Federal Aviation Administration's 2020 NextGen Mandate: Benefits and Challenges for General Aviation

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BACKGROUND

There have been considerable technical advances in air traffic navigation over the past 30 years leading to potentially safer and, from a commercial perspective, more efficient air travel network. The changes allow, for example, reduced separation between aircraft that permit greater flexibility in routing. In particular, a move from ground-based radar technology to satellite systems offers many long-term advantages. There are a multiplicity of air navigation providers around the world currently developing, and at various stages of implementing, a wide-range of new technologies aimed at developing a common platform for satellite based navigation and control systems. The challenges nationally and internationally to bringing about a shift to satellite systems are both technological and economic in nature.

As with any change, reaching an accord on common standards and transitioning this into a working system is not a simple technical matter. In terms of costs, there is the need for new equipment, an inevitable transitional wastage from duplication as the old and new systems overlap in time, and considerable stranded costs as technically sound radar based systems are made economically redundant. There are still concerns about the technical reliability of the systems being introduced, and, for example, their capacity to handle large volumes of information, particularly in the transition phase, and, as far as general aviation is concerned, over the anonymity of the information obtained. Added to this is the matter of how the new system is to be financed. There have been problems in the past in financing and administrating the ground based elements of the system. The 2012 FAA Air Transportation Modernization and Safety Improvement Act, for example, was the first reauthorization of Federal Aviation Administration funding since 2007; the Administration had the uncertainty of 23 extensions in the interim.[1]

[1] This is a topic that is not dealt with here but has posed practical issues in the United States as well as elsewhere; e.g. see; OFFICE OF INSPECTOR GENERAL, *Audit Report: Federal Aviation Administration's Contraction Practices are Insufficient to Effectively Manage its Systems Engineering 2020 Contracts Federal*, Report Number: ZA-2012-082, 2012.

The automatic dependent surveillance-broadcast (ADS-B) technology that forms one of the cornerstones for the new approach to air navigation, and which is to be a requirement for use of certain United States airspace by 2020, is a cooperative surveillance technology for tracking aircraft.[2] The Federal Aviation Administration rule requiring the uptake of this technology was announced in 2011. The system relies on aircraft or airport vehicles broadcasting their identity, position and other information derived from on-board systems. The information is more accurate than that available to primary systems, such as radar surveillance.

The ADS-B Out signals transmitted from an aircraft can be captured for surveillance purposes on the ground but only on board other aircraft equipped for ADS-B In. The latter enables airborne traffic situational awareness, spacing, separation and self-separation applications; basically it provides a three dimensional halo around each plane. With ADS-B In an aircraft essentially determines its own position via satellite navigation and broadcasts this via a radio frequency with knowledge of what is going on about it. For a comprehensive ADS-B structