



**Approved by the NextGen Advisory
Committee March 2018**

**Priorities for Improving
Operational Performance in the
Northeast Corridor through CY2021**

Report of the NextGen Advisory Committee in Response to a Tasking from
The Federal Aviation Administration

March 2018

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Executive Summary

In February 2017, the NextGen Advisory Committee (NAC) identified the importance of modernizing air transportation through the application of NextGen in the Northeast Corridor (NEC). Delays in the NEC account for nearly 50% of all delays in the entire National Airspace System (NAS)¹, and since so many scheduled flights go through the NEC, improvement in its performance impacts the entire NAS and operations around the world. In June 2017, the NAC delivered “Goals and Priorities for Improving Operations in the Northeast Corridor Phase One” which identified goals for the NEC. The desired outcomes are:

- Enhanced airport and airspace throughput in all weather conditions
- Predictable departure and arrival times for passengers
- Reduced number and duration of delays
- Good for the environment: noise mitigation and reduced emissions

This effort will only be successful if these outcomes are achieved with no degradation to safety.

In October 2017, the NAC approved “Joint Implementation Commitments for Improving Operations in the Northeast Corridor Phase Two - Interim Report” which identified an initial set of capabilities and associated commitments for the next 18 months (through March 2019).

Following the NAC meeting in October 2017, the NEC NIWG has worked diligently to define the next set of initiatives and commitments for the NEC, to be included in the “NextGen Joint Implementation Plan CY2019-CY2021.” As a starting point to these deliberations, the NEC NIWG has articulated ten key operational needs. These operational needs map directly to the goals and capability objectives identified in the NEC Phase 1 report, and address the NAC’s request to have a clearer understanding of the issues that recommended initiatives will address. The ten operational need areas are noted below, grouped into three categories:

Deconfliction of airports

- Improvement for constrained NEC departure routes - during normal and severe weather operations
- Address loss of airport throughput due to airport/airspace interactions when arriving LGA 13
- Address loss of airport throughput due to airport/airspace interactions when arriving LGA 31
- Improvement in arrival throughput at EWR and delay reduction (i.e. Ground Delay Programs)
- Provide satellite airport access to NY area airspace and deconflicting satellite operations with the major airports where possible

¹ Source: FAA analysis of FY2017 OPSNET Delay by Region/Airport and Causal Factor

Enhancement of airport and airspace throughput

- Provide full utilization of available LGA capacity
- Improvement of JFK runway usage and delay reduction
- Improvement of PHL runway usage and delay reduction
- Provide reduced separation and spacing and improved access to NEC airports

Improving the balancing of demand and capacity in NEC traffic flow

- Evolve TFM to incorporate data-driven decision-making to better manage demand/capacity imbalances in the NEC

Finding solutions to these operational needs requires focus and clarity of purpose. FAA and Industry resources are limited, and must be centered on the initiatives that will provide widespread benefit to the operation. Interconnectivity of activities must be considered in the recommendation of any initiative. To address these operational issues, Industry has proposed a set of initiatives (detailed later in the report) as a mid-term (March 2019 to December 2021) plan for the NEC, building on the pre-implementation and implementation commitments taken in the NEC Phase 2 Interim Report. These initiatives were taken from a list of over 100 concepts and ideas generated as part of the initial NEC Phase 2 deliberations.

This reduced set is intended to be a cohesive and integrated plan. The proposed items are consistent with the FAA's iTBO plans, which was discussed at length with the NEC NIWG. This draft set of initiatives assumes that milestones through March 31, 2019 are proceeding and are unaffected. The NEC NIWG Industry members acknowledge that multiple initiatives noted in this report are expected to begin with feasibility assessments that can lead to actual implementation timelines. There is agreement that PBN is a tool for solving problems and should be pursued.

The FAA is currently conducting internal reviews of these proposed initiatives and joint commitments will be delivered to the NAC in June 2018. The proposed set of initiatives must be considered in relation to existing commitments, and other factors such as operational feasibility, compatibility with FAA acquisition efforts, resource planning (including staffing and procedure development requirements), and community involvement. Discussion of the FAA's TBO concept, iTBO plan, and the Community Involvement strategy are included in the report to reflect these critical considerations. An update on airport enhancements occurring within the NEC is also included.

FAA staffing and other resource limitations continue to be a significant challenge in the NEC, particularly at the New York facilities. The FAA is making progress in addressing these concerns, but the NEC NIWG recognizes that the pervasiveness of this issue will limit effectiveness of any operational enhancements proposed by the group.

The NEC NIWG believes that PBN is part of the overall solution approach, and that key decisions concerning equipage must be data driven. These decisions include leveraging the equipage that already exists within the NEC, validating the level of equipage that is needed, incentivizing equipage, and implementing tools to address mixed equipage. The report includes discussion of what additional efforts are required to further these discussions collaboratively in a productive consensus environment.

Similarly, other advanced technologies and concepts may be beneficial to the NEC, and the NAC has asked the NEC NIWG to include these options. The deliberations and recommendations of the Advanced Technology subgroup around four key capabilities, Ground-Based Augmentation System, Enhanced Flight Vision Systems, Cockpit Display of Traffic Information (CDTI), and Flight Interval Management, are included in the report.

Finally, this report includes the initial elements of a measurement plan for the NEC NIWG. During the October 2017 meeting, several members of the NAC questioned how results were going to be classified and measured. The identification of the operational needs areas provide an outline of the problems to be addressed, and the starting point for a measurement plan. Additionally, the Joint Analysis Team (JAT), a group of FAA and industry experts that examines performance impacts and benefits that can be attributed to the implementation of NextGen capabilities, has developed an initial measurement plan tied to the March 2019 implementation commitments. A summary of this plan is included in this report.

Background/Introduction

In its February 22, 2017 meeting, the NextGen Advisory Committee (NAC) reached consensus to move forward with a tasking to focus on implementing NextGen in the Northeast Corridor (NEC) (Washington, DC/Baltimore, Philadelphia, New York and Boston airports and associated airspace). During the Committee's deliberations, members recognized that making continuous improvements to the system in the Northeast Corridor operationally benefits the entire US aviation system. They agreed that the work should start with defining what is included in implementing NextGen in the Northeast Corridor, highlighting the need for addressing the technical, operational and community issues that must be identified up front and then mitigated through the NAC collaborative process.

The Federal Aviation Administration (FAA) formally tasked the NAC in April 2017² (Appendix D) to develop recommendations for the collective set of FAA, airport and operator initiatives that focus on implementing NextGen in the Northeast Corridor. Recommendations were developed by the NEC NextGen Integration Working Group (NIWG).

This report responds to Phase 2 of the task request:

² Tasking letter dated April 13, 2017 from Ms. Victoria Wassmer to Margaret Jenny, RTCA President.

Use the deliverables in Phase 1³ to define joint implementation commitments for the Northeast Corridor, including government and industry milestones, and define how implementing those priorities would lead to measurable benefits. Subsequent to implementation, ensure benefits are measured.

Specifically, the industry and the FAA are working collaboratively to identify implementations for March 2019 to December 2021 that will be prioritized based on the benefits, readiness and availability of resources to implement. These actions build on the previous recommendations⁴ that are being implemented in the October 2017 to March 2019 timeframe and are driven by the priorities documented in this report.

Each implementation includes:

- Description of the Initiative/Implementation/operational capability
- Benefit(s) Expected from the Implementation of the capability
- Key Risks
- Timeline and Commitment by FAA/Industry (Addendum for NAC consideration in June 2018)

Methodology

Industry and FAA representatives jointly led development of this report while the FAA's Air Traffic Services managed coordination and facilitation of discussions with NEC ATC facilities.

Operators and airports in the NEC NIWG collaboratively developed a focused set of high priority operational needs for the NEC. Additionally, industry operators and airports recommended which needs and associated initiatives should be focused on and sequenced first. This input from industry was a primary driver of identifying implementation priorities for the NEC. Each industry operational need is detailed in the body of this report.

Additionally, the NIWG pursued multiple parallel efforts (listed below) to inform NEC priorities and this recommendation. This included:

- The NEC NIWG discussed concepts for advancing RNP and identified specific activities that would inform the aviation community of the benefits of advanced NextGen operations under varying resource, funding and equipage scenarios.

³ Phase 1 Tasking approved by the NAC on June 28, 2017: "By June 2017, define success in terms of benefits to include determining how benefits will be measured. Identify opportunities most likely to lead to success and identify hurdles that could result in implementation challenges. The emphasis should be on opportunities that can be implemented in less than 18-months. Implementations of up to three years may also be considered."

⁴ "Joint Implementation Commitments for Improving Operations in the Northeast Corridor Phase Two - Interim Report", approved by the NAC in October 2017

- The FAA reviewed its plans to migrate to Trajectory Based Operations (TBO), including initiatives that may be targeted for the NEC as a part of Initial TBO (iTBO).
- An Industry-FAA sub group evaluated four Advanced Technologies options and provided recommendations to the NEC NIWG about which hold most promise for the NEC.
- An NEC NIWG sub group engaged Airport operators in the NEC to understand and document airport infrastructure priorities.
- The FAA solicited feedback from the following: Northeast Corridor facilities, Program offices and Headquarters management. The feedback was shared in an iterative manner with the NIWG, allowing for industry engagement and discussion with the FAA. The NIWG process was collaborative and productive.
- The FAA and industry discussed the key principles on community involvement, including briefings from the ATO Community Involvement Manager for Airspace Projects and a review of the recommendations made from the NAC to the FAA in June 2016.
- The NEC NIWG reviewed the operational needs and the information above to collaboratively identify the set of priorities for the NEC through the end of Calendar Year 2021. Specific pre-implementation, implementation and industry milestones associated with these priorities will be provided to the NAC in June 2018.

NEC Industry Priorities for Operational Needs through End of CY2021

The industry members of the NEC NIWG identified a set of 10 operational needs that are detailed in this section. For each of these consensus-based priorities, an explanation of the need is included along with the benefits and respective risk. The FAA and industry will subsequently develop an addendum for the report with specific pre-implementation, implementation and industry milestones to capture as much of the benefits as feasible, given the associated risks.

Benefits of Improving Performance in the NEC

The NEC NIWG has identified goals, benefits and initial implementations for improving performance in the Northeast Corridor. The Phase 1 NEC report approved by the NAC in June 2017 identified three tiers of operational benefit for the NEC:

1. Improve execution of today's operation in the NEC
2. Operate today's flights more efficiently
3. Grow the capacity and schedule

The Phase 1 NEC study identified the following capabilities as highest priority to achieve these benefits. These priorities align with this report's detail on the industry's operational needs for the NEC:

- Deconfliction of Airports

- Improving Airport/Airspace Throughput
- Improvement of Flow Management Capabilities

Finally, the NEC NIWG identified the following metrics as those that best measure the benefits in the NEC:

- Completion Factor
- Delay versus Schedule
- Block Times
- Throughput

Implementation Risks

The NEC NIWG identified the following set of risks⁵ as critical to planning implementations between now and the end of CY2021. These guided the work of developing the 10 operational needs. These were originally identified in Phase 1 and enhanced in the subsequent work:

- Overarching: Controller and support staffing and resources⁶
- Collaborative engagement among all Air Traffic Control (ATC) operational lines of business and operators in the airspace
- Collective (industry/FAA) ability or willingness to (de)prioritize specific projects or initiatives
- Collective (industry/FAA) ability to adjust existing plans and schedules
- Cultural issues – i.e. controller, pilots, dispatcher acceptance and implementation
- Environmental - community issues and concerns require a robust community involvement process by airport operators, aircraft operators, and the FAA as critical partners in communicating the initiatives and their benefits with communities
- Timeline and availability of resources to develop new procedures
- Facility-level feedback and nuances that may impact individual initiatives
- Funding and budget priorities
- Mixed equipage⁷ of aircraft/differing capabilities – rates of Performance Based Navigation (PBN) equipage or ability to leverage available equipage
- Operator staffing and resources
- Pre-operational planning and agile flexibility in consideration of unforeseen constraints that require real time adjustments to the plan
- Results of feasibility and/or safety assessments
- Training for operational personnel, including pilots and controllers

⁵ These are similar to those identified by Task Force 5 and the NAC 2013 Prioritization.

⁶ Industry members have reviewed and endorse FAA actions to improve staffing levels. Additionally, industry members have additional perspectives on how it may support improvement of staffing and these will be shared with the NAC.

⁷ Balancing the correct level of PBN capability to address the intended goals for the implementation.

Industry Consensus on Operational Needs

Operators and airports in the Northeast Corridor collaboratively identified their highest priority operational needs between March 2019⁸ and the end of CY2021. The following operational needs for the NEC represent the industry's perspective on the highest priority and most vexing challenges in the NEC to achieving the benefits reviewed above. Each need is further detailed below:

Deconfliction and Throughput Focused Operational Needs

- Improvement for constrained NEC Departure Routes - During Normal and Severe Weather Operations
- Address loss of Airport Throughput due to Airport/airspace Interactions when Arriving LGA 13
- Address loss of Airport Throughput due to Airport/airspace Interactions when Arriving LGA 31
- Improvement in Arrival Throughput at EWR and Delay Reduction (i.e. GDPs)
- Provide satellite Airport Access to NY Area Airspace and Deconflicting Satellite Operations with the Major Airports where possible

Growth Focused Operational Needs

- Provide full Utilization of Available LGA Capacity
- Improvement of JFK Runway Usage and Delay Reduction
- Improvement of PHL Runway Usage and Delay Reduction
- Provide reduced Separation and Spacing and Improved Access to NEC airports

Data Driven Traffic Flow Management

- Evolve TFM to Incorporate Data-Driven Decision-Making to Better Manage Demand/Capacity Imbalance in the NEC

Detail on Operational Needs

Each operational need is discussed in further detail below, including qualification of the expected benefits (as defined in the NEC Phase 1 Report) and the implementation risks (as defined above). Note that addressing each of the operational needs below is expected to require community involvement. The approach to this is detailed in the section later in this report titled 'Community Involvement for NEC Implementations':.

