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FAA Navigation Services, AJM-321

LPVs - Not Just for North America!

In the U.S. and Canada, the number of new WAAS Localizer Performance with Vertical guidance (LPV) approach procedures continues to grow, but North America is not the only region of the world where LPVs are available. Europe is also developing and implementing LPVs made possible by the European Geostationary Navigation Overlay Service (EGNOS) Safety of Life (SoL) service.

According to a paper presented at the International Civil Aviation Organization (ICAO) Navigation Systems Panel May, 2012, there were 9 published LPVs in Europe at the end of February 2012. These included 5 in France, two in Switzerland, and two in the United Kingdom (UK). The number of European LPVs continues to increase at a rapid rate. According to a more recent document posted on the European Satellite Services Provider (ESSP) website (search for the full list of actual airports with EGNOS-based procedures), there are currently 16 European LPVs. By July 12th, the total number of LPVs for France alone is expected to reach 17. More LPVs are planned for Europe. The locations of these future LPVs include Austria, Switzerland, the Czech Republic, Germany, Spain, Finland, France, U.K., the Netherlands, Norway, Poland, Slovakia, and Sweden.

Just as in the U.S., LPV approach procedures in Europe are providing significant benefits. According to a May 2012 news article, "New EGNOS LPV procedures published in France," posted on the ESSP website, the main advantage of this kind of EGNOS-based procedure is to enable SBAS approaches similar to ILS category I approaches. "Airports will now benefit from an inexpensive backup," or an additional and safer alternative to existing nonprecision approaches "to their runway ends and hence increase airport availability in case of bad weather conditions".

In France, plans are to provide LPVs for most of their IFR runway ends (a total of about 200). According to Benoit Roturier, the Global Navigation Satellite Service (GNSS) Program Manager for DSNA (Direction des Services de la Navigation Aérienne), France sees the benefits as threefold: the improvement of safety by providing vertical guidance everywhere; the improvement of airport accessibility on runways not currently equipped with ILS, or in the case that an ILS is out of service; and the ability to cut back on the dense network of ILS Category (CAT I) systems by providing an equivalent capability. To achieve those benefits as soon as possible, France is working with major aircraft manufacturers, such as Airbus, ATR, Dassault-Aviation, and Eurocopter, to increase the number of EGNOS capable aircraft and rotorcraft.

More information about EGNOS and Europe's LPV plans can be found on the ESSP website at http://www.essp-sas.eu.

- Mary Ann Davis, FAA AJM-321/NAVTAC

The *SatNav News* is produced by the Navigation Services AJW-91 branch of the Federal Aviation Administration (FAA). This newsletter provides information on the Global Positioning System (GPS), the Wide Area Augmentation System (WAAS) and the Ground Based Augmentation System (GBAS).

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Tell Us Your WAAS Story

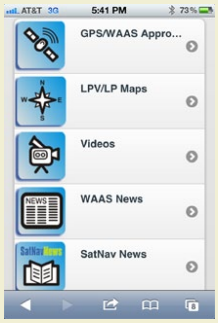
We're collecting testimonials about the benefits of Wide Area Augmentation System (WAAS) navigation from users. If you are a pilot, passenger, airport manager, airline employee, or are involved in aviation in any capacity - whether you fly fixed-wing or vertical flight aircraft - we want to hear from you! Please send your stories and contact information to Scott Speed at scott.ctr.speed@faa.gov

Horizon's Reasons to Equip with WAAS

As a result of experience gained from an FAA sponsored project, Horizon Air of Seattle, Washington has decided to equip its entire fleet of 48 Bombardier Q400 turboprops with Wide Area Augmentation System (WAAS) avionics. Steve Bush, Technical Pilot for Horizon Air, recently outlined the rationale behind this decision, describing the information provided to airline management to justify the financial investment in equipment and training required by transitioning the entire fleet to WAAS navigation.

Horizon Air plans to start the WAAS avionics retrofit their fleet in

Calling All GNSS Mobile Website Enthusiasts



The FAA GNSS Program Office is investigating the use of mobile websites as a new outreach tool.

We have developed the inaugural version of our mobile website using the most popular content from our full GNSS/WAAS website (http://gps.faa.gov).

We are most interested in feedback from our readers on ease of use and on the value of the information provided, but all feedback is welcome!

Below are steps to help you add the GNSS mobile website icon to your smart phone home screen. The site is optimized for use with Apple or Android phones.

We look forward to your feedback and hope that you enjoy trying out the new mobile website!

To add the GNSS Mobile Website icon to your iPhone home screen:

1. With your iPhone, open the following the link:
http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/mobileAll/
2. The mobile web site will appear on your screen. Push the middle button at the bottom of your iPhone and select "Add to Home Screen".
3. Confirm the selection and the GNSS icon will appear on your home screen.
4. Tap the GNSS icon and start using the mobile website.

To add the GNSS Mobile Website icon to your Android home screen:

1. With your Android, open the following the link:
http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/mobileAll/
2. Bookmark the page that opens.
3. Go to the home screen where you want to add the link.
4. Long-press in an empty space to bring up the "Add to Home Screen" menu.
5. Select "Shortcuts".
6. Select "Bookmark".
7. Choose your bookmark.

The new mobile website is designed to provide you with quick and easy access to information on the FAA's GNSS program. We look forward to your feedback. Please send feedback to MaryAnn.CTR.Davis@faa.gov.

-Mary Ann Davis, FAA AJM-321/NAVTAC

September 2012 and finish within one year. The conversion is relatively intrusive resulting in an estimate of approximately 120 man-hours per plane.

Justifications presented in support of the fleet-wide retrofit included the following:

1. The WAAS system is a primary means of navigation

Using WAAS as a primary means of navigation, Horizon Air may dispatch aircraft based on the use of RNAV (GPS) approaches at any destination or required alternate airport, including destination and driftdown alternates. Having this ability allows Horizon, in certain circumstances, to depart with less fuel required resulting in more payload capacity.

2. Eliminates the need for RAIM prediction

Receiver Autonomous Integrity Monitoring (RAIM) checks required by AC 90-100A and AC 90-101A for approaches down to RNP 0.3 are not required for aircraft equipped with WAAS. This relieves Horizon's dispatching department from having to perform the tasks necessary to check and monitor RAIM, reducing costs and freeing up valuable dispatcher time , allowing them to concentrate on other tasks.

3. Reduced visibility requirements enable fewer flight cancellations

Aircraft landing on runways without ILS typically use VOR or non-augmented RNAV (GPS) approaches which typically have higher ceiling and visibility requirements. Poor weather conditions can effectively close these runways. If equipped with WAAS, however, the aircraft benefit from the lower weather minimums available and can safely land on these runways using RNAV (GPS) approaches with LPV. This results in fewer flight cancellations and diversions. Also, the vertical guidance provided by an RNAV (GPS) approach to LPV lines of minima, allow for a vertically guided stable descents to runway ends where we used to employ the conventional step-down method to descend to minimums. The stable descent greatly enhances safety.

4. Prompt Return on Investment (ROI)

The estimate accepted by Horizon Air management as an ROI is less than 2 years, which compared favorably with the potential return of other investments.

5. Training cost reduction

Although costs are involved in training pilots to use LPV approaches, great savings will be realized by eliminating training in procedures rendered unnecessary by WAAS equipage. This includes eliminating training for NDB and, potentially, VOR approach procedures.

- Scott Speed, FAA AJM-321/NAVTAC

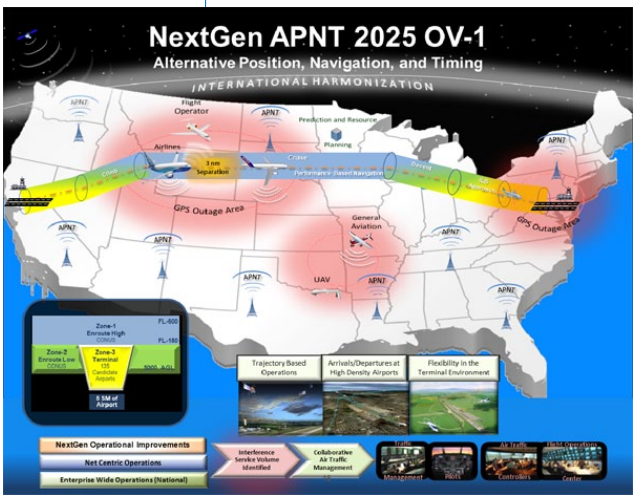
APNT Industry Day

The Federal Aviation Administration's (FAA) Navigation Services Global Navigation Satellite System (GNSS) Group held its first NextGen Alternate Position, Navigation, and Time (APNT) Industry Day in fiscal year 2012 with more than 100 people in attendance. That is an exceptional turnout and the GNSS group would like to thank all attendees for taking time out of their busy schedules. The overall response to this event was worthwhile and valuable.

