FAA Navigation Programs Update

8th Meeting of the ICG

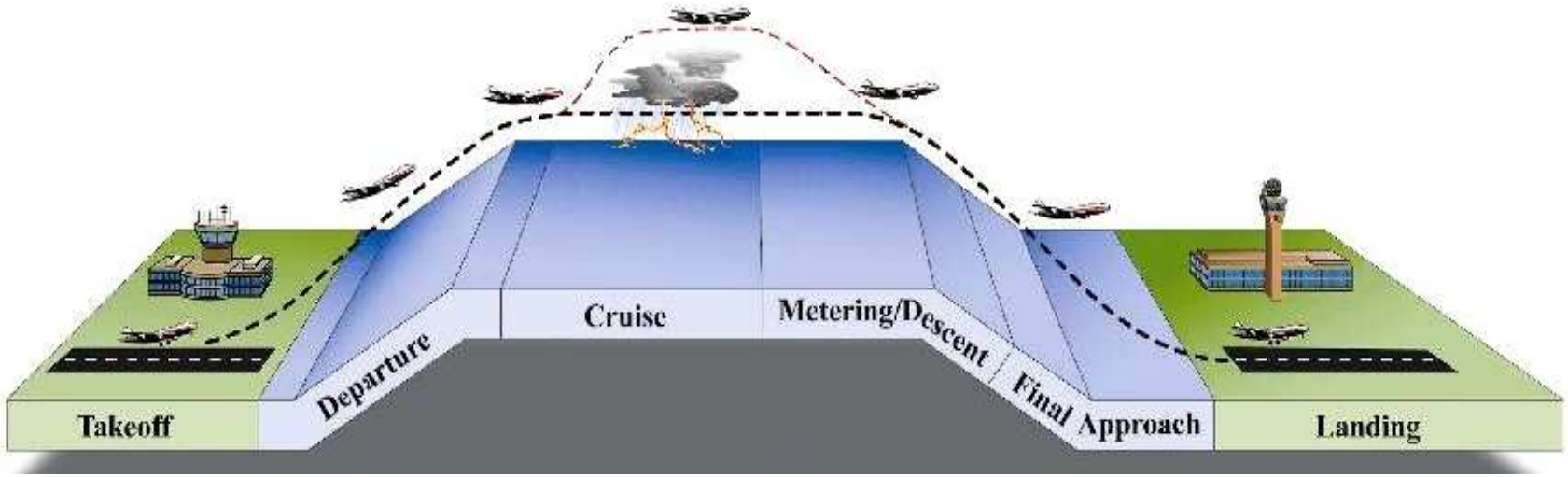
November 2013

Dubai, UAE

Agenda

- Navigation Transition
- Legacy Programs
- Satellite Navigation
- GNSS Intentional Interference and Spoofing Study Team (GIISST)
- Satellite Operations Coordination Concept (SOCC)
- NextGen Initiatives
- Summary

Navigation Services in Today's Operating Environment



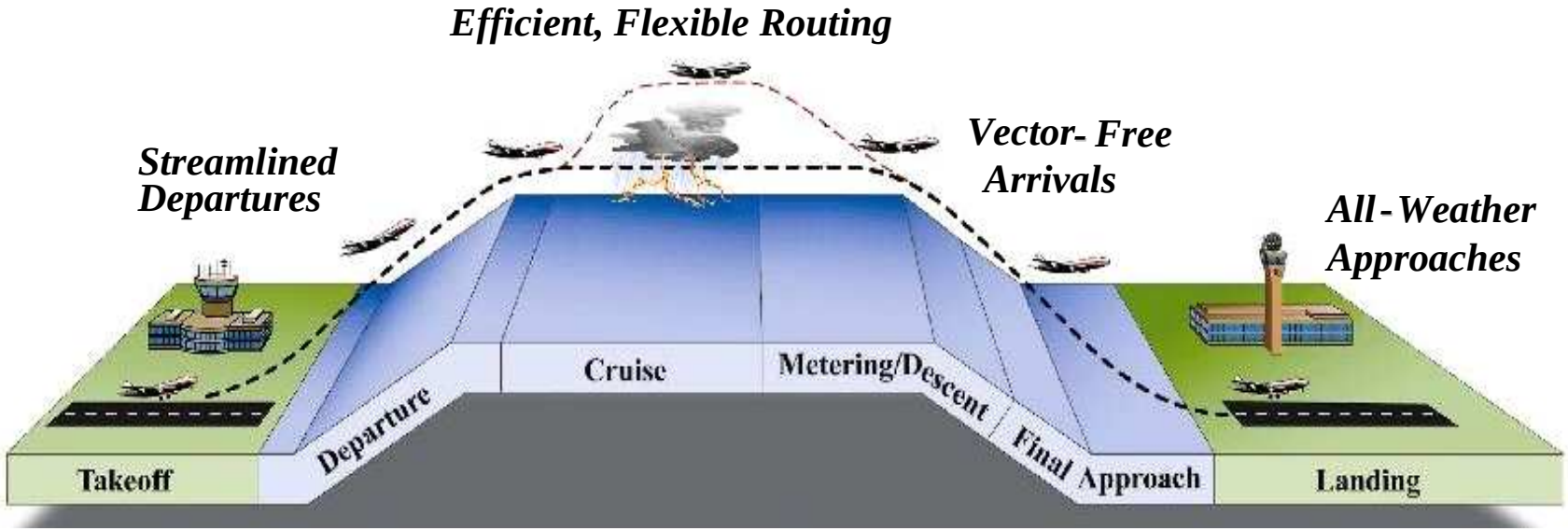
Takeoff	Departure	Cruise	Metering/Descent	Final Approach	Landing
LOC	VOR	VOR	VOR	VOR	LOC GS RVR
RVR	HPDME	HPDME	HPDME	NDB	LPDME TACAN
GNSS	TACAN	TACAN	TACAN	LPDME	MALSR* ALSF-2
	GNSS	GNSS	GNSS	TACAN	REIL PAPI
				GNSS	GNSS

GNSS = Global Navigation Satellite System – satellite constellations with or without augmentations. FAA implementation is GPS/WAAS/GBAS
*MALSR supports CAT I 1/2-mile visibility capability.

