NAS Transformation: The Whole is Greater than the Sum of Its Parts

by Frank L. Frisbie and Suzette Matthews[1]

A tidal wave of unprecedented new entrant aircraft is threatening to overwhelm the National Airspace System (NAS) as we know it. FAA predicts explosive growth in UAS operations, even in the near term.[2] The global commercial drone marketplace is predicted to grow at a 23.7% compound annual rate, to $21.69 billion by 2030.[3] Revenue of $319 billion globally was attributable to the commercial space industry in 2019.[4] Even today commercial space launches are contributing to troublesome localized airspace congestion, and their number is predicted to double as soon as 2025.[5] Aerospace industry innovators are already manufacturing an entirely new category of Jetson-like personal flying cars—Vertical Takeoff and Landing (VTOL)-capable, electric-powered, and automated for non-pilot operations--that could flood the skies with garage-to-destination itineraries.[6]

Today's NAS is unprepared to accommodate this volume and diversity of new traffic. Look skyward on any day, even in suburban localities, and wide-open airspace can be seen in all directions. Human operated--especially passenger carrying--aircraft are routed into fixed or ATC approved flight paths, and any other air vehicles which might cross their paths are either forced into positive ATC control, or prohibited from flying altogether. The largest volume of airspace is completely unoccupied, and going to waste. UAVs and automated personal aircraft, which could take advantage of this open space, are relegated to specific altitudes or segregated airspace, subjected to unique restrictions (no flying over people), and burdened or foreclosed by certification regimes and flight rules designed for licensed pilots only.

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[2] *See* FAA Aviation Forecasts Years 2021-2040, Unmanned Aircraft Systems, https://www.faa.gov/sites/faa.gov/files/data_research/aviation/aerospace_forecasts/Unmanned_Aircraft_Systems.pdf

[3] https://www.bloomberg.com/press-releases/2022-02-24/commercial-drones-market-to-reach-21-69-billion-globally-by-2030-at-23-7-cagr-allied-market-research

[4] https://www.euroconsult-ec.com/press-release/space-economy-valued-at-385-billion-in-2020-with-commercial-space-revenues-totaling-over-310-billion/

[5] Space launches and private jet operations are already causing troublesome congestion in Florida airspace. *See* Hetzner, "Private jets and billionaire space launches are crippling Florida airspace" (2022), *https://fortune.com/2022/05/04/private-jets-and-billionaire-space-launches-are-crippling-florida-airspace/. See* also FAA Aviation Forecasts Years 2021-2040, https://www.faa.gov/sites/faa.gov/files/data_research/aviation/aerospace_forecasts/Commercial_Space.pdf

[6] "The global flying cars market is expected to grow from $52.2 million in 2021 to $84.39 million in 2022 at a compound annual growth rate (CAGR) of 61.7%. The market is expected to grow to $488.56 million in 2026 at a compound annual growth rate (CAGR) of 55.1%," "Flying Cars Global Market Report 2022," https://www.reportlinker.com/p06280935/Flying-Cars-Global-Market-Report.html . *See* also https://simpleflying.com/flying-cars-2022/; https://www.reuters.com/business/autos-transportation/joby-receives-faa-nod-start-air-taxi-services-commercially-2022-05-26/; *Cf*, Goldstein, "It's 2022: Where are the Flying Cars We Were Promised?", https://www.forbes.com/sites/michaelgoldstein/2021/12/30/its-2022-where-are-the-flying-cars/?sh=1fca59483f7b

Nor does anything in today's NextGen future planning take us where we need to go. What is on the books in the NextGen architecture[7] perpetuates the current approach of applying technical and operational patches, often only in segregated airspace, to address the complaints of operator constituencies.[8] Or it simply polishes decades old "innovations" whose potential are pretty much already exhausted.[9] The fundamental weakness of this approach is that it embraces, and even enhances, balkanization of the airspace without any real construct for resolving incompatibility and performance issues at the boundaries, or for integrating the various airspace puzzle pieces into a seamless, cohesive continuum.

