NextGEN

GPS and the Next Generation Air Transportation System

Joseph Post, Office of Systems Analysis & Modeling

April 2, 2012

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Outline

- What is NextGen?
- Why do we need NextGen?
- What are the NextGen GPS Technologies?
  - RNAV/RNP
  - WAAS
  - GBAS
  - ADS-B

What is NextGen?

- NextGen represents the transformation of our national airspace system
- It integrates new and existing technologies, procedures and policies

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Safety
Policy
Comm
Weather
Navigation
NextGEN
Procedures
Surveillance
Airframes &
Engines
Fuels
Airspace
Automation

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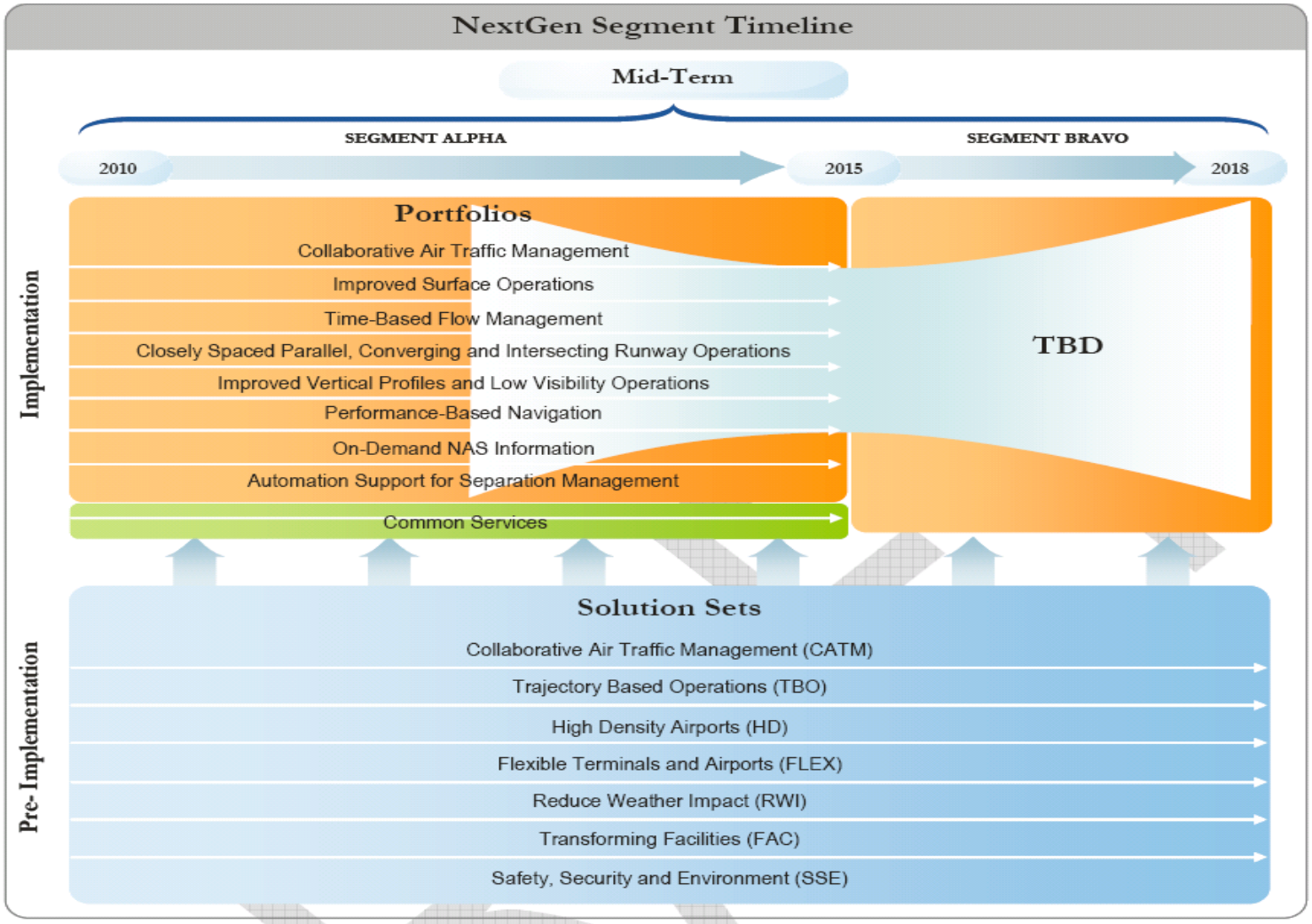
NextGen Portfolio Approach



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Federal Aviation Administration

Efficient Cruise

RNAV, **RNP** and **RVSM** utilize reduced separation requirements increasing airspace capacity. Aircraft fly most optimal path using trajectory-based operations considering wind, destination, weather and traffic. Re-routes determined with weather fused into decision-making tools are tailored to each aircraft. **Data Communications** reduce frequency congestion and errors. **ADS-B** supported routes available for equipped aircraft.

Integrated Flight Planning

Operators and traffic managers have immediate access to identical weather information through one data source.

Streamlined Departure Management

RNAV and **RNP** precision allow multiple departure paths from each runway. Departure capacity increased.

Streamlined Arrival Management

Arrival sequence planned hundreds of miles in advance. **RNAV** and **RNP** allow multiple precision paths to runway. Equipped aircraft fly precise horizontal and vertical paths at reduced power from descent point to final approach in almost all types of weather. Time and fuel are saved. Emissions and holding are reduced.

Flight Planning | Push Back / Taxi / Takeoff | Domestic / Oceanic Cruise | Descent / Final Approach / Landing

Surface Traffic Management

Automation optimizes taxi routing. Provides controllers and pilots all equipped aircraft and vehicle positions on airport. Real-time surface traffic picture visible to airlines, controllers, equipped aircraft, ramp operators and airports. Surface movement management linked to departure and arrival sequencing. **ADS-B** and **ASDE-X** contribute to this function. Taxi times reduced and safety enhanced.

Enhanced Surface Traffic Operations

Pilots and controllers talk less by radio. **Data Communications** expedite clearances, reduce communication errors. Pilot and controller workloads reduced.

Enhanced Surface Traffic Management

Runway exit point, assigned gate and taxi route sent by **Data Communications** to pilots prior to approach. Pilot and controller workload reduced and safety improved.

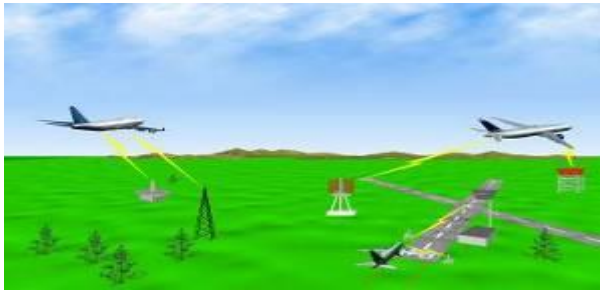
NextGen PHASES OF FLIGHT

www.faa.gov/nextgen

March 2012

Transforming Our National Airspace System (NAS)

Today's NAS		*NextGen*
Ground-based Navigation and Surveillance	→	Satellite-based Navigation and Surveillance
Air Traffic Control Communications By Voice	→	Routine Information Sent Digitally
Disconnected Information Systems	→	Information More Readily Accessible
Air Traffic "Control"	→	Air Traffic "Management"
Fragmented Weather Forecasting	→	Forecasts Embedded into Decisions
Airport Operations Limited By Visibility Conditions	→	Operations Continue Into Lower Visibility Conditions
Forensic Safety Systems	→	Prognostic Safety Systems
Focus on major airports	→	Focus on metropolitan areas



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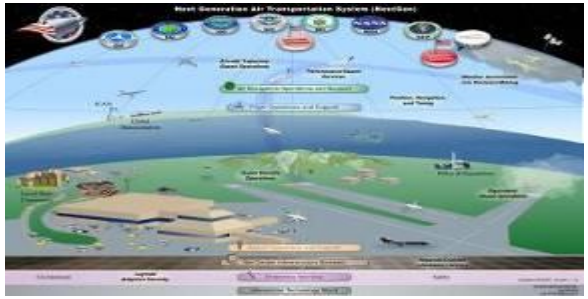

Delivering safety, efficiency and environmental stewardship

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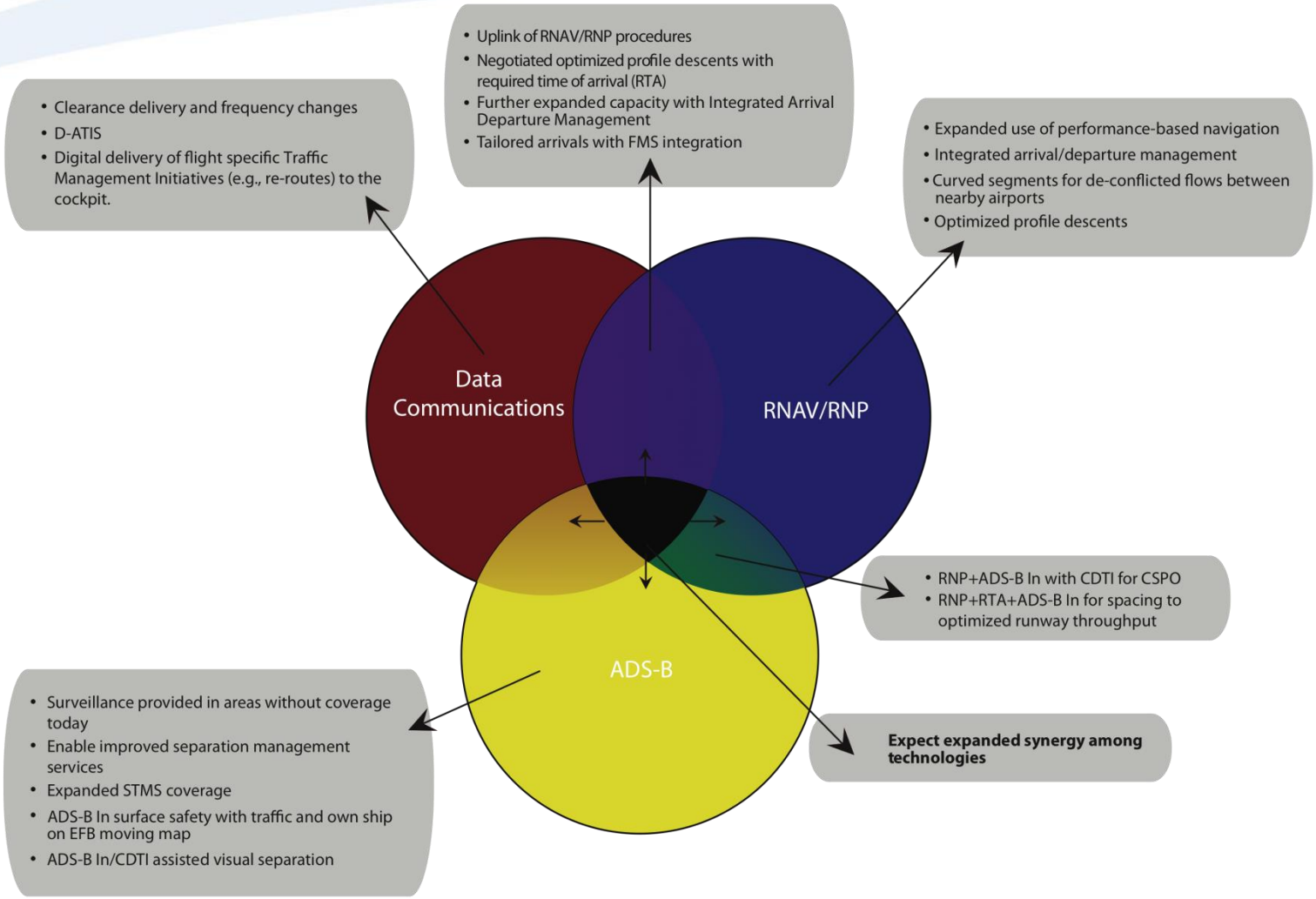
Equipage Components

Many NextGen capabilities are dependent on ADS-B, DataComm, and PBN equipage



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WHY NEXTGEN MATTERS

Aviation is an Engine of Our Economy

- $1.3 Trillion in Economic Activity

- 5.2% of GDP

Reducing Environmental Impact Is *A Top Priority*

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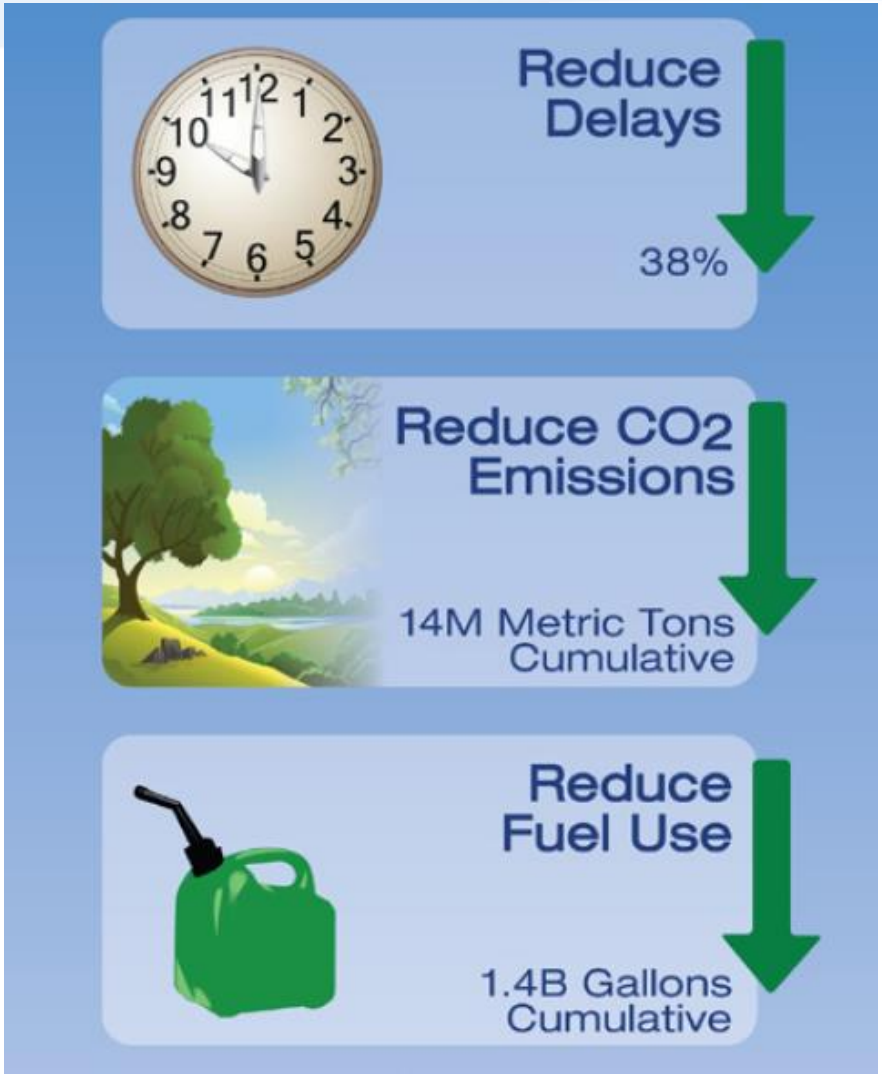
Mid-Term Performance Improvements thru 2020



