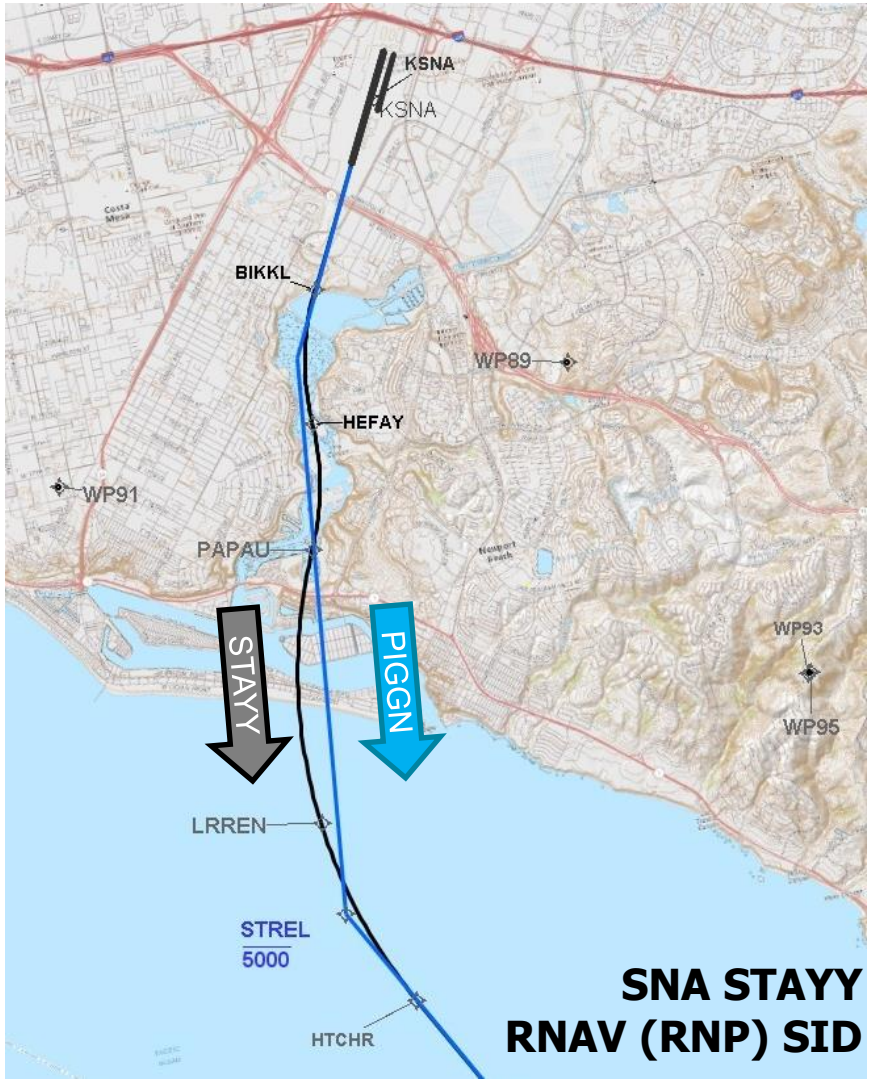
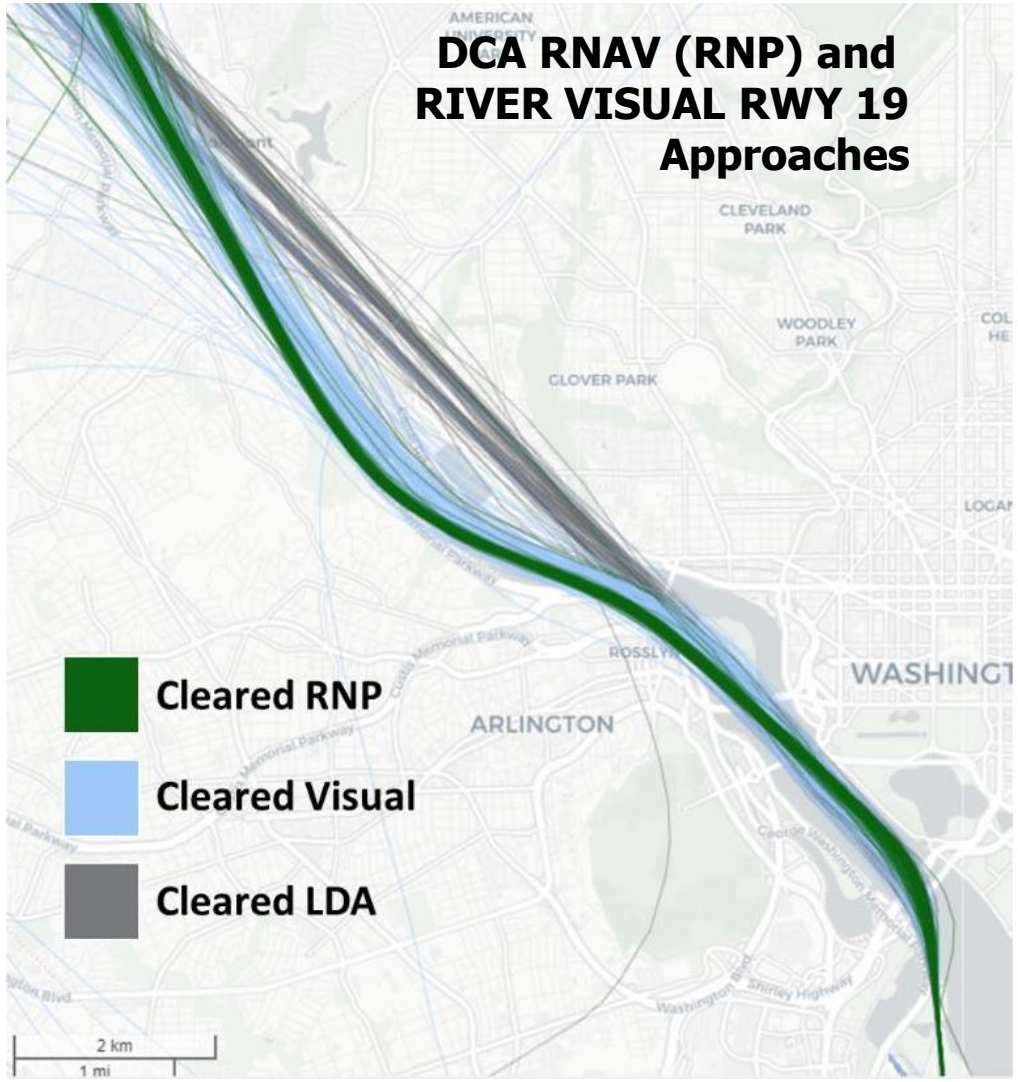
…but Precise, Repeatable Paths can be Beneficial





