



**Approved by the Tactical Operations  
Committee February 2014**

**VOR MON Criteria Prioritization**

---

*Report of the Tactical Operations Committee in Response to Tasking from  
The Federal Aviation Administration*

*January 2014*

# VOR MON Prioritization

## Contents

|   |    |
|---|----|
| Background/Introduction .....                       | 3  |
| Executive Summary.....                              | 3  |
| Methodology.....                                    | 4  |
| Criteria Definitions .....                          | 5  |
| Criteria Evaluation Results .....                   | 7  |
| Recommendations .....                               | 8  |
| Appendix A: Members of the VOR MON Task Group ..... | 10 |
| Appendix B: FAA Tasking Letter .....                | 11 |

## Background/Introduction

In order to transition from the use of a very high frequency (VHF) Omni-directional Range (VOR) based route structure to that of a Performance-Based Navigation (PBN), the VOR Minimum Operational Network (VOR MON) Implementation Program was established by the FAA. It is one of a myriad of activities required to shift resources and operations from the legacy National Airspace System (NAS) to NextGen. The VOR MON Task Group (TG) was tasked by the RTCA Tactical Operations Committee (TOC) in July 2013 to provide recommendations to the FAA on the MON Implementation Program<sup>1</sup> so as to meet the target date of January 1, 2020.

Prior to the Task Group forming, the FAA developed initial draft VOR MON criteria and published them in the Federal Register for comment in December 2011 and addressed in a subsequent notice in August of 2012<sup>2</sup>. Efforts separate from the VOR MON are ongoing to identify Alternative Position, Navigation, and Timing (APNT) solutions that will provide a full-scale backup system to GPS. In addition, TACAN and DME are not considered by the VOR MON program.

In Fall of 2013, the Task Group completed Task #1 which was “to review and validate the VOR MON selection criteria and assumptions and make additional recommendations as needed.” The VOR MON Task Group limited its review of criteria for the decommissioning of domestic, FAA-owned VORs. The Task Group also limited its efforts to establishing and validating criteria only for operators flying IFR.

This report responds to Task #2 which is focused on review and validation of the draft candidate VOR MON list. Completion of Task #2 was requested by April 2014 but the Task Group has completed the task early and is submitting its report in February 2014.

## Executive Summary

This document provides the Task Group’s response to Task #2 of the FAA tasking letter and is focused on review and validation of the draft candidate VOR MON list. It enumerates the methodology the Task Group undertook to evaluate and comment on the FAA’s proposed criteria for retaining VORs under the VOR MON concept.

The VOR MON TG had a choice to either provide feedback on the MON or provide feedback on the criteria used to evaluate the MON. The TG determined that FAA would be the definitive source for selecting individual VORs for inclusion in the MON after considering the TG’s input on criteria. The TG itself would not be involved in a VOR by VOR evaluation for the MON. The Task Group also limited its efforts to establishing and validating criteria only for operators flying IFR.

The VOR MON TG identified two categories of criteria for evaluation of the VOR MON. The first set of criteria is from the FAA’s existing work on the MON. The second group of criteria were those identified during Task #1 of the VOR MON TG. In addition, the TG consolidated two criteria referencing GPS interference (jamming and “other”) into one criterion. The TG then undertook a prioritization effort of the remaining eight criteria. The TG decided not to prioritize “Retain Oceanic VORs” and “Retain VORs in Western Mountainous regions” since retention of these were considered a given by the TG.

---

<sup>1</sup> Letter from Elizabeth L. Ray (Vice President, Mission Support Services) to Margaret Jenny (RTCA President) dated July 10, 2013.

<sup>2</sup> Federal Register notice, August 21, 2012

The TG recommends that the FAA apply this updated, weighted criteria against the current MON. The TG detailed a process by which the FAA could accomplish this through evaluation of VORs outside of the current MON. The FAA could then identify VORs that rate highly on the prioritized criteria for consideration to be swapped with VORs in the MON or selectively added into the MON.