Constrained NEC Departure Routes – During Normal and Severe Weather Operations

Departure route agility for both operators and air traffic is a significant challenge in the NEC, given the proximity of airports all contending for the same departure airspace. When convective weather drives periodic closing or constraining of departure corridors, the problem

⁸ During the discussions, current tactical needs were also identified.

is exacerbated, especially in the New York area. When this occurs, departure queues develop at airports driving surface congestion and, at times, impacting the flow of arriving aircraft to the gate. Additionally, there is opportunity to expedite the re-opening of closed or constrained departure routes. Impacts to departures can result in operational complexity and significant customer disruptions.

Benefits	Risks
<ul style="list-style-type: none"> • Utilization of all available departure options to maintain departure throughput and flow • Reduction in departure and arrival delay and improved predictability • Reduced last minute cancellations due to exceeding FAR 117 crew duty time requirements, improving completion factor 	<ul style="list-style-type: none"> • Airspace limitations to adjust departure routes • Training and cultural issues with traffic management and operator personnel to adjust to alternate departure routes

Loss of Airport Throughput due to Airport/airspace Interactions when Arriving LGA 13

When LGA arrives on runway 13, the LGA arrival stream conflicts with operations at EWR or TEB. The sharing of airspace between LGA, EWR and TEB reduces throughput at all the airports.

Benefits	Risks
<ul style="list-style-type: none"> • Deconfliction enables LGA, EWR and TEB to operate independently, improving each airport's throughput • Reduces delay, particularly large ones, and improves Completion Factor • Allows use of LGA runway 4 for departures to assist balancing environmental effects 	<ul style="list-style-type: none"> • Dependent on positive results of feasibility and/or safety assessments –of approach transitions to LGA ILS 13 or other approaches to LGA 13 that allow for appropriate separation between operations at all three airports and which aircraft can reliably operate • High use of regional jets may complicate use of RNP solutions • Resources at air traffic facility and in procedure development to design and develop a new approach procedure or transition

Loss of Airport Throughput due to Airport/airspace Interactions when Arriving LGA LOC-31

When LGA arrives on the localizer to runway 31, the LGA arrival stream conflicts with airspace used for JFK arrivals. This forces JFK to arrive on 31's and reduces JFK's overall throughput.

Benefits	Risks
<ul style="list-style-type: none"> • Allows JFK to balance its operation to favor arrival or departure throughput, according to demand • This reduces average Delay and improves Completion Factor at JFK • Multiple approach reduces flying miles and allows balancing of environmental effects 	<ul style="list-style-type: none"> • Dependent on positive results of feasibility and/or safety assessments – technical feasibility of an approach to LGA 31 that allows for appropriate separation from JFK arrival airspace • Availability of aircraft equipage to operate a procedure that reliably deconflicts LGA 31 arrivals from JFK arrival airspace • Resources at air traffic facility and in procedure development to design and develop a new approach procedure or transition

Improvement in Arrival Throughput at EWR and Delay Reduction - i.e. Ground Delay Programs (GDPs)

Scheduled demand has increased since October 2016 when EWR was no longer a slot-controlled airport. To reliably operate the daily schedule at EWR, two arrival runways are required. However, there has been no consistent utilization of a second arrival runway (4L/22R or 11/29), and GDPs are regularly issued at EWR, even on clear weather days. Controller staffing may be a contributing factor to the ability to utilize a second runway at EWR.

Benefits	Risks
<ul style="list-style-type: none"> • Improved Arrival Throughput at EWR • This results in reduced arrival delay, improved completion factor and greater schedule reliability 	<ul style="list-style-type: none"> • Technical feasibility of deconflicting flows to second arrival runway from other traffic in the New York area • Staffing can be a current limitation to utilization of a second runway

Satellite Airport Access to NY Area Airspace and Deconflicting Satellite Operations with the Major Airports where possible

There are 3 major airports and 2 busy satellite airports within a 20-mile radius of New York as well as multiple other satellite airports within the terminal airspace. While procedures have been developed over time between major and satellite airports to allow independent operations, there are still instances where flows will affect each other between these airports. At times, operations from satellite airports are subject to lengthy delays due to conflicts with the major airports in the area. There may be further opportunity to utilize NextGen technology and procedures to enable aircraft operating to or from satellites to access or depart these airports independently of the major airports, especially through newly designed procedures to deconflict the satellite airports from major airports.

Benefits	Risks
<ul style="list-style-type: none"> • Expedite departures from satellites without waiting for gap in primary flows • Reduces arrival delays due to increased in-trail spacing • Increases access to operationally advantageous runways • Allows routing that would primarily overfly industrial areas and use of preferred noise abatement procedures 	<ul style="list-style-type: none"> • Technical feasibility of deconflicting flows between major and satellite airports based on available airspace and aircraft capability • Availability of procedure development resources to develop procedures that are deconflicted between airports • Staffing can be a current limitation to handle potential increases in satellite traffic

Full Utilization of Available LGA Capacity

Most days of the week, LGA operates a schedule that is at the airport's capacity in visual conditions. Even in good weather, any variation in operation or airport configuration can cause GDPs, ground stops, holds and departure delays due to missed arrival or departure slots. Utilization of metering and sequencing tools to ensure a consistent flow of arrival aircraft to LGA would help limit any disruptions in the LGA operation.

Benefits	Risks
<ul style="list-style-type: none"> • Maintain use of available Throughput, resulting in reduced arrival and departure queuing • This reduces average Delay and improves reliability • Supports dispersion of Runway 13 departures to assist balancing of environmental effects • Reduced controller workload 	<ul style="list-style-type: none"> • Staffing resources available to adapt metering and sequencing tools to LGA operation • Training and cultural issues to utilize metering and sequencing tools

Improvement of JFK Runway Usage and Delay Reduction

JFK has opportunity for further utilization of its available runways. Departure and metering delays are experienced due to the shared departure runways. There are potential alternative runway configurations and supporting procedures for JFK that should be considered.

Benefits	Risks
<ul style="list-style-type: none"> Improves airport Throughput This reduces average Delay, improves Predictability and may improve Block Times Profile descent procedures enable more efficient flows with less noise impact 	<ul style="list-style-type: none"> Controller staffing in the TRACON and tower to feed and accept a higher rate of traffic at JFK Availability of TRACON airspace for arriving/departing aircraft

Improvement of PHL Runway Usage and Delay Reduction

PHL has an opportunity for modernizing procedures due to changes in the US Standard for Terminal Instrument Procedures (TERPS) that could enhance utilization of runways at PHL. Additionally, airfield improvements are possible to improve staging of departing aircraft to better feed demand to the runways based on constraints in the airspace.

Benefits	Risks
<ul style="list-style-type: none"> Improves airport Throughput This reduces average Delay, improves Predictability and may improve Block Times 	<ul style="list-style-type: none"> Availability of aircraft equipage to operate NextGen procedures Resources at air traffic facility and in procedure development to design and develop a new approach procedure or update existing ones based on new criteria

Reduced Separation and Spacing and Improved Access to NEC airports

Given the density and complexity of the NEC operations, any new approaches or waivers in the NAS intended to provide reduced separation should be considered in the NEC. This would provide improved approaches with lower minima and less chance of a go around while maximizing use of available airfield capacity.

Benefits	Risks
<ul style="list-style-type: none"> Improves airport Throughput This reduces average Delay, improves Predictability and may improve Block Times 	<ul style="list-style-type: none"> Dependent on positive results of technical and safety feasibility assessments Availability of aircraft equipage to operate modern NextGen procedures Resources at air traffic facility and in procedure development to design and develop a new approach procedure or update existing ones based on new criteria

Evolve TFM to Incorporate Data-Driven Decision-Making to Better Manage Demand/Capacity Imbalance in the NEC

When there are weather constraints in the NEC, TFM works to balance demand and capacity requiring setting appropriate arrival and departure rates and delivering aircraft at that rate.

There is industry need to leverage ‘big data’-driven tools and advanced analytics to enhance rate setting. Additionally, there is need to define a clear approach to implement use of such data in the traffic management and operational environment in collaboration with aircraft operator and ATC front line personnel. It is important for operators and airports to access the same data utilized to assist in traffic management decisions to inform their corresponding operational decisions.

Benefits	Risks
<ul style="list-style-type: none"> Improves airport and airspace throughput, particularly during severe weather This reduces average Delay and improves reliability as well as Completion factor Improves industry situational awareness Enables the success of other initiatives based on this as a foundational capability 	<ul style="list-style-type: none"> Potential big data analytics tools are not necessarily on the current Collaborative Air Traffic Management (CATM) implementation path and are at risk of being unfunded in the future Training and cultural issues with traffic management and operator personnel to utilize the data and tools to make decisions

Sequencing the Priorities

A list of potential implementation initiatives that could impact these operational needs was identified and is included in the detail in Appendix C. Stakeholders recognize that there are numerous challenges to implementation, including, but not limited to, availability of funding and resources. The ten operational needs identified above represent industry focusing in on the most important needs; hence, all are deemed important. However, given well-understood resource challenges, industry provided further input on which initiatives it would recommend sequencing and implementing first. This is presented below with further detail in Appendix C:

Initiative Category	Initiative Specifics
Data Driven TFM	<ul style="list-style-type: none"> Collaborative SOP around existing available or prototype capabilities (IDRP, RAPT, NOD w DRS) for use during SWAP 2018 Emerging applications and capabilities for opportunities within iTBO scope/waterfall for 2018+
Multiple Airport Deconfliction	<ul style="list-style-type: none"> RNAV transition to ILS LGA13, and RNAV LPV, RNP and/or GLS to LGA13 Modified LGA/EWR airspace to deconflict EWR29 GPS, and new GPS and RNP approach Multiple PBN approaches for LGA31, including RNAV (GPS) transitions to existing procedures and exploitation of RNAV to LOC RWY 31

Crosscutting Departure Throughput	<ul style="list-style-type: none"> • PDRR with technology and process changes in place • Expanded low altitude and escape route structure • Enhanced management for fix/route closure during irregular ops • ZDC09 (MAP changes, splitting sector)⁹ • Vertical climb escape route/high performance escape route • ACP and ZNY offshore routes⁹ • TBFM metering and pre-scheduling
Metro NY Airport Throughput and Efficiency	<ul style="list-style-type: none"> • Existing tools/investments to increase airport throughput: CRDA for JFK, high-speed turn-offs at EWR • Existing PBN procedures modified as needed to increase use and reduce pilot and controller workload • Tools to assist managing final approach spacing <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><u>LaGuardia</u></p> <ul style="list-style-type: none"> • Dispersal headings (TNNIS, NTHNS, GLDMN) <p><u>Kennedy</u></p> <ul style="list-style-type: none"> • EoR for 13R • ROBER OPD to 22L </div> <div style="width: 45%;"> <p><u>Teterboro</u></p> <ul style="list-style-type: none"> • RNAV SID TEB19 • RNAV approach procedures for TEB19 and TEB24 <p><u>Newark</u></p> <ul style="list-style-type: none"> • 22L and 29 arrivals • 4L visuals </div> </div>

Addressing the operational needs through the initiatives noted above is expected to deliver benefit against industry metrics such as Completion Factor, Delay and Block Time average and variability as well as Throughput.

Initial Trajectory Based Operations (iTBO)

The FAA is implementing new capabilities, which leverage investments made by the FAA and operators in support of the Performance-Based Navigation (PBN) NAS Nav Strategy and other enabling infrastructure, to transform the National Airspace System (NAS) to Trajectory Based Operations (TBO) as part of the Next Generation Air Transportation System (NextGen) program.

Introduction to TBO

TBO is an air traffic management method for strategically planning, managing, and optimizing flights by using time-based management (TBM), information exchange between air and ground systems, and the aircraft's ability to fly precise paths. The trajectory includes a path between origin and destination with predicted crossing time estimates at key points along the path which are much more accurate than the estimates used today for strategic planning. Use of time provides a common planning reference across all phases of flight, including pre-departure

⁹ These initiatives address overlying airspace constraints and have wide-spread benefit to the whole NEC

resulting in gate-to-gate operational improvements. The trajectory facilitates integration across Air Traffic Management (ATM) domains, enables the FAA to account for user objectives, and allows for more collaborative and flight-specific solutions in response to NAS constraints. This represents a great improvement over today's strategic planning initiatives and tactical flow management techniques and addresses many of today's operational shortfalls. Altogether, TBO is well-aligned with the operational needs that have been identified by industry as part of the NEC NIWG.

TBO Background

The transition to TBM, a key part of TBO, is outlined in a collaborative FAA and Industry document, the *PBN NAS Navigation Strategy*, which was endorsed by the NAC in 2016. That document outlines a roadmap for enabling the efficiencies available through PBN equipage.

In October 2016, a Time, Speed, and Spacing (T/S/S) task group provided recommendations towards achieving the commitments outlined by the PBN NAS Navigation Strategy. Those recommendations were approved by the NAC in October 2016. A core principle described in that report is that a transition to a time-based system is necessary to enable higher percentages of PBN operations; the goal is to provide speed or time control to keep flights on their optimal path. Achieving this goal is dependent upon improved flow management which requires leveraging existing and future decision support tools for controllers and traffic managers, as well as new flight deck technologies. Success also requires effectively addressing the large cultural shift that will be experienced by the ATM and operator workforces. The recommendations made in the T/S/S report include the need to clarify the end state vision, the continued deployment of enabling capabilities, and developing a plan to institutionalize the operational culture shift.