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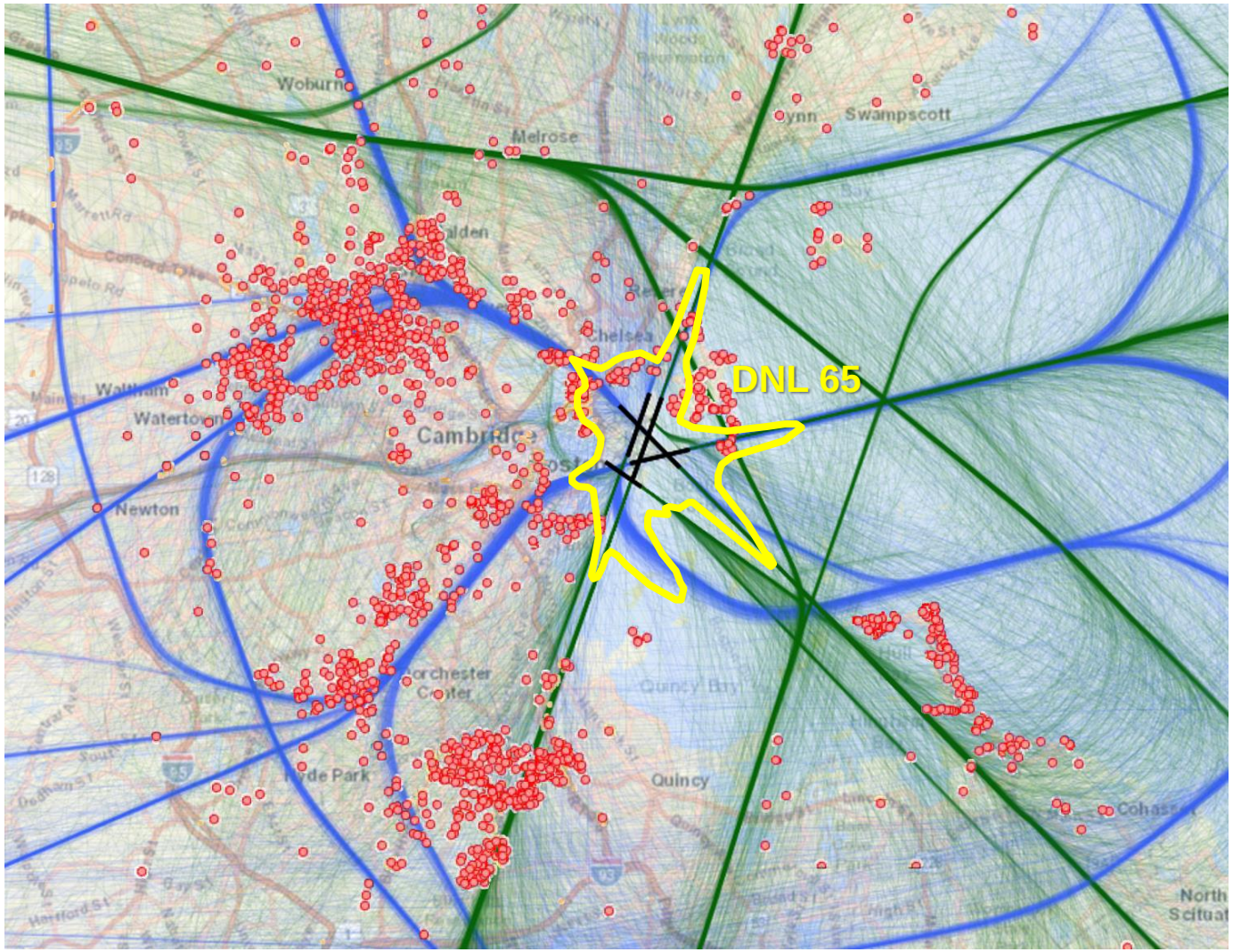
Current Noise Metrics may not Fully Reflect Community Perspectives