Finally, the Task Group believes that the weighted criteria provide the basis for an exception process for the FAA to use. The Task Group targeted its criteria evaluation on a national level, recognizing that local circumstances may drive a different weighting of criteria for select VORs. The Task Group recommends the FAA utilize a rigorous and transparent process with NAS users and local communities to evaluate exceptions. Then, as the FAA receives feedback from NAS users and local communities on individual VORs slated for decommissioning, the weighted criteria will provide a basis for orderly exception processing. Any VOR that is re-evaluated for decommissioning can be measured against the weighted criteria and compared on these measures to other VORs in its peer group.

## Methodology

The FAA's Task #2 for the VOR MON Task Group was to review and validate the draft candidate VOR MON list. Specifically, the Task Group was requested to do the following:

1. Review and validate the candidate VOR MON list based on the criteria and, if the TOC recommends amending the criteria, update the candidate list based on the amendments as appropriate. If specific options were considered but not adopted via consensus, please provide the range of options and/or alternatives considered.
2. Advise FAA from a stakeholder perspective on why, how, and whether exceptions should be made to valid criteria. Again, please provide specific details to include the range of options and/or alternatives discussed.

The Task Group made a distinction in its work between providing feedback on the MON and providing feedback on criteria used to evaluate the MON. The Task Group is providing input on the criteria that should be used to create and evaluate the MON and not on the MON itself. The Task Group membership did not have the correct technical resources to evaluate VOR by VOR against all of the criteria. Rather the Task Group felt it should focus on two things: 1) refine a high-level set of criteria with which the FAA can produce an initial MON, and 2) recommend a process with which the FAA can work with appropriate constituents to approve minor exceptions to the MON (additions or subtractions) based on local priorities.

To provide recommendations on these two areas, the Task Group prioritized the combined set of original FAA and Task Group recommended criteria. Prioritization of criteria addressed both of the focal areas mentioned above. A prioritized set of criteria may be used to evaluate members of an initial MON. Additionally, prioritized criteria may be used with various stakeholder and community groups to evaluate exceptions. The Task Group utilized an analytical process, known as the Analytical Hierarchy Process, to develop relative weightings of the full set of criteria.

## Criteria Definitions

The VOR MON Task Group identified two categories of criteria for evaluation of the VOR MON. The first set of criteria are those original criteria from the FAA’s work on the MON. This set of criteria is as follows (full definition below):

- Retain VORs in Western Mountainous region
- Retain Oceanic VORs
- Retain VORs to enable navigation to a “safe landing” airport within 100 NM (nautical miles)
- Provide full en-route coverage at or above 5,000 ft AGL
- Ensure ability to hold for Core 30 airports

The second category of criteria were those identified during Task #1 of the VOR MON Task Group. This set of criteria includes:

- Retain VORs that are in a known GPS “jamming” location
- Retain VORs in proximity to areas of GPS interference
- Retain VORs to enable adequate navigation for non-RNAV capable aircraft
- Retain VORs necessary for training

Given redundancy between the first two criteria above, the Task Group combined the criteria “Retain VORs in proximity to areas of GPS interference” into the criteria “Retain VORs that are in a known GPS “jamming” location”.

The Task Group then defined each of the remaining eight criteria before prioritization. The following table includes the final definitions used by the Task Group:

