Approved by the Tactical Operations Committee August 2017

Recommendations for the Performance Based Navigation (PBN) Route System

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

March 2017

Recommendations for the Performance Based Navigation Route System

Contents

Introduction

In September 2016, the Federal Aviation Administration (FAA) published the "Performance Based Navigation NAS Navigation Strategy 2016"[1] which "refocuses our priorities and milestones to transition to a truly PBN-centric NAS".

Transitioning to a Performance Based Navigation (PBN)-centric National Airspace System (NAS) includes multiple parallel efforts. The following areas are noted in the Navigation Strategy document:

- Operating with PBN throughout the NAS, using the right procedure to meet the need;
- Using navigation structure where beneficial and flexibility where possible;
- Shifting to time- and speed-based air traffic management;
- Delivering and using resilient navigation services;
- Modernizing the FAA navigation service delivery to reduce implementation time;
- Enabling lower visibility access; and
- Innovating and continuously improving.

At least two of the areas above directly relate to defining the future PBN low and high altitude route system in the NAS. First, the strategy calls for having navigation structure where beneficial and flexibility where possible. This leads to the question of where structure is required and where it is not.

Second, the strategy references delivering and using *resilient* navigation services throughout the NAS. Resiliency implies that backup navigation exists in the case of a GPS outage, and one approach to accomplishing this is retaining a certain level of legacy navigational infrastructure. While the FAA seeks to provide resiliency, it is also working to avoid the costs of managing both a legacy and PBN infrastructure. The FAA's Very High Frequency Omni-directional Range (VOR) Minimum Operating Network (MON) Program is an effort that plans to remove approximately 300 VORs from the NAS over the next ten years. This will reduce cost by decommissioning about one-third of the FAA's VORs while retaining some of today's VOR network as an alternative or backup to PBN. As the primary ground based navigation aid used for low and high altitude flight, VORs anchor the existing en route structure in the NAS. The VORs that remain will provide resilient navigation, but, for the 300 that are removed, current en route structure will not be operational. This identifies the question of where PBN structure is required in the future.

To address the open questions around the future of the PBN Route System, the FAA developed the PBN Route Structure Concept of Operations (PBN RS CONOPs) in January 2015[2]. The highest level guiding principle for this CONOPs is to institute PBN structure where needed and allow for user-preferred trajectories everywhere else. The CONOPs is expected to drive the evolution of the route system across

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[1] See: https://www.faa.gov/nextgen/media/PBN_NAS_NAV.pdf

[2] Any reference in this report to the PBN RS CONOPs is specific to the following report: Performance-Based Navigation (PBN) Route Structure (PBNRS) Concept of Operations (CONOPS), Revision 01, The MITRE Corporation, January 2015.

the NAS, and the FAA identified a need and value to receive industry input to the Concept. In March 2016, the FAA requested RTCA's Tactical Operations Committee (TOC) to review the PBN RS CONOPs and provide feedback on the following four issues. The FAA tasking letter is included at the end of this introductory section:

- Task 1 - Use broader expertise and data to refine or validate CONOPs problem statement.
- Task 2 - Recommend refinement to the criteria-based methodology for establishing low and high altitude PBN route structure.
- Task 3 - Recommend a NAS-wide point-to-point navigation strategy.
- Task 4 - Recommend alternatives to the proposed approach for design and implementation.

The TOC established a Task Group to respond to this tasking letter and this report serves as the TOC's response to the task request.

Terminology

PBN RS: in this report, the "S" in PBN RS refers to "System" and not "Structure". Both FAA and operators are interested in a future PBN Route System in which structure is implemented where necessary and users can operate their preferred trajectories elsewhere. Given this overarching principle, the Task Group expressed concern that the basic naming of the CONOPs should directly reference the term *Structure.* Instead, the Task Group viewed the CONOPs as defining how the future PBN Route System should work – both route structure as well as point-to-point operations. Hence, any reference to PBN RS in this report is intended to note the PBN Route System. When this report refers to issues specific to route structure, the term structure is still used.

High Altitude: any reference to the High Altitude system corresponds to flight levels 180 and above

Low Altitude: any reference to the Low Altitude system corresponds to flight levels below 180

CONUS: refers to the Contiguous United States, also known as the Lower 48 States. This report includes Low Altitude recommendations focused on the Lower 48 Contiguous States (CONUS) as well as Alaska. A brief discussion is included on Hawaii and the Caribbean, but these geographies are not addressed as part of the CONUS in this report.

Methodology

The TOC initially established one Task Group to develop the draft recommendations for PBN RS. Given the variability of user communities and needs in the high altitude and low altitude domains, as well as Alaska versus the CONUS, the Task Group established three Sub Groups to consider the PBN RS CONOPs and develop draft recommendations for the following:

- High Altitude route system across the NAS
- Low Altitude route system in the CONUS
- Low Altitude route system in Alaska

Each Task Group consisted of industry and FAA subject matter experts across a variety of disciplines, including flight planners, pilots, PBN, system operations, etc. Many of these disciplines and individuals participated in development of the PBN NAS Navigation strategy document. The full set of participants in each Task Group is included in Appendices throughout this report. The Task Groups met regularly to review issues and develop recommendations. The recommendations from these three groups were compiled into this report into three separate sections. Recommendations across the groups have been compared to ensure a minimum level of consistency.

Executive Summary

Task Groups focused on the future PBN Route System in the High Altitude, CONUS Low Altitude and Alaska Low Altitude developed recommendations intended to further mature the FAA's Concept of Operations for PBN RS. The recommendations address a wide range of issues including the following:

- Industry perspectives on the future desired state of PBN RS operations for both high and low altitude operations
- Criteria and decision trees to determine where and when structure is required
- Operator preferences for point-to-point operations, including the key distinctions between the needs of low and high altitude operators
- Resiliency concerns in the High altitude, CONUS low altitude and Alaska low altitude
- Approaches for implementation of PBN RS for all three groups
- Alaska-specific concerns including, but not limited to, terminal deficiencies, future considerations for VORs and NDBs in Alaska and unique GPS requirements

There are 26 recommendations for the High altitude, 43 for the CONUS low altitude and 23 for the Alaska low altitude. The full set of recommendations in this report are listed below. Full context for all of these recommendations is found in the detailed report that follows. The report is organized into three major sections focused on recommendations for the High altitude (pages 17-52), CONUS low altitude (pages 53- 82) and Alaska low altitude (pages 83-99).

SUMMARY OF HIGH ALTITUDE RECOMMENDATIONS

CONOPs Problem Statement

HIGH ALTITUDE Recommendation 1.	There is a compelling need for the PBN Route System but consideration should be made to adjusting the CONOPs Problem Statement as noted below.

Future Desired State

HIGH ALTITUDE Recommendation 2.	The PBN Route System CONOPs should provide a high level depiction of the expected future state when implemented.
HIGH ALTITUDE Recommendation 3.	Structure in the NAS should be implemented and utilized at a segment level.
HIGH ALTITUDE Recommendation 4.	There should be a mechanism to ensure operators are aware of which routes are required, where and at what times.
HIGH ALTITUDE Recommendation 5.	In addition to PBN ATS routes, a more agile form of structure should also be utilized in PBN RS.
HIGH ALTITUDE Recommendation 6.	Airspace boundary realignment should be considered as the PBN route system evolves.
HIGH ALTITUDE Recommendation 7.	Structure requires regular review and maintenance.
HIGH ALTITUDE Recommendation 8.	Expansion of the network of DMEs should move forward.

Criteria for Establishing En Route Structure

HIGH ALTITUDE Recommendation 9.	The FAA should develop and publish national guidance that defines criteria for establishing high altitude route structure.

High Altitude Point-to-Point

HIGH ALTITUDE Recommendation 10.	The NRS grid should not be removed from the NAS.
HIGH ALTITUDE Recommendation 11.	The NRS grid training process for pilots and controllers should be evaluated and improved to ensure front-line personnel are familiar with the grid.
HIGH ALTITUDE Recommendation 12.	En route displays should allow Air Traffic Controllers to view NRS grid points for reroutes.
HIGH ALTITUDE Recommendation 13.	Evaluate concepts that optimize grid density in a manner that is operationally acceptable to controllers and Flight Management System capabilities.
HIGH ALTITUDE Recommendation 14.	Explore international harmonization of the NRS grid.
HIGH ALTITUDE Recommendation 15.	Evaluate waypoint use and remove those that are not used and not required.

HIGH ALTITUDE Recommendation 16.	Any evaluation of or change to the NRS grid should be done collaboratively with all operational stakeholders.

Implementation of the PBN Route System

HIGH ALTITUDE Recommendation 17.	PBN RS needs to be implemented as a top-down multi-year funded program with national priority.
HIGH ALTITUDE Recommendation 18.	A National Working Group (NWG) for PBN RS that includes representatives from operators should be established to oversee the national PBN RS effort.
HIGH ALTITUDE Recommendation 19.	The proposed regional design group structure in the PBN RS CONOPs is logical though consideration should be made to splitting the Mississippi Valley into a North and South sub-section; the National Work Group should make the decision.
HIGH ALTITUDE Recommendation 20.	The Regional Work Groups conducting the detailed local design of routes should include a cross-section of experts with front-line experience.
HIGH ALTITUDE Recommendation 21.	Preliminary activities for PBN RS implementation should focus on data gathering and establishing appropriate Regional Workgroups.
HIGH ALTITUDE Recommendation 22.	All proposed PBN structure must be validated by the regional workgroup against a Decision Tree using national criteria during the Design Activities Phase.
HIGH ALTITUDE Recommendation 23.	During design development conduct early tests on designs utilizing state-of-the-art evaluation and simulation capabilities.
HIGH ALTITUDE Recommendation 24.	Any procedures or routes impacting the en route system (including Q routes proposed through the IFP gateway) should be redirected to the National Workgroup for evaluation against national priorities and assignment to regional WGs, as appropriate.
HIGH ALTITUDE Recommendation 25.	The PBN RS implementation process should formally evaluate and include mechanisms to account for key interdependencies.
HIGH ALTITUDE Recommendation 26.	The PBN RS process should plan for a staggered sequence of implementation.

<u>SUMMARY OF CONUS LOW ALTITUDE RECOMMENDATIONS</u>

Implementation Concept

CONUS LOW ALTITUDE Recommendation 1.	The Task Group supports utilizing the JO 7100.41 process for PBN RS development and recommends geographically separating the work by Service Center and Alaska.
CONUS LOW ALTITUDE Recommendation 2.	The FAA should create, remove, optimize, or retain route structures based on the criteria detailed in the decision trees below.
CONUS LOW ALTITUDE Recommendation 3.	Future new low altitude routes in CONUS should solely be RNAV routes.

CONUS LOW ALTITUDE Recommendation 4.	A new RNAV route should be implemented in conjunction with the removal of pre-existing routes.
CONUS LOW ALTITUDE Recommendation 5.	The FAA should more accurately define the impacts of GPS intentional interference events as they relate to real-time navigation, and improve the process of communicating the impacts of these events to internal and external stakeholders-- including providing interference advisories on the Notice to Airmen (NOTAM) Search website.
CONUS LOW ALTITUDE Recommendation 6.	Colored Federal Airways should be transitioned out of the CONUS en route structure (excludes the Caribbean).
CONUS LOW ALTITUDE Recommendation 7.	While international NDB airways will remain in the CONUS, the FAA should ensure these airways are maintained.
CONUS LOW ALTITUDE Recommendation 8.	The FAA needs to request a larger allocation of RNAV Routes.
CONUS LOW ALTITUDE Recommendation 9.	The FAA should identify the areas projected to lack surveillance coverage in 2025 and evaluate the benefit of expanding ADS-B coverage to surveil these areas.
CONUS LOW ALTITUDE Recommendation 10.	The FAA should solicit industry input into the Airport Surveillance Radar (ASR) decommissioning CONOPs.
CONUS LOW ALTITUDE Recommendation 11.	The FAA should ensure there is a long-term, funded sustainment plan for those NAVAIDs determined to be integral to the NAS.
CONUS LOW ALTITUDE Recommendation 12.	The FAA should consider the MON needing to be in place beyond 2045 so must put in place an infrastructure recapitalization plan.

Point-to-Point Navigation Strategy

CONUS LOW ALTITUDE Recommendation 13.	For those VOR MON NAVAIDs that are decommissioned and those airways that are correspondingly removed, create an RNAV waypoint at the previous NAVAID location and retain all fixes and intersections along that route currently in place by amending their definition to that of an RNAV waypoint.
CONUS LOW ALTITUDE Recommendation 14.	The FAA should: (a) retain the existing five letter pronounceable name for the conventional intersections/fixes that are transitioned to RNAV waypoints; (b) if no NAVAID is to be retained, create an RNAV waypoint at that same lat/long and evaluate utilizing a five letter pronounceable name that is related to the NAVAIDs original name; and (c) if the DME is retained, continue to utilize its three letter identifier.
CONUS LOW ALTITUDE Recommendation 15.	There needs to be a defined process for users and local air traffic facilities to request new waypoints or request removal of unnecessary waypoints.
CONUS LOW ALTITUDE Recommendation 16.	In order to accommodate the expansion of point-to-point operations, the FAA should evaluate all airspace above 1,200’ AGL for establishment of Class E airspace.
CONUS LOW ALTITUDE Recommendation 17.	The FAA needs to ensure MEAs are established with an emphasis on providing the lowest possible altitude with consistency across the NAS.

CONUS LOW ALTITUDE Recommendation 18.	The FAA should update policy to remove the notice of proposed rulemaking requirement for ATS routes in the en route domain, as recommended in the PBN NAS Navigation Strategy.
CONUS LOW ALTITUDE Recommendation 19.	The FAA should remove the Off Route Obstruction Clearance Altitude (OROCA) from IFR en route charts and replace with a Grid Minimum IFR Altitude (MIA) that can be used for off route RNAV navigation and that would assure a pilot compliance with Federal Aviation Regulation (FAR) 91.177. A Grid MIA should be provided for Alaska with dimensions of 1 degree of latitude by every 1 degree of longitude.
CONUS LOW ALTITUDE Recommendation 20.	The FAA should provide georeferenced MIA/MVA data for all ARTCCs and Terminal Radar Approach Control Facilities (TRACONs).
CONUS LOW ALTITUDE Recommendation 21.	The FAA should evaluate whether the requirement to file a waypoint within 200 NMs of a preceding center's boundary is still necessary.
CONUS LOW ALTITUDE Recommendation 22.	The FAA should publish best practices for point-to-point navigation in the Instrument Procedures Handbook and Instrument Flying Handbook to promote the culture shift to primarily random RNAV navigation.
CONUS LOW ALTITUDE Recommendation 23.	The FAA's guidance should be updated to encourage usage of the IFR system by helicopters in the NAS.
CONUS LOW ALTITUDE Recommendation 24.	The VOR MON reception altitude should be shown using an interactive map, such as Google Earth, similar to what is provided for ADS-B coverage to improve operator awareness of en route impact.
CONUS LOW ALTITUDE Recommendation 25.	The FAA should modify pilot test questions to emphasize off-route RNAV as this would assist with increasing pilot's knowledge and competency of these operations.
CONUS LOW ALTITUDE Recommendation 26.	The FAA should promote the purpose and availability of the Instrument Flight Procedures Information Gateway.
CONUS LOW ALTITUDE Recommendation 27.	The FAA should conduct a study of all existing Part 95 designated mountainous areas to determine if these areas can be reduced in size. This study should include industry participation.
CONUS LOW ALTITUDE Recommendation 28.	The FAA should chart all NAVAIDs that are permanently out of service with the crosshatched pattern to indicate shutdown status.

Alternatives to the Proposed Approach for Design and Implementation

CONUS LOW ALTITUDE Recommendation 29.	The FAA should have a unified, national approach to develop and implement public RNAV routes that meet the needs of the helicopter community.
CONUS LOW ALTITUDE Recommendation 30.	The FAA should establish an initiative to promote their ability to conduct helicopter route construction including automation to handle those requests efficiently.
CONUS LOW ALTITUDE Recommendation 31.	The FAA should initiate a demonstration project implementing an RNP 0.3 helicopter route.

CONUS LOW ALTITUDE Recommendation 32.	The FAA should initiate a program to assume the ongoing maintenance requirements for public-use and special (privately developed) helicopter routes.
CONUS LOW ALTITUDE Recommendation 33.	In areas with high potential for IFR helicopter operations, the FAA should establish (a) additional ADS-B radio stations to enable surveillance coverage to altitudes equal to that of the controller MIA/MVA and (b) radio sites where reception issues regularly require the helicopter to operate above MIA/MVA.
CONUS LOW ALTITUDE Recommendation 34.	Add GNSS MEAs to existing conventional routes and evaluate user demand for RNAV-only routes.
CONUS LOW ALTITUDE Recommendation 35.	The FAA should make several improvements to the JO 7100.41 process to better capture low altitude operator input.
CONUS LOW ALTITUDE Recommendation 36.	The FAA should support an increase in the number of PBN co-leads.
CONUS LOW ALTITUDE Recommendation 37.	FAA prioritization of route development should include factors such as propensity for icing, alternate forms of access, etc., and not solely driven by usage.
CONUS LOW ALTITUDE Recommendation 38.	The Instrument Flight Procedures Information Gateway should be better tailored to route submittals.
CONUS LOW ALTITUDE Recommendation 39.	The FAA should interconnect RNAV routes with adjoining ANSPs where beneficial.
CONUS LOW ALTITUDE Recommendation 40.	Real time SAA status must be made available and provided to operators in a variety of ways, including directly to pilots by NOTAM Search, in a manner ingestible by industry via System Wide Information Management (SWIM), to Flight Service, and via Flight Information Services-Broadcast (FIS-B).
CONUS LOW ALTITUDE Recommendation 41.	The FAA should provide ATC LOAs/SOPs on the NOTAM Search website and make them available in a manner ingestible by industry.
CONUS LOW ALTITUDE Recommendation 42.	The FAA should provide greater visibility/advertising of unique SAA LOA requirements that facilitate relief for operators.

Additional Related Topics beyond Scope of PBN RS

CONUS LOW ALTITUDE Recommendation 43.	The FAA should evaluate an affordable solution for general aviation to receive IFR clearances via their mobile device.

SUMMARY OF ALASKA LOW ALTITUDE RECOMMENDATIONS

CONOPs Implementation in Alaska

ALASKA LOW ALTITUDE Recommendation 1.	The FAA should comprehensively evaluate the en route navigation needs of Alaska and ensure a baseline level of service is being provided as part of the PBN RS CONOPs implementation.

Terminal environment deficiencies

ALASKA LOW ALTITUDE Recommendation 2.	The FAA should task the TOC to evaluate the long-term terminal IFR infrastructure needs of Alaska as part of the development of an Alaska terminal CONOPs.
ALASKA LOW ALTITUDE Recommendation 3.	The FAA should add AWOS surface weather reporting stations to those airports that contain instrument approaches, but lack certified weather reporting, given the improvements to en route weather forecasting that they would provide.

Airways based on NDBs

ALASKA LOW ALTITUDE Recommendation 4.	The FAA should transition the Alaskan en route navigation structure away from any dependency on NDBs.
ALASKA LOW ALTITUDE Recommendation 5.	The FAA should evaluate all Colored Airways for: (a) direct replacement (i.e., overlay) with a T-Route that offers a similar or lower MEA; (b) the replacement of the colored airway with a T-Route in an optimized but similar geographic area while retaining similar or lower MEA; or (c) removal with no route structure (T-Route) restored in that area because value was determined to be insignificant.
ALASKA LOW ALTITUDE Recommendation 6.	The FAA's criteria to identify the priority of removal of an NDB from the en route structure should include operational considerations.
ALASKA LOW ALTITUDE Recommendation 7.	The FAA should ensure there is a process for operator and air traffic feedback prior to decommissioning a Colored Airway that would not be replaced with a T-Route (should there not be redundant routes available).

Airways based on VORs

ALASKA LOW ALTITUDE Recommendation 8.	The FAA should maintain all VORs and Victor Airways in Alaska.

ADS-B radio station density

ALASKA LOW ALTITUDE Recommendation 9.	The FAA should install additional ADS-B radio stations to expand coverage of surveillance and broadcast products.
ALASKA LOW ALTITUDE Recommendation 10.	The FAA should work with industry to help create the ADS-B expansion benefits case and evaluate where coverage is needed.

Providing low MEAs

ALASKA LOW ALTITUDE Recommendation 11.	The FAA should utilize the Flight Procedures waiver process to provide relief to overly restrictive airway design requirements in areas with a justifiable equivalent level of safety.
ALASKA LOW ALTITUDE Recommendation 12.	The FAA should provide lower MEAs on certain segments of an airway to increase the likelihood of breaking out in VFR conditions.

En route communication issues

ALASKA LOW ALTITUDE Recommendation 13.	The FAA should expand communication coverage to areas identified by industry and consider the role that Remote Communications Outlets (RCOs) serve for en route operations.
ALASKA LOW ALTITUDE Recommendation 14.	The FAA should formalize a process to allow air traffic communication gaps along routes in areas where the MEA would be positively reduced and the FAA should chart these communication gaps.

NOTAM issues

ALASKA LOW ALTITUDE Recommendation 15.	The FAA must convene a Safety Risk Management Panel (SRMP) before any modification to the 224-day T-NOTAM criteria and include industry.
ALASKA LOW ALTITUDE Recommendation 16.	The FAA must conduct timely repairs and maintenance on NAVAIDs that are components of the en route structure, and communicate their plan for returning these systems to service.

GPS issues

ALASKA LOW ALTITUDE Recommendation 17.	The FAA should evaluate the GPS (TSO-C129/196) operational requirements for Alaska that do not exist for CONUS and either justify their retention or remove the requirement.
ALASKA LOW ALTITUDE Recommendation 18.	The FAA should support adoption of advanced navigation technology by ensuring operation specifications, management specifications, and letters of authorization support operators.

Outreach

ALASKA LOW ALTITUDE Recommendation 19.	The FAA should encourage operators to utilize the IFR system in Alaska and engage with industry to better understand their IFR needs.
ALASKA LOW ALTITUDE Recommendation 20.	The FAA should promote financial assistance programs for WAAS and ADS-B equipage.

Equipage Incentives

ALASKA LOW ALTITUDE Recommendation 21.	The FAA should initiate a financial incentive, namely a rebate, to increase the WAAS equipage rate in Alaska for general aviation (Part 91, 91K, 135).
ALASKA LOW ALTITUDE Recommendation 22.	The FAA should expand the existing ADS-B rebate program for general aviation operators in Alaska (Part 91, 91K, 135).

Alaska Resiliency

ALASKA LOW ALTITUDE Recommendation 23.	The FAA should commission a study to compose a VOR MON plan for Alaska.

FAA Tasking Letter

U.S. Department
of Transportation
Federal Aviation Administration

MAR 8 2016

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

Dear Ms. Jenny:

Today's conventional Air Traffic Service (ATS) route system is defined by very high frequency omnidirectional range (VOR) radials and low/medium frequency non-directional beacons. The low-altitude airway system consists primarily of a VOR-based network of approximately 700 routes known as Victor airways. The high-altitude jet route system consists of approximately 300 VOR-based routes that are predicated solely on VOR and navigation facilities with co-located VOR and tactical air navigation (TACAN) beacons (VORTAC).

As the Federal Aviation Administration (FAA) transitions to a foundational performance based navigation (PBN) service environment, there is a need to migrate away from the increasingly obsolete VOR-based navigational infrastructure and the mounting costs associated with maintaining that aging system. This is especially true because the majority of operators no longer use the signals from the VORs.

Retaining all VOR-based conventional ATS routes in addition to a more flexible PBN structure would be counterproductive and costly. The recapitalization and rising maintenance costs associated with the VOR-based system are a drain on the FAA budget. In addition, the divestment of VORs from the route structure is a requirement for the achievement of the VOR minimum operational network (MON).

The FAA has initiated several programs to support the transition to a foundational PBN service environment and leverage increasing PBN capabilities. Programs such as Metroplex have been designed around the localized development of PBN routes and procedures. Due to the localized nature of these programs there has been minimal integration of efforts, which has resulted in ineffective or underutilized elements of the national airspace system (NAS) and little clear connectivity between areas determined to benefit from the PBN ATS structure. This lack of strategic alignment has led to various concerns, including:

- disjointed route structure;
- costly growth and maintenance of route structure with little systemic value that has resulted in a need to "right-size" the NAS;
- inability to procedurally de-conflict aircraft on parallel routes in congested airspace;

- unclear guidance on whether ATS structure or point-to-point navigation is preferred;
- restrictive traffic management initiatives due to inefficient use of airspace; and,
- reduced ability to circumvent or utilize special activity airspace avoidance points.

To address the present lack of a holistic national strategy regarding ATS route structure, an FAA workgroup, with the assistance of various external stakeholders, has drafted a PBN Route Structure (PBN-RS) Concept of Operations (CONOPs). This draft document describes a conceptual strategy and methodology for the transition of the national high- and low-altitude ATS route structures to a predominantly PBN environment.

The FAA remains committed to collaboratively identifying and addressing these issues that directly impact the efficiency of the NAS. The current draft CONOPs is based largely on an air traffic control perspective. In order to help the FAA address the issues discussed, we would like to task the TOC to provide recommendations from a broader system perspective in several key areas.

The FAA requests that the TOC perform the following tasks:

Task 1 - Use broader expertise and data to refine or validate CONOPs problem statement.

Task 2 - Recommend refinement to the criteria-based methodology for establishing low and high altitude PBN route structure.

Task 3 - Recommend a NAS-wide point to point navigation strategy.

Task 4 - Recommend alternatives to the proposed approach for design and implementation.

Completion of these tasks will provide the FAA with clearer insight into what industry values and help to inform better decision making moving forward. The FAA will provide subject matter experts as needed to support these tasks.

Sincerely,

for

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

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Recommendations for High Altitude PBN Route System

Guiding Principles for PBN Route System

The High Altitude Task Group met monthly for nearly a year and held extensive discussions on the history of the route system in the NAS, what has worked and not worked previously, individual operator preferences for PBN RS as well as each component of the task request (criteria, point-to-point operations and implementation). Through the course of these meetings, the Task Group identified a series of themes that should drive the concept, criteria and implementation of the PBN RS. These themes are presented below as this Task Group's Guiding Principles for PBN RS:

Overarching

- Establish structure only where required
- When structure is needed, it should be designed collaboratively with operational stakeholders
- Build options into the route structure, providing flexible predictability (e.g., parallel Q routes or North Atlantic (NAT) tracks)
- The PBN RS should improve access from en route to terminal and vice versa
- Focus on saving time and/or minimizing delay as the primary objective of flight operators
- Do not constrain PBN RS to legacy flows as this will simply re-create today's system
- Ensure the PBN RS is resourced as a national priority
- Ensure controllers maintain the required level of predictability in busy sectors

Value of Structure in Congested Airspace

- Structure provides predictability for the air traffic system and streamlines traffic flows to increase efficiency and sector capacity by reducing the controller's workload because of reduced or minimized complexity
    - Defined routes can establish structured, parallel, de-conflicted traffic flows to decrease sector conflicts
    - Where parallel structure is not efficient, and crossing traffic exists, creating route structure can establish clearly-defined crossing points, reducing sector complexity
    - Route structure in congested airspace can keep aircraft inside sector boundaries (eliminating boundary runners), reducing coordination with adjacent facilities and sectors
- PBN RS routes should remove constraints of the location of legacy VORs which restricts route flexibility and results in converging routes. This adds complexity and limits sector capacity.
- PBN RS should enable straighter, deconflicted tracks that minimize track miles or flying time, also maximizes airspace utilization and manages sector complexity in congested airspace.