The event was hosted by the FAA's APNT Project Manager, Pamela Ahn,. Speakers included NextGen's Performance Based Navigation (PBN) Portfolio Manager, Leo Eldredge, and GNSS Acting Manager, Deborah Lawrence. This Industry Day session reviewed the research progress on the FAA APNT initiative. The APNT research aims to support continued PBN operations in the National Airspace (NAS) during Global Positioning System (GPS) outages. Industry day's opening speaker, Chris Metts, Vice President of the FAA's Program Management Organization (PMO), stressed the importance of coordination and collaboration between the PMO and its NextGen planning and program initiatives, such as APNT.

The APNT team shared perspectives on future requirements and continues to solicit inputs from industry on perceived requirements and potential APNT solutions. The APNT solution will support all users operating in instrument flying conditions (IMC) throughout the NAS. The APNT system architecture will take into consideration ways to leverage existing or planned FAA technologies or systems. The effort is considering conventional APNT options to meet transition strategy functional requirements and the agency's Destination 2025 goals. In addition, industry has been invited to provide feedback on the Concept of Operations (CONOPS) document, as well as participate in an open session of questions and answers with the APNT subject matter expert team members.

In prior APNT Industry Day sessions, feedback indicated the desire of a



NextGen APNT Operational View

Canadian airports with one or more runways with LPV approaches (as of February 24, 2012)

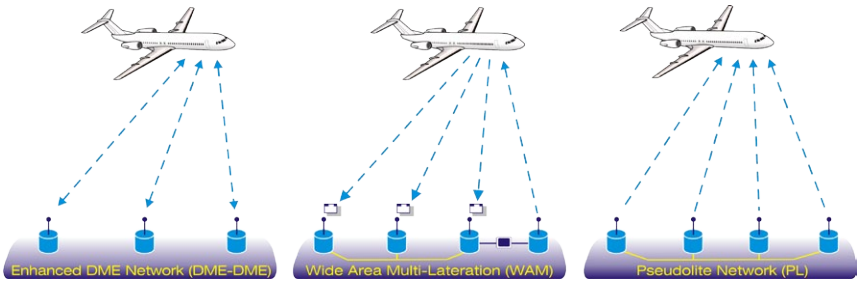


Figure 1: Candidate Technology

low cost solution and consideration to minimize aircraft out of service time. If new equipage is required, the FAA will leverage former equipage requirements and timelines to minimize aircraft out of service time loss. The FAA response to previous Industry Day feedback endorses that alternative solutions are being evaluated to balance the best user benefit versus cost while identifying technology or capacity limitations to meet APNT requirements.

Performance Based Navigation and future NextGen Operational Improvements will be dependent on GPS for its ability to provide advanced capabilities for precision navigation. GPS is the principle enabler of PBN and Automatic Dependent Surveillance Broadcast (ADS-B). Future PBN capabilities and benefits increase the dependence on GPS and alternative PNT services over time. Today's existing conventional navigation infrastructure does not meet the planned future performance needs.

The APNT's mission is to:

- Maintain safety and security while minimizing economic impacts during a GPS outage
- Enable a smooth transition to backup navigation that supports continued operations where economically beneficial
- Minimize impacts on NextGen operational benefits during a GPS RFI event
  - Fuel Consumption
  - Emissions
  - Travel Time

The APNT mission must maintain safety and security while minimizing economic impacts during a temporary GPS outage. In the case of an RFI outage, waiting for the interference source to be turned off is unacceptable. APNT must enable a smooth transition to backup navigation to seamlessly continued flight operations and allow stakeholders to remain within a safe workload condition.

The FAA reviewed three candidate technologies being considered for the APNT alternative solution (See Figure 1): Distance Measuring Equipment. Wide Area Multi-lateration, and Pseudolite. Each system characteristics, benefits, and avionic impacts were reviewed. The final solution architecture may be a combination of technologies or a hybrid solution.

Coordination with Industry continued at the Joint Navigation Conference in Colorado Springs, Colorado, June 2012 and future planned industry coordination will be at the Institute of Navigation Conference in Nashville, Tennessee, September 2012. NextGen APNT white papers are being developed and will be published for upcoming conferences. The FAA invites industry to continue to provide feedback as the NextGen APNT research initiative matures.

- Darin Chapman, FAA AJM-321/NAVTAC

Contract Awarded for New WAAS Safety Computers

On Thursday, June 7, 2012, the Federal Aviation Administration (FAA) awarded the WAAS Safety Computer replacement contract to Verocel, Inc. The WAAS Safety Computer is a critical component of WAAS. It executes safety-certified application software that conducts real-time monitors and message verification to ensure safe WAAS operation. This application software is integral to the WAAS safety architecture.