Source: Graphic compiled using complaint data from Massport complaint system and noise contours from the Boston-Logan International Airport 2015 Environmental Data Report.

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Noise is Impacting the Ability to Implement NextGen…

Longer Implementation Timelines

Houston Metroplex only took **2.4 years to complete**

SoCal Metroplex took **4.7 years** due to scope of environmental review and litigation

Increased Costs

Houston Metroplex Environmental Assessment cost to FAA: **$880,000**

SoCal Metroplex Environmental Assessment cost to FAA: **$2.3 Million**

Operational Efficiencies not Realized

Procedures implemented at Phoenix saved **1,750 flying miles per day** but **had to be undone**

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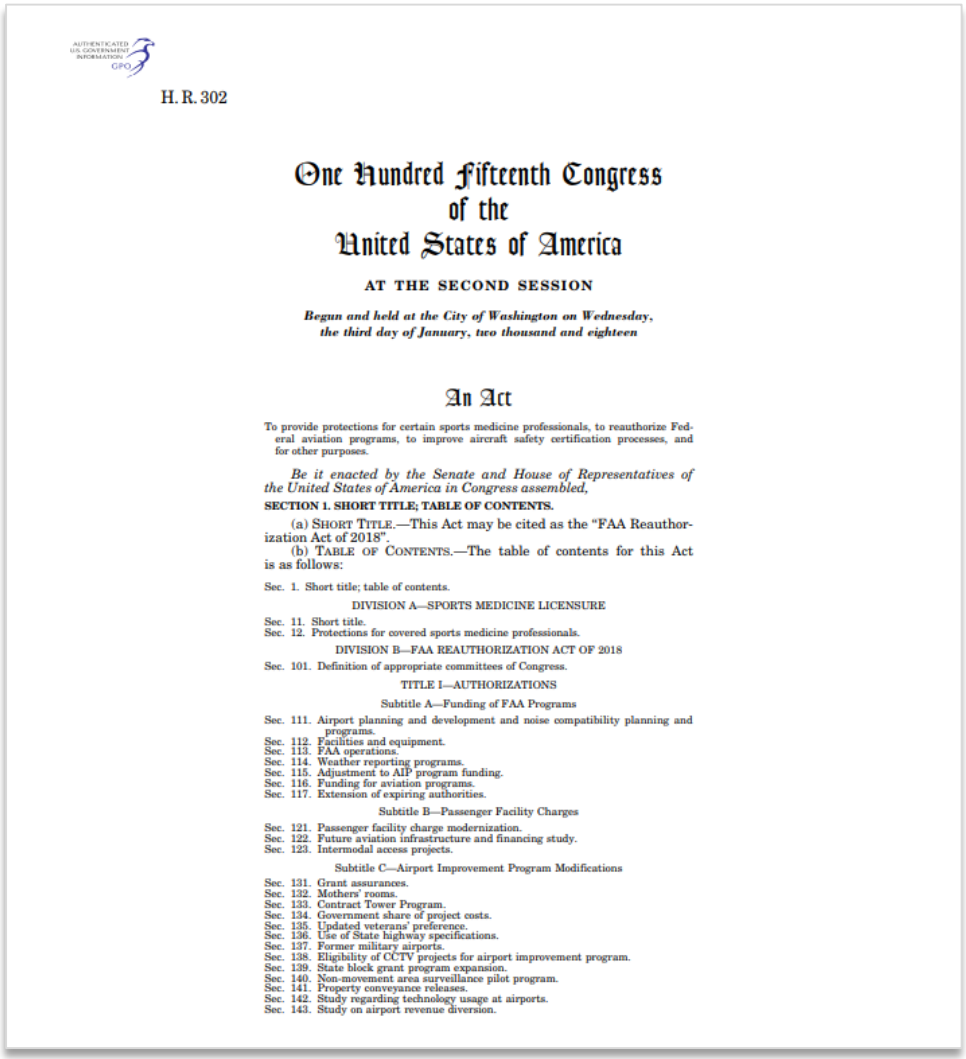
...and Congress is Getting Involved

- Dispersal Procedures — Sec. 175
- Reduced Speed Takeoffs — Sec. 179
- Supersonic Transport — Sec. 181

- Alternative Noise Metrics — Sec. 173, Sec. 188
- Aircraft Noise Exposure — Sec. 187
- Stage 3 Study — Sec. 186

- Enhanced Community Engagement — Sec. 176
- Regional Ombudsmen — Sec. 180



H. R. 302

One Hundred Fifteenth Congress
of the
United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Wednesday, the third day of January, two thousand and eighteen

An Act

To provide protections for certain sports medicine professionals, to reauthorize Federal aviation programs, to improve aircraft safety certification processes, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "FAA Reauthorization Act of 2018".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

Image Source: http://congress.gov

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Addressing the Aircraft Noise Challenge Requires Efforts in Multiple Areas

Reducing Noise

Airframe modifications

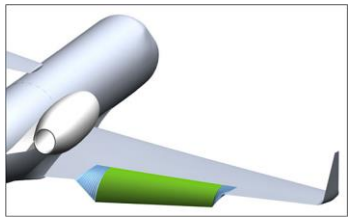


Image Source: Flexsys Inc.

Quieter engines

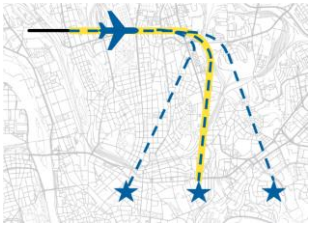
Image Source: Pratt & Whitney

New aircraft designs

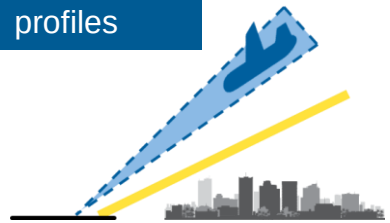
Image Source: NASA, MIT, Aurora Flight Sciences

Managing Noise

Dispersion



Modified vertical profiles



Speed restricted departures

Involving the Public

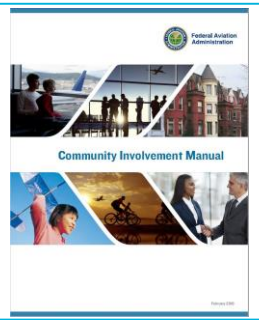


Image Source: FAA

Image Source: Queens Chronicle, 19 April 2018

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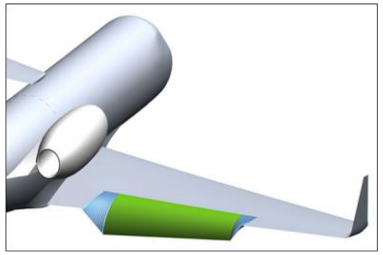
Reducing Noise

Airframe Modifications

Noise-reducing vortex generators
Image Source: Condor

Slat cove fillers
Image Source: Boeing



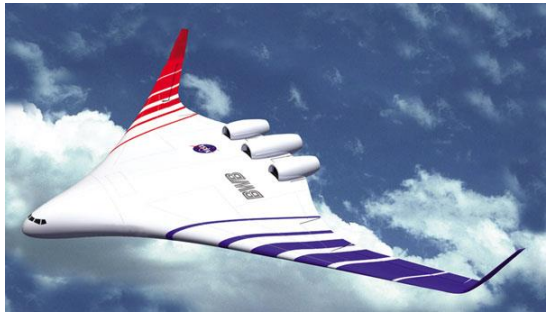
Adaptive trailing edges
Image Source: Flexsys Inc.

Quieter Engines

Ultra-high bypass geared turbofan engine

Continuous Lower Energy, Emissions & Noise
CLEEN
Federal Aviation Administration

New Aircraft Designs



Blended Wing Body
Image Source: NASA

"Double Bubble" D8 Series

Image Source: NASA, MIT, Aurora Flight Sciences

New aircraft designs offer the greatest opportunity for a step change in noise reduction but also take longer to reach maturity

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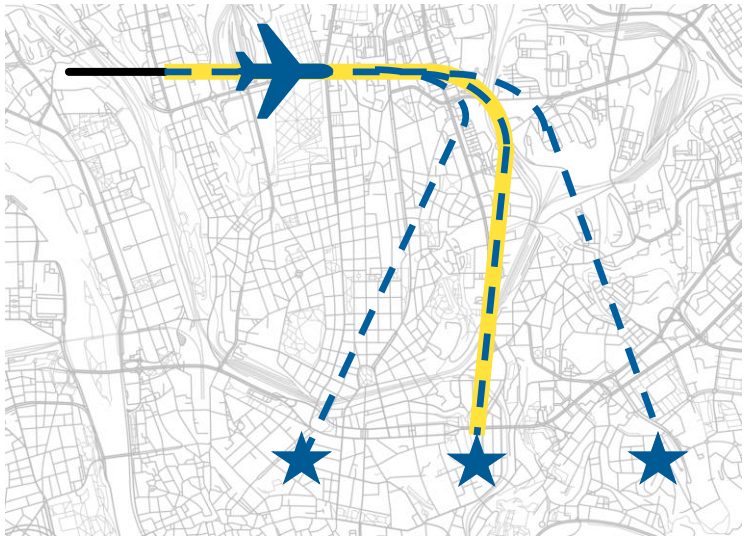
Managing Noise

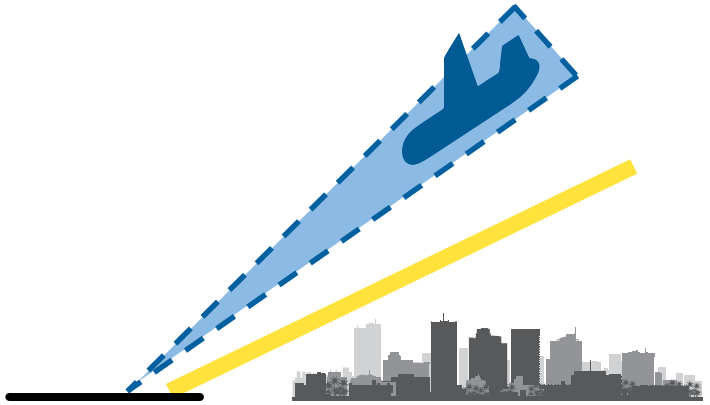
Dispersion



Dispersed Flow

Concentrated Flow

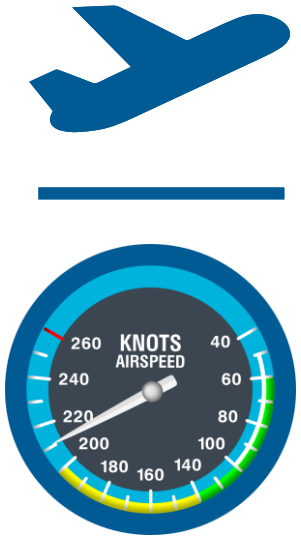
Modified vertical profiles



Modified Profile

Existing Profile

Speed restricted departures



The above introduce inefficiencies or operational tradeoffs that must be balanced against relatively modest noise reductions

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Involving the Public

FAA's Role

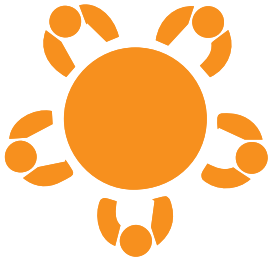
Give meaningful consideration to community concerns

Work collaboratively with airport and aircraft operators

Inform and involve the public

Aircraft and Airport Operators Role

Act as advocates for the proposed initiatives



Partner with FAA on engagements with roundtables, elected officials, stakeholders and the public

Provide relevant historical information, input on specific community concerns, and feedback on proposed initiatives

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New Entrants Bring Additional Noise Challenges

UAS and UAM will introduce aircraft noise where it does not exist today

High operational tempo

Image Source: Amazon

Flights closer to the ground

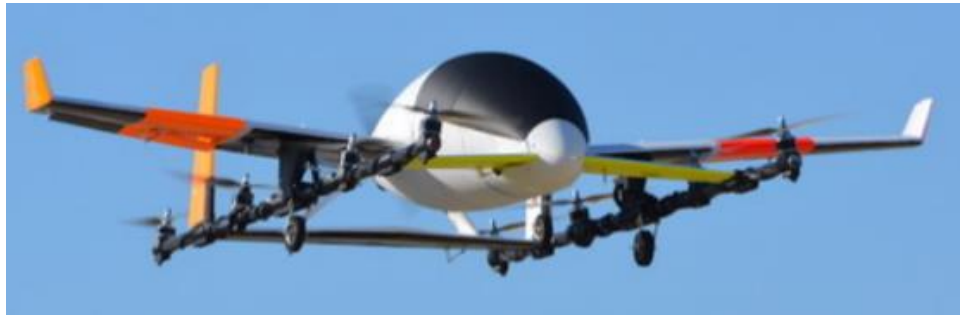

Image Source: Aurora

Flights in high population centers

Image Source: Volocopter

Image Source: Lockheed Martin

Supersonic transports could make a comeback

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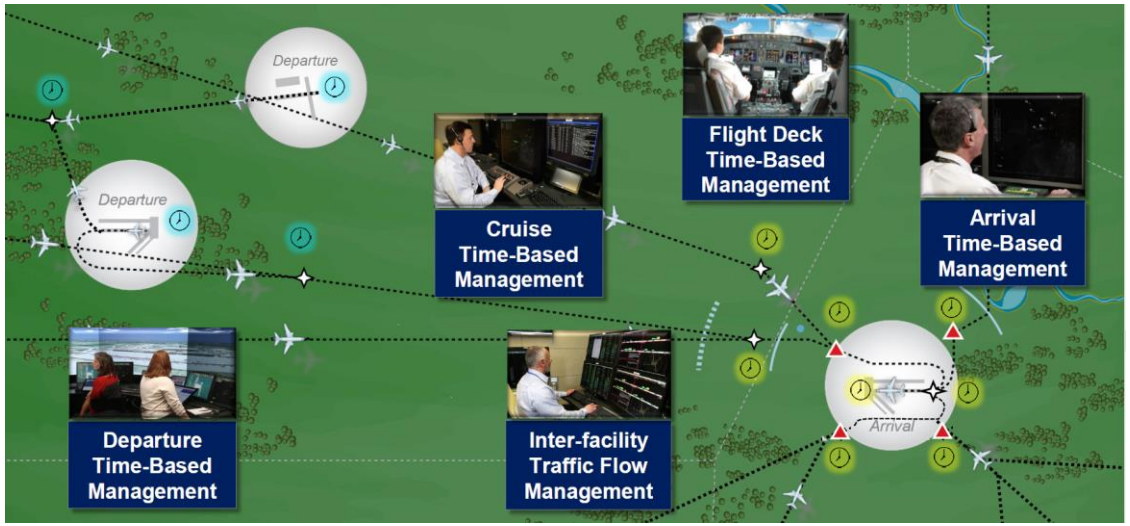
Future NextGen Capabilities May Offer New Challenges but also Opportunities