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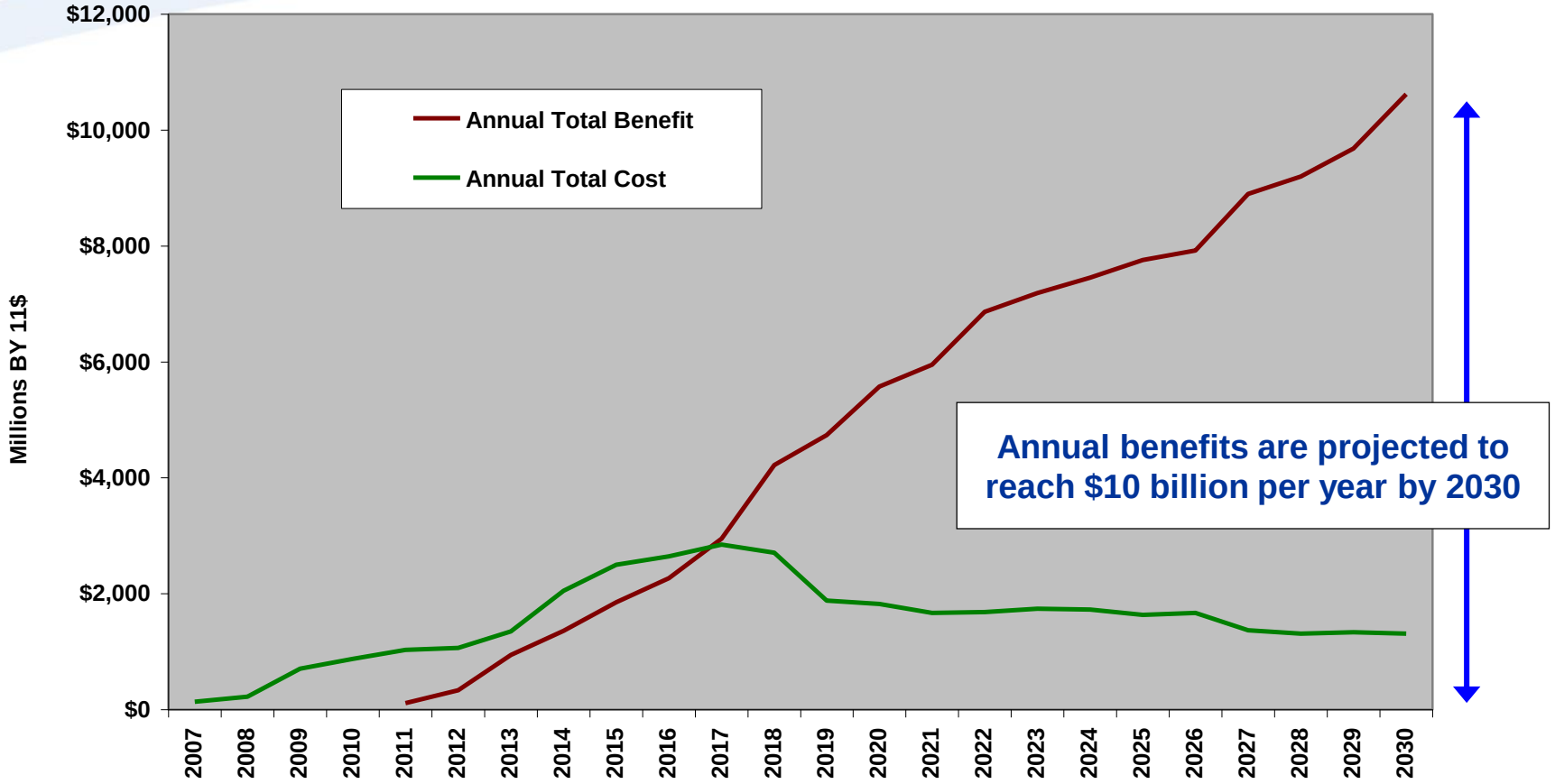
Comparing Annual Costs and Benefits of NextGen Mid-Term Capabilities



"Total cost" is the estimated cost needed to deploy and maintain NextGen mid-term operational improvements. This includes FAA Facilities and Equipment (F&E) and Operations and Maintenance (O&M) costs, and the estimated cost to system users for avionics upgrades. Likewise, "total benefit" includes the stream of benefits generated by these capabilities, relative to a baseline scenario.

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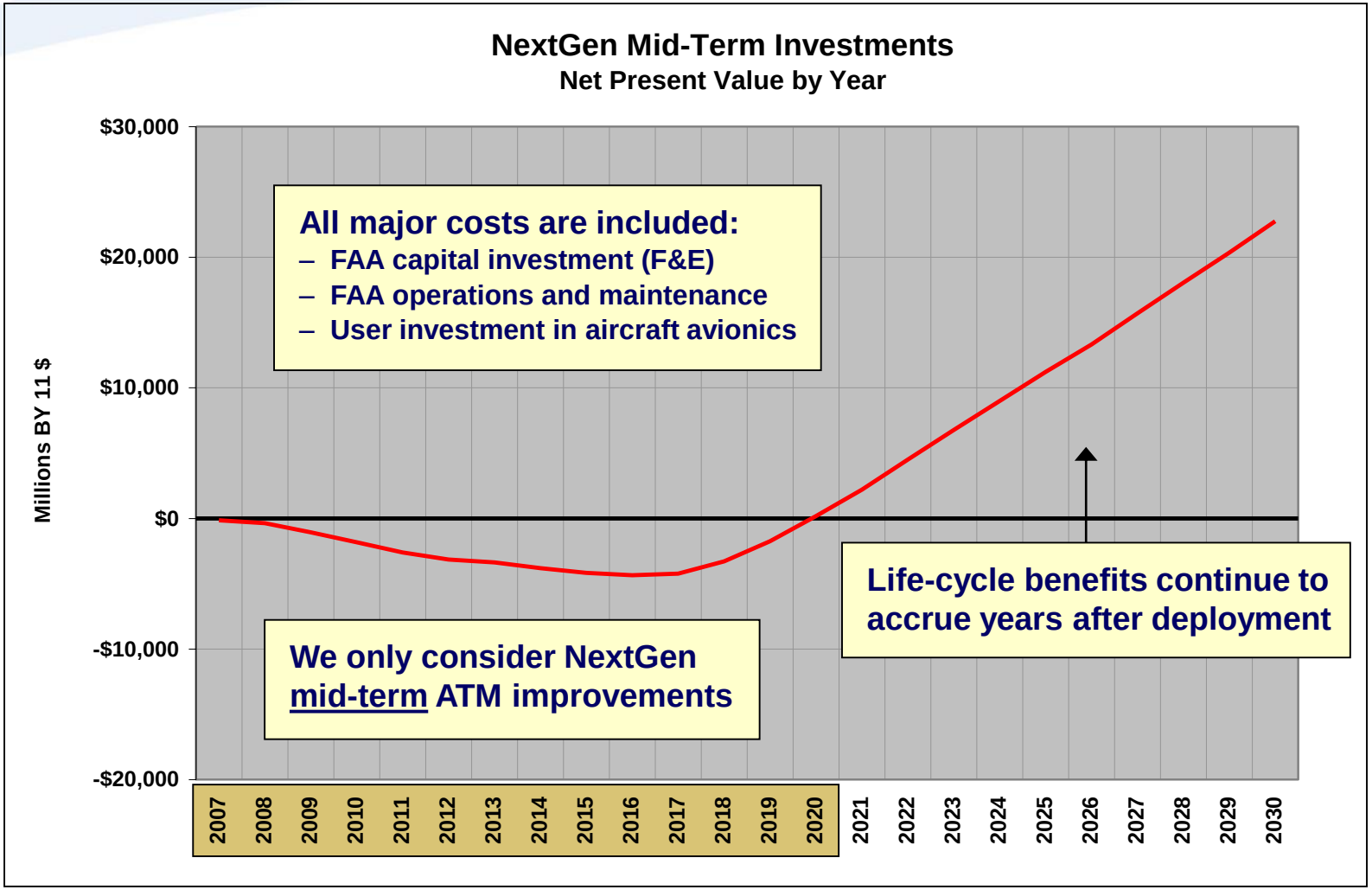
Estimated Net Present Value (NPV) of NextGen Mid-Term Improvements is $23 Billion



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Many Stakeholders with Diverse Interests to Be Served

Government
FAA
DOT
DOD
DHS
NASA
Congress
Administration

People
Employees
Unions
Pilots
Controllers
HR/LR

International
ICAO
IATA
EU–SESAR
States

Industry
Manufacturers
Airlines
ATA
NBAA
R&D

Stakeholders
AOPA
Airports
Communities

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International Cooperation…A Necessity

Daily interaction with 18 foreign ATC systems

Global Positioning System (GPS)

Space Segment

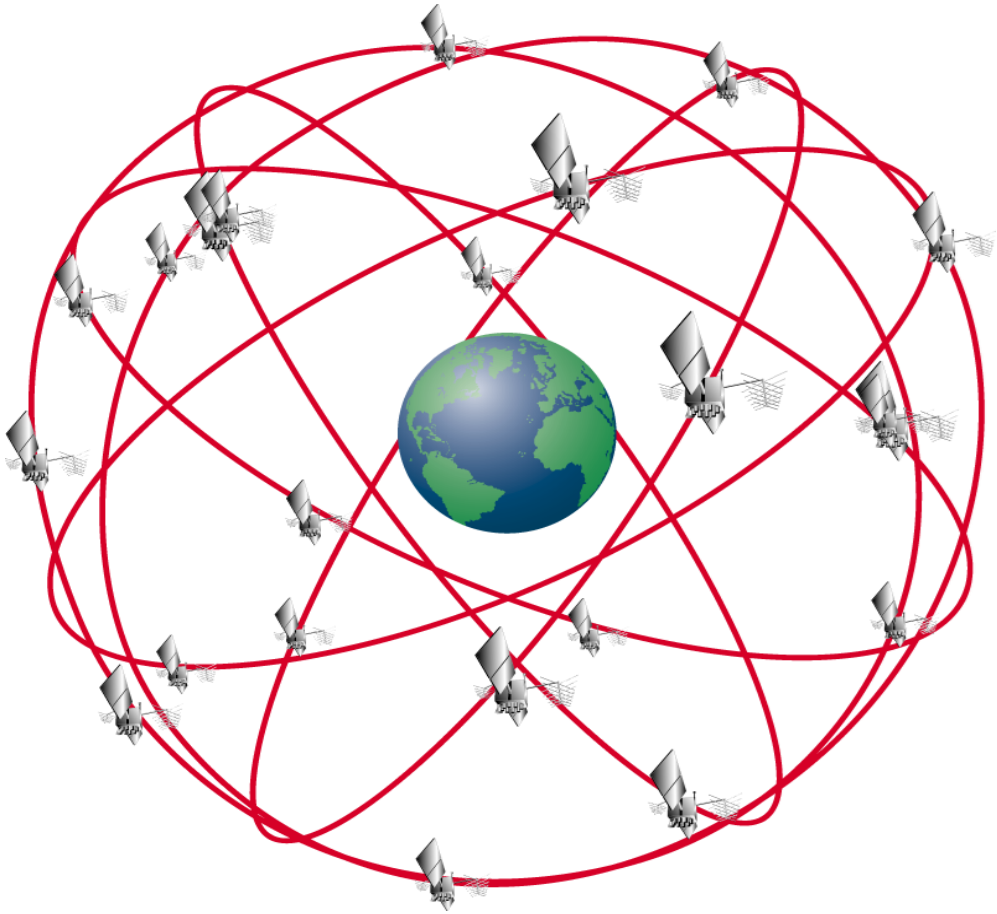
- **24 Orbit Slots**
- **6 Orbital Planes**
- **4 Satellites Per Plane (Nominal)**
- **55 Degrees Inclination**
- **Orbit at 10,800 Miles**
- **Orbits Once Every 12 Hours**

Control Segment

- **5 GPS Monitor Sites**
- **13 NGA Monitor Sites**
- **2 Operational Control Centers**

User Segment

- **Military & Civil Receivers**
- **Precise Positioning Service (PPS)**
- **Standard Positioning Service (SPS)**



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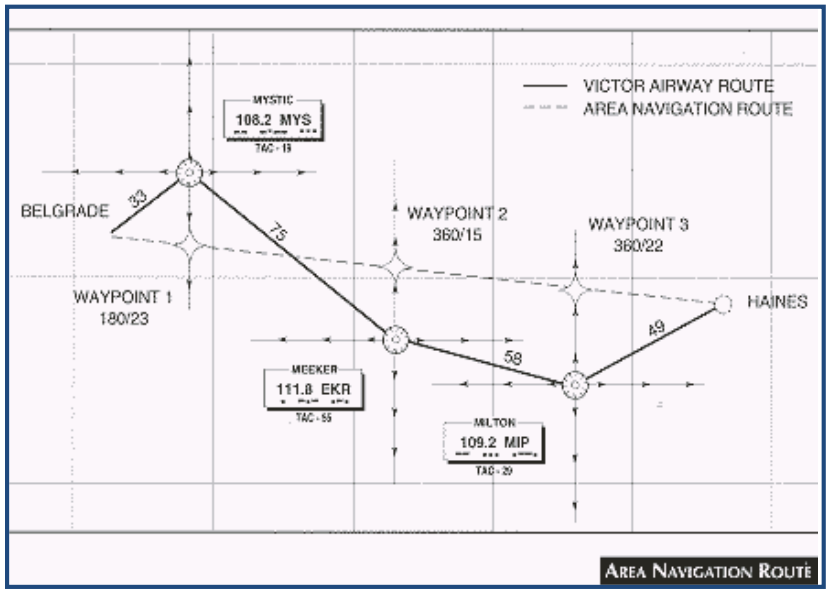
Area Navigation (RNAV)
and
Required Navigational Performance (RNP)

Area Navigation (RNAV)

RNAV is a method of navigation that permits aircraft operation on any desired flight path within the coverage of ground or space based navigation aids or within the limits of the capability of self-contained aids, or a combination of these. In the future, there will be an increased dependence on the use of RNAV in lieu of routes defined by ground-based navigation aids.

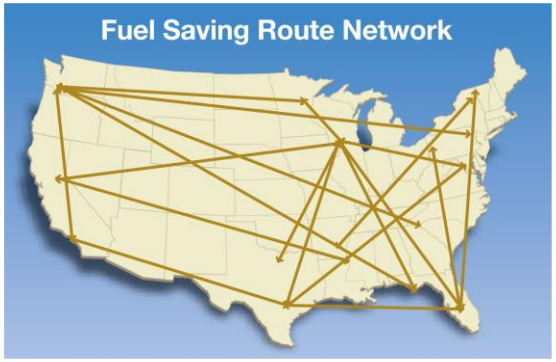
RNAV routes and terminal procedures, including departure procedures (DPs) and standard terminal arrivals (STARs), are designed with RNAV systems in mind. There are several potential advantages of RNAV routes and procedures:

1. Time and fuel savings,
2. Reduced dependence on radar vectoring, altitude, and speed Assignments allowing a reduction in required radio transmissions, and
3. More efficient use of airspace.