The current Safety Computer must be replaced because it can no longer be repaired due to piece-part obsolescence, although there are sufficient spares for ongoing operations. In addition, the current Safety Computer lacks the processing capability for future Dual Frequency Service introduction into the WAAS. The increased processing power of the new Safety Computer can meet the requirements for processing data related to Dual Frequency Service.

A Market Survey was conducted with Verocel as the single respondent. Verocel is a small business headquartered in Westford, Massachusetts with offices in Germany, Poland, and the UK. The company was founded in 1999. The total contract value is $6.225 million.

The Safety Computer project including the design, testing, and initial fabrication of Safety Computers will take place over two years. Completion is planned for the summer of 2014. Verocel will design, construct, and verify the new Safety Computer and assist the FAA in verification of the Safety Computer within the WAAS environment. The contract will conclude with the procurement of 28 Safety Computers ready for integration into the WAAS system. An additional 40 computers may be purchased after the initial contract concludes.

- Ed Sigler, FAA AJM-321/NAVTAC

VOR Minimum Operational Network (MON) Information Paper

The following is an abridged version of the information paper on the Very High Frequency Omnidirectional Range (VOR) Minimum Operational Network (MON) presented by the United States in May 2012 at a meeting of the Navigation Systems Panel of the International Civil Aviation Organization (ICAO) in Montreal, Canada.

Executive Summary

The United States (US) has announced plans to reduce the Very High Frequency Omnidirectional Range (VOR) based navigation network to provide an alternate means of navigation in case of Global Navigation Satellite System (GNSS) outage. This VOR Minimum Operational Network (MON) should be in place by the year 2020.

The MON will provide terrestrial based navigation at 5,000 ft AGL for VOR equipped aircraft to navigate VOR to VOR and/or to an airport served with an Instrument Landing System (ILS) or VOR approach procedure.

1. Introduction

The use of the Global Positioning System (GPS) for aircraft navigation has increasingly obviated the need for ground based navigation aids for most domestic flights under Instrument Flight Rules (IFR). The result is that many aviation users no longer use Very High Frequency Omnidirectional Ranges (VORs) for normal navigation over Victor and Jet airways and navigate safely using augmented GPS. As discussed in the FAA's recent Federal Register Notice (FRN) (Reference 1), the United States Federal Aviation Administration (FAA) is planning on a gradual discontinuance of VORs to a Minimum Operational Network (MON) of VORs by the year 2020.

2.0 Discussion

2.1 Future Terrestrial Navigation Infrastructure

The Global Navigation Satellite System (GNSS) has the capability of supporting all phases of flight. With suitable augmentations, GNSS can support all phases of flight with extremely high availability, continuity and integrity. Furthermore, the existing VOR infrastructure provides an overabundance of VORs in the US National Airspace System (NAS). Recapitalization of the complete VOR infrastructure in the United States (US) would cost in excess of one billion dollars.

To restructure terrestrial based navigation services, the FAA has undertaken the MON project. This project will provide an alternate means of navigation in the event of a GNSS outage. The major elements of the project are:

- The reduction in the number of VORs in the NAS.
- Provisioning of a minimum network of VORs that will support VOR to VOR navigation and proceeding to airports with Instrument Landing System (ILS) or VOR approach procedures.
- Navigation coverage above 5,000 ft Above Ground Level (AGL) in the continental US (CONUS).
- Support international arrivals and departures.

2.2 VOR Service Discontinuance

In considering VORs for discontinuance, the goal is to retain an efficient terrestrial based navigation network to meet future aviation needs. The FAA will convene a working group that will develop a candidate list of VORs for discontinuance using relevant operational, safety, cost, and economic criteria. As part of the process, this working group will engage aviation industry stakeholders and other members of the public for input.

2.3 Purpose of the MON

The purpose of the MON is to maintain an alternate means of navigation capability to provide VOR to VOR navigation service for VOR-equipped aircraft in case of a GNSS outage. The MON will permit non-GNSS guidance to an airport within 100 nautical miles (nm) that has an ILS or VOR approach procedure. With the MON, all VORs will be retained in Alaska, the Western U.S. Mountainous Area (WUSMA), and U.S. Islands and territories. The WUSMA area and the MON coverage at 5,000 ft AGL are depicted in Figure 1.