| Criteria   | Definition   |
|--|--|
| Retain VORs in Western Mountainous regions   | Retain VORs that define Victor air routes in which the route crosses terrain that has a minimum elevation figure of 12,000 feet or above.  |
| Retain Oceanic VORs  | Retain VORs that support international arrival airways from the Atlantic, Pacific and the Caribbean.   |
| Retain VORs to enable navigation to a “safe landing” airport within 100 NM           | The capability to navigate by VOR to an airport within 100 NM of any point in the CONUS where that capability exists today.  |
| Provide full en-route coverage at or above 5,000 ft AGL                              | Support VOR-to-VOR navigation capability. To support full en-route coverage, service volume needs to extend to a 77 NM radius at 5,000 ft AGL. VOR service volume may be modified below 5,000 ft.  |
| Ensure ability to hold for Core 30 airports  | Ensure ability for ATC to hold aircraft for the Core 30 airports when GPS is unavailable.<br><br>(Core 30 airports are ATL, BOS, BWI, CLT, DCA, DEN, DFW, DTW, EWR, FLL, HNL, IAD, IAH, JFK, LAS, LAX, LGA, MCO, MDW, MEM, MIA, MSP, ORD, PHL, PHX, SAN, SEA, SFO, SLC, TPA) |
| Retain VORs that are in a known GPS “jamming” location                               | Ensuring there remains an ability to navigate in known GPS “jamming” locations. For instance, the DOD has several known areas throughout the country where routine GPS jamming is conducted.   |
| Retain VORs to enable adequate navigation for non-RNAV capable aircraft <sup>3</sup> | Provide reduced network for navigation throughout the NAS  |
| Retain VORs necessary for training   | Retain VORs that are heavily used by DoD training aircraft <sup>4</sup> or high-volume local flight schools to learn or practice VOR operations.   |

During the process of defining criteria, the Task Group made some additional observations about the criteria:

- The Task Group elected to not prioritize two criteria: “Retain Oceanic VORs” and “Retain VORs in Western Mountainous regions”. The group agreed with these criteria and took these as given.
- Clarification of the criteria “Necessity of the VOR to enable adequate navigation for non-RNAV capable aircraft” was required. This criterion addresses the operators that will be unable to upgrade to RNAV or will require additional time to do so, necessitating VORs for navigation. This

<sup>3</sup> Most DoD aircraft will not be IFR RNAV capable until after 2025.

<sup>4</sup> VORs are heavily used by Army helicopters, necessary for Air Force and Navy initial flight training and for currency and proficiency requirements for many DoD pilots.

issue was of particular importance to the Department of Defense and certain General Aviation operators.

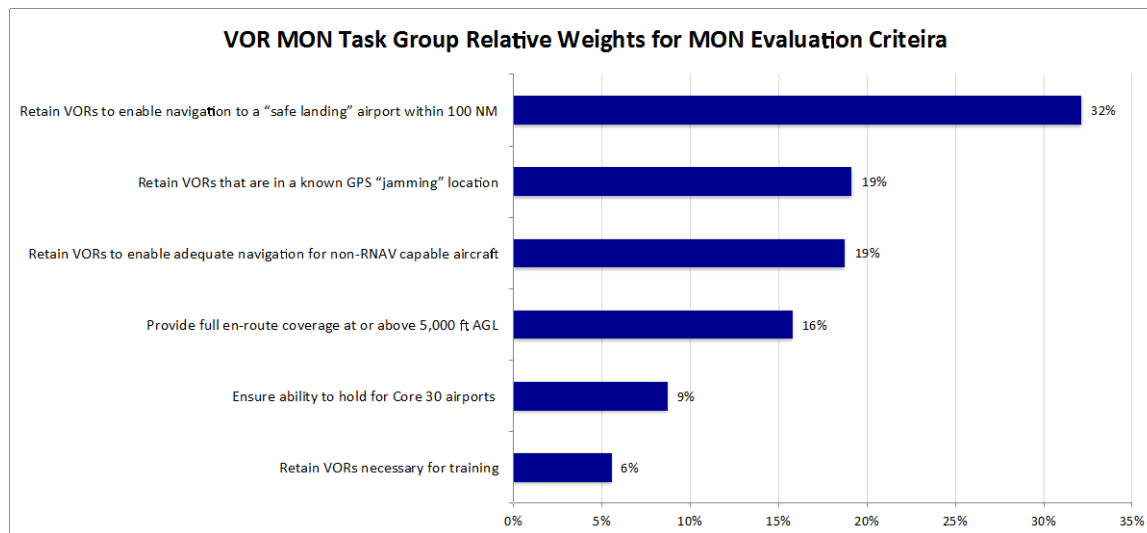
- The definition for “Western Mountainous regions” generated discussion amongst the Task Group. Some participants felt that the minimum elevation of 12,000 feet for terrain was too low. An alternative of 10,000 feet was mentioned. The group elected to retain the 12,000 foot figure with the recognition that there may be exception cases in which terrain is a relevant consideration of VOR retention even if the terrain is not 12,000 feet.