Scope of Concept

- PBN RS CONOPs should address Planning and Weather operational scenarios
- PBN RS CONOPs should identify how the use of structure may change day-to-day
- PBN RS should consider both lateral and vertical component[3] of routing

[3] Some examples where the vertical component of routes require consideration include altitude restrictions in Letters of Agreement (LOAs) or Special Activity Airspace (SAA) and Distance Measuring Equipment (DME) coverage

- PBN RS should consider how flows into a busy terminal are segregated from flights flying over the terminal area
- PBN RS should consider how routes link into and out of terminal airspace, including both primary and satellite airports, for access and efficiency[4]. Standard Instrument Departure (SIDs)/Standard Terminal Arrival Route (STARs) do not necessarily have to connect to PBN routes.

Additional Considerations in Concept Development

- PBN RS must be developed in consideration of FMS capability
- CONOPs should strive to harmonize globally, at least Canada, Caribbean, Mexico and Europe
- Consistent with the PBN NAS Navigation Strategy, CONOPs needs to address all operator types, including those with limited/no PBN equipage
- Implementation should be a phased and evolutionary approach
- Minimize the number of WGs during implementation to require less integration
- The PBN RS should utilize consistent methodology, tools, criteria and rationale for building structure across the NAS

Assumptions for PBN Route System[5]

In addition to Guiding Principles, during its monthly meetings, the Task Group identified a series of assumptions relating to PBN RS, future air traffic operations and FAA/operator systems. These assumptions were documented throughout the course of the Task Group's effort and are presented below:

PBN Route System

- PBN RS will be implemented by 2025
- All jet routes will be canceled by 2025
- Airspace boundaries may evolve with implementation of PBN RS
- Route development historically takes about 18-30 months

Operations in 2025

- Operating 4D trajectories with critical information available via System Wide Information Management (SWIM)
- Flight operation will also be more dynamic with Time Based Flow Management (TBFM) working to manage trajectories and En Route Datacomm providing en route changes
- There is still variability across what routes operators will file, given differences in operator flight planning systems, algorithms, ops specs, cost index, etc. As a result, even with less structure and more option for user-preferred routes, planned routes are not expected to bunch together and create spikes in sector demand.
- Operators will file Trajectory Option Sets (TOS)

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[4] Some operators, particularly those at satellite airports, experience delay accessing the en route system due to congestion. As PBN RS is designed and deployed in the PBN RS, efforts should be made to identify solutions in the route system that allow for transitions into the en route domain from all underlying airports.

[5] Some assumptions reference the Future Desired State which is presented in a subsequent section of this report

- A suite of Traffic Management tools and initiatives as part of a multi-faceted Traffic Management strategy that derives maximum benefit from these capabilities will assist in managing demand and controller workload

Information and Collaboration

- Dynamically updated status on Special Activity Airspace (SAA) will be available to operators by 2025 or earlier through Aeronautical Information Management Modernization (AIMM) Segment 3[6]
- Digital Letters of Agreement (LOA) and Standard Operating Procedures (SOP) information will be available to operators by 2025 or earlier through AIMM Segment 3
- Through AIMM Segment 3 and the Aeronautical Common Service (ACS), operators will also have access to daily required structure information and any other airspace status information required for flight planning
- Future flight planning will be a negotiated flight plan environment (vs today's "file and forget")
- Existing collaboration mechanisms between FAA System Operations and Industry will mature to effectively manage a larger number of, but more specific and tailored, required routes

FAA Systems and Programs

- VOR MON will have minimal impact to Jet routes until 2021
- Non-PBN equipped aircraft will be able to navigate the NAS VOR to VOR using the VOR MON
- Time, speed and spacing tools will mature in the 2025-2030 timeframe to link route structure, particularly random routes, with Terminal Radar Approach Control Facilities (TRACONs), maximize runway throughput and enable OPDs
- En route datacomm capabilities will begin to be available in 2019 with full en route capabilities[7] by 2023
- En Route Automation Modernization (ERAM) will be capable of adapting routes in the future desired state
- Traffic Flow Management's Monitor Alert Parameter (MAP) values will be re-evaluated

Operator Systems

- Flight planning systems will continue to have a variety of levels of sophistication
- Some flight planning systems will be able to dynamically plan routes based on winds
- Flight planning systems will be capable of planning within the new PBN route system; some systems may need to evolve to conform to the future PBN RS
- There will be variation in PBN equipage for aircraft in the NAS, including some aircraft with no PBN equipage
- Flight management systems (FMS) will be capable of operating within this system
- There will be variation in FMS database capability for aircraft in the NAS, including some aircraft with FMS database limitations

[6] A Final Investment Decision (FID) for AIMM S3 is expected in March 2019

[7] Full en route datacomm includes, but is not limited to, data communications around en route altitudes, speeds, crossing restrictions, airborne reroutes (all by 2021) and direct-to-fix (by 2023)

General Perspectives on Route Structure

One of the first activities of the Task Group was to solicit perspectives on route structure from the operational community. The findings from this, as well as follow on analysis efforts, are summarized below and represent inputs from airlines, business aviation, controllers and the military.

Flexibility in Routing has Value to Operators

Airlines plan routes of flight using flight planning automation systems. These systems typically include route databases from which the airline selects a route based on the days' winds, weather, Traffic Management Initiatives (TMIs), etc. Operators can save time, distance and/or cost by having flexibility in the route they plan. The graphic below is drawn from a major US airline's flight planning system and presents a typical constrained route (in red) in comparison to a completely unconstrained route (in black) from Chicago O'Hare International Airport (ORD) to San Francisco International Airport (SFO). The unconstrained route requires 12 minutes less flying time and saves 147 gallons of fuel for an Airbus 320 aircraft. Note that the unconstrained route does traverse an SAA which is marked with a red cross hatch, making the 12 minute savings an upper bound for this example.

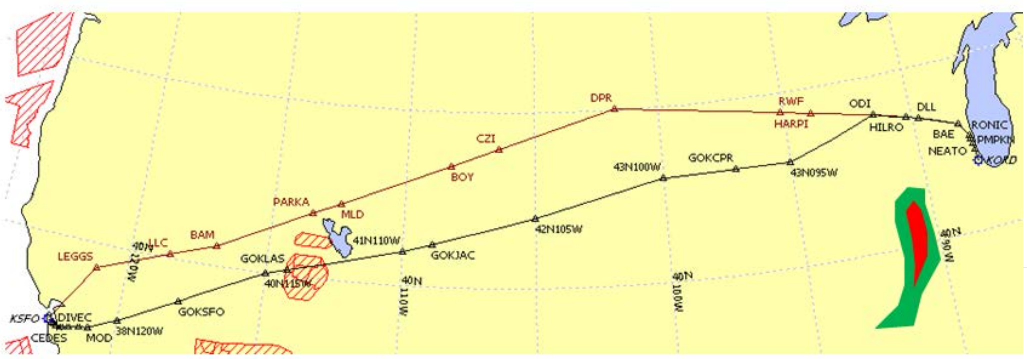


Figure 1 Constrained (red) and Unconstrained (black) Route from ORD to SFO

Today's large airlines each operate thousands of daily flights in the NAS. Using a conservative $50 per minute[8] of Direct Operating Cost (DOC) for commercial airline operations, only 50 daily flights saving 1 minute generates over $1 million in annual savings for the industry. Even small savings accrued over thousands of daily operations add up to significant operational cost savings.

[8] Airlines 4 America (A4A) estimates the 2015 cost of aircraft block for US passenger airlines' Mainline fleet at $65.43 per minute. See: http://airlines.org/data/per-minute-cost-of-delays-to-u-s-airlines/. Analysis from MasFlight presented at the 2014 AGIFORS estimates Regional Jets' cost per minute is about 55% of Mainline operations. See: http://airinsight.com/wp-content/uploads/2014/10/Updating-airline-cancellation-costs-and-customer-disruption.pdf. Applied to the A4A Mainline estimate, this results in $36 per minute for regional jets. Analysis of scheduled US domestic flights for December 2016 show RJs representing 26% of scheduled block minutes and non-RJs 74%. The weighted average (26% at $36 per minute and 74% at $65 per minute) of cost per block minute is $57. Using this data, the group estimated that industry cost per minute of block time was at least $50 per minute.

High Altitude Recommendations 5, 6 and 9 later in this report focus on approaches to ensuring as much flexibility as feasible for operators in the PBN Route System.

Natural Variation in Airline Planned Routes

While flight operators seek the flexibility to optimally flight plan, there is variation in flight planning that will result in natural dispersion in the "optimal" route for different airlines. Differences across airlines include different flight planning systems with different algorithms, differences in cost index of flying, operational specification variation that may impact selected route, airlines infrastructure constraints on the ground, aircraft equipage and maintenance status.

The Task Group conducted an experiment to evaluate one example of variation across airlines in flight planning. Multiple airlines used their internal flight planning systems to assess what their "optimal" flight plan would be for Monday, September 12, 2016 departing 1900Z on the following city pairs:

- Los Angeles International Airport (LAX) to John F. Kennedy International Airport (JFK)
- Newark Liberty International Airport (EWR) to LAX
- O'Hare International Airport (ORD) to LAX
- Ronald Reagan Washington National Airport (DCA) to Dallas/Fort-Worth International Airport (DFW) George Bush Intercontinental Airport (IAH) to Washington Dulles International Airport (IAD)
- San Francisco International Airport (SFO) to Miami International Airport (MIA)
- Hartsfield-Jackson Atlanta International Airport (ATL) to Seattle-Tacoma International Airport (SEA)

The graphic below presents the "optimal" flight plans that airlines would have filed for 1900Z on 9/12/16 for LAX-JFK. Note the dispersion in what constitutes an optimal route among multiple airline systems:

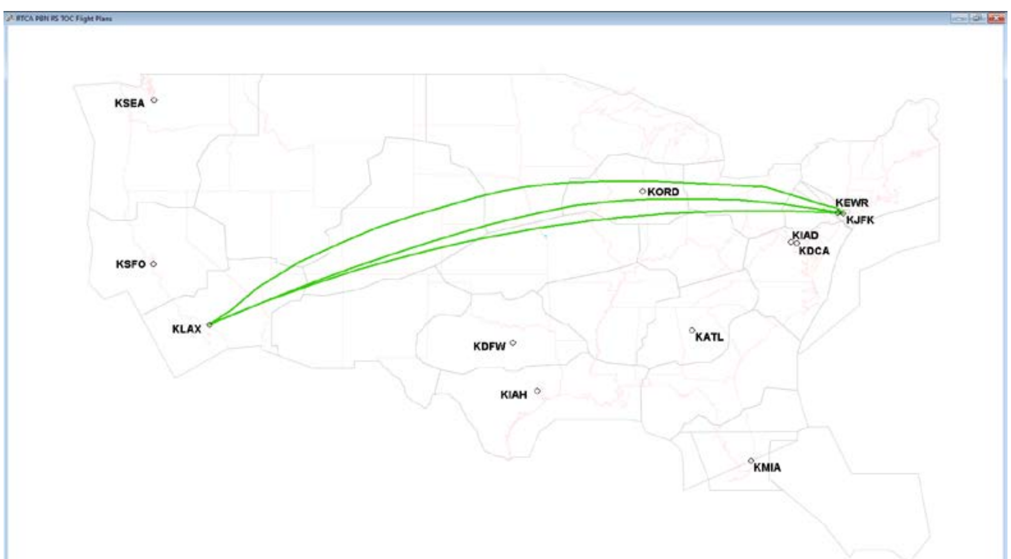


Figure 2 Dispersion of Optimal Routes for Different Airlines on LAX-JFK Route, 9/12/16 at 1900Z

Focus on Route Segments

A key operator concern with the use of route structure in the current system is when flights are "stuck" on a route beyond the constraint that warrants the structure. For example, Coded Departure Routes (CDRs) are defined between city pairs, and operators on a CDR from JFK to SFO may fly along the entire defined structure of the CDR even though the weather constraint requiring the CDR may have only been at the origin. One operator referenced this scenario as a "3000 mile final approach course". For CDRs specifically, operators referenced that subgroups within the Collaborative Decision Making (CDM) group have previously suggested developing segment-level CDRs instead of CDRs between origin and destination.

The discussion around segment-level route structure versus defined structure between city pairs motivated the Task Group to further examine use of route structure. The MITRE Corporation conducted a series of analyses to build understanding of usage of high altitude jet routes. The analyses lead to three observations:

1. Usages of Jet routes in the NAS today is lower than expected. There are approximately 300 Jet routes in the NAS, and in CY2015, the 20th most used J route was only used 83 times a day in a NAS with tens of thousands of daily Instrument Flight Rules (IFR) operations.
2. The ratio of route utilization to route filing is also lower than expected. For example, the most utilized Jet route in the NAS, J75, was filed 670 times per day in CY2015 but only utilized 332 times per day, or about 50%. Other striking examples include J121 which was utilized 29% of the time it was filed and J79 which was used 19% of time filed.
3. Route usage in the NAS today primarily occurs at a segment level. The following diagram presents usage of Jet route 75, the most utilized route in the NAS, by the routes' segments. Note that South of the Taylor VOR (TAY), there is almost no usage of J75, and between Modena (MXE) and COPES is the highest usage.

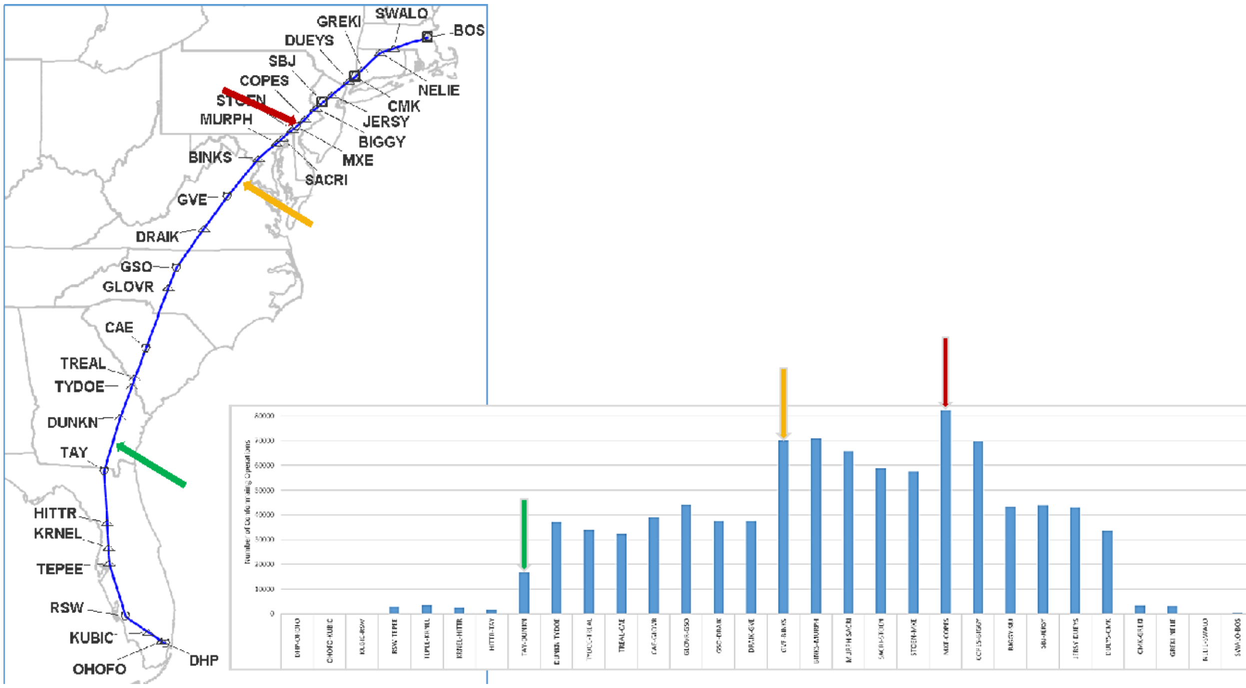


Figure 3 Use of Jet Route 75 by Segment

The group recognizes that structure is needed in certain airspace, but current usage demonstrates that structure is not necessarily required on an entire route. Challenges for the FAA and operator community will be in ensuring clarity of which airspaces require structure and when. Flight planners in airlines may then build a full route by linking together segments of required PBN route segments with point-to-point segments.

High Altitude Recommendation 3 later in this report addresses the segment-level approach to future route structure.

Need for Operators to have Complete Understanding of Required Structure

Operators struggle to maintain a complete understanding of what structure ATC requires for each flight. Some elements of structure, such as LOAs between facilities and SOPs, are fairly static in nature but remain inaccessible to operators. An example of an LOA may be for an aircraft to cross between two facilities at a specific altitude. Large airlines that operate many flights in and out of hub airports have learned such constraints over time around their hubs and coded them into their flight planning databases. However, these airlines remain unaware when a LOA changes and perhaps a constraint is removed. Also, airlines that operate less frequently into certain airports or regions may not build the same level of understanding. Finally, business aviation, which may operate into an airport or airspace very infrequently, has no volume of operations to build an understanding of LOAs or SOPs over time. Letters of Agreement that impact routings must be more transparent to operators so that incorporation into flight planning databases is accommodated.

Another, more dynamic, challenge for operators is having an understanding of the real-time status of SAA and whether the airspace will be open or not. The FAA is in process of implementing systems to provide real-time information on SAA status but this remains years out.

Finally, the most dynamic impact to required structure is evolving weather and demand. An area that needs structure at one time of day may not need it in lower demand times or after weather clears. Operators wish to be well informed of both static and dynamic structural requirements. The objective of operators is to have a full understanding of all required constraints so they can determine the route of flight that makes most sense for their business objectives.

High Altitude Recommendation 4 later in this report addresses operator need for route and other constraint information for flight planning.

Use of the NRS Grid

Operators stated emphatically that any perception of the Navigation Reference System (NRS) grid being unnecessary or obsolete is flawed. Instead, data analysis shown below demonstrates that use of the NRS waypoints has grown in recent years. Operators confirmed that their use of the NRS grid is important and saves time and fuel for them. The airlines also mentioned that after initial implementation of the grid, there were "growing pains" as users – Dispatchers and Pilots – went through a process of learning about the grid. Over time, though, stakeholders have increased their use of the grid and user complaints or errors related to the grid's naming structure, have decreased significantly. At a minimum, the NRS grid should remain.

In addition, the group sees opportunities to improve the NRS naming convention that could be explored further. These are discussed in the Point-to-Point section later. Any change in the grid naming convention must be a real improvement to justify the cost of changing the many software packages using NRS.

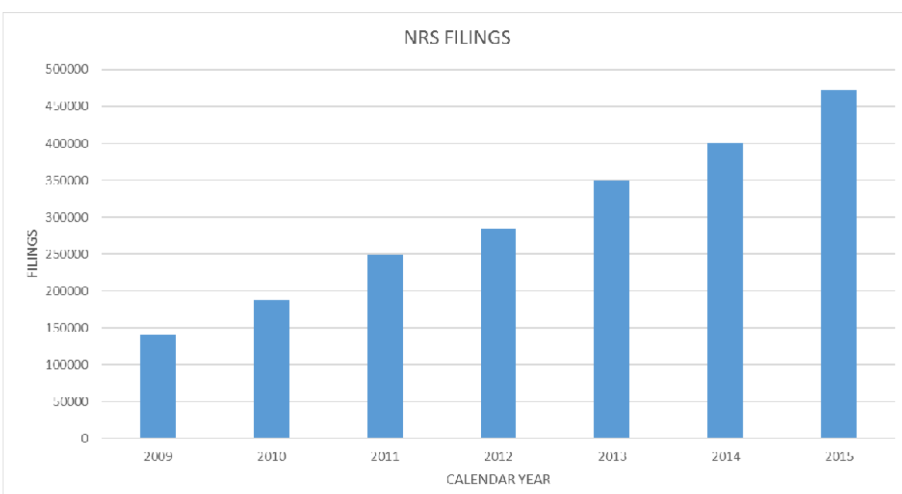


Figure 4 NRS Grid Filings by Year: 2009-2015

High Altitude Recommendations 10 – 16 later in this report address the NRS grid.

Routing System Interdependency Issues

Operators noted that any pursuit of the PBN route system raises a number of considerations on the relationship with other FAA Programs. Some of these include:

- VOR MON: the schedule for decommissioning VORs will drive changes to Jet routes, and the sequence for PBN RS implementation could and should be synchronized with VOR decommissioning.
- Data Communications: new Data Comm capabilities for terminal and en route will come online between now and 2025, and the PBN Route System concept should consider how these capabilities impact the PBN RS design.
- PBN Sequencing and Spacing: Traffic management tools of the future need to be designed to accommodate aircraft on structured routes as well as those that are not.
- AIMM Segment 3 and Negotiated Flight Planning: the flow of information and negotiation around flight planning is expected to improve and should be considered in the PBN Route CONOPs
- ERAM/Standard Terminal Automation Replacement System (STARS): capabilities and limitations of automation systems must be considered in development of the PBN RS.

High Altitude Recommendation 25 later in this report addresses key interdependencies.

Challenge of Technology Alignment

Migration to a PBN NAS highlights the challenge that multiple operators exist with varying technology. There is variability in sophistication between flight planning systems. Another key issue is the level of database storage on aircraft Flight Management Systems. There are capacity issues and, though some databases are growing, there is a lag time for the installed base to change. During a transition from current route structure to future PBN route system, there is operator concern that FMS databases could be required to hold double the amount of route structure data which would exceed the capacity of many databases. During transition to PBN RS, as new waypoints are added into the NAS, a similar volume should be removed to ensure the data requirement does not grow. Also, implementation must be phased in a way that no one publication cycle drives too significant a change in database requirements.

The concept of PBN RS is challenging given the variability of infrastructure and technology across operators in the NAS. This makes collaboration between implementation teams, navigation data providers, FMS manufacturers, controllers and operators paramount for success.

High Altitude Recommendation 26 later in this report addresses challenges of technology alignment.

Metroplex/Terminal Interactions with En Route

Any changes to routes raise questions about the interactions between the routes and terminal area flight procedures. Metroplex initiatives are ongoing and expected to continue in the NAS. As high altitude route structure is redesigned in support of a PBN RS and SIDs and STARs are changed in Metroplex's, these efforts need to be coordinated.

Resiliency

In a transition to an all PBN NAS, there is concern over what the backup plan is in a GPS outage scenario. Commercial airlines utilize a DME-DME solution for PBN, and the FAA has an effort underway to further build the NAS DME network to solidify DME-DME coverage. The need for this DME backbone to provide resiliency is critical for operators.

For general aviation, business aviation and regional jet operators, operators which have less DME capabilities, concern remains over how a backup scenario will work given the decay of the VOR structure.

High Altitude Recommendation 8 later in this report addresses resiliency.

Gaps Between Industry Perspective and CONOPs

Industry perspectives noted above were compared to the PBN RS CONOPs and, along with the tasking letter, the following areas of focus were identified to organize the Task Group's recommendations:

1. **Definition of the Desired Future State of PBN Route System**: industry perspectives offered some vision of what future PBN en route operation would look like. The CONOPs does not include a depiction of the future state of operations and recommendations are offered below on this.
2. **Criteria of where and when Structure is Required**: Task #2 requested Committee perspective on criteria for structure. Industry perspectives also emphasized the importance of this issue.
3. **Point-to-Point Operations where Structure is Not Needed**: Task #3 requested Committee perspective on point-to-point operations. Additionally, the Task Group perspectives demonstrated a value to the NRS grid and effectively rejected the CONOPs position to remove the NRS grid.
4. **Plan for Design and Implementation**: the Task Group identified multiple issues with respect to implementation, including Program interdependencies and technology issues. Recommendations on design and implementation are offered and align with Task #4.

Problem Statement for PBN Route System

Based on the gaps noted above, recommendations that align with Tasks #2-4 follow. The FAA's tasking to the TOC includes an additional component which states: "Task 1 - Use broader expertise and data to refine or validate CONOPs problem statement."

The draft PBN Route CONOPs includes the following three issues in its problem statement:

- FAA's cost of maintaining a route structure based on aging VORs,
- Lack of flexibility of existing routes given location is driven by VOR location,
- Lack of a holistic national strategy for PBN route structure.

The TOC validates that the existing route system in the NAS is antiquated and approximately 30% of VORs, which anchor the existing jet and victor route structure, are expected to be retired in the next 10 years. Hence, there is a clear operational need for a future route system and this concept is necessary to begin the process of addressing this need.

HIGH ALTITUDE Recommendation 1.	There is a compelling need for the PBN Route System but consideration should be made to adjusting the CONOPs Problem Statement as noted below.

Four areas of feedback are offered on the existing PBN RS problem statement:

- The first component, which references the cost of maintaining a route structure based on aging VORs, is not a necessary component of the PBN Route System Problem Statement. This issue drives the VOR MON and highly relevant in the NAS. However, on its own, it is not a key issue that drives a need for a future PBN route system.
- The FAA may consider incorporating the fact that new technology, particularly PBN, is being used to navigate in the NAS. This use of new technology predicates that future route system *should* be a PBN based route system.
- Another motivation for a new route system may be the low usage of routes in the NAS today. This suggests that many routes may not provide structure where structure is required and warrants a re-evaluation.
- An additional motivation for a new route system is the opportunity for more effective route design to improve NAS efficiency. With routes no longer subject to the location of ground based Navaids, there is opportunity to develop a system with less conflicting routes, and the ability to build more parallel routes to optimize airspace capacity.
- Finally, in its review, the group found the terminology "Problem Statement" unclear and believes that this section of the CONOPs seeks to address whether there is an "Operational Need for PBN Route System in the NAS". The FAA may consider renaming this section under the heading of Operational Need.

Future Desired State for the NAS Route System

HIGH ALTITUDE Recommendation 2.	The PBN Route System CONOPs should provide a high level depiction of the expected future state when implemented.

The following section describes how the group anticipates a notional future flight would operate in the future high altitude PBN Route System. In the graphic, a flight does the following:

1. The flight begins by departing from a busy hub airport through structure required to exit the departure airport terminal area.
2. Then, the flight flies point-to-point until it circumnavigates Special Activity Airspace. Circumnavigating the SAA may occur by way of a PBN route, a preferential route or a series of waypoints.
3. After circumnavigating the hot SAA, the flight again flies point-to-point until it overflies a busy terminal area. At that time, the flight traverses PBN route structure that is independent and

deconflicted from other structure utilized by flights departing from or arriving into the terminal area.

4. The flight then traverses some "day of" ad hoc structure that is a required route due to weather.
5. After some additional point-to-point flying, the flight then traverses structure that is comprised of multiple parallel routes supporting highly constrained and high demand airspace.
6. Finally, the flight flies through structure required at a specific time of day to line up flows into an arrival airport.

