

## A Minimum Operational Network (MON) of VORs

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 (VHF) Omni Ranges (VORs) for normal navigation and navigate safely using augmented GPS. As discussed in the FAA's recent Federal Register Notice (FRN)<sup>1</sup>, the FAA is planning on removing many of the 954 federally-owned and operated VORs<sup>2</sup> and establishing a Minimum Operational Network (MON) of VORs not later than 2020. In considering VORs for discontinuance, each facility will be evaluated on its own merits. 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.

The purpose of the MON is to maintain a backup navigation capability to provide service for VOR-equipped aircraft<sup>3</sup> in case of a GPS outage. In the MON, all VORs will be retained in Alaska, the Western U.S. Mountainous Area (WUSMA), and U.S. Islands and territories.

A key feature of the MON is that, in case of a GPS outage, CONUS aircraft outside of the WUSMA will be able to navigate using VOR at or above 5000 ft Above Ground Level (AGL) to an airport within 100 NM and land at that airport using non-GPS-based landing aids (i.e., an Instrument Landing System (ILS-), localizer-, or VOR-based approach). Radar vectors, DME or Automatic Direction Finding (ADF) equipment will not be required for transit or a safe landing. Aircraft operating in the WUSMA, Alaska, or U.S. islands or territories will have the same VOR infrastructure that is currently provided.

The MON will provide a safe landing for VOR-equipped aircraft flying under IFR in the case of a GPS outage. However, in general, the MON will not provide an efficient or useable navigation network for VOR-only aircraft (i.e., aircraft not equipped with GPS or Wide Area Augmentation System (WAAS) avionics). VOR-based navigation using only the MON would likely be circuitous, and not all airports will have instrument approaches that will be useable by VOR-only aircraft. The MON could be used by aircraft flying under Visual Flight Rules (VFR), but the primary purpose of the MON is to support safe landing of IFR aircraft during a GPS outage.

Table 1 is a summary of the number of VORs retained in a notional MON, and Figure 1 is a graphic depiction of CONUS VORs retained and divested in that MON. Figure 2 is a depiction of airports where landing capability will be retained for VOR-equipped aircraft, and this landing capability will 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. Figure 3 depicts MON coverage at 5000 ft AGL

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<sup>1</sup> FAA, 15 December 2011, "Proposed Provision of Navigation Services for the Next Generation Air Transportation System (NextGen) Transition to Performance-Based Navigation (PBN)," Federal Register, Volume 76, Number 241, Washington, D.C. U.S.A.

<sup>2</sup> This paper is concerned with the VOR function of VOR, VORTAC, and VOR/DME facilities. For simplicity, all of these facilities will be referred to as "VORs."

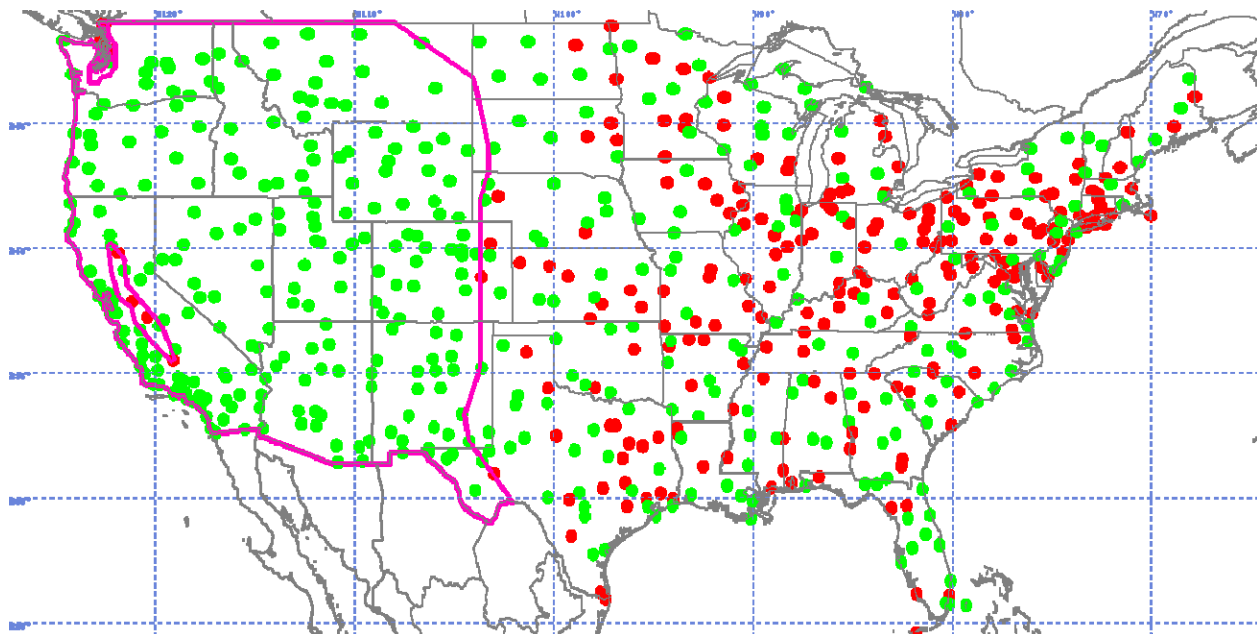
<sup>3</sup> The term "VOR-equipped" aircraft will be used to refer to non-DME/DME aircraft equipped with a VOR. A backup concept for DME/DME has been developed but is beyond the scope of this paper.

There are a number of significant transition issues that are beyond the scope of this paper, such as instrument procedure and chart revisions, VOR airways, broadcast services, etc. These issues are being carefully addressed as part of this effort. Comments on the MON are welcome, as described in the FAA FRN.

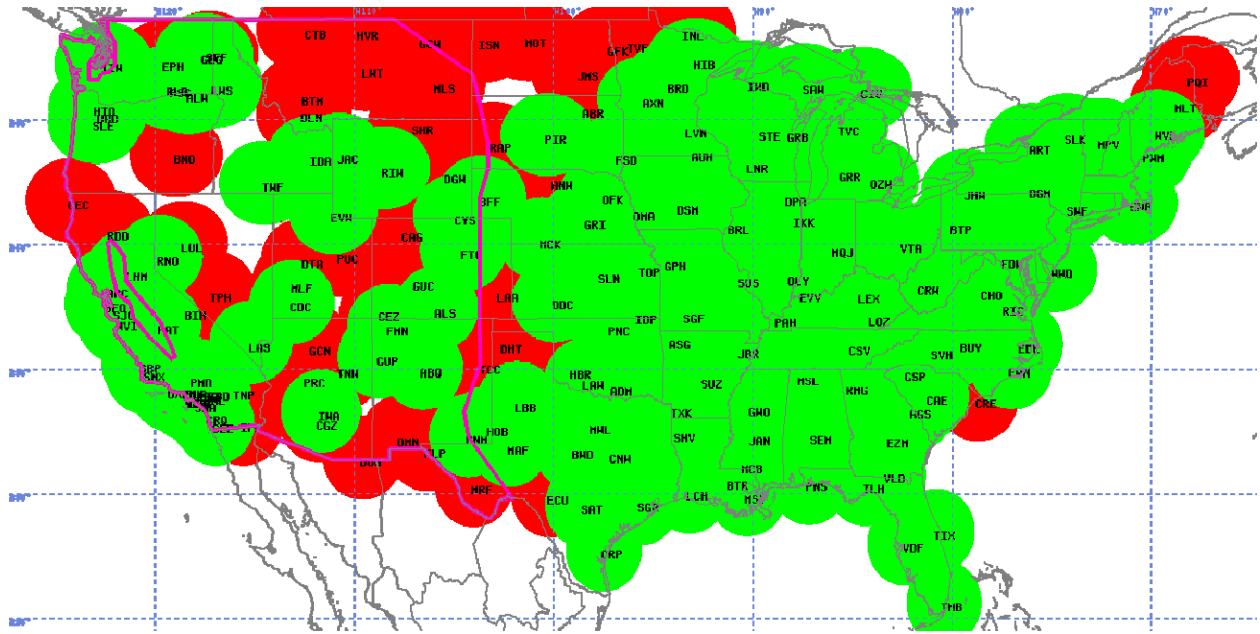
**Table 1. VORs to be Retained in the Notional MON**