Multiple layers of navigation services in each phase of flight driven by: (1) need to maintain legacy systems and support transitions; and (2) variations in aircraft equipage

NextGen Navigation Services

- **Operational capability based on GPS**
- **Consistent with ICAO Global Vision**
- **Fully operational by 2030**



*MALSR (CATI-1/2 mile visibility) and ALSF-2 (CATII/III) Lighting Systems are required for Precision Approaches

NextGen Navigation Services

En Route Transition




2013 — 2020 — 2030

Current	**2020 (Transitional)**	**2030 (Future)**
Very High Frequency Omni-directional Range (VOR)	VOR Minimum Operational Network (MON)	Limited VOR Infrastructure
Distance Measuring Equipment (DME)	DME/DME with or without Inertial Reference Unit	DME/DME with or without Inertial Reference Unit
Non-Directional Beacons (NDB)	Few NDBs	No NDBs
WAAS GPS Single Frequency	WAAS GPS Dual Frequency (2nd civilian freq.)	WAAS GPS Dual Frequency (2nd civilian freq.) Multi-Constellation
APNT Definition	Transitional APNT (for service efficiency)	NextGen APNT

Terminal Transition

2013 — 2020 — 2030

Current	2020 (Transitional)	2030 (Future)
VOR	VOR Minimum Operational Network (MON)	Limited VOR Infrastructure
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APNT Definition	Transitional APNT (for service efficiency)	NextGen APNT

Terminal / Precision Infrastructure

(Final Approach)



2013 — 2020 — 2030

Current	**2020 (Transitional)**	**2030 (Future)**
Instrument Landing System (ILS) Category I	ILS Category I	ILS Category I
Wide Area Augmentation System (WAAS) LPVs*	WAAS LPVs*	WAAS LPVs GPS Dual Frequency (2nd civilian freq.) Multi-Constellation
Ground Based Augmentation System (GBAS) CAT I	GBAS CAT I	GBAS CAT I
ILS CAT II/III	ILS CAT II/III	ILS CAT II/III
MALSR, ALSF-2 RVR, PAPI, REIL	MALSR, ALSF-2, RVR, PAPI, REIL	Advanced Lighting Concepts (ALC)

Potential 2016 ILS reduction enabled by WAAS LPV deployment*

GBAS Cat I's are non-fed only

Contingent on 2016 GBAS Cat II/III Decision

**LPV = Localizer Performance with Vertical Guidance*

NextGen Precision Approach Strategy

- By 2016, WAAS LPV approaches will be available at all qualifying runway ends in the NAS (> 5000)
- CAT I ILS
  - Retain as needed to provide an alternative approach and landing capability during GPS outages
  - Provide for Enhanced Low Visibility Operations (ELVO) where beneficial
- New CAT I precision approach requirements will be met with WAAS LPV
- CAT II/III ILS
  - Retain for the foreseeable future
- Explore the feasibility of achieving:
  - WAAS CAT I/II
    - CAT II precision approach service (w/single & dual frequency GPS)
    - CAT I/II Autoland
  - Category- II/III precision approach service utilizing the Ground Based Augmentation System (GBAS) and/or advanced cockpit systems

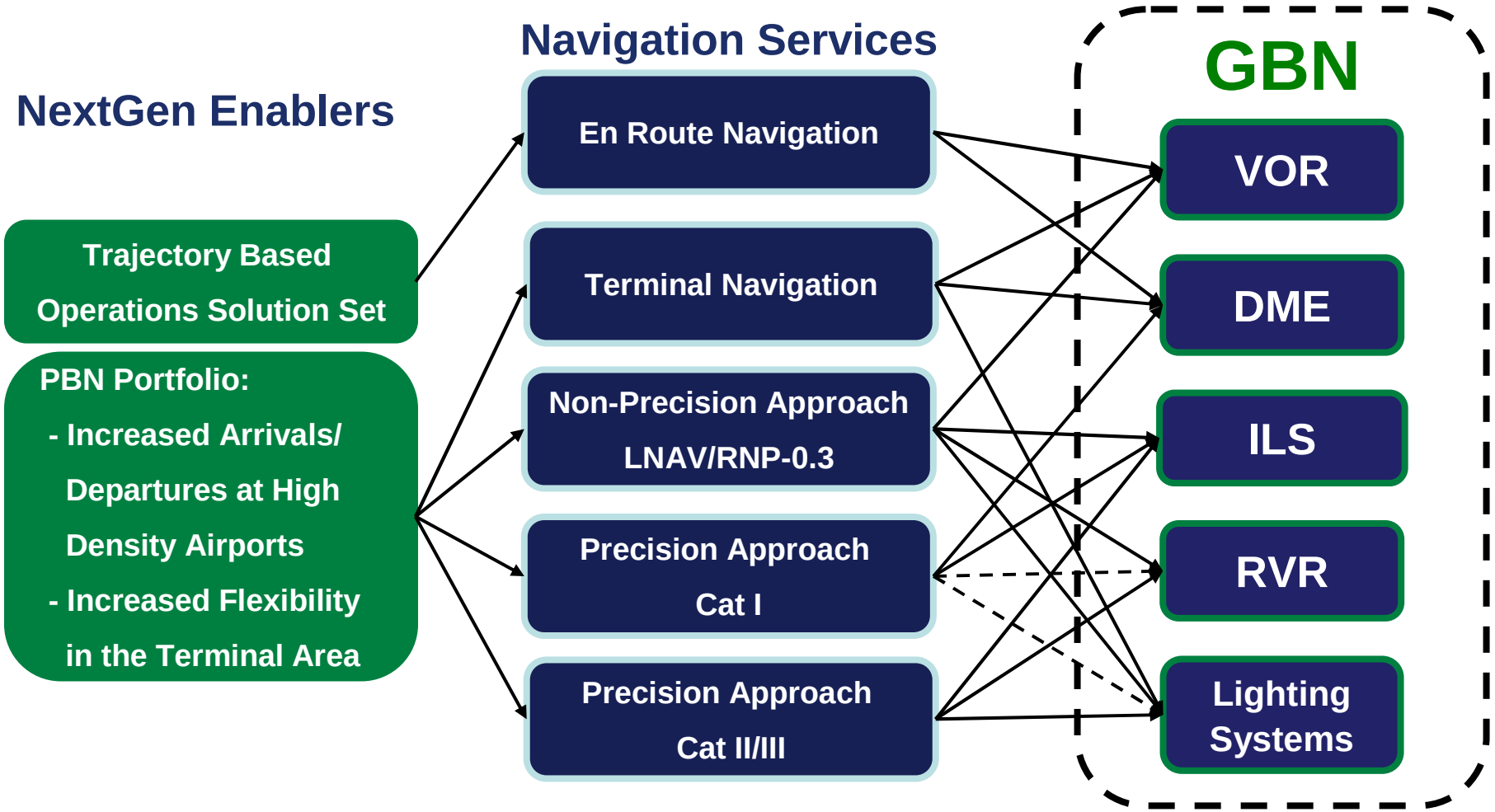
Key Assumptions

- Aircraft will need to be appropriately equipped for desired service
  - GNSS Equipage
  - VOR MON to provide operational buffer
- New procedures and routes will have to be established before those in the current operating environment can be discontinued
  - Timeframe: VORs will be reduced to MON by 2020

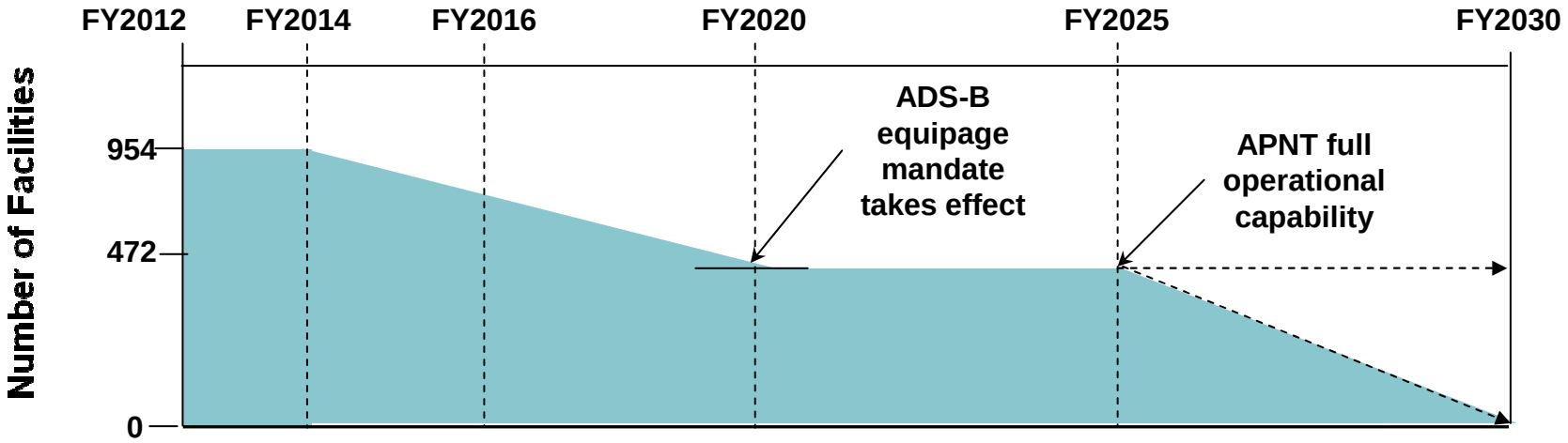
Legacy Programs

Ground-Based Navigation (GBN) Evolution Strategies

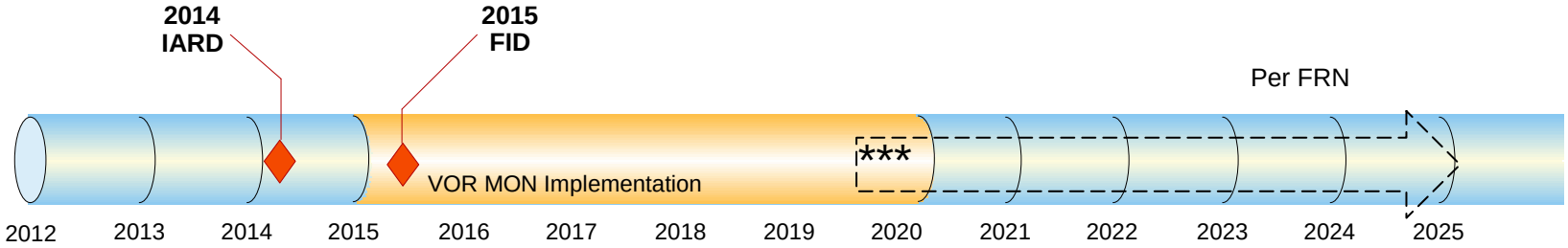
Where GBN Fits Into the NAS/NextGen Today



VHF Omnidirectional Range (VOR)



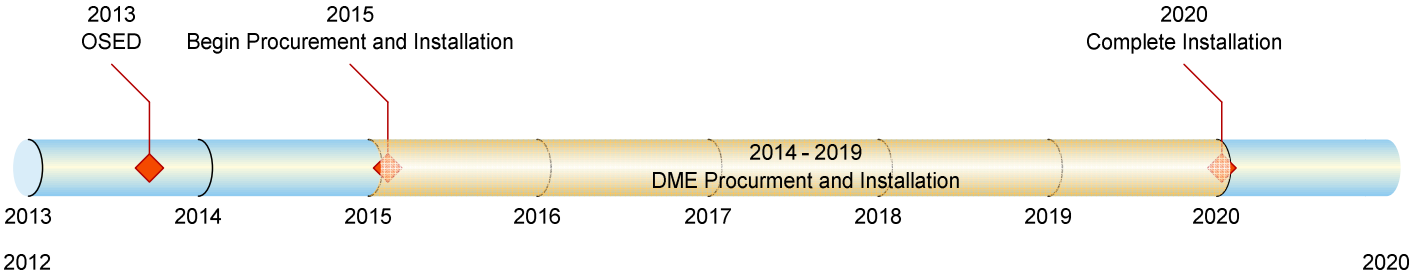
- **Goal: Significantly reduce dependence on VORs**
  - **First step: Discontinue VORs to achieve a Minimum Operational Network (MON)**
  - **Next: Discontinue majority of remaining VORs after NextGen APNT service and equipage by 2030**



*** Detailed discontinuance plan needs to be worked, the end date will be changed accordingly

NextGen DME Strategy

- **En route**: Provide DME-DME RNAV Coverage throughout CONUS at FL 240
- **Actions required:**
  - Fill Gaps in coverage (~8 new facilities/locations)
  - Convert existing low coverage volumes to high (~72 existing locations)
  - Improve availability of geographically critical DMEs to preclude loss of RNAV service (~30 existing locations)
- **Terminal**: Provide seamless DME-DME coverage down to 5000' AGL to support RNAV procedures in metroplex terminal areas for non-IRU equipped aircraft
- **Actions required**
  - Filling metroplex terminal area gaps in coverage will require only one or two new DMEs each, a total of approximately 25 DMEs
- NextGen Strategy: Utilize existing contract to procure High Power DMEs
- Requires Operational Services Environment Description (OSED)

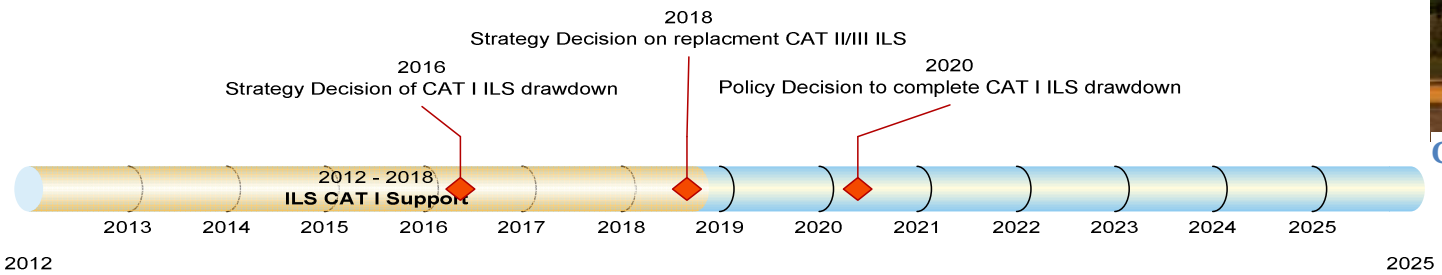


Instrument Landing System (ILS)

- **Supports landing aircraft safely in both Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC)**
  - **ILS Components**
    - Localizer
      - Provides lateral (centerline) guidance
    - Glide Slope
      - Provides vertical (glide path) guidance
- **ILS Transition Strategy**
  - Replace aging Cat I ILS (5/year) based on Cost Benefit
  - CAT I ILS Drawdown Decision CY2016
  - Evaluate Cat II/III Requirements
  - Determine sustainability issues of maintaining ILS services through 2030 through Business Case Analysis (BCA)

Localizer

Glide Slope

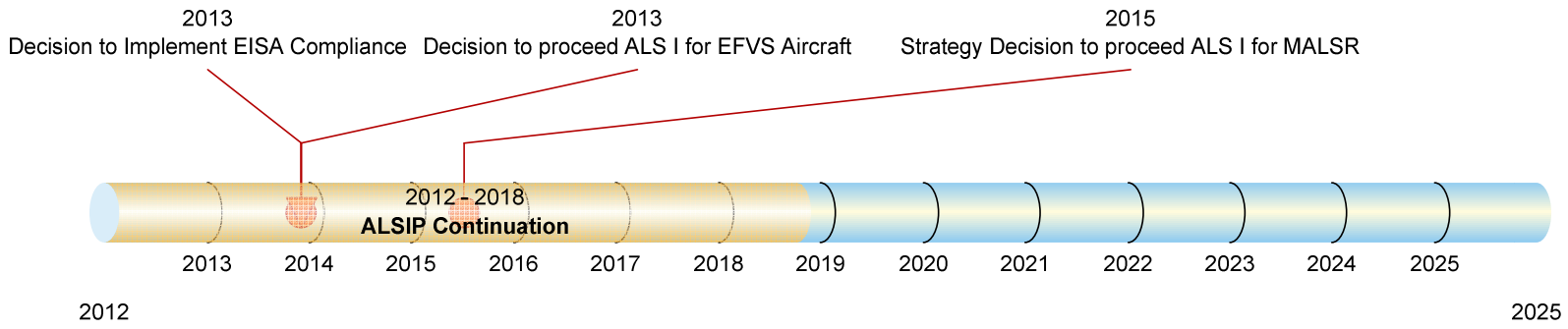


Legacy Programs

Lighting Systems Strategies

Lighting Systems Future Initiatives

- ALSF-2/MALSR : Conduct Analysis on the feasibility of reducing the footprints of these lighting systems
- If operational test with infrared emitters are successful, replace the MALSR incandescent lamps with LED lamps
- Redesign MALSR systems based on LED technology



Satellite Navigation

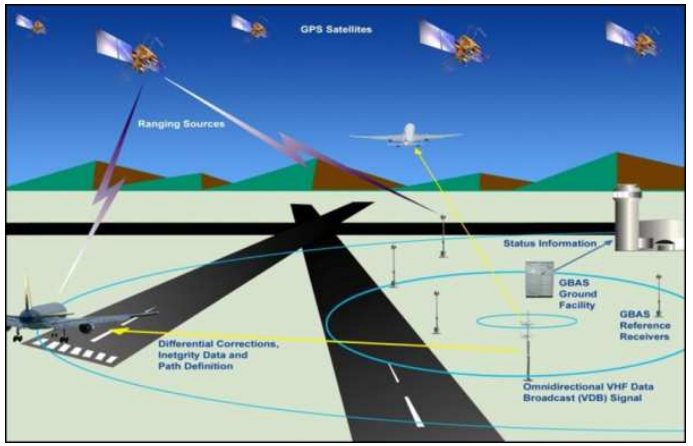
Wide Area Augmentation System

- WAAS is a combination of ground based and space based system that augments the GPS Standard Positioning Service (SPS)
- WAAS provides the capability for increased availability and accuracy in position reporting, allowing more time for uniform and high quality worldwide air traffic management
- WAAS provides service for all classes of aircraft in all phases of flight - including en route navigation, airport departures, and airport arrival

WAAS Dual Frequency Operations

- 'Sunset' of L2 P(Y) compels WAAS to utilize another signal to maintain current service
  - USG Federal Register Notice states 'sunset' for L2 P(Y) signal use in December 2020
- New dual frequency L1/L5 service needed to further improve WAAS availability and continuity
- Segment 1
  - Develop of infrastructure improvements to support use of L5
    - 5 to 7 year effort
  - G-III Reference Receiver Integration, Communications Upgrade, Safety Computer Integration
- Segment 2
  - Implementation of L1/L5 user capability
    - 5 to 7 year effort
    - Dual Frequency Messaging
- GEO sustainment will occur during both segments
  - Maintain minimum of dual coverage over WAAS service area
  - GEO Sustainment currently planned until 2044

Ground Based Augmentation System (GBAS)



- CAT I Status
  - Newark, NJ – Operational Sept 2012
    - Non-Fed installation owned by Port Authority of New York and New Jersey
  - Houston, TX – Operational April 2013
    - Non-Fed installation owned by the Houston Airport System
  - Moses Lake, WA
    - Non-Fed installation owned by Boeing for private use only
    - FAA/Boeing have planned CAT III validation activities using this system
- CAT III Status:
  - Focus on validation of draft ICAO SARPS for GBAS Approach Service Type D (GAST-D) Requirements
    - Intended to support Approach and Landing operations using CAT III minima
  - NextGen has developed ground station and avionics prototypes to support validation
    - Both prototypes developed by Honeywell
    - Avionics prototype completed in January 2013
    - Ground prototype installed at FAA Technical Center to support flight testing
    - FAA flight testing completed in March 2013
  - Validation work will continue to enable formal amendments to SARPS for GAST-D and support future operational approvals by industry

GNSS Intentional Interference and Spoofing Study Team (GIISST)

GIISST Overview

- GNSS is vulnerable to intentional interference and spoofing
  - Recognized by the *Federal Radio Navigation Plan* and other government reports
  - Subject of growing public debate
- FAA Navigation Programs and Aircraft Certification established the GIISST to
  - Examine threat assessments, studies, and data
  - Develop specific, actionable recommendations for the FAA by the end of FY13
- GIISST Team consists of a broad cross section FAA offices as well as private sector input from organizations such as Stanford University, MITRE, ZETA and Regulus Group

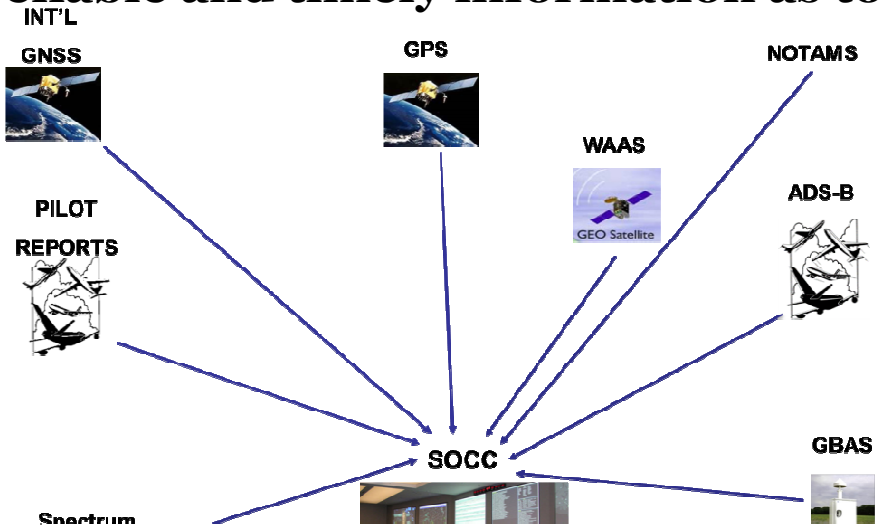
Current Status

- Intentional interference and spoofing threat scenarios identified
  - 7 of 8 scenarios obtained from the November 2012 DHS GPS *National Risk Estimate*
    - *4 interference and 3 spoofing scenarios*
  - 1 additional scenario – "unintentional spoofing" – added due to reported incidents with GPS re-radiators
- Uses of GNSS within the NAS identified and characterized
  - Additional work ongoing to ensure completeness
- Assessment of threat scenario impacts
  - Preliminary assessments under review by team
  - Additional assessments may be necessary if more GNSS uses within the NAS identified
- Mitigations
  - Numerous technical, operational, and legal mitigations identified
  - Characterizations are now underway, which will drive conclusions/recommendations
- Recommendations
  - Include spoofing detection in GNSS equipment
  - Accelerate APNT development
  - Provide guidance to Navigation equipment integrators which cross-check GPS sensor data