Q Routes and T Routes

- Q Routes are routes that can be flight planned for use by aircraft with RNAV capability, subject to any limitations or requirements noted on en route charts, in applicable Advisory Circulars, or by NOTAM.
- Published RNAV routes are RNAV-2 except when specifically charted as RNAV-1.
- T Routes are similar to Q Routes, but are intended for lower altitudes. T Routes are depicted on low altitude en route charts, and are intended for flights below FL180.
- These routes require system performance currently met by GPS or DME/DME/IRU RNAV systems that satisfy the criteria discussed in AC 90-100A, U.S. Terminal and En Route Area Navigation (RNAV) Operations.



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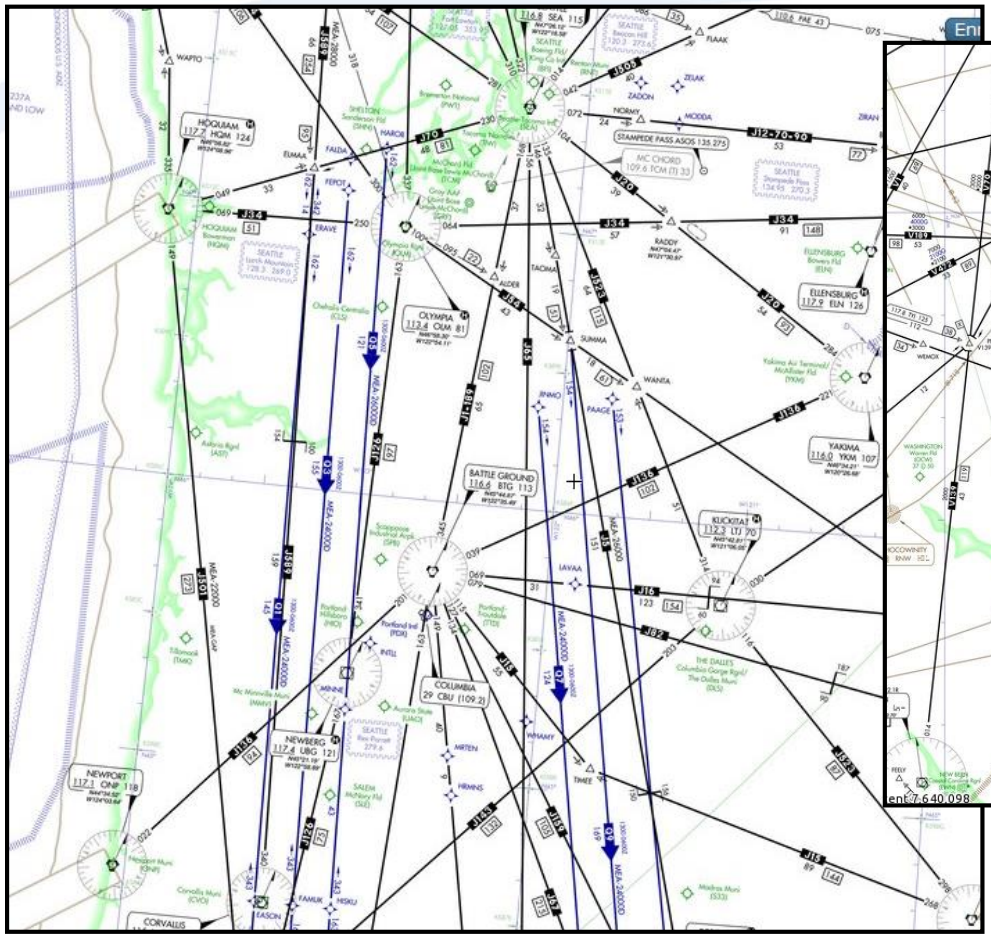
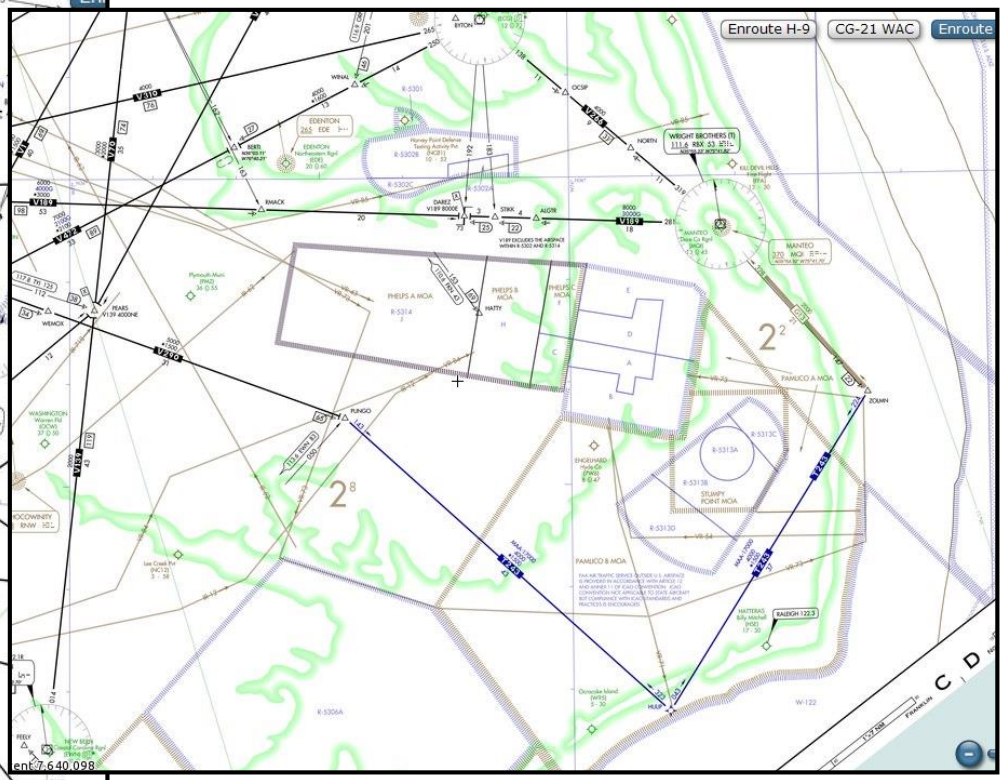
Q Routes

T Routes





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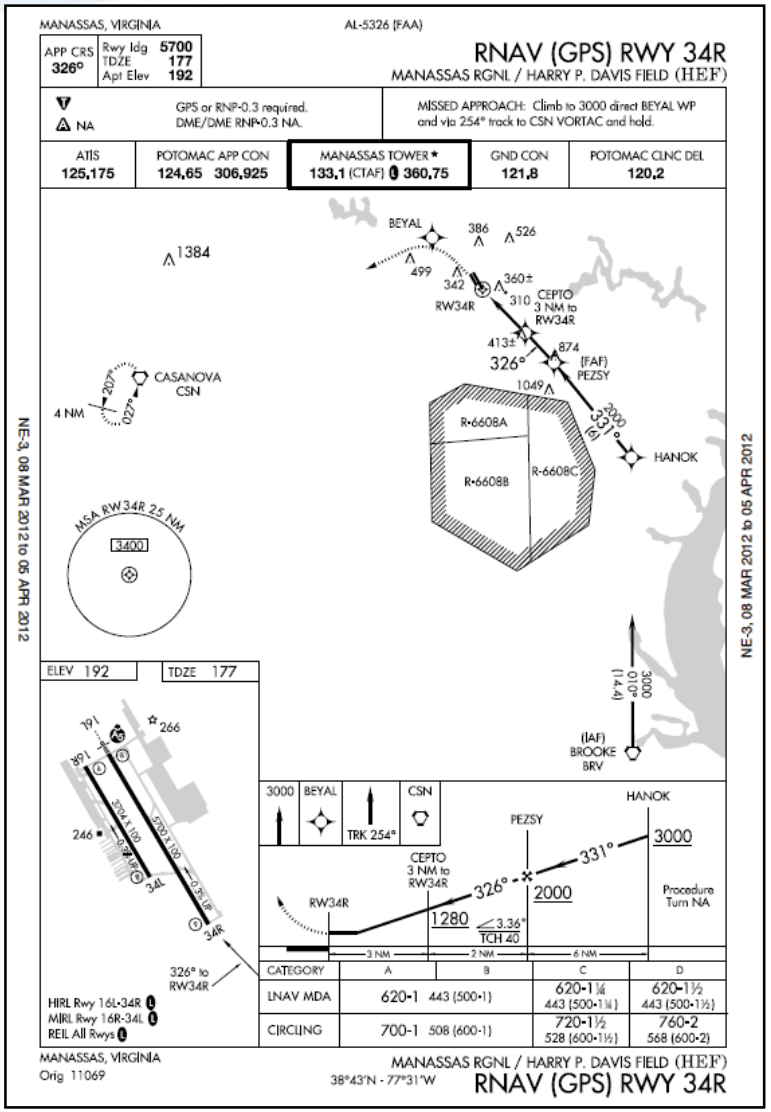
RNAV Approach Procedures



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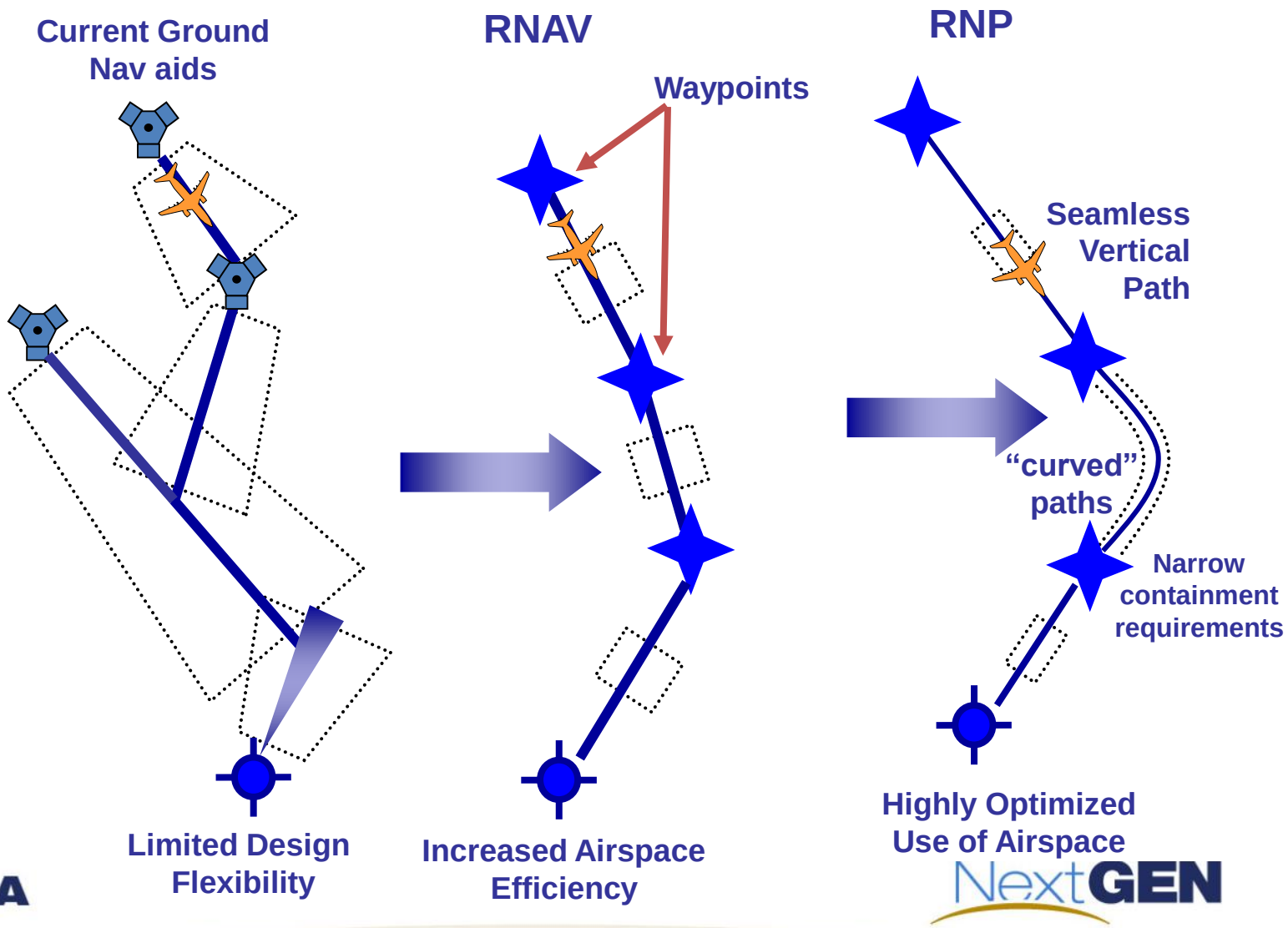
Required Navigational Performance (RNP)

RNP is RNAV with on-board navigation monitoring and alerting, RNP is also a statement of navigation performance necessary for operation within a defined airspace. A critical component of RNP is the *ability of the aircraft navigation system to monitor its achieved navigation performance, and to identify for the pilot whether the operational requirement is, or is not being met during an operation*. This on-board performance monitoring and alerting capability therefore allows a lessened reliance on air traffic control intervention (via radar monitoring, automatic dependent surveillance (ADS), multilateration, communications), and/or route separation to achieve the overall safety of the operation. RNP capability of the aircraft is a major component in determining the separation criteria to ensure that the overall containment of the operation is met.

Performance-Based Navigation (PBN)



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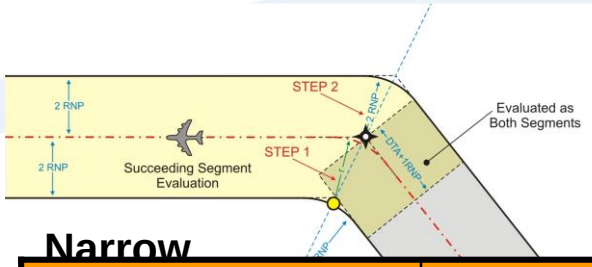
Benefits Overview

- As infrastructure and airplane capabilities evolve, meeting stricter performance criteria and leading to reduced separation standards, FAA and industry expect to reap substantial benefits from RNAV and RNP
  - Increased capacity in en route and terminal airspace
  - Reduced noise and emissions
  - Improve airport access
  - More direct and flexible routes
  - Increased schedule reliability and reduced delays
  - Reduced fuel consumption
  - Reduced controller-pilot communications
  - Reduced workload
  - Reduced risk of controlled flight into terrain

RNP Approach Enabling Features

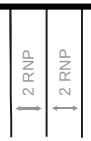
Narrow lateral linear segments
(RNP-0.3 or less with no secondary buffers)

Curved segments anywhere along the approach
(Radius to fix legs with shorter leg lengths)

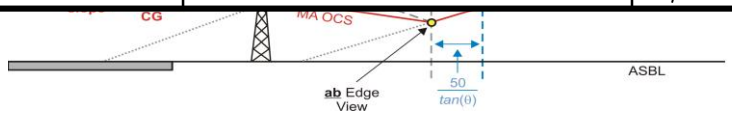


Narrow

Parallel Operations	Converging Operations	Adjacent Airport Operations	Single Runway Access
750' - <4300'		Airport A	Conventional RNP
RNP Feature: Narrower, linear segments	**RNP Feature:** Early, guided turns on missed approach	**RNP Feature:** Curved final approach segment	**RNP Feature:** Narrower, linear segments and vertical guidance
		Airport B	



RF Segments



VEB & Missed Approach

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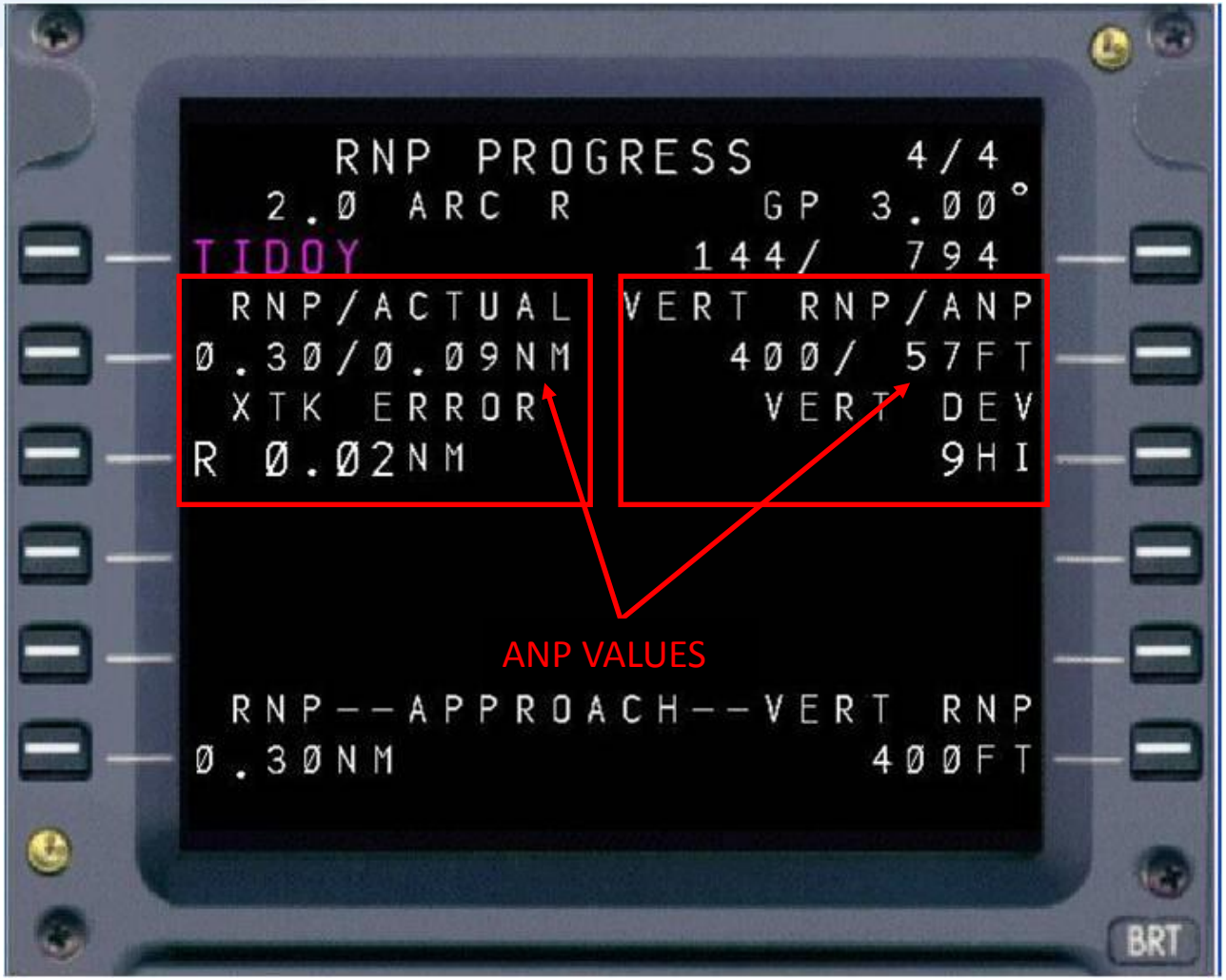
Flight Deck Annunciation – Actual Navigation Performance (ANP) vs. RNP



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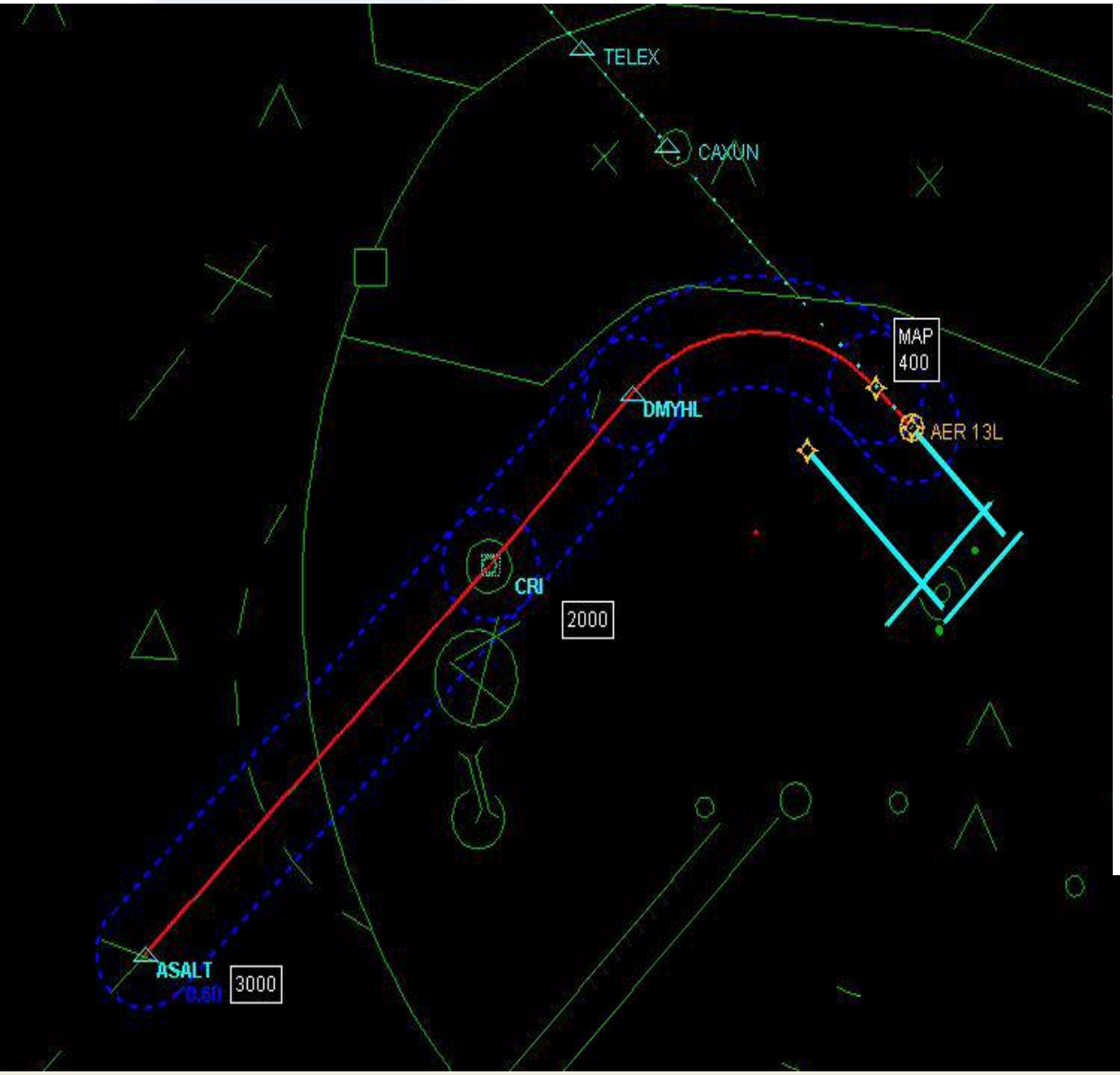
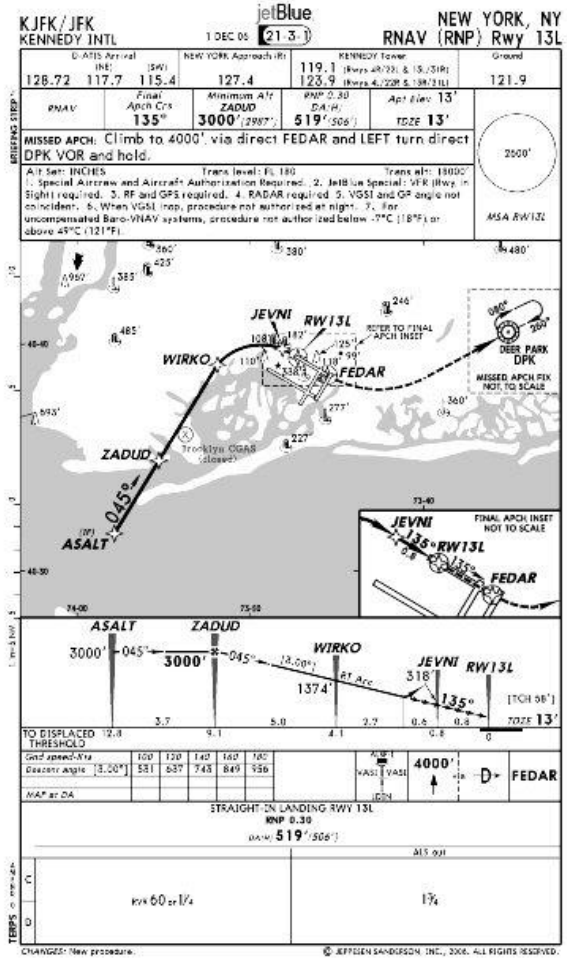
Example: JFK-LGA De-Confliction