<b>Reason for Retention in the MON</b>	<b>VORs Retained</b>
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	134
Support for VOR approaches	57
5,000 ft AGL coverage fillers	20
Core 30 airports fillers	17
<b>Total VOR to be Retained</b>	<b>483</b>

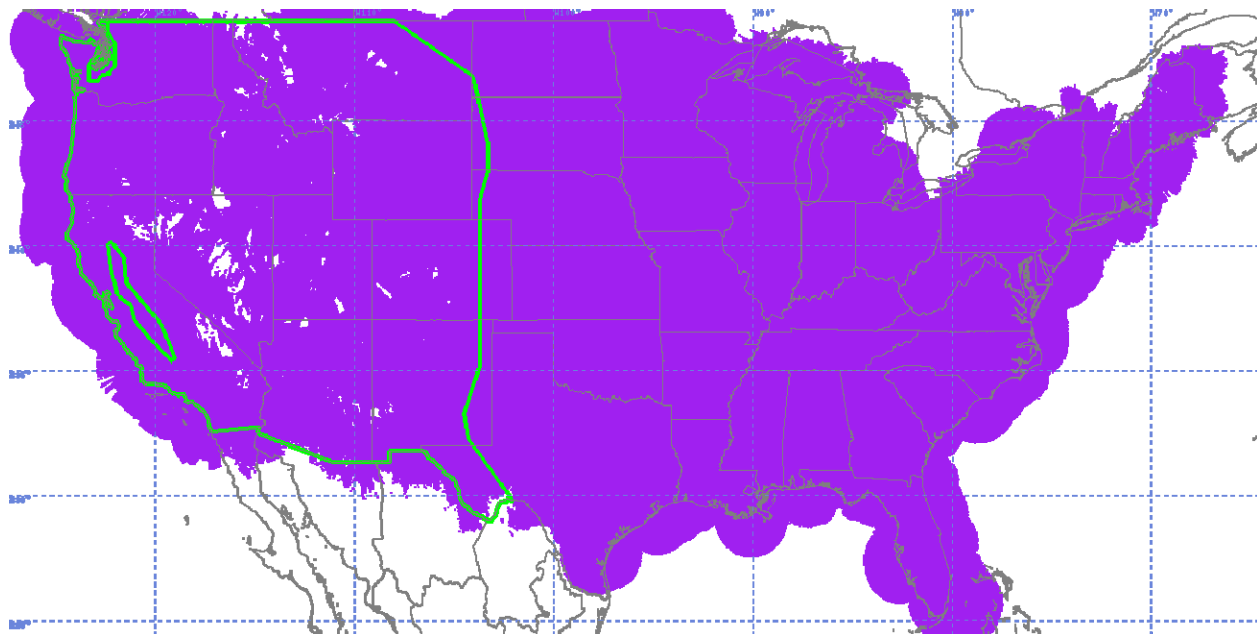
Note: Some VORs are double counted. Therefore the column total is not 483.



**Figure 1. Federally Owned and Operated VORs  
(Green VORs to be Maintained and Red VORs to be Divested in the Notional MON)  
WUSMA Shown in Magenta Outline**



**. Figure 2. Airports with ILS or Localizer Approaches (100 NM Green Circles) or VOR Approaches (100 NM Red Circles) that do not Require Radar, DME, or ADF  
WUSMA Shown in Magenta Outline**



**Figure 3. Coverage at 5000 ft AGL Using Notional MON VORs  
WUSMA Shown in Green Outline**