There is a chasm between the well-documented requirements of the growing number and increasing sophistication of new aircraft, versus what can be safely handled by today's ATC system, even assuming improvements underway and on the boards of NextGen. Despite endlessly iterative testing projects, analyses, proposed rulemakings, and individual authorizations by exception, *we simply are not getting there from here*. Mere motion should not be confused with real progress. We need to be honest with ourselves, and with new entrant proponents. There cannot be universal accommodation of large numbers of new and innovative aircraft types without a complete transformation of the existing air traffic system, not only its equipment and procedures, but its foundational operational paradigm.

This transformational new paradigm must encompass the entire volume of National airspace. It must open equal access for all operators, both legacy and newcomers, without discrimination by class of aircraft. And it must be capable of maximizing utilization of airspace, while still safely separating (deconflicting) those aircraft, in real time (not just strategically), in a fair, economic, and efficient way. This expansive role is a tall order, and certainly not one into which the legacy ATC system can gracefully evolve and grow, which seems to be the current collective delusion.[10]

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[7] https://www.faa.gov/nextgen/programs/; *see*, e.g., FAA's version of NextGen TBO, https://www.faa.gov/air_traffic/technology/tbo/

[8] For example, the UAS con ops provides a construct for widespread operations, but only under 400 feet. https://www.nasa.gov/sites/default/files/atoms/files/2020-03-faa-nextgen-utm_conops_v2-508_1.pdf. Similarly, although the commercial space con ops call for regular integration into the NAS, current operations accommodate those aircraft only by sanitizing airspace in TFOs, and nothing on the books in the NextGen architecture changes that. https://www.faa.gov/space/airspace_integration/media/Final_CSINAS_ConOps.pdf; https://www.faa.gov/space/airspace_integration/ As noted above, fn. 4 herein, this approach is already eliciting complaints from commercial carriers that space launches are becoming frequent enough to cause congestion and delays for regular air service. And improvements suggested in NASA's Urban Air Mobility con ops are still only in the "visioning" stage, and have not yet made their way into the NextGen Architecture, even though many such vehicles are beyond the conceptual stage into manufacturing and certification. https://ntrs.nasa.gov/api/citations/20205011091/downloads/UAM%20Vision%20Concept%20of%20Operations%20UML-4%20v1.0.pdf. ; [cite press releases showing personal cars]

[9] E.g., Data Comm, https://www.faa.gov/newsroom/data-communications-data-comm-0?newsId=21994; Collabortive Decision Making CDM), https://cdm.fly.faa.gov/

[10] "The AAM [Advanced Air Mobility] market is here and growing. The complexity, scope, and dynamic nature of operations forecast will stress the ATC system beyond anything seen in ATC history. The FAA's NextGen efforts offering the foundation to support his new market are well underway. However, technology still has *at least a decade to go* before it is mature enough to allow the more robust sub-set of AAM, UAM to truly 'take flight.'" [Emphasis added]. Johnson, "ATC in

The good news is that the FAA Acquisition Management System (AMS) does articulate a policy, and establishes a procedure for identifying, analyzing, and addressing just such *whole-NAS* deficiencies. FAA's Service Analysis and Strategic Planning (SASP) process[11] begins with a "Shortfall Analysis and Report", which describes both the shortfall and the legacy case,[12] and defines "the difference between future service need and current capability."[13]

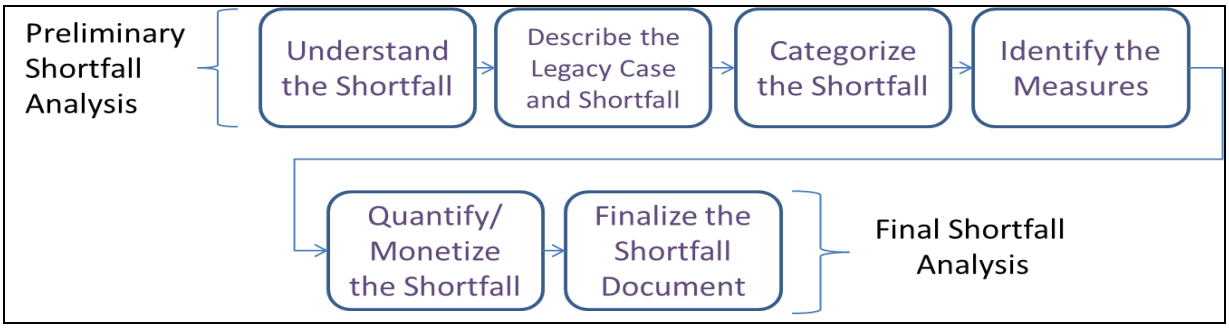

Figure 1: Shortfall Analysis Process

Source: FAA Shortfall Analysis Report Guide, v.2, March 2022, p. 4, download at https://fast.faa.gov/NFFCA_ServiceAnalysis_StrategicPlanning.cfm .

Once a shortfall is identified and described, the benefits of various alternatives for improving NAS performance are competitively analyzed and quantified:

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the Era of Advanced Mobility," Air Traffic Control Association Journal of Air Traffic Control, p. 24, Summer 2022, http://lesterfiles.com/pubs/ATCA/journal/2022/summer/#p=26.

[11] SASP [Service Analysis and Strategic Planning] is the evaluation of how well FAA legacy assets satisfy existing needs and emerging demands for new services." FAA Guidelines for Service Analysis & Strategic Planning (SASP) and Concept & Requirements Definition (CRD), March 2022, p.7, download at https://fast.faa.gov/NFFCA_ServiceAnalysis_StrategicPlanning.cfm

[12] "The legacy case description *does not* include any additional investment (e.g., technology refreshment) beyond what is already included in its investment segment baseline as approved by the Joint Resources Council." Shortfall Analysis Report Guide, March 2022, p. 8, download at https://fast.faa.gov/NFFCA_ServiceAnalysis_StrategicPlanning.cfm

[13] "A key step in the AMS lifecycle management process is understanding and articulating the service shortfall. This step is part of Service Analysis and Strategic Planning (SASP) (terminology and context found in FAST section 2.3) as well as Concept and Requirements Definition (CRD) (terminology and context found in FAST section 2.4). At a high level, Service Analysis and Strategic Planning determine what capabilities must be in place now and in the future to meet Agency goals and the service needs of customers. Concept and Requirements definition, among other things, quantifies the service shortfall in sufficient detail for the definition of realistic preliminary requirements and the estimation of potential costs and benefits during Investment Analysis.
FAST section 2.3.1 states 'The shortfall is the difference between future service need and current capability. A service shortfall is usually addressed by a sustainment action for existing assets or a new service delivery idea, including cloud services, for predicted gaps. A new idea or concept should deliver existing services more efficiently or provide new services of value to the FAA and aviation industry.'" FAA Shortfall Analysis Report Guide, p. 2, *ibid*.