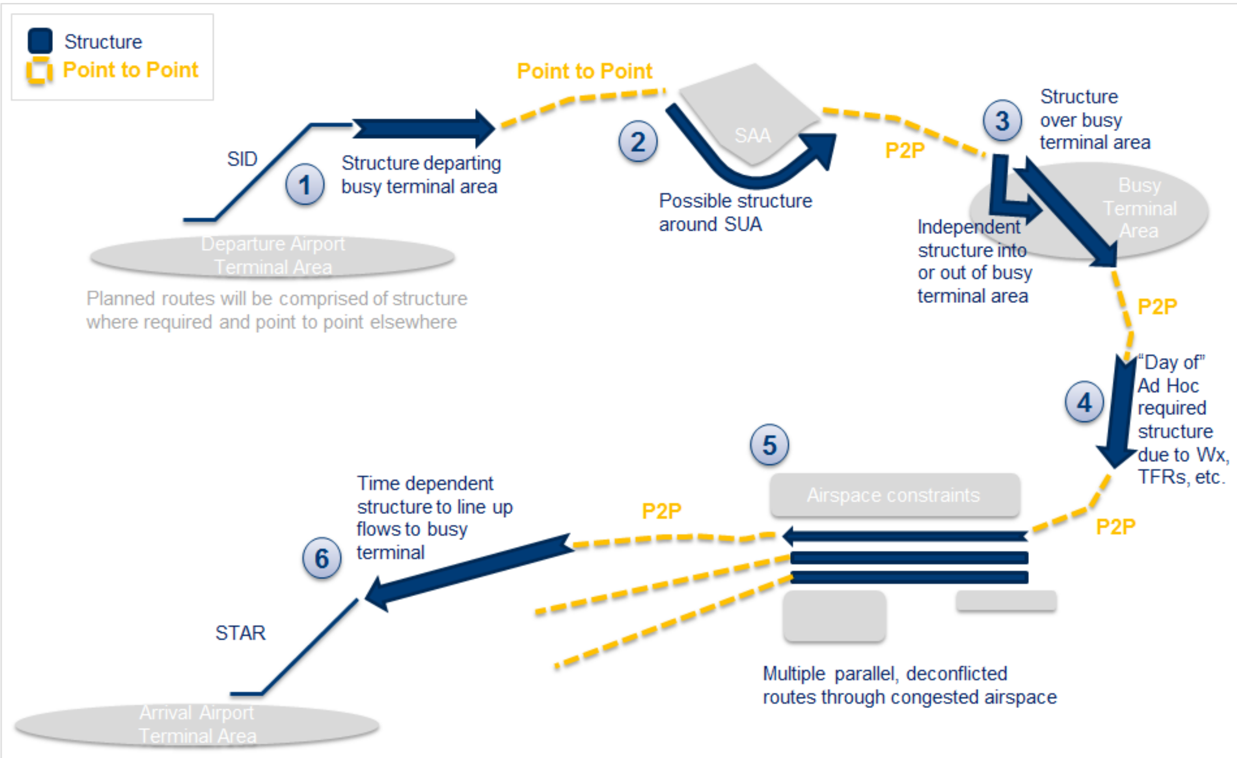


Figure 5 Notional Future Flight in a PBN Route System

Key to this notional flight is that structure is utilized where required and that point-to-point is used elsewhere. This also emphasizes the use of structure in key segments of airspace where it is necessary.

This future PBN en route operation is expected to achieve benefits for operators, including reduction of flight time and fuel. Additional benefits include improved throughput in congested airspace as well as reduced delay to access airspace.

HIGH ALTITUDE Recommendation 3.	**Structure in the NAS should be implemented and utilized at a segment level.**

Operators note that this future PBN Routing System concept is conducted to an extent in the NAS today. Flights today do not fly entire routes but operate along segments and fly point-to-point in certain parts of the country. The Task Group's expectation is that future PBN RS will simply expand use of point-to-point, remove structure where it is not required and build capacity improving structure where appropriate.

HIGH ALTITUDE Recommendation 4.	**There should be a mechanism to ensure operators are aware of which routes are required, where and at what times.**

Operators would like to understand the required NAS structure in any airspace at any time so they can build their optimal flight plan within these constraints. In order to have greatest flexibility in system, operators need to know where they can or cannot go prior to taking off. Hence, there needs to be some capability that ensures operators are aware of which routes are required, where and at what times.

For operators to have complete visibility into understanding where they can or cannot fly prior to departure, there are two additional important areas of information:

- Operators currently remain unaware of some static elements of structure, namely LOAs and SOPs. There is a need to share non-secure LOA information with operators for planning and operations, at least for Center-to-Center, Center-to-Terminal and Terminal-to-Terminal boundaries.
- Operators also are unaware of the dynamic status of Special Activity Airspace, another element of structure in the NAS. There is further need for sharing SAA status information for operator planning and operations.

As structure becomes more segment focused and dynamically required, the current system of collaboration between operators and the FAA needs to mature to a state robust enough to effectively disseminate a greater volume of required route information.

HIGH ALTITUDE Recommendation 5.	**In addition to PBN ATS routes, a more agile form of structure should also be utilized in PBN RS.**

The NAS needs different forms of structure to meet the needs of the NAS. Q routes are important for airspace in which route structure is regularly or always required. However, Q routes should not necessarily be utilized to meet all needs for structure. For example, structure that may need to change may be well served by something other than Q routes. Routes connecting to a terminal area that is expected to go through a Metroplex activity in the future may be one such example. Additionally, an airspace that infrequently requires structure, due to weather or event-driven spikes in demand, may require structure but not a Q route.

The FAA's process and timelines for publishing Preferred Routes may serve as a model for implementing portions of the future PBN system where a Q route is not warranted. Preferred Routes may be published and changed every 56 days and do not require rulemaking, providing agility and the option to make timely adjustments. Such an approach could work well for non ATS-route PBN structure.

HIGH ALTITUDE **Recommendation 6.**	**Airspace boundary realignment should be considered as the PBN route system evolves.**

As the PBN Route System is instituted in the NAS, airspace boundary realignment should be considered. The optimal design of routes should not be limited by current facility, sector or other airspace definitions. During the Washington DC Metroplex, for example, over 70 modifications to sector boundaries were made as the design evolved. This Task Group recognizes that changing sector boundaries is challenging as it impacts frequency coverage and staffing. That said, airspace boundaries were defined decades ago and can have fundamental impacts to system performance. As long as such fundamental issues with airspace structure remain, the benefits of an optimized PBN en route system may be limited.

The Atlantic Coast Route Program (ACRP) is another example of a project that focused on implementation of PBN routes, but also required enabling airspace changes. In some airspace, two parallel streams of traffic are being replaced with four tightly spaced parallel streams with some small boundary changes. Such changes improve capacity in high demand regions and should result in controllers being able to safely and efficiently accommodate increased volume. However, if any changes result in splitting a sector, this may increase controller staffing requirements. Overall air traffic controller staff availability is currently stretched, so any impacts that increase the need for controllers require careful examination.

HIGH ALTITUDE **Recommendation 7.**	**Structure requires regular review and maintenance.**

Many of today's routes in the NAS have become obsolete as they have not been maintained over time. For routes to remain relevant to the changing demand and constraints in the NAS, they require periodic review, maintenance and, potentially, adjustment.

HIGH ALTITUDE **Recommendation 8.**	**Expansion of the network of DMEs should move forward.**

A key concern for PBN operations is maintaining operation in the case of GPS jamming or possible outage. For commercial operators, many achieve PBN operations through DME-DME navigation and the FAA has communicated intent to further build out its DME network. This expansion of the DME network should continue as it helps to ensure the resiliency of PBN operations. The DME-DME network must be robust enough to permit operations at near Satellite Navigation levels. Additional concepts to further improve resiliency of PBN should be considered as well, particularly for non-DME-DME operators.

Criteria for Establishing En Route Structure

The highest level guiding principle for the PBN RS CONOPs is to institute structure where and when needed and to allow for user-preferred trajectories elsewhere. While operators seek to minimize required structure in the NAS, they understand there are conditions in which structure is required.

Critical to Identify Conditions that Warrant Structure

Operators wish to operate flight routes optimal for each individual flight and/or their network operation. However, for air traffic controllers, the desires of efficiency for each individual flight are balanced against demand, complexity and volume of airspace. Structure is the tool controllers and planners utilize to achieve predictability of flows in the face of complexity and/or high demand. The predictability that structure affords helps to optimize airspace capacity and efficiency and ensure operational safety. When utilized appropriately, structure can optimize the airspace to enable the highest and most efficient flow through it.

In certain circumstances, structure may also enable flexibility. Parallel Q routes through airspace, for example, add additional structure, but may enhance airspace capacity to allow operators the flexibility to select altitudes and routes. The tracks along the North Atlantic are an example of structure that manages the high volume of NAT traffic but creates a system with capacity that allows for some level of user flexibility.

While structure is required in certain airspace to enable predictability, it is by no means required in all airspace and has multiple negative impacts if applied incorrectly. Structure that is not addressing an operational need can reduce capacity, efficiency and even make the controller’s job more challenging and increase workload. Hence, the art of designing PBN route structure will be in identifying those operational conditions in which stakeholders clearly agree that structure is warranted to manage the operation most efficiently.

Building Structure vs Applying Structure

Just because structure exists does not necessarily mean it must be utilized 24 hours a day and 7 days a week. Structure may be static – i.e., activated all the time – or it may be variable – i.e., activated only when needed. This Task Group expects that some structure that is developed as a part of the PBN RS effort will only be utilized a portion of the time. However, the optimized structure needs to exist so it can be utilized when necessary.

The core guiding principle of only instituting structure where needed applies not only to the building of structure but also to when and how structure is applied. Static, defined use of structure at all times and under all conditions should be abandoned. The FAA and industry stakeholders need to be careful to ensure that established structure is only utilized when operationally required. Failure to do so can result in less efficient flight trajectories and as well as increases in controller workload.

Required structure should be defined at the segment level and when it is required. In today’s NAS, ATC Required Wind Routes are an example of segment-level structure that has certain active and required times. The NAS should move in this direction of determining and defining where and when structure is required. This will require enhanced collaboration and information flow between industry and the FAA in the decisions around applying NAS structure day-to-day.

Additional forms of structure beyond PBN routes will remain and may be most logical for certain conditions. Required routes comprised of route segments, NRS grid points or point-to-point direct routings may be defined based on operational conditions. Playbook routes or Coded Departure Routes are also options for pre-defined non-Q route structure that may continue to be utilized on a dynamic basis during specific conditions.

Finally, route structure in the NAS will evolve over time and needs to be managed and maintained. As demand evolves in the NAS, route system changes may follow. Additionally, technology developments may reduce certain needs for route structure and the PBN RS should be evaluated periodically for continued relevance.

The following list is this Task Group's compilation of operational conditions that warrant route structure[9]:

Need for Structure	Description
Optimize Throughput in Constrained Airspace	For busy and constrained sectors, PBN route structure can create more routing options because routes are not limited by the location of ground based Navaids. This allows the designer to create routes closer to actual separation standards and potentially increase throughput.
Organize and Deconflict Separate Flows	In busy airspace, controllers may be sequencing multiple flows of aircraft that are destined for the same or adjacent airports. Air traffic routes can help to separate aircraft destined for different airports. For example, in a sector, flows would be well organized if aircraft destined for airport A were all on Route 1 while those destined for airport B were all on Route 2.
Limit Sector Conflicts	In sectors with complex, crossing traffic, route structure can serve to structurally deconflict traffic and minimize conflicts within a sector, thus reducing controller workload and increasing efficiency. This may be through parallel, deconflicted routes or structure with clearly-defined crossing points.
Reduce Required Coordination	Structure in congested airspace can keep aircraft inside sector boundaries, reducing coordination with adjacent facilities and sectors.
Available Structure for Offloading	Busy airspace with highly utilized structure may periodically require reroutes to weather or other changes in airspace capacity. In these high volume areas, adjacent routes may be used to reroute and offload aircraft, reducing the impacts of the airspace constraint.
Efficiently Avoid Active SAAs	Structure may assist commercial or business aviation operators to most efficiently avoid hot SAAs.
Link Neighboring Airspaces	Structure may be used to most effectively provide links across airspace boundaries. This could include linking oceanic to domestic airspace or airspace over a busy terminal area with surrounding en route airspace.
Structure to Use for Rerouting	For facilities that regularly experience severe weather or capacity limiting situations, such as New York or North Texas, local facilities may benefit

[9] Note that while these criteria are for high altitude route structure, some are applicable to low altitude route structure as well

	from establishing alternate routes to allow aircraft to depart or arrive to an airport in airspace not restricted due to weather. In such cases, having pre-defined structural options to select from may assist a facility to best utilize the available capacity. Today there are Coded Departure Routes that identify route structure between city pairs but segment level CDRs may have greater value in the future.
Structure to Use for Surge Capacity	Some routes, such as Holiday Routes, are provided to commercial users for seasonal demand surges. Defining these routes aids in effective flight planning and utilizing them when available.
Reduce Frequency Congestion	In busy sectors, frequency congestion may limit sector capacity. In such cases, controllers can more easily issue reroutes with predefined routes rather than using routings consisting of multiple waypoints that may need to be relayed phonetically.

HIGH ALTITUDE **Recommendation 9.**	**The FAA should develop and publish national guidance that defines criteria for establishing high altitude route structure.**

There is tremendous variability in the NAS, with numerous facilities handling high altitude traffic (Air Route Traffic Control Centers [ARTCCs], Combined En Route Approach Control [CERAPs]) characterized by multiple areas and sectors of different sizes, levels of complexity and traffic volumes within each facility. If every area or sector were to define the need for structure individually, there would be risk of inconsistency throughout the NAS. Hence, national guidance will be critical to ensuring standardization of route structure design and a minimum level of consistency across facilities in the NAS.

The operational conditions that warrant route structure described above define a set of criteria for high altitude route structure in the NAS. These should be consolidated, possibly expanded and matured, to form the national set of criteria for high altitude route structure. The proposed national criteria for high altitude route structure are:

- Optimize Throughput in Constrained Airspace
- Organize and Deconflict Separate Flows
- Limit Sector Conflicts
- Reduce Required Coordination
- Available Structure for Offloading
- Efficiently Avoid Active SAAs
- Link Neighboring Airspaces
- Structure to Use for Rerouting
- Structure to Use for Surge Capacity
- Reduce Frequency Congestion

In a later section of this report - *Implementation of the PBN Route System* - recommendations are offered on how PBN RS design teams should utilize these criteria within the PBN Implementation

Process to ensure consistency of PBN RS design throughout the NAS. See High Altitude Recommendation #22 and Figure 10 for further detail.

High Altitude Point-to-Point

Operators seek flexibility to plan their optimal trajectory after considering weather, volume and other operational factors. (See High Altitude Recommendation #4.) Although operators recognize the need for structure where high volume, weather and complexity are present, the flexibility accorded with less structure allows for increased optimization of preferred trajectory.

The NAS has had previous initiatives to improve route flexibility and the option for point-to-point operations. In 2003, a phased implementation of the NRS grid, part of the High Altitude Redesign (HAR), commenced to allow operators increased en route flexibility.

HAR Phase 1 NRS implementation in 2003 encompassed seven centers in the Western and Northwest regions. HAR Phase 1 NRS usage suffered due to limited awareness and training. The limited awareness and training began at the operator community and extended to the FAA field facilities. To address the limited knowledge of the HAR project, FAA immediately began briefing operators and providing training sessions to increase the awareness and utilization of the NRS grid system, as well as the new Q-Routes, with the operator community.

Despite early implementation challenges of the NRS grid, usage of the grid continues to grow over time. Additionally, multiple airlines have identified significant value of the NRS grid to their operations:

- One large airline notes that it derives nearly $1-2 million in value per month from use of the NRS grid
- Another airline stated that 100% of its flights heading Westbound each afternoon utilizes the NRS grid
- One airline noted that after initial implementation of the grid, pilots reported confusion about the naming convention. However, in the past 18 months, the same airline reported no such pilot reports.

Finally, different airlines also provided individual case studies of flights using the NRS grid and the value of the NRS grid to these flights.

One airline planning an MD10-30 aircraft between Memphis International Airport (MEM) and Oakland International Airport (OAK) found a route utilizing the NRS grid (FOXOM KK39E KD45W HVE MONOH) was better by 1 minute, 320 lbs of fuel and 10NM of flying distance than a route not utilizing the NRS grid (FOXOM RZC ICT J28 GCK J28 MLF J80 ILC TATOO MONOH). The route in blue is the non-NRS route and the route in white is the one that includes an NRS waypoint:

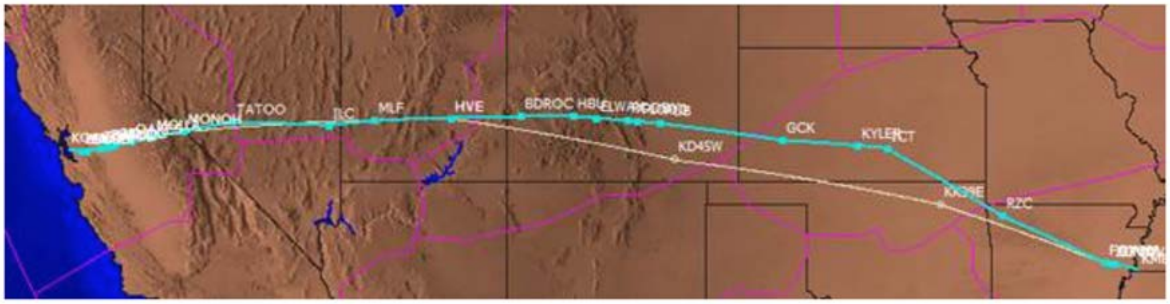


Figure 6 Routes between MEM and OAK - with NRS waypoints (blue) and without NRS waypoints (white)

Another operator, planning a narrowbody aircraft flight between LAX and Charlotte-Douglas International Airport (CLT), found a savings of 20NM of flying by utilizing the NRS grid:

	Route	NM
Current Route	**KLAX HOLTZ9 TRM PKE J74 SJN J18 ABQ J78 TUL J46 VXV JOHNS2 KCLT**	**1945**
NRS Route	**KLAX HOLTZ9 HOLTZ KL24K HIDAT KK36A RZC VXV JOHNS2 KCLT**	**1925**

Savings of 20 nm

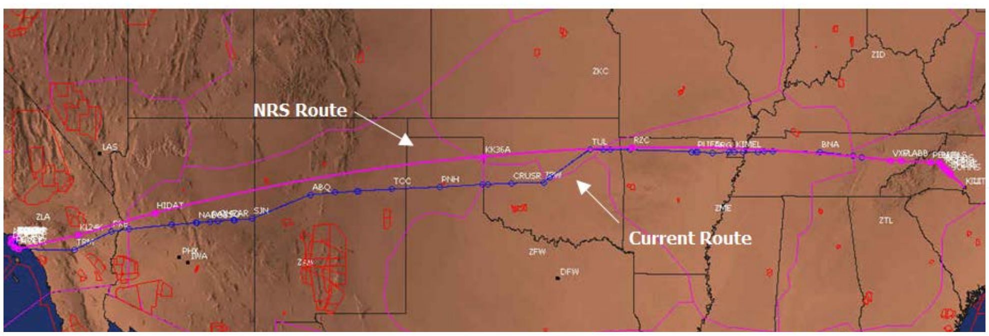


Figure 7 Routes between LAX and CLT - with and without NRS waypoints

Another airline planning a narrowbody flight between Minneapolis-St. Paul International Airport (MSP) and LAX identified a savings of 300 pounds of fuel and an overall reduction in the cost of operating the flight. The green route below represents the flight plan without the NRS grid and the white represents the plan utilizing the NRS grid.

MSP-LAX

ID	Cost	Burn	Brn Diff	Trip Tm	ETA	Arv Df	Init FL
.GEN.NRP.1.1.U-EDIT.2	0	26613		03:31	23:31	0:06	360
.GEN.NRP.1	52	26913	300	03:27	23:27	0:02	360

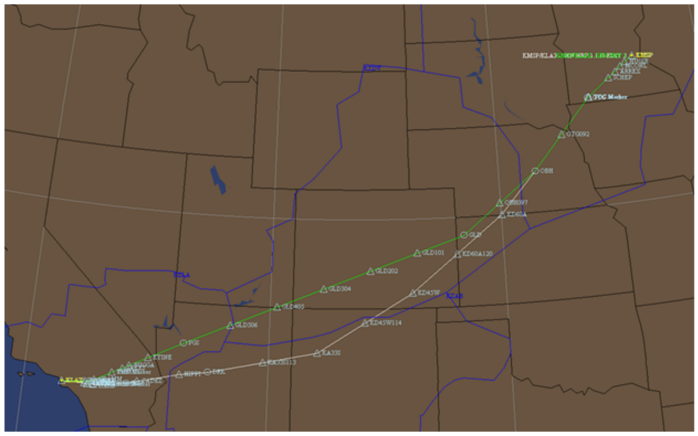


Figure 8 Routes between MSP and LAX - with NRS waypoints (white) and without NRS waypoints (green)

Finally, one regional operator has creatively utilized the NRS grid to define an NRS waypoint as an initial transition fix from a small satellite airport to the en route system. This approach has been utilized in multiple Air Route Traffic Control Centers (ARTCCs) in the NAS and may have broader applicability throughout the NAS for satellite airports.[10]

Recommendations for point-to-point operations in the NAS are as follows:

HIGH ALTITUDE Recommendation 10.	**The NRS grid should not be removed from the NAS.**

The PBN RS CONOPs calls for the removal of the NRS grid and replacement with a set of additional “floating” waypoints. This Task Group recommends changing that aspect of the CONOPs to retain the NRS grid as operators derive significant value from it today.

HIGH ALTITUDE Recommendation 11.	**The NRS grid training process for pilots and controllers should be evaluated and improved to ensure front-line personnel are familiar with the grid.**

The initial implementation of the NRS grid saw slow uptake given the limited training provided to controllers and pilots. Today use of and value from the grid is growing. Looking forward, pilots and controllers should receive sufficient training on the NRS grid to maximize its utilization.

HIGH ALTITUDE Recommendation 12.	**En route displays should allow Air Traffic Controllers to view NRS grid points for reroutes.**

NRS grid points are used effectively in flight planning. However, previous human factors studies from

[10] However, the NRS grid should not become applicable to operations below FL180.

NASA indicate a real-time limitation of use of NRS grid for reroutes was the ability of controllers to view new routes with grid points on their display. Most displays for Air Traffic Controllers, however, lack the capability to view NRS grid points on their scopes. ERAM has the capability to display NRS waypoints, but few facilities have adapted this information into the displays. If NRS grid points are to be used in a reroute capacity in the future, the points will need to be displayed on controller scopes. The FAA may consider prioritizing the display of NRS grid points on those displays where traffic is most likely to be operating point-to-point.

HIGH ALTITUDE **Recommendation 13.**	**Evaluate concepts that optimize grid density in a manner that is operationally acceptable to controllers and Flight Management System capabilities.**

Aircraft have, and will continue to have, variation in the amount of data their flight management systems can accommodate. Operators are concerned about having the lowest capability, i.e., the most data-constrained FMS, limit the robustness of the grid system. Instead, operators would like to see the most robust grid system possible. Those operators with the full complement of grid data would be able to utilize the full grid while those with lesser capabilities would only utilize part of the grid. The grid itself should not be limited due to issues with the FMS.

A concern for air traffic controllers is the risk of not knowing what navigation data an aircraft has. Controllers expect that operators would have all information and today have no mechanism to know if an operator does not have certain infrastructure information. If controllers need to reroute aircraft due to weather or other complicating factors, they would expect aircraft to have the appropriate waypoint or route information to comply with their instructions.

During the course of this Task Group's discussions, operators identified concepts for optimizing grid density in a way that is acceptable to controllers. One concept is for a primary and secondary database of waypoint and route information. The primary database would be less dense and required of all operators in the high altitude domain while the secondary database would be more dense, provide more options and carried by those with greater capacity. Another concept was deployment of a highly dense grid that any operator could use in flight planning. However, controllers would expect operators to carry a defined sub-component of the grid, and this required sub-grid could become more dense over time. Note that these concepts were discussed in the course of this Task Group's work but have not been fully evaluated. They are not endorsed by this Task Group but should be evaluated further.

HIGH ALTITUDE **Recommendation 14.**	**Explore international harmonization of the NRS grid.**

Operators would welcome a grid that works around the world. This would ease current handoff challenges that exist using NRS grid points for flights between the US and Canada or Mexico. Additionally, many US and foreign operators fly aircraft in the US and other parts of the world, and seek international harmonization.

HIGH ALTITUDE Recommendation 15.	**Evaluate waypoint use and remove those that are not used and not required.**

In addition to the NRS grid, operators are expected to utilize waypoints in the NAS for planning and operating point-to-point operations. Criteria should be developed for removing waypoints, and an audit should be conducted of waypoint usage. The PBN RS should evaluate and recommend the removal of waypoints in conjunction with the transition from jet airway to Q route or NRS environment.

Currently there are approximately 10,000 floating waypoints in the NAS, i.e., those that are not tied to a procedure or a route. Not all of these “orphaned” waypoints are necessarily in all navigation databases.

HIGH ALTITUDE Recommendation 16.	**Any evaluation of or change to the NRS grid should be done collaboratively with all operational stakeholders.**

Multiple concepts of improvements to the NRS grid are suggested above – training process, controller displays, concepts for increasing grid density and international harmonization. Any changes done to the NRS grid should be evaluated and implemented with the participation of the broader aviation stakeholder community. This includes, but is not limited to, air traffic controllers, experts in ERAM/STARS/Advanced Technologies & Oceanic Procedures (ATOP), pilots, dispatchers, flight planning system vendors, navigation database vendors and flight management system manufacturers. There are enough topics for the NRS grid that require future attention that this Task Group suggests the FAA stand up a new Work Group focused on addressing these open questions.

Additionally, the FAA has expressed an interest to evaluate options to change the NRS grid naming convention. If the FAA elects to consider new naming options, this too should be done with participation from the stakeholder community. Changing the naming would involve significant effort and investment from operators and ATC, so changing it should only happen if there is a clear logic and economic benefit for doing so. The current naming system is not “broken”, however, this Task Group agrees that it may be improved. During the course of this Task Group’s effort, new concepts for the naming convention that would improve density and make international harmonization feasible were proposed by members of the Task Group. These concepts are included in this report in High Altitude Appendix B for consideration. The Task Group does not endorse these concepts but suggests that they be given proper consideration by any future group that evaluates the NRS naming convention.

Implementation of the PBN Route System

Implementation of the PBN Route System in the NAS will be a significant undertaking. To achieve value from this significant effort, the implementation process must include affecting real change in the NAS. The approach taken by Walt Disney in designing walkways at the original opening of Disney World should be considered as a guiding principle for the PBN RS. At the time of opening, Disney elected to erect no sidewalks or fences, opting for open grass instead. He wanted to allow visitors to determine where they wanted to walk in the park and added sidewalks only after seeing where the grass was worn down. Ideally, the future route system in the NAS would be designed in a similar fashion – by understanding where users want to fly and designing the NAS to offer the greatest amount of flexibility to maximize route efficiencies.

The challenge is that there is existing structure in the NAS, in terms of routes, airspace structure and frequency coverage that was historically designed around outdated avionics using ground based navigational aids. The implementation process should seek to evolve the PBN route system, to the extent feasible, in the approach suggested by Walt Disney to utilize new technologies on the aircraft and within flight operating systems that airlines have invested in. This may incrementally evolve changes to facility boundaries and en route flows in the NAS.

Lessons Learned from the Atlantic Coast Route Project (ACRP)

During 2016, the ACRP project has been working to redesign the PBN route system along the Atlantic Coast. Lessons learned from this effort should be considered in planning implementation for the PBN RS initiative. The lessons include the following:

- Design should be done by individuals who are directly involved with the operation. Individuals who are controlling traffic, flying or dispatching aircraft should identify the challenges in the current operation and the structural solutions.
- The ACRP process fit within the existing .41 process for route development in which the PBN Leads and FPTs in the Service Centers drove the formal process.
- The ACRP effectively utilized Subject Matter Experts and historical data from the Performance Data Analysis and Reporting System (PDARs) to evaluate routes filed against routes flown to understand how structure is used in the system
- A first iteration of route design was done through a significant in person design workshop involving all key stakeholders – controllers, Service Center personnel, charting experts, individuals from flight standards, etc. Significant progress can be made in an initial session if the right individuals are involved.
- After an initial design was developed, evaluation was conducted utilizing the Terminal Area Route Generation and Traffic Simulation (TARGETS).
- After ensuring the design and fly-ability was acceptable a detailed analysis was completed using a simulation lab to model some level of increased demand and allow controllers and pseudo pilots to test the design.

Overarching Recommendation

HIGH ALTITUDE Recommendation 17.	**PBN RS needs to be implemented as a top-down multi-year funded program with national priority.**

Development and deployment of a PBN RS needs to be fully funded and a committed to through the transition period in terms of budget and adequate staffing. Without a thoughtful, programmatic approach, the system will continue to evolve in the piecemeal fashion it has to date, which will result in discontinuities and inefficiencies in the network, increased maintenance costs for the conventional procedures and NAVAIDS, and a slower evolution towards a PBN route system as the primary means of NAS navigation.