## Criteria Evaluation Results

After the final vetting and discussion of the criteria, there were six criteria considered in the prioritization analysis:

1. Retain VORs to enable navigation to a “safe landing” airport within 100 NM
2. Provide full en-route coverage at or above 5,000 ft AGL
3. Ensure ability to hold for Core 30 airports
4. Retain VORs that are in a known GPS “jamming” location
5. Retain VORs to enable adequate navigation for non-RNAV capable aircraft
6. Retain VORs necessary for training

A cross section of operators, airports, manufacturers and the Military participated in the criteria evaluation. The overall results of the prioritization are presented in the chart below:



The Task Group observed that the criteria fit into three tiers of importance. First, the criteria “Retain VORs to enable navigation to a “safe landing” airport within 100 NM” was the clear first priority. The Task Group observed that it was not surprising to see the most safety critical criteria at the top of the list.

The next three criteria form a second tier:

- Retain VORs that are in a known GPS “jamming” location

- Retain VORs to enable adequate navigation for non-RNAV capable aircraft
- Provide full en-route coverage at or above 5,000 ft AGL

Finally, “Ensure ability to hold for Core airports” and “Retain VORs necessary for training” were in the third tier of importance.

Metrics that evaluate the rating process were provided from the software utilized in the analytical process. A measure of “Alignment” of the prioritization process was 67%. Too high of a measure of Alignment (such as 90%) would suggest the group had too much “group think” in its responses. Too low of a measure (such as 30%) would suggest the group’s responses were so scattered that no meaningful pattern could be discerned from the data. A result of 67% is a strong result for a group analytical process like the one conducted by the Task Group.

Additionally, the software measured “Inconsistency” of responses. Any individual respondent may rate criteria A higher than B and B higher than C. If the respondent then does not rate A higher than C, there is a level of inconsistency in the response. The overall group Inconsistency was 3.5%. A measure of 10% or less indicates a reliable prioritization process.

## Recommendations

Given the results of the criteria prioritization, the Task Group can validate the FAA’s original selection criteria in development of the MON. The following are the original criteria used by the FAA:

- Retain VORs in Western Mountainous region
- Retain Oceanic VORs
- Retain VORs to enable navigation to a “safe landing” airport within 100 NM
- Provide full en-route coverage at or above 5,000 ft AGL
- Ensure ability to hold for Core 30 airports

In the prioritization process, the Task Group agreed with the first two criteria and considered them as given. The criteria of navigation to a “safe landing” airport was the most important criteria in the analysis and the en-route coverage was in the second tier. The only criterion used originally that raises any questions was “Ensure ability to hold for Core 30 airports”. This criteria, while in the third tier, remains a relevant criteria so long as it was not overemphasized in importance in development of the MON.

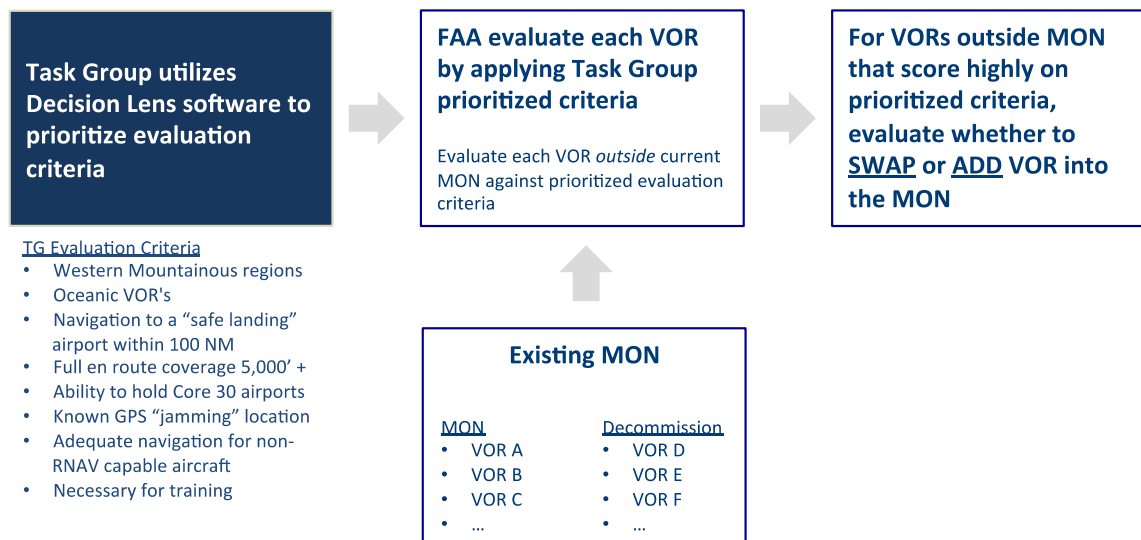
The Task Group also recommends inclusion of three additional criteria for evaluation of the VOR MON:

