Backup Navigation During GPS Interference

The Very High Frequency Omni-Directional Range (VOR) Minimum Operational Network (MON)

NextGen Distance Measuring Equipment (DME) Program

April 12, 2024

Federal Aviation Administration

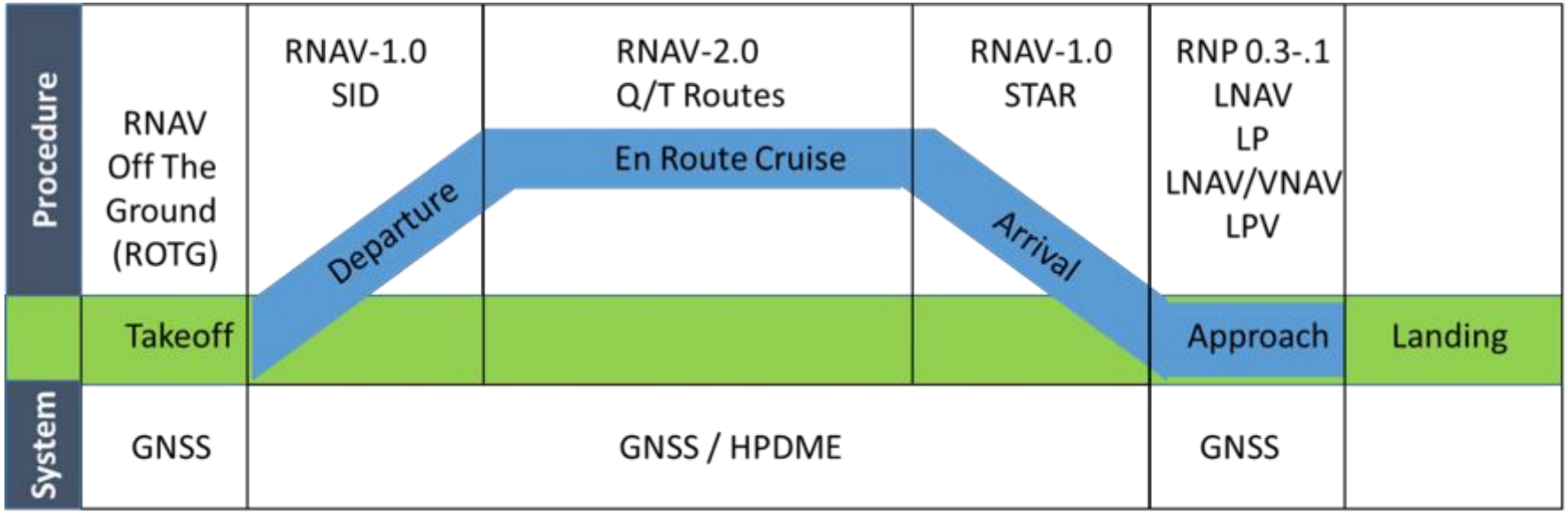
Background

- In 2006, the FAA started the transition to Performance Based Navigation (PBN) primarily using the Global Positioning System (GPS) and Area Navigation (RNAV).
  - Although VORs are not used for PBN, a Minimum Operational Network (MON) would need to be retained in order to provide a backup during GPS interference.
- In 2011, the VOR MON concept was published in Federal Register Notice (FRN) 76 FR 77939: *Proposed Provision of Navigation Services for the Next Generation Air Transportation System (NextGen) Transition to Performance-Based Navigation (PBN).*

Navigation Strategy

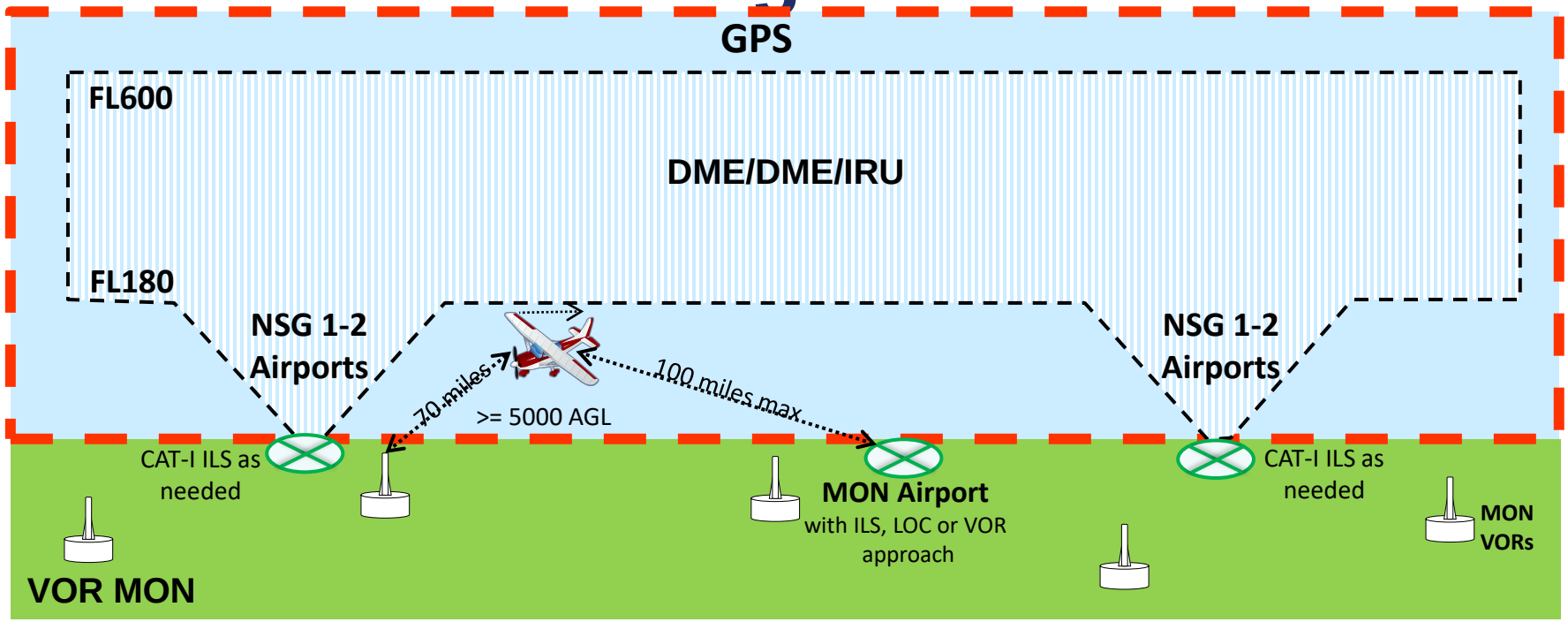
- Provide resilient navigation services per the Performance Based Navigation (PBN) National Airspace System (NAS) Navigation Strategy (2016).
  - The Global Positioning System (GPS) and the Wide Area Augmentation System (WAAS) enable all PBN operations and Automatic Dependent Surveillance Broadcast (ADS-B).
- The main concern is a loss of GPS signal for navigation.
  - Several recent events have underscored the necessity for resilience.
- Resilience to be provided by:
  - VOR MON (primarily for general aviation aircraft).
  - NextGen DME (primarily for air carrier aircraft).
  - Legacy conventional navigation aids must be sustained to provide a resilient NAS infrastructure.

PBN Implementation in the NAS



- The principal means of navigation is the Global Navigation Satellite System (GNSS).
  - GPS and WAAS are the approved GNSS systems in the U.S.

Resilient Navigation Services



- GPS is the primary enabler for all PBN (RNAV and Required Navigation Performance (RNP)) and ADS-B accuracy & integrity for all separation levels.
- Distance Measuring Equipment (DME)/DME/IRU (Inertial Reference Unit) provides a backup to GPS.
- VOR MON can be used by aircraft that are not DME/DME/IRU RNAV equipped or in areas where DME/DME/IRU RNAV service is not available.
- MON airports will have Instrument Landing System (ILS), Localizer (LOC), or VOR approaches to recovery in the event of GPS interference.

The VOR MON Program

Background

- The FAA considered input from the public, industry, other government agencies (including the military), and the RTCA Tactical Operations Committee (TOC) to develop the VOR MON.
- In 2016, the final policy was published in FRN 81 FR 48694: *Provision of Navigation Services for the Next Generation Air Transportation System (NextGen) Transition to Performance-Based Navigation (PBN) (Plan for Establishing a VOR Minimum Operational Network).*
- The program consists of two Phases:
  - Phase 1 (FY2016 – FY2020): 82 VORs discontinued.
  - Phase 2 (FY2021 – FY2030): 221 VORs planned for discontinuance.

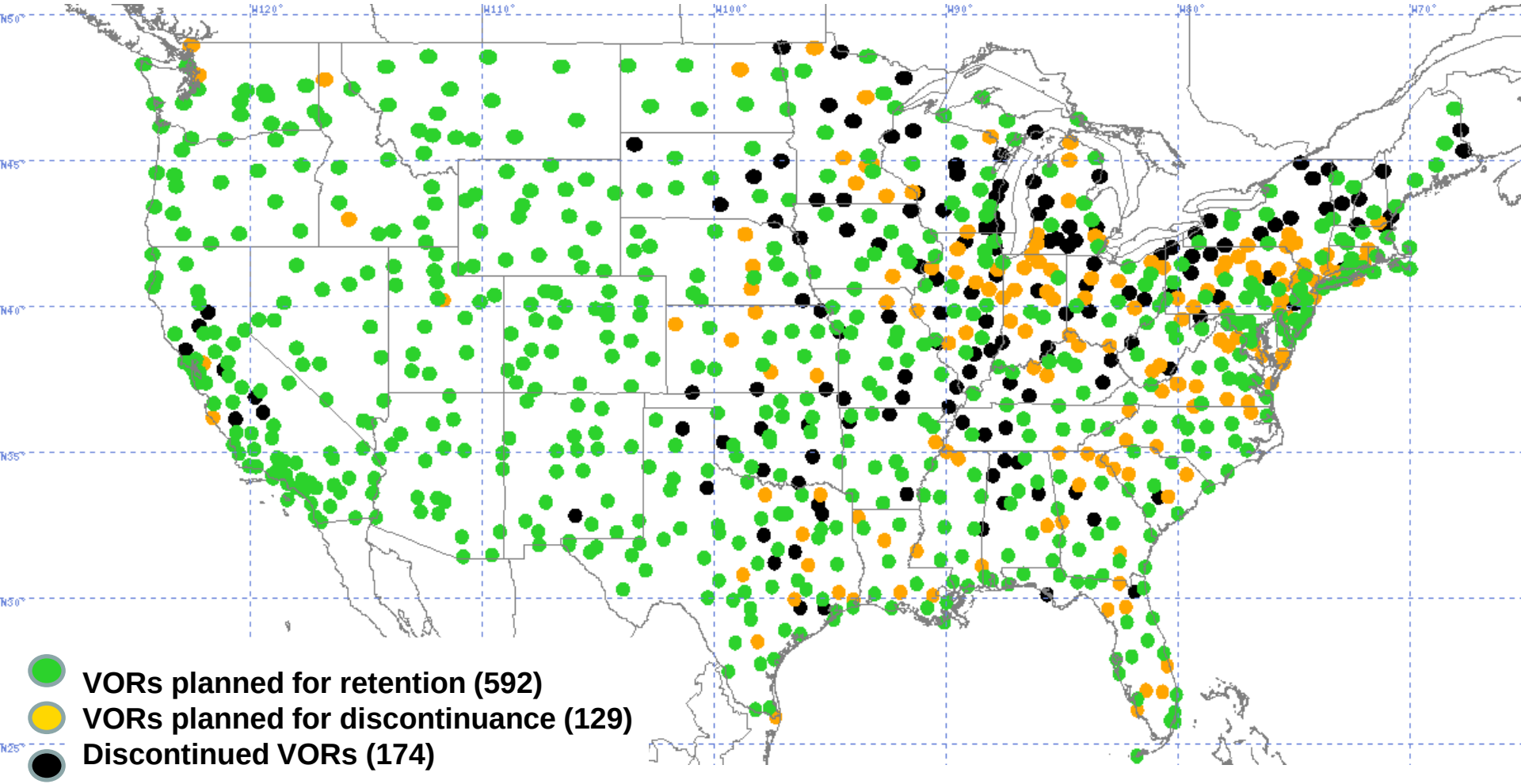
VOR MON Implementation

- In order to re-purpose the CONUS VOR network from the primary means of navigation to a backup, VOR signal must be available starting at 5,000 feet Above Ground Level (AGL).
  - Coverage will exist below 5,000 ft but may not be continuous.
- To provide the required coverage, two new VOR Standard Service Volumes (SSVs) were established.
  - MON VORs will be flight inspected and their class codes changed to the new SSVs.
  - To Date, 381 out of 499 new VOR SSVs have been published.
- In addition, at least one conventional approach will be available within 100 nautical miles (NM) at designated MON airports.
- VORs that do not meet the VOR MON criteria are targeted for discontinuance.
  - To Date, 174 out of 303 VORs have been discontinued.

VOR Discontinuance Process

- Although the VOR MON program addresses a large group of VORs, each VOR discontinuance is a separate action by the FAA in accordance with standard procedures.
- Each VOR undergoes a discontinuance study to identify all published procedures and uses for the VOR.
  - Public comments are solicited.
- When approved, all airway, fix, and procedure changes are implemented.
- When all required changes are published, the VOR is removed from charts and databases.

VOR Discontinuance Status



- **VORs planned for retention (592)**
- **VORs planned for discontinuance (129)**
- **Discontinued VORs (174)**

Concept of Operation and Development

VOR MON Concept of Operation

- During a GPS interference event in CONUS, pilots can:
  - Tune and identify a VOR at or above 5,000 feet AGL and
  - Navigate VOR-to-VOR or along airways through the interference,

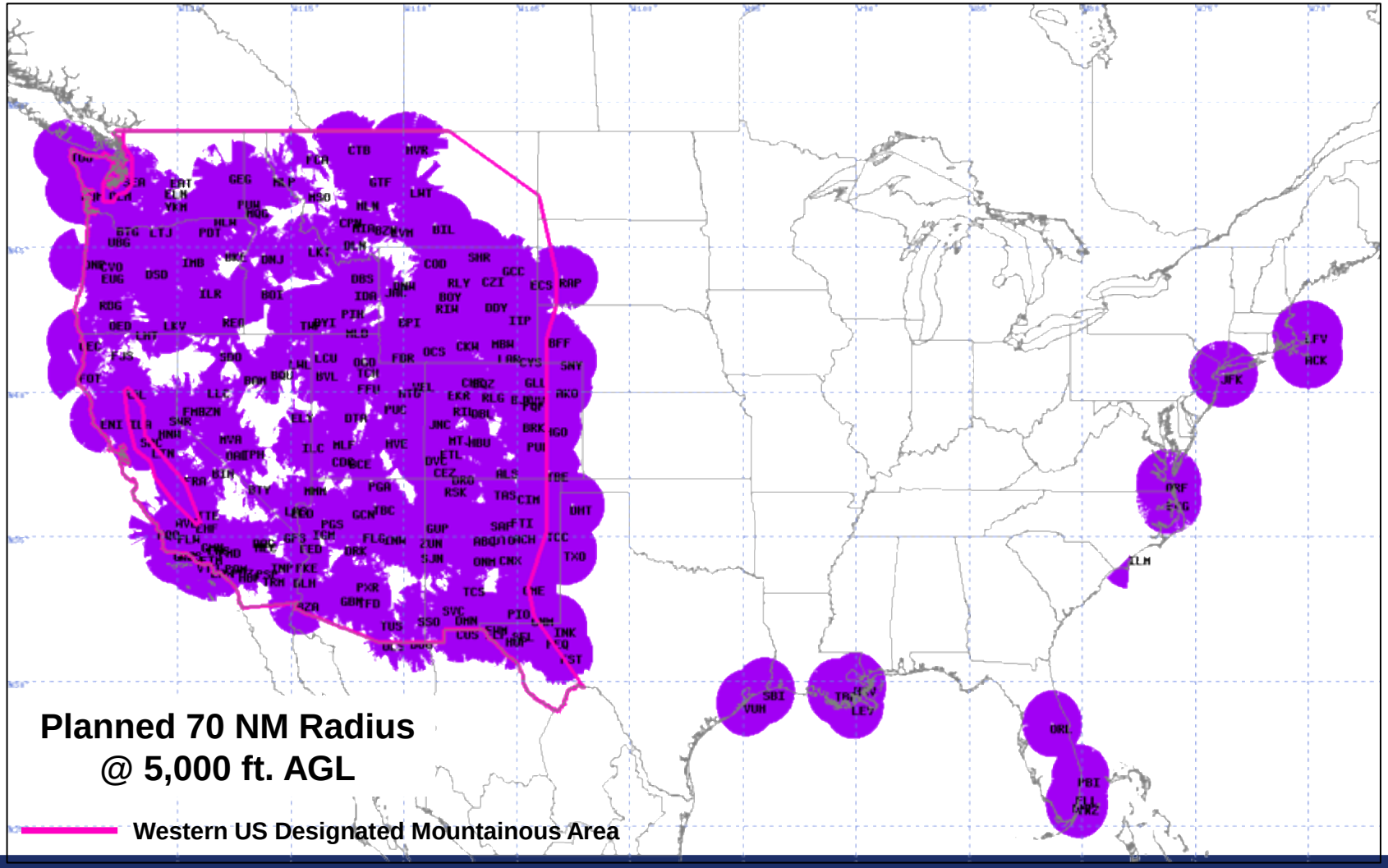
    or
  - Navigate to an airport within 100 nautical miles to fly an Instrument Landing System (ILS), Localizer (LOC) or a VOR approach.
- Distance Measuring Equipment (DME), Automatic Direction Finder (ADF), surveillance, and GPS will not be required for the approach.

VOR MON Development

1. Retain most of the VORs in the Western U.S. Mountainous Area.
   - Especially those anchoring Victor airways through high elevation terrain.
2. Retain VORs to support international oceanic arrival routes.
3. Retain VORs to navigate to an ILS, LOC, or VOR approach at a MON airport within 100 NM of any location within CONUS (where the capability currently exists).
   - Approaches will not require ADF, DME, surveillance, or GPS.
4. Retain VORs to provide coverage at and above 5,000 ft. AGL plus some VORs near large airports.

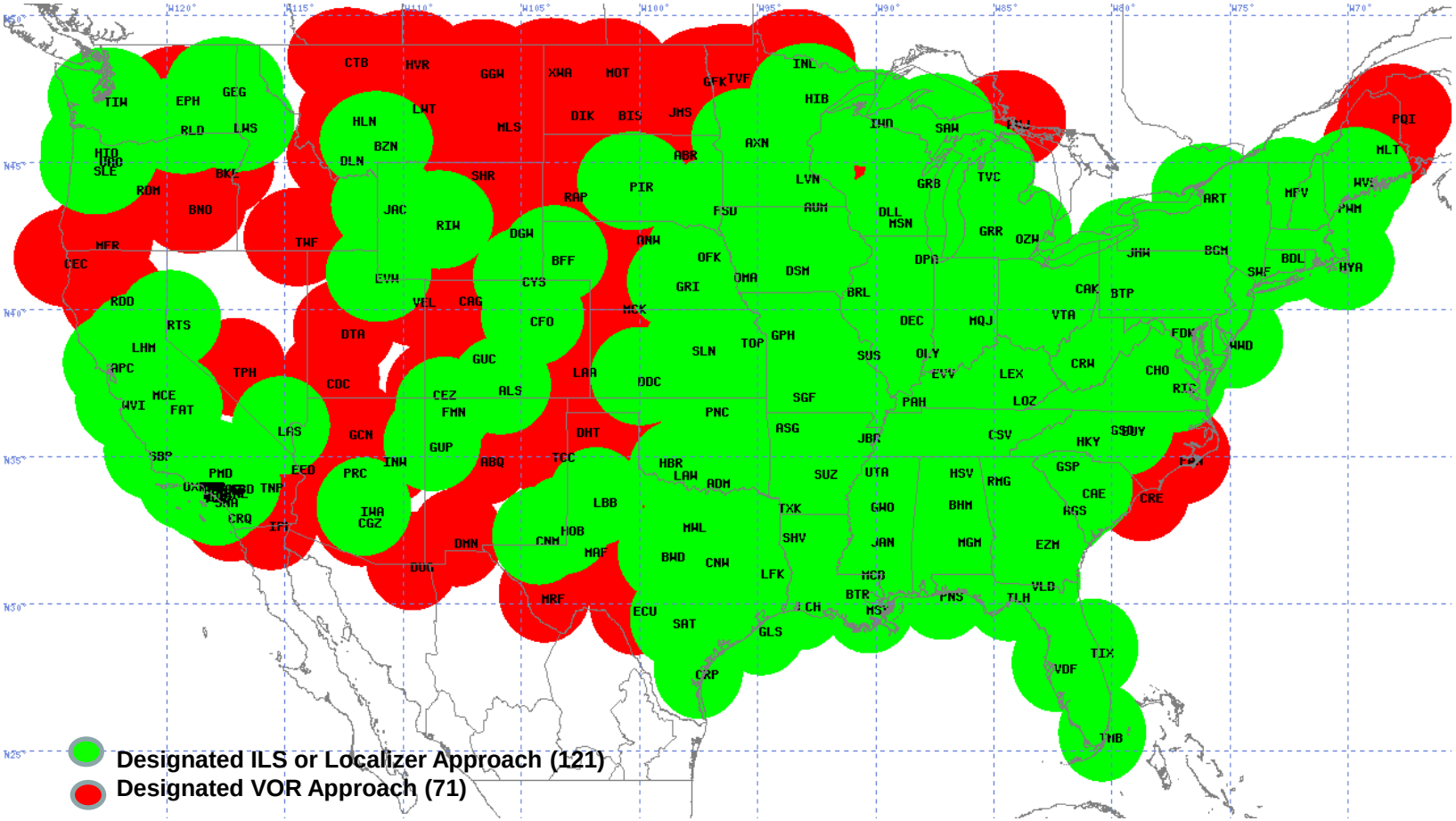
Note: Only FAA-owned VORs in the CONUS were considered.

Retain VORs in Western Mountainous Area and International Air Routes



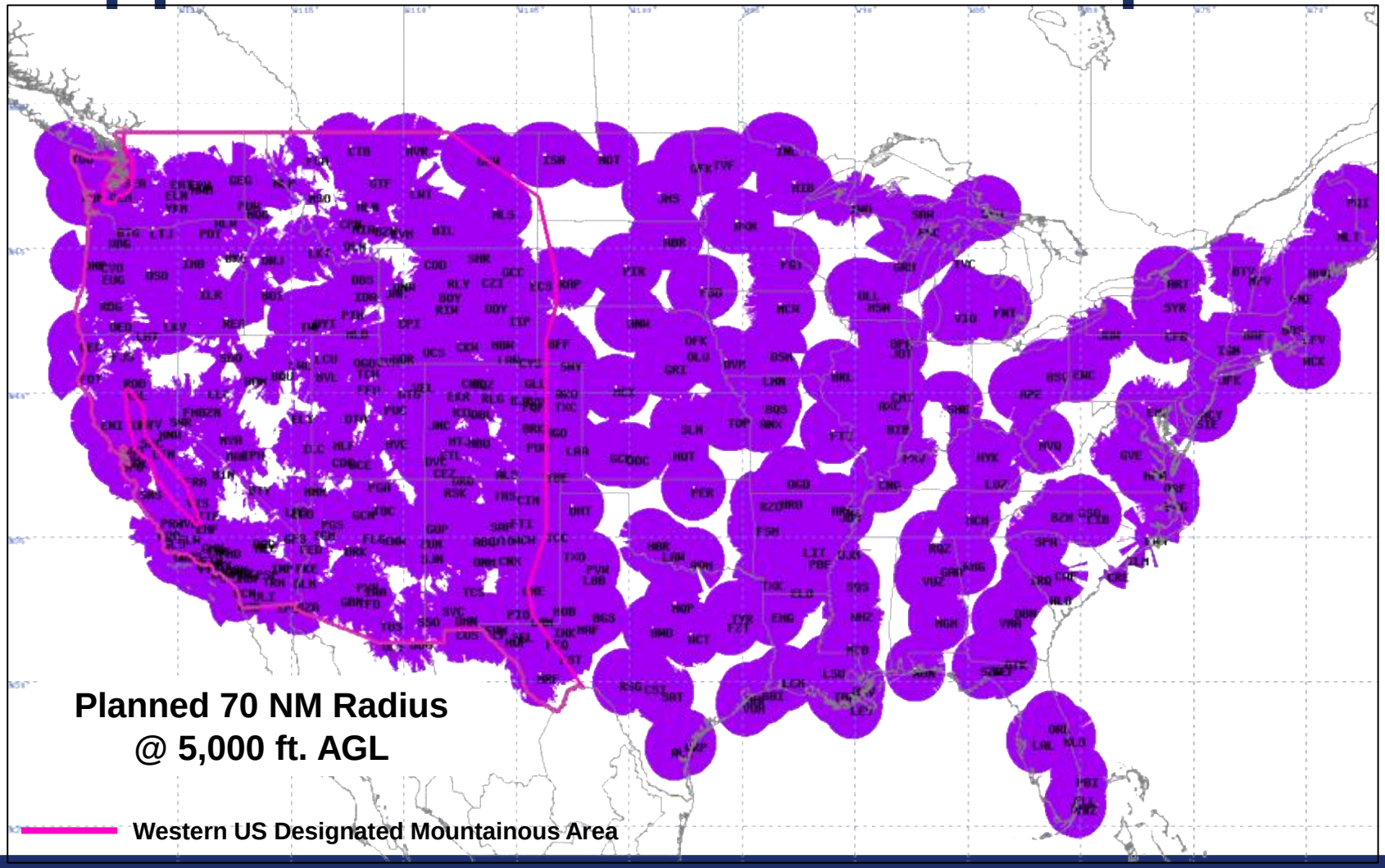
MON Airports (ILS/LOC or VOR Approaches)

100 NM Radius, No Requirement for DME/ADF/surveillance

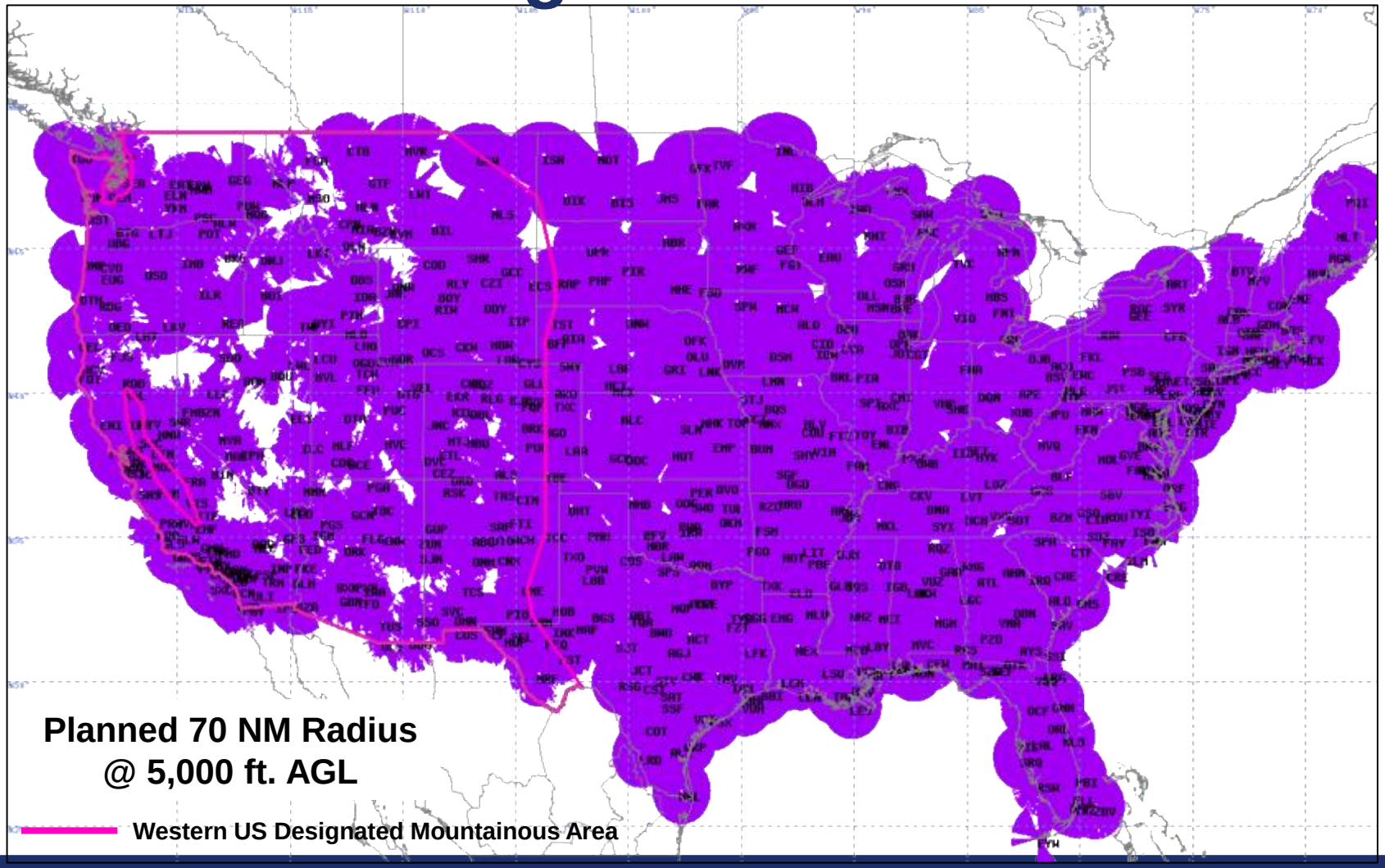


The circles depict 100 nm around the MON airports. MON airports ensure that an aircraft is within 100 nm of a location where an LOC, ILS or VOR approach may be flown, where the capability currently exists.

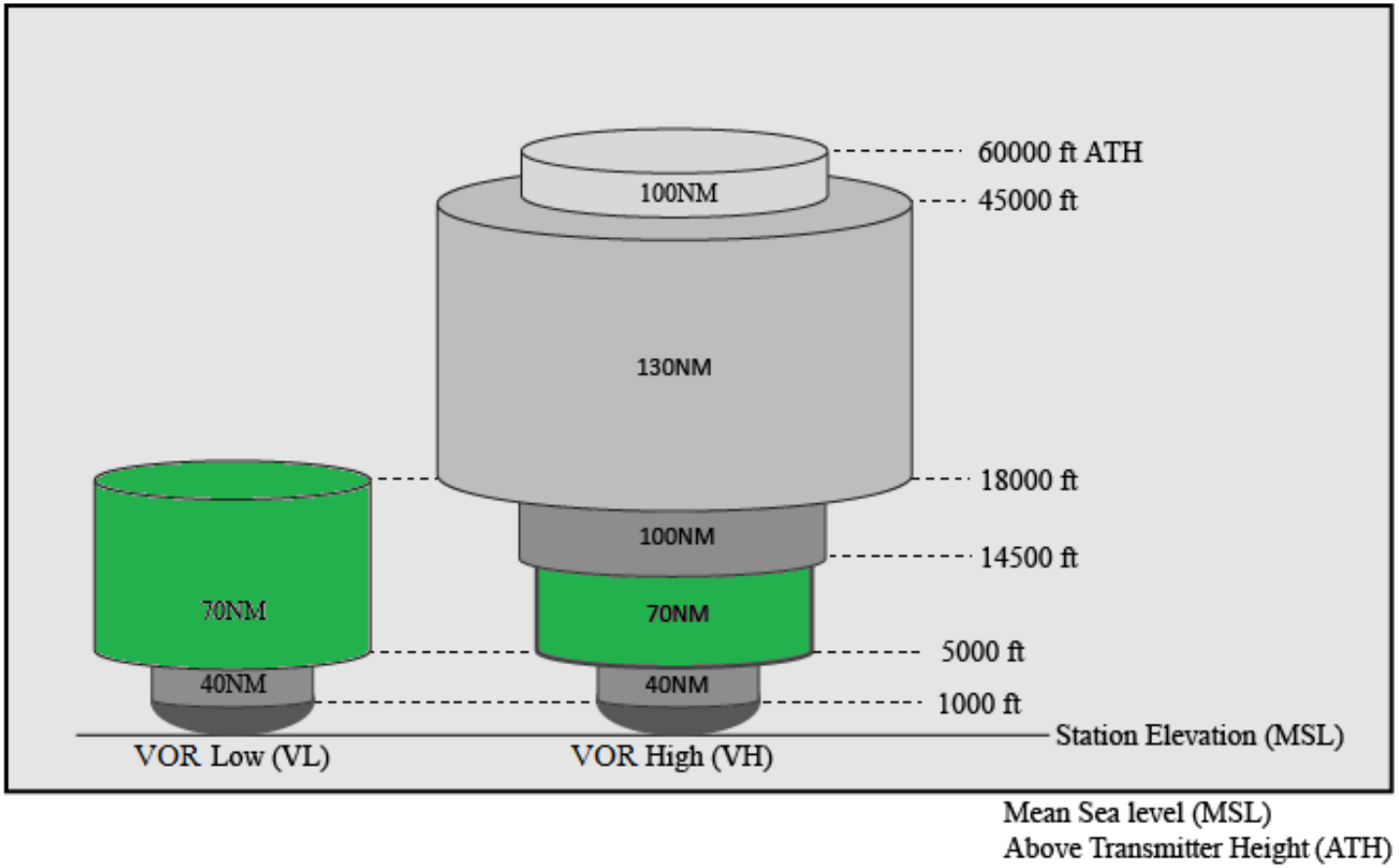
Retain VORs Needed for Designated Approaches at VOR MON Airports



Retain Gap Fillers to Support 5,000 ft. AGL Coverage and Other Criteria



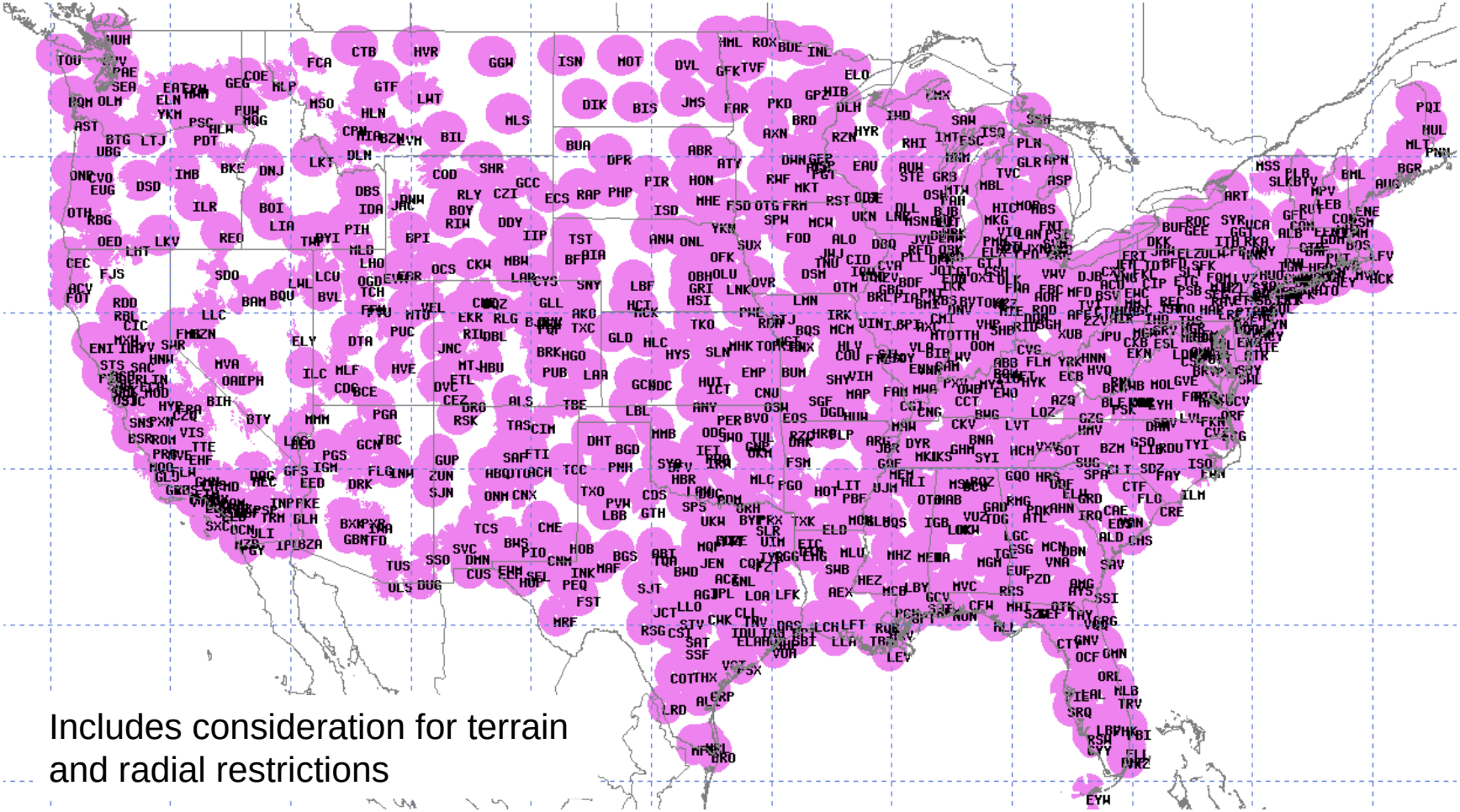
New VOR Standard Service Volumes



Note: No avionics changes are required to use the new service volumes.

2015 FAA VOR Network Coverage

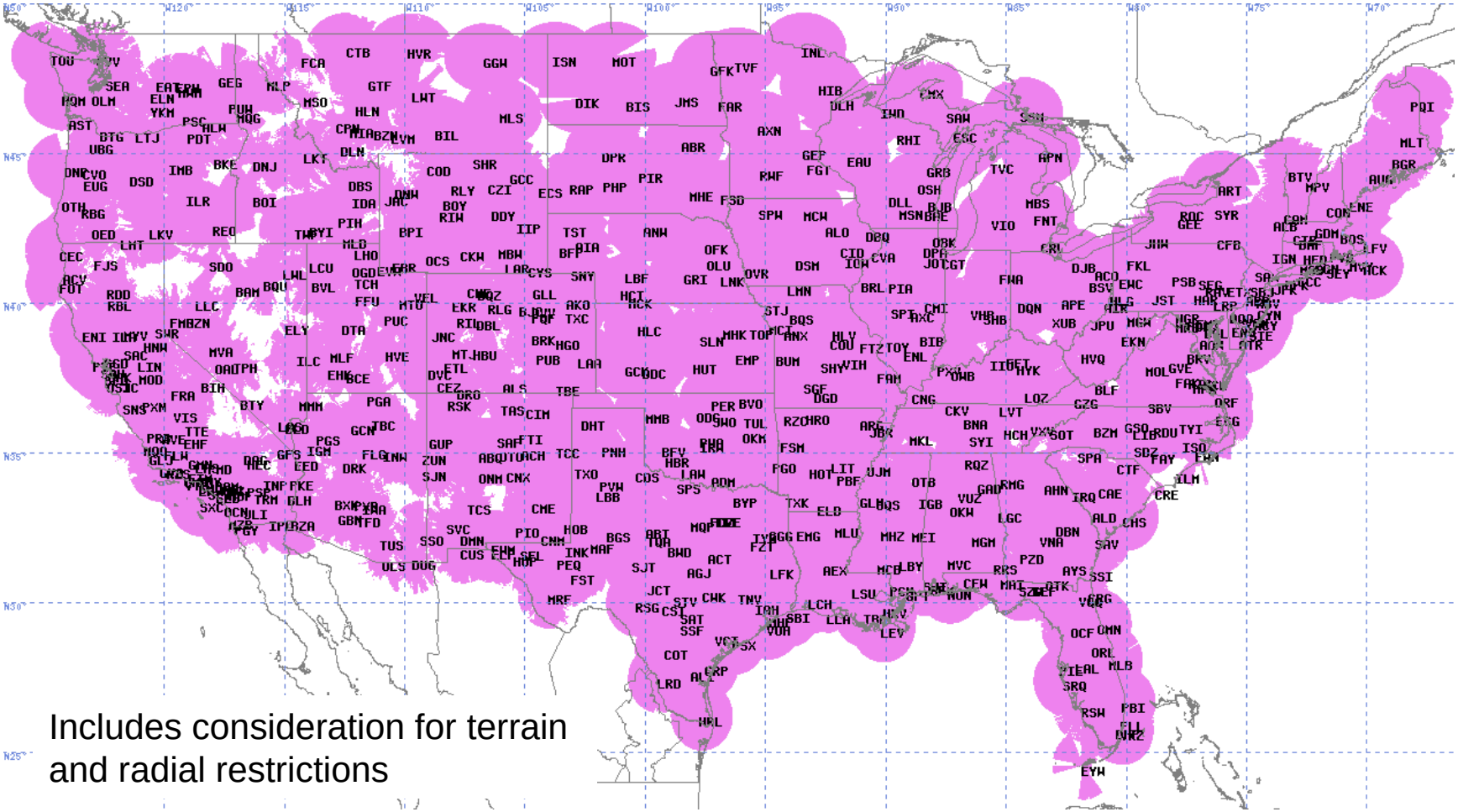
40 NM Service Volume at 5,000' AGL



Includes consideration for terrain and radial restrictions

Planned VOR MON Coverage

70 NM Service Volume at 5,000' AGL

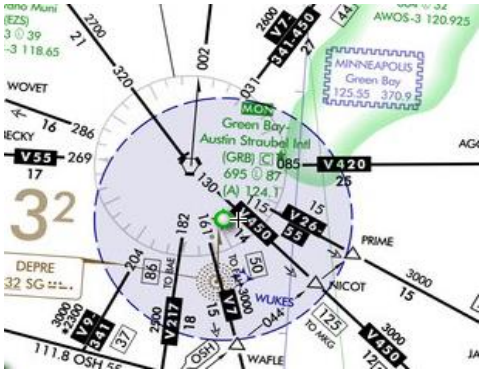


Includes consideration for terrain and radial restrictions

Charting MON Airports

- The terminology for airports to be used for the VOR MON is “MON Airport” (Capital M-O-N and A) both in the source database and publications.
  - The Chart Supplement has the list of MON Airports.
- MON Airports *are published* on high, low, and area en-route IFR charts. The associated airport text contains “MON” in uppercase.
  - MON Airports *are not published* on charts principally used for VFR flight (e.g., sectionals).

Examples
FAA High and Low En-route
Other Chart Providers Could be Slightly Different



Other Services at VOR Sites

- DMEs and TACANs will generally be retained at sites where the VOR service is removed, and an RNAV waypoint will remain.
- FSS communication provided by non-MON VORs will generally be discontinued (i.e., 122.1 MHz).
  - Equivalent Radio Communications Outlet (RCO) service will be retained.
- Federally owned Automated Weather Observing System (AWOS), Automated Surface Observing System (ASOS), and Automatic Terminal Information Service (ATIS) transmissions over VORs will be moved to a VHF transmitter as required.
- The FAA has discontinued HIWAS.

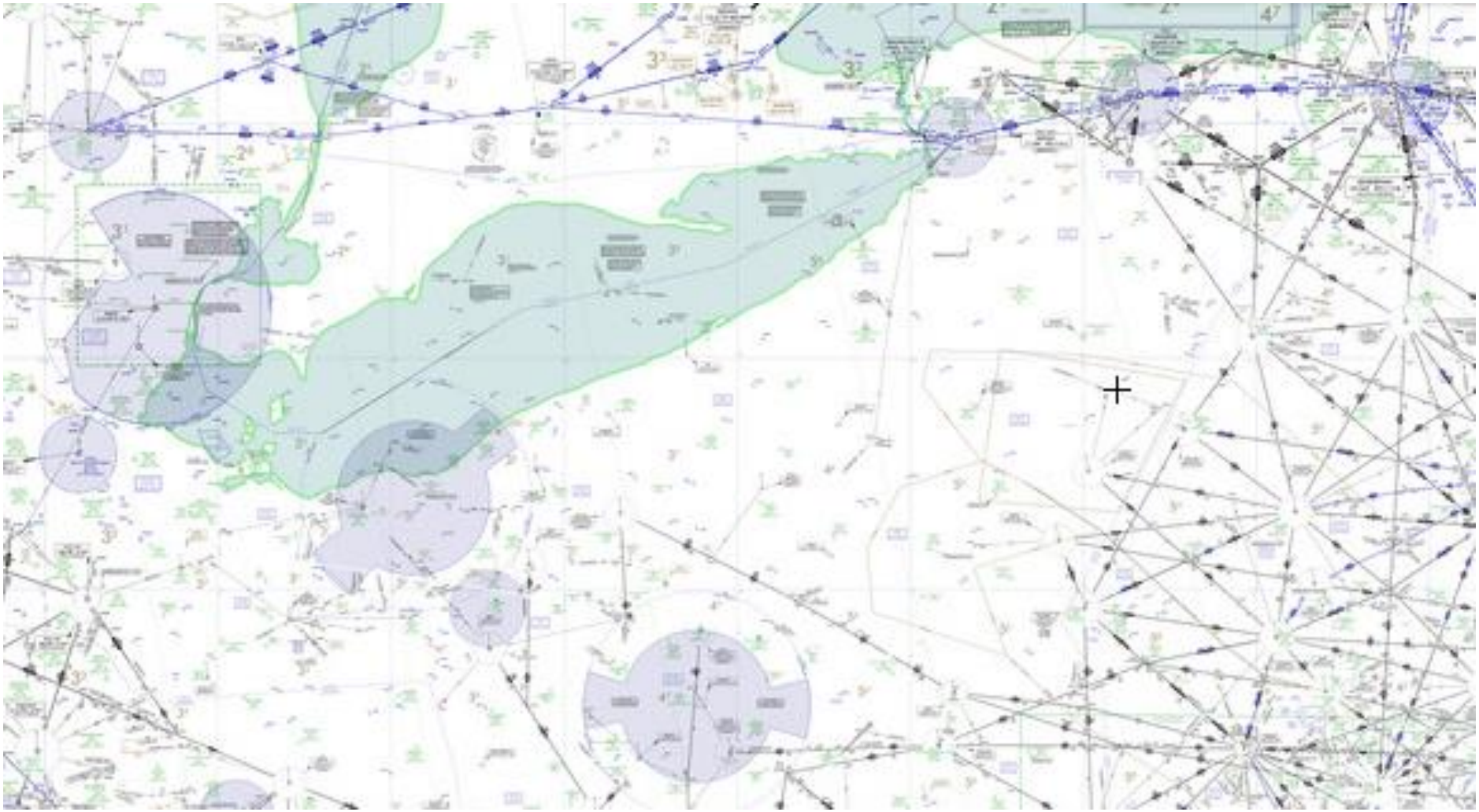
No Change to Requirements

- There will be *no change* in current equipage, fuel reserve, and alternate filing rules:
  - 14 CFR Part 91 (non-Subpart K).
    - Aircraft equipped with non-WAAS GPS will continue to be required to carry an alternate form of navigation appropriate to the route.
    - WAAS-equipped aircraft will continue to *not* be required to carry an alternate form of navigation (when WAAS is in operation).
  - Others (14 CFR part 121, 135, 91 Subpart K, etc.).
    - Must carry an appropriate independent non-GPS-based navigation system (in addition to GPS and/or WAAS).

Changes to Airways

- VOR discontinuation affects the conventional airway network.
  - Jet Routes and Victor Airways are required by law to be defined and anchored by VORs.
  - Conventional fixes along these airways are defined by VORs.
- As the VOR MON program discontinues VORs, the conventional route structure will either be canceled, amended, or replaced by RNAV airways (e.g., T-routes or Q-routes) as needed for air traffic control.

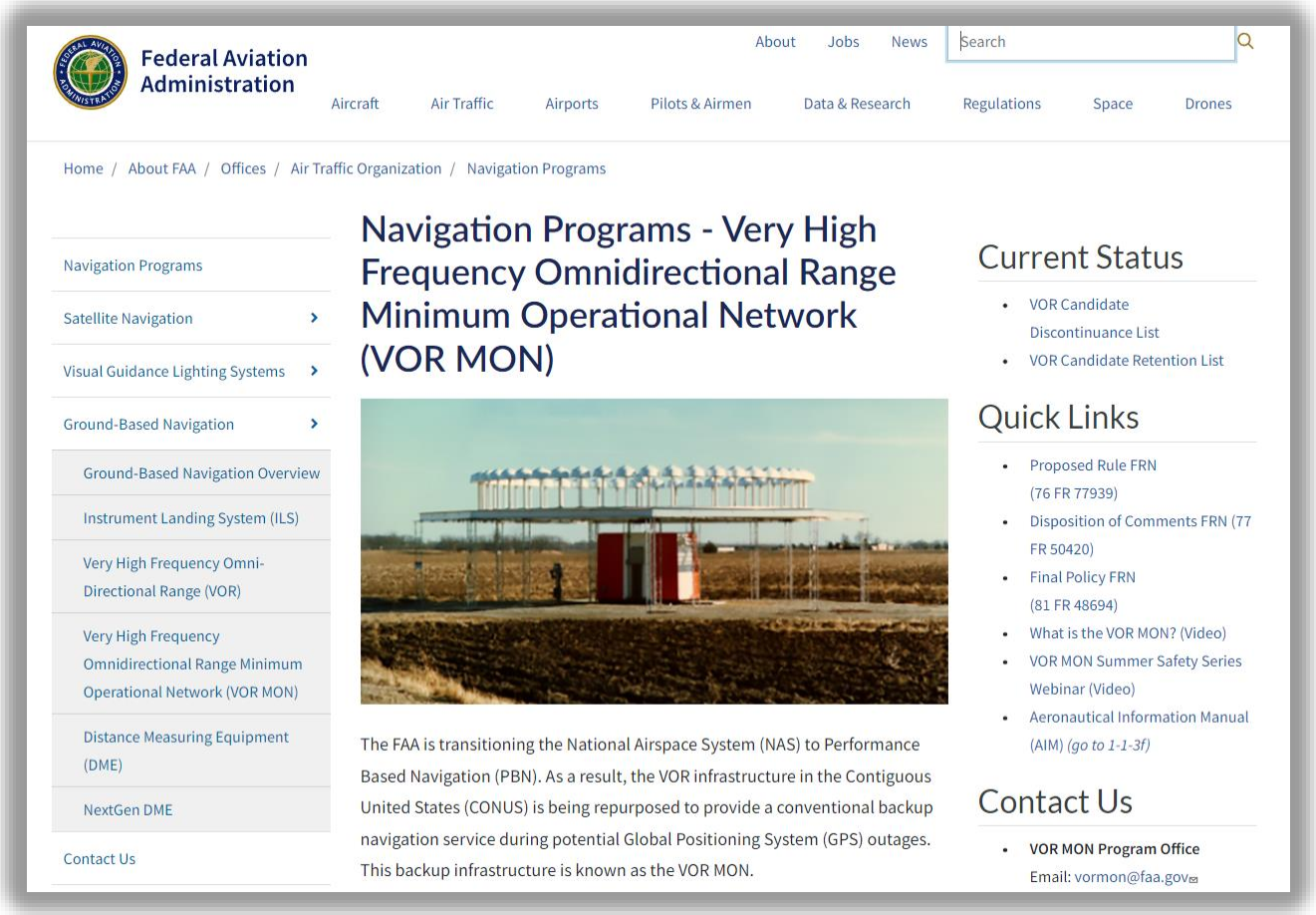
Airways Already Discontinued



Summary

- The VOR MON will provide a backup during a potential GPS interference event.
- Users can navigate through an interference event or land at a MON Airport without GPS, DME, ADF, or Surveillance.
- Users not equipped with GPS can still operate in the NAS, but likely with reduced efficiency.
- There will be no changes to current equipment or flight plan filing requirements.

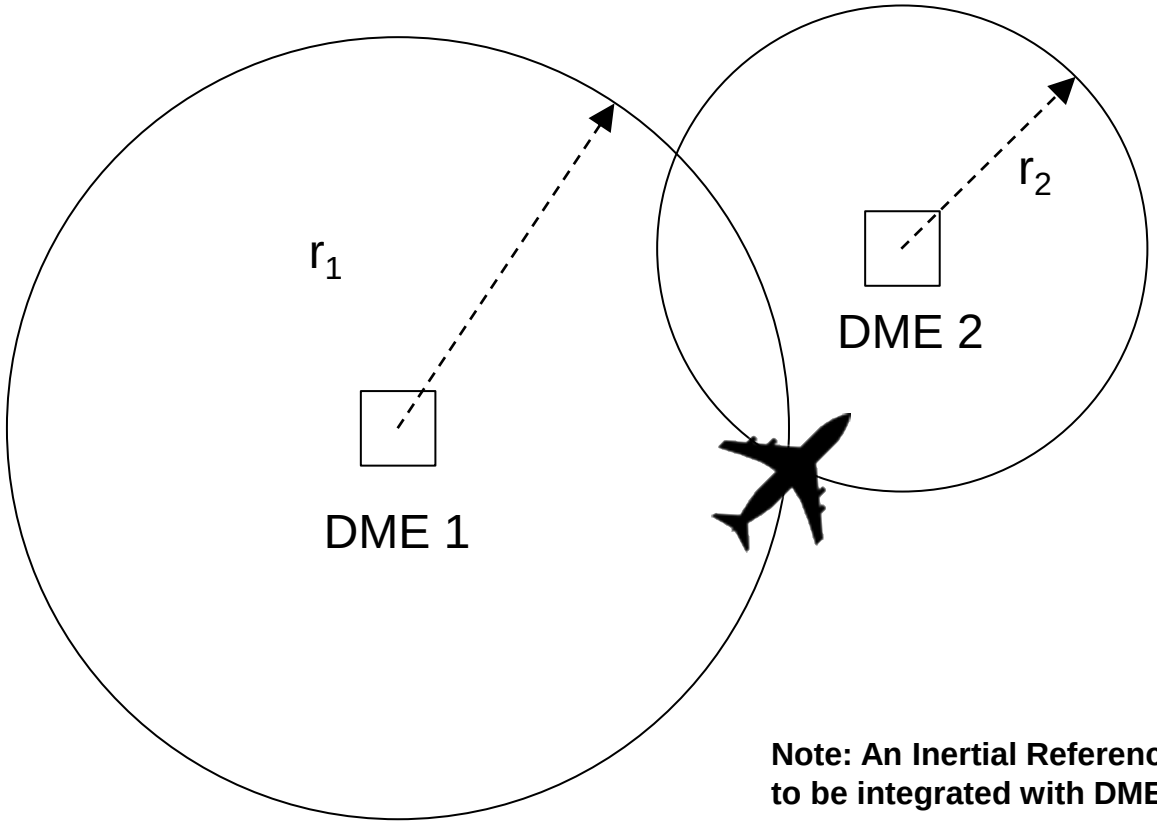
VOR MON Website



www.faa.gov/go/VORMON

The NextGen DME Program

RNAV Using DME/DME



Note: An Inertial Reference Unit (IRU) is required to be integrated with DME/DME in the U.S.)

Current Issues with DME/DME Coverage

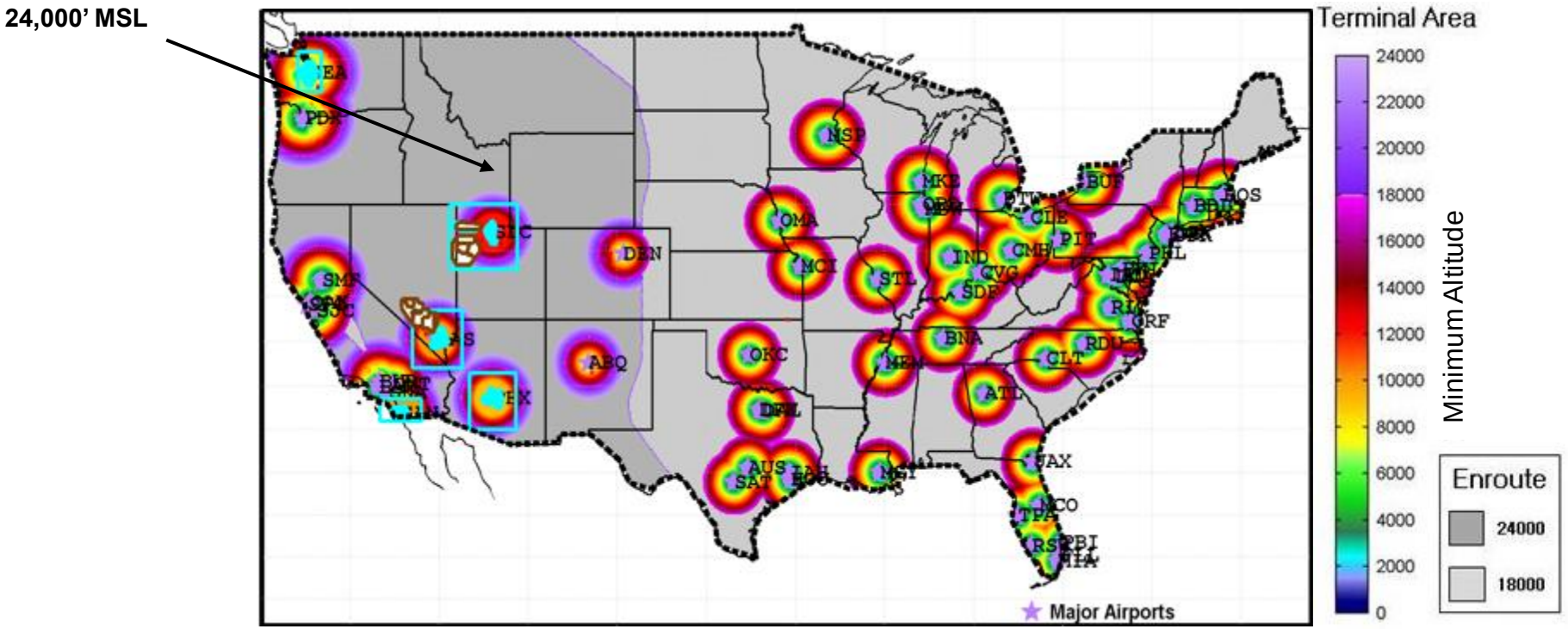
- DMEs were not sited for DME/DME use.
  - DMEs were originally co-located with VORs as a source of range information.
- There are gaps in high altitude coverage.
  - There is no complete backup for GPS.
    - Full transition from Jet Routes to RNAV routes (Q-routes) cannot be completed without seamless coverage.
- Gaps in terminal areas result in:
  - Preflight checks of “Critical” DME NOTAMs.
  - Limits in design of arrival and departure procedures that are “GPS Required.”

NextGen DME Program Coverage Objectives

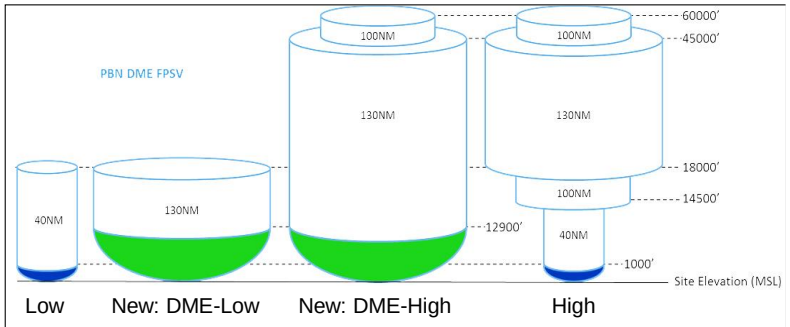
- Redundant DME/DME RNAV at high altitude for enroute:
  - No single DME outage/failure will result in a loss of coverage.
  - All existing and future Q-routes covered.
    - No “GPS-required” restrictions.
  - Can provide coverage for any dynamic routing.
  - Can eliminate Jet routes.
- DME/DME RNAV service in 62 major terminal areas.
- No critical DMEs on operationally significant RNAV arrival and departure procedures.

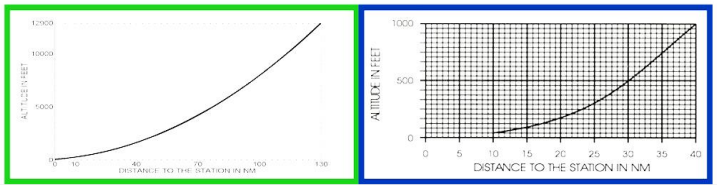
Minimum Altitude for Future DME/DME

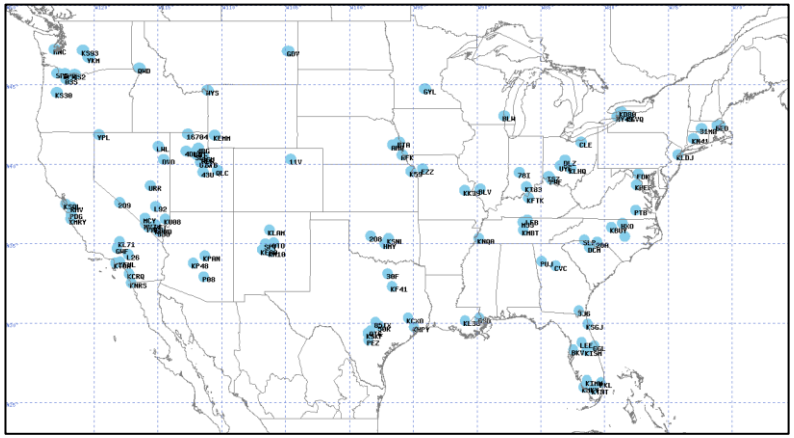
- Colored rings: Terminal area cones
- Gray: En-route 18,000’ and 24,000’ MSL



Changes to Meet NextGen DME Goals



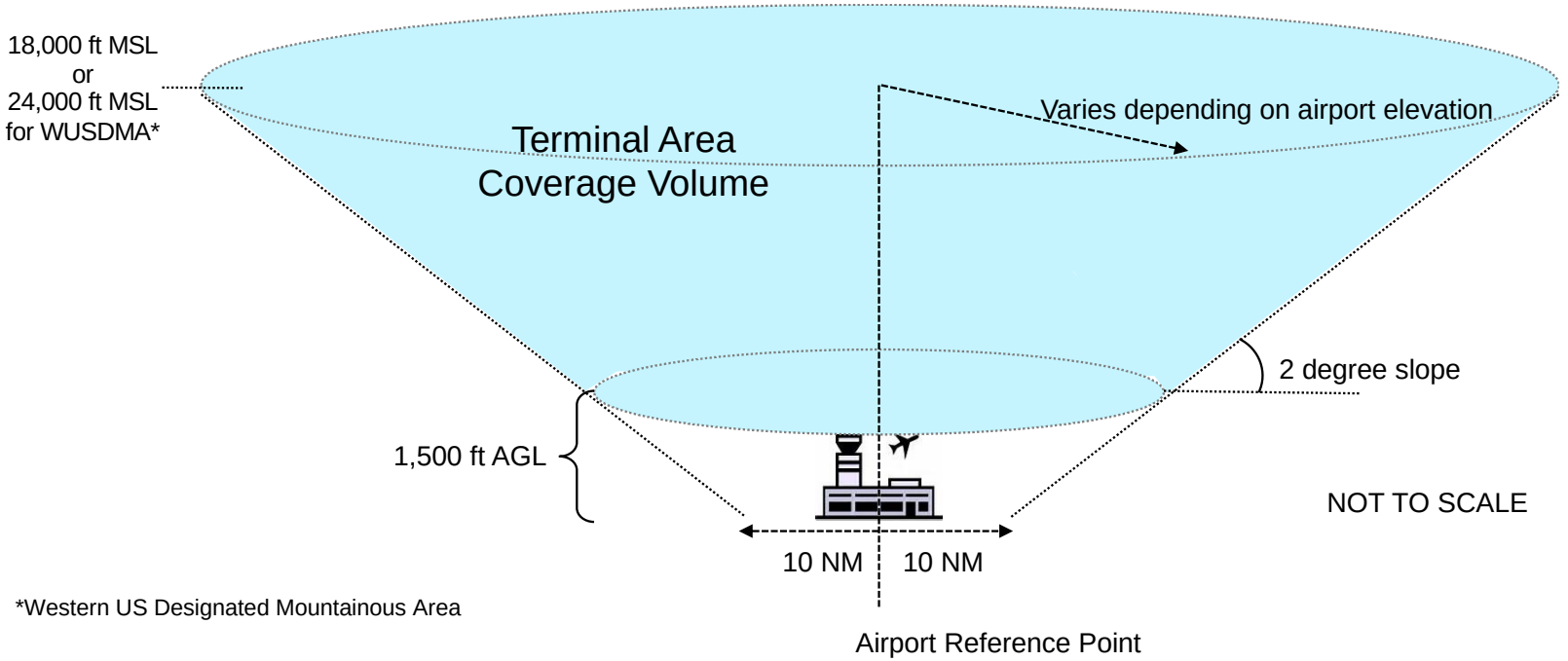




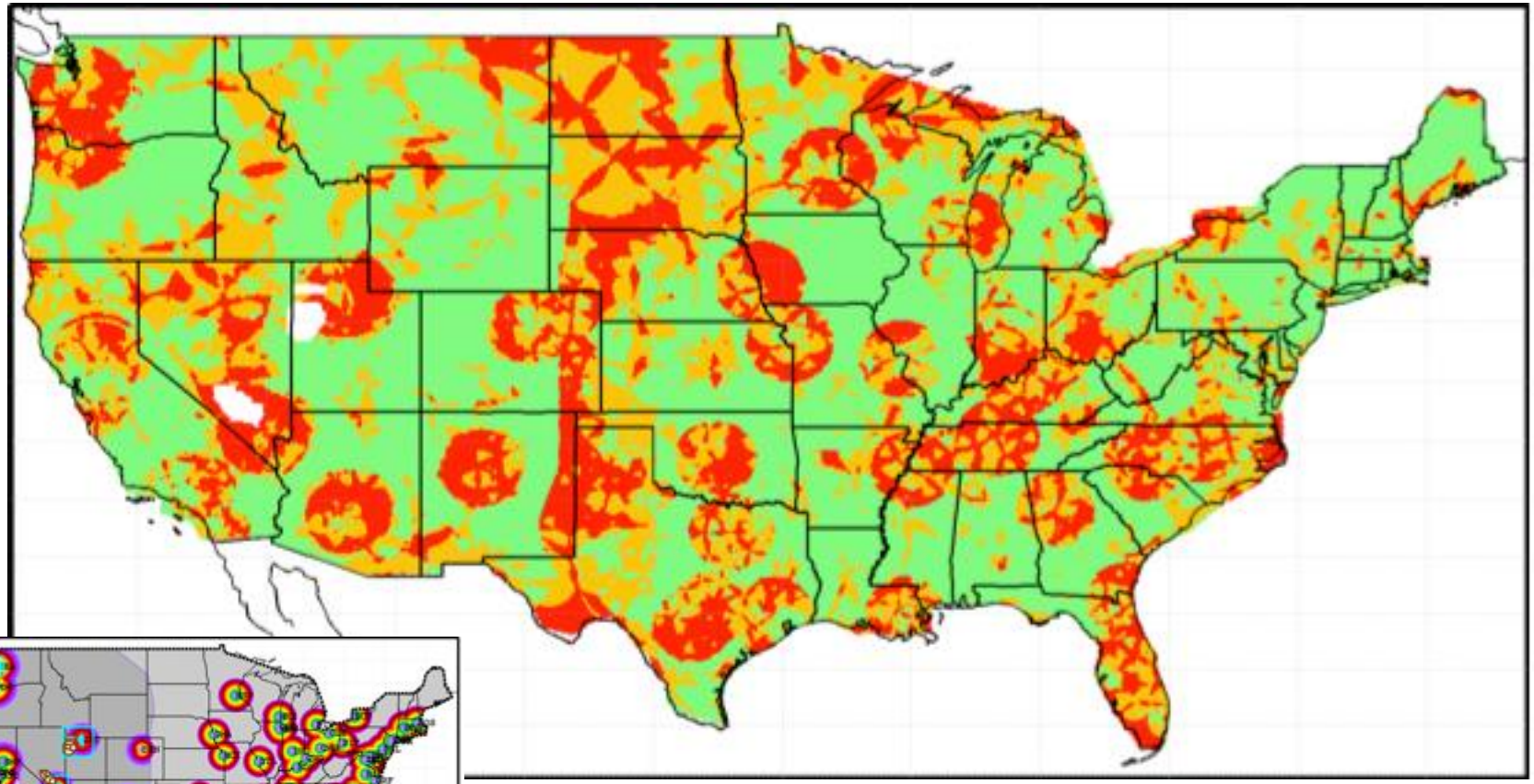
- New DME service volume definitions: “DME High” and “DME Low”.
  - DME service volumes will be separated from VOR service volumes.
- 104 out of 590 new DME service volumes have been published.
- 8 out of 129 new DME sites have been implemented to fill gaps in both en-route and terminal area coverage.

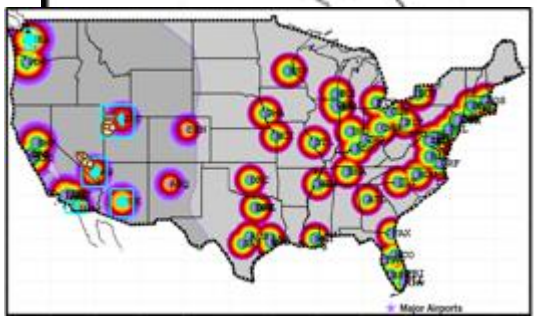
Terminal Area Cone

- Busiest 62 airports for DME/DME equipped aircraft.