Satellite Operations Coordination Concept (SOCC)

Background

- **Purpose**
  - **To provide the appropriate Air Traffic Organization decision making authorities a means to understand the air traffic impact of GNSS anomalies and thus minimize their impact on NAS operations**
  - **To make available to the users, operators and stakeholders of the NAS, reliable and timely information as to the status of the GNSS**



Current Status

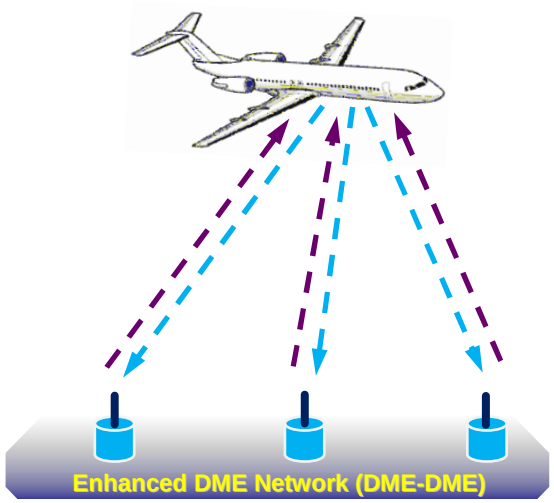
- Concept of Operations
  - Concept will need to be reviewed by the Concept Steering Group and approved by the NextGen Review Board
  - SOCC Trials
    - Will set up a series of “table top” exercises to evaluate SOCC operational issues
      - Participants will include National Operations Control Center (NOCC), WAAS Ops, Others as required
    - Objective will be to exercise the concept and derive any changes or additional requirements
    - Trial start date is TBD but should begin before the end of the CY
- Project Plan
  - Being revised to reflect changes in the ConOps
  - Target completion date may slip to 2Qtr FY14
  - Next revision will be out for review in mid-late September

NextGen Initiatives

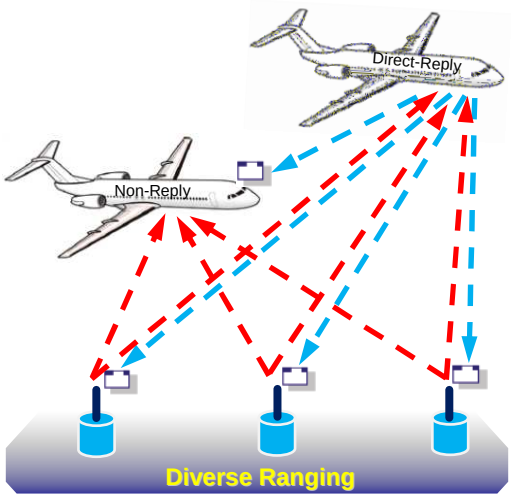
Alternative Positioning, Navigation & Timing (APNT)

- Many NextGen operational improvements (OIs) depend on Position, Navigation, and Timing (PNT) services to enable area navigation (RNAV), and required navigation performance (RNP)
  - Greater dependence on GPS-based PNT
- National Policy requires FAA to provide a backup in the event of a Global Positioning System (GPS) interference event or outage
  - National Policy HSPD-7/NSPD-39/PPD-21
  - Maintain safety and security and preclude significant economic impact
- Today's APNT consists of legacy VOR, DME, TACAN systems that will not support the NextGen OI's, provides limited function for RNAV and no function for RNP or TBOs

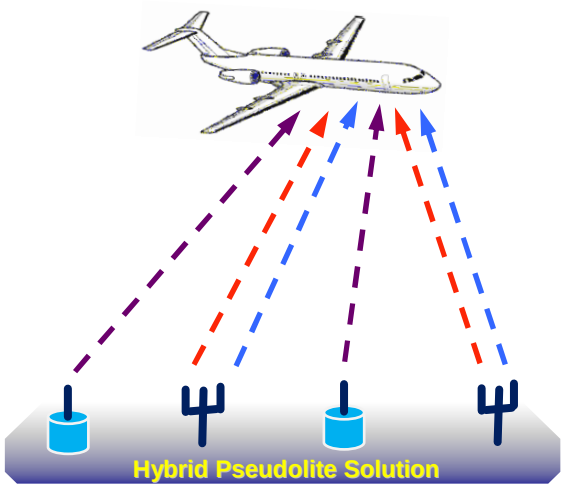
Alternatives under evaluation



- Leverages Existing DME/DME Technology
- RNAV Today; Impacts to Avionics to realize RNP
- Evaluating means to support both IRU and non-IRU aircraft