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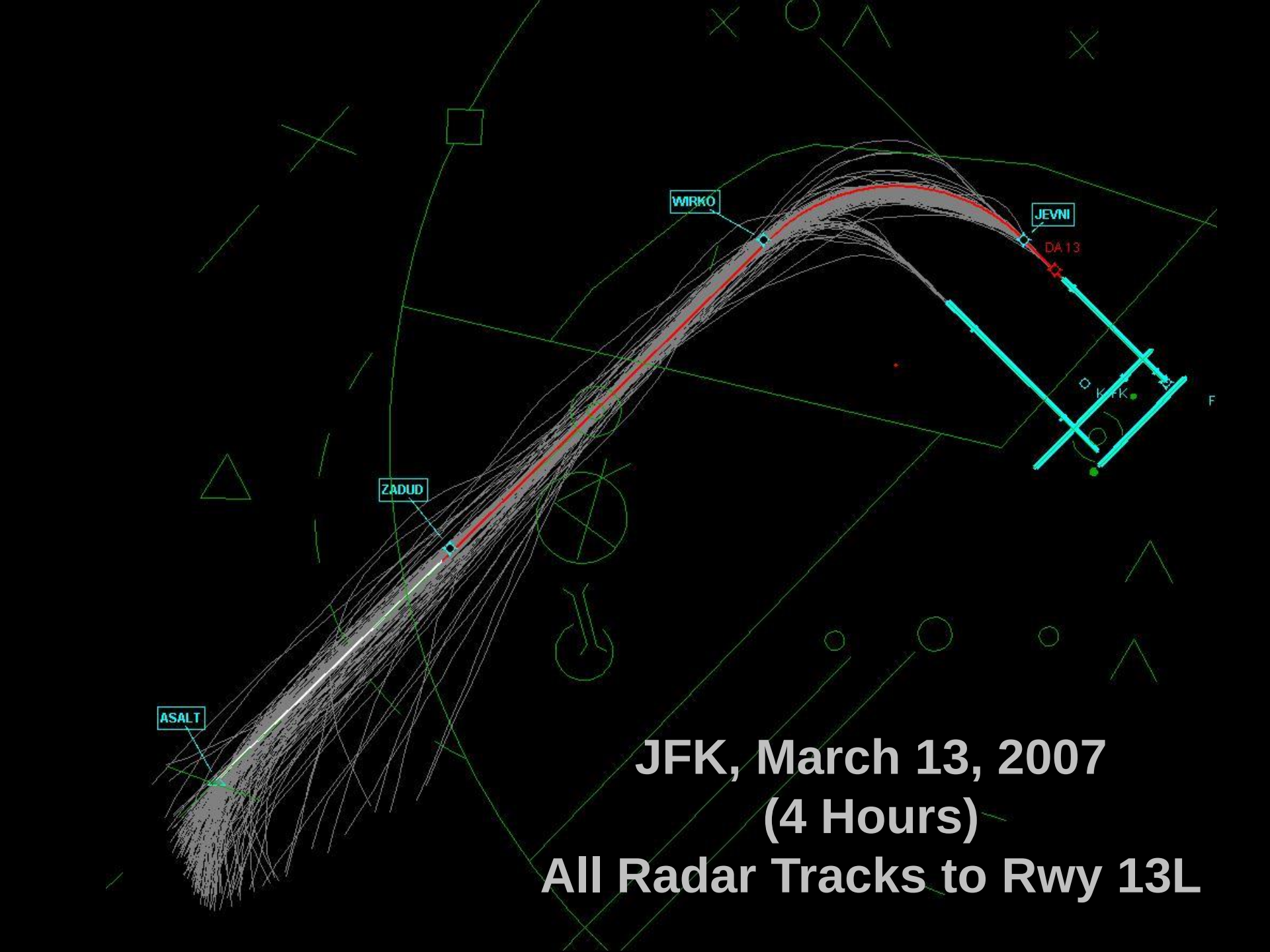
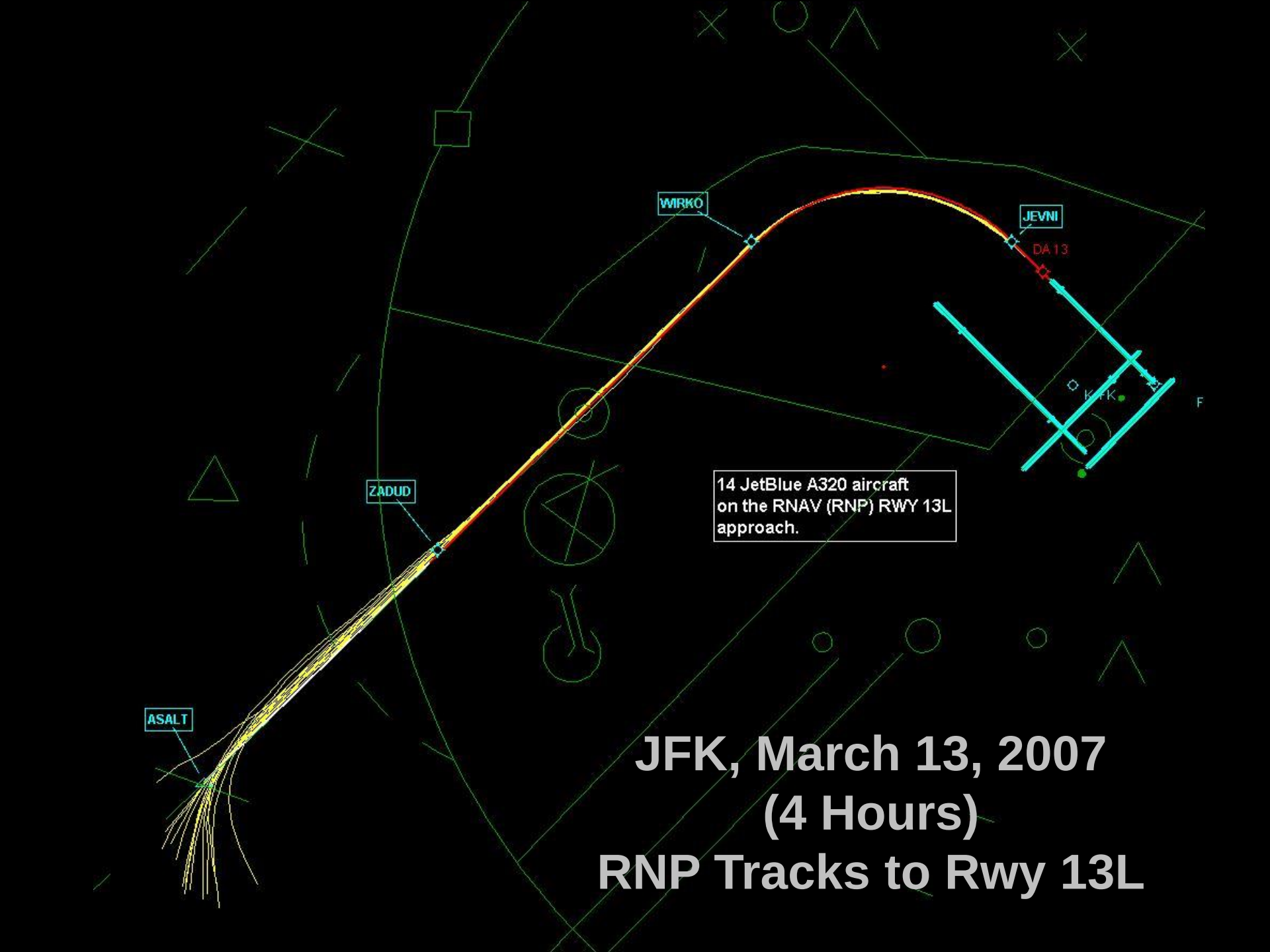
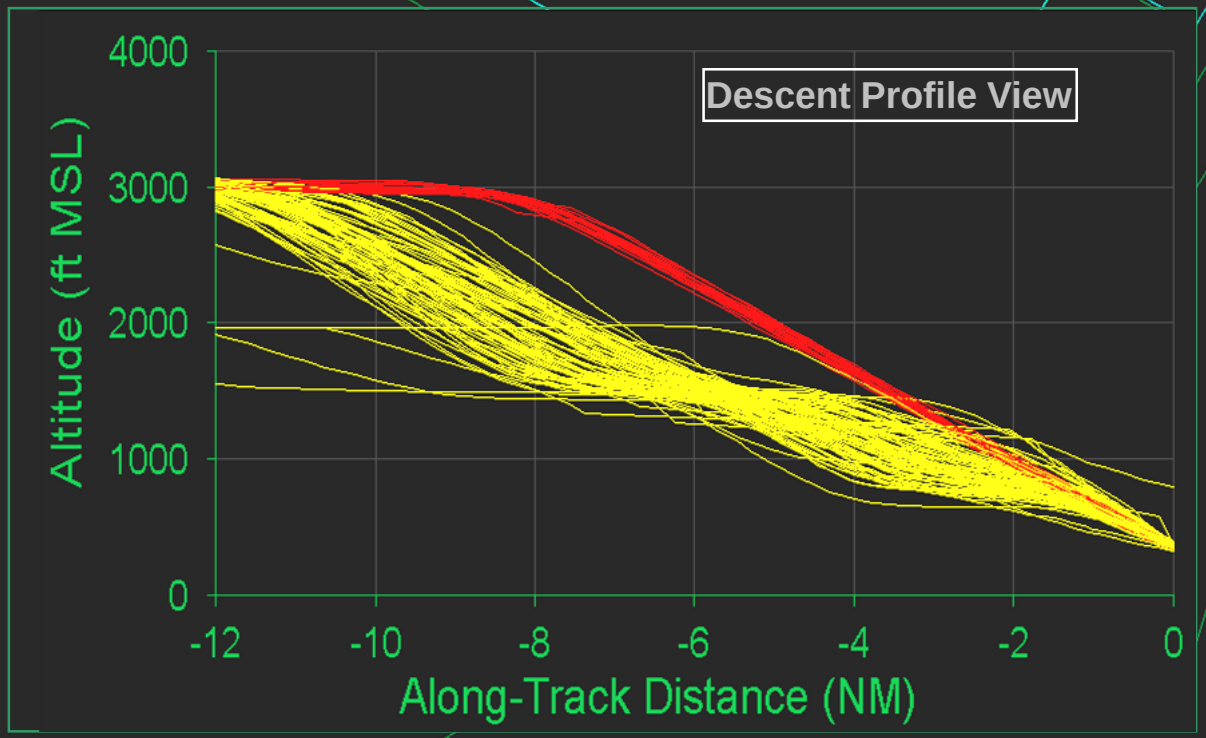

WIRKO
JEVNI
DA 13
ZADUD
ASALT
JFK, March 13, 2007
(4 Hours)
All Radar Tracks to Rwy 13L

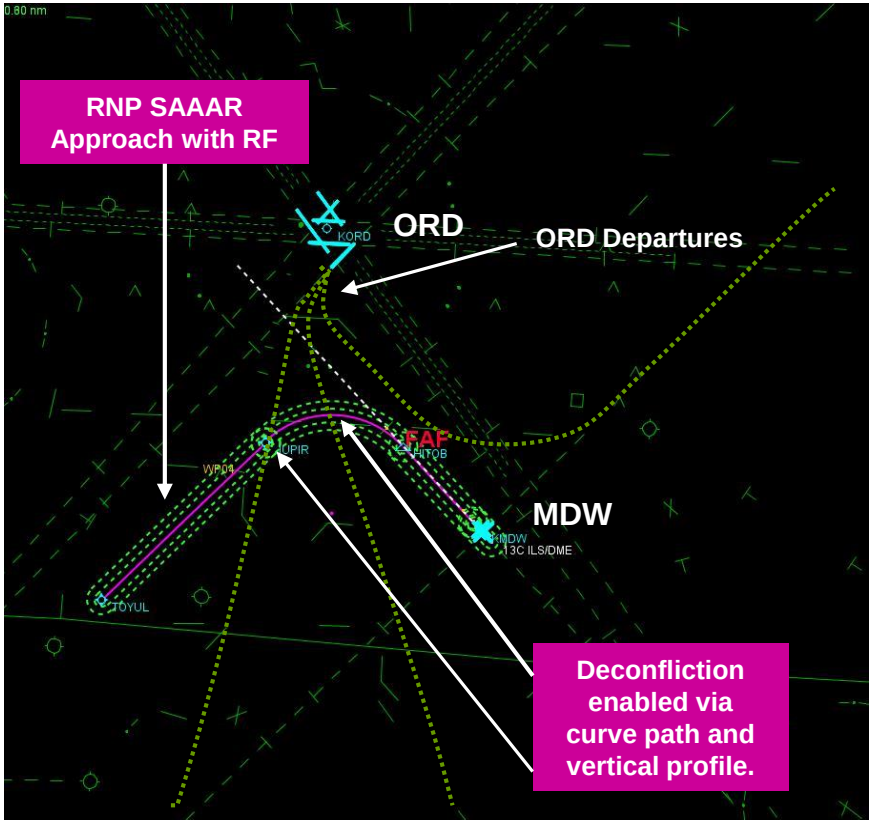

WIRKO
JEVNI
DA 13
ZADUD
ASALT
14 JetBlue A320 aircraft
on the RNAV (RNP) RWY 13L
approach.
JFK, March 13, 2007
(4 Hours)
RNP Tracks to Rwy 13L

JFK Visual/VOR vs. RNP Approaches

JFK



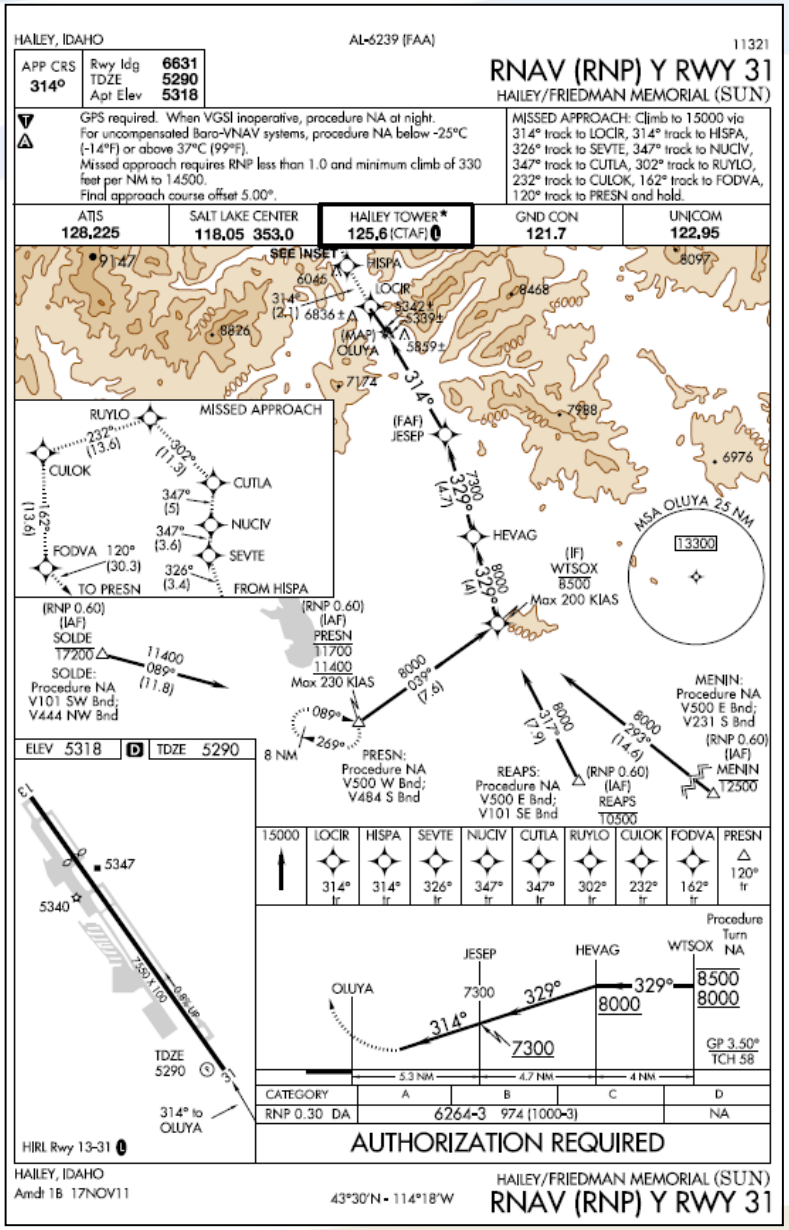
Example: MDW/ORD De-Confliction



De-conflict traffic interactions

- **MDW and ORD operations significantly impacted when conditions require MDW to land ILS 13C**
  - ORD – 22L departures and 14R arrivals must stop to allow MDW to land; or
  - MDW – 13C approaches stopped to allow ORD to flow
- **MDW and ORD flows are now separated based on use of RNP AR approach**
  - MDW: RNP AR approach published to 13C

Example: SUN RNP 31

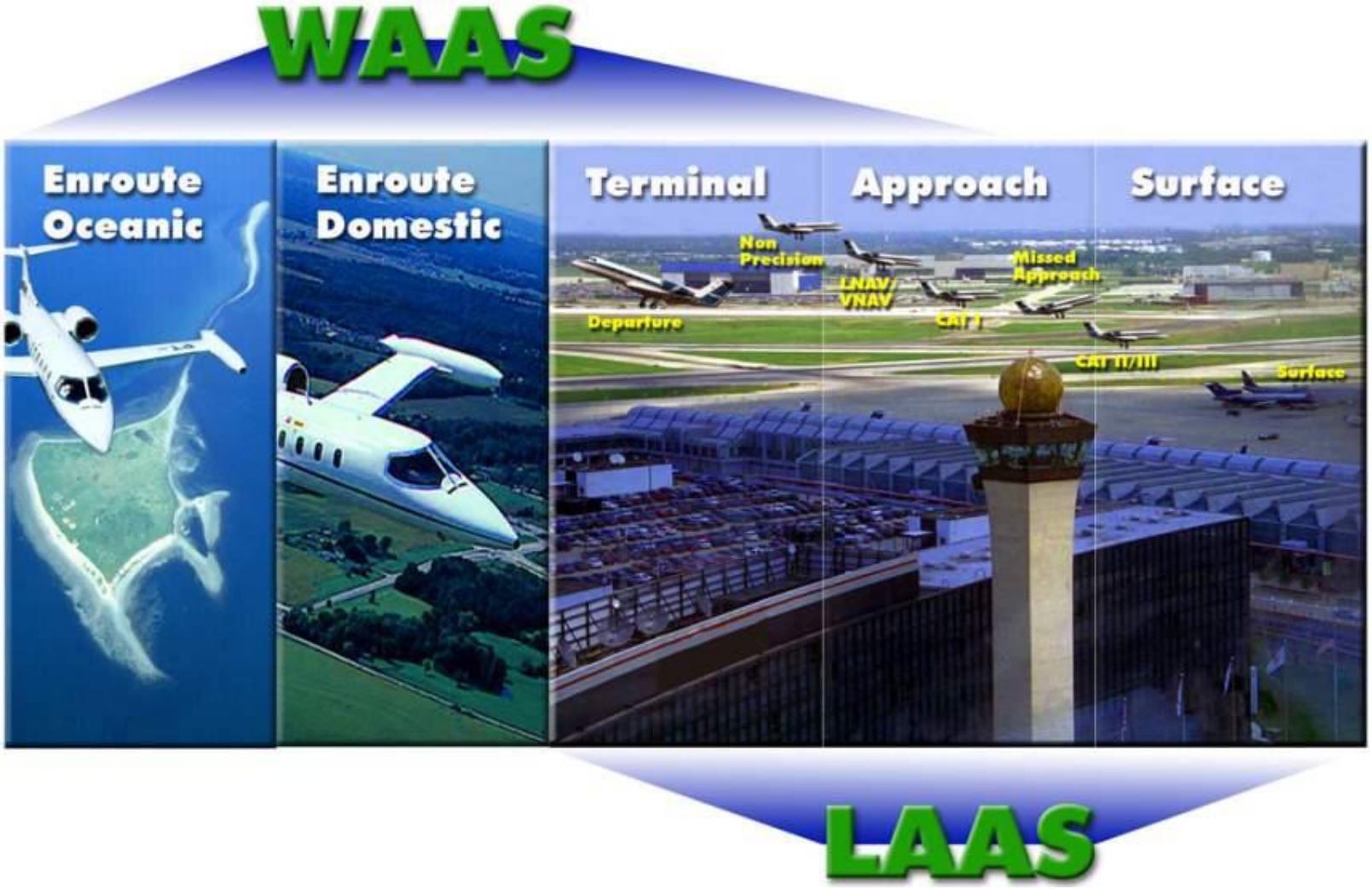


Wide Area Augmentation System (WAAS)

and

Local Area Augmentation System (LAAS) [otherwise known as Ground-Based Augmentation System (GBAS)]