TBO is expected to result in more efficient use of system capacity by maximizing airspace and airport throughput, improved operational predictability through more accurate gate-to-gate strategic planning, enhanced flight efficiency through integrated operations, and increased operational flexibility through increased user collaboration regarding trajectories and priorities. TBO objectives are also consistent with the tenets of the FAA's NextGen Segment Implementation Plan (NSIP) which states that, "the overarching objectives for the future remain the same — maximizing airspace capacity with more sophisticated and seamlessly integrated information about the future position of aircraft at a given time — while maintaining the safest air travel possible." Additionally, the NAC has emphasized the need for achieving visual meteorological conditions (VMC) performance in instrument meteorological conditions (IMC) and the TBO vision will support initiatives and new procedures that support that goal.

iTBO and the NEC

The FAA has prioritized the North East Corridor (NEC) for initial TBO implementation, which is expected to span now through 2022. The success of TBO in the NEC will be dependent on implementation of multiple elements, including operator capabilities. These elements include

implementation of PBN procedures and aircraft operators equipping to use those procedures; operator provision of data elements and trajectory options which reflect flight status, intent, and preferences; data communications between the air and ground; and the use of Decision Support Systems like Time-Based Flow Management (TBFM), Terminal Flight Data Manager (TFDM), and Traffic Flow Management System (TFMS).

The FAA's implementation strategy for TBO includes assessing the current status of TBO capabilities in the NEC, reviewing current deployment waterfalls for TBO capabilities, and then identifying gaps between the desired end state and what is currently planned. FAA Headquarters is working with the field facilities to develop a plan for initial TBO capabilities in the NEC. This will inform selection of the commitments proposed for the NEC in the March 2019-December 2021.

iTBO Capability Examples

Decision support tools for controllers and traffic managers are critical in evolution of this transition to TBM, particularly the expanding set of metering tools and applications, being operational in ATC facilities across the NAS. The TBFM system is the primary platform for implementing TBM in the EnRoute environment. The TBFM system provides traffic managers an integrated timeline for flights destined to a particular airport or an EnRoute constraint point. The timelines also include the amount of adjustments (or delay) each flight will need to take based on evolving capacity constraints. As opposed to traditional miles-in-trail (MIT) restrictions which impose a static spacing to all flights in a flow, the TBFM system will assign delay only where needed for accomplishing integrated flow management.

When airborne metering is active, TBFM provides information to controllers regarding how much delay specific flights need to absorb before entering the TRACON airspace. This means that delay is redistributed to more fuel-efficient altitudes in EnRoute airspace where trajectory adjustments can be made at higher altitudes and over a longer distance. TBFM airborne metering has been available for EWR arrivals for over a decade; however, there is a need to update and revise the metering adaptation and practices to fully leverage that capability. Additionally, the FAA is considering the application of TBFM airborne metering for other NY airports, such as LGA.

TBFM also provides information to Tower controllers for flights that are departing into a constrained flow. TBFM estimates the appropriate runway departure time that will ensure a flight will merge smoothly with the overhead airborne stream via the Integrated Departure Arrival Capability (IDAC). IDAC was deployed to 6 Towers in the NEC in December 2017 and is used with TBFM for departure operations; these goals were captured by the within 18-month NEC commitment set. The use of IDAC is one element in the eventual subsumption of the Departure Sequencing Program (DSP).

The Converging Runway Display Aid (CRDA) is a situational awareness tool that assists a TRACON controller with synchronizing two streams of traffic by displaying 'ghost' targets,

allowing them to understand the relationship of merging/converging flows sooner so that speed control can be more effectively applied. This tool allows some airport configurations to be used in situations or conditions where it would otherwise not be possible. It can be used more effectively when arrival flows are metered—it helps TRACON controllers fine-tune spacing across flows for converging and crossing runway operations. It is also used with ATPA to tighten up in-trail spacing on final approach. For this reason, the FAA is also considering commitments regarding applying use of CRDA to support a number of airport configurations.

Implementation of TBO aligns with many of the within 18-month NEC commitments, as well as the 18-48 month commitment set currently being considered encompassing new PBN procedures, improved use of existing flow management capabilities, and implementation of new flow management capabilities. These commitments both address near-term operational needs and establish the core foundation for achieving initial TBO to/from NEC airports.

Advancing RNP at New York Airports

In its October 2017 meeting, the NAC requested the NEC NIWG include stretch goals to utilize NextGen capabilities and strategies. Performance Based Navigation plays an instrumental role in the NEC solution space, as evidenced in both the Industry sequencing of priorities and in the FAA's TBO strategy. While utilizing existing RNAV capabilities provides an essential foundation to address needs in the NEC, particularly in the near term, the NIWG recognizes that utilizing advanced navigation capabilities may be necessary to resolve the broader issues in the NEC. For example, the tighter containment of advanced RNP¹⁰ could provide solutions for airport deconfliction that cannot be afforded by RNAV solutions. The NEC is considering how to balance commitments that utilize existing capabilities to provide near-term relief to NEC challenges with expediting achievement of advanced RNP operations in the NEC¹¹.

Advanced RNP is important for meeting the needs of NEC stakeholders for the established goals of increasing overall throughput, completing the flight, arriving according to schedule and delivering reliable departure and arrival times. This can also have positive impacts on the environment and safety.

Implementation and effective use of advanced RNP is dependent upon at least three key actions to mitigate risks: 1) having published procedures developed with community involvement (further discussed in the *Implementation Risks* and *Community Involvement*

¹⁰ Defined in the FAA's PBN NAS Navigation Strategy 2016 as: "Advanced-RNP functions provide more capability than default PBN procedures. Advanced-RNP functions include radius-to-fix (RF) legs, parallel offsets, RNAV holding, scalable RNP, fixed radius turns (FRT) and Time of Arrival Control."

¹¹ In the October report to the NAC, the NIWG identified two examples of PBN concepts in the NextGen Initiatives section of its Phase 2 Interim Report and has developed more detail:

- Conduct feasibility assessment of EoR simultaneous operations to 13R RNP and 13L ILS at JFK
- Assess concept to allow simultaneous operations at widely spaced approaches to different airports

sections), 2) having critical mass of appropriately equipped aircraft, and 3) availability of controller and ATCSCC decision support tools to manage aircraft flows. The pace at which industry and FAA achieves advanced RNP operations will be directly linked to these three areas.

PBN remains a broadly supported and foundational element of NextGen. Implementation of fully leveraged PBN capabilities, such as Advanced RNP in the NEC is limited with mixed equipage fleets by the ability to segregate aircraft equipped for advanced RNP operations from non-equipped aircraft, particularly on single runway operations. At LGA airport, for example, the level of non-equipped aircraft currently poses a challenge to managing the flow of aircraft for advanced RNP operations. At JFK and EWR, which have greater equipage and possible use of a second arrival runway, advanced RNP may be more feasible sooner.

Objective data and analysis are needed to inform the extent to which advanced RNP operations are feasible in mixed equipage environments. Data can identify the threshold of equipage required to reliably operate advanced RNP in the NEC (noting that different airports and operations may have different thresholds). Additionally, data can inform whether thresholds change with the implementation of certain controller decision support tools such as sequencing tools.

Operators continually evaluate their fleets to determine whether to equip their aircraft with the capability to operate advanced RNP. Some operators have fully equipped while others have not. Additionally, some, but not all, equipped operators have received operational approval to fly advanced RNP.

Data and analysis are also needed to inform decisions about modernizing equipment. Operators, particularly those whose networks are served by aircraft not equipped for advanced RNP operations, seek objective data to substantiate RNP related benefits and thus investments. Without this data, the benefits of advanced RNP airspace procedures cannot be substantiated. Conversely, operators who have modernized fleets are not able to consistently conduct advanced RNP operations with their capable aircraft.

Data would inform operators developing business cases to modernize non-capable aircraft to participate in advanced RNP operations, and the NEC NIWG is considering commitments to developing such data. This would help ensure that the benefits are coordinated between stakeholders and commensurate with the investment. The NEC NIWG recognizes that any commitment regarding generation of such data needs to be bounded to ensure the information is timely.

The high-level data should address questions regarding the viability of advanced RNP. These results would inform operator equipage, FAA policy and airport investment decisions by quantitatively informing the following types of questions:

- What are equipage thresholds to achieving benefits?
- How much benefit do non-equipped aircraft leave on table?

- How much system benefits are sacrificed due to lack of equipage?
- How much benefit is still achievable with mixed equipage?
- How do benefits change given level of resource applied?
- How do benefits change given pace of implementation and acceptance of tools and procedures?

Commitments should include evaluation of operational or financial incentives for equipped aircraft. Operational incentives may include access at certain times of day for aircraft equipped for advanced RNP or exemption from traffic management restrictions. Financial incentives may be similar to those used for the DataComm program.

Both industry and FAA are keenly focused on an approach to advancing RNP that coordinates development of procedures and controller tools with aircraft equipage. The NEC NIWG does not want to implement NextGen procedures, develop new controller tools or add equipage with no operational benefit. Nor does the NEC NIWG seek to create a highly complex or multi-year term modeling requirement that does nothing to further needed decision making. Rather the intent is to encourage a collaborative analysis forum, with the participation of all operational stakeholders, that is focused and delivers timely results (within 12 months). The June report to the NAC will identify any commitments on generation of data and analysis to inform advancing of RNP, including scope and required participation from Industry, Airports, and the FAA.

Advanced Technologies

At its October 4, 2017 meeting, the NextGen Advisory Committee (NAC) requested the Northeast Corridor (NEC) NextGen Integration Working Group (NIWG) to assess if, and/or how to leverage the capabilities of Enhance Flight Visions Systems (EFVS) in the NEC including correlating benefits with varied levels of equipage.

In subsequent discussions by the NAC Subcommittee, the Advanced Technology Subgroup was created to perform this assessment. As the NACSC discussed the NAC request, the inclusion of Flight Interval Management (FIM) or potentially other new capabilities was also suggested for inclusion.

The detailed report is included as Appendix (F). Many of the time frames for the advanced technologies recommendations extend beyond the time frame covered by this report. Certain initiatives will be incorporated in the operational needs as appropriate.

The following summarizes the three areas (four technologies) identified by the Advanced Technology Subgroup:

Ground Based Augmentation System (GBAS) – funded by airports, with technical support from the FAA, and specific equipage for aircraft operators, GBAS offers the potential for immediate benefits (GBAS enables system installation at any airport in the world). By providing

navigational accuracy to within 1/2 meter, GBAS allows precision approaches where none are currently available, with potential for all weather CAT III capability.

Some aircraft operators have invested in GBAS, however greater airport equipage and FAA support is needed for leveraging benefits from GBAS in the NEC. The NEC is recommending a set of near term industry and FAA actions that support the delivery of benefits from the operation of the non-Federal GBAS facilities by approving new facilities, developing and publishing GLS approach procedures, training controllers, and providing flight inspection services. The NEC is recommending a set of near-term industry and FAA actions

Enhanced Flight Vision System (EFVS) – EFVS is an electronic means to provide a display of the forward scene topography through imaging sensors and includes display element, sensors, computers and power supplies, indications, and controls. EFVS provides an operational credit to lower required visibility/RVR minima on instrument approaches and significantly increases situational awareness during low visibility operations with some limitations.

EFVS primarily benefits smaller, less capable airports without Cat II/III equipment. At higher density locations, opportunities exist for use to runways without an approach procedure or secondary runways. By providing enhanced flight visibility to perform the visual segment of an instrument approach procedure, properly equipped aircraft can use EFVS to initiate and/or continue any instrument approach procedures utilizing glideslope or VNAV vertical navigation down to touchdown and rollout with weather minimums well below those required for the approach.

Potential exists to change the way the NAS works, particularly the NEC, in relation to weather situations with less than visual approach conditions. EFVS could lower IFR minimums thus maintaining higher runway rates during lower than visual approach conditions.

Further studies are necessary to determine requirements for reaching benefits similar to Cat II/III operations in the NEC, as well as breaking down the relative advantages to primary and secondary airports and how often arrival rates would improve if these benefits did exist. In addition, studies are needed to analyze the effects of mixed equipage aircraft operations in the NEC, including what level of equipage is required to begin realizing significant benefit.

ADS-B In

Cockpit Display Traffic Information (CDTI) Assisted Pilot Procedures (CAPP) – is the concept that involves enhanced Traffic Collision Avoidance System (TCAS) using ADS-B In data that enable pilots to adhere to a controller's clearance without visual acquisition and include technology that replaces the pilot's view to acquire traffic to follow.

The primary potential benefit of these capabilities is stabilizing runway rates even when visibility is not, allowing near VFR arrival rates in IMC conditions with minimal changes, benefiting both aircraft operators and the NAS. CAPP has the potential to improve runway rates during IMC without changing procedural designs or requiring airspace changes.

There are specific issues that need to be evaluated for deployment in the NEC. These include determining whether leading and following aircraft must be on the same approach and how controllers will know if an aircraft is equipped to participate. Modifications to controller automation (e.g. STARS, ERAM) may be needed to include information in the data tag. FAA investment in such modifications may be contingent on the level of operator equipage.

Flight Interval Management (FIM) – uses ADS-B In traffic information to provide speed cues to pilots in order to manage inter-arrival spacing. Implementation of FIM is a fundamental change in the way traffic is managed. Pilots will have a new task of following changing speed guidance from avionics. Pilots will not be responsible for separation; their only responsibility will be to follow speed guidance from the avionics. Controllers are responsible for separation.

The goal of IM is to reduce the variation in inter-arrival spacing, thus increasing runway throughput. The more direct control loop enabled by calculation of speed by IM avionics results in a significant reduction in the standard deviation of the inter-arrival rate. This leads to more available capacity, compared to current operations with ATC vectoring and speed assignments. Since IM arrivals end with instrument approach procedures, there is no need to conduct visual approaches to achieve maximum capacity. Maintaining higher arrival rates, similar to VMC arrival rates, will be possible with IM during periods of lower ceiling and visibilities, down to Category 1 approach minimums. Research indicates that FIM system performance may also allow for further increases in capacity.

