The Promise and Challenges of NextGen

By Naveen C. Rao

The United States and Europe are in the midst of large-scale efforts to fundamentally transform air traffic management (ATM). The parallel U.S. and European endeavors, known respectively as the Next Generation Air Transportation System (NextGen) and the Single European Sky ATM Research (SESAR), were initiated in anticipation of growth in air traffic volumes that will far outstrip the capacity of existing ATM systems.[1] The decades-old methods and paradigms of existing ATM have repeatedly been scaled upward as traffic grew, but are rapidly approaching or exceeding their natural limits. These limits stem primarily from the realities that blocks of airspace may only be subdivided a finite number of times and individual air traffic controllers can only monitor a certain number of aircraft simultaneously.

NextGen and SESAR both involve the phased development and introduction of interoperable, complementary aviation technologies. Even before attaining an "end-state" at which implementation will be substantially complete, the progressive introduction of NextGen and SESAR technologies is expected to deliver benefits to aircraft operators, passengers, and society generally in the form of reduced airspace congestion, aircraft noise, and exhaust gas emissions; greater efficiency; and increased system capacity. As technological milestones draw near and high-profile public and private investments are made in NextGen, the initiatives have garnered greater media attention and have begun permeating the public's understanding of aviation. NextGen and SESAR pose formidable challenges for governments and private stakeholders due to their complex technologies, multiple system interdependencies, high costs, uncertain benefits, and increasingly volatile government budgets.

This article first describes the key concepts and technological underpinnings of the ambitious NextGen program. The article then examines the statutory authority for NextGen and its implementation, and identifies aspects of the existing FAA regulatory scheme that may require revision and even some creative restructuring to foster innovation and expedite realization of the benefits of NextGen.

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What Is NextGen?

NextGen is an interoperable portfolio of communication, navigation, and surveillance technologies centered heavily around the Global Positioning System (GPS) satellite constellation.[2] Among other things, these technologies promise to vastly improve the precision of aircraft navigation and the quality of aircraft position data available to air traffic controllers, while reducing the burdens of air-to-air and air-to-ground communications. The technologies of NextGen are often defined in terms of eight concepts or capabilities rather than specific avionics systems:

1. Net-Centric Operations;
2. Performance-Based Operations and Services;
3. Weather Assimilated into Decision Making;
4. Layered, Adaptive Security;
5. Positioning, Navigation, and Timing (PNT) Services (Broad-Area Precision Navigation);
6. Trajectory-Based Operations (TBO);
7. Equivalent Visual Operations; and
8. High-Density Arrival/Departure Operations.[3]

These concepts "encompass air traffic management, airports, security, and environmental management, to achieve greater safety and efficiency; protect our airspace, people, and infrastructure; and leverage innovative technologies, such as satellite-based navigation and surveillance in order to create a scalable NAS [National Airspace System]."[4] In order to understand these concepts, it is helpful to explore how NextGen technologies overcome technical limitations that are pushing the existing system towards obsolescence. The sections below describe technologies that fall into the NextGen concepts of Performance-Based Operations, PNT, and TBO.[5]

"Positional Uncertainty" and NextGen Technologies

One of NextGen's most consequential changes will be a dramatic reduction in the problem known as "positional uncertainty," which is a technical limitation affecting both aircraft navigation and ATM.

Air Traffic Surveillance and ADS-B

Aircraft typically fly at speeds ranging from just over 100 miles per hour to multiples of that number depending on type and other factors. Existing air traffic control (ATC) radars sweep an area approximately every 10–12 seconds in en-route airspace and every

five seconds in terminal airspace.[6] Additional time lapses between emission of a radar signal and the appearance of an aircraft as a "blip" on air traffic controllers' displays. During this latency period, aircraft can travel significant distances and change course, thus giving rise to uncertainty about their exact position at any point in time. These factors necessitate the use of conservative spacing buffers between aircraft.