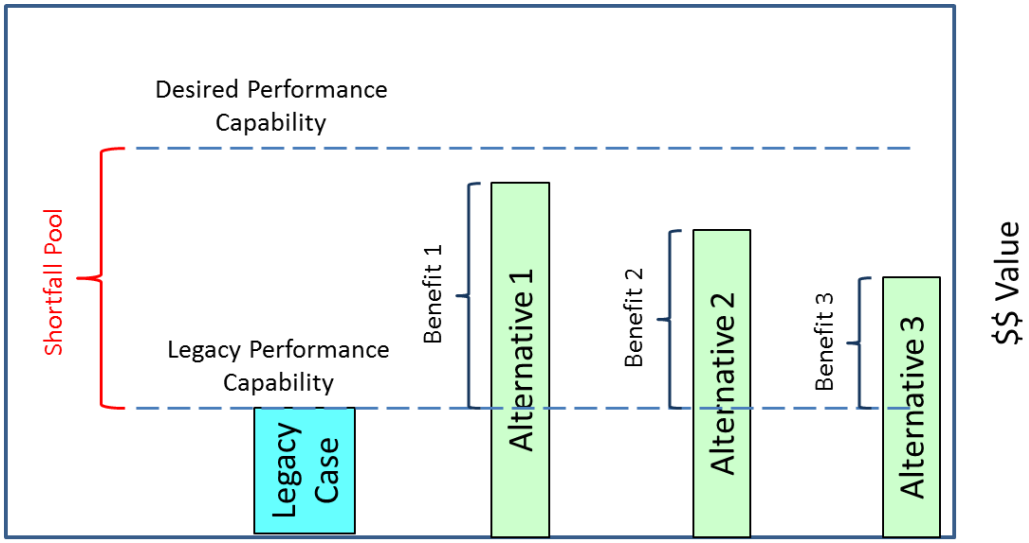
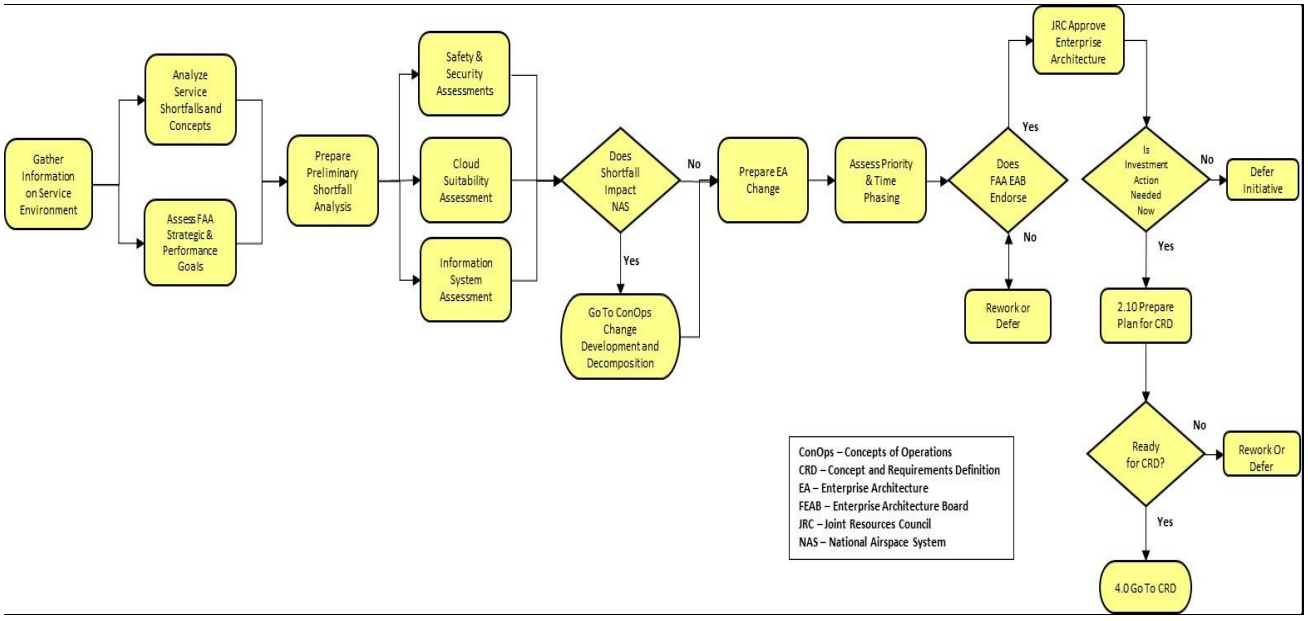


Figure 2: Shortfall vs. Benefits

(Notional, not to scale)

Source: FAA Shortfall Analysis Report Guide, p. 5, *ibid*.