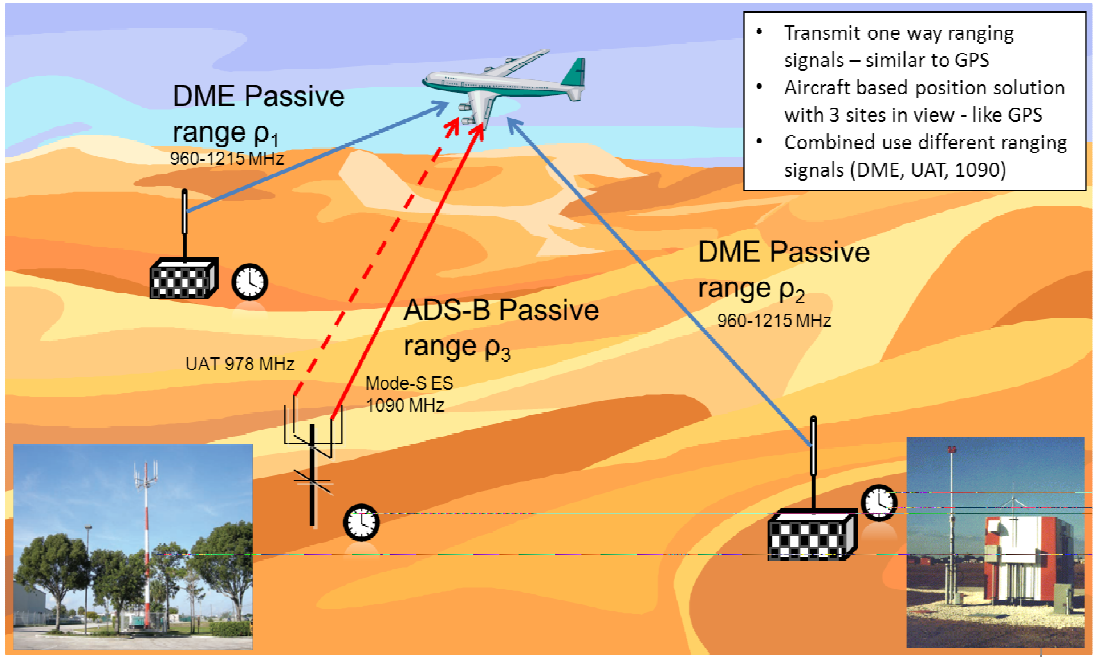
- New Concept
- Uses Ground and Aircraft-based emitters for coverage
- Leverages Planned and Existing ADS-B Technology and Air/Ground Infrastructure
- Provides precise time to aircraft
- Impact to Avionics



- New Concept
- Leverages DME/GBT Infrastructure
- Provides precise time to aircraft
- Impact to Avionics

Hybrid Passive Ranging Concept

- **DME based using existing pulse pairs**
  - 500 pulse pairs per second, transparent to existing users (basically a sequenced DME squitter)
  - Provides data (~1000 bytes per second) and accurate ranging
- **Universal Access Transceiver (UAT) based using ground segment & Traffic Information Service – Broadcast (TIS-B)**
  - Ground segment already has capability
  - TIS-B messages can have capability Minimum Operational Performance Standards (MOPS)
- **1090 based using TIS-B, Automatic Dependent Surveillance – Re-broadcast (ADS-R)**
  - Good multipath performance due to wideband
- **Service coverage based on ranging signals from both Surveillance and Broadcast Services (SBS) Radio Transmitters (RTs) & DME stations**
  - ~ 680+1100 stations



NextGen Navigation Initiatives (NNI)

- Currently is focused on Standalone Distance Measuring Equipment (DME) to support Area Navigation (RNAV) with DME-DME and without Inertial Reference Unit (IRU)
  - Working to achieve standalone DME that is not co-located with a VOR, allowing additional terminal airspace
  - Allow move from U.S. protection limit to 8dB from 11 dB

HPDME (at VOR)

- Enhanced Low Visibility Operations (ELVO) Phase III
  - Increasing capacity at many runways through Special Authorization Cat II Operations
  - Phase III: Special Authorization CAT II with lower minimums (Decision Height and RVR)