FAA officials have selected Automated Dependent Surveillance–Broadcast (ADS-B) technology to ameliorate positional uncertainty in ATM.[7] ADS-B is a cornerstone technology of NextGen, of which several avatars exist. ADS-B "Out" broadcasts an aircraft's highly precise GPS (or other suitable navigation satellite) position at one-second intervals, thereby providing controllers with a stream of real-time data rather than instantly obsolete radar returns.[8] ADS-B Out will be required to operate in most U.S. airspace as of January 1, 2020.[9] ADS-B "In" refers to equipment that enables flight crews to receive and view depictions of ADS-B Out broadcasts of other aircraft, thereby improving their situational awareness. Despite a statutory mandate and substantial prospective benefits, technical and economic challenges make it unlikely that the FAA will mandate ADS-B In equipage in the near term.[10]

Navigation and RNAV/RNP

Many existing flight paths and landing systems rely on terrestrial VHF radio navigation aids. A traditional route or "airway" is a line between two or more radio navigation aids that, for many flights, is an indirect path between origin and destination. Positional uncertainty arises because VHF signals, like beams from a flashlight, "splay" as they reach further from the emission source. Thus, an aircraft is more likely to drift off-center as it moves farther away from the navigation aid, which requires that routes be eight to ten nautical miles wide.

The FAA has begun replacing VHF-defined routes with routes defined by a series of GPS latitude and longitude "waypoints" untethered to any object on the ground. This method of navigation is generally known as Area Navigation (RNAV).[11] The imprecision caused by the splay of VHF signals is nonexistent for GPS waypoints. Thus, GPS routes maintain uniform precision regardless of distances between waypoints. Because of these attributes, air traffic managers can create routes that are more direct than "zig-zag" VHF routes and require far smaller containment "pads" than traditional routes. The benefits are enhancements to airspace capacity and the creation of routes in areas where radio navigation is impractical, such as mountainous terrain. As a refinement to RNAV, airspace designers can also specify levels of precision for certain routes, which is known as Required Navigation Performance (RNP). For crew using an RNP 0.1 path, the aircraft must be capable of staying within 0.1 mile of the route's centerline. In a further refinement, the dimension of time can also be grafted onto a three-dimensional RNP flight path, which allows for four-dimensional trajectory (4DT) operations. The addition of time allows air traffic managers to assign a Required Time of Arrival (RTA) to each waypoint—defined by latitude, longitude, and altitude—along a flight path, thus defining an aircraft's trajectory in four dimensions. The technologies described above represent merely the cusp of a much larger array of innovations that NextGen will deliver. Other noteworthy programs such as NextGen Data Communications will have similar transformative effects in other ATM domains.

The Statutory Framework of NextGen and ATM

The genesis of NextGen can be traced to the Vision 100—Century of Aviation Reauthorization Act (Vision 100), which amended the Federal Aviation Act of 1958 (the Act).[12] Vision 100 established an interagency organ, the Joint Planning and Development Office (JPDO), and charged it with creating, planning, and coordinating the U.S. government's NextGen policy and research efforts. JPDO is comprised of officials from the Departments of Transportation, Commerce, Defense, and Homeland Security; the FAA; NASA; and the White House Office of Science and Technology Policy. Vision 100 also charged the Secretary of Transportation with establishing a senior policy committee comprised of cabinet-level officials and agency heads (or their designees) to "work with the Next Generation Air Transportation System Joint Planning and Development Office" by providing policy guidance and other support.[13] In short, Vision 100 established a framework for organizing the U.S. government's NextGen-related efforts, but the Act remains the operative law under which NextGen technologies will be developed, certified, and deployed into service.