FAA GPS Augmentation



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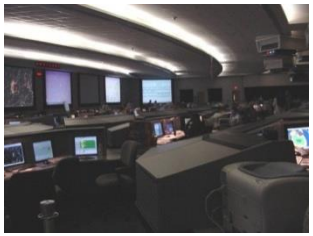
WAAS Architecture

38 Reference Stations

3 Master Stations

4 Ground Earth Stations

2 Geostationary Satellite Links



2 Operational Control Centers

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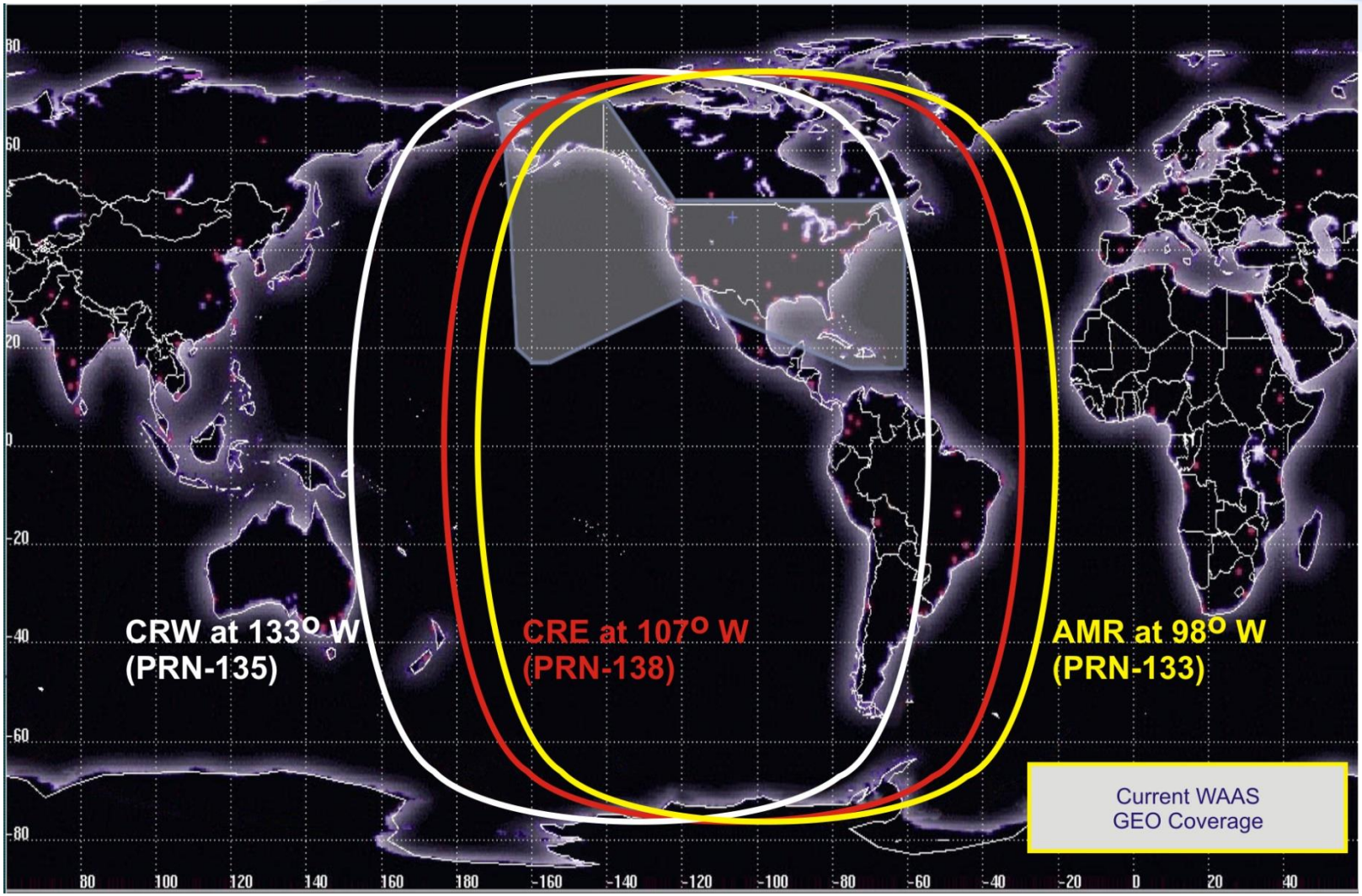
Current WAAS GEOs



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WAAS Accuracy Performance

	GPS Standard	GPS Actual	WAAS LPV-200 Standard	WAAS LPV-200 Actual
Horizontal 95%	36 m	2.74 m	16 m	1.08 m
Vertical 95%	77 m	*3.89 m	4 m	1.26 m

** Use of GPS vertical not authorized for aviation without augmentation (SBAS or GBAS)*

WAAS Performance evaluated based on a total of 1,761 million samples (or 20,389 user days)

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Summary of RNAV(GPS) - Minima

LPV - Localizer Performance with Vertical

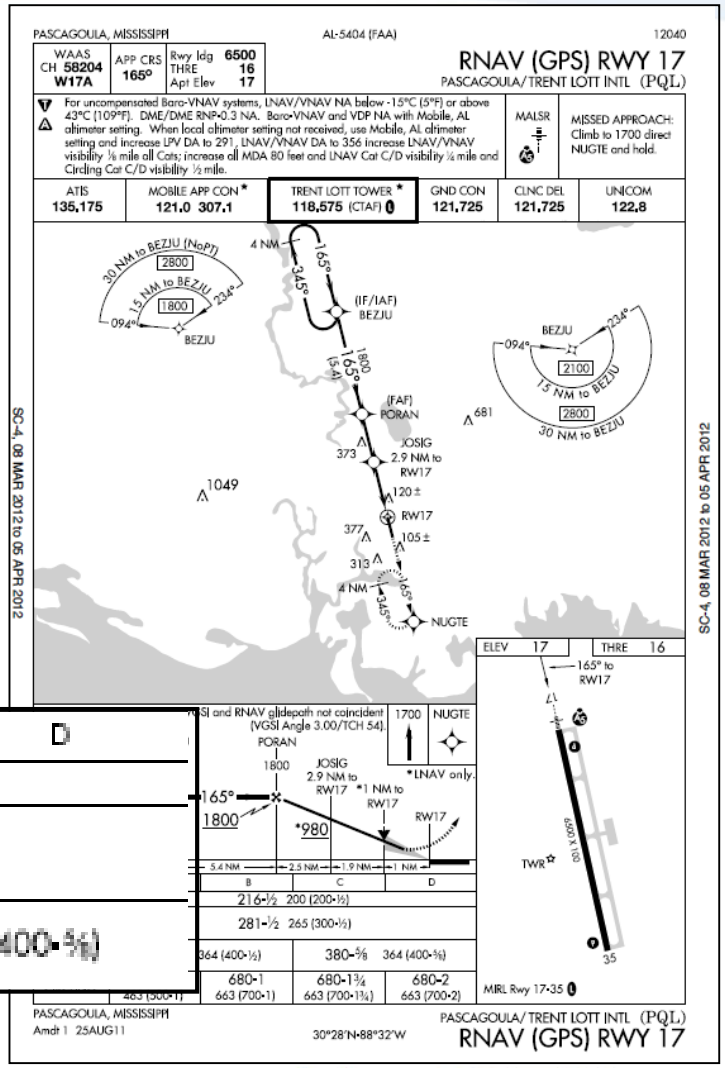
WAAS avionics minima

LNAV/VNAV – Lateral Navigation With Vertical

Baro-VNAV, or WAAS Avionics

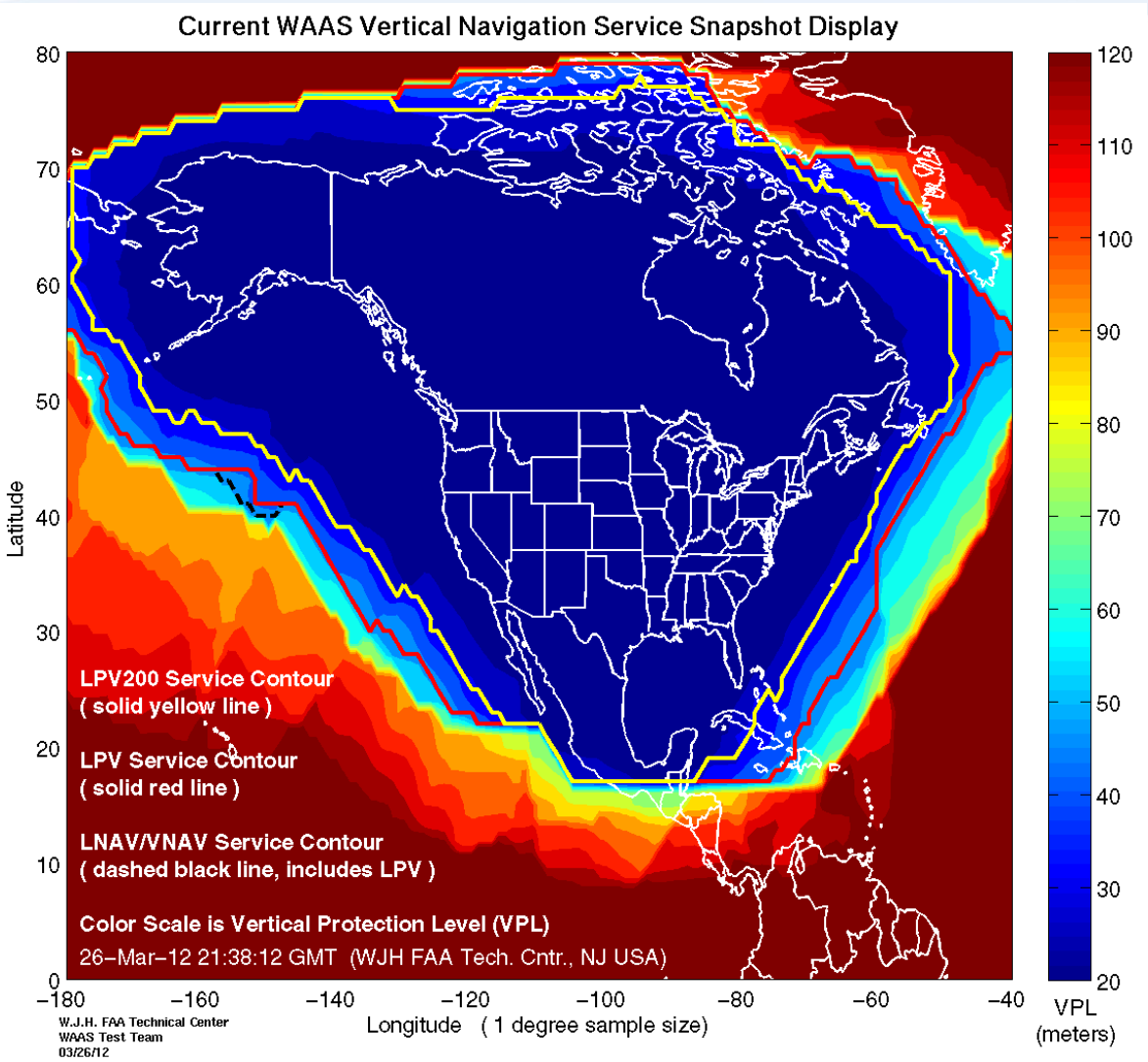
LNAV - Lateral Navigation

Non-Precision Approach (NPA)

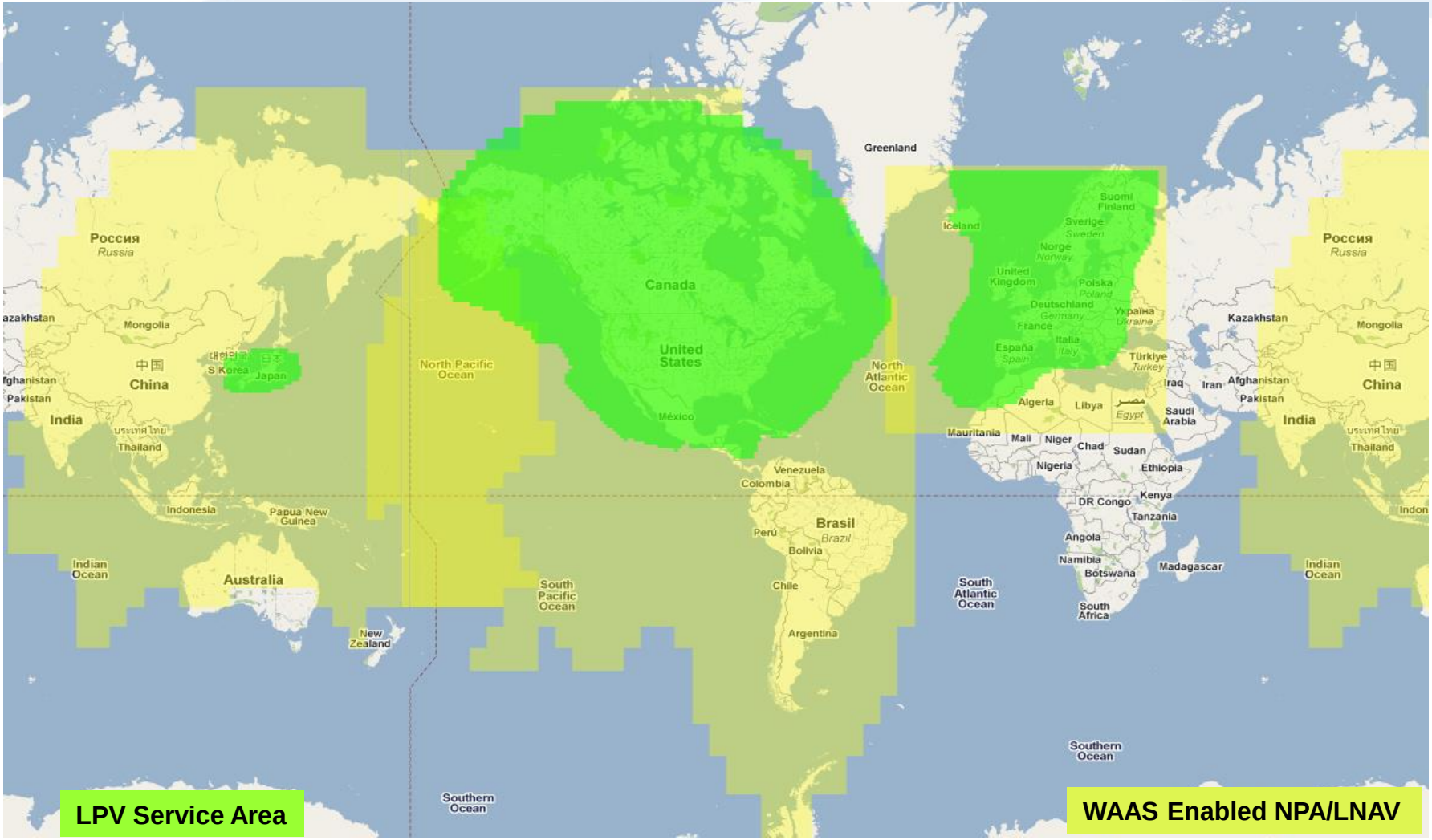


CATEGORY	A	B	C	D
LPV DA	216-½ 200 (200-½)			
LNAV/VNAV DA	281-½ 265 (300-½)			
LNAV MDA	380-½ 364 (400-½)		380-⅝ 364 (400-⅝)	