Near-term

NextGen operations will require continued noise management and public involvement



Longer-term

Options to more effectively distribute noise may be possible

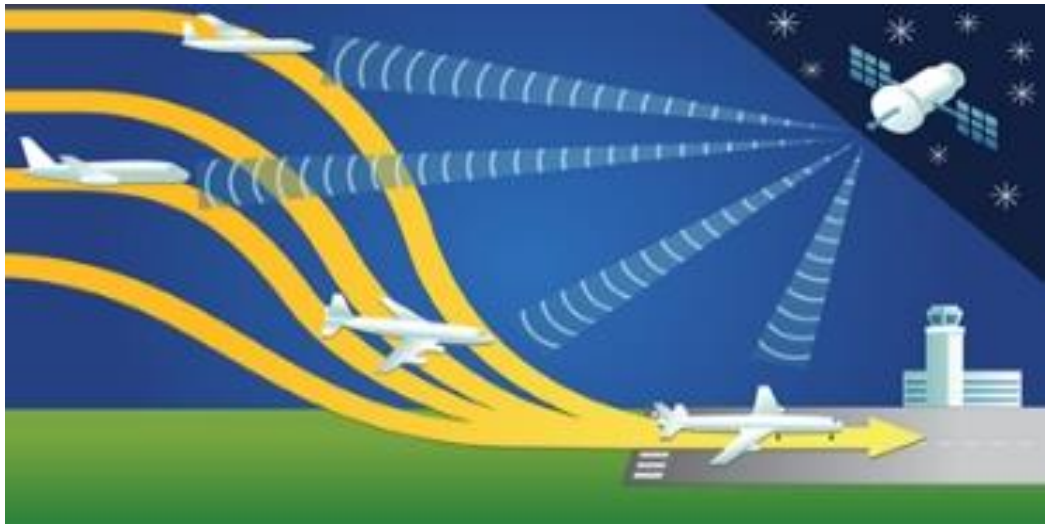


Image Source: FAA

Summary

Summary

- **NextGen is a suite of critical improvements to modernize the NAS**
- **NextGen provides a range of benefits to pilots, controllers, and the traveling public**
  - Access
  - Capacity
  - Environment
  - Efficiency
  - Flexibility
  - Predictability
  - Safety
- **Some NextGen capabilities increase navigational accuracy, predictability, and repeatability, which may result in flight path concentration**

Open Discussion

Supplemental Information

Resources

(1 of 2)

Below are the links for all the videos in this document:

- **Slide 41:** https://www.faa.gov/nextgen/faqs/#q5
- **Slide 43:** https://www.faa.gov/nextgen/how_nextgen_works/
- **Slide 50:** https://www.faa.gov/tv/?mediaId=1793
- **Slide 51:** https://www.faa.gov/tv/?mediaId=1520
- **Slide 52:** https://www.faa.gov/tv/?mediaId=1526
- **Slide 54:** https://www.faa.gov/tv/?mediaId=1714
- **Slide 56:** https://www.faa.gov/tv/?mediaId=1528
- **Slide 62:** https://www.faa.gov/tv/?mediaId=1689
- **Slide 63:** https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/asdex.html
- **Slide 81:** https://www.faa.gov/nextgen/how_nextgen_works/new_technology/pbn/
- **Slide 84:** https://www.faa.gov/tv/?mediaId=1426
- **Slide 91:** https://www.faa.gov/tv/?mediaId=1437