The SASP analysis then proceeds to additional phases:



Source: FAA Guidelines for Service Analysis & Strategic Planning (SASP) and Concept & Requirements Definition (CRD) v.9, March 2022, p.9, download at https://fast.faa.gov/NFFCA_ServiceAnalysis_StrategicPlanning.cfm

The authors assert that the herein recommended entire-NAS shortfall analysis should be unbounded and wide ranging. Too often, NextGen future planning begins by setting boundaries and narrowing the scope of inquiry by accepting pre-existing assumptions, many of which are artificial or unwarranted. For example, the whole of navigable airspace, not just selected volumes or altitudes, should be considered for transformation. Existing limitations on aircraft or ATC performance, or historic reservations of airspace according to aircraft class or mission, should not be allowed to limit our thinking about what volumes of airspace can or should be shared. Assumptions about government budget "realities", or aircraft operators' financial ability or willingness to retrofit or upgrade their aircraft should not be allowed to contract the range of technical options under consideration.[14] And revolutionary change-out of the entire legacy NAS ATC operating system, versus evolutionary upgrade only, should be considered within the realm of the possible.

There are at least three potential alternative operating constructs that should be considered for resolving the shortfall: Free Flight (universal self-separation), universal Four Dimension Trajectory (4DT) air traffic control, and a hybrid version[15] of those constructs. The authors have previously discussed the comparative merits and drawbacks of Free Flight versus universal 4DT.[16] Without prejudging the outcome of a comprehensive shortfall analysis, universal 4DT seems most likely of all alternatives to meet future needs, safely, with least cost and disruption to operators and the system.

Although analyses of the costs and financial feasibility of performance-enhancing improvements are properly the province of later phases in NextGen planning, it is fair to say that whatever the cost of a comprehensive new NextGen paradigm, it will be dwarfed by the opportunity costs of delaying or denying access to new and future entrants rushing at the floodgates of the NAS. Granted, there are myriads of people and companies, including legacy aircraft operators, who are financially and professionally invested in the NAS status quo and its "measured" evolution. But to achieve a necessary and true transformation that can fully exploit the navigable airspace and open access to everyone, some institutionalized projects will have to be scrapped, not just revised, "re-baselined", and perpetuated.

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[14]An increased cost burden on operators is not necessarily fatal to NAS transformation. Whatever the approach, it might make sense for the government to incentivize or subsidize aircraft equipage, and there are ways to do that. *See* Frisbie and Matthews, "The second time around there ought to be a law…", https://www.safeaccess4uas.com/paper-avionics-equipage--second-time-around.html.

[15] This appears to be the path we are on, by default. Whether this hybrid approach can evolve technically to the point of being able to fully and economically satisfy the operational and business objectives of all aircraft operations, and at what cost to them as well as to the ATC system, has yet to be systematically and fully explored and analyzed. To be considered an acceptable alternative to Free Flight or universal 4DT, the hybrid construct would have to include a fully matured architecture for providing safe and equal access to all volumes of airspace, to all operators, and a realistic way for ATC to provide seamless operations across diverse airspace boundaries.

[16]For a comparative analysis of the advantages and drawbacks of Free Flight (self-separation) versus universal 4DT ATC, *see* Frisbie and Matthews, "To 4DT or Not 4DT, is there Really a Question?"(2021), https://www.safeaccess4uas.com/paper-to-4dt-or-not-4dt.html ; Frisbie and Matthews, "FAA: Tear Down That Airspace Wall!" (2022), https://www.safeaccess4uas.com/paper-faa---tear-down-airspace-walls.html .

It is almost *thirty years* since FAA Administrator J. Lynn Helms introduced the NAS Modernization Plan featuring the Advanced Automation System, the first version of systemwide 4DT air traffic management. And yet we're still here, waiting for real modernization to start. It's way past time to venture forward into today's understanding of what the future will be, not what we envisioned three decades ago. We have no choice. Let's get on with it.

The authors:

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