- Retain VORs that are in a known GPS “jamming” location
- Retain VORs to enable adequate navigation for non-RNAV capable aircraft
- Retain VORs necessary for training

The Task Group recommends that the FAA iterate through the current MON based on the weighted criteria results for the combined set of original FAA and Task Group criteria. The following diagram indicates a possible process by which the FAA could accomplish this: through evaluation of VORs outside of the current MON, the FAA may identify VORs that rate highly on the prioritized criteria for



consideration to be Swapped or Added into the MON. The Task Group does not recommend recreating a new initial MON.



Finally, the Task Group believes that the weighted criteria provide the basis for a VOR exception process for the FAA. The Task Group targeted its criteria evaluation on a national level, recognizing that local circumstances may drive a different weighting of criteria for select VORs. Going forward, as the FAA receives feedback from NAS users and local communities on individual VORs slated for decommissioning, the weighted criteria provide a basis for orderly exception processing. The Task Group recommends the FAA utilize a rigorous and transparent process with NAS users and local communities to evaluate exceptions. Any VOR that is re-evaluated for decommissioning can be measured against the weighted criteria and compared on these measures to other VORs in its peer group. Such criteria provide a structured way in which the FAA can evaluate individual exceptions.

## Appendix A: Members of the VOR MON Task Group

### Members of the VOR MON Task Group

|                       |  |
|-----------------------|--|
| Kal Bala              | RTCA, Inc.   |
| Phillip Basso         | DoD Policy Board on Federal Aviation                     |
| Mark Boquski          | Thales ATM US  |
| Rich Boll             | National Business Aviation Association                   |
| Andy Cebula           | RTCA, Inc.   |
| Dale Courtney         | Federal Aviation Administration (Subject Matter Expert)  |
| <b>Donald Dillman</b> | <b>Airlines for America (Co-Chair)</b>                   |
| Bob Ferguson          | NetJets Association of Shared Aircraft Pilots            |
| Jens Hennig           | General Aviation Manufacturers Association               |
| Mark Hopkins          | Delta Air Lines, Inc.                                    |
| Tom Kramer            | Aircraft Owners and Pilots Association                   |
| <b>Bob Lamond</b>     | <b>National Business Aviation Association (Co-Chair)</b> |
| Deborah Lawrence      | Federal Aviation Administration (Subject Matter Expert)  |
| David Manville        | U.S. Army  |
| Vince Massimini       | The MITRE Corporation                                    |
| Don McClure           | Air Line Pilots Association                              |
| Trin Mitra            | RTCA, Inc.   |
| Rick Niles            | The MITRE Corporation                                    |
| Matthew Ross          | Real NewEnergy   |
| Edwin Solley          | Southwest Airlines                                       |
| Stephen Sorkness      | SkyWest Airlines   |
| Greg Tennille         | The MITRE Corporation                                    |
| Robert Utley          | National Air Traffic Controllers Association             |
| David Vogt            | Delta Air Lines, Inc.                                    |