Working Group Structure

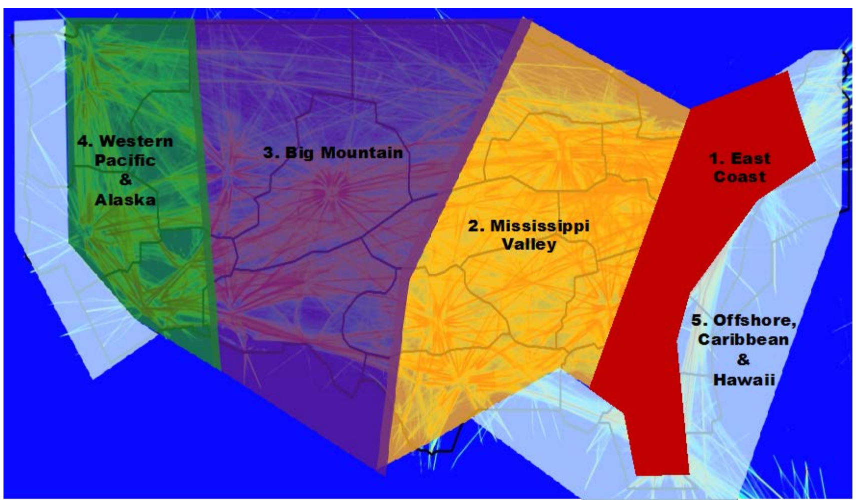
HIGH ALTITUDE **Recommendation 18.**	**A National Working Group (NWG) for PBN RS that includes representatives from operators should be established to oversee the national PBN RS effort.**

There needs to be a national overarching group that is managing the process, ensuring integration and continuity across WGs and "launches" the individual, regional WGs with the appropriate SMEs. The function of this National Work Group would be to ensure synchronized development of PBN RS that precludes duplication of effort. It would be the centralized clearinghouse for supervision of all route development throughout NAS responsible to resolve any potential conflicts from competing projects.

The National Work Group should include representatives from local operational facilities, the Command Center, PBN office, Air Traffic Procedures (AJV-8), airlines, business aviation, etc. Flight operators are particularly interested in understanding the development of route system designs from the earliest stage of the process and would like to have a "seat at the table" from the beginning.

HIGH ALTITUDE **Recommendation 19.**	**The proposed regional design group structure in the PBN RS CONOPs is logical though consideration should be made to splitting the Mississippi Valley into a North and South sub-section; the National Work Group should make the decision.**

The following diagram, which is Figure 6-2, from page 42 in the FAA's draft PBN RS CONOPs represents the proposed regional group structure in the CONOPs:



The following aspects of the proposed CONOPs workgroup structure are logical:

- The groups on the East and West coast will be primarily concerned with North/South flows making the physical structure of the East Coast and Western Pacific & Alaska groups consistent with the predominant flows.
- The Big Mountain group is the region with the least need for route structure and the group anticipates more structure will be dissolved in this area than others.
- The Mississippi Valley group is the one the National Work Group may consider splitting.
- A Sixth workgroup focused on Transcontinental flying may be required as well.

HIGH ALTITUDE Recommendation 20.	The Regional Work Groups conducting the detailed local design of routes should include a cross-section of experts with front-line experience.

Controllers who are working traffic, time-based systems experts, Traffic Flow Management, dispatchers, pilots, flight planning system vendors who are developing the flight planning systems, etc. Front-line personnel would have time commitments to the PBN RS activity but it would not be an extended full-time responsibility for these individuals.

Process Recommendations

The PBN RS CONOPs calls for utilizing the process described in FAA Order 7100.41A, PBN Implementation Process, (.41) for route development. The process provides a development and implementation process for PBN procedures and/or routes. The process meets requirements of the Safety Management System (SMS) and is deemed compliant by Office of Safety. The .41 process implements a work group business case analysis process for proposed new or amended PBN procedures and/or routes. New and amended procedures are processed in accordance with applicable design criteria and environmental and public outreach polices and directives. The five phases of the .41 process are as follows:

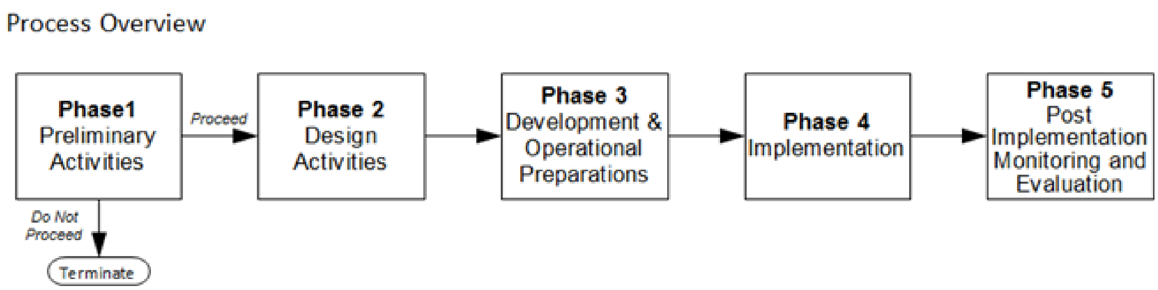


Figure 9 FAA's Five Phase Dot 41 Process

The group accepts this approach for PBN RS with some recommendations to adjust the process:

HIGH ALTITUDE Recommendation 21.	Preliminary activities for PBN RS implementation should focus on data gathering and establishing appropriate Regional Workgroups.

For application of the .41 process to the PBN RS, the following focus is suggested for Phase 1:

Background data, including heat map data on route and route segment usage as well as operator input, should be gathered, prepared and studied in this phase. This should include actual filing by segment and the corresponding usage for these route segments. When routes are filed but not used, data should include what flight track is operated instead. Using historical data provides an important perspective but is naturally limited by today's structure and LOAs and SOPs.

Additionally, a combination of operators, flight planning vendors or air traffic analysis companies should compile data on what tracks operators would operate with no constraints. This theoretical analysis would serve to measure the impact that current constraints such as a LOAs, SOPs and SUAs have on operations. Understanding the difference between current and optimal may serve to drive design activity.

Local designers should leverage existing route filing and usage as well as ideal flight tracks as submitted by industry as input to the design process. Such information should be considered in the design process while always applying the rule that PBN design should limit structure to the fullest extent given airspace complexities. Additional data input into this process would be any issues that impact the movement of sector boundaries, such as spectrum studies. This phase 1 would parallel the study team activity of the Metroplex efforts.

HIGH ALTITUDE **Recommendation 22.**	**All proposed PBN structure must be validated by the regional workgroup against a Decision Tree using national criteria during the Design Activities Phase.**

The Design stage of PBN RS should include an initial design of route structure that is then compared and validated against national criteria. The diagram below represents Task Group's perspective on a national criteria decision tree to validate the need for structure:

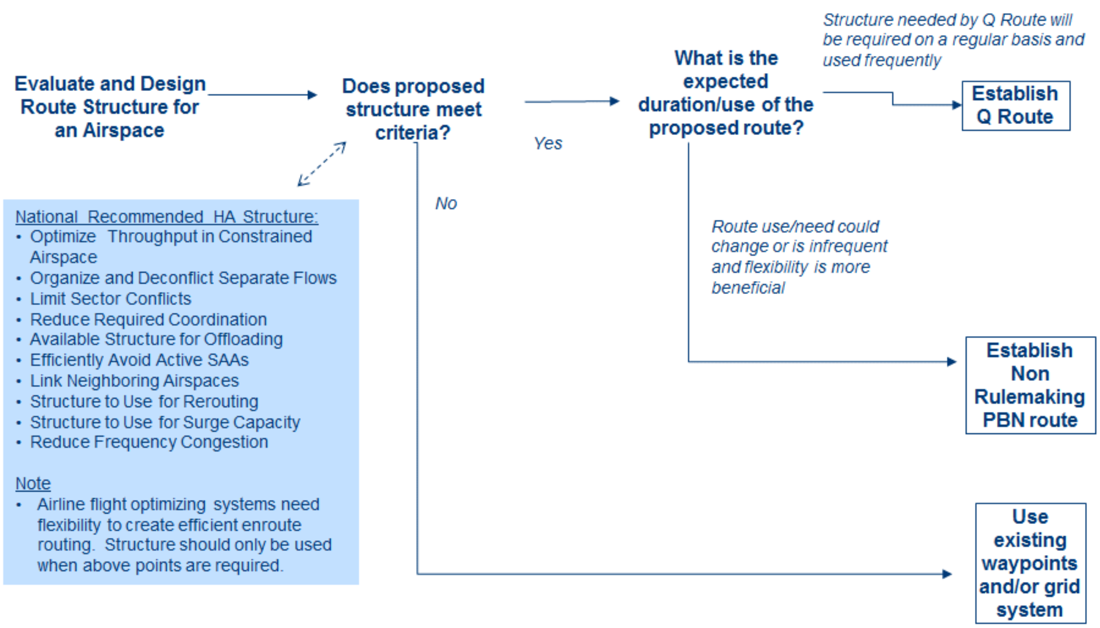


Figure 10 Decision Tree to Validate Proposed High Altitude Structure

Note that the national level criteria are those discussed in the Criteria section above. For any given airspace, a design team will ensure that each individual component of structure meets at least one of the national criteria noted in the picture above.

Create, Remove, Retain, Optimize

The original PBN RS CONOPs includes the idea of creating Q routes, removing Q or J routes, retaining existing Q routes or optimizing existing Q or J routes. The implementation thinking in this report is heavily influenced by the experience of the ACRP in which structure was designed not at an individual route level but instead for an airspace. The product of a design exercise is a set of routes that is intended to meet the air traffic structural needs for the airspace going through PBN RS design. Comparison of this set of designed routes to what exists in that airspace today leads back to the original concept of Create, Remove, Retain, Optimize. Reconciliation of the future design with current means any of the following may be required to adjust the airspace structure to achieve the future design:

- Retain existing Q route
- Optimize an existing Q route
- Remove an existing Q route and not replace it
- Remove a Jet route and replace with either the same Q route or an optimized Q route
  Remove a Jet route and not replace it

HIGH ALTITUDE Recommendation 23.	**During design development conduct early tests on designs utilizing state-of-the-art evaluation and simulation capabilities.**

In an effort to avoid proceeding too far with development of an operationally infeasible design, analysis tools should be leveraged to simulate designs early in the process. Use of tools such as TARGETS and the ISim software served to provide early and important validations during the ACRP effort.

HIGH ALTITUDE Recommendation 24.	**Any procedures or routes impacting the en route system (including Q routes proposed through the IFP gateway) should be redirected to the National Workgroup for evaluation against national priorities and assignment to regional WGs, as appropriate.**

Given the scale and complexity of the PBN RS effort, any external impacts to the PBN route system should not be handled independently of the PBN RS. Should any new route proposals be submitted through the Instrument Flight Procedures (IFP) Gateway or otherwise, they should be funneled to and adjudicated by the NWG and/or the appropriate Regional Work Groups of the PBN RS effort.

HIGH ALTITUDE Recommendation 25.	**The PBN RS implementation process should formally evaluate and include mechanisms to account for key interdependencies.**

Given the complexity of the NAS and the PBN RS effort, it is not surprising that the PBN RS would have numerous interdependencies with other issues and aspects of the NAS. Notable interdependencies include, but are not limited to, the following:

- FMS databases are limited in storage capacity. If routes are "doubled up" this could cause database challenges for operators.
- Charting of routes: if both old and new routes are present at the same time, charts may become cluttered with route information
- VOR MON Program: the sequential implementation of PBN RS needs to be synchronized with the VOR MON Programs' sequence of decommissioning VORs and their corresponding impacts on ATS route structure
- Time Based operations: Time, Speed, Spacing tools should be developed to handle traffic on PBN Q routes as well as those operating point-to-point

HIGH ALTITUDE **Recommendation 26.**	**The PBN RS process should plan for a staggered sequence of implementation.**

Designing and implementing PBN RS across the NAS will require resources and all Working Groups will not be able to work in parallel. Some resources will be required on multiple or all WGs. Hence, the National Work Group should identify the appropriate implementation sequence.

High Altitude Appendix A: Members of the PBN RS Task Group

Rune Duke, Aircraft Owners and Pilots Association

Michael Cirillo, Airlines for America

Steve Baker, Alaska Airlines

Lynae Craig, Alaska Airlines

Desmond Keany, American Airlines

Michael O'Brien, American Airlines

Dave Surridge, American Airlines (Co-Chair)

Rico Short, Beacon Management Group

Mark Hopkins, Delta Air Lines (Co-Chair)

Ed Olsen, Delta Air Lines

Denise Fountain, DoD Policy Board on Federal Aviation

Steve Anderson, Federal Aviation Administration

John Dutton, Federal Aviation Administration

Cliff Keirce, Federal Aviation Administration

Jeff Kerr, Federal Aviation Administration

Robert Novia, Federal Aviation Administration

Gary Petty, Federal Aviation Administration

Jeff Richards, Federal Aviation Administration

Leonixa Salcedo, Federal Aviation Administration

Lori Zuest, Federal Aviation Administration

Phil Santos, FedEx Express

Bill Murphy, International Air Transport Association

John Moore, Jeppesen

Joe Bertapelle, JetBlue Airways

Lee Brown, Landrum and Brown

Bennie Hutto, National Air Traffic Controllers Association

Jim McAllister, National Air Traffic Controllers Association

Eric Owens, National Air Traffic Controllers Association

John Vogelsang, National Air Traffic Controllers Association

Bill Wise, National Air Traffic Controllers Association

Jeff Woods, National Air Traffic Controllers Association

Nat Iyengar, National Business Aviation Association

Heidi Williams, National Business Aviation Association

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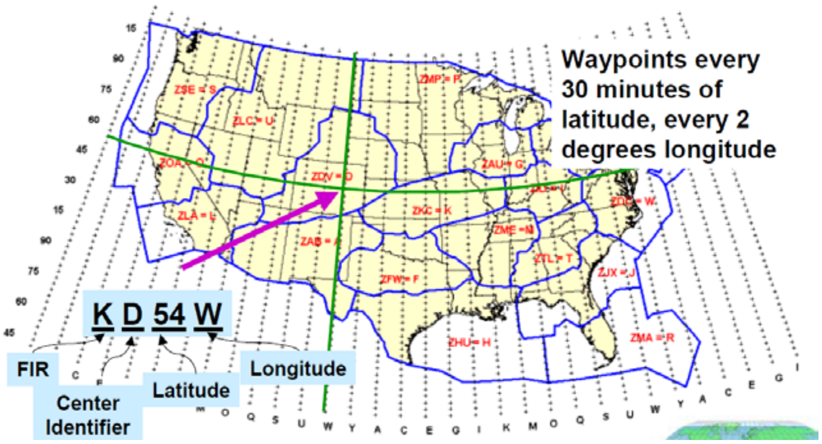
Stephen Sorkness, SkyWest Airlines
Perry Clausen, Southwest Airlines
Richard Dalton, Southwest Airlines
John Brandt, The MITRE Corporation
Howard Callon, The MITRE Corporation
Bobby Kluttz, The MITRE Corporation
Shweta Mulcare, The MITRE Corporation
Tommy Nicholson, The MITRE Corporation
Jeff Shepley, The MITRE Corporation
Perry Lewis, United Airlines
Glenn Morse, United Airlines
Allan Twigg, United Airlines
Jonathan Bonds, United Parcel Service

High Altitude Appendix B: Task Group Ideas for Alternative NRS Grid Naming

Background

The current National Reference System (NRS) is based on five characters, ½ degree latitudinal separation and 2 degree longitudinal separation.



Limitations

This current NRS has limitations that needs improvement to provide an efficient coordinate system for the future.

- NRS is not worldwide compatible.
- The use of the Air Route Traffic Control Center (ARTCC) in the naming convention is not conducive for future changes to ARTCC boundaries.
- The latitude field uses repetitive values resulting in the same latitude identifier for multiple latitudes.
- The longitude field uses repetitive letters resulting in the same latitude identifier for multiple longitudes.
- Locating a specific point is not intuitive, and requires extensive knowledge and memorization of the entire system's FIR/ARTCC structure.

Objective

This proposal will provide solutions to the current system's limitations with following objective and constraints:

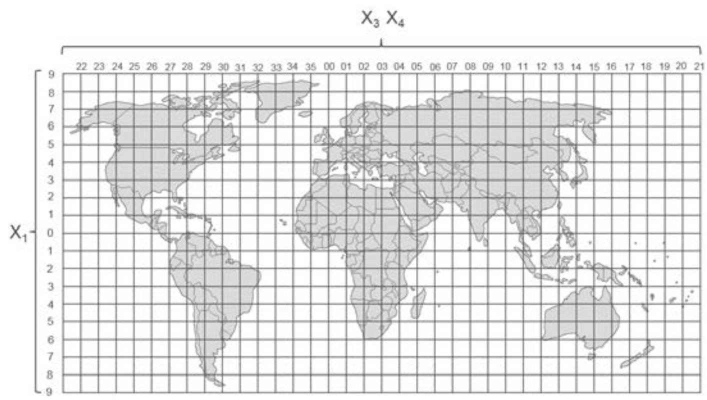
- Worldwide compatible
- Restricted to five characters
- Will not use a mix of letters and numbers for a single identifier
- Avoid the letters I,L,O,V, and Z to reduce confusion with numbers or other letters
- Increase coordinate system granularity

Solutions

The following solutions will use $\underline{X}_1 \underline{X}_2 \underline{X}_3 \underline{X}_4 \underline{X}_5$ to describe the identifiers.

Solution 1

- 1 degree latitudinal separation and ½ degree longitudinal separation
- X_1: First digit of the two digit latitude (0-9)
- X_2: Second digit of the two digit latitude represented by a letter that will differentiate North and South.
  - o North: A=0N, B=1N, C=2N, D=3N, E=4N, F=5N, G=6N, H=7N, J=8N, K=9N
  - o South: M=0S, N=1S, P=2S, Q=3S, R=4S, S=5S, T=6S, W=7S, X=8S, Y=9S
- $X_{3\text{-}4}$: First two digits of the three digit longitude. (00-35 east to west)
- X_5: Single's digit and ½ degree of the three digit 0-359 longitude system represented by a letter.
  - o A=0, B=0.5, C=1, D=1.5, E=2, F=2.5, G=3, H=3.5, J=4, K, M, N, P, Q, R, S, T, W, X=9, Y=9.5

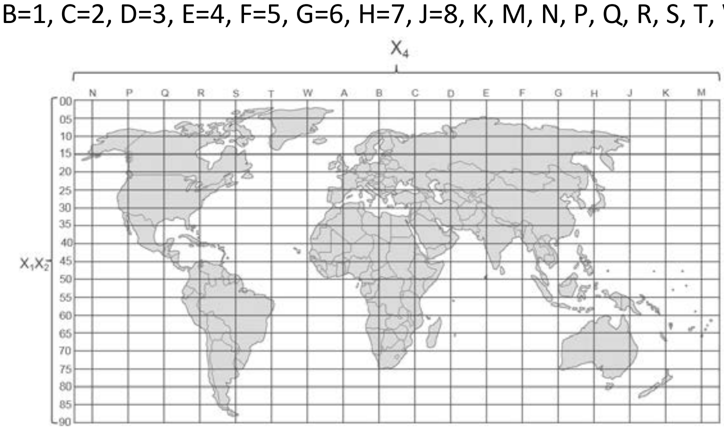


X_2: Single's digit of the latitude. North: A=0, B=1, C=2, D, E, F, G, H, J, K=9. South: M=0, N=1, P=2, Q, R, S, T, W, X, Y=9

X_5: Single's digit and half degree of the longitude. A=0, B=0.5, C=1, D=1.5, E=2, F, G, H, J, K, M, N, P, Q, R, S, T, W, X, Y

Solution 2

- $^1/_{10}$ degree latitudinal separation and 1 degree longitudinal separation
- $X_{1\text{-}2}$: Latitude is divided into 90 two degree segments. (00-90 N→S)
- X_3: Each 2 degree segment is divided into 20 tenth degree segments.
  - o A, B, C, D, E, F, G, H, J, K, M, N, P, Q, R, S, T, W, X, Y
- X_4: The 360 degrees of longitude are broken into 18 twenty degree sections represented by:
  - o A=0-19, B=20-39, C=40-59, D, E, F, G, H, J, K, M, N, P, Q, R, S, T, W,
- X_5: Single degree indicator within the 20 degree sections of longitude.
  - o A=0, B=1, C=2, D=3, E=4, F=5, G=6, H=7, J=8, K, M, N, P, Q, R, S, T, W=17, X=18, Y=19

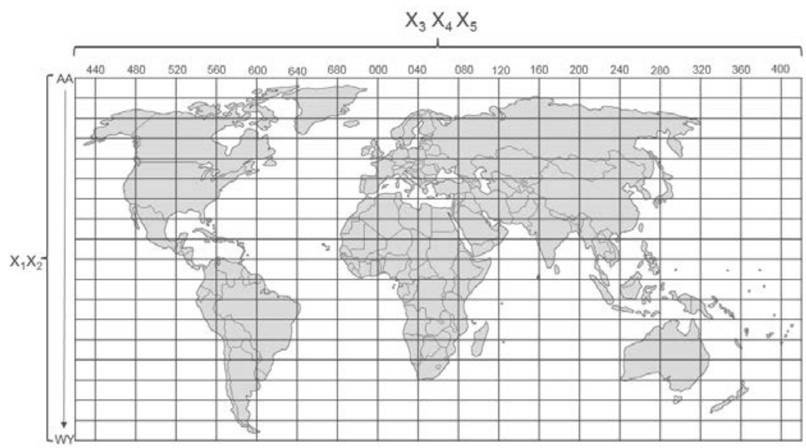


X_3: Tenth degree latitudinal separation. A, B, C, D, E, F, G, H, J, K, M, N, P, Q, R, S, T, W, X, Y

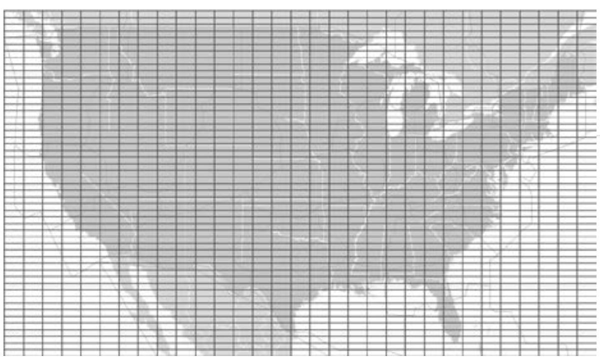
X_5: Single degree identifier in each section of longitude. A=0, B=1, C=2, D=3, E, F, G, H, J, K, M, N, P, Q, R, S, T, W, X, Y

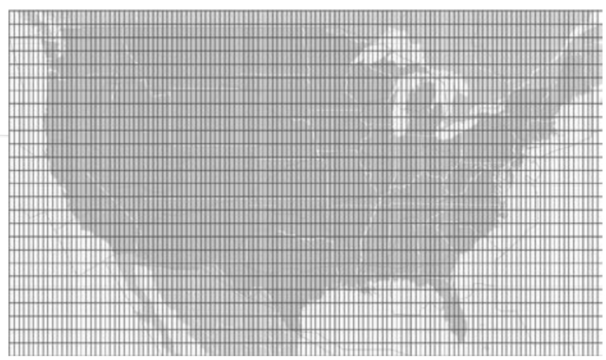
Solution 3

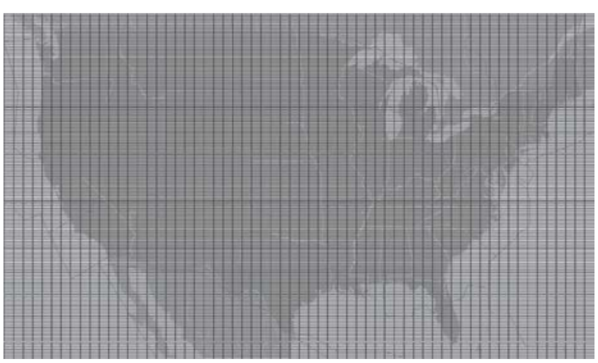
- ½ degree latitudinal separation and ½ degree longitudinal separation
- $X_{1\text{-}2}$: The 180 degrees of latitude are labeled from North pole to South pole
    - AA → WY using A, B, C, D, E, F, G, H, J, K, M, N, P, Q, R, S, T, W, X, Y
- $X_{3\text{-}5}$: The 360 degrees of longitude are broken into 720 half degree sections numbers 0-719.

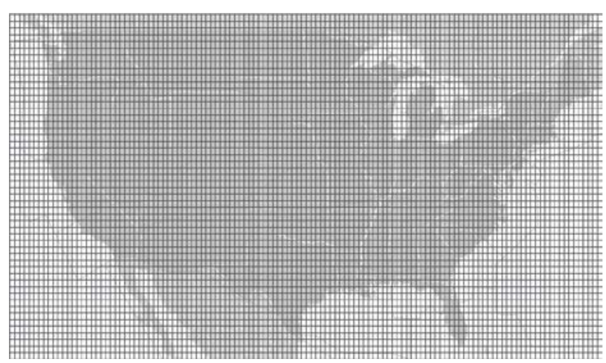


Coordinate System Granularity


Current NRS


Solution 1


Solution 2


Solution 3

Additional Solutions
Additional solutions that do not follow the initial constraints.

Solution 3 (modified)
- Latitude: AA → ZZ (Every 20 minutes / Requires 24 letters)
- Longitude: 000 → 719

Solution 4
- Latitude: AA → ZZ
- Longitude: 000 → 999

Solution 5
- Latitude: AA → ZZ (Every 20 minutes / Requires 24 letters)
- Longitude: AAA → ZZZ

Solution Comparison
Current NRS:

Latitude: ½° Longitude: 2° Dimensions: 360x180 Waypoints: 64.8k

	#1	#2	#3	#3m	#4	#5
Example	3A28G	25MRD	FC566	AA→ZZ 0→720	AA→ZZ 000→999	AA→ZZ AAA→ZZZ
Separation	Lat: 1° Long: ½°	Lat: $^1/_{10}$° Long: 1°	Lat: ½° Long: ½°	Lat: $^1/_3$° Long: ½°	Lat: ~$^1/_4$° Long: $^1/_3$°	Lat: ~$^1/_4$° Long: $^1/_{50}$°
Dimensions	180 x 720	1800 x 360	360 x 720	540 x 720	676 x 1000	676 x 17576
Waypoints	129.6k	648.0k	259.2k	388.8k	676k	11,881k
Compared to Current	2x	10x	4x	6x	10x	183x

Solution 1 vs Solution 2
Solution 1 is more intuitive due to its similarity with the current latitude/longitude coordinate system. Solution 1 provides numeric values for the latitude (based on the latitude naming convention) and longitude, while solution 2 uses a different numeric latitude naming convention and does not use numeric values for longitude.

Solution 2 is more efficient for east-west flying in combination with jet stream patterns due to increased latitude fidelity over solution 1. Solution 2 has improved ease of use for pilots by having numbers and letter grouped separately, rather than going back and forth between numbers and letters.

Database Concerns
The entire grid system can be made available from Day 1 for utilization by operators (flight planning systems, dispatchers, pilots) and ATC. Operators with database capacity issues can add waypoints as

their database memory capability increases. The FAA can roll coordinate system requirements out in Phase. This allows the operator to use as high a level of fidelity as they desire, but limits the ATC expectation to the current phase when rerouting aircraft via NRS waypoints.

Summary

All solutions:

- Global naming convention, unlike the current NRS model that is strictly for the US.
- Double the fidelity/capacity over the current NRS model.
    - 10x fidelity/capacity (Solution 2)
- Not tied to center boundaries that could change in the future. It is not recommended to base the future naming convention of the national reference system off boundaries that were put in place decades ago, and are susceptible to change.
- Do not reuse values for latitude or longitude, unlike the current NRS model that includes the same numeric value for multiple latitudes and the same letter for multiple longitudes.
- Do not require any knowledge of the system's FIR or center structure to locate waypoints, unlike the current NRS model that is based on ARTCCs.

The solutions presented in this analysis increase efficiency, capacity, compatibility, and intuitiveness over the current NRS naming convention.

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Recommendations for Low Altitude CONUS PBN Route System[11]

PBN provides operational efficiency and cost savings that are already benefiting low altitude operators. It is clear that all categories of low altitude users have embraced PBN as it has become the predominant form of navigation. The low altitude Task Group evaluated flight plan filings, route conformance, avionics equipage statistics, and interviewed a wide range of stakeholders to ensure that the recommendations that follow account for the different perspectives and missions that take place below Flight Level 180 (FL180). What is clear from the information collected is that structure is not necessary in many geographic locations or operational scenarios; however, because of the necessity for many pilots to operate below icing conditions and at the lowest minimum IFR altitude, route structure will be needed in the low altitude domain for the foreseeable future.

The Task Group validated and wholly supports the overarching guiding principle of the PBN RS: "PBN Air Traffic Services (ATS) routes where necessary and point-to-point navigation structure where it is not." The decommissioning of VOR MON NAVAIDs and the PBN RS effort offers an opportunity for the FAA to ensure the structure that is in the NAS provides value to users and is effective. The Task Group found numerous opportunities to remove structure and to enhance the routes existing in the NAS to provide a greater benefit to operators.

The Task Group concluded that the en route needs for certain users, namely helicopter operators and those who fly in the Alaskan region, are not being met. Both of these stakeholders routinely operate at low altitude and in challenging conditions. The safety and efficiency of their operation is being negatively impacted by neglected infrastructure, outdated FAA policies, and the lack of committed agency resources. In order for these operators to make the financial commitment to equip and participate in the PBN RS, the FAA needs to invest in providing the necessary infrastructure and modernization of policy. Until the FAA addresses these barriers, the NAS will not be able to collectively move forward and realize all the PBN RS benefits. The Task Group believes implementing the following recommendations will bring us closer to achieving the FAA's and user's goals, and we acknowledge that the recommendations need not be implemented in parallel.

Future Desired State

The following section describes how the Task group anticipates a notional flight would operate in the future low altitude PBN Route system. In the graphic, the following scenario occurs:

1. A flight departs a general aviation airport using a departure procedure and continues direct to their first waypoint for point-to-point flight.
2. The aircraft encounters a large area of SAA and uses a PBN Tango Route, or T-Route, or Victor Airway to transit this area efficiently.

[11] As noted in the Introduction, Low Altitude is Flight Level 180 and below and CONUS references the Lower 48 Contiguous states.

3. After passing the SAA, the flight continues at the lowest Minimum Instrument Flight Rule Altitude (MIA) to remain clear of icing. The charted Grid MIA allows safe point-to-point operations at low altitude. The pilot may also use a route to transit an area of high terrain to remain at a low en route altitude.
4. For non-Global Navigation Satellite System (GNSS) aircraft, NAVAID to NAVAID navigation will still be conducted
5. For Air Traffic Control (ATC) to efficiently separate aircraft in a non-radar environment, structure will be utilized to transit these areas. Aircraft will proceed point-to-point when operations allow.
6. Structure will be necessary in congested airspace, such as Class B, to allow transient aircraft to efficiently circumvent or pass through the airspace. Helicopter access will be enhanced via a helicopter only route structure.
7. Finally, the aircraft will proceed direct to the Initial Approach Fix (IAF) tied to the instrument approach the aircraft will fly at their destination airport.

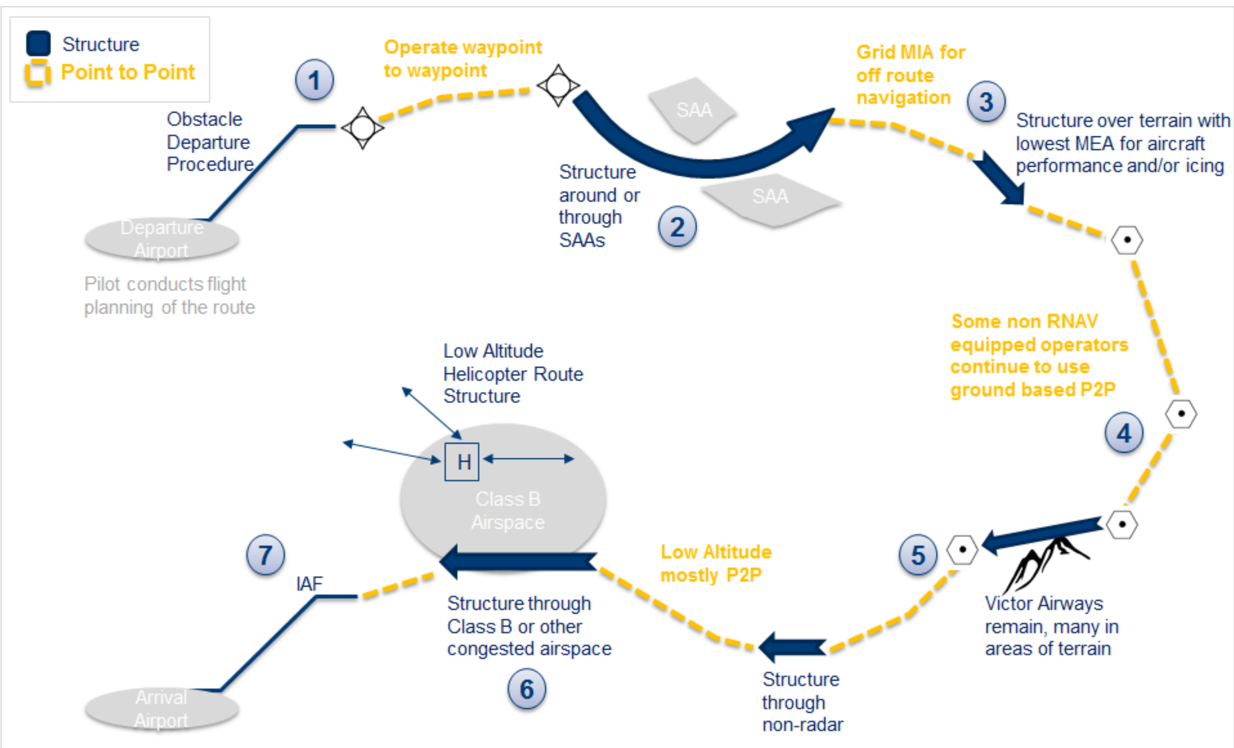

Figure 11 Future Desired State for Low Altitude Route System

Implementation Concept – Service Center Approach for RNAV[12] Routes

CONUS LOW ALTITUDE **Recommendation 1.**	**The Task Group supports utilizing the JO 7100.41 process for PBN RS development and recommends geographically separating the work by Service Center and Alaska.**

[12] Throughout this report, RNAV routes refer to both T and TK routes

The Task Group supports the PBN RS CONOPs proposal that route design be conducted at the Service Center level. Service Centers are also utilized for the MON program and it would be ideal that these programs be coordinated. In CONUS, the VOR MON will drive the implementation sequence for adding or removing route structure so the MON program office must be included in the coordination process. Routes may also be proposed through the Instrument Flight Procedure (IFP) Gateway in CONUS.

In Alaska, the group recommends the Western Service Center establish a Working Group focused on a more comprehensive evaluation, design, and development of low altitude route structure.

A national coordination office that would be aware of all route efforts was also validated and supported. Additional coordination with local users and air traffic facilities in Alaska, Hawaii, and the Caribbean is needed given their local peculiarities.

Decision Tree for Route Structure

As low altitude route amendments or new routes are proposed through the VOR MON Program, from the IFP Gateway or through an Alaska region design effort, the FAA will need criteria to evaluate each route. To identify when route structure is beneficial, the committee created several decision trees. These decision trees were foreseen to be used by the FAA as part of the Baseline Analysis Report (BAR) to determine if a route is warranted as part of the JO 7100.41 route implementation process or as part of an existing airspace review.

CONUS LOW ALTITUDE Recommendation 2.	**The FAA should create, remove, optimize, or retain route structures based on the criteria detailed in the decision trees below.**

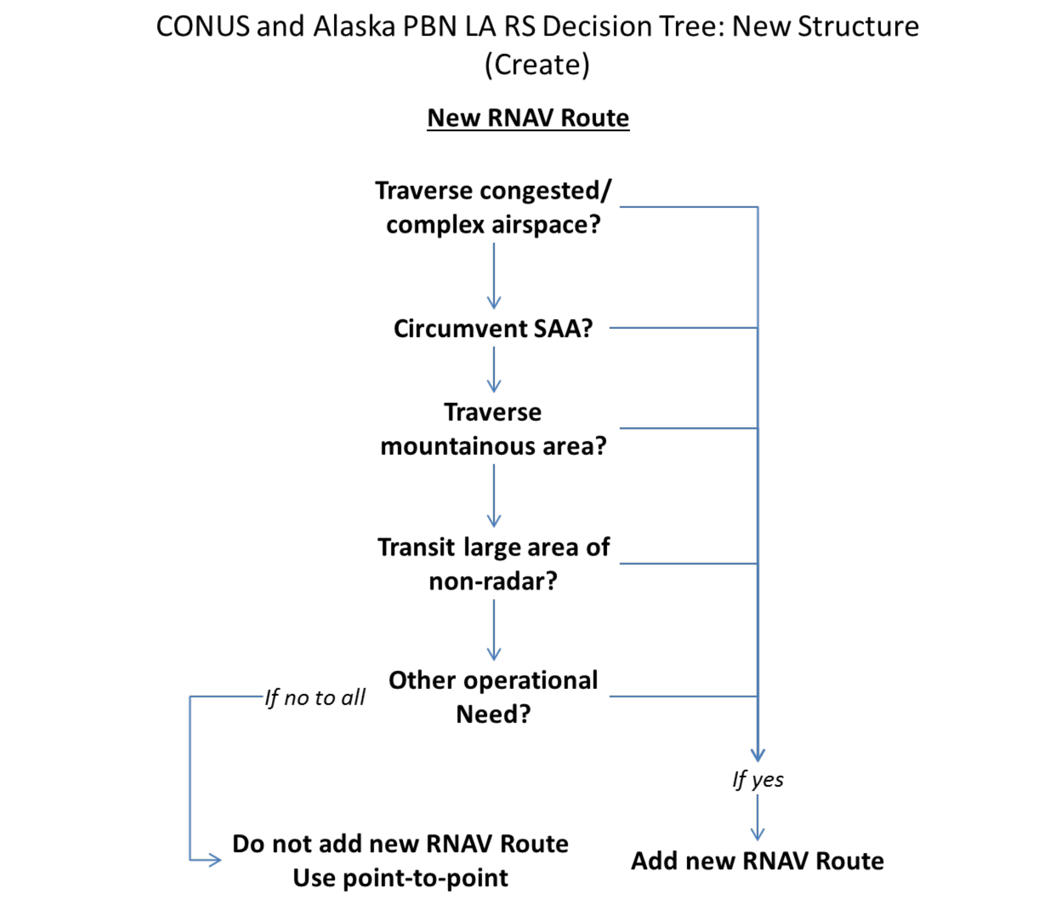

Figure 12 Decision Tree for Evaluating New Routes

New structure case studies

- **Traverse congested/complex airspace**

Routes through a busy terminal area or complicated airspace provide efficiency and value. One example is T-319 which was created to provide "routing through, around and over the busy Atlanta terminal airspace," according to the FAA's Final Rule. Another example is T-261 which transits San Francisco and Oakland airspace, providing efficient access to general aviation airports in the southern area of the Bay.

- **Circumvent Special Activity Airspace (SAA)**

With a growing number of SAA in the NAS, providing efficient routes that circumvent military airspace, when active, and allow operations to proceed efficiently are important. An example is T-209 which was created in the Augusta, GA area "to assist pilots navigating around the Bulldog A Military Operations Area (MOA)," per an FAA Federal Register notice.

- **Traverse mountainous area**

Routes in mountainous areas have unique benefits as they allow aircraft to fly lower altitudes in areas where performance limitations can be a factor (high altitudes) and can allow aircraft to remain out of icing conditions. In 2016, Seattle Air Route Traffic Control Center (ARTCC) requested several T-Routes to transit the Cascade mountains to help general aviation remain clear of icing conditions.

- **Transit large area of non-radar**

Gaps in surveillance coverage occur most frequently at low altitudes. In an expansive area of non-radar in South Dakota, T-288 was established to facilitate efficient operations in an airspace previously rarely utilized. Although, there is not a high volume of traffic in the area, the complexities posed by the varied types of traffic, all using the same airspace, make the airways invaluable for separation.

- **Other operational need**

The Task Group expects there will always be unique situations where a route may have value but not be covered by one of the categories discussed above. For example, T-616 in rural Michigan was established “to accommodate route changes being made in Canadian airspace as part of Canada's Windsor-Toronto-Montreal (WTM) airspace redesign project,” per the FAA’s Final Rule. The Task Group believes international route harmonization is one of many important considerations that could fall under this criteria bucket. See CONUS Low Altitude Recommendation 39.

Another consideration that falls within this bucket is helicopter routes. Although there are only two TK-Routes in the NAS, these routes have considerable value for ATC and are utilized by helicopter operators. These routes should be the beginning of an expanded helicopter route structure, and helicopter routes should be considered valuable per the “other operational need” bucket.

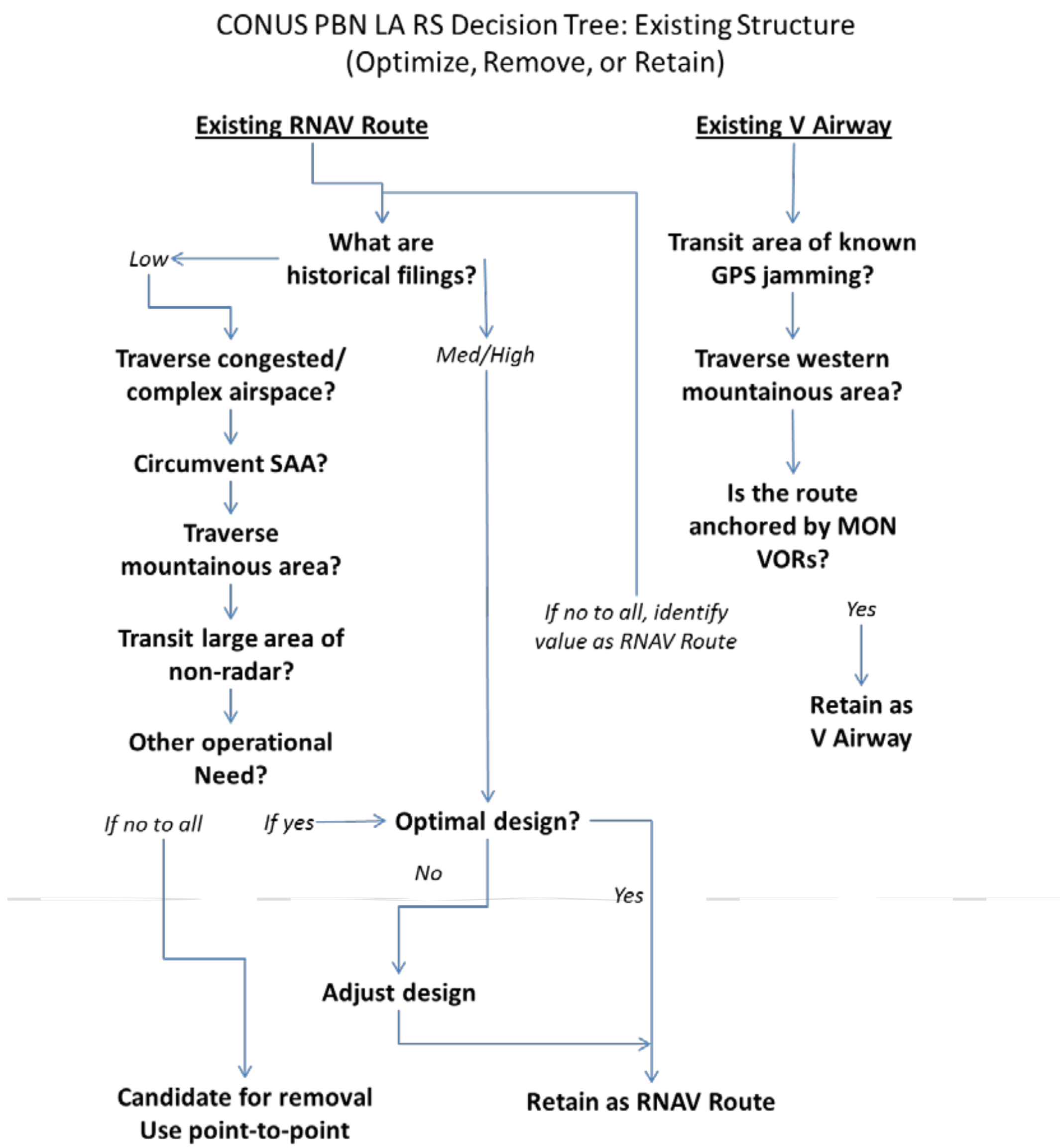

Figure 13 Decision Tree for Evaluating whether to Optimize, Remove or Retain Existing Route[13]

Existing structure case study

In 2016, the Brainerd VORTAC, located in Minnesota, was announced as scheduled for decommissioning due to a land lease issue. This decommissioning impacts several Victor Airways in an expansive non-radar area. Following the decision tree for these existing Victor Airways, one can determine the answer is “No” to all the Victor Airway specific questions and then move to identifying whether these routes may be of value as a T-Route, as this route is focused on fixed-wing aircraft.

[13] This Decision Tree is for CONUS only. Issues pertinent to Optimizing, Removing, or Retaining routes in Alaska are detailed in the Alaska section. See Alaska Low Altitude Recommendations 5 and 8 for further discussion on Victor and Colored Airways in Alaska.

The historical filings are assumed to be low due to this being a sparsely populated area of the US. One must now determine the value of the route by answering each of the five sub questions. The answer is "Yes" to the question regarding a large non-radar area. Minneapolis ARTCC has already requested rulemaking for new T-Routes to replace the Victor Airways impacted by the decommissioning of the Brainerd VORTAC. There would be a noticeable impact to efficiency should there be a lack of route structure in this area. The Brainerd VORTAC and the intersections along the Victor Airways will all become RNAV waypoints. The Brainerd example also highlights a successful engagement with local users as general aviation, flight schools, and local commercial operators were all involved in the route development.

Decision Tree considerations

- **Qualitative and quantitative input**

Like many existing routes, the utilization or flight plan filing numbers may be considered low; however, removing or modifying an existing route should not be determined solely based on quantitative data. Many less frequently used routes provide value, therefore it is important the qualitative analysis be applied, as provided in the Decision Tree. Later in this report, see CONUS Low Altitude Recommendation 37.

- **User and facility feedback**

It is important to solicit feedback from local users and air traffic facilities when considering removing route structure. Not all of the unique impacts can be identified without receiving local feedback. This can be accomplished through the Regional Airspace and Procedures Team (RAPT) and/or circularization process currently utilized by the VOR MON effort. Including industry during the creation and optimization process is also important. See CONUS Low Altitude Recommendation 35.

- **Replacing Victor Airways with T-Routes**

The FAA should avoid creating T-Routes that overlay existing Victor Airways which are being removed due to VOR MON. To get the full benefits of PBN, it is beneficial to avoid creating structure based solely on the legacy positioning of routes based on NAVAIDs. It is important an analysis is conducted to determine whether replacement structure is needed. However, should the FAA be limited by the number of T-Routes available, they should retain additional Victor Airways to provide a valued and cohesive route structure. See CONUS Low Altitude Recommendation 8.

- **The design process should include an assessment for whether a route has the lowest possible Minimum En route Altitude (MEA)**

As the FAA designs new routes and reviews existing routes, achieving the lowest possible MEA is an important part of the criteria for how that route is finally implemented. A low MEA is a high priority for low altitude operations. See CONUS Low Altitude Recommendation 17.

CONUS LOW ALTITUDE **Recommendation 3.**	**Future new low altitude routes in CONUS should solely be RNAV routes.**

The Task Group did not see a benefit in the creation of new Victor Airways in CONUS. The equipage statistics and trend support the PBN NAS Navigation concept. Implementing additional conventional routes would be counter to that strategy.

CONUS LOW ALTITUDE **Recommendation 4.**	**A new RNAV route should be implemented in conjunction with the removal of pre-existing routes.**

The FAA staff developing and maintaining routes have limited capacity, and the removal of many Victor Airways should assist in the long-term by allowing staff to focus on a consolidated route structure. However, many new RNAV routes, primarily T-Routes, will be needed in places where Victor Airways will be removed, and the new route should be implemented in conjunction with the removal of any preexisting route. Ensuring this process takes place in the correct order is important to the overall reduction of staff time, especially as it pertains to the mandatory environmental review process. Having both airways charted at the same time can also cause clutter issues and increase the overall workload for the FAA. The FAA should work to reduce the development time required for new routes.

The FAA should minimize the number of chart cycles a new RNAV route may be overlaid on a conventional route when the goal is for the conventional route to be removed. Having both airways charted at the same time can cause clutter issues. It would be beneficial to synchronize the conventional routes decommissioning with the activation date of the new RNAV route and thus have no overlap on the chart.

Resiliency

VORs are recognized to be the backup navigation source for low altitude operators should GPS become unavailable. For CONUS, the VOR MON is being enacted and is outside the scope of this group; however, the MON was continually validated through committee discussions and considered to be sufficient.

CONUS LOW ALTITUDE **Recommendation 5.**	**The FAA should more accurately define the impacts of GPS intentional interference events as they relate to real-time navigation, and improve the process of communicating the impacts of these events to internal and external stakeholders-- including providing interference advisories on the Notice to Airmen (NOTAM) Search website.**

The FAA should work to minimize the impacts of intentional GPS interference and should consider tasking the TOC to evaluate the existing process and provide recommendations. Real-time awareness of GPS service disruptions is critical to operational efficiency. The interference flight advisory notices are currently provided on the FAAST webpage, which is not a normal preflight resource. Pilots find the notices helpful as they include a graphic of where the interference impact is occurring; however, providing these notices on the NOTAM Search website and linking them to the applicable NOTAM will assist with pilot situational awareness when conducting preflight planning.

The current notification process results in a NOTAM that is applicable to large regions resulting in operator confusion as to how credible the NOTAM truly is. The FAA currently lacks the data to quantify the impact of predictable intentional GPS disruption on aircraft. As we transition to a satellite-based navigation and surveillance NAS, it is important these impacts are understood so that they can be mitigated and so operators can be better informed.

Reducing the impact size to a more finite area, one based on an increased likelihood, would be beneficial for operators. The FAA should conduct a study to determine if a smaller, more probable area of impact could be depicted, and should take action on the improvements proposed in the PBN NAS Navigation Strategy regarding communicating interference events. The FAA should make it a priority to protect the reliability and availability of GPS, especially at the low altitude levels.

Ultimately, large-scale events of GPS interference further discourage Automatic Dependent Surveillance-B (ADS-B) and GPS equipage.

CONUS Non-Directional Beacon (NDB) Airways

CONUS LOW ALTITUDE **Recommendation 6.**	**Colored Federal Airways should be transitioned out of the CONUS en route structure (excludes the Caribbean).**

The Performance Data Analysis and Reporting System (PDARS) data shows 99% of the utilization of several en route NDBs are navigated by RNAV capable aircraft. NDBs no longer serve a purpose as part of the CONUS en route infrastructure. With only a few airways based upon NDBs remaining in CONUS, and the PBN NAS Navigation Strategy to remove NDB approaches by 2025 and most NDB infrastructure by 2020, this Group did not see a benefit in the long-term retention of Colored Federal Airways. Additionally, other colored airways in CONUS, such as Atlantic Routes, no longer need to have NDBs as anchors; these anchors can be replaced with RNAV waypoints and the route transitioned to require RNAV capability.

Each existing Colored Federal Airway has unique benefit so each one was analyzed for specific recommendations. Two Colored Federal Airways remain in CONUS according to the JO 7400.9: G-13 in NC and B-9 in FL.

- G-13 should be replaced by extending T-243 and turning Manteo NDB (MQI) into an RNAV waypoint.
- B-9 should be replaced by a T-Route due to its importance for general aviation access to the Florida Keys. It is important the existing low MEA is retained.

CONUS LOW ALTITUDE **Recommendation 7.**	**While international NDB airways will remain in the CONUS, the FAA should ensure these airways are maintained.**

Certain NDB airways that transit CONUS airspace may not comply with US Standards for Terminal Instrument Procedures (TERPS) or ICAO Procedures for Air Navigation Services – Aircraft Operations

(PANS OPS) criteria. For example, B-646[14] may be impacted by an obstruction that could require the MEA to be considerably higher; however, it appears to have an artificially low MEA. The low MEA makes it particularly valuable to operators but safety could be compromised. This airway should be replaced with an RNAV route that would span from Key West to Marathon and that would retain the colored airways' low MEA. It is important that these routes are periodically reviewed by the FAA office with oversight authority to ensure new obstacles are taken into account. In the case of B-646, Miami ARTCC is responsible for maintaining the route with the service center coordinating obstructions.

Number of Available RNAV Routes

CONUS LOW ALTITUDE **Recommendation 8.**	**The FAA needs to request a larger allocation of RNAV Routes.**

The US has been allocated 300 T-Routes by ICAO, and approximately 130 T-Routes are in place today. There will be an increasing need for low altitude RNAV routes during and after the PBN RS transition, so it is foreseeable that more than 300 unique routes will be necessary for the US. The existing number limitation should not be allowed to prevent the enactment of a route that would improve efficiency or safety for an area.

The current allotted amount of 150 TK-Routes will not be sufficient to meet the needs of the growing IFR helicopter community. Helicopter operators are an increasing user of the IFR system and need better infrastructure in order to achieve the full benefits of PBN. As the National Transportation Safety Board (NTSB) has stated, a more effective IFR system specific to helicopters would allow the Helicopter Air Ambulance (HAA) industry a safer environment in which to complete their critical mission. The Task Group echoes the NTSB's recommendation (see Safety Recommendation A-09-093 and A-09-94) and believes a robust helicopter route structure is necessary.

The FAA can obtain the greatest value from the number of routes currently allocated by using the same RNAV route identifier for several segments that may not necessarily be contiguous. Additionally, the FAA, should it become necessary, could retain certain Victor Airways when that airway segment is anchored by MON VORs and there is no availability of route designators to implement the preferred RNAV route.

Non-Radar

CONUS LOW ALTITUDE **Recommendation 9.**	**The FAA should identify the areas projected to lack surveillance coverage in 2025 and evaluate the benefit of expanding ADS-B coverage to surveil these areas.**

Expanding ADS-B surveillance coverage in remote areas would enhance the efficiency of the airspace by reducing the separation required between aircraft operating on point-to-point routings. Pilots would

[14] B-646 is a Bahamas route that goes through FAA controlled airspace. It is an international route; however, its construction and maintenance is still the FAA's responsibility.

save time, fuel, and money by flying point-to-point instead of an inefficient airway system that is predicated on ground-based NAVAIDs. This could ultimately lead to more operators recognizing the benefit of equipping with PBN equipment and ADS-B. The greater accuracy of ADS-B surveillance will contribute to better search and rescue. Additional benefits of ADS-B apply to helicopters, see Recommendation 33.

Case study

There are numerous gaps in radar and ADS-B surveillance in the Powder River Training Complex area of North and South Dakota. For example, ADS-B coverage is not available at the MIA or MEA north of Rapid City, SD in the vicinity of the Powder River Training Complex. Increasing surveillance coverage to lower altitudes in this area would increase the efficiency of point-to-point operations by allowing the use of radar separation as opposed to the use of non-radar separation, as well as the through put of the routes in that area, such as V120.

CONUS LOW ALTITUDE Recommendation 10.	**The FAA should solicit industry input into the Airport Surveillance Radar (ASR) decommissioning CONOPs.**

The FAA Surveillance and Broadcast Services (SBS) program office is considering decommissioning more than 80% of terminal radars in CONUS as ADS-B equipage increases. Removing legacy radar systems will impact the surveillance coverage in many of the areas where ADS-B equipage may be limited, such as areas not near Class B or C airspace in CONUS. It is foreseeable many aircraft in remote areas will not be equipped with ADS-B so there would be an increase in non-radar operations, and in inefficiency, should the ASR be decommissioned. Once the FAA drafts the decommissioning CONOPs, industry should be involved in its validation.

NAVAID sustainment plan

CONUS LOW ALTITUDE Recommendation 11.	**The FAA should ensure there is a long-term, funded sustainment plan for those NAVAIDs determined to be integral to the NAS.**

VORs, TACANs, and Distance Measuring Equipment (DMEs) will remain key components of the resiliency and navigation structure and they should be maintained with a high degree of availability. The average age for 94% of VORs and 100% of TACANs is over 30 years old; however, the FAA lacks a long-term sustainment plan for these critical NAVAIDs. Sustaining the navigation infrastructure on which the remaining route system is based upon is critical.

CONUS LOW ALTITUDE Recommendation 12.	**The FAA should consider the MON needing to be in place beyond 2045 so must put in place an infrastructure recapitalization plan.**

Cannibalizing parts from VORs being decommissioned to sustain other equally old systems should be a short-term plan, not long-term. There is not a foreseeable resiliency plan for the majority of aircraft which is affordable and effective beyond the VOR system that currently exists. Hence, the MON is likely to be necessary for many years.

Point-to-Point Navigation Strategy

The Committee reviewed all available equipage and operations data, and various general aviation pilots' surveys to understand how pilots file and fly below FL180. The results indicate overwhelmingly that pilots have embraced point-to-point flying and PBN equipage. The Committee endorses the concept of limiting route structure to only those areas where it would be of value, as indicated by the recommendations, and promoting point-to-point in all areas of the NAS that can support it.

Waypoint System

CONUS LOW ALTITUDE **Recommendation 13.**	**For those VOR MON NAVAIDs that are decommissioned and those airways that are correspondingly removed, create an RNAV waypoint at the previous NAVAID location and retain all fixes and intersections along that route currently in place by amending their definition to that of an RNAV waypoint.**

With the removal of much of the route structure and their defining waypoints, there will be a gap in how pilots can navigate and how they communicate their route to ATC unless a waypoint system remains. This effort is already being implemented by the MON Program Management Office (PMO) as part of their draw down effort and should be sustained. The Task Group concluded that where waypoints are needed today, they will be needed during the transition to the PBN RS. Without the retention of these waypoints, the VOR MON would cause an increasing amount of inefficiency in navigation and communication. For those VOR MON NAVAIDs that are decommissioned and those airways that are correspondingly removed, create an RNAV waypoint at the previous NAVAID location and retain all fixes and intersections along that route currently in place by amending their definition to that of an RNAV waypoint.

CONUS LOW ALTITUDE **Recommendation 14.**	**The FAA should: (a) retain the existing five letter pronounceable name for the conventional intersections/fixes that are transitioned to RNAV waypoints; (b) if no NAVAID is to be retained, create an RNAV waypoint at that same lat/long and evaluate utilizing a five letter pronounceable name that is related to the NAVAIDs original name; and (c) if the DME is retained, continue to utilize its three letter identifier.**

Low altitude operations will continue to be heavily dependent on radio communications so retaining pronounceable waypoint names is critical to efficient communication. The name of a decommissioned NAVAID should be used for its five letter pronounceable name as part of becoming solely an RNAV waypoint. For example, the Patuxent VORTAC (PXT) is being decommissioned and, should the DME not be a retained, a new RNAV waypoint named PTXNT could be effective.

The committee did not see any value in the Navigation Reference System (NRS) waypoint grid system being extended below FL180. Pronounceable names are important to low altitude operations and the NRS system could cause considerable educational and operational issues.

CONUS LOW ALTITUDE **Recommendation 15.**	**There needs to be a defined process for users and local air traffic facilities to request new waypoints or request removal of unnecessary waypoints.**

The FAA should modify the IFP Information Gateway to allow users a simplified process to submit requests for new waypoints. There must also be a process for local air traffic facilities to be able to request the removal of underutilized or redundant waypoints. The Task Group considered the local air traffic facility the best source for waypoint removal given their understanding of utilization and value.

Class G Airspace

CONUS LOW ALTITUDE Recommendation 16.	In order to accommodate the expansion of point-to-point operations, the FAA should evaluate all airspace above 1,200' AGL for establishment of Class E airspace.

The FAA should proceed to rulemaking and provide justification for the effective removal of uncontrolled airspace in any area deemed to be of value; however, the safety benefits for the IFR operator conducting point-to-point through an area of controlled airspace was deemed to outweigh any negative impacts to those operators who need the weather requirement flexibility offered by uncontrolled airspace. Positive impacts of expansion of Class E above 1,200' AGL, where justified, include separation services by ATC, vector capability by ATC, and reduction of MIAs in those areas.

Allowing point-to-point flight in uncontrolled airspace above 1,200' AGL can result in ATC not providing traffic separation services to aircraft under their control, pilots not being told when entering or exiting this area, and ATC unable to vector a pilot unless requested. It would increase efficiency and safety to replace high altitude Class G airspace with Class E airspace in areas beneficial for point-to-point flight.

Providing Lowest Altitude for IFR navigation

Pilots need to know how low they can fly in a given area. This is particularly important during icing conditions and in areas of high elevation where aircraft performance limitations can be a factor. This information is currently communicated to a pilot via the MEA of an airway. Pilots can reference crossing or adjacent airways to get a picture of what en route altitude they can expect. However, with the removal of many routes and the greater occurrence of point-to-point navigation, there is a gap in providing the lowest usable en route altitude to pilots. Many of the recommendations that follow relate to the need to enhance information for pilots concerning the lowest altitude for IFR navigation.

CONUS LOW ALTITUDE Recommendation 17.	The FAA needs to ensure MEAs are established with an emphasis on providing the lowest possible altitude with consistency across the NAS.

Ensuring we are obtaining all the benefits from an existing and future route structure is critical for efficient operations. Several airways exist today with higher MEAs than necessary due to an inefficient design. It is important operators see the benefit in equipping with PBN, so improving older RNAV routes with MEAs that match or are lower than the conventional route is important.

Normally an air traffic facility or operator requests a route with flight procedure designers who conduct a feasibility study to evaluate that request. These user requests are not always stated in the most advantageous manner; however, flight procedure designers do not always feel it is within their authority to diverge from the request to provide a more effective route. The FAA needs to ensure route developers are empowered to work directly with the proponent to design a final product that has efficient routing in terms of flight miles and MEA. This flexibility is key to future route structure supporting user needs.

The Task Group analyzed several areas of MEA inconsistences and learned that in most cases the peculiarities were the result of newer criteria not being applied to an existing route. This newer criteria should be applied to routes as part of the four-year periodic review; however, largely due to increasing workload, the reviews are not evaluating the routes for compliance with all existing criteria. It is important route design policy be consistently applied to ensure pilots are provided the lowest MEAs that maintain safety.

As navigation and automation technology advance, design criteria should be correspondingly updated. The FAA should strive to provide lower MEAs based on the best technology available.

Case studies

In Alaska, T-222 (BET to MCG) underlies V-480 but the RNAV route has a higher MEA than the conventional route. Due to T-222's legal description having no waypoints along a 220 NM stretch, there is no opportunity for segmentation to mitigate obstacles. When evaluating this route between Aniak and ZIDMU, the controlling obstacle results in a much higher MEA than otherwise would be necessary if the T-Route was doglegged by just 1 NM north or if this route had additional segments.

Helicopter routes need to be at altitudes that reduce the impact of icing. LifeFlight of Maine has established a statewide system of PINS (point in space approach and departure procedures) linked to a route structure traversing the state with feeder segments from the islands and western mountains. The system links rural hospitals, communities, and islands with the Maine's three major trauma medical centers with extension into Boston. In the absence of ADS-B to the ground and in order to maintain ATC radar coverage, the primary route structures are at elevations in which icing significantly limits the potential use of the routes. An example is the NR06 Route linking Northern Maine Medical Center in Fort Kent (47.2587° N, 68.5895° W) with the trauma center in Bangor. At 3400' altitude this is the highest route in the Northeastern section of LifeFlight's procedures. Other primary routes have similar icing impacted elevations with 2900' as the highest in the Southern part of the state and 4700' altitude in in the Northwest section. Lower MEA's with adequate surveillance would significantly improve air medical services to rural communities.

CONUS LOW ALTITUDE **Recommendation 18.**	**The FAA should update policy to remove the notice of proposed rulemaking requirement for ATS routes in the en route domain, as recommended in the PBN NAS Navigation Strategy.**

A frequently cited concern and barrier to improving older route MEAs is workload. Enabling a reduction in the MEA of many routes would require lengthy rulemaking that currently takes over 6 months. Removing the rulemaking requirement would allow efficient modifications to existing routes and the swifter enactment of new routes. The FAA must consider how the environmental evaluation of a low altitude route would be able to proceed efficiently should the rulemaking component be altered or removed.

OROCA not for Navigation

CONUS LOW ALTITUDE **Recommendation 19.**	**The FAA should remove the Off Route Obstruction Clearance Altitude (OROCA) from IFR en route charts and replace with a Grid Minimum IFR Altitude (MIA) that can be used for off route RNAV navigation and that would assure a pilot compliance with Federal Aviation Regulation (FAR) 91.177. A Grid MIA should be provided for Alaska with dimensions of 1 degree of latitude by every 1 degree of longitude.**

The OROCA is depicted on en route IFR charts. However, this altitude does "not provide the pilot with an acceptable altitude for terrain and obstruction clearance for the purposes of off-route, random RNAV" according to the FAA's Instrument Procedure Handbook. The Grid MIA would consist of the OROCA grid square being retained. The highest applicable MIA in that grid square would replace the OROCA value. Utilizing a Grid MIA would allow the retention of many of the benefits of a route structure and would communicate to pilots an acceptable point-to-point minimum altitude. The benefits of utilizing a gird MIA include:

- It is similar to what ATC will clear aircraft for;
- It is what pilots should expect;
- Meets FAR 91.177 requirements (see NTSB A-98-081);
- Includes ROC reductions, i.e., can be 1,500' or 1,700' AGL in certain mountainous areas (precipitous terrain considered);
- Factors in controlled airspace (300' buffer – same as routes, see FAAO 8260.19, 3-3-2);
- Does not factor in radar surveillance;
- Does not factor in communication coverage;
- Incorporates low MEAs from existing routes (preserves benefits);
- Provided for all areas of the NAS (all ARTCCs);
- Very similar to OROCA;
- Can be used for off route navigation.

An example from Oakland ARTCC of what the Grid MIA would look like compared to the existing OROCA is depicted below. Each MIA sector altitude (in purple) is provided, the OROCA square is highlighted in thin red, the OROCA altitude is outlined in thick red and the Grid MIA altitude value (that would replace the OROCA altitude) in purple:

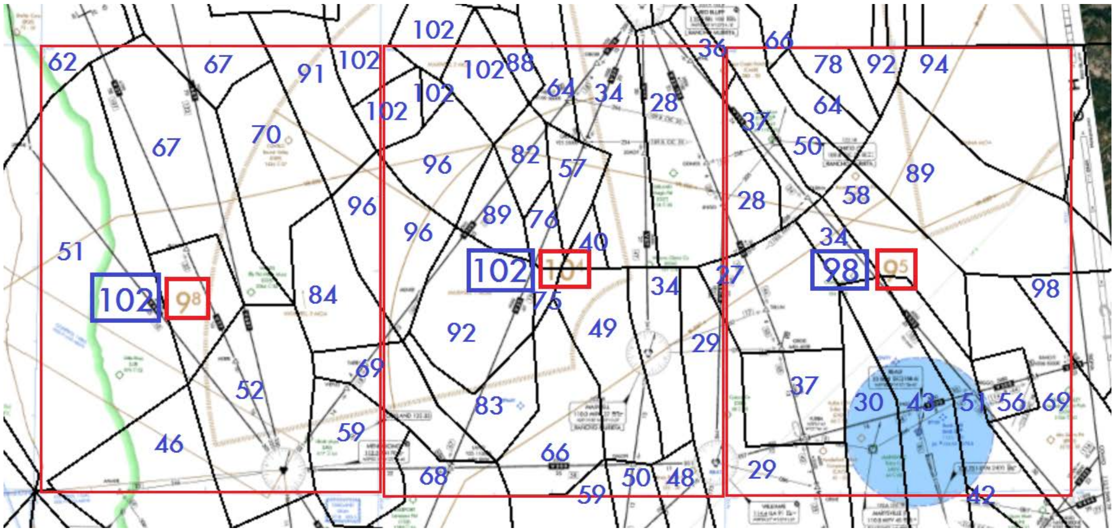

Figure 14 Example of Grid MIA Concept for Oakland ARTCC

Alaska has many isolated points of high terrain that, without the finer granularity of the Grid MIA size, would render grid squares to be inaccessible for piston-powered aircraft wishing to fly point-to-point IFR.

Below is an example from Anchorage ARTCC, comparing the Grid MIA concept to the existing OROCA.. Each MIA sector altitude is depicted in purple. The OROCA square is presented as a thin red line with the OROCA altitude values in red (located above the square adjacent to the highest MIA for each grid cell). The Grid MIA altitude that would replace the OROCA altitude is shown in blue, within the proposed smaller grid squares:

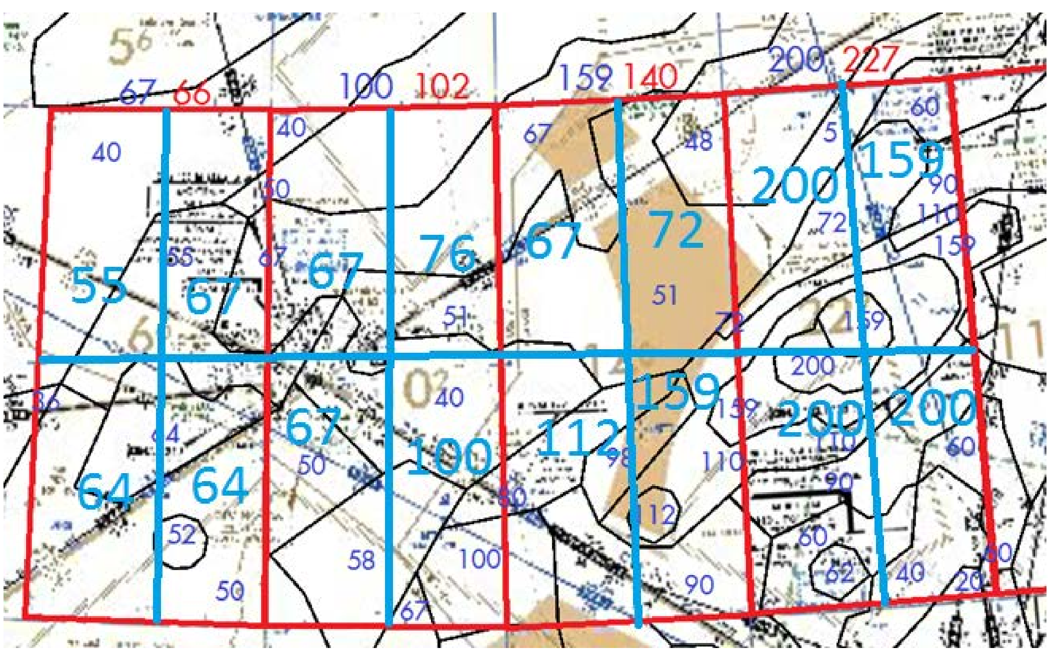

Figure 15 Example of Grid MIA Concept for Anchorage ARTCC

CONUS LOW ALTITUDE **Recommendation 20.**	**The FAA should provide georeferenced MIA/MVA data for all ARTCCs and Terminal Radar Approach Control Facilities (TRACONs).**

The FAA provides MIA/MVA (Minimum Vectoring Altitude) charts for some facilities in a manner not ingestible by industry automation (in PDF format today) and not georeferenced. Operators would benefit from georeferenced information as it would allow third parties to find innovative ways of providing that information to pilots via data driven charting. Providing this information for all facilities in Aeronautical Information Exchange Model (AIXM)/Geography Markup Language (GML) can help pilots anticipate what the lowest usable altitude may be for a specific flight path.

Education

There is confusion among the pilot community regarding route planning and flight plan filing when it comes to off-route flying. In many cases, pilots receive short cuts in flight based on their RNAV capability. In other airspace, a pilot may file point-to-point but be given a new route clearance requiring them to utilize a circuitous route structure. An effort is necessary to communicate to pilots what the expectation is for point-to-point flying versus using the route structure, particularly for general aviation pilots who normally develop and file their own route.

CONUS LOW ALTITUDE **Recommendation 21.**	**The FAA should evaluate whether the requirement to file a waypoint within 200 NMs of a preceding center's boundary is still necessary.**

The Aeronautical Information Manual (AIM) states in 5-1-8(d)(2)(f) that pilots filing RNAV flights must "file a minimum of one route description waypoint for each ARTCC through whose area the random route will be flown. These waypoints must be located within 200 NM of the preceding center's boundary." This requirement may have been necessary based on previous air traffic automation requirements which may no longer be applicable. The requirements provided in the AIM should be removed from pilot guidance, or modified to reflect current needs.

CONUS LOW ALTITUDE **Recommendation 22.**	**The FAA should publish best practices for point-to-point navigation in the Instrument Procedures Handbook and Instrument Flying Handbook to promote the culture shift to primarily random RNAV navigation.**

The current pilot literature is unclear on expectations and best practices for point-to-point filing. The Instrument Procedures Handbook and Instrument Flying Handbook are out dated and lacking guidance on off-route RNAV, and should educate pilots on the transition to a primarily PBN NAS.

An ATC issued reroute is likely if a pilot does not frequently fly in that area and is unfamiliar with what to expect. Pilots are unsure if they should file direct to destination, to an IAF, or to intermediate waypoints and, if so, how far apart. ATC expectations are inconsistent and difficult to anticipate. Clarifying these expectations in the Instrument Procedures Handbook and the Instrument Flying Handbook will improve pilot knowledge for point-to-point filing.

Additionally, the FAA needs to ensure consistency and clarity on requirements for random RNAV operations in non-radar environment. The surveillance requirement for non-radar random RNAV changed in 2014; however, primary instrument pilot guidance has not incorporated this change. It is important to keep information consistent and for there to be clarity between requirements in Alaska versus CONUS.

CONUS LOW ALTITUDE **Recommendation 23.**	**The FAA's guidance should be updated to encourage usage of the IFR system by helicopters in the NAS.**

The FAA should promote the safety benefits of IFR flying for helicopter operators and investigate ways to further operator acceptance. In order for helicopter operators to complete the challenging certification for IFR, utilize the IFR en route system and achieve the full benefits of PBN, the FAA must support the destination needs of this industry and promote the procedures available. Publishing a greater number of public Copter approaches and routes is critical to increasing operator utilization of the system.

CONUS LOW ALTITUDE **Recommendation 24.**	**The VOR MON reception altitude should be shown using an interactive map, such as Google Earth, similar to what is provided for ADS-B coverage to improve operator awareness of en route impact.**

With VOR MON guidance being added to the AIM in 2017, it would be beneficial to provide a graphical depiction of the expected VOR service volume/coverage. Pilots would find it useful to understand the MON's impact on VOR coverage. For example, a pilot may choose to fly into an area impacted by a GPS interference NOTAM as they were able to determine VOR coverage was acceptable for en route navigation, should their GPS become unusable.

CONUS LOW ALTITUDE **Recommendation 25.**	**The FAA should modify pilot test questions to emphasize off-route RNAV as this would assist with increasing pilot's knowledge and competency of these operations.**

The questions pilots encounter on knowledge tests are largely related to route structure and do not test pilots on the knowledge required for modern off-route en route operations.

CONUS LOW ALTITUDE **Recommendation 26.**	**The FAA should promote the purpose and availability of the Instrument Flight Procedures Information Gateway.**

From an Alaska Airmens Association (AAA)/Aircraft Owners and Pilots Association (AOPA) survey, it was clear over 80% of Alaskan general aviation pilots were not aware of the IFP Gateway. It is likely awareness in CONUS is similarly poor. The FAA should promote this communication link between users, who can use the IFP Gateway to define their needs, and the procedure developers responsible for evaluating those requests.

Part 95 Mountainous Areas Definition

CONUS LOW ALTITUDE **Recommendation 27.**	**The FAA should conduct a study of all existing Part 95 designated mountainous areas to determine if these areas can be reduced in size. This study should include industry participation.**

The definition for mountainous areas in Part 95 is overly conservative and does not reflect the advanced navigation technology available today which could allow a safe reduction in their size. The FAA should investigate the safety implications of improving the granularity of these areas (reducing areas designated as mountainous) while exploring the benefits of refining the definitions to allow lower MIAs/MEAs. Notably, the VOR MON program office identified the removal of several routes in the Western US Mountainous Area after determining those areas were relatively flat and the route's removal would not impact operators. For example, many areas of Nevada are flat.

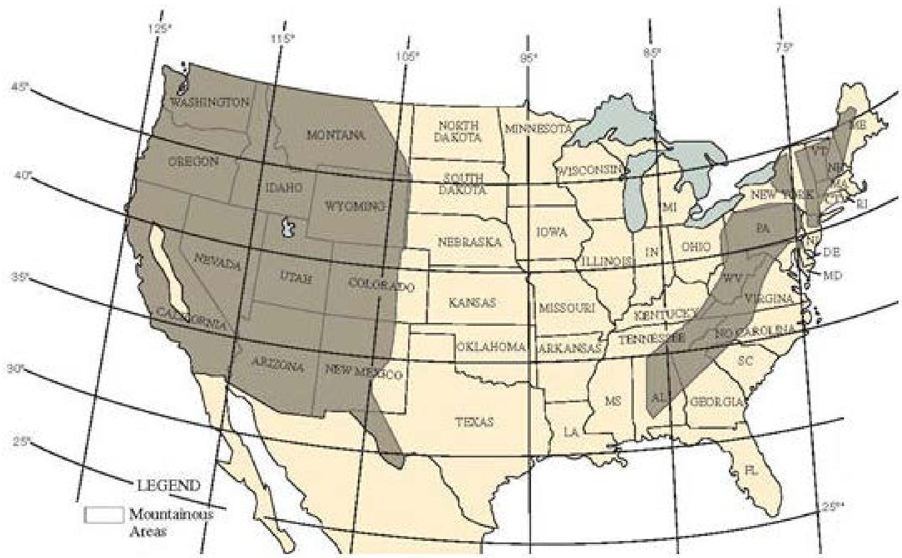

Figure 16 Designated Mountainous Areas in the CONUS

Higher quality digital elevation data is now available for Alaska. Modern analytical methods should allow increased spatial detail to identify and outline low-relief areas where reduced Required Obstacle Clearance (ROC) may be used to generate lower MEAs to help keep aircraft out of icing conditions. The FAA should revise their method of determining Part 95 mountainous areas to increase the percentage of non-mountainous areas, which impact the design of airways and FAR 91.177 altitude requirements.

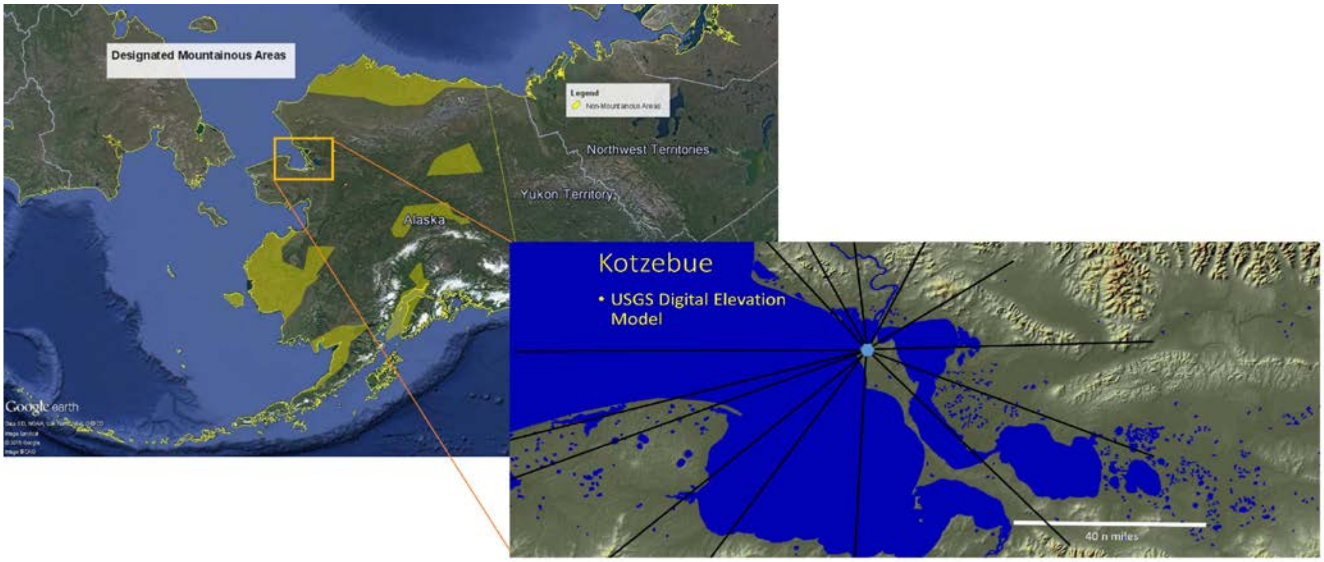

Figure 17 Most of Alaska is designated as Mountainous Areas but significant areas, such as around Kotzebue, are relatively low relief.

Charting Shutdown NAVAIDs

CONUS LOW ALTITUDE Recommendation 28.	The FAA should chart all NAVAIDs that are permanently out of service with the crosshatched pattern to indicate shutdown status.

NOTAMs are frequently published that indicate a permanently decommissioned or out-of-service NAVAID. However, the FAA fails to indicate the intermediate phase on the aeronautical chart prior to decommissioning, when the NAVAID is removed from the chart.. A shutdown NAVAID is charted with crosshatches covering the frequency. Providing this visual indication that the NAVAID is unavailable for conventional navigation is important to supporting safe en route navigation. Shutdown status does not change the procedures tied to the NAVAID or utility of the NAVAID, but it does remove the NOTAM and changes how the NAVAID is charted.

Case study

A NAVAID that exemplifies this issue is the Lansing VORTAC (LAN) which has been out of service since September 20, 2010, or over six years. Through coordination with the applicable Service Center and the Aeronautical Information Service, the National Airspace System Resource (NASR) entry was correctly updated to indicate shutdown status for the November 10, 2016 charting cycle. Correctly charting the NAVAID's operational status allows a NOTAM to be removed, increased visibility of the NAVAID's unavailability for pilots not using RNAV, providing an instant indication that the NAVAID is only usable as an RNAV fix.

Alternatives to the Proposed Approach for Design and Implementation

Helicopter Considerations

CONUS LOW ALTITUDE **Recommendation 29.**	**The FAA should have a unified, national approach to develop and implement public RNAV routes that meet the needs of the helicopter community.**

Although point-to-point navigation occurs frequently for helicopter operators, there is an increasing demand for RNAV routes within this demographic given the need to fly at low altitudes, in congested airspace, and often to off-airport destinations. The demand for helicopter routes may not be fully appreciated by the FAA, given the routine nature of helicopter routes designed via third parties and as special (non-public) procedures.

Newly certified helicopter routes should take advantage of the advanced capabilities of IFR equipped helicopters in that local area, and should be designed with lower MEAs than otherwise would be available with T-Routes, where possible. It is important for the FAA to develop this strategy in partnership with the helicopter community. The development of each unique route should include helicopter operators and air traffic engagement.

Below are several factors that increase the value and utility of a route for rotary wing:

- Lower MEA;
- Connectivity to terminal (or intended destination) procedures (Point-in-Space approaches);
- Allows ATC to support helicopter operations more efficiently, eliminating potential confusion for both pilots and controllers;
- Supports enhanced use of helicopters for critical operations (HAA, disaster response, etc.);
- Allows ingress and egress sequencing of congested airspace with minimal delay.

When undergoing route development specific to helicopters, the FAA should evaluate the necessity of community outreach and education regarding noise. Noise continues to be one of the most vocal issues for members of a local community that oppose helicopter routes. It is important to ensure the local communities are involved in the route design process to mitigate noise concerns. Local education of the community should include explaining to the public that the the route will provide a greater capability for the HAA operators. The FAA should reference the NextGen Advisory Committee (NAC) Community Engagement approach.

CONUS LOW ALTITUDE **Recommendation 30.**	**The FAA should establish an initiative to promote their ability to conduct helicopter route construction including automation to handle those requests efficiently.**

This initiative should receive adequate staffing and prioritization by the FAA (i.e., Flight Procedures) so the development time is similar to or less than that of any other route. FAA automation needs to be modernized to allow the application of helicopter-specific criteria. The safety benefits are numerous and operators clearly see a value based on the number of special routes currently in use. The FAA should add a helicopter category within the Instrument Flight Procedures Information Gateway for routes.

CONUS LOW ALTITUDE Recommendation 31.	**The FAA should initiate a demonstration project implementing an RNP 0.3 helicopter route.**

The FAA should design and implement a helicopter route system that based on Required Navigational Performance (RNP) 0.3 navigation performance requirements. Routes should be designed with the goals of: (a) improving rotary wing access to congested city centers and critical areas (hospitals, heliports, etc); (b) having as low an MEA as possible; and (c) improving air traffic services available to IFR helicopters. The demonstration project should focus on resolving the issues related to a helicopter-only RNP 0.3 routes, including: charting considerations, ICAO route identifier, and operator acceptance.

In the spring of 2017, the FAA initiated a demonstration helicopter route project in partnership with the Maryland State Police and the Potomac TRACON. The routes are RNP 0.3 and wholly contained within Potomac's airspace sectors. This committee strongly supports this initial project and believes it should be expanded and the lessons learned (and best practices) be leveraged for future helicopter route development.

CONUS LOW ALTITUDE Recommendation 32.	**The FAA should initiate a program to assume the ongoing maintenance requirements for public-use and special (privately developed) helicopter routes.**

In order for the FAA to assume the responsibility for these routes and for them to be public, the routes must: (a) meet the FAA's criteria for a TK-Route, T-Route, or new criteria yet to be established (for example, RNP 0.3 helicopter route); (b) be considered beneficial to the public (i.e., would be utilized by HAA operations and/or multiple commercial and private operators); and (c) would improve the ability for additional helicopters to use the IFR en route system. The FAA should conduct outreach on this voluntary program with all special route developers, sponsors, and maintainers. The FAA should ensure the benefits of participating in the program are advertised; however, it is understood some operators may not participate given the proprietary nature of specific routes. These public-use routes would then be charted, available to the public, and the FAA would be responsible for future associated costs to maintain them.

Figure 18 Example of privately developed Special Route that provides connectivity with Point-in-Space instrument approaches. Courtesy of LifeFlight of Maine.

CONUS LOW ALTITUDE **Recommendation 33.**	**In areas with high potential for IFR helicopter operations, the FAA should establish (a) additional ADS-B radio stations to enable surveillance coverage to altitudes equal to that of the controller MIA/MVA and (b) radio sites where reception issues regularly require the helicopter to operate above MIA/MVA.**

Echoing previous NTSB recommendations, increasing helicopter IFR operations requires an investment and expansion in the infrastructure necessary to support them. The FAA should identify those areas that would benefit from increased surveillance coverage and evaluate expanding coverage in these areas. Expanding ADS-B surveillance should be a key initiative given it supports PBN operations and greater coverage would improve operator acceptance.

Communication should be improved to at least that of FAR 91.177, Minimum Altitudes for IFR Operations, in areas where helicopters frequently operate. Requiring helicopters to fly at higher altitudes puts them at greater risk for icing and outside of their usual altitude range. Ensuring communications with helicopters are continuously available at the MIA/MVA in high traffic areas supports the helicopter community's needs.

An example of where ADS-B surveillance was improved specifically for helicopters was in the Gulf of Mexico[15]. Before ADS-B, helicopters operated in its own 20-by-20 mile airspace grid during periods of low visibility. With ADS-B, helicopter operators substantially increased the number of flights conducted on IFR flight plans with pre-ADS-B filings going from about 1,500 a year to almost 20,000 for one large

[15] See https://www.faa.gov/nextgen/library/media/getsmart_gomex.pdf for additional detail on this case study.

Gulf helicopter operator when surveillance was implemented. The ADS-B surveillance capability allowed increased en route efficiency[16] for the helicopter operators and has increased the safety of the operations. Surveillance in the Gulf has also greatly increased ADS-B equipage rates locally.

Over 47 million Americans in rural areas depend on medical helicopters for access to time sensitive trauma, cardiac, and stroke care. ADS-B coverage at the ground to 500' AGL is significantly lower in rural and mountainous regions than in more urban centers. These same areas also present challenges to coverage by ATC ground based radars. As examples, in the urban northeast over 50% of the land mass of Vermont, New Hampshire and Maine is not covered by ADS-B at 500'. Effective ADS-B surveillance is critical to helicopter IFR operations to maintain working altitudes below icing.

Caribbean & Hawaii

Although the Caribbean and Hawaii were included as part of the CONUS Low Altitude Task Group, additional study and local engagement is needed to fully account for the operators needs during the transition to 2025 and beyond. The Task Group made some initial conclusions and general observations that we believe the FAA should consider as they look at the routes in these locations and work to develop a complete CONOPs.

- **Local operator and air traffic facility input is needed when drafting the Caribbean and Hawaii section of the PBN RS CONOPs.**

The Task Group supports not removing conventional routes until evaluating the RNAV equipage levels and local support for structure removal. Hawaii and the Caribbean are in the scope of the PBN RS CONOPs, but they have unique local peculiarities that make a national policy difficult to apply, similar to Alaska. Removing, replacing, or modifying routes in these locations would best be conducted with greater local input than what would occur in CONUS.

- **The Task Group validated and urges the FAA to implement the "Recommendations to Improve Operations in the Caribbean" TOC report.**

Key areas of the Caribbean TOC report that impact low altitude operations include:

  - Need for increased ADS-B coverage – additional ADS-B radio stations are needed to improve surveillance and reduce areas of non-radar;
  - Improvements for communications coverage – additional radio stations are needed to improve communication coverage;
  - Effective information sharing between facilities and Air Navigation Service Providers (ANSPs) – efficient operations between air traffic facilities is important for en route operations.

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[16] The July 2013 Volpe report, "Fuel Consumption of ADS-B and non-ADS-B Helicopter Operations in the Gulf of Mexico," documents the efficiency and fuel savings gained by improved IFR operations in the Gulf which was made possible by ADS-B.

- **Implement RNAV routes that meet low-altitude operators needs with consideration to direct paths between major city pairs and routes that allow island hopping.**

Developing a PBN route structure for offshore operations would increase operator acceptance and equipage in these areas. Several MEA inconsistencies were identified in the Caribbean where the conventional route had a lower MEA than the RNAV route which could impact the RNAV route's utilization. Additionally, controlled airspace started at higher altitudes in many areas that adversely impacted route MEAs. The FAA should work to update existing routes as part of any route expansion project.

CONUS LOW ALTITUDE **Recommendation 34.**	**Add GNSS MEAs to existing conventional routes and evaluate user demand for RNAV-only routes.**

Hawaii noticeably has no RNAV routes or GNSS based MEAs and the Caribbean has many conventional routes that lack GNSS MEAs. Providing GNSS MEAs on existing airways could facilitate lower en route altitudes given NAVAID reception coverage would not be a factor.

Improvements to Implementation Process

CONUS LOW ALTITUDE **Recommendation 35.**	**The FAA should make several improvements to the JO 7100.41 process to better capture low altitude operator input.**

Recommendations include:

- The Order needs to better discuss soliciting the general aviation perspective and inclusion in Full Work Group;
- Lead Industry Representative for low altitude RNAV Routes should have a focus on general aviation;
- Incorporate "FAA and Industry Partners Roles and Responsibilities in Achieving PBN Navigation Goals" document;
- Proponent must be kept in the loop and provided feedback during the process, including if initial analysis indicates not to proceed;
- The FAA should reach out to national general aviation associations (such as the National Business Aviation Association [NBAA], AOPA, Helicopter Association International [HAI]) and regional associations (such as AAA and Alaska Air Carriers Association [AACA]) to solicit local operators input (flight schools, Part 135, etc.) when it comes to Full Work Group.

CONUS LOW ALTITUDE **Recommendation 36.**	**The FAA should support an increase in the number of PBN co-leads.**

There is a multi-year delay for the development and implementation of new routes, largely due to an expanding workload for a finite number of people. In order to facilitate an effective transition to a PBN Route Structure, the FAA should invest in additional PBN co-leads to reduce the production timeline. Additional chokepoints exist in the process and should be addressed by the FAA in an effort to reduce the development timeline.

Post-CONOPs Route Implementation

CONUS LOW ALTITUDE **Recommendation 37.**	**FAA prioritization of route development should include factors such as propensity for icing, alternate forms of access, etc., and not solely driven by usage.**

When prioritizing route development, the FAA needs to consider aspects in addition to utilization numbers, such as the values identified by the decision tree, and local considerations including the propensity for icing conditions. Although a route may have little utilization, it could provide key access for a local community, including supporting medivac services.

CONUS LOW ALTITUDE **Recommendation 38.**	**The Instrument Flight Procedures Information Gateway should be better tailored to route submittals.**

The IFP Gateway lacks an intuitive layout for users making a route request. As this is the primary interface for the public, the FAA should ensure entering a route request via this website is a straightforward process.

Connecting with International Route Structure

CONUS LOW ALTITUDE **Recommendation 39.**	**The FAA should interconnect RNAV routes with adjoining ANSPs where beneficial.**

Providing international connectivity supports harmonization and continuity for cross-border operations. One example is decommissioning of the DKK VORTAC, which prompted a US-Canada effort to create over 20 T-Routes.

Special Activity Airspace (SAA) and Letters of Agreement (LOA)

All areas of the NAS are impacted by SAA with low altitude operations particularly impacted by the large numbers of SAA below FL180. Each SAA effectively becomes a barrier to efficient point-to-point navigation. Given the need for and utilization of SAA will not diminish for the foreseeable future, it is important more detailed and timely information is provided to operators so they can both adequately plan and adjust operations in real time to reduce the negative impacts. Likewise, making air traffic facility LOAs publicly available will improve transparency and elevate pilot understanding of constraints to en route navigation, which are not always apparent.

SAA

CONUS LOW ALTITUDE **Recommendation 40.**	**Real time SAA status must be made available and provided to operators in a variety of ways, including directly to pilots by NOTAM Search, in a manner ingestible by industry via System Wide Information Management (SWIM), to Flight Service, and via Flight Information Services-Broadcast (FIS-B).**

As part of Aeronautical Information Management Modernization (AIMM) Segment III, the FAA is working to provide real-time SAA status. Providing real-time information requires clear communication between

ATC, airspace schedulers, and automation that facilitate communication of the information to users. SAA accounts for many of the barriers to point-to-point efficiency for low altitude operators. Providing a greater awareness of those barriers will improve efficiency.

The FAA should consolidate the information on the graphical Special Use Airspace (SUA) website into the NOTAM Search website. Reducing the number of places pilots need to visit in order to receive a thorough preflight briefing will improve the visibility of this information. Much of the SUA website is based on NOTAMs so it should fit within the scope of the NOTAM Search website.

Making real-time SAA status available to third party providers is important in empowering them to ingest the data and create innovative solutions that display the airspace status for users. SWIM is the industry accepted standard for how that information should be provided.

Many low altitude operators rely on Flight Service for inflight updates; however, real-time SAA status remains one of the key pieces of information only ATC has. Providing SAA status to low altitude focused resources, i.e., Flight Service and FIS-B, pilots will be empowered with the information to make their own decisions and frequency congestion will be reduced. Advanced awareness of SAA status along route of flight is important as a lack of awareness can result in lengthier reroutes and inefficiency.

Where possible, SAA status and coordination information should be directly communicated to civil aviation users from military range controls to allow direct communication by telephone and radio on a real-time basis. This is presently utilized in the Joint Pacific Alaska Range Complex (JPARC) airspace in Alaska to facilitate deconfliction and access either to aid obtaining an IFR clearance from the FAA, or to proceed VFR when appropriate. This allows coordination at a finer time scale than ATC scheduling normally supports, and allows increased situational awareness for all users of the airspaces involved.

LOAs/SOPs

CONUS LOW ALTITUDE Recommendation 41.	**The FAA should provide ATC LOAs/SOPs on the NOTAM Search website and make them available in a manner ingestible by industry.**

Air traffic LOAs and SOPs provide important information and insight for all pilots; however, they are not publicly available. Publishing this information on the NOTAM Search website, which is becoming a one-stop shop for key aeronautical information beyond solely providing NOTAMs or Letters to Airmen, allows a consolidation of aeronautical websites and increased visibility of this information. Providing this information is related to the goals of the FAA's External Data Access initiative.

When providing the air traffic LOAs and SOPs, it is important the data is in a format that is ingestible by automation to allow key details to be quickly identified. For example, html format allows automation to parse the information; however, a scan of the document in PDF format will not allow parsing. This information could be provided via an online database or via SWIM.

Once available, the information contained within each document could be manipulated by third parties and lead to innovative methods of displaying a known constraint to an operator. For example, an alert could appear telling a pilot an air traffic altitude constraint based off the flight plan they are creating.

CONUS LOW ALTITUDE **Recommendation 42.**	**The FAA should provide greater visibility/advertising of unique SAA LOA requirements that facilitate relief for operators.**

In nearly all cases when new SAA is formed, there is the establishment of an LOA with the overlying FAA air traffic facility. These LOAs may contain approval to give civil operators preferences to the airspace, such as improved access when weather is IFR. However, these agreed upon reliefs are normally not well publicized or known even for local pilots. For example, in the VOLK SAA in WI, civil IFR arrivals are not to be delayed when IMC exists despite the MOA being active. This mitigation is not published except in the Record of Decision. Publicizing the specifics of these agreements in the Chart Supplement and on the NOTAM Search website are important steps to alerting pilots of what impact that SAA may have on their flight.

Additional Related Topics beyond Scope of PBN RS

Receipt of IFR Clearances via EFB/Cell

CONUS LOW ALTITUDE **Recommendation 43.**	**The FAA should evaluate an affordable solution for general aviation to receive IFR clearances via their mobile device.**

Datacomm solutions are focused on commercial operators and are cost prohibitive for many low altitude operators. General aviation accounts for more IFR operations than the airlines and the military; however, there has been a lack of recognition of what benefit datacomm could bring to low altitude operations. For example, over 15,000 IFR clearances are provided at non-pre-departure clearance towered airports and uncontrolled airports per day. Allowing pilots to receive a pre-departure clearance electronically could increase efficiency, reduce read-back/hear-back issues, and promote the benefits of embracing advanced technology in the cockpit.

More than 80% of pilots use a portable or mobile device for aviation so equipage costs would be minimal. A 2016 AOPA survey revealed 75% of pilots agreed they would find it operationally advantageous to receive their clearance for an IFR flight plan, on the ground at an uncontrolled airport, via communication with ATC using an App. The FAA should evaluate this type of solution initially for on the ground clearances and then evaluate inflight, en route clearance delivery via electronic means as well. Pilots, NATCA, and other stakeholders should be included in this study.

Figure 19 Screenshot from MITRE Prototype App for Electronic Transmission of Pre-Departure Clearances

CONUS Low Altitude Appendix A: Members of the PBN RS CONUS Low Altitude Task Group

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Recommendations for Alaska's PBN Low Altitude Route System[17]

Over 80% of Alaskan communities are not connected to the road network, and dependent on aviation for access to mail, food, medicine, and transportation. Alaska is the largest state in terms of size and its residents and businesses rely on aviation year-round to span the great distances that separate communities. Despite this state's reliance on aviation, it has a noticeably disjointed, aging, and insufficient en route infrastructure.

The majority of Alaskan operators have adopted satellite-based technology and wish for a modernizing of the Alaskan NAS to meet their PBN needs. In fact, most Alaskan operators indicated they routinely file and fly point-to-point. However, unlike CONUS, icing and mountainous terrain are the routine operating environment in Alaska, which necessitates an extensive route structure to accommodate non-radar operations and low operating altitudes. The desire of Alaskan operators is to transition away from reliance on legacy ground-based infrastructure and for the FAA to comprehensively tackle the barriers to achieving the efficiency PBN brings.

In an effort to comprehensively evaluate the infrastructure needs for Alaska, the Western Service Center formed the Alaska En Route Navigation Team (AkENT). The PBN RS Low Altitude Task Group evaluated the AkENT analysis completed thus far and worked alongside this group's subject matter experts to provide the following recommendations. The overview below provides context of where AkENT falls within the modernization effort of transitioning to a PBN NAS.

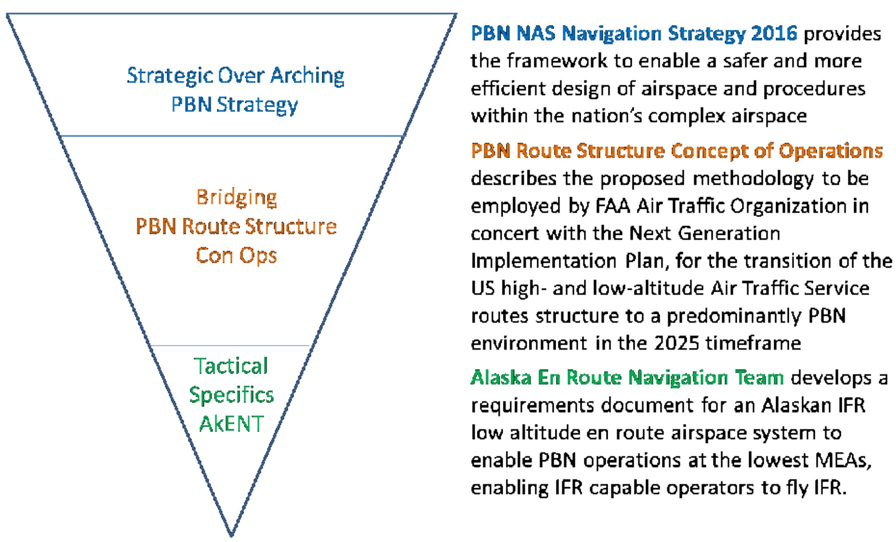

Figure 20 Relationship between NAS Navigation Strategy, PBN RS and AkENT

[17] Note that many rural communities in the CONUS have many of the same challenges as Alaska, especially in regards to helicopter operations

CONOPs Implementation in Alaska

ALASKA LOW ALTITUDE **Recommendation 1.**	**The FAA should comprehensively evaluate the en route navigation needs of Alaska and ensure a baseline level of service is being provided as part of the PBN RS CONOPs implementation.**

The FAA has failed to complete a baseline review of Alaska's IFR needs leading to operators and ATC reporting a feeling of neglect by the FAA and frustration with the delay of the FAA enabling an effective and efficient Alaskan NAS. The Task Group believes the FAA should commit the resources to implementing the PBN RS CONOPs in Alaska with the goal of a comprehensive modernization that meets the following user needs:

- A review of existing route structure for optimization and effectiveness of MEAs;
- Enable pilots to fly point-to-point effectively by expanding communication and surveillance coverage;
- Transition away from dependencies on legacy ground-based NAVAIDs except for providing a resilient NAS and where Victor Airways are beneficial;
- Ensure a harmonious and robust IFR network is provided that will meet Alaska's extensive aviation needs.

The Task Group believes action on all recommendations should be conducted in one modernization effort and with the commitment from the FAA that it will dedicate the resources to comprehensively address the Alaskan issues identified.

Terminal environment deficiencies

There is a general lack of infrastructure in Alaska in comparison to the CONUS, which impacts both en route as well as terminal operations. This includes the density of NAVAIDs, standard surface observations, coverage with Next Generation Weather Radar (NexRad), and communications with both ATC and Flight Service. Due to the lack of terminal infrastructure in Alaska, the Task Group believes the greatest benefit and effectiveness of the PBN RS CONOPs will occur if the terminal environment in Alaska is addressed concurrently.

ALASKA LOW ALTITUDE **Recommendation 2.**	**The FAA should task the TOC to evaluate the long-term terminal IFR infrastructure needs of Alaska as part of the development of an Alaska terminal CONOPs.**

As the Committee evaluated the existing en route structure in Alaska and the PBN RS CONOPs, there were many deficiencies in connectivity of the en route system to the terminal system noted. Limited surface weather observation systems and instrument approach procedures contribute to the challenges of flying in Alaska. Additionally, many recommendations in this document impact the terminal environment and it is important these impacts are evaluated prior to any changes being made. The FAA should engage with industry to determine a comprehensive plan for the terminal needs of Alaskans.

ALASKA LOW ALTITUDE **Recommendation 3.**	**The FAA should add AWOS surface weather reporting stations to those airports that contain instrument approaches, but lack certified weather reporting, given the improvements to en route weather forecasting that they would provide.**

Alaska would need almost 200 additional surface weather reporting stations to have a comparable density of weather reporting to CONUS, and the sparse nature of this network influences safety and access. The impact is critical for Part 135 operators who are unable to utilize the approaches and are forced to fly VFR. For example, Alaska has many airports that currently have IFR instrument procedures but lack surface weather reporting with the following 21 as the top priorities:

1. Akiak
2. Allakaket
3. Beaver
4. Central
5. Chalkyitsik
6. Chuathbaluk
7. Coldfoot
8. Eek
9. Kasigluk
10. Kobuk
11. Kokhanok
12. Kotlik
13. Koyukuk
14. Napaskiak
15. Nondalton
16. Nulato
17. Perryville
18. Tatitlek
19. Tok
20. Venetie
21. Willow

The addition of weather stations at these and other airports will improve the inputs to the models used by the National Weather Service to forecast both en route and terminal weather, including Terminal Aerodrome Forecasts (TAF). The TAF's availability is required for many commercial operators to be able to dispatch to an airport. Should surface weather not be available, IFR operations to that airport may not even be possible. Given the severe lack of NexRad radar to map the spatial extent of active weather systems, additional surface observations, beyond the sites listed above, are needed to help fill some of the gaps in the observation network. The overall scarcity of weather observing and forecasting infrastructure in Alaska, and its impact on IFR and VFR operations, needs to be examined in greater detail. While beyond the scope of this task, it is important to address the shortage of weather data, and explore cost effective measures which may be specific to the Alaska region.

Additionally, weather information is an issue and concern, particularly in rural CONUS regions and for helicopter operations. Without improved AWOS density, the benefit of IFR to rural hospitals and airports is diminished. One helicopter operator in the state of Maine has funded and installed 18 AWOS stations at rural airports and hospitals to ensure it can operate IFR.

Airways based on NDBs

ALASKA LOW ALTITUDE **Recommendation 4.**	**The FAA should transition the Alaskan en route navigation structure away from any dependency on NDBs.**

The Committee found nearly all commercial and general aviation operators in Alaska were using RNAV to navigate to/from NDBs in the en route environment and favored the removal of this NAVAID from the en route structure. However, NDBs still have dependencies that need to be addressed prior to their removal from the en route structure:

- NDBs define the Colored Airway structure – In many cases these routes offer lower MEAs than GNSS MEAs (see Alaska Low Altitude Recommendations 5 and 6);
- NDBs are utilized in the terminal environment – This recommendation should not be interpreted as extending to terminal NDB operational value as this NAVAID's value and significance in terminal operations was not evaluated;
- NDBs continue to be important NAVAIDs in parts of Alaska, whether operational or not, solely due to unique Alaska GPS requirements that require pilots to utilize these NAVAIDs (see Alaska Low Altitude Recommendation 17);
- Local feedback should be solicited, particularly from Part 121/135 operators, prior to the decommissioning of any NDB given their incorporation in certain Operations Specifications (OpsSpecs) (see Alaska Low Altitude Recommendation 18).

The Committee believes there is little benefit to maintaining an aging NDB infrastructure that is primarily being flown by RNAV equipped aircraft and thus Alaska should not need ground-based NAVAIDs in the en route environment except for resiliency and a limited Victor Airway route structure.

ALASKA LOW ALTITUDE Recommendation 5.	**The FAA should evaluate all Colored Airways for: (a) direct replacement (i.e., overlay) with a T-Route that offers a similar or lower MEA; (b) the replacement of the colored airway with a T-Route in an optimized but similar geographic area while retaining similar[18] or lower MEA; or (c) removal with no route structure (T-Route) restored in that area because value was determined to be insignificant.**

As the FAA removes all Colored Airways from Alaska, the FAA must consider the impact to operations that would occur should the new routes result in higher MEAs. Direct replacement (overlay) or optimized (same geographic area) GNSS routes will need to have similar or lower MEAs as the Colored Airway to be of value to operators who, due to issues like performance and icing limitations, must fly as low as possible. Optimizing replacement routes to achieve lower MEAs and efficient routings not predicated on ground-based infrastructure is important.

- **T-Route with NDB anchor**

For those T-Routes that are anchored by NDBs, those anchors should be transitioned to an RNAV waypoint to remove any incorporation of NDBs as part of the en route structure.

- **Victor Airway with NDB anchor**

For those Victor Airways that have a segment anchored by an NDB, the FAA should evaluate that segment for either: (a) direct replacement (i.e., overlay) with a T-Route that offers a similar or lower MEA with one anchor being the VOR and the other an RNAV waypoint; or (b) removal with no route structure restored in that area because value was determined to be insignificant.

[18] Similar is defined as an altitude that does not increase the MEA by more than 1,000 feet. The definition of Similar is further clarified in Alaska Low Altitude Recommendation 6.

ALASKA LOW ALTITUDE Recommendation 6.	**The FAA's criteria to identify the priority of removal of an NDB from the en route structure should include operational considerations.**

The FAA has identified four categories of NDBs, correlated to priority of removal, which will determine how easily an NDB could be removed from the en route structure. Again, this recommendation is independent of terminal considerations as the impacts of removing an NDB from terminal procedures would need to be evaluated separately. Below are the proposed categories and the Task Group's recommended modifications underlined:

Category 1: NDBs that are not being used for an airway <u>or have special considerations due to OpSpec requirements</u>.

Category 2: NDBs that are being used for a <u>Colored</u> Airway and there is a Victor Airway <u>or T-Route</u> that provide redundancy. An airway is considered redundant if the MEA <u>for the Victor Airway or T-Route</u> is no more than <u>1,000</u>' higher than the colored airway <u>and the other routes will not result in an operationally significant increase in flight miles</u>.

Category 3: NDBs that are being used <u>to define</u> a <u>Victor Airway or T-Route</u> that would require airway modification or development before the associated NDB could be decommissioned. <u>An analysis would need to be conducted to determine if that NDB should be replaced by an RNAV waypoint and T-Route or if there is no value in that segment being replaced. Any replacement segment should have an MEA at or below the existing MEA or see an increase no more than 1,000'.</u>

Category 4: NDBs in areas where there are no existing redundant airways <u>and it was determined a route would be of value</u>, and the MEA <u>would be</u> more than <u>1,000'</u> higher <u>for a replacement T-Route</u>.

ALASKA LOW ALTITUDE Recommendation 7.	**The FAA should ensure there is a process for operator and air traffic feedback prior to decommissioning a Colored Airway that would not be replaced with a T-Route (should there not be redundant routes available).**

Given the historical reliance on NDBs for navigation in Alaska, it is important there is outreach prior to the initiation of a process to remove a Colored Airway that would not be replaced by a T-Route. An effective opportunity to inform stakeholders is during the FAA Industry Council meetings in Alaska.