Localizer Precision Vertical (LPV) Coverage

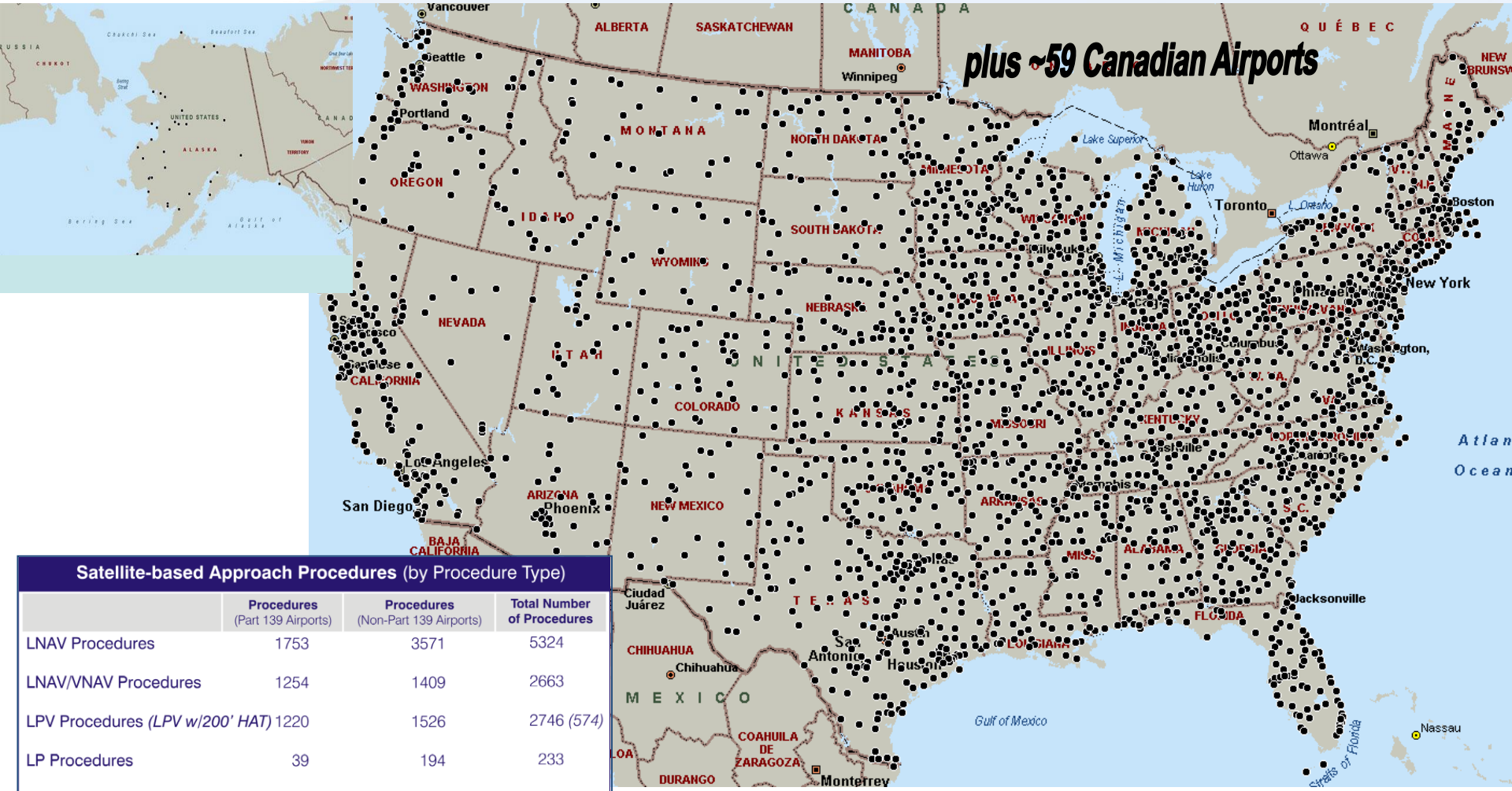


Combined SBAS Snapshot



See http://www.sxbluegps.com/sbas-made-easy.html for more information.

Airports with WAAS LPV/LP Instrument Approaches



Satellite-based Approach Procedures (by Procedure Type)

	Procedures (Part 139 Airports)	Procedures (Non-Part 139 Airports)	Total Number of Procedures
LNAV Procedures	1753	3571	5324
LNAV/VNAV Procedures	1254	1409	2663
LPV Procedures *(LPV w/200' HAT)*	1220	1526	2746 *(574)*
LP Procedures	39	194	233
GPS Stand-Alone Procedures	22	253	275

Note: Number of GPS Stand-Alone will continue to decrease as they are replaced by RNAV procedures
(Data as of December 15, 2011)

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WAAS Avionics Status

- Garmin:
  - 68,306+ WAAS LPV receivers sold
  - Currently largest GA panel mount WAAS Avionics supplier
  - New 650/750 WAAS capable units brought to market at the end of March 2011 to replace 430/530W units
- AVIDYNE & Bendix-King:
  - 140 Avidyne Release 9 units sold to date. Introduced IFD540 FMS/GPS/Nav/Com System with Touch screen
  - Bendix King KSN-770 certification pending
- Universal Avionics:
  - Full line of UNS-1Fw Flight Management Systems (FMS) achieved avionics approval Technical Standards Orders Authorization (TSOA) in 2007/2008
  - 1,929+ WAAS receivers sold as 3 November 2011
- Rockwell Collins:
  - Approximately 1,900 WAAS/SBAS units sold to date
- CMC Electronics:
  - Achieved Technical Standards Orders Authorization (TSOA) certification on their 5024 and 3024 WAAS Sensors
  - Convair aircraft have WAAS LPV capable units installed (red label) and expect WAAS LPV certification by August 2012
  - Canadian North B-737-300 obtained STC for SBAS(WAAS) LPV using dual GLSSU-5024 receivers
- Honeywell:
  - Primus Epic and Primus 2000 w/NZ 2000 & CMC 3024 TSO Approval
  - Primus 2000 FMS w/CMC 5024 TSO pending

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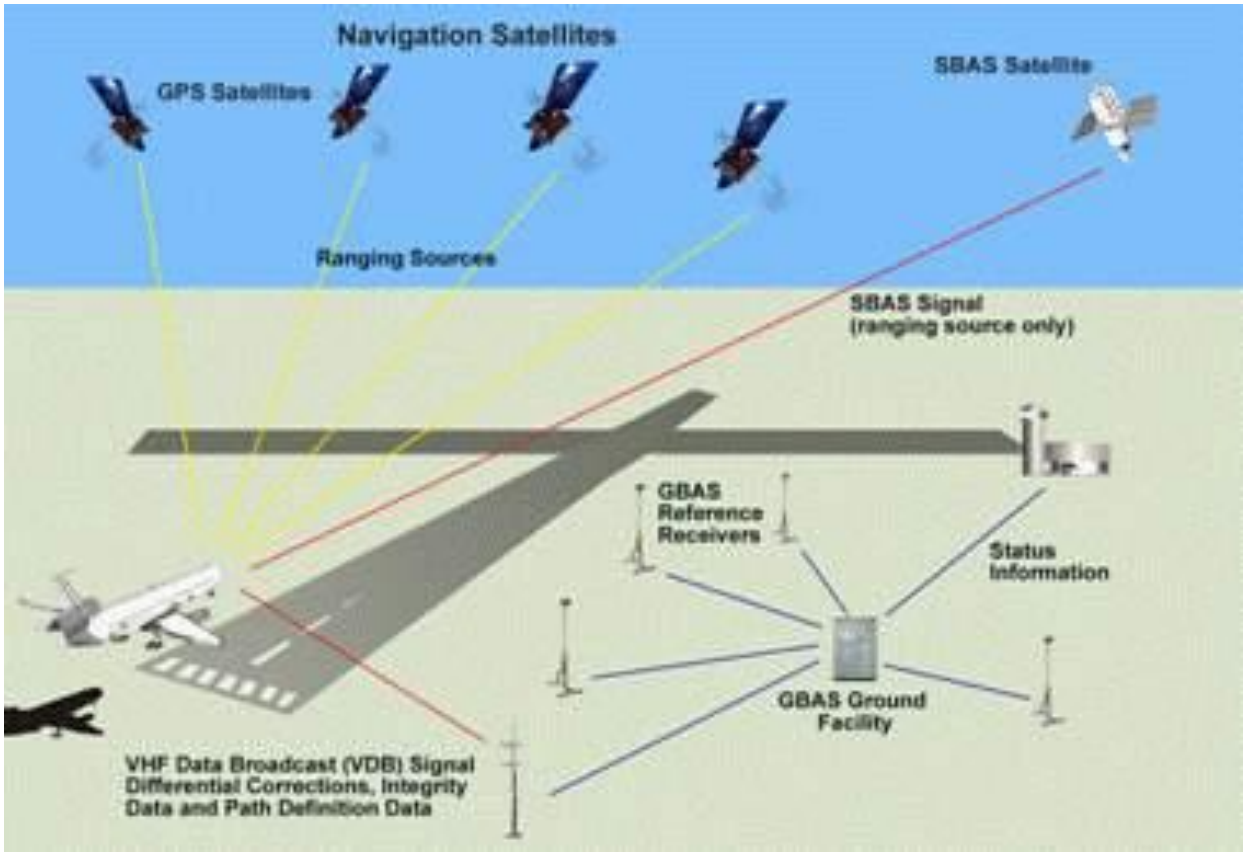
Ground Based Augmentation System (GBAS)

- Provides Precision Approach Capability, CAT I/II/III Service.
  - Performance equivalent to Instrument Landing System (ILS)
  - Complements the Wide Area Augmentation System (WAAS)
    - Provides CAT I where WAAS is not available.
    - Uses WAAS integrity information when in coverage of a WAAS GEO.
  - Requirements coordinated internationally to support harmonization efforts.
- CAT I/II/III Architectures Have Common Baseline Configuration and are fully interoperable.
- Full Category I Non-Federal GBAS system design approval was completed in September 2009.
  - Honeywell SLS-4000 is the first approved GBAS.
- SLS-4000 was installed at Newark Liberty International Airport (EWR) in November 2009
  - FAA is working to resolve environmental interference at EWR

GBAS Architecture

- Precision Approach For CAT- I, II, III
- Multiple Runway Coverage At An Airport
- Terminal Area Procedures for Arrival and Departure



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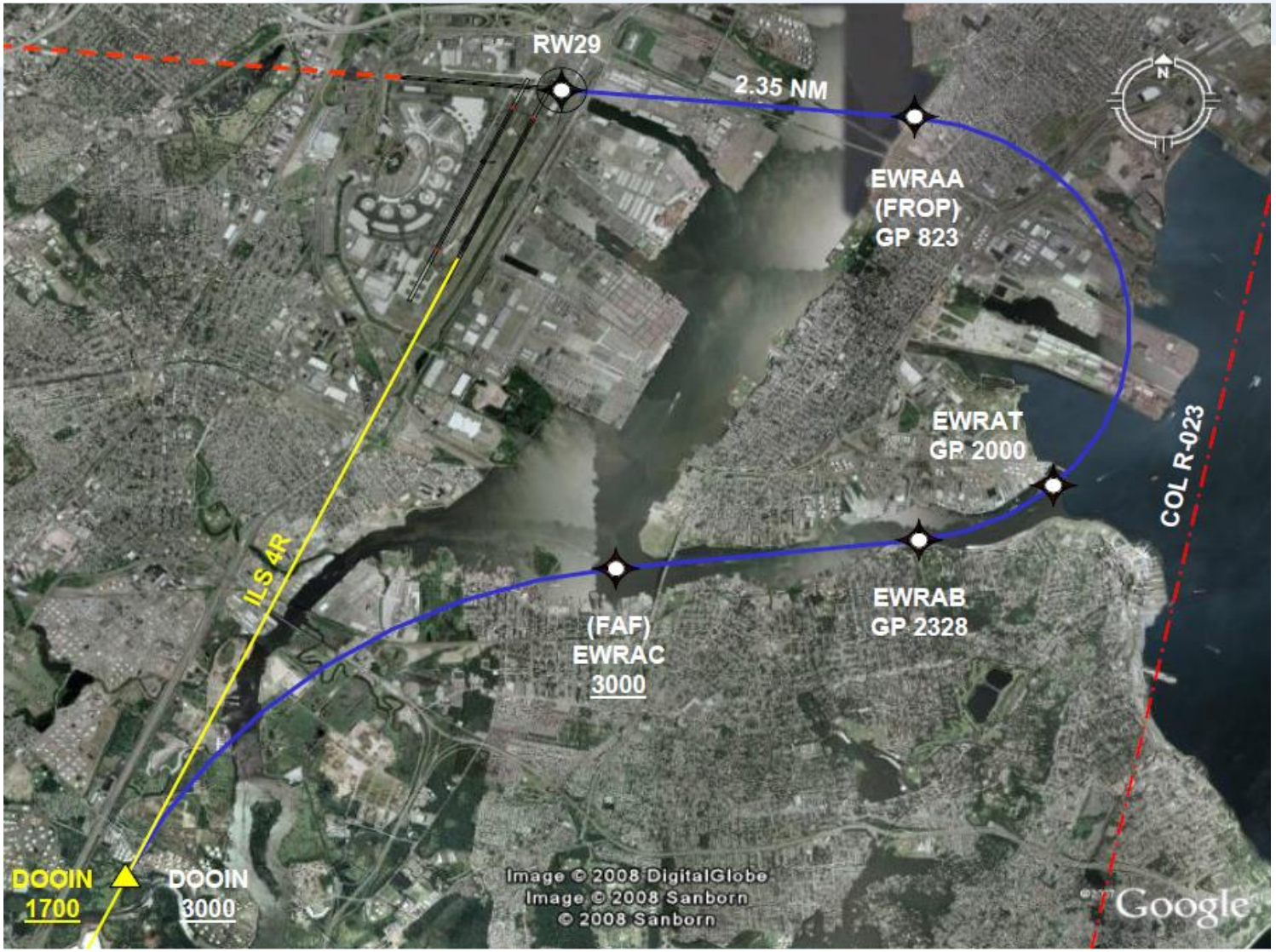
Possible Newark GLS Approach



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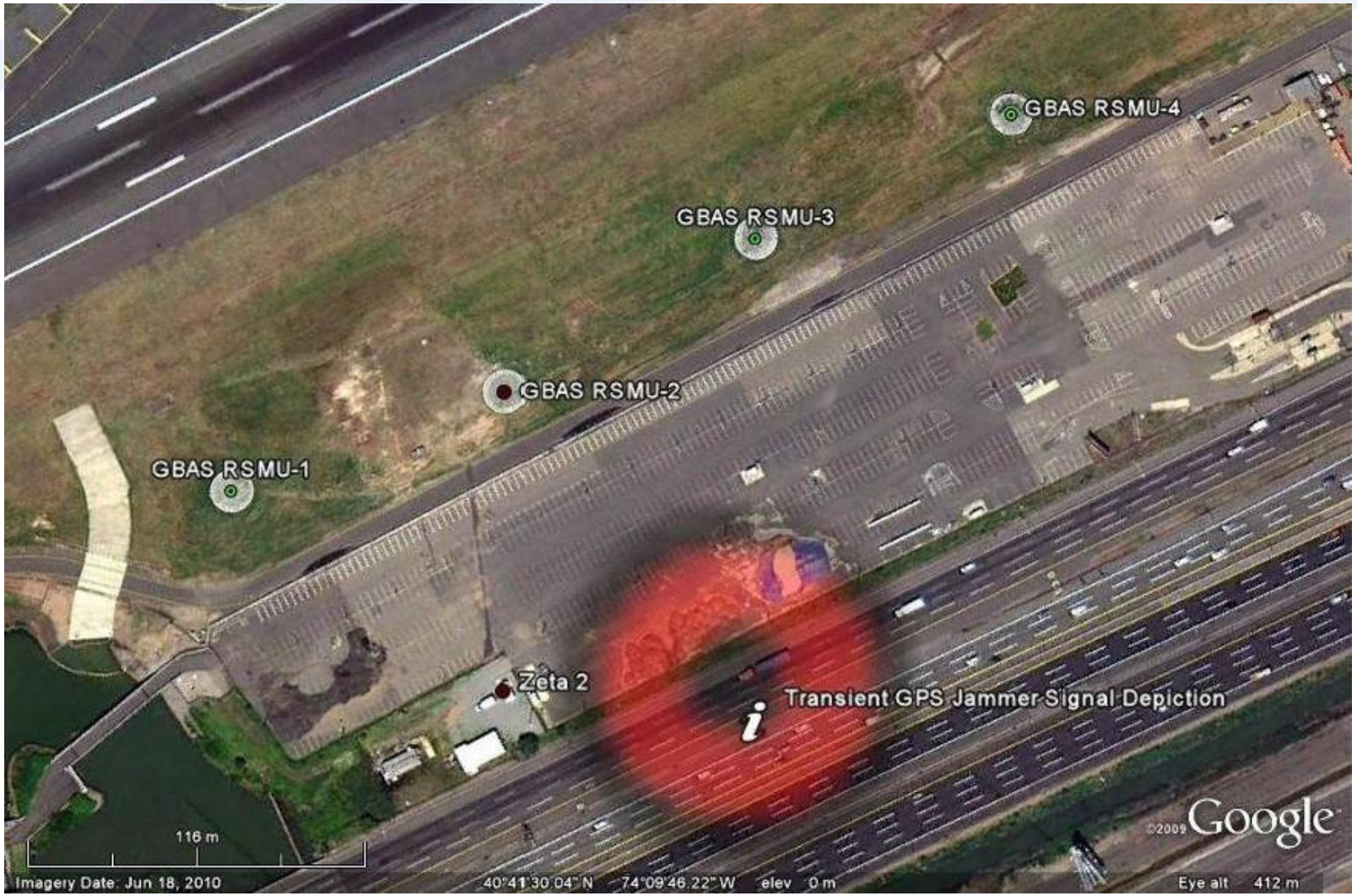
GPS RFI on NJ Turnpike



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GPS Jammer Availability

disable GPS signal from...

BUY NOW

Handheld GPS Jammer GJ02

The portable GPS signal jammer GJ-02 is very esy to operate.Just plug it directly into the car cigarrette lighter device,it begins to...

$33.00

BUY NOW

Handheld GPS Jammer Mini GJ

The portable GPS jammer Mini GJ is small and light, it can be easily put inside your pocket or hand bag. It can fully disable GPS signal from...

$69.99

BUY NOW

Portable GPS Jammer GJ Pro

The portable GPJ jammer GJ Pro is of high power. It can disable both GPS L1 and L2 bands. The isolating radius is up to 20 meters. It comes...

$155.00

BUY NOW

Displaying 1 to 4 (of 4 products)

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Find the Jammer!

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Automatic Dependent Surveillance - Broadcast (ADS-B)

Automatic Dependent Surveillance - Broadcast (ADS-B)

- **Automatic**
  - Periodically transmits information with no pilot or operator input required
- **Dependent**
  - Position and velocity vector are derived from the Global Positioning System (GPS) or a Flight Management System (FMS)
- **Surveillance -**
  - A method of determining position of aircraft, vehicles, or other asset
- **Broadcast**
  - Transmitted information available to anyone with the appropriate receiving equipment

- "**ADS-B Out"** refers to an appropriately equipped aircraft's broadcast of various aircraft information
- "**ADS-B In"** refers to the ability of an appropriately equipped aircraft to receive ADS-B Out transmissions from other aircraft and information broadcast from ground stations

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Surveillance and Broadcast Services (SBS) Program

- Services provided:
  - Air Traffic Control surveillance using ADS-B Out
  - Traffic Information Service - Broadcast (TIS-B)
  - Flight Information Service - Broadcast (FIS-B)

TIS-B is a service which provides ADS-B In equipped aircraft with position reports from secondary surveillance radar on non-ADS-B equipped aircraft.

FIS-B transmits graphical National Weather Service products, temporary flight restrictions (TFRs), and special use airspace to ADS-B In equipped aircraft.

Ground-Based Transceiver (GBT)

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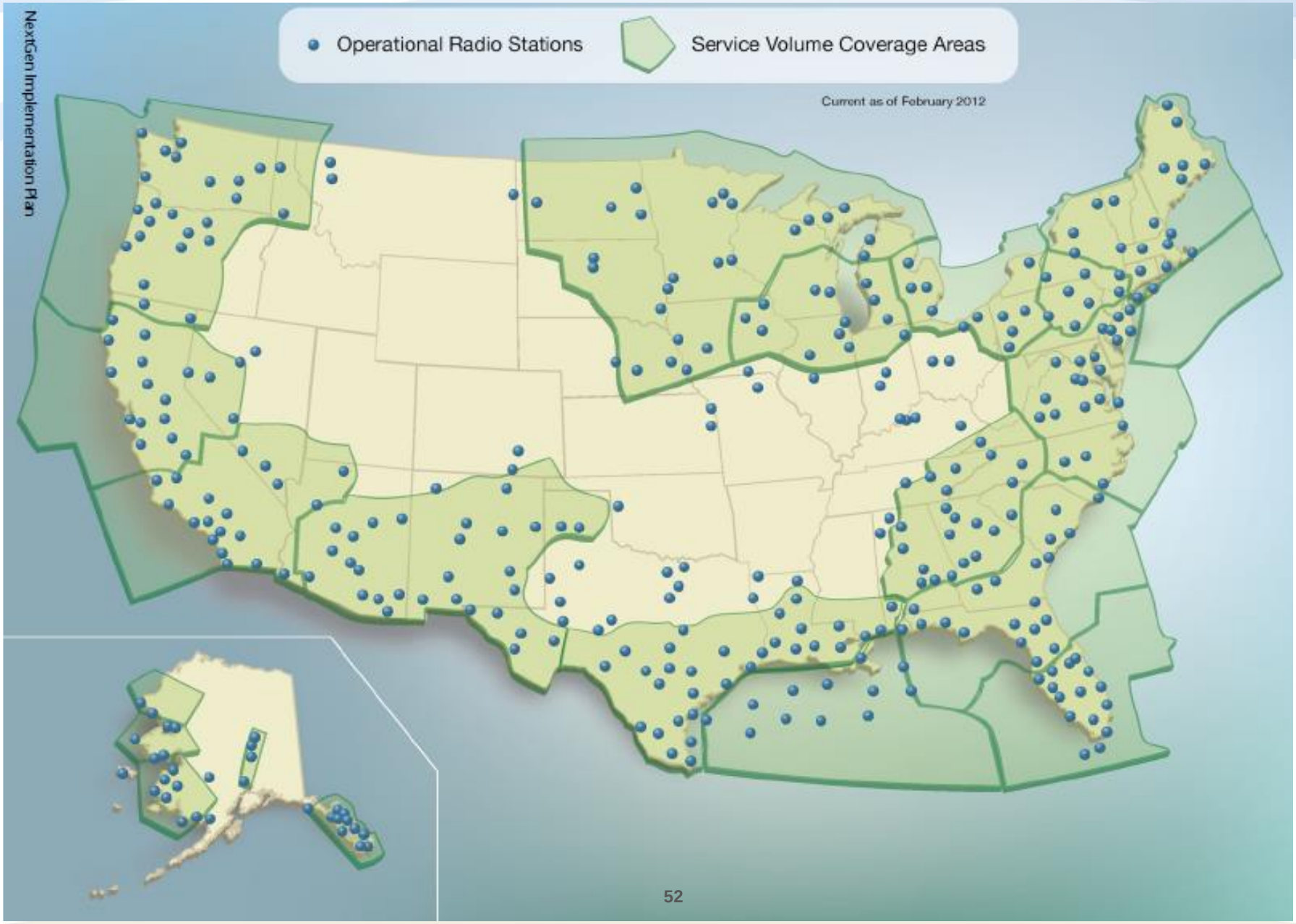
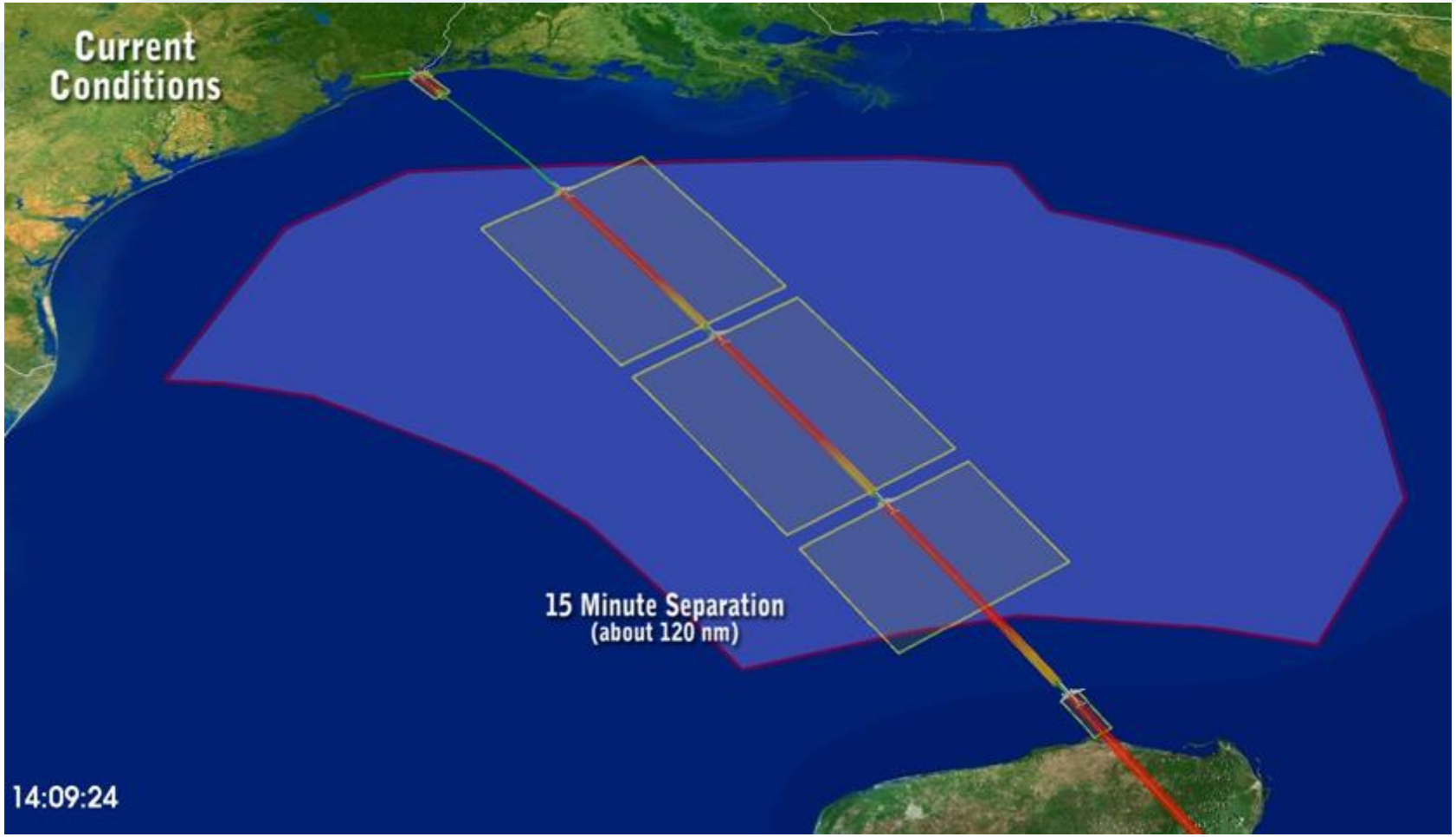
ADS-B Implementation Status



Gulf of Mexico: Current Conditions



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Gulf of Mexico: ADS-B Enabled

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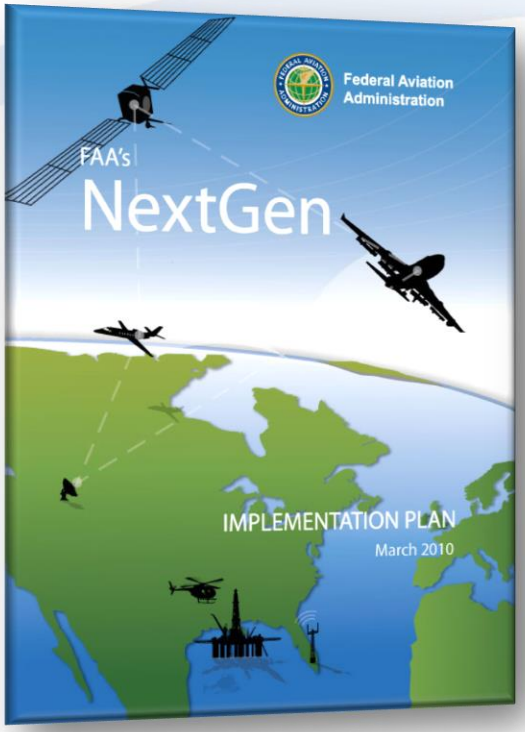
Resources Available to Stay Informed



www.faa.gov/nextgen

NextGen Implementation Plan Summarizes:

- Target for NextGen - 2018
- Work accomplished
- NextGen benefits
- FAA's work plan through 2015

Online:

- Overviews
- News
- Videos
- NextGen Documents
- And more…

Interactive Flash Map:

- ADS-B
- RNAV/RNP
- LPVs
- NextGen Demos
- And more…

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Questions?

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