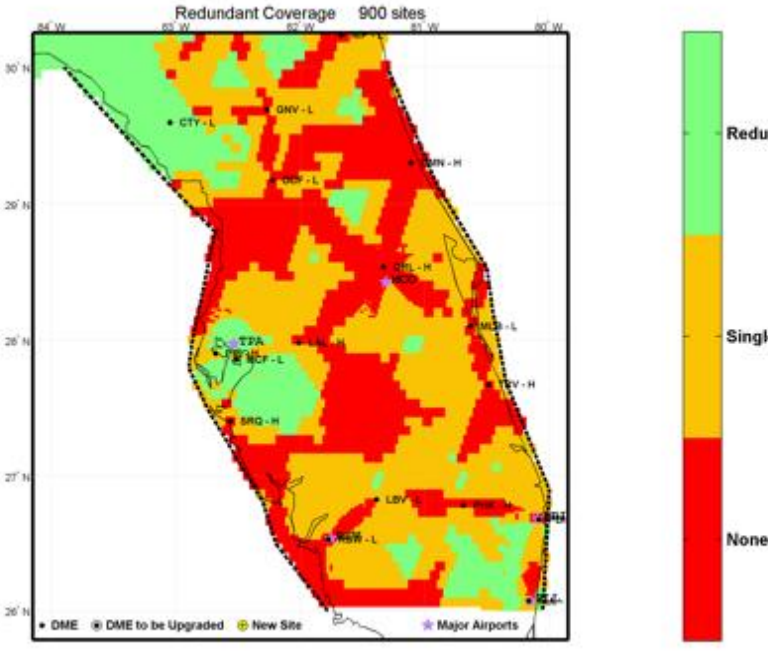


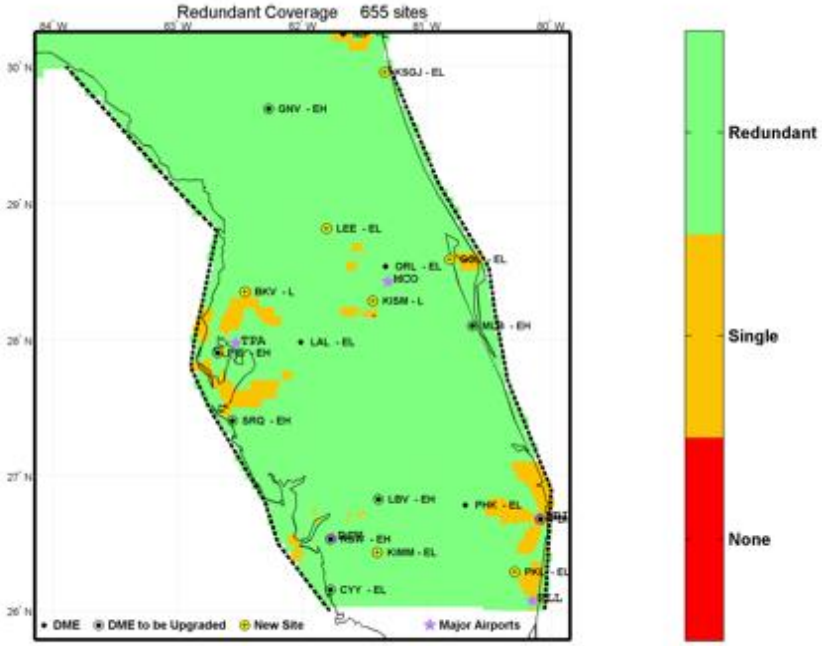
2015 DME Coverage



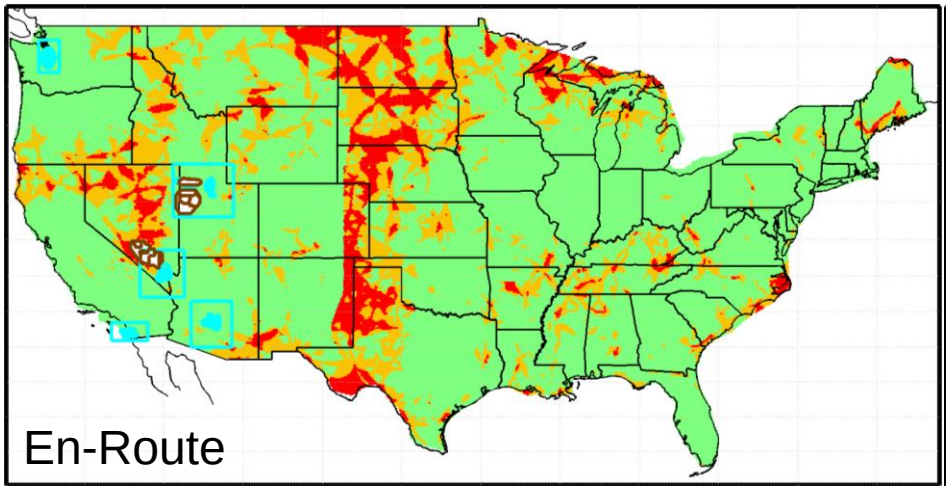


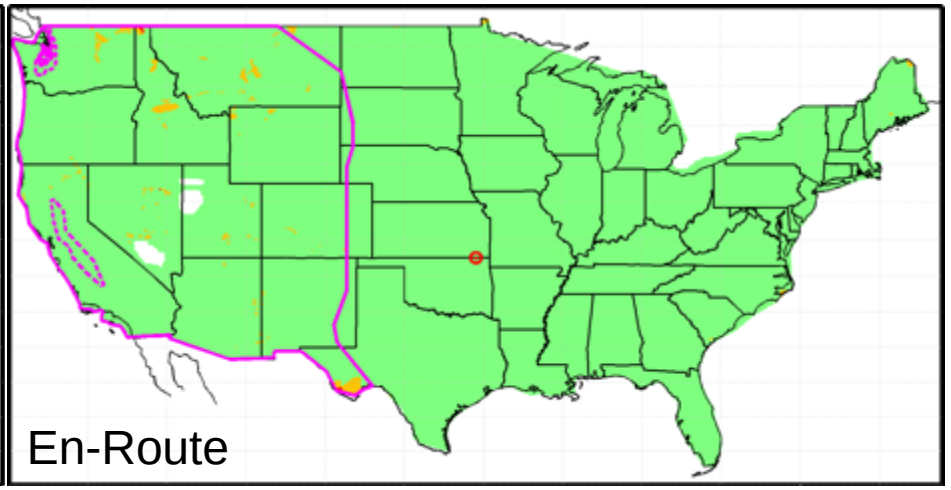
Terminal Coverage Enhancement

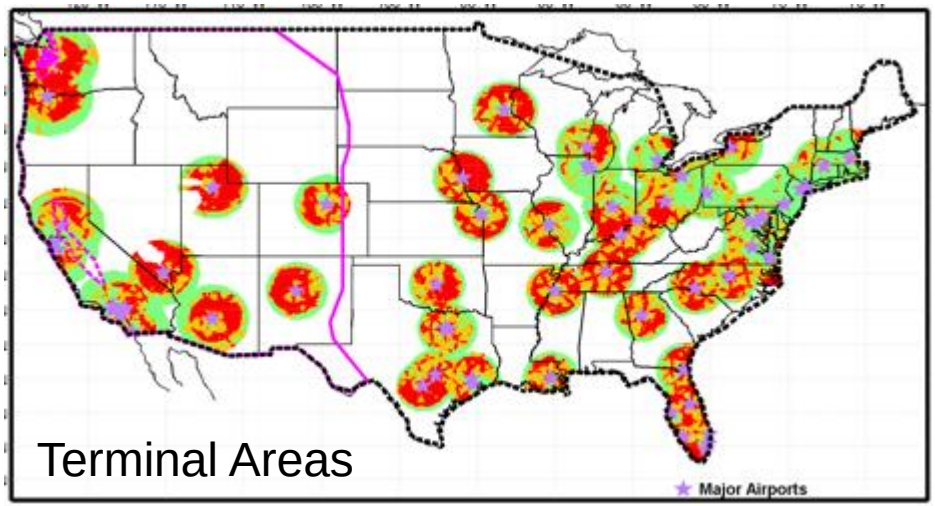


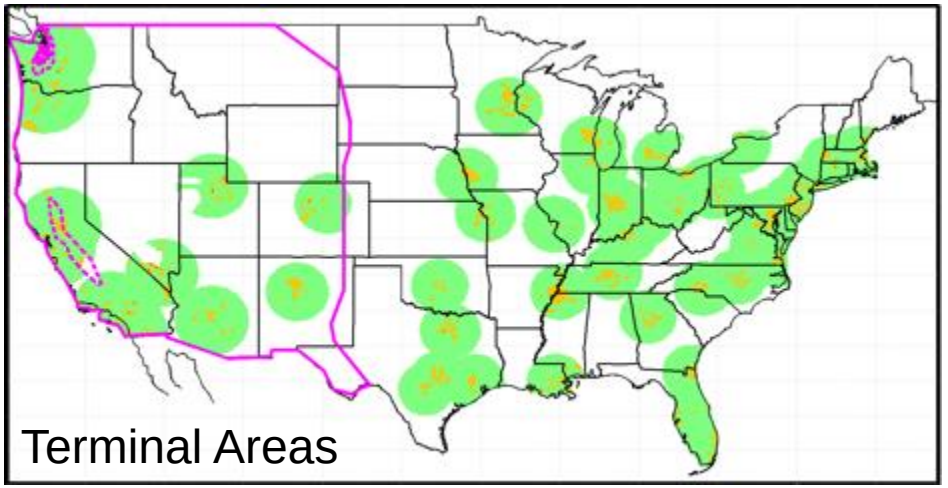


DME Coverage Before and After







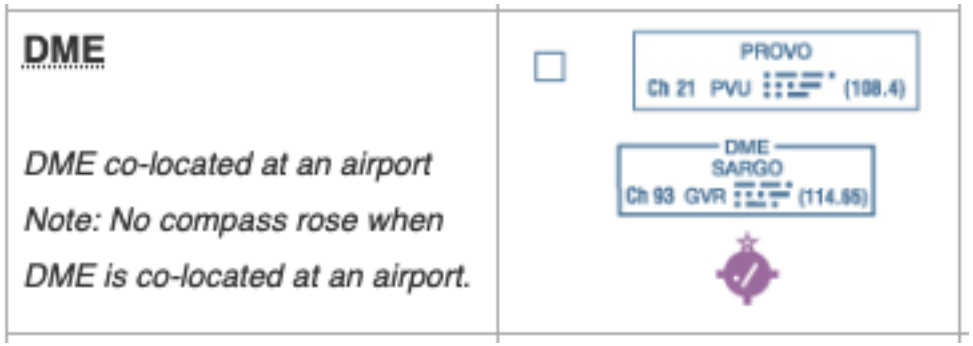


Charting Changes

- Q13 from central Oregon to Las Vegas had "GNSS REQUIRED" for the entire 591 NM.
  - This has been fixed by the NextGen DME Program (above FL 250).

- Frequencies will need to change for some existing DME and any VOR associated with those DME.

- DME "only" sites.



Deployment Schedule

- **Segment 1: En-route 2017-2027**
  - Commissioning of sixteen (16) new en-route site locations.
  - Changing the service volume for 461 of 590 sites.
- **Segment 2: Busiest terminal areas 2022-2029**
  - Terminal areas ranked by number of operations by aircraft equipped to perform DME/DME RNAV.
  - Provide terminal coverage for 15 Navigation Service Group (NSG) -1 and 11 NSG-2 airports.
- **Segment 3: Remaining busy terminal areas 2025-2035**
  - Provide terminal coverage for 36 NSG-2 airports.

VOR/DME/TACAN SSVs

- Remember the previous Standard Service Volumes (SSVs)?

RADIO CLASS DESIGNATIONS

VOR/DME/TACAN Standard Service Volume (SSV) Classifications

SSV Class	Altitudes	Distance (NM)
(T) Terminal	1000′ to 12,000′	25
(L) Low Altitude	1000′ to 18,000′	40
(H) High Altitude	1000′ to 14,500′	40
	14,500′ to 18,000′	100
	18,000′ to 45,000′	130
	45,000′ to 60,000′	100

VOR/DME/TACAN SSVs cont'd

- Current SSVs

RADIO CLASS DESIGNATIONS

VOR/DME/TACAN Standard Service Volume (SSV) Classifications

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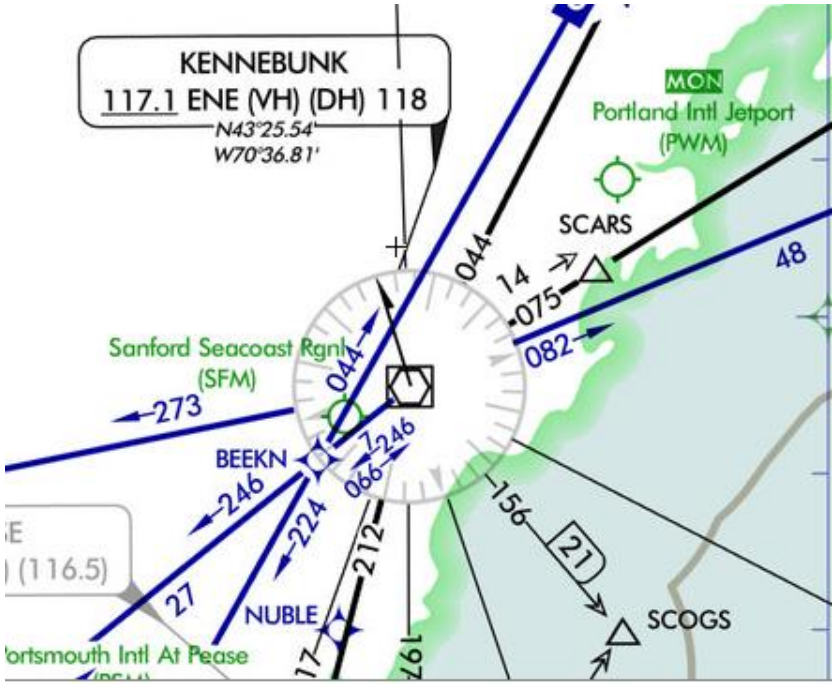
	14,500′ to 18,000′	100
	18,000′ to 45,000′	130
	45,000′ to 60,000′	100
(VL) VOR Low	1000′ to 5,000′	40
	5,000′ to 18,000′	70
(VH) VOR High	1000′ to 5,000′	40
	5,000′ to 14,500′	70
	14,500′ to 18,000′	100
	18,000′ to 45,000′	130
	45,000′ to 60,000′	100
(DL) DME Low & (DH) DME High*	1000′ to 12,900′	40 increasing to 130
(DL) DME Low	12,900′ to 18,000′	130
(DH) DME High	12,900′ to 45,000′	130
	45,000′ to 60,000′	100

*Between 1000′ to 12,900′, DME service volume follows a parabolic curve used by flight management computers.

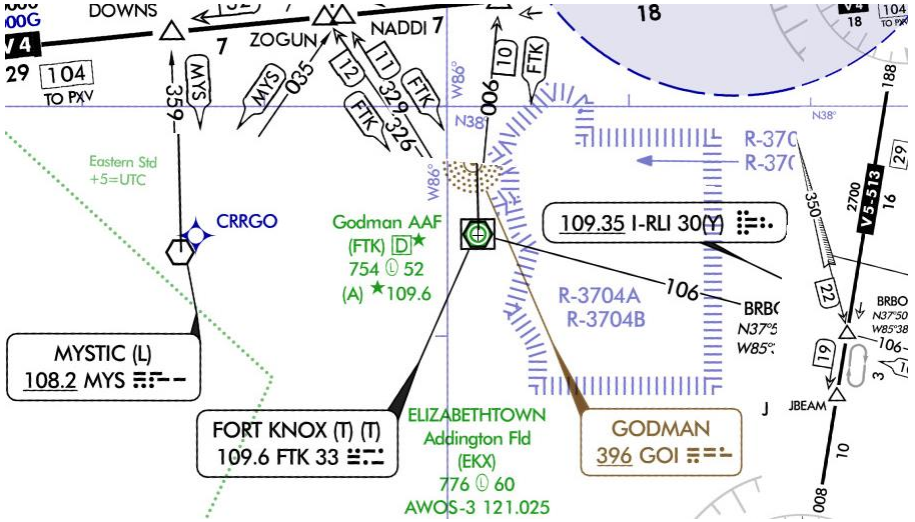
Charting VOR and DME/TACAN SSVs

- **The VOR and DME/TACAN SSVs were previously the same for each location.**
  - This may still occur at some locations, but generally a collocated VOR and the associated DME/TACAN will not have the same SSV.
  - This is generally due to the longer ranges now used for the DME/TACAN. These ranges are largely driven by DME/DME RNAV capabilities.

SSV Chart Depictions



High Enroute Chart



Low Enroute Chart

Summary

- The FAA is transitioning to PBN.
- Resilient navigation will be provided:
  - GPS and WAAS enable all PBN operations and ADS-B.
  - The NextGen DME Program provides an RNAV backup to mitigate GPS interference.
  - The VOR MON Program repurposes VORs to provide a backup for non-DME aircraft.
  - Legacy navigation aids will be sustained for the resilient infrastructure.

Questions