Issues such as mixed equipage, cultural issues for pilots and controllers, and accommodation of go-arounds and departures from close-in airports must be addressed for the TBO environment. The cost and benefits also needs further definition. The policy and procedures associated with enabling FIM need to be defined. Aircraft operators also need information for the business case to invest in IM capable ADS-B-in avionics.

Airport Infrastructure Priorities

Airports within the NEC continue to improve and modernize their infrastructure. In response to the NAC recommendation to pursue initiatives that are more forward leaning, several additional initiatives were identified that could benefit from the collaborative NEC process to advance towards implementation. In general, many of these are projects that were being discussed in various forums, but had not yet advanced to actual, mature projects with planned implementation schedules. The projects have significant potential to contribute to improved operations in the NEC, through connected benefits with improved surface flows or reliable access during poor weather.

Most of these initiatives are identified as pre-implementation, in that further analysis and decision making is needed among stakeholders to reach a decision on proceeding with actual development and the overall scope of the project. This can include benefits analysis to arrive at

an investment decision, stakeholder collaboration on advanced development planning, and revisions to the airport layout plan. Most of these initiatives are industry goals since they involve physical construction on the airport.

Airport	Initiative	Notes
BOS	Create additional tower space for TFDI equipment to enable surface metering (I)	Massport owned tower space that is leased to FAA ATCT
	Conduct GBAS assessment/evaluation (I/PI)	Benefits assessment for airport investment decision
JFK	Install non-fed GBAS (I)	PANYNJ installation of GBAS equipment, with initial goals of providing additional resiliency and approach overlays to all runway ends
LGA		
PHL	Conduct assessment of departure queue taxiways to feed Runway 27R (I/PI)	Develop benefits assessment and revise airport layout plan, in coordination with stakeholders (airlines, ATCT, FAA)
	Conduct assessment of additional high-speed exit to improve arrival throughput on Runway 27L (I/PI)	
	Conduct assessment of taxiway extensions for end-around operations to improve surface flow (I/PI)	
DCA	Conduct assessment of north end hold pads and stub taxiways to improve surface efficiency (I/PI)	With development of the New North Concourse, reconfigured and expanded hold pads and stub taxiways on the north end could improve efficiency and ease surface congestion
NEC airports	Conduct benefits assessment of gate docking technologies to improve surface management (PI)	FAA led study with MITRE to assess if more widespread use of gate docking technologies, particularly during convective weather, would significantly improve NEC operations

Although not listed as NEC initiatives, the NEC airports continue to fund and implement significant improvements to their infrastructure (including major airside and terminal development) with support from their airlines and FAA. The airport sponsors and airlines in the NEC have spent over \$5 billion combined in the past five years and are anticipated to fund approximately \$15 billion over the next five years on critical airport infrastructure. These projects are maturing and will provide significant benefits to the airports' operation and enhance the overall passenger experience. Since they are already independently progressing towards implementation and may not directly impact airfield and airspace utilization, they were not included as NEC initiatives. Instead, focus on the initiatives identified above is substantive for the NEC process given the upside potential to develop projects that could further improve NEC operations.

Community Involvement for NEC Implementations

An important element for successful implementation of NEC initiatives will be the communication and affirmation of the need for change and the engagement and support of all stakeholders throughout the process. There is a recognition from the FAA, aircraft operators, and airport operators outlined in the June 2016 recommendation¹² by the NAC that a key step is also the communication and engagement with local communities. We must engage early and often on multiple levels to ensure an understanding of the need for the changes and what they will mean to the community. All of those who are interested in the success of NextGen implementation in the NEC must be involved.

The framework and key principles for conducting community involvement during implementation of NEC commitments will follow the *FAA Community Involvement Manual* and include the following:

- Throughout the NEC community involvement process, airport operators, aircraft operators, and the FAA are critical partners who are committed to explaining the initiatives and their benefits and in communicating with communities.
- The level of community involvement will be tailored to the initiatives under consideration and the potential impact of specific initiatives. In some cases, this may mean going beyond satisfying applicable legal requirements.
- Successful community involvement activities will leverage community aviation roundtables and other stakeholder groups throughout the NEC.
- Communication with elected officials, local agencies, the public, and other stakeholders on project status will be timely and ongoing. Comments and feedback on specific initiatives from all stakeholders will be considered to inform decision making and project refinements.

Given that the NEC is a collection of multiple initiatives of different types (airspace & procedures, airports, tools, and tactical) across differing timeframes, there should be regular communications regarding NEC activities to ensure that the set of initiatives fits together in a cohesive way and that cumulative noise impacts across all applicable initiatives are addressed.

Part 150 studies¹³ are ongoing as part of a separate process at several locations, but it will be necessary to address any overlaps and dependencies, and coordinate communications strategies.

¹² PBN Blueprint Community Outreach Task Group recommendation, June 2016.

¹³ Federal Aviation Regulation, Part 150, Airport Noise Compatibility Planning, is the primary Federal regulation guiding and controlling planning for aviation noise compatibility on and around airports. Part 150 established procedures, standards, and methodologies to be used by airport operators for preparation of Airport Noise Exposure Maps (NEMs) and Airport Compatibility Programs (NCPs) which may be submitted to the FAA.

Joint Analysis Team Evaluation of Impact

The Joint Analysis Team (JAT) is an FAA-Industry collaborative team that evaluates the operational benefits from NextGen implementations. In the October 2017, the NAC approved a report from the NEC that detailed implementation commitments in the NEC through March 31, 2019. These commitments include 8 implementations that are expected to directly impact operational performance in the NEC.

The JAT has developed measurement plans to evaluate the benefits of each of these implementations as they begin to ‘touch the operation.’ A summary of the JAT’s measurement plan for the 8 initiatives is presented below:

Initiative	Initial Ops Availability	Supporting Org.	Study Periods ¹⁴	Benefits Assessment
Implement EDC at ZNY	Q1 2018	FAA MITRE AA, DL, UA, JB, WN	Mar-Sep 2017 vs. Mar-Sep 2018	Preliminary: Oct 2018 Initial: Feb 2019 Final: Apr 2019
Implement TBFM IDAC at 4 NY Towers	Q1 2018			
Implement BOS SWIM Visualization Tool at ZBW	Q2 2018			
Implement SCIA to PHL 9R/17	Q3/Q4 2018	FAA MITRE AA	Jan -Jun 2018 vs. Jan -Jun 2019	Preliminary: Apr 2019 Initial: Oct 2019 Final: Jan 2020
Implement CRDA DCIA application for PHL 27R/35 for RNAV approaches	Q1 2019		Apr -Oct 2018 vs. Apr -Oct 2019	Preliminary: Oct 2019 Initial: Feb 2020 Final: Apr 2020
Improve airborne metering to PHL ¹⁵	Q1 2019			
Expand consistent usage of defined and existing capping and tunneling for departures/arrivals to/from the NEC through required advisories	Q1 2019			
Implement TBFM Pre-Departure Scheduling at selected airport	Q1 2019			

Further detail on the JAT’s plan to measure these initiatives are covered in a separate document that is available from RTCA. As the NEC NIWG identifies new implementation milestones, evaluation of these will be integrated into the JAT’s measurement plan.

¹⁴ Study period and Benefits Assessment dates may need to be adjusted based on the actual initial ops availability date and data availability; analysis of baseline performance will be conducted and reported on prior to the preliminary reporting

¹⁵ May need to compare 2017 to 2019 study periods to eliminate periods with inconsistent use of metering

Appendix A: FAA Tasking Letter



U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Deputy Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

April 13, 2017

Ms. Margaret Jenny
President, RTCA, Inc.
1150 18th St. NW.
Washington, DC 20036

Dear Ms. Jenny:

The NextGen Advisory Committee (NAC) met on February 22, 2017, and agreed to make the Northeast Corridor (NE Corridor) a priority region in the Federal Aviation Administration's (FAA) ongoing implementation of NextGen. The FAA supports the aviation industry's recommendation to address improvements in the NE Corridor, defined for this task as the airspace from Washington, D.C., to Boston, including Philadelphia and New York City.

NAC member input received to date underscores the complexity of the NE Corridor in implementing and effectively utilizing NextGen capabilities. Success will require collaboration and consensus among many diverse and competing stakeholders. Consequently, we believe it is essential that stakeholders begin by working together to define what they view as the primary challenges and opportunities, as well as how success will be defined. Given the broader infrastructure program being contemplated by the administration, we would like the NAC to begin work immediately to inform the infrastructure program for improvements in the region.

We all recognize that NextGen requires significant investment from a variety of stakeholders, including the government, as well as those who manage airports and operate aircraft in the aviation system. Here is the question to be addressed by the NAC: What collective set of FAA, airport, operator and community initiatives can improve the NE Corridor?

The FAA requests that the NAC undertake the NE Corridor tasking in the phases outlined below.

- Phase 1: By June 2017, define success in terms of benefits to include determining how benefits will be measured. Identify opportunities that are most likely to lead to success, and identify hurdles that could result in implementation challenges. The emphasis should be on initiatives that can be implemented in less than 18 months. Implementations of up to three years may also be considered.
- Phase 2: By October 2017, use the deliverables in Phase 1 to define joint implementation commitments for the NE Corridor, including government and industry milestones, and

define how implementing those priorities would lead to measurable benefits. Subsequent to implementation, ensure benefits are measured.

The NE Corridor tasking should leverage the 2013 NextGen Prioritization criteria. As appropriate, the tasking should incorporate previous NAC recommendations to the fullest extent possible and leverage previous Tactical Operations Committee recommendations.

The FAA and other aviation stakeholders involved in implementing the NE Corridor initiative have limited resources. The NAC will need to include recommendations on which commitments and/or other existing priorities should be removed from current NextGen Priorities.

It is important to draw on what has worked well in the past and identify how to move forward. We look forward to the opportunity to share lessons learned at the upcoming NAC subcommittee meeting. If I can be of assistance, please contact me or James T. Eck, FAA Assistant Administrator for NextGen, at (202) 267-7111 or email James.Eck@faa.gov.

Sincerely,

A handwritten signature in black ink, appearing to read "VB Wassmer". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Victoria B. Wassmer
Acting Deputy Administrator

cc: James T. Eck, Assistant Administrator, NextGen
Teri L. Bristol, Chief Operating Officer, Air Traffic Organization
Winsome Lenfert, Acting Associate Administrator, Airports
Jenny Solomon, Assistant Administrator for Policy, International Affairs, Environment and Energy
John Hickey, Deputy Associate Administrator, Aviation Safety

Appendix B: NEC NextGen Integration Task Group

Air Line Pilots Association (ALPA)
Airlines for America
American Airlines, Inc.
Baltimore/Washington International Thurgood Marshall Airport (BWI)
Beacon Management Group
Delta Air Lines, Inc.
Federal Aviation Administration (FAA)
FedEx Express
General Aviation Manufacturers Association
Harris Corporation
HMMH (DP)
JetBlue Airways
Landrum-Brown
Leidos
Massachusetts Port Authority
Metron Aviation, Inc.
Metropolitan Washington Airports Authority
MIT Lincoln Laboratory
NASA
National Air Traffic Controllers Association (NATCA)
National Business Aviation Association
NOISE (The National Association to Insure a Sound Controlled Environment)
PASSUR Aerospace
Philadelphia Airport
Port Authority of New York & New Jersey
Professional Aviation Safety Specialists (PASS)
Raytheon
RTCA, Inc.
Sandel Avionics, Inc.
Southwest Airlines
The Boeing Company
The MITRE Corporation
United Airlines, Inc.
United Parcel Service (UPS)

Appendix C: Assumptions and Guiding Principles for the NEC

Assumptions

From Phase 1, the industry members from the NextGen Advisory Committee Subcommittee (NACSC) served as the Northeast Corridor (NEC) Task Group (TG) and identified the following Assumptions for the effort to impact the Northeast Corridor:

- The NEC includes the Washington, DC/Baltimore, Philadelphia, New York and Boston airports and associated airspace
- Time frames for NEC effort are the first 18-months, 18-36 months, 3+ years
- Adverse weather is a major issue in improving operations in the NEC
- Factors for Success/Hurdles/Risk Factors
 - Assume financial support will materialize to move forward on prioritized initiatives
 - FAA Northeast corridor staffing key to success, daily operations and implementing new capabilities
 - Unless sufficient staffing levels are achieved in the Controller work force, Traffic Management Units, Air Traffic Control System Command Center and supervisory workforce in facilities providing service in the Northeast corridor, the goals outlined in this document relative to implementation of technologies, procedures and processes will not be achievable.
 - Priorities for NEC may negatively impact timing of other initiatives
 - Equipage may determine desire to implement certain initiatives and ability to achieve benefits
 - Environmental issues/concerns are critical in reviewing capabilities
- Areas of Focus
 - Key driver of variation in operations is decision-making by different individuals (operator & air traffic), each with own experience and skill level
 - Scheduled operators are focused on schedule integrity and reduction of block times where opportunities exist
 - On-demand operators focused on flying time minimization
- Willingness to be key site for new capabilities

Guiding Principles

The Task Group identified the following Guiding Principles for the effort to improve performance in the Northeast Corridor:

- Capabilities should have an overall positive system-wide effect on NEC
 - Improving overall system performance may have some limited local negative impacts; these should be minimized
 - Capability discussion requires understanding of trade-offs – develop strategies to address
- Effort should establish quantitative “stretch” goal(s)
- Block times and called and actual rates should be the focus through this effort
- No new equipage mandates
- NEC is unique; hence capabilities in the NE Corridor may be unique
- Considerations in establishing priorities
 - Priorities should enable full utilization of available capacity in NEC, especially during peak demand periods and/or during irregular operations (IROPs)
 - Buy-in from local communities and governments should be sought as soon as possible
 - Effort should remain consistent with the overall NextGen’s TBO Vision and PBN NAS NAV Strategy
 - Process needs to recognize “burn-in” (i.e., technical and non-technical issues associated with the introduction of new capabilities into the system) component to implementation; burn-in should be addressed and continually improved
 - Priorities should be consistent with critical resource availability (technical, controllers, tech pilots, etc.)
 - Important to evaluate the effects of improvements/enhancements at an airport/airspace area adjacent or in close proximity