2012 FAA Reauthorization

The FAA Modernization and Reform Act of 2012 (the FAA Reauthorization Act) contains multiple provisions intended to focus and accelerate the FAA's NextGen efforts.[14] For example, the legislation directs the FAA to prioritize certain projects, make plans for accelerated implementation of RNP and Data Communications technology, and streamline certification of new technologies.[15] It also creates a new position, Chief NextGen Officer, who will report directly to the FAA Administrator, and re-designates the director of the JPDO as an FAA Associate Administrator.[16]

From a regulatory standpoint, one of the most noteworthy changes wrought by the new law appears in the definition of "air navigation facility." The definition of "air navigation facility" had long been

> a facility . . . including a landing area; a light;

> apparatus or equipment for distributing weather information, signaling, radio-directional finding, or radio or other electromagnetic communication; and another structure or mechanism for guiding or controlling flight in the air or the landing and takeoff of aircraft.[17]

This definition now reads:

> "[A]ir navigation facility" means a facility . . . including a landing area; runway lighting and airport surface visual and other navigation aids; apparatus, equipment, *software, or service* for distributing aeronautical and meteorological information to air traffic control facilities or aircraft; communication, navigation, or surveillance equipment for air-to-ground or *air-to-air applications*; any structure, equipment, or mechanism for guiding or controlling flight in the air or the landing and takeoff of aircraft; and *buildings*, *equipment*, and *systems* dedicated to the national airspace system.[18]

The inclusion of "software," "service," "air-to-air applications," and "buildings," in addition to "systems" and "equipment," evince an understanding by Congress that the scope of NextGen technologies is broader than that of existing air navigation facilities. This new, broader definition should prove durable as technologies evolve and emerge, providing a foundation for future regulatory frameworks to support emergent technologies and new paradigms of service provision.

Section 215(a)(2) of the FAA Reauthorization Act calls for the agency to "accelerate and streamline" the process for certifying NextGen technologies. Among other things, it requires the

> identification of the specific activities needed to certify NextGen technologies, including the establishment of NextGen technical requirements for the manufacture of equipage, installation of equipage, airline operational procedures, pilot training standards, air traffic control procedures, and air traffic controller training. . . .[19]

This language is significant because it evinces Congress's recognition that NextGen technologies are highly interdependent and require the FAA to "connect the dots" across its internal organizational boundaries. For instance, the creation of a 4DT route structure would be rendered meaningless if airlines cannot timely receive conforming operation specifications, if equipment is not timely certified, if pilots lack training standards, or if air traffic controllers lack procedures to issue clearances for such routes.[20]

Section 221 requires the agency to develop plans to "expedite" equipage of commercial and general aviation aircraft with NextGen technologies. The plans must be based on "public-private partnership principles" and "leverage the use of private sector capital."[21] This provision is supportive of initiatives such as NEXA Capital's NextGen Fund (the Fund), which would use a federal loan guarantee to finance, on favorable commercial terms, $1 billion of upgraded and modernized avionics to retrofit a critical mass of the U.S. commercial fleet.[22] The Fund's function is twofold. First, it provides operators with a means of mitigating investment risks created by FAA program implementation delays, which historically have created a "last mover advantage" among operators.[23] Second, it could allow more aircraft to be equipped than would a traditional grant program because of the ability to access larger pools of private capital than would be otherwise available. This is significant because certain NextGen technologies will deliver benefits only after a certain proportion of the fleet becomes equipped in what might be described as a form of network effects.

The Regulatory Framework

To date, the FAA has issued only one NextGen-specific regulation: the mandate to equip with ADS-B Out by 2020.[24] Because the FAA provides air traffic services in the United States, procedural changes affecting provision of those services will likely be made through revisions of FAA Orders and Notices. These documents will have increasing practical and legal significance as NextGen unfolds because pilots are required to comply with ATC instructions.[25]

The most consequential changes may manifest as revisions to FAA Notices JO 7110.65T and JO 7110.10U governing in-flight services. These Notices state, in relevant part, that FAA employees should "[p]rovide inflight services in accordance with the procedures in this chapter to aircraft on a 'first come, first served' basis, as circumstances permit." One of the fundamental precepts of NextGen is performance-based operations and a paradigm of service provision most pithily stated as "best equipped, best served" or "BEBS." The principle behind BEBS is to create equipage incentives by offering better-equipped operators preferential air traffic services.[26]