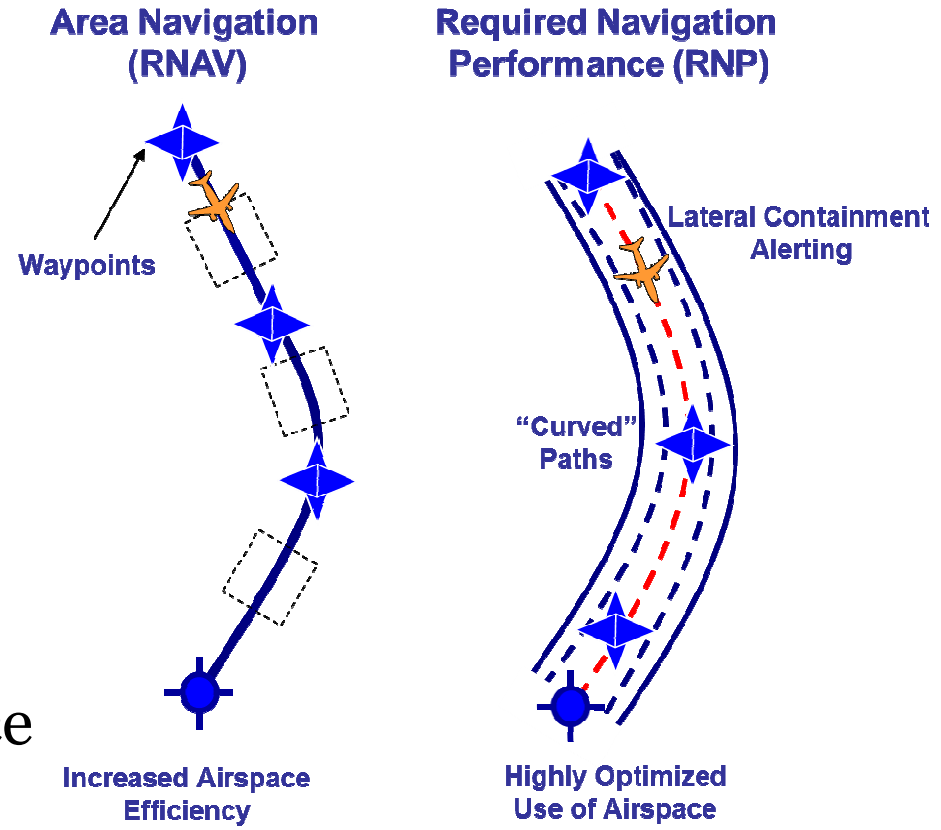
Summary

- Navigation Programs will:
  - Sustain existing positioning, navigation and timing services while reducing the overall cost of service provision
  - Transform services to support NextGen capabilities and operational improvements to realize RNAV everywhere in the NAS and RNP where beneficial for safety, environmental, capacity and efficiency improvements
  - Reducing VOR footprint while increasing DME coverage to ensure an adequate backup capability exists throughout the transformation to NextGen
  - Transitioning to energy efficient and lower maintenance LED airport lighting
  - Continued transition to a primarily satellite based navigation infrastructure via GPS and augmentations to enable precise navigation via WAAS and GBAS
  - Investigate solutions to mitigate GPS interference events
  - Make available to the users, operators and stakeholders of the NAS, reliable and timely information as to the status of the GNSS via a centralized command center
  - Exploring new options for an alternate navigation infrastructure to address localized GPS outages and ensure NextGen navigation proceeds unimpeded in the future

Questions

Future State of Navigation

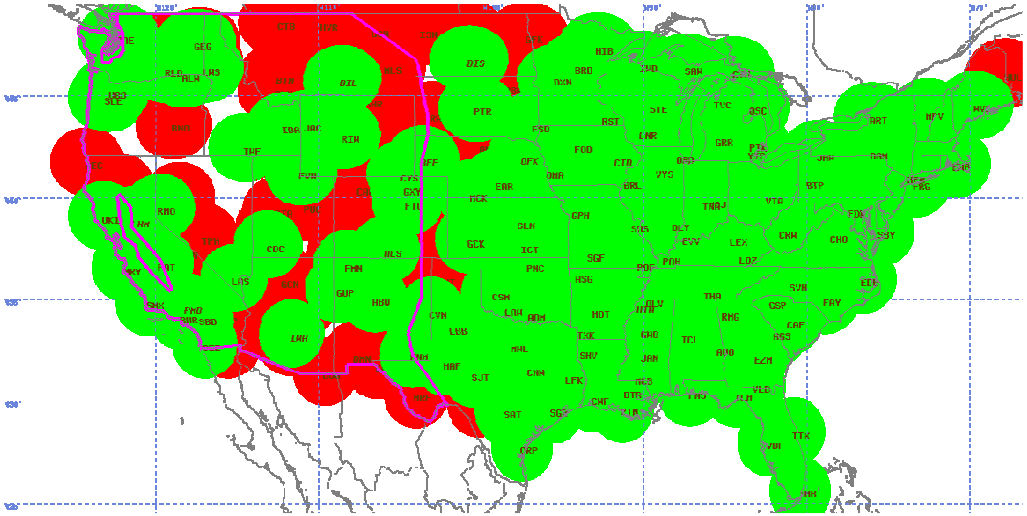
- RNAV
  - Enabled by GPS, WAAS and DME/DME/IRU
- RNP
  - Enabled by GPS and WAAS
- ADS-B
  - Supported by GPS/WAAS
- Electronic Aided surface navigation with advanced surface movement, guidance and control



VOR Minimum Operating Network (MON)

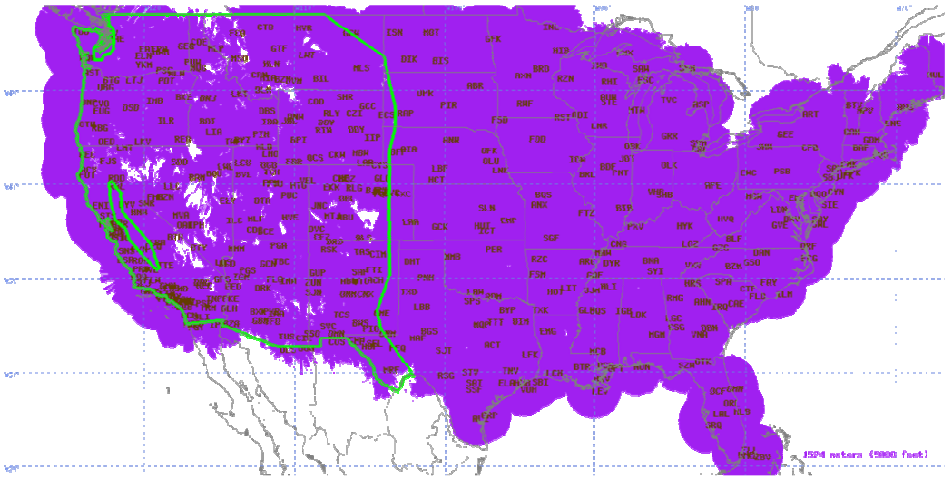
- The FAA will transition from VOR-defined route structures as the primary means of navigation to Performance-Based Navigation (PBN)
  - PBN uses Area Navigation (RNAV) and Required Navigation Performance (RNP)
- VORs must give way to a safer, more reliable, and efficient means of air navigation
  - Objective is to provide improved accuracy, availability, integrity, and continuity to support PBN

Coverage for Approaches and Landings at National MON Airports



VOR MON (Con't)

- The VOR Minimum Operational Network (MON) Implementation Program
  - Focuses on safety and coordination across organizational lines of business (LOBs)
  - Transitions from a legacy network of 967 VORs to a MON of approximately 500 VORs by January 1, 2020
  - One the activities required to shift resources from the legacy NAS into NextGen
- The VOR Minimal Operational Network (MON) will provide:
  - A backup capability for lower end GA IFR aircraft in the event of a GPS outage
  - An operational contingency instead of full robust network of current VORs
  - A transitional network of VORs to allow users time to transition to RNAV and RNP



Notional VOR MON for En route coverage at 5000 ft AGL

MON assures no impact to current level of coverage