Appendix D: Detail on Operational Needs in the NEC



Contents

- **Overview of Operational Need Areas**
- Potential Initiatives to Address Operational Needs
- Operator Input on Initiatives to Sequence First
- Detail on Sequencing Input

1



Ten Operational Needs in NEC

Deconfliction & Throughput Focus

- Improvement for constrained NEC departure routes - during normal and severe weather operations
- Address loss of airport throughput due to airport/airspace interactions when arriving LGA 13
- Address loss of airport throughput due to airport/airspace interactions when arriving LGA 31
- Improvement in arrival throughput at EWR and delay reduction (i.e. Ground Delay Programs)
- Provide satellite airport access to NY area airspace and deconflicting satellite operations with the major airports where possible

Throughput/Growth Focused

- Provide full utilization of available LGA capacity
- Improvement of JFK runway usage and delay reduction
- Improvement of PHL runway usage and delay reduction
- Provide reduced separation and spacing and improved access to NEC airports

Data Driven Traffic Flow Management

- Evolve TFM to incorporate data-driven decision-making to better manage demand/capacity imbalance in the NEC

2



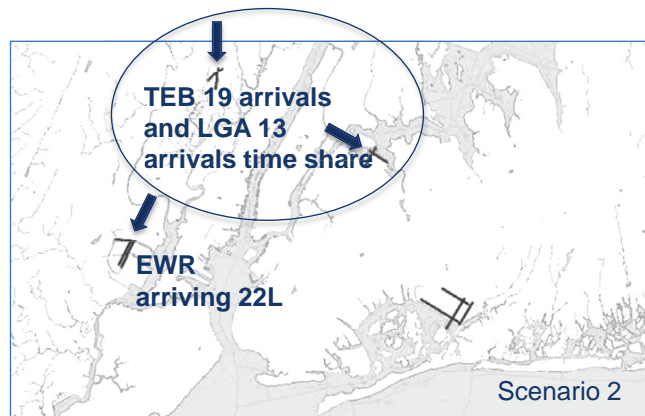
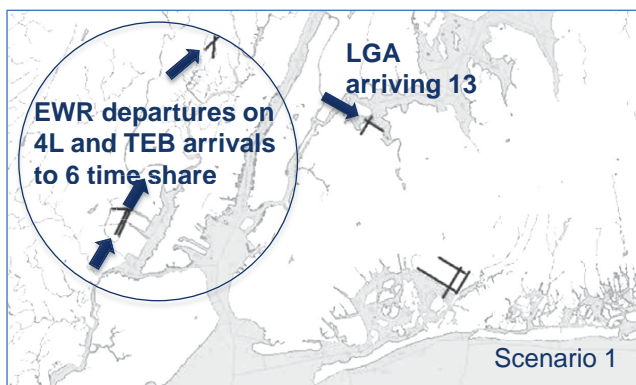
Improvement for Constrained NEC Departure Routes - During Normal and Severe Weather Operations

- **Focus on Airport and Airspace Throughput**
- Departure route agility has been identified as significant NEC challenge
- Convective weather causes the highest number of customer disruptions
- Lack of effective planning exacerbates delay issues and results in numerous last minute cancellations due to FAR 117 crew duty time exceedances

3



Address Loss of Airport Throughput Due to Airport/Airspace Interactions when Arriving LGA 13

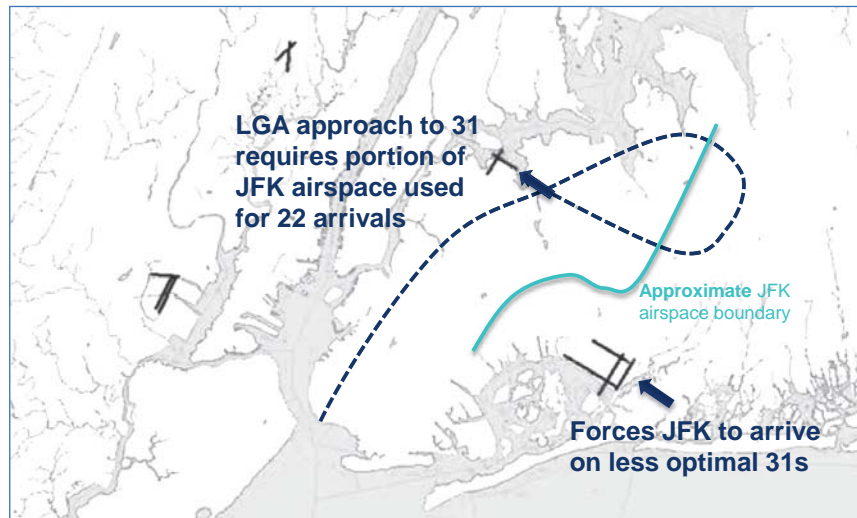


- **Focus on Deconfliction, Airspace Throughput & Airport Throughput**
- LGA RNAV 13 de-conflicts LGA from EWR and TEB, but has limitations on LGA operation
- Airport configuration autonomy allows greatest throughput and system benefit for all airports
- Airspace sharing at LGA/TEB/EWR is inefficient and unpredictable
- Greater use of land 13 / depart 4 - dispersal flight paths for noise mitigation

4



Address Loss of Airport Throughput Due to Airport/Airspace Interactions when Arriving LGA 31



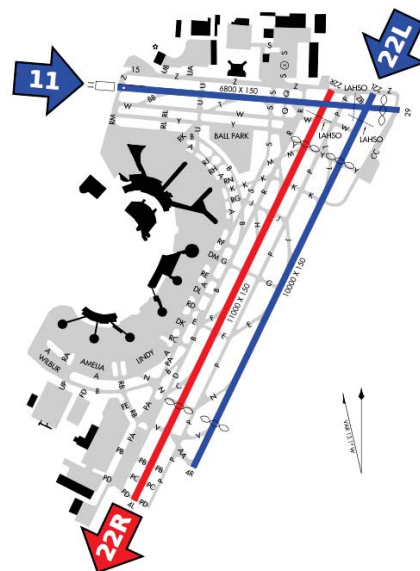
- **Focus on Deconfliction, Airspace Throughput & Airport Throughput**
- When LGA forced on 31 localizer, takes a portion of JFK airspace to sequence, forces JFK to 31 operation; limits JFK

5



Improvement in Arrival Throughput at EWR and Delay Reduction (i.e. Ground Delay Programs)

- **Focus on Airport Throughput**
- Two arrival runways needed, but no consistent utilization of second arrival runways (4L/22R or 11/29)
- In October 2016 EWR change from Level 3 slot controlled airport to Level 2 slot facilitated airport – scheduled demand has increased
- GDP regularly issued for weather/wind, but also on VFR days
- Additional arrival throughput needed that does not reduce departure throughput
- Controller staffing may be contributing factor to use of 2nd runway



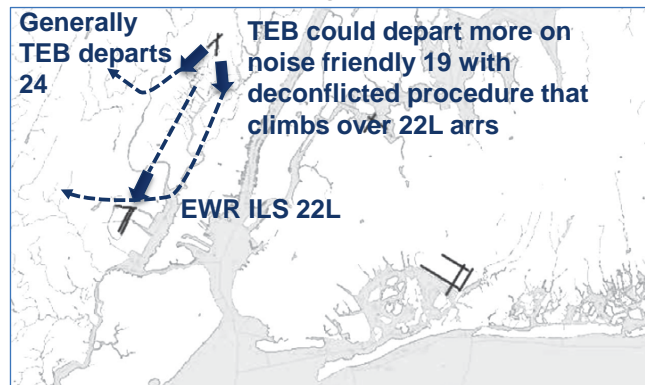
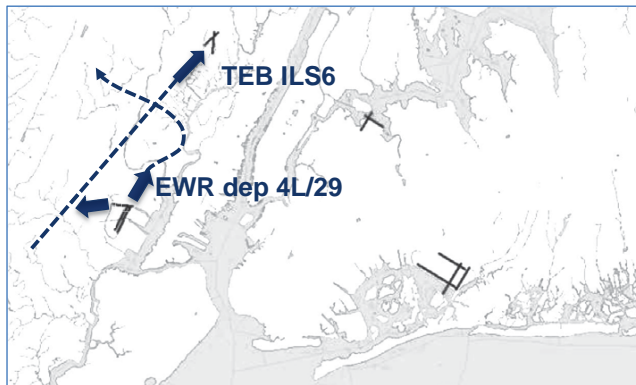
Example of two arrival runway scenario at EWR
Image from "Impact of Heavy Aircraft Operations on Airport Capacity at Newark Liberty International Airport," Ioannis Simaiakis, Alexander D. Donaldson and Hamsa Balakrishnan, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

6



Provide Satellite Airport Access to NY Area Airspace and Deconflicting Satellite Operations with the Major Airports Where Possible

Examples of interactions include following



- **Focus on Deconfliction and Airport Throughput**
- Deconflict operations between EWR -TEB - other EWR satellites
- Utilize available capabilities to expedite departures
- TEB 19 preferred noise abatement procedure
- Other interactions to be identified

7



Provide Full Utilization of Available LGA Capacity

- **Airport throughput**
- When operating at capacity most of the day (eg LGA) any variation in arrival flow can cause ground delay programs
- Any variation in airport configuration (i.e. runway change) can cause ground delay programs, ground stops, holding and missed departure opportunities leading to departure delays
- Ground stops, holding and missed departure slots leading to departure delays

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Improvement of JFK Runway Usage and Delay Reduction

- **Airport throughput**
- JFK does not effectively utilize all of the available runways
- Departure and metering delays are experienced due to the shared departure runways

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Improvement of PHL Runway Usage and Delay Reduction

- **Airport throughput**
- Leverage recent TERPS changes
- Modern procedures for PHL
- Airfield improvements to support better departure staging

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Provide Reduced Separation and Spacing and Improved Access to NEC Airports

- **Airspace & airport throughput**
- Density and complexity of the NEC operations call for improvement
- Provides improved approaches with lower minimums and less chance of go around; maximize utilization of available airfield capacity

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Evolve TFM to Incorporate Data-Driven Decision-Making to Better Manage Demand/Capacity Imbalance in the NEC

- **Focus on Airport and Airspace Throughput**
- Determine what rates of throughput are achievable and sustainable
- Predictably deliver the demand to those rates
- Clear approach to TFM processes and procedures
- Best information on weather forecasts, demand forecasts, etc. needed to establishing rates
- Implement in the traffic management and operational environment in collaboration with operator/ATC front line personnel

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Many Initiative Options to Impact Operational Needs