Agency rules of procedure and practice generally are exempt from the notice-and-comment requirements of the Administrative Procedure Act (APA).[27] However, because changes to certain FAA air traffic service-related Orders directly impact flight operations, that exemption may not apply in some instances. In a case in which FAA rules governing the adjudication of civil penalties were at issue, the U.S. Court of Appeals for the District of Columbia Circuit held such rules were not exempt from the APA's notice-and-comment requirements because, among other things, they "'substantially alter the rights or interests of regulated parties'" or encode a

"'substantive value judgment.'"[28] The preferential air traffic services contemplated within the BEBS concept might include assignment to fuel burn optimal routings and altitudes and, as such, could "substantially alter the interests" of operators. Moreover, BEBS-based Orders arguably may encode a "substantive value judgment" by the FAA that more equipage is better than less.

Possible Regulatory Developments

In availing themselves of the enhanced statutory definition of an "air navigation facility," the FAA and stakeholders might consider amendments to 14 C.F.R. Part 171 governing the certification of nonfederal navigation facilities. Part 171 currently contains certification standards only for legacy and obsolescent technologies, including VHF omnidirectional radio (VOR), instrument landing systems (ILS), nondirectional radio beacons (NDB), and microwave landing systems (MLS). Part 171, however, could be amended to include standards for emergent technology that may be developed and operated by the private sector, such as certification of Airbus subsidiary Quovadis' SAT-4Flight service as an air navigation facility.[29] Like a weather forecast, SAT4Flight provides operators with a planning tool for flights for which RNP procedures are part of the flight plan. Specifically, it predicts GPS signal availability at particular locations and times. In the existing regulatory framework, the legal basis for use of services such as SAT4Flight lies typically within the FAA's approval of operators' use of RNP procedures or other lesser administrative approvals.[30] Under the new statutory definition, SAT4Flight and related software might be considered "air navigation facilities" that could be certificated like an aircraft, airman, airport, or air carrier.[31] Ultimately, providers of other navigation technologies could begin to offer their wares to operators with a freestanding FAA certification in hand rather than offering a service the approval for which is intertwined with or otherwise dependent upon each operator's use of it.

By broadening Part 171 to include certification of new air traffic control technologies, the FAA also might foster the type of competitive innovation seen in other areas of aviation, such as airframes, engines, and avionics. The benefits of such innovation would inure not only to the agency itself, but also to other air navigation service providers, operators, and the public. Many ATC and navigation technologies are currently "regulated" primarily by FAA procurement specifications, and technological advancements largely proceed based on the FAA's perceived needs. The FAA could establish regulatory standards for "virtual" control towers that will be sited remotely from airports that FAA planners envision as supplementing or supplanting traditional airport control towers.[32] This might encourage the development of systems and innovations that the FAA cannot yet anticipate. It also could lessen the dependence of the development of NextGen technology on an increasingly constrained and unpredictable federal budget. Moreover, such an approach by the FAA to certification might be emulated by non-U.S. regulators and could serve to enhance the FAA's global leadership role in the field of aviation regulation.[33] In any revision of Part 171, the FAA might consider the Australian counterpart regulations as a possible template. In contrast to the FAA's Part 171 regulation, the Australian regulations generally apply to navigation facilities rather than being structured around specific technologies.[34]

The FAA and industry stakeholders also might consider revising the framework of 14 C.F.R. Part 93 as a means to generate benefits for early adopters of NextGen technology. Part 93 contains special air traffic rules that apply only at certain locations in the nation's airspace, including several major airports.[35] The FAA could amend Part 93 to reserve preferred arrival and departure routes for NextGen-equipped aircraft for all or part of each day. Such regulations could be tailored to local conditions. In some areas, the prerequisite for obtaining such preferred access could be navigation performance capability or other equipage that would generate incremental airspace capacity and efficiency benefits for both private operators and the public. An amended Part 93 could facilitate realization of these benefits without consuming an inordinate amount of air traffic control resources.

Conclusion

NextGen represents a fundamental transformation of aviation. Its dramatic technological advances will drive changes to the legal, institutional, and economic frameworks of the global aviation system. The prospects for timely realization of NextGen according to the U.S. government's plans seem bleak for various reasons. First, large-scale and complex technology transformations, whether in the public or private sector, are susceptible to numerous execution risks, some of which cannot be foreseen. NextGen's implementation is already facing delays. For instance, the FAA's key En Route Automation Modernization Program (ERAM), which will link multiple NextGen systems, has faced problems and is estimated to be four years behind schedule.[36] Finally, political disputes over the federal budget have become a chronic problem that casts a lengthening shadow over all long-term federal investments. The confluence of these factors serves to encourage aircraft operators to delay investments in the avionics, training, and procedures that are essential for NextGen to work. In light of these challenges, it is vitally important for private and public sector stakeholders to plan, coordinate, and execute their efforts, including the development of an optimal

regulatory framework, to minimize risks and costs and maximize systemic benefits.

Endnotes

1. In 1981, the U.S. air transportation system carried 281 million passengers. In 2008, the system transported nearly 650 million passengers. *About Us*, Joint Planning & Dev. Office, http://www.jpdo.gov/About_Us.asp.

2. The U.S.-operated GPS is one of several global navigation satellite systems (GNSS). Other satellite systems include the European Union's Galileo, Russia's GLONASS, and China's Compass system. In addition, there are regional satellite augmentation systems, such as the U.S. WAAS, India's GAGAN, and Japan's MSAS. Each system has or is intended to have the capability to support navigation or surveillance functions or both.

3. Joint Planning & Dev. Office, Concept of Operations for the Next Generation Air Transportation System, Version 3.2, at ES-2–ES-3 (2009).

4. *Id*. at 3.

5. Performance-Based Operations are air traffic services that will be provided based on aircraft performance attributes. Simply stated, better-equipped and capable aircraft are expected to receive preferred routings and clearances. The PNT concept involves use of satellite navigation to determine actual versus desired position and trajectory. Simply stated, PNT will untether aircraft routes from ground-based navigation aids and enable more direct routings. TBO refers to the dynamic adjustment of flight paths as defined by longitude, latitude, altitude, and *time*. By introducing the dimension of time into ATM, aircraft can be managed with greater precision.

6. Douglas Helton & Ariel Scheirer, *The Case for Alternative Position, Navigation, and Timing (APNT) Development for Navigation*., J. Air Traffic Control, Fall 2011, at 41.

7. Fed. Aviation Admin., Dep't of Transp., Automatic Dependent Surveillance—Broadcast (ADS–B) Out Performance Requirements to Support Air Traffic Control (ATC) Service; Final Rule, 75 Fed. Reg. 30,160 (May 28, 2010).

8. *Id*.

9. 14 C.F.R. §§ 91.225, 91.227.

10. FAA Modernization and Reform Act of 2012 (FAA Reauthorization Act), Pub. L. No. 112-95, § 211, 126 Stat. 11, 44; *Report from the ADS–B In Aviation Rulemaking Committee to the Federal Aviation Administration*, Sept. 30, 2011, http://www.faa.gov/nextgen/portfolio/trans_support_progs/adsb/media/ADSB%20In%20ARC%20Report%20with%20transmittal%20letter.pdf.

11. 14 C.F.R. § 1.1.

12. Vision 100—Century of Aviation Reauthorization Act, Pub. L. No. 108-176, §§ 709–10, 117 Stat. 2490, 2582 (2003); 49 U.S.C. § 40101 note (although some would argue that NextGen has its genesis in the FAA's numerous modernization initiatives dating back several decades).