A key feature of the MON is that, in case of a GNSS outage, aircraft navigating in the CONUS, outside of the WUSMA, will be able to navigate at or above 5,000 ft AGL and to an airport within 100 nm and land at that airport using non-GNSS-based landing aids, i.e., an ILS, Localizer, or VOR-based approach. Radar vectors, Distance Measuring Equipment (DME) or Automatic Direction Finding (ADF) equipment will not be required for transition to an approach and safe landing at these locations. Aircraft operating in the WUSMA, Alaska, or U.S. islands or territories will have access to the same VOR infrastructure that is currently provided.

2.4 MON Navigation Coverage

The MON will provide navigation and approach and landing for VOR-equipped aircraft flying under IFR in the case of a GNSS outage, however, VOR-based navigation using only the MON will be less efficient and more time consuming when compared with performance based navigation (PBN). Notional coverage of the MON at 5,000 ft AGL is depicted in Figure 1. The WUSMA is outlined in green.

2.5 Retention of VORs to Support the MON

Table 1 is a summary of the number of VORs retained in a notional MON. The tabled information is notional. The actual number of retained VORs

Reason for Retention in the MON	VORs Retained
Western US Mountainous Area	232
Alaska	40
Hawaii	11
Puerto Rico and U.S. Virgin Islands	6
Guam, Samoa, and Grand Turk (1 each)	3
International Routes (Atlantic and Pacific)	20
Support for ILS approaches	192
Support for VOR approaches	57
5,000 ft AGL coverage fillers	34
Core 30 airports fillers	17
Total VORs to be Retained	**497**

Table 1. VORs to be Retained in the Notional MON

in the end state MON may differ from the tabled values. The target number to be retained is 497.

Reasons for retention include:

- MON Coverage.
- Navigation coverage in mountainous areas.
- Areas outside of the Continental United States (CONUS), such as, Alaska, and island possessions.
- Support ILS and/or VOR approach procedures.
- Support for International arrival and departure routes.

2.6 Retained and Divested VORs

Figure 2 is a notional graphic depiction of CONUS VORs to be retained for the MON and those that may be divested. Green dots represent VORs to be retained in support of the MON. The red dots represent the VORs that may be divested. The WUSMA is outlined in magenta. The only VOR service to be discontinued in the western US are VORs located in the Central Valley of California and the Puget Sound Area. The large number of VORs to be divested in the northeast is an artifact of the redundancy of the Victor and Jet airway structure in this portion of the US. It is noted that terrain elevation also plays a role in determination of VORs to be retained in support of MON coverage. The goal of MON coverage is navigation coverage at 5,000 ft AGL.

2.7 MON Approach Procedure Coverage

Figure 3 is a depiction of airports where landing capability will be retained for VOR-equipped aircraft. These locations have ILS or VOR approach procedures that do not require radar vectors, DME, or ADF. Each airport is surrounded by a 100 nm green circle if the airport has an ILS- or localizer-based approach and a 100 nm red circle if the airport has a VOR-based approach. Other airports will, of course, be available for landing. However, approaches to other airports may require DME, ADF, or radar vectors.

3.0 Existing and Resulting Airway Structures

A comparison demonstrating the strategic planning for a future terrestrial based navigation infrastructure is made in figures 4 and 5. Figure 4 depicts the existing VOR Airway Structure in the CONUS. Victor Airways are depicted in green and Jet Routes in red.

Figure 5 depicts the Victor Airways and Jet Routes in the CONUS with the MON, keeping in mind the primary purpose of the MON is to provide VOR to VOR navigation as alternate means of navigation in case of GNSS outage.

3.1 Consistency with ICAO Planning

The MON project is consistent with the ICAO strategy of accelerating transition to PBN with an RNAV and RNP centric airspace system. The MON is anticipated to be an interim step towards further reductions of VORs as alternatives for alternate PNT services evolve over the long term.

Figures 1-5: VOR Minimum Operational Network (MON) Information Paper

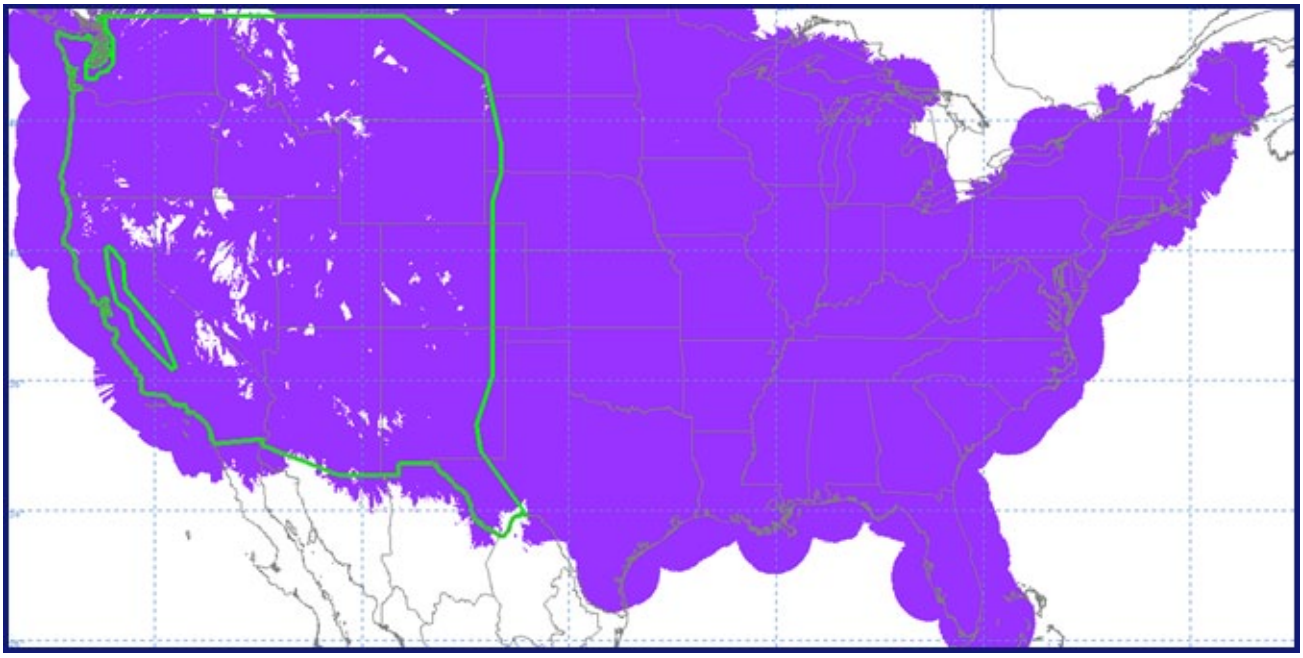


Figure 1. Coverage at 5000 ft AGL Using Notional MON VORs. WUSMA Shown

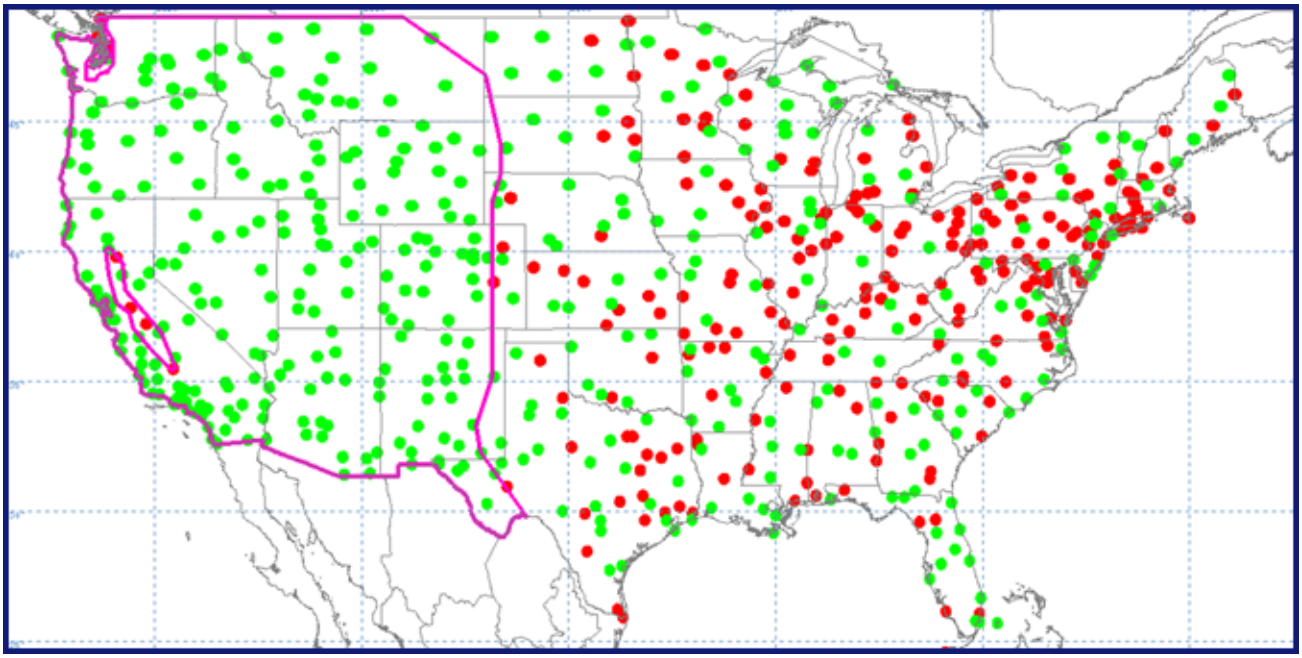