## **Appendix B: FAA Tasking Letter**



U.S. Department  
of Transportation  
**Federal Aviation  
Administration**

Mission Support Services  
800 Independence Avenue, SW.  
Washington, DC 20591

JUL 10 2013

Ms. Margaret T. Jenny  
President  
RTCA, Inc.  
1150 15th Street, NW  
Suite 910  
Washington, DC 20036

Dear Ms. Jenny:

In order to provide navigation services in a more efficient and cost effective manner and meet the goals of the Next Generation Air Transportation System (NextGen), a transition from the use of a very high frequency Omni-directional Range (VOR) based route structure to that of a Performance-Based Navigation (PBN) based route structure is necessary and underway. To meet the goals of NextGen, current processes for defining airways, routes, and developing procedures using VORs must give way to routes and procedures with improved accuracy, availability, integrity, and continuity using PBN. The VOR Minimum Operational Network (VOR MON) Implementation Program has been established and is one of a myriad of activities required to shift resources and operations from the legacy National Airspace System (NAS) into NextGen. The VOR MON Program is designed to be a collaborative effort, which includes various lines of business (LOBs) within the Federal Aviation Administration (FAA) as well as numerous aviation stakeholder groups, to provide the tactical and strategic planning and implementation guidance to safely and systematically transition from a legacy network of 967 VORs to a MON of approximately 500 VORs by January 1, 2020.

The timing of the VOR MON Program is critical. Our current operating system of Federal Airways is based on 546 VOR/tactical air navigation (TACAN)s and 421 VOR/distance measuring equipment (DME)s. All of these VORs are beyond their economic service life. By 2020, the FAA projects the widespread availability of PBN procedures and the mandate of Automatic Dependent Surveillance-Broadcast (ADS-B) Out will result in most operators having a global positioning system (GPS) or wide area augmentation system (WAAS) and flying both PBN and conventional procedures using PBN avionics. This transition to PBN as the primary means of navigation will result in a significant decrease in the reliance on VORs. The remaining VORs will serve as a backup navigation service to non-DME/DME/Inertial Reference Unit equipped aircraft but PBN functionality will be limited. The VOR MON will provide backup navigation services to non-GPS and non-WAAS equipped aircraft but it will not be as efficient.

The VOR MON is envisioned to allow an aircraft to safely navigate VOR to VOR to land at an airport with a GPS independent approach within 100 nautical miles (nm) of any location within the Continental United States (CONUS). Efforts are ongoing to identify Alternative

Position, Navigation, and Timing solutions that will provide a full-scale backup system to GPS and are separate from the VOR MON effort. The FAA developed the initial draft VOR MON criteria and published them in the Federal Register for comment in December 2011. Based on comments, the criteria were clarified and a draft candidate list was established. Based on the draft candidate list, the VOR MON Program Office worked with the Service Areas and various FAA Headquarters organizations and identified some preliminary implementation issues. We also held some early discussions with the Department of Defense (DoD) to facilitate future coordination and to assess any impacts to DoD CONUS operations. TACAN and DME are not considered by the VOR MON program. Several other stakeholder groups have also been briefed about the program but we are requesting the assistance of the Tactical Operations Committee (TOC), to provide recommendations in three key areas:

Task One – Review and validate the VOR MON selection criteria and assumptions and make additional recommendations as needed.

Task Two – Review and validate the draft candidate VOR MON list, based on the above criteria.

Task Three – Review implementation planning to date and make recommendations to the preliminary waterfall schedule developed by the FAA.

Task Four – Provide recommendations to the FAA on outreach and education that should be accomplished to prepare the industry for the VOR MON reduction. More detail on each task follows.