Constrained NEC departure routes, during normal ops & during SWAP	Route planning <ul style="list-style-type: none">Understand industry readiness for TOS submissionsFacilitate development of advanced planning capabilities such as Nas Play and other Lincoln Lab weather and route impact tools. Explore other potential game planning opportunities in conjunction with the PERTI planning process. Capabilities to identify reroutes at the right time <ul style="list-style-type: none">Implement all technology enhancements to facilitate PDRR use in short termEnhanced departure scheduling and sequencing capabilities. This is a major chokepoint in the NEC and particularly within the NY area. – IDAC (6 towers mid Dec 2017), EDC in process (turned off in SWAP?) Creating route options to get out <ul style="list-style-type: none">Fully design and implement Northeast tunnel route structure (build off current)International Departure Route Flexibility – facilitate EWR departures via BETTE/HAPIE (normally JFK int'l dep route) or new route to augment departure capacity. Develop procedures (flight planning) to enable use during 2018 SWAP season.Westgate escape routes from the NY area. This could be via South or North fixes. The South fixes would be preferred due to the structure of the weather and its impacts to the Northeast. An example of this concept was discussed approximately 25 years ago with conceptual routes designed. Basic concept was for traffic to depart NY/PHL southbound and join up on established routes once aircraft were able to turn westbound. Airspace limitations to routes <ul style="list-style-type: none">Split ZDC09 for volume – study underway, Spectrum engaged, may be ready for Summer 2019, moving to workload based MAP values, potential ACRP impact	Improve Satellite access to NY area airspace, deconflict satellite operations with Address conditions favoring LGA 31 - Reduced separation and improved access to NEC airports	Deconflict EWR/TEB flows (ILS 6/29 arrivals and departures eg) <ul style="list-style-type: none">Develop TEB 19 noise abatement departure to include climb and then turn over ILS 22L arrivals to EWR[Others based on additional EWR/TEB interaction issues]Other satellite airport conflicts (MMU/CDW/IRG/HPN) Design approaches to LGA 31 which deconflict JFK/LGA; Belmont LOC 22 switch <ul style="list-style-type: none">Implement RNAV approaches to Runways 31/22/13 to further deconflict the LGA runwaysModify LGA/EWR airspace boundary to deconflict with EWR29 RNAV GPS approachModify final approach separation standards to allow compression inside 4 DME, that is, do not require controllers to maintain separation to runway threshold, including for wake separations. Model program after procedures currently in use at LHR.Authorize 2.5 nm within 20 nm on final; ensure all runways are authorized for 2.5 nm and allow ASDE-X to be used to determine clear of the runway.Evaluate the use of Time Based Separation at all NEC airportsRNAV (RNP) approaches to available runway endsGBAS capabilities explored as system is deployed at EWR and future installations at JFK/LGA/TEB. How can we use this technology to improve the efficiency of the airspaceStandardize RNAV Visual adjustments to allow procedures to become public (guided visual approach)Separation waivers between two arrivals or between an arrival and a departure on intersecting runways similar to EWR 4R/29 waiver: Other possibilities: LGA 22/31, LGA 4/31, LGA 13/4; EWR 11/22L; JFK?Reduce separation from the 3 mile requirement when using RNAV or RNP procedures
	Loss of airport throughput due to airport/airspace interactions: LGA 13 <ul style="list-style-type: none">Improving future operations<ul style="list-style-type: none">Design LGA ILS13 RNAV transition and airspace changes to support simultaneous operations at LGA/TEB/EWR in all weather conditionsDesign LGA RW4 SID to facilitate two LGA runway operationImproving current operations<ul style="list-style-type: none">Establish traffic flow strategy to increase departure throughput when RNAV 13 is in use: Reroute IGA arrivals over IJZZI; Use FCA or CTOP to manage remaining traffic from North; Use airspace line on controller scope; Establish baseline arrival rate at 3XMay require transition to EWR below 3000 ft; not necessarily one for LGAIndustry have notional design?Intercept glide slope too high? Stable approach feasible?Links to widely spaced parallel concept	Full utilization of available LGA capacity <ul style="list-style-type: none">Implement TBFM metering to optimize arrival flow and hence optimize throughputExpand use of TBFM scheduling and pre-scheduling in conjunction with meteringDeploy tool(s) to assist in managing the correct final spacing TSAS and CRDA for example Improvement of JFK runway usage and delay reduction <ul style="list-style-type: none">Implement TBFM metering to optimize arrival flow and hence optimize throughputExpand use of TBFM scheduling and pre-scheduling in conjunction with meteringDeploy tool(s) to assist in managing the correct final spacing TSAS and CRDA for exampleEvaluate the potential runway configurations include IAH50 operations. Similar to the NASA work NY Novell Airspace Configurations (NWNAC)Enhance Surface Management through the use of Ground Management System currently in use and to transition into TFDmImprovements to Taxiways to improve the surface movements	Appropriate RNAV to PHL 27L for parallel approaches to 27L/R for SAPR <ul style="list-style-type: none">PHL change to 7110.308 for decreased separationIndependent Cat 1 approaches to PHL 26Taxiway additions that focus on easier 27R departure staging and reduced 27L runway occupancy times
Improvement in arrival throughput at EWR and delay reduction (i.e. GDPs)	CRDA 22L and 29 using an RNAV (GPS) Runway 29 (existing or new). This would be similar to the 4R/29 procedure. Resolving the conflict with LGA airspace for the north flow is a high priority. Procedures would be used during the upcoming closure of 4R at JFK, which will force JFK to the 31's more frequently and allow LGA to use the localizer 31 approach. <ul style="list-style-type: none">Runway 04L Visual App's (Parallel visuals to 4's); Parallel visuals to 22's.7110.308 procedures at EWR. Glide slopes adjusted to support the procedures. Use procedures in VMC for sequencing approaches to 4L and 22R to avoid VMC GDPs.EWR Land 29, depart 22L/R; Consistent use of Dispersal Headings will reduce departure delays.Usable during lower arrival demand periods. (Eliminates the need for arrivals to cross the departure runway.)Use of terminal sequencing tool (eg TSAS) to sequence the arrivals to the overflow runway.Reduces controller workload and provides an efficient flow to the secondary runways.	Improvement of PHL runway usage and delay reduction	

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Sequencing: A Transitional Approach

- Initiatives through March 31 2019 were identified because they could be implemented in T+18
 - Do not necessarily address the highest priority need areas
- TBO offers promise, but operational benefit appears to be longer term (5+ years)
- A set of transitional solutions are needed to bridge us through iTBO and TBO



Key Industry Considerations in Proposing Initiatives through CY2021

- Implement ideas and initiatives that were put forward with pre-implementation milestones for the Mar 31 2019 timeframe
 - Feasibility and safety studies should expedite operational change
- Identify opportunities that will address needs of the flying public, operations, and communities
- Leverage available capabilities/investments, on airfield and in aircraft
- Use procedures that are already in the SOPs



Proposed NEC Mid-Term Implementation Plan

Data Driven TFM	<ul style="list-style-type: none"> • Collaborative SOP around currently available capabilities (IDRP, RAPT, NOD w DRS) for use during SWAP 2018 • Emerging applications and capabilities for opportunities within iTBO scope/waterfall for 2018+ 			
Multiple Airport Deconfliction	<ul style="list-style-type: none"> • RNAV transition to ILS LGA13, and RNAV LPV, RNP and/or GLS to LGA13 • Modified LGA/EWR airspace to deconflict EWR29 GPS, and new GPS and RNP approach • Multiple PBN approaches for LGA31, including RNAV (GPS) transitions to existing procedures and exploitation of RNAV to LOC RWY 31 			
Crosscutting Departure Throughput	<ul style="list-style-type: none"> • PDRR with technology and process changes in place • Expanded low altitude and escape route structure • Enhanced management for fix/route closure during irregular ops • ZDC09 (MAP changes, splitting sector) • Vertical climb escape route/high performance escape route • ACRP and ZNY offshore routes • TBFM metering and pre-scheduling 			
Metro NY Airport Throughput and Efficiency	<ul style="list-style-type: none"> • Existing tools/investments to increase airport throughput: CRDA for JFK, high-speed turn-offs at EWR • Modified existing PBN procedures to reduce pilot and controller workload • Tools to assist managing final approach spacing (CRDA, ATPA) 			
	LaGuardia <ul style="list-style-type: none"> • Dispersal headings (TNNIS, NTHNS, GLDMN) 	Kennedy <ul style="list-style-type: none"> • EoR for 13R • ROBER OPD to 22L 	Teterboro <ul style="list-style-type: none"> • RNAV SID TEB19 • RNAV app procedures for TEB19 and TEB24 	Newark <ul style="list-style-type: none"> • 22L and 29 arrivals • 4L visuals



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Data Driven TFM

- Operationalize an existing capability that improves TFMS's ability to identify demand/capacity imbalances in the NEC and develop an executable plan
- Stand up a joint operational team comprised of flight operators, Command Center personnel, traffic management personnel, etc.

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Operationalize Existing Capabilities

- Implementation milestone for summer 2018 to operationalize an existing capability that improves TFMS's ability to identify demand/capacity imbalances in the NEC and develop an executable plan
- The following ideas have been identified as options that may meet this objective:
 - Follow-on to the National Operations Dashboard (NOD) trial milestone: provide industry access to the NOD with Departure Resource Status (DRS). Training would require both training on 'buttonology' as well as training on operational use.
 - Include RAPT as part of 'Spring Training' to ensure its effective use in Summer 2018.
 - Offer training on IDRP to ensure its effective use in Summer 2018.

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Joint Operational Team

- Stand up a joint operational team comprised of flight operators, Command Center personnel, traffic management personnel, etc.
 - Evaluate existing FAA and industry/3rd party tools and analysis capabilities that impact this operational need
 - There are a variety of capabilities that may assist in data-driven decisions that are worth considering
 - The objective by Q3 2018 is to identify a short list of existing capabilities that best impact this operational need.
 - Develop the process, procedure and policy around the capabilities selected in the preceding milestone that leads to the selected capabilities 'touching the operation' - request this milestone be complete in time to impact Summer of 2019

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Multiple Airport Deconfliction

- RNAV transition to ILS LGA13, and RNAV LPV, RNP and/or GLS to LGA13
- Modified LGA/EWR airspace to deconflict EWR29 GPS, and new GPS and RNP approach
- Multiple PBN approaches for LGA31, including RNAV (GPS) transitions to existing procedures and exploitation of RNAV to LOC RWY 31

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Multiple Airport Deconfliction

RNAV Transition to ILS LGA13

- Allows all three airports to run independently during the most restrictive operations in the NY airspace
- Directly de-conflicts LGA/TEB and EWR providing autonomous configuration; indirectly allows more JFK runway configuration flexibility
 - Eliminates the timesharing of airspace between LGA and TEB arrivals.
- Use of ILS approach provides lowest minimum and max use potential
- Use of RNAV transition supports near 100% participation
- Allows for departures off LGA04; could benefit the neighborhoods around airport
- Arrival rate could potentially be raised from 28 (typical) to 30 or even 32
- Complements JFK EoR and Widely-Spaced concepts, can develop approaches that allow for higher altitudes for both EWR and LGA arrivals (compared to today's operation)
- May require RNAV transition to EWR 22L and/or RNAV SID off 4L (northeast flow)

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Modify LGA/EWR Airspace to Deconflict EWR29 GPS

- Deconflict LGA/JFK from the EWR 4R/29 operation by allowing the use of the expressway approach rather than switching configuration to the LOC 31 approach
- Reduces flying miles
- Additionally paves the way for the EWR 22L/29 operations
- Environmentally: avoids use of the LOC 31 approach which has a negative impact on many communities

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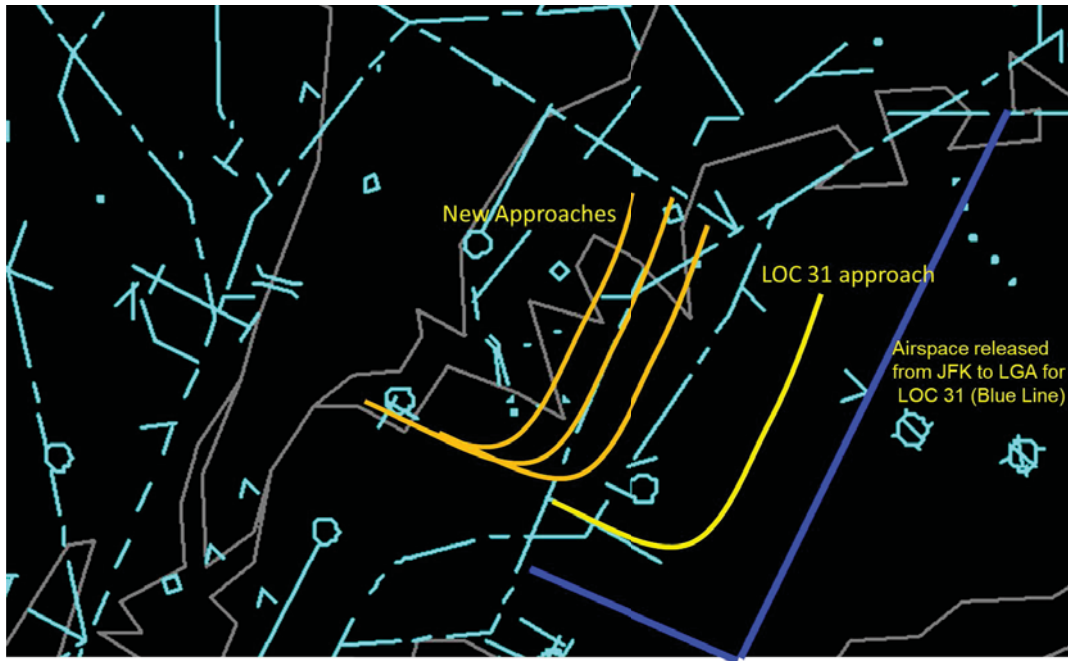
Multiple PBN Approaches for LGA31

- Deconflict LGA and JFK operations and supports independent operations
- Proposed multiple approaches
 - One is to clear the 22L/R operation at JFK
 - Other is to remain within the normal LGA boundaries
 - Third approach could be developed to offer some noise relief based on the various approach paths
- Reduces track miles for the arrivals

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Multiple PBN Approaches for LGA31



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Crosscutting Departure Throughput

- PDRR with technology and process changes in place
- Expanded low altitude and escape route structure
- Enhanced management for fix/route closure during irregular ops
- ZDC09 (MAP changes, splitting sector)*
- Vertical climb escape route/high performance escape route
- ACP and ZNY offshore routes*
- TBFM metering and pre-scheduling

* These initiatives address overlying airspace constraints and have wide-spread benefit to the whole NEC

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PDRR with Tools and Process In Place

- Provides departure route agility during SWAP
- Directly addresses departure throughput issues during SWAP and high volume periods
- Promotes use of TOS by Industry
- Must include ERAM changes as well as DSP to fix color coding issue in towers

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Expanded Low Altitude and Escape Route Structure

- Improved airspace and airport throughput
- Taking advantage of airspace and routes that are not heavily used
- Enhance the SERMN routes to include tunneling options

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Better Management of Fix/Route Closures

- Need to focus on process – not technology
- Dedicated person would monitor and input all route/fix closures and restrictions into common platform
- Same person would query facility, at regular interval
 - Closed fix/route or applied “excessive” restrictions are still necessary
 - Try to relieve constraint or send pathfinder
- Incorporates RAPT/IDRP into the normal operating procedure to stay ahead of weather and volume scenarios

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ZDC09 Sector Split

- Create another sector above ZDC09 at or above FL400
 - Initial design for the creation of Mason Ultra High completed
- Mostly effects departures through ZDC09
- Longstanding problem for southbound traffic from NY
- Reduce GDPs on departures headed south
- Helps address excessive MIT during SWAP and volume on southbound routes from NY
- Need to check the frequencies, and other dependencies

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Vertical Climb Escape Route/High Performance Escape Route

- Use the capability of the high performance aircraft that primarily fly into and out of the NY satellite airports with Focus on TEB/HPN initially



ACRP and ZNY Offshore Routes

- Airspace and airport throughput benefits expected are reduced restrictions in the NY/PHL operations
- Reducing the delays associated with these restriction. Traffic Flow management also a large part of this operation



TBFM Metering and Pre-Scheduling

- Implement first at LGA, then at JFK
 - LGA “blue sky” GDP when land 31 depart 4
- More precise tool to condition arrival flow into airports at capacity/demand line
- Improved operational arrival flows allows for less holding and provides improved performance
 - Less GS, GDP and holding delay
- Improved arrival spacing facilitates greater departure throughput; supports proper spacing (gaps) for departures

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Metro NY Airport Throughput and Efficiency