Figure 2. Federally Owned and Operated VORs to be Retained or Divested

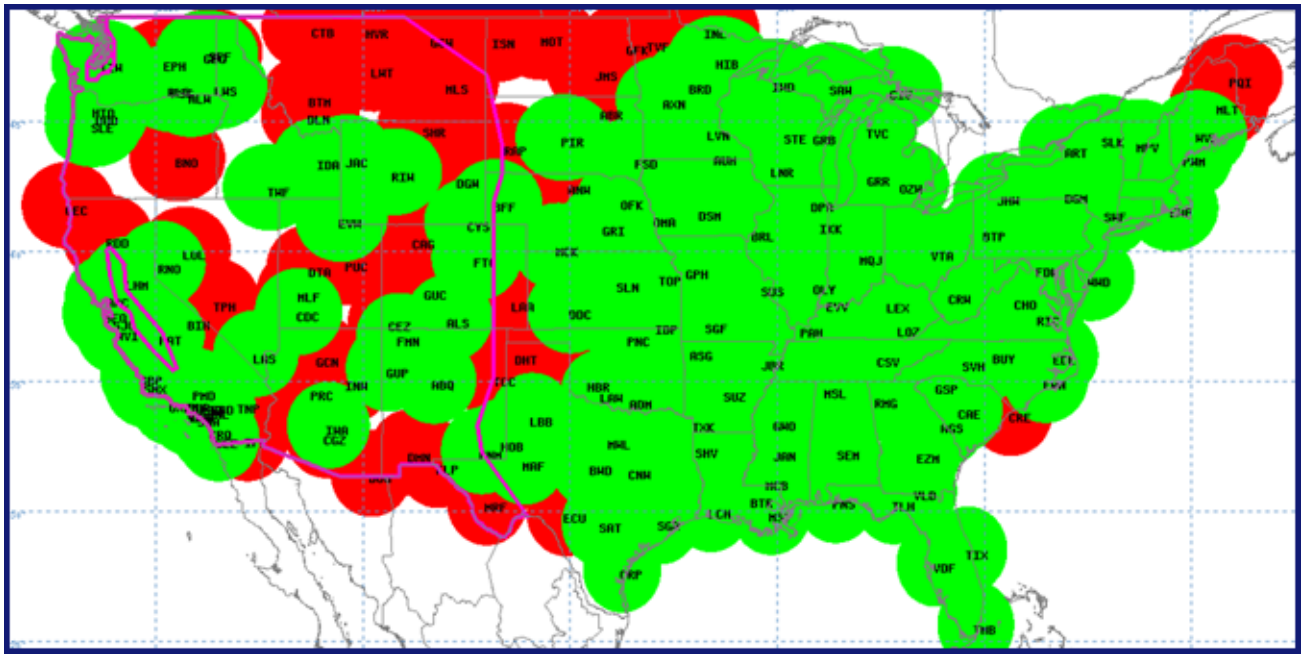


Figure 3. MON Airports with ILS or Localizer Approaches (100 nm Green Circles) or VOR Approaches (100 nm Red Circles).