Airways based on VORs

ALASKA LOW ALTITUDE Recommendation 8.	**The FAA should maintain all VORs and Victor Airways in Alaska.**

Alaska lacks a resiliency plan and the infrastructure that could accommodate a plan similar to the CONUS VOR MON. It is important the VORs and airways currently in place are maintained as they are important to en route navigation. The existing Victor Airways should be re-evaluated for lower MEAs and optimal design as part of the PBN RS implementation. Additionally, new Victor Airways should be formed if new VORs are added to Alaska.

ADS-B radio station density

ALASKA LOW ALTITUDE **Recommendation 9.**	**The FAA should install additional ADS-B radio stations to expand coverage of surveillance and broadcast products.**

The FAA should follow the recommendations made by the 2007 ADS-B Aviation Rulemaking Committee (ARC), 2009 NextGen Mid-Term Implementation Task Force Report (Task Force 5), and 2011 ADS-B In ARC final report to install additional ADS-B radio stations to expand coverage of surveillance and broadcast products to facilitate greater efficiency in the IFR en route environment. Additional radio stations are needed to provide essential and operationally significant information to ATC to facilitate greater efficiency of PBN operations. Increasing surveillance coverage has been shown to have substantial safety impact and operational impacts, and in Alaska may be required for certain GPS (TSO-C129/196) operations.

Additionally, the inadequate number of ADS-B radio stations in Alaska results in poor coverage of FIS-B which is important for en route access to aeronautical information. FIS-B provides weather and NOTAM information to the cockpit which are important for IFR and VFR flight safety.

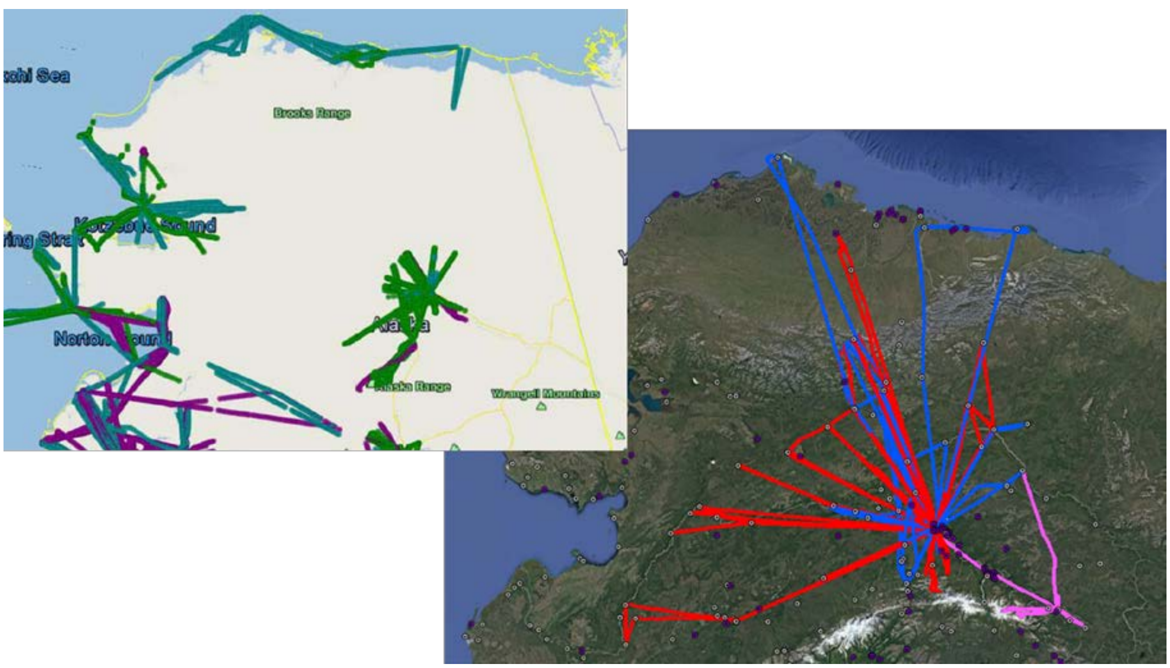

Figure 21 Areas southwest, southeast and north of Fairbanks void of ADS-B coverage as seen by surveillance coverage (left) shown for a routine day of flights (right: flight tracks provided by GPS tracking devices)

ALASKA LOW ALTITUDE **Recommendation 10.**	**The FAA should work with industry to help create the ADS-B expansion benefits case and evaluate where coverage is needed.**

In Alaska, the FAA installed multiple ADS-B radio stations to provide coverage where radar coverage did not already exist. The Task Group believes additional coverage is needed and echoes the 2007 ADS-B ARC recommendation:

> "No. 4 - Extend the coverage of the ADS–B ground infrastructure to include high-value non-radar areas beyond those currently identified. The benefits of ADS–B in terminal surface and en route environments where radar exists today provides substantial value. The FAA should establish a forum to determine which areas outside that baseline would provide the greatest benefits to NAS operators. Surveillance and broadcast services in areas where no coverage exists today provide the most relative value and safety increases to the existing surveillance infrastructure. The FAA should have a mechanism to evaluate how the SBS program's scope might be expanded to accrue benefits in non-radar areas."

Providing low MEAs

ALASKA LOW ALTITUDE **Recommendation 11.**	**The FAA should utilize the Flight Procedures waiver process to provide relief to overly restrictive airway design requirements in areas with a justifiable equivalent level of safety.**

The FAA allows a procedure developer to request the application of non-standard criteria via Form 8260-1, Flight Procedures Standards Waiver. The waiver process is regularly used for terminal procedures; however, this Task Group could not find evidence of a waiver being approved for any airway. We believe the waiver process, which has considerable oversight, should be available and utilized to account for certain peculiarities that exist in Alaska in the en route structure.

There are many examples in Alaska of a T-Route having a higher MEA than the coincidental conventional airways. During our review, we found three T-Routes that had a slightly higher MEA (800'-1,000') and two that had significantly higher MEAs (1,000'-2,000'). In many cases, the reason for the difference was because the route's initial design lacked segmentation or criteria was not being applied during periodic review. Additionally, due to changes in TERPS criteria and variation in flight inspection's application of their requirements, an existing conventional airway may have a lower MEA than a new T-Route in the same area, contrary to the goal of GNSS routes providing greater benefits than conventional routes.

The Alaskan operators regularly noted that Colored Airways have the lowest MEAs and it would be detrimental to their ability to operate should the Colored Airway be removed and all that remains is a T-Route with an MEA several thousand feet higher. In some cases, operators are forced to scud run VFR versus fly into icing. As noted in Recommendation 5, the FAA should ensure that replacement structure for a Colored Airway, whether an existing or new T-Route, should offer a similar or lower MEA than the Colored Airway.

Given the high usage and importance of Colored Airways to Alaska operations, the Task Group believes the FAA should submit waivers for the overlying T-Routes (which may be optimized – not direct overlays) in order to reduce or provide a similar MEA, and noted the following possible equivalent levels of safety for consideration:

- In the segment requiring a waiver, there is air traffic communication and/or surveillance coverage;
- The segment with the waiver could be limited to less than 40 NMs (approximately 15 mins of flight time);
- A minimum of 1,000' of ROC is applied to obstacles in the primary area;
- AFS could oversee the initial 6 months of the waiver being in place;
- Alaska GNSS MEAs can only be flown using WAAS equipment which provides fault detection and exclusion which increases lateral positional accuracy and awareness;
- Route would be flight inspected;
- Aircraft that use these routes at the lowest MEA are normally small, non-turbine aircraft;
- Despite historical safe utilization not being a factor for consideration, the Task Group strongly believes that the decades of safe utilization of the lower MEA is indicative of the lower MEA being safe;
- The alternative, a higher MEA, will result in the route not meeting operator needs and create a safety issue due to additional need for scud running.

ALASKA LOW ALTITUDE **Recommendation 12.**	**The FAA should provide lower MEAs on certain segments of an airway to increase the likelihood of breaking out in VFR conditions.**

Alaskan operators routinely need to operate to airports with no terminal procedure or to off-airport locations which, when it is IFR, can result in scud running many miles. In order to reduce the need to fly VFR in marginal conditions at low altitudes, the FAA should design certain segments of an airway to allow pilots to "letdown" and see if they can break through the clouds and then cancel IFR[19]. It is envisioned the segment would be made up of three fixes: one to define where the descent begins, a center fix to define the optimal location to be at the lowest altitude (known as a "community waypoint" or "off ramp fix"), and a third fix to define a minimum crossing altitude for those aircraft that may not be able to break out.

An example of how this procedure is already used informally today is accessing Lake Clark using NONDA and FORAX waypoints. Many operators will file IFR and then fly as low as possible along this segment in the hope of descending below the cloud ceiling. Air traffic controllers can clear aircraft to the MIA in that area to assist them getting as low as possible. There are many examples of locations that are near or along an existing airway that would benefit from a formal policy, or a waiver process, to allow an alternative to scud running. Education should be provided to pilots about this type of procedure and how to request it.

En route communication issues

ALASKA LOW ALTITUDE **Recommendation 13.**	**The FAA should expand communication coverage to areas identified by industry and consider the role that Remote Communications Outlets (RCOs) serve for en route operations.**

[19] This concept is of high interest to helicopter operators as well, both in CONUS and Alaska.

Surveys conducted by AOPA/AAA and the AACA all reported problems with en route communication coverage. Each group provided white papers of areas that operators and air traffic would benefit from the communication coverage being improved. For example, the main IFR route between the two largest cities in the state has a significant communication gap at the MEA. Industry stakeholders should be involved in the process of developing a prioritization plan for new communication sites.

Given the high cost of Remote Center Air/Ground Communications (RCAGs) facilities, and the range of needs, the FAA should evaluate several factors to develop an optimum communication strategy. For example, RCO's serve in some locations as a means for pilots to file and receive IFR clearances, or to cancel their IFR clearance allowing ATC to send a second aircraft into the airspace. Routinely ZAN relies on RCOs for the relay of clearances. Some remote communities even lack cell service making it difficult for pilots to request a clearance and obtain a release time before departing, which leads to taking off VFR and hoping they are able to reach a suitable altitude to contact ATC before encountering IMC. From this perspective, additional RCO's may be a better investment by the FAA as they facilitate VFR and IFR communications.

In Alaska, the Anchorage ARTCC uses the Voice Communications and Switching System (VSCS) for all of their air-to-ground and ground-to-ground communications. This system has outlived its useful life. Due to the VSCS limitations, the Anchorage ARTCC can no longer accept any new RCAGs for air-to-ground communication in the areas identified by the AOPA/AAA and AACA surveys. The FAA should take this into account in their planning in an effort to enhance communications capabilities for the Anchorage ARTCC.

Similar to earlier discussions of weather reporting, ADS-B and breakout VFR, communications is another issue for which helicopter operators have parallel challenges in both CONUS and Alaska.

ALASKA LOW ALTITUDE Recommendation 14.	**The FAA should formalize a process to allow air traffic communication gaps along routes in areas where the MEA would be positively reduced and the FAA should chart these communication gaps.[20]**

It has been a historical practice to allow a communication gap along published routes in many areas of Alaska and western states despite ICAO Annex 4, TERPS, and the Flight Inspection Manual requiring adequate air/ground communication for the MEA. ATC may communicate to Flight Inspection the value of the lower MEA in these areas with the tradeoff being the aircraft may be out of communication coverage for a period of time. These gaps are known to ATC who may proactively issue lost communication instructions. However, the communication gaps are not known to pilots and it is not clear that there is a formal process to permit communication gaps in those areas that may benefit. In order to make the existing route structure effective for general aviation, it is important that MEAs are as low as possible particularly in those areas of high terrain where communication coverage may be most limited.

[20] While this recommendation is most impactful in Alaska, it may be relevant to parts of the CONUS as well.

The Committee believes there should be a formal policy regarding allowance of communication gaps and they should not be handled via a waiver process.

This issue became noticeable to the committee when noting MEA inconsistencies. For example, there are GNSS MEAs that are not lower than a Colored Airway MEA because the GNSS MEA has communication coverage as controlling. At this time, the Committee considers the lack of evidence for communication gaps impacting safety adequate for this recommendation. The Committee consensus is that the lack of problems over the last 20+ years is sufficient evidence to support our recommendation.

In order for the modification to FAA policy to safely occur, the Committee believes pilots should be educated about communication gaps with improvements made to pilot guidance, such as the AIM and IPH, and there should be new chart symbology or notation along route segments known to have a communication gap on the En route Low Altitude chart.

The Committee believes the following locations would benefit the most from routes with communication gaps; however, this section should not be construed to be a criteria:

- The MEA would be lower so as to allow saving a cardinal altitude or a reduction in the MEA of at least 1,000’;
- The impacted route segment has traffic counts that point to the communication gap not having an operational or efficiency impact;
- The route is in an area designated as mountainous per Part 95;
- There is an existing route (e.g., Colored Airway) with a lower MEA in the area where the proposed route is to be created.

As communication gaps already exist in the NAS, there are already a wide array of mitigations in place, such as: surveillance coverage, RCO coverage, and the local ATC facility is included in the design process and provides input on route utilization and operational impact. The Committee feels the following mitigations should also be considered by route developers to assist with the equivalent level of safety:

- Ensure not coincident with an MEA gap (NAVAID not receivable), if applicable;
- Communications gaps are charted;
- Pilot guidance is updated to address what a communication gap is.

NOTAM issues

ALASKA LOW ALTITUDE Recommendation 15.	**The FAA must convene a Safety Risk Management Panel (SRMP) before any modification to the 224-day T-NOTAM criteria and include industry.**

The FAAO 8260.19 states an Flight Data Center (FDC) T-NOTAM (temporary condition) is issued for interim IFR flight procedures such as ATS route changes. The FAA allows the NOTAM to have up to a 224-day duration; however, the temporary condition requiring NOTAM action, e.g., NAVAID restrictions, may not be able to be corrected within 224-days, thus the NOTAM issuing authority must obtain approval from AFS-460 for the NOTAM to remain in effect beyond the 224-day limitation, i.e., a new NOTAM issued. AFS-460 serves as the approval authority for requests that temporary NOTAMs be allowed to extend beyond the 224-day timeframe. This oversight is important to ensuring temporary issues that may extend beyond 224-days are reviewed for the opportunity of publication/charting.

The FAA proposed in 2016 increasing the number of days an FDC T-NOTAM could be in the system prior to requiring AFS-460's approval. The Committee believes any changes to long-term NOTAMs (duration over 224-days) could have an operational and safety impact, and the FAA must conduct an SRMP that includes industry participation should they proceed with modifying the NOTAM timeline policy. This may apply to CONUS as well as Alaska.

The FAA has over time increased the number of days a T-NOTAM can be in place prior to requiring the change to be charted: raised from 45 days to 120 days in 1984 and then to the current cutoff of 224 days in 1998. Charting has been repeatedly noted to be the most effective manner of providing long-term changes to pilots, and long-term NOTAMs have repeatedly resulted in Aviation Safety Reporting System (ASRS) reports due to their being frequently overlooked.

ALASKA LOW ALTITUDE **Recommendation 16.**	**The FAA must conduct timely repairs and maintenance on NAVAIDs that are components of the en route structure, and communicate their plan for returning these systems to service.**

As of July 1, 2016, 21% of NDBs and 14% of VORs in Alaska were NOTAMed as out of service. Operators rely heavily upon these systems for navigation, more so in Alaska due to the GPS rules and limited NAVAID infrastructure. However, the FAA regularly takes years to fix critical NAVAIDs and routinely leaves operators in the dark about their plan. The FAA must communicate to operators the status of NAVAIDs that are out of service and must communicate their intent and timeline for the NAVAID's decommissioning or return to service. Operators suggest consideration of using a webpage or the RAPT as possible methods for this communication. The FAA should also consider adding to the Alaska Supplement "Notices" section NAVAID outage status, duration of outage and the expected reinstatement times. The Alaska Supplement is issued every two months.

The FAA needs a long-term NAVAID sustainment plan for Alaska; however, for those NAVAIDs that are not being decommissioned in the short-term nor will be operationally available for a period of time, the FAA should chart the NAVAID as shutdown (see CONUS Low Altitude Recommendation 28). The FAA must commit to maintaining their infrastructure as it is necessary for accessing many communities.

GPS issues

ALASKA LOW ALTITUDE **Recommendation 17.**	**The FAA should evaluate the GPS (TSO-C129/196) operational requirements for Alaska that do not exist for CONUS and either justify their retention or remove the requirement.**

Part 91 pilots flying in Alaska, unlike in CONUS, are restricted to using TSO-C145/146 (GPS/WAAS) equipment when flying: (a) T-Routes; (b) GNSS MEAs; (c) Q-Routes (except can use non-WAAS GPS (TSO-C129/196) when under radar surveillance); and (d) outside the operational service volume of ground-based NAVAIDs. In other words, a GPS without WAAS (TSO-C129/196) can be used in Alaska to fly an appropriate instrument approach procedure at an airport, conduct an alternate means of navigation (per AC 90-108 the underlying NAVAID must be operational), or to fly point-to-point if under radar surveillance.

Pilots are not being presented clear requirements from the FAA and existing guidance is confusing. The FAA includes information in SFAR (Special Federal Aviation Regulation) 97, the AIM, AC 90-108, and AC 20-138 pertinent to allowable utilization of GPS in Alaska. Some of this guidance is confusing, for example the FAA states “there is an ongoing program to either revise or delete the SFAR 97 requirements” in AC 20-138; however, it is not clear the regulatory basis for the requirements stated in the SFAR 97 Notices to Airmen Publication (NTAP) entry, the AIM, and the note on En route Low Altitude charts unless SFAR 97 is controlling.

These different requirements for GPS usage in Alaska have operational and financial impacts for operators. A restriction unique to Alaska that is discussed in the AIM is the requirement for a pilot navigating using RNAV to be under radar surveillance when using certain GPS equipment. This restriction was removed from CONUS in 2013 with a subsequent increase in efficiency anecdotally noted by operators. We believe Alaska to be similar to CONUS in terms of RAIM reliability[21], GPS interference impacts, and overall capability as it pertains to GPS navigation (TSO-C129/196). Alaska, being the largest of all fifty states, shares many similarities with the terrain of many states in CONUS, including areas of flat land and mountains.

The Committee believes the current policy is overly restrictive for Alaskans and should be altered to be consistent with the rest of the NAS or clear justification provided to pilots as to why harmonization would present a hazard. In any case, current guidance should be consolidated, updated, and out dated information removed.

ALASKA LOW ALTITUDE **Recommendation 18.**	**The FAA should support adoption of advanced navigation technology by ensuring operation specifications, management specifications, and letters of authorization support operators.**

The Task Group believes the FAA needs to support Alaskan operators desire to utilize advanced technology and should not be a barrier to the realization of PBN benefits. It is important OpSpecs, Management Specifications (MSpecs), and LOAs evolve as PBN technology matures and becomes the predominant form of navigation. For example, the improvements made to AC 91-70B, Oceanic and Remote Continental Airspace Operations, facilitates greater flexibility for operating in Alaska’s unique environment.

Outreach

ALASKA LOW ALTITUDE **Recommendation 19.**	**The FAA should encourage operators to utilize the IFR system in Alaska and engage with industry to better understand their IFR needs.**

[21] See the Oct. 31, 2016, “GPS Performance Analysis Report,” which indicates Alaska RAIM sites between 1 July and 30 September 2016 had RAIM reliability for operations of RNP 0.3 100% of the time and RNP 0.1 capability over 99.9% of the time, similar to that of CONUS. These figures were calculated with fault detection being utilized.

One Alaskan operator noted “when the weather is too bad to go IFR, we go VFR.”

The pilot culture in Alaska still has ingrained in it that scud running is sometimes the safest and only manner to complete a mission. It is important the FAA promote utilization of the IFR system and more importantly listen to the operators needs and invest in the requisite support infrastructure. There continues to be accidents due to controlled flight into terrain because of VFR into IMC largely due to an inadequate IFR infrastructure. The FAA should consider an education campaign along with advertising the improvements to the IFR system being made to encourage greater investment/utilization by Alaska pilots.

Although over 21 years old, the NTSB’s safety study of Alaska (see NTSB SS-95-03) still very much applies and it points out the continuation of issues long before identified. The report notes:

> “An improved low altitude [IFR] system…would reduce the incidence of fatal accidents involving VFR flight into [IMC]in the State and result in a net safety improvement for Alaska aviation. The current low altitude [IFR] system in Alaska has several deficiencies that prevent it from fulfilling the State’s air transportation needs: inadequate navigational aid coverage for en route low altitude navigation and for instrument approaches; insufficient instrument approach procedures at destinations served by commercial operators; and inadequate voice communications and aircraft position surveillance capabilities for air traffic control.”

ALASKA LOW ALTITUDE Recommendation 20.	**The FAA should promote financial assistance programs for WAAS and ADS-B equipage.**

About three quarters of pilots indicated in the AOPA/AAA survey that they were unaware of the State of Alaska's "Alaska Capstone Avionics Low Interest Loan Program." This program is available to assist with purchasing and installing eligible WAAS and/or ADS-B avionics equipment in aircraft that are principally operated in Alaska. The lack of visibility of the program likely hurts the number of people taking advantage of it. Other programs, such as the FAA’s ADS-B rebate program, should also be promoted in Alaska.

Equipage Incentives

Alaska is a diverse and unforgiving environment to fly in, but communities rely on aviation here for survival. There can be older aircraft, such as a 1950s DC-6 navigating by ADF, flying in the same airspace as an advanced aircraft, like a WAAS equipped Cessna 172. Cost for the operators, with many being single aircraft owner-operated, to equip their aircraft can require an investment beyond the ability for many Alaskan commercial operators and general aviation pilots. With so many different types of aircraft and capabilities operating in the low altitude environment, it is foreseeable that realizing a PBN NAS in Alaska will be a challenge as mixed equipage will continue. Mixed equipage is inefficient for the NAS and requires an investment by the FAA in older NAVAIDs, routes, and technology in order to support older aircraft. Additionally, safety will continue to be a concern as less reliable systems continue to be the cheapest and most favored solution.

The FAA should take a long-term, cost conscious, and proactive view to improving Alaskan aviation by providing financial assistance to operators to equip with WAAS and ADS-B. The quantifiable benefits include: (a) a reduced accident rate given more pilots would not have to scud run; (b) reduced cost in maintenance and operations of NAVAID infrastructure; (c) greater efficiency for en route operations; (d) reduced cost for operators as mission completion rates increase with communities benefiting from a more dependable system; and (e) a faster realization of PBN benefits.

The Task Group believes the FAA would save money and save lives in the long-run if they would invest in the PBN equipage of Alaskan operators.

ALASKA LOW ALTITUDE **Recommendation 21.**	**The FAA should initiate a financial incentive, namely a rebate, to increase the WAAS equipage rate in Alaska for general aviation (Part 91, 91K, 135).**

The AOPA/AAA and AACA surveys revealed that Alaskan operators ranked a financial incentive for WAAS equipage high on their list of programs they would want and would take advantage of. Of those pilots who have not yet equipped, all but 11% indicated their intention to equip once the cost of a WAAS system reached an acceptable level. Based on the feedback received, the Task Group makes the following conclusions:

- **Price point to incentivize equipage**

The FAA should provide a financial incentive that would bring the price point for a WAAS unit to $3,000. About 55% of the general aviation pilots who are delaying equipage due to cost, indicated that they would be able to equip if the price point was $3,000. The Task Group considered this price point significant as it brings a WAAS unit into the same price range as non-WAAS GPS units.

- **Minimum incentive amount**

The FAA should provide a minimum incentive of $3,000 per system. About 68% of pilots indicated that if a federal tax credit or rebate were offered to assist with buying an IFR certified WAAS GPS system, the minimum incentive that would allow them to equip sooner than otherwise planned was $3,000.

The FAA's 2014 GA Survey (Part 91, 135) indicates there are approximately 5,300 active aircraft in Alaska with an electrical system and, of those, about 3,500 lack an IFR certified GPS. Based on AOPA/AAA's two IFR surveys, approximately 32% of pilots who are active and IFR certified do not fly IFR and would likely not take advantage of this program. Assuming that percentage translates into a direct decrease in the number of participating aircraft, approximately 2,400 aircraft would be the target number. If $3,000 was provided for each aircraft, the total investment by the FAA would be $7.2 million, a sum quickly realized by the cessation of maintenance and operation of just a few of the 80 NDBs currently in service.

- **Type of financial incentive**

The FAA should provide the financial incentive in the form of a rebate. The Task Group does not believe a loan program to be effective for general aviation pilots who generally do not upgrade avionics until they can afford to pay outright for all aspects. The goal of the rebate would be to incentivize early equipage and provide assistance for the many owners who would not be able to afford WAAS otherwise. The rebate would need to apply to multiple aircraft types and allow a single person or entity to receive more than one rebate given the goal is to equip as many aircraft as possible and there are owners with multiple aircraft.

ALASKA LOW ALTITUDE Recommendation 22.	**The FAA should expand the existing ADS-B rebate program for general aviation operators in Alaska (Part 91, 91K, 135).**

Alaska ATC has improved surveillance capability thanks to the installation of the approximately 40 ADS-B radio stations in the state. However, the majority of aircraft in Alaska do not have ADS-B Out installed, per the AOPA/AAA survey, and would not be able to take advantage of the benefits of ADS-B surveillance for en route flight. Many of these aircraft owners are delaying equipage due to hardware cost. The current ADS-B rebate program is designed to increase equipage in the most price-sensitive category, piston powered, single-engine aircraft, and it does not target the needs of Alaskan operators.

Mirroring the language used in the AOPA/ERAU survey conducted as part of Equip 2020, the AOPA/AAA survey sought to determine the benefit of an expanded ADS-B rebate for Alaska. About half the Alaskan pilots surveyed indicated the maximum price they would pay for ADS-B Out would be $2,000 with the other half indicating largely $4,000 or less. An avionics shop in Anchorage noted that the cost to purchase and install ADS-B was ranging between $5,500 and $8,500 for a general aviation aircraft. The cost of a WAAS position source and installation also greatly increases the overall cost should the WAAS system provide navigation capability in addition to ADS-B position source compliance.

The Task Group concluded that a rebate of $1,000 per ADS-B system for Alaskan general aviation aircraft (Part 91, 91K, 135) should be implemented. That amount includes getting the systems to Alaska and in the shop costs for installation. The rebate would support small owner-operators, who are the most price sensitive, to equip and be able to take advantage of ADS-B benefits, including increased surveillance coverage which supports en route efficiency and safety.

Alaska Resiliency

An outage of GPS in Alaska, just like in CONUS, would have widespread safety and operational impacts. There is a need for there to be a minimum operating network of VORs to ensure aircraft can safely navigate to an airport and land. Continuity of operations is all the more important in Alaska given the reliance on aviation by the many geographically isolated communities.

ALASKA LOW ALTITUDE Recommendation 23.	**The FAA should commission a study to compose a VOR MON plan for Alaska.**

An Alaska VOR MON plan should be comparable to the plan for CONUS (harmonized to the greatest extent possible) and evaluate the addition of VORs to ensure an effective level of coverage. This plan should include VOR and Instrument Landing System (ILS) as the sole aircraft equipage required for en route navigation and for safe landing airports, as required for CONUS, with no additional equipage requirement to participate.

The Task Group strongly believes additional VOR infrastructure and a commensurate expansion of Victor Airways is necessary for an effective VOR MON plan in Alaska. Today, the density of VORs in Alaska is thinner than the planned density of the eventual MON in the CONUS. It is understood the North Slope, which has an extensive NDB network, will need to have additional VORs commissioned to accommodate a resiliency plan that is effective for operators. Operators do not believe NDBs should be part of any resiliency plan due to the removal of these NAVAIDs from the en route structure and a reduction in Automatic Direction Finder (ADF) equipage across the fleet.

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