- | | |
|-----------|--|
| LaGuardia | ● Dispersal headings (TNNIS, NTHNS, GLDMN) |
| Kennedy | ● EoR for 13R
● ROBER OPD to 22L |
| Teterboro | ● RNAV SID TEB19
● RNAV approach procedures for TEB19 & TEB24 |
| Newark | ● 22L & 29 arrivals
● 4L visuals |
- Use of existing tools/investments to increase airport throughput: CRDA for JFK, high-speed turn-offs at EWR
 - Review and modify existing PBN procedures to reduce pilot and controller workload
 - Tools to assist managing final approach spacing (CRDA, ATPA)

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Dispersal Headings (TNNIS, NTHNS, GLDMN)

- Airport throughput and airspace deconfliction. Look at the potential for the three climbs to be used more often which would deconflict JFK from LGA and increase the flexibility of JFK operation
- Allow for dispersal headings off multiple runway, improving LGA departure throughput and also reducing the community impacts by dispersing noise rather than concentrating it

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EoR for JFK13R

- Reduces the significant impacts to the overall operation
- The current RNP approach (JBU) can be utilized
- Should also look at a GBAS approach to 13R as the system will be install by 2019
 - Expect a large number of equipped aircraft that could use the GBAS technology as well
 - Will have lower minimums than the current RNP approach
- Could reduce the usage of the 22's and the 4's during these conditions which would provide relief to some communities

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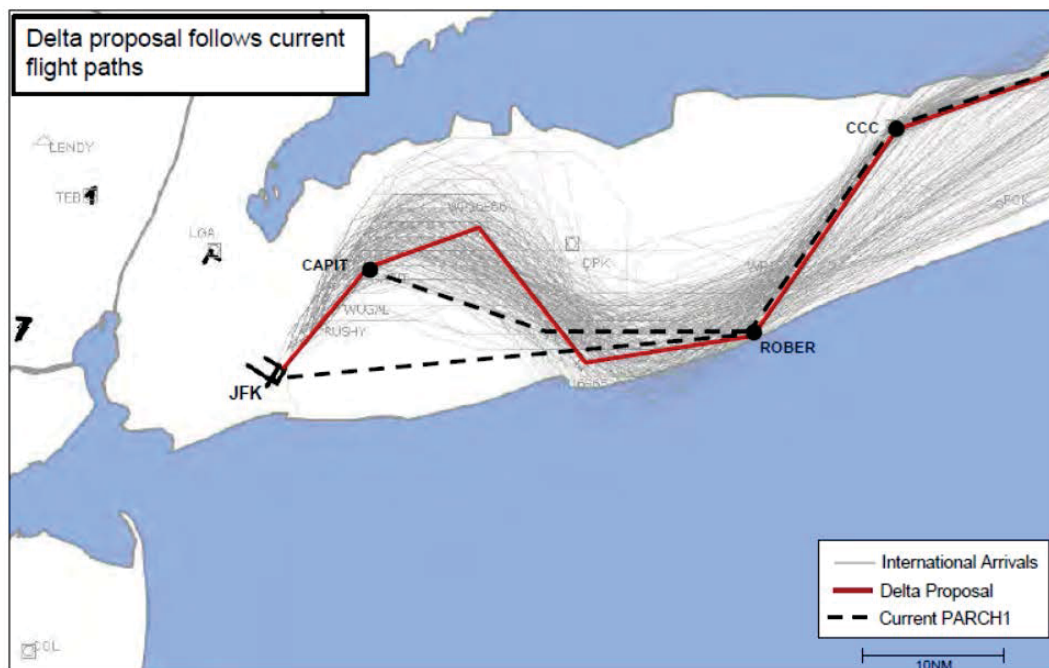
ROBER OPD to JFK 22L

- Improved descent into the ROBER fix
- Previously proposed and could easily be developed for use during the JFK 13L/22L arrival operation
- Initially use existing flows in N90 airspace with the eventual plan to move this traffic to a much more efficient flow with less noise impact

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ROBER OPD to JFK 22L





TEB19 SIDs

- Allow TEB19 departures to climb straight, essentially south or southeast
 - Initially slight turn to the left, ~170 and then a climb to 3000'
 - In a few miles turn to the southwest 220 and then a westbound turn overhead EWR or prior to EWR
 - Once the aircraft turns westbound it can be climbed above 3000'
- If apply a diverging course rule, eliminates need for gap in EWR 22L arrivals
 - The reason a gap is needed with today's procedure is because of the turn back under the final not the initial departure off the runway
- Procedure could be designed inside EWR airspace



TEB19 SIDs

- Expedite departures from TEB without waiting for hole in EWR flow
- TEB19 has the benefit of being the longer of the two runways, some operators have to opt for a 19 departure due to fuel weight required for long-haul flights
- From a noise perspective...
 - Noise solution for the overnight hours
 - Ground track could be designed to minimize the noise footprint
 - Allows for a reduction in the airport noise footprint as most of the land use off the departure end of 19 is compatible
 - Frees operators from the burden of meeting the reduced noise limit off 24
- A TEB19 departure is needed given upcoming 06/24 closure



TEB RNAV Approach Procedures

- Reduces TEB, CDW, MMU arrival delays
 - Current operation uses increased in-trail spacing, treating all relievers as single destination
 - Segregating TEB flow reduces arrival delays
- Better utilization of airspace with RNAV
- Simplifies complexity by segregating the flows to TEB from MMU and CDW



Newark: 22L & 29 Arrivals 4L Visuals

- Second landing runway needed at EWR, to support increases in traffic
- Need a flow when landing 22L that supports a second landing runway
- 22L and 29 utilizing CRDA should allow for a very efficient operation
- Airspace conflicts need to be worked out but would reduce EWR GDPs significantly
- 4L visuals are an existing procedure and was used many years ago; additional option for two landing runways



Use of Existing Tools/Investments to Increase Airport Throughput

- CRDA for JFK
 - Create new runway configurations to allow for improved throughput and delay reduction
 - DCIA for 13L/22L, 4R/13R to 1000' and 3 minimums
 - Surface analysis would also need to be performed
- High-speed turn-offs at EWR
 - Reduced separation on final for EWR arrivals using 22L or 4R to use high speed exits
 - Allow for aircraft to compress to less than the standard separation
 - Improve runway throughput for arrivals and will work well with the compression separation discussed with NIWG

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Tools to Better Manage Final Approach Spacing

- Expand CRDA usage
 - Include other configurations at EWR
 - JFK can use it to develop new operational configuration improving the efficiency of the airport
 - Adapt CRDA for LGA to develop to enhance the LGA spacing requirements
- ATPA at LGA
 - Could it be modified to provide controller with the correct final spacing requirements for the various runway configurations at the LGA
 - Primarily landing 31/departing 4, and landing 4/departing 13
 - Departure delays are typical in these configurations because of the high potential of lost gaps or too much spacing

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Appendix E: Detail on Advanced Technologies



Advanced Technology Working Group

*Report of the Advanced Technology Subgroup of the Northeast Corridor NextGen
Integration Working Group Team in Response to a request from the NextGen
Advisory Committee as part of a Tasking from
The Federal Aviation Administration*

February 2018

Advanced Technology

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Background/Introduction

At its October 4, 2017 meeting, the NextGen Advisory Committee (NAC) requested the Northeast Corridor (NEC) NextGen Integration Working Group (NIWG) to assess if, and/or how to leverage the capabilities of Enhance Flight Visions Systems (EFVS) in the NEC including correlating benefits with varied levels of equipage.

In subsequent discussions by the NAC Subcommittee, the Advanced Technology Subgroup was created to perform this assessment. As the NACSC discussed the NAC request, the inclusion of Flight Interval Management (FIM) or potentially other new capabilities was also suggested for inclusion.

Executive Summary

There are three areas (four technologies) identified:

Ground Based Augmentation System (GBAS) – funded by airports, with technical support from the FAA, and specific equipage for aircraft operators, GBAS offers the potential for immediate benefits (GBAS enables system installation at any airport in the world). By providing navigational accuracy to within 1/2 meter, GBAS allows precision approaches where none are currently available, with potential for all weather CAT III capability.

Some aircraft operators have invested in GBAS, however greater airport equipage and FAA support is needed for leveraging benefits from GBAS in the NEC. The NEC is recommending a set of near term industry and FAA actions that support the delivery of benefits from the operation of the non-Federal GBAS facilities by approving new facilities, developing and publishing GLS approach procedures, training controllers, and providing flight inspection services. The NEC is recommending a set of near-term industry and FAA actions

Enhanced Flight Vision System (EFVS) – EFVS is an electronic means to provide a display of the forward scene topography through imaging sensors and includes display element, sensors, computers and power supplies, indications, and controls. EFVS provides an operational credit to lower required visibility/RVR minima on instrument approaches and significantly increases situational awareness during low visibility operations with some limitations.

EFVS primarily benefits smaller, less capable airports without Cat II/III equipment. At higher density locations, opportunities exist for use to runways without an approach procedure or secondary runways. By providing enhanced flight visibility to perform the visual segment of an instrument approach procedure, properly equipped aircraft can use EFVS to initiate and/or continue any instrument approach procedures utilizing glideslope or VNAV vertical navigation down to touchdown and rollout with weather minimums well below those required for the approach.

Potential exists to change the way the NAS works, particularly the NEC, in relation to weather situations with less than visual approach conditions. EFVS could lower IFR minimums thus maintaining higher runway rates during lower than visual approach conditions.

Further studies are necessary to determine requirements for reaching benefits similar to Cat II/III operations in the NEC, as well as breaking down the relative advantages to primary and secondary airports and how often arrival rates would improve if these benefits did exist. In addition, studies are needed to analyze the effects of mixed equipage aircraft operations in the NEC, including what level of equipage is required to begin realizing significant benefit.

ADS-B In

Cockpit Display Traffic Information (CDTI) Assisted Pilot Procedures (CAPP) – is the concept that involves enhanced Traffic Collision Avoidance System (TCAS) using ADS-B In data that enable pilots to adhere to a controller's clearance without visual acquisition and include technology that replaces the pilot's view to acquire traffic to follow.

The primary potential benefit of these capabilities is stabilizing runway rates even when visibility is not, allowing near VFR arrival rates in IMC conditions with minimal changes, benefiting both aircraft operators and the NAS. CAPP has the potential to improve runway rates during IMC without changing procedural designs or requiring airspace changes.

There are specific issues that need to be evaluated for deployment in the NEC. These include determining whether leading and following aircraft must be on the same approach and how controllers will know if an aircraft is equipped to participate. Modifications to controller automation (e.g. STARS, ERAM) may be needed to include information in the data tag. FAA investment in such modifications may be contingent on the level of operator equipage.

Flight Interval Management (FIM) – uses ADS-B In traffic information to provide speed cues to pilots in order to manage inter-arrival spacing. Implementation of FIM is a fundamental change in the way traffic is managed. Pilots will have a new task of following changing speed guidance from avionics. Pilots will not be responsible for separation; their only responsibility will be to follow speed guidance from the avionics. Controllers are responsible for separation.

The goal of IM is to reduce the variation in inter-arrival spacing, thus increasing runway throughput. The more direct control loop enabled by calculation of speed by IM avionics results in a significant reduction in the standard deviation of the inter-arrival rate. This leads to more available capacity, compared to current operations with ATC vectoring and speed assignments. Since IM arrivals end with instrument approach procedures, there is no need to conduct visual approaches to achieve maximum capacity. Maintaining higher arrival rates, similar to VMC arrival rates, will be possible with IM during periods of lower ceiling and visibilities, down to Category 1 approach minimums. Research indicates that FIM system performance may also allow for further increases in capacity.

Issues such as mixed equipage, cultural issues for pilots and controllers, and accommodation of go-arounds and departures from close-in airports must be addressed for the TBO environment. The cost and benefits also needs further definition. The policy and procedures associated with enabling FIM need to be defined. Aircraft operators also need information for the business case to invest in IM capable ADS-B-in avionics.

Methodology

The Advanced Technology Working Group (Appendix A) is comprised of representatives from a cross-section of stakeholder groups who have been engaged in planning and implementing various aspects of NextGen capabilities. This includes operators, airports, automation providers, technical advisors and a diverse set of FAA Subject Matter Experts who have provided leadership in NextGen planning, pilot and demonstration programs, and other implementations.

The following technical experts provided briefings to the Subgroup:

- Enhanced Flight Vision Systems (EFVS) - Chris Hope, FAA; Dan Allen, FedEx Express
- Flight deck Interval Management (FIM) in the Northeast Corridor - Rocky Stone, United Airlines
- Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS) - Dave Surridge, American Airlines
- Ground-Based Augmentation System from an airline's/operator's perspective - Ron Renk, United Airlines

The workgroup accessed advanced technology capabilities according to the performance objectives outlined in the NEC phase 1 report.

De-conflict Airports

Improve Individual Airport Throughput

Improve Airspace Throughput

Improve and Integrate Existing Flow Management Capabilities

Implement New Flow Management Decision Support Tools

Improve NAS Information, Common Situational Awareness

Create New Noise Abatement Procedures

Assumptions & Guiding Principles

- Implementation timelines and deliverables are in the 10-year time frame (Recognizing there are pre-implementation milestones)

- Recommendations will be limited to Flight Deck and FAA infrastructure
- The scope is limited to the North East Corridor
- Recommendations should be consistent with the Trajectory Based Operation (TBO) Vision and be based in the iTBO concepts
- Recommendations should support the NEC performance objectives (identified above as part of Phase 1 from the FAA's NEC tasking)
- Aircraft will not be universally equipped with Advanced Technologies, benefits should be afforded those equipped
- Airborne equipment requirements should be compatible with the technology and dates of the ICAO Aviation System Block Upgrade plan. Where appropriate, the recommendation should be consistent with SESAR and other ATC modernization plans for aircraft equipage

Recommended Capabilities

The subgroup identified four technology areas that offer potential throughput and efficiency benefits for NEC operations. Those potential benefits are dependent on operator investment decisions as well as the FAA's continued policy development and procurement decisions. The investments are based on business case assessments by operators and this affects the timing and scope of implementations. The recommendations encompass a set of pre-implementation commitments that will serve as a constructive path to expediting necessary investments for aircraft operators, airports, and the FAA.

Ground-Based Augmentation System (GBAS)

Description: GBAS provides more accurate GPS using satellite signals and corrected aircraft position through Multi-Mode Receiver (MMR). The ground system consists of a computer and five antennas in a small airport siting footprint. GBAS is a highly accurate navigational system (within 1/2 meter) with the potential to provide all weather CAT III capability, as well as adding precision approaches where none are currently available. GBAS enables staggered thresholds for noise relief and higher glideslope angles (up to Autoland limits) for potential obstacle clearance. During severe weather events (heavy snow and ice, hurricane, etc.) GBAS antennas can be removed and replaced when the weather has improved.

Applications and Benefits to NEC:

- EWR: Develop an approach to runway 29 (could mimic the current GPS X runway 29. This runway is used for overflow and would provide arrival rate benefits to the current operation. Develop a curve path approach to tie into the current GLS to runway 11. Develop approaches to 4L and 22R to permit use as overflow runways, but some type of sequencing tools are needed in this scenario. This may also be used for a .308 operation.

- LGA: Potential for improved minimums to runway 31 and development of approaches that de-conflict the JFK and LGA airspace to runway 31. Develop approaches to runway 13 that can turn final within the confines of LGA airspace and de-conflict EWR, TEB and LGA. Aircraft from the south would save approximately flying 15 miles compared to the current ILS approach to 13. Sequencing tools would be needed to manage mixed equipage scenarios.
- JFK: Potential for improved minimums to 13R, which has no ILS, as well as developing offset approaches to 4L or 4R, allowing simultaneous independent approaches to these runways. Develop a straight-in approach (ILS is offset) to runway 22R (improved minimums over the offset approach) and parallel curved approaches to 13L and 13R.
- BOS: Conduct an evaluation of potential GBAS implementations and quantify the expected benefits related to redundancy/sustainability and improvements in safety/throughput. Utilize the results to inform an airport investment decision for a GBAS ground station.

Recommendations: Some aircraft operators have invested in GBAS, however greater airport equipage and FAA support is needed for leveraging benefits from GBAS in the NEC. The NEC is recommending a set of near term industry and FAA actions that support the delivery of benefits from the operation of the non-Federal GBAS facilities by approving new facilities, developing and publishing GLS approach procedures, training controllers, and providing flight inspection services.

FAA Should:

- Retain current level of support per PBN NAS Nav Strategy
- Support GLS Cat II operational approval for a Cat I system and leverage GBAS adverse all-weather capability.
- Study GLS options for noise abatement in the NEC by using higher GP angles not to exceed Autoland limitations.
- Partner with Airports and Industry in NEC to support training and advanced procedure development as more aircraft are equipped to take advantage of capability.
- Support future industry investments in GLS Cat III capability if/when needed.

Enhanced Flight Vision Systems (EFVS)

Description: EFVS is an electronic means to provide a display of the forward scene topography through imaging sensors and includes display element, sensors, computers and power supplies,

indications, and controls. EFVS provides an operational credit to lower required visibility/RVR minima on instrument approaches and significantly increases situational awareness during low visibility operations with some limitations.

Equipment for EFVS is entirely aircraft-centric, with no changes to flight procedures or ground equipment required. The regulatory change effective in March 2017 authorizes EFVS operations to touchdown and rollout without reliance on natural vision. Authorization to use EFVS operational minimums for dispatch/ flight release and to descend on the final instrument approach segment was included in the 2017 rule.

Applications and Benefits to NEC:

EFVS primarily benefits smaller, less capable airports without Cat II/III equipment. At higher density locations, opportunities exist for use to runways without an approach procedure or secondary runways. Regulatory changes effective March of 2017 allow specific benefits for equipped operators and qualified flight crews using EFVS in lieu of natural vision on takeoff, approach and landing. By providing enhanced flight visibility to perform the visual segment of an instrument approach procedure, properly equipped aircraft can use EFVS to initiate and/or continue any instrument approach procedures utilizing glideslope or VNAV vertical navigation down to touchdown and rollout with weather minimums well below those required for the approach.

Potential exists to change the way the NAS works, particularly the NEC, in relation to weather situations with less than visual approach conditions. EFVS could lower IFR minimums thus maintaining higher runway rates during lower than visual approach conditions. Potential EFVS benefits in the NEC include:

- Increased arrival rates on any instrument approach procedures in below minimum visibility conditions.
- The NY area airports have several runway ends with higher than normal minimums due to the lack of approach lighting systems, precision approaches and/or obstructions, LGA runway 4 and 31; JFK runway 4L, 31L, 22R, 13R; and EWR runway 29/11. These higher minimums will sometimes result in less than optimal configurations reducing the available capacity of the airports and increased delays. This is especially true during construction or snow events where we alternate runway closures. As an example, JFK would be landing runway 4R, CAT III capable, and needs to close for runway treatment. Runway 4L would become the arrival runway but due to the high approach minimums, $\frac{3}{4}$ mile visibility or 4000' Runway Visual Range (RVR), we may not have an approach causing airborne holding and possibly diversions. EFVS could allow aircraft to continue to operate on 4L during these events.

- Possibility for ground stops to include caveats for EFVS equipped aircraft, allowing access if the operator is capable of approach and landing on a secondary runway (BOS 32).
- Secondary airports experiencing below minimums weather would have EFVS equipped aircraft landing instead of diverting (White Plains), with the additional benefit of lessening the number of aircraft diverting to better equipped, higher density airports in these situations.
- Provides enhancement to safety for surface operations (aircraft and vehicles).

Recommendations: Further studies are necessary to determine requirements for reaching benefits similar to Cat II/III operations in the NEC, as well as breaking down the relative advantages to primary and secondary airports and how often arrival rates would improve if these benefits did exist. In addition, studies are needed to analyze the effects of mixed equipage aircraft operations in the NEC, including what level of equipage is required to begin realizing significant benefit. As EFVS installation is completely dependent on the operator, these studies will help define benefits for each specific carrier's operations, as well as the potential timeframe to achieve immediate return on the investment.

- The FAA should complete benefits studies to determine requirements for reaching Cat II/III equivalent operations in the NEC. These studies should include the relative advantages to primary and secondary airports and how often arrival rates would improve if these benefits did exist.
- The FAA should complete studies to analyze the effects of mixed EFVS equipage aircraft operations in the NEC, including determining what level of equipage is required to begin realizing significant benefit. As EFVS installation is completely dependent on the operator, these studies will help define benefits for each specific carrier's operations, as well as the potential timeframe to achieve immediate return on the investment.

ADS-B In

Cockpit Display of Traffic Information (CDTI)

Description: CDTI applications involve enhanced TCAS using ADS-B-in data that enable pilots to adhere to a controller's clearance without visual acquisition and include technology that's replaces the pilot's view to acquire traffic to follow. The two applications discussed by the subgroup are:

- Cockpit Assisted Visual Separation (CAVS) - only conducted in VFR conditions, must remain clear of clouds and notify ATC if entering IMC.

- CDTI Assisted Pilot Procedures (CAPP) - CDTI-assisted pilot procedures that use ADS-B-IN with aircraft guidance display to acquire traffic to follow. CAPP provides increased situational awareness for the pilot, making it easier to identify traffic.

Applications and Benefits to NEC:

The primary benefit of these capabilities is stabilized runway rates even when ceilings or visibility do not allow for visual approaches. CAPP may allow for near VFR arrival rates in IMC conditions with minimal changes, benefiting both aircraft operators and the NAS. CAPP has the potential to improve runway rates during IMC, creating a natural transition from CAVS. Unlike CAVS that requires users to have traffic in sight, CAPP permits pilots to use ADS-B-IN/CDTI to identify and follow traffic, with only minor changes needed to identify the target aircraft. No new FAA equipment or airspace changes are needed, although automation modification may be needed. FAA Flight Standards work is required to define the limitations of when CAPP procedures are allowable.

Recommendations:

Potential issues with CAPP include determination of whether leading and following aircraft must be on the same approach. Also need to determine how controllers will know if an aircraft is equipped to participate. Modifications to controller automation (e.g. STARS, ERAM) may be needed to include information in the data tag. FAA investment in such modifications may be contingent on level of operator equipage.

- The FAA should accelerate the development of operational criteria for the CAPP use, including conducting studies to determine lead/follow requirements, controller requirements, and defining the conditions under which CAPP procedure is allowable.

Flight Interval Management (FIM)

Description: Flight deck Interval Management uses ADS-B In traffic information to provide speed cues to pilots in order to manage inter-arrival spacing. Implementation of FIM is a fundamental change in the way traffic is managed. Pilots will have a new task of following changing speed guidance from avionics. Pilots will not be responsible for separation; their only responsibility will be to follow speed guidance from the avionics. Controllers are responsible for separation, however to achieve increased throughput, they may need to apply smaller buffers to the minimum separation standard than those applied today.

For FIM to be viable there must be:

- A closed path RNAV arrival all the way to the runway. Future design of terminal airspace must include closed path arrivals that de-conflict arrival and departure corridors for all major airports in the terminal area.
- Sequencing of traffic occurring in the EnRoute environment

- Accommodations must be made for mixed equipage
- ATC decision support tools in place as a precursor to FIM: Time Based Flow Management, Ground Interval Management, and Terminal Sequencing and Spacing

Issues such as accommodation of go-arounds and departures from close-in airports must be addressed for the TBO environment.

Applications and Benefits to the NEC:

The goal of IM is to reduce the variation in inter-arrival spacing, thus increasing runway throughput. The more direct control loop enabled by calculation of speed by IM avionics results in a significant reduction in the standard deviation of the inter-arrival rate. This leads to more available capacity, compared to current operations with ATC vectoring and speed assignments. Since IM arrivals end with instrument approach procedures, there is no need to conduct visual approaches to achieve maximum capacity. Maintaining higher arrival rates, similar to VMC arrival rates, will be possible with IM during periods of lower ceiling and visibilities, down to Category 1 approach minimums. Research indicates that FIM system performance may also allow for further increases in capacity.

Recommendations:

The ADS-B-In ARC recognized that the cost and benefits needed further definition. The policy associated with separation standards also needs to be researched. If the flight demonstration and HITLS shows a standard deviation in the inter-arrival rate similar to that predicted through analysis and simulation, the FAA may have a good business case to continue the development of IM. Likewise, airlines may have a good business case to invest in IM capable ADS-B-In avionics.

- The FAA and Industry should conduct a review of the results of 2018-2019 FIM demonstrations, including the cost and benefits, prior to the FAA's final investment decision. The review determines the final status of future recommendation on IM development and implementation.
- The FAA should conduct a NEC-specific benefit study (including safety cases, demonstration data, etc.). This study should be followed by presentations for FAA and Industry Executive leadership, creating a critically important collective commitment to close the business case. The FAA should simultaneously clarify policy roles and responsibilities.

Summary

The following is the list of the recommendations contained in the report.

Ground-Based Augmentation System (GBAS)

FAA Should:

- Retain current level of support per PBN NAS Nav Strategy
- Support GLS Cat II operational approval for a Cat I system and leverage GBAS adverse all-weather capability.
- Study GLS options for noise abatement in the NEC by using higher GP angles not to exceed Autoland limitations.
- Partner with Airports and Industry in NEC to support training and advanced procedure development as more aircraft are equipped to take advantage of capability.
- Support future industry investments in GLS Cat III capability if/when needed.

Enhanced Flight Vision Systems (EFVS)

- The FAA should complete benefits studies to determine requirements for reaching Cat II/III equivalent operations in the NEC. These studies should include the relative advantages to primary and secondary airports and how often arrival rates would improve if these benefits did exist.
- The FAA should complete studies to analyze the effects of mixed EFVS equipage aircraft operations in the NEC, including determining what level of equipage is required to begin realizing significant benefit. As EFVS installation is completely dependent on the operator, these studies will help define benefits for each specific carrier's operations, as well as the potential timeframe to achieve immediate return on the investment.

ADS-B In

Cockpit Display Traffic Information (CDTI) Assisted Pilot Procedures (CAPP)

- The FAA should accelerate the development of operational criteria for the CAPP use, including conducting studies to determine lead/follow requirements, controller requirements, and defining the conditions under which CAPP procedure is allowable.

Flight Interval Management (FIM)

- The FAA and Industry should conduct a review of the results of 2018-2019 FIM demonstrations, including the cost and benefits, prior to the FAA's final investment decision. The review determines the final status of future recommendation on IM development and implementation.
- The FAA should conduct a NEC-specific benefit study (including safety cases, demonstration data, etc.). This study should be followed by presentations for FAA and Industry Executive leadership, creating a critically important collective commitment to

close the business case. The FAA should simultaneously clarify policy roles and responsibilities.

In conclusion, there are opportunities that industry review has identified for the NEC based on current capabilities. As the NAS NAV strategy document is revised, it is important that the application of advanced technology be reviewed. Investment strategies, equipage will change, and the industry believes it is important to revisit advanced technologies in the NEC.

Appendix A: Members of the Advance Technology Working Group

Airbus
Alaska Airlines
American Airlines, Inc.
Delta Air Lines, Inc.
Federal Aviation Administration (FAA)
FedEx Express
General Aviation Manufacturers Association
Gulfstream Aerospace Corporation
Honeywell International, Inc.
JetBlue Airways
L-3 Communications
Landrum-Brown
Leidos
NASA
National Air Traffic Controllers Association (NATCA)
PASSUR Aerospace
Port Authority of New York & New Jersey
Rockwell Collins, Inc.
RTCA, Inc.
Southwest Airlines
The Boeing Company
United Airlines, Inc.
United Parcel Service (UPS)