Resources
(2 of 2)

- **Additional FAA Videos: https://www.faa.gov/tv/**
- **NextGen Website: https://www.faa.gov/nextgen/**
- **NextGen Performance Snapshots Website: https://www.faa.gov/nextgen/snapshots/**
- **NextGen Community Involvement: https://www.faa.gov/nextgen/nextgen_near_you/community_involvement/**

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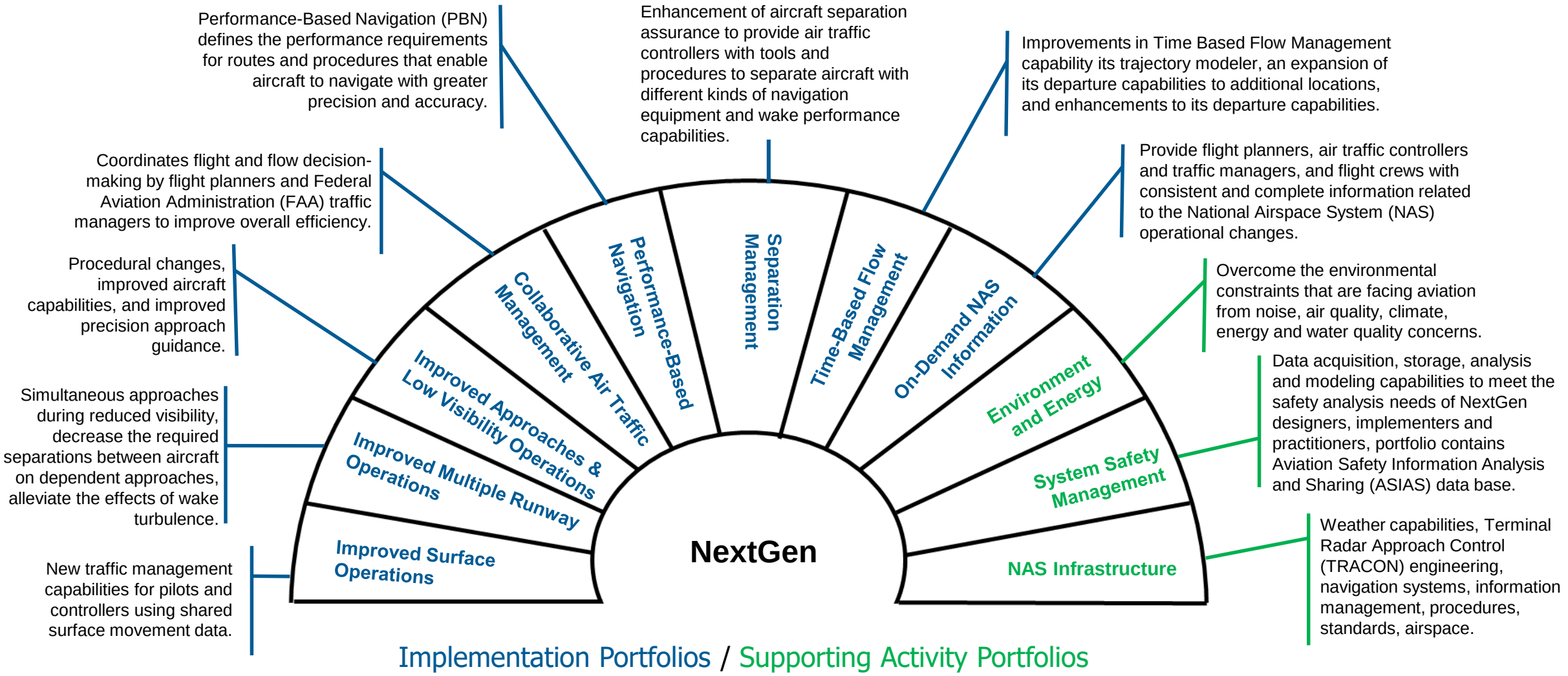
Eleven NextGen Portfolios



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