13. Vision 110, *supra* note 12, §§ 709–10, 117 Stat. at 2584.

14. FAA Reauthorization Act, *supra* note 10, 126 Stat. 11.

15. *Id*. §§ 202, 213, 215.

16. *Id*. §§ 204, 208.

17. 49 U.S.C. § 40102(a)(4) (2008).

18. FAA Reauthorization Act, *supra* note 10, § 205 [emphasis added].

19. *Id*. § 215(a)(2).

20. *See, generally*, 14 C.F.R. pts. 21, 61, 91, 119; FAA Order 7110 series.

21. FAA Reauthorization Act, *supra* note 10, § 221.

22. NEXA Gen. P'ship & Mgmt. Co. & ITT Corp., *NextGen Equipage Fund, LLC: Aviation Industry Overview* (Apr. 4, 2011), http://www.nextgenfund.com/files/downloads/NEF_Brief_-_Website_Overview_2011-0404.pdf. NextGen Fund financing, including the government loan guarantee, may also be available to the general aviation community.

23. The FAA has a checkered history in implementing new technology, which has generally caused airlines to be cautious about embracing FAA technology initiatives. *See generally* Edward A. Lester & R. John Hansman, Report No. ICAT-2007-2, Benefits and Incentives for ADS-B Equipage in the National Airspace System 34 (Aug. 2007).

24. Fed. Aviation Admin., Dep't of Transp., Automatic Dependent Surveillance—Broadcast (ADS–B) Out Performance Requirements to Support Air Traffic Control (ATC) Service; Final Rule, 75 Fed. Reg. 30,160 (May 28, 2010).

25. 14 C.F.R. § 91.123.

26. Fed. Aviation Admin., Dep't of Transp., *NextGen Governing Principles for Avionics Equipage*, https://wwwstage.faa.gov/nextgen/inv_opps/governing_principles/index.cfm?print=go. Other FAA Orders that could be subject to substantial revision or replacement as a consequence of NextGen include the 8260 series of Orders and Notices, which regulate instrument procedure design, and the 7400 series, which addresses how the FAA designates airspace and establishes reporting points.

27. 5 U.S.C. § 553(b)(3)(A).

28. Air Transp. Ass'n v. Dep't of Transp., 900 F.2d 369, 376 (D.C. Cir. 1990), *vacated as moot*, 933 F.2d 1043 (D.C. Cir. 1991) (quoting Am. Hosp. Ass'n v. Bowen, 834 F.2d 1037, 1041 (D.C. Cir. 1987)).

29. 49 U.S.C. § 44702; *GPS/RAIM Prediction*, Quovadis (2010), http://www.quovadisway.com/1-31595-GPS-RAIM-Prediction.php.

30. FAA Advisory Circular 90-101, app. 4, para. 2(c) (2005); *see also* News Release, Jeppesen, Jeppesen Receives FAA Approval for Its RAIM Prediction Report (Sept. 11, 2008), http://ww1.jeppesen.com/company/newsroom/articles.jsp?newsURL=news/newsroom/2008/FAA_approval_RAIM.jsp.

31. 49 U.S.C. § 44702.

32. Fed. Aviation Admin., An Operational Concept for Next-Gen Towers, Version 5.1 (Sept. 2008); John Croft, *Vision Quest: Virtual Towers Gain Real Ground*, Aviation Wk. & Space Tech., Oct. 8, 2012, at 38.

33. 49 U.S.C. § 40104(b).

34. Civil Aviation Safety Auth. (Austl.), CASR Part 171 (1998); Civil Aviation Safety Auth. (Austl.) Advisory Circular

171-1 (Mar. 2006).

35. 14 C.F.R. Part 93 contains rules for airspace near airports in New York, Los Angeles, and Washington, D.C., in addition to other locations.

36. Office of Inspector Gen., Dep't of Transp., Audit Rep. AV-2012-179, Weaknesses in Program and Contract Management Contribute to ERAM Delays and Put Other NextGen Initiatives at Risk 3 (Sept. 13, 2012).