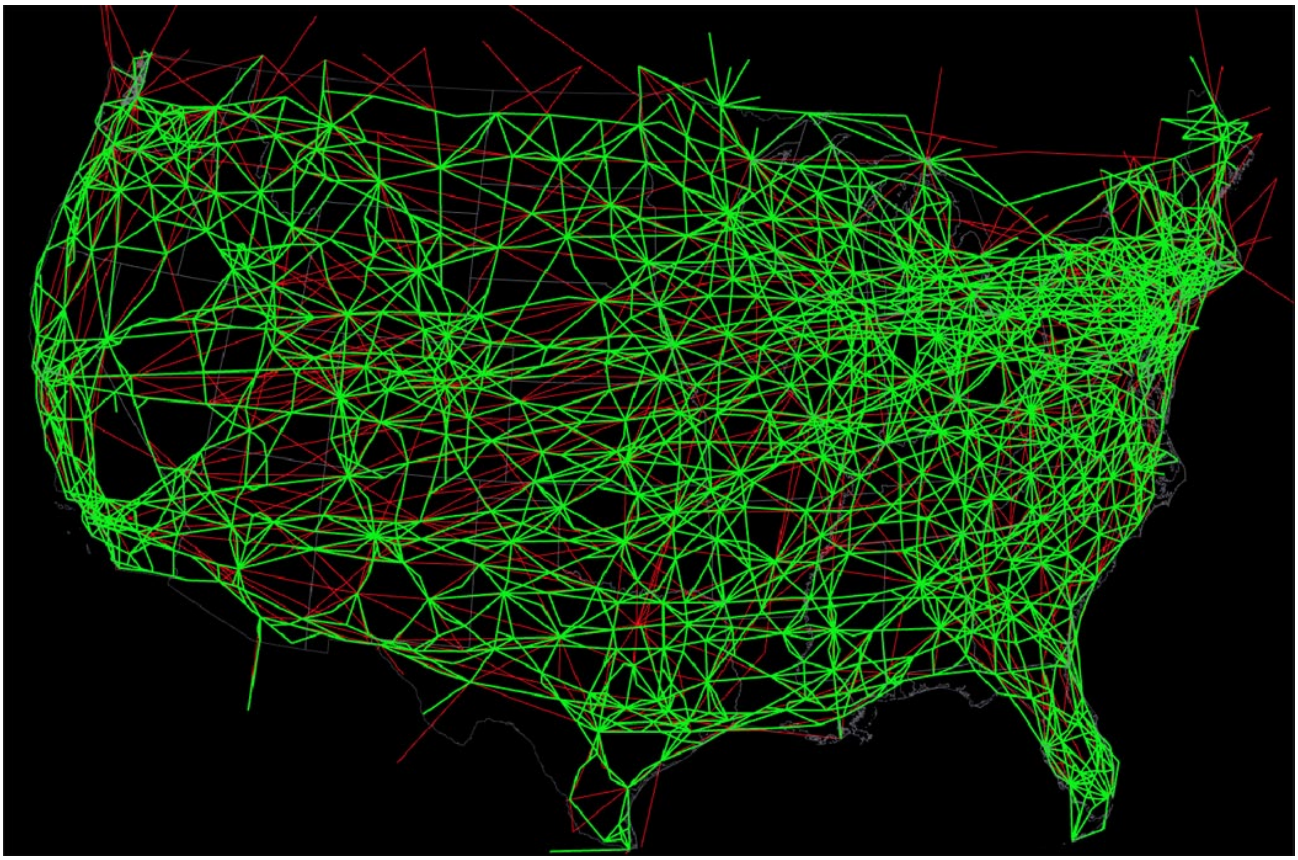


Figure 4. Existing VOR Airway Structure in the CONUS

Figure 5. MON Network VOR Structure in the CONUS

Satellite Navigation Approach Procedures Update

June 2012 – The number of Wide Area Augmentation System (WAAS)-enabled approach procedures continues to increase.

The tables shown here reflect the latest numbers. More information about WAAS approach procedures can be found on our GNSS - GPS/WAAS Approaches web page (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/approaches/index.cfm).

- Mary Ann Davis, FAA AJM-321/NAVTAC

What's New on the Web!

Just type http://gps.faa.gov into any web browser to access the best and most accurate information available from the FAA's Navigation Services Global Navigation Satellite System (GNSS) website.

Click on recently posted articles on the "In the News" sliding banner to stay informed of developments in satellite navigation.

Satellite-based Approach Procedures (by Procedure Type)

	Procedures (Part 139 Airports)	Procedures (Non-Part 139 Airports)	Total Number of Procedures
LNAV Procedures	1760	3699	5459
LNAV/VNAV Procedures	1269	1497	2766
LPV Procedures *(LPV w/200' HAT)*	1263	1616	2879 *(653)*
LP Procedures	46	276	322
GPS Stand-Alone Procedures	20	207	227

Note: Number of GPS Stand-Alone will continue to decrease as they are replaced by RNAV procedures
(Data as of June 2012)

Instrumentation Approach Procedures (IAPs) Based on Traditional Navaids

ILS	1,280
ILS (CAT II)	160
ILS (CAT III)	113
NDB	845
VOR	1,310
VOR / DME	968

(Data as of May 31, 2012)

Table truncated for publication. Full table available at Instrument Flight Procedures (IFP) Inventory Summary