### **Task 1: Review and validate the VOR MON selection criteria and assumptions**

We plan to transition from VOR defined route structures as the primary means of navigation to PBN using Area Navigation (RNAV) and Required Navigation Performance (RNP) by January 1, 2020. Since VORs do not enable advanced RNAV, RNP, or ADS-B operations, FAA will reduce operating costs by reducing the number of FAA-provided VORs and associated conventional procedures and routes. Reductions in VORs will be limited to the CONUS. Most VORs in the western mountains and all FAA- owned VORs outside CONUS will be retained. Remaining VORs will form the VOR MON and will accomplish the following:

- Provide navigation coverage above 5000 feet above ground level.
- Allow an aircraft in the CONUS to fly safely VOR to VOR or to a safe landing site with a GPS-independent approach within 100 nm of any location in CONUS.
- Support international arrival routes and operations at the Core 30 airports.
- Support Hazardous In-Flight Weather Advisory and Flight Service Station voice services.

We request the TOC:

- Review and validate the basic program assumptions made to date concerning the selection criteria. We will ensure the TOC has complete information on studies and analysis done to date as well as access to subject matter experts within the FAA.
- If amendments are recommended, please provide specific details with the recommendations to include the range of options and/or alternatives discussed.

We request this tasking be complete by January 2014 with an interim report in October 2013.

### **Task 2: Review and validate the draft candidate VOR MON list**

Based on the criteria noted above, we have developed a preliminary candidate list for the VOR MON. Those VORs not on the list would be slated for discontinuance. FAA Service Areas have reviewed the lists and commented based on the criteria above. We request the TOC:

- Review and validate the candidate VOR MON list based on the criteria and, if the TOC recommends amending the criteria, update the candidate list based on the amendments as appropriate. If specific options were considered but not adopted via consensus, please provide the range of options and/or alternatives considered.
- Advise the FAA from a stakeholder perspective on why, how, and whether exceptions should be made to valid criteria. Again, please provide specific details to include the range of options and/or alternatives discussed.

We request this tasking be complete by April 2014 with an interim report in January 2014.

### **Task 3: Review implementation planning to date and make recommendations to the preliminary waterfall schedule developed by the FAA**

We have identified the need to develop a waterfall schedule taking into account instrument procedures cancellation activities, Optimization of Airspace and Procedures in the Metropolises, and the development of high altitude (Q) and low altitude (T) area navigation routes. Clearly the effort has to be carefully coordinated with other activities which result in the development and charting of instrument flight procedures and routes in the NAS. Each VOR not on the candidate MON will likely have numerous conventional procedures or routes associated with the VOR. These procedures and routes will either need to be replaced or canceled. The order or timing of VOR cancellations must not reduce safety in the NAS. For example, Victor 3 extends from Maine to Florida and has 14 VORs identified for discontinuance/decommissioning. Should we implement based on an entire route like this?

Should we transition the entire route to a PBN based route structure first and retain end to end flight planning capability and minimize automation issues? We request the TOC:

- Examine and analyze the PBN Route Strategy in light of the VOR MON Program and recommend up to three possible implementation/waterfall scenarios. Advise the FAA of the pros and cons of each. If incremental actions are needed in any of the scenarios, please identify those with specificity. Please include the range of options and/or alternatives discussed in the documentation. We will provide the TOC with a draft copy of the PBN Route Strategy.
- Provide recommendations on which victor and jet routes should be retained in the 2013-2020 timeframe and why. Please include the range of options and/or alternatives discussed in the documentation.
- Provide high level industry perspective on the feasibility and actions needed to completely retire the legacy route structure after 2020.

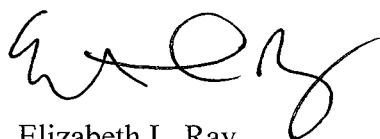
We request this tasking be complete by July 2014 with an interim report in April 2014.

**Task 4: Provide recommendations to the FAA on outreach and education that should be accomplished to prepare stakeholders for the VOR MON reduction**

- Advise the FAA, from an external stakeholder perspective, of what existing policies, processes, procedures or training will need to be modified to successfully implement the VOR MON.
- Advise the FAA on an outreach strategy to include modes of outreach, timelines, etc. and provide recommendations on how the industry can assist the FAA in outreach efforts.

We request this tasking be complete by July 2014 with an interim report in April 2014.

Sincerely,



Elizabeth L. Ray  
Vice President, Mission Support Services  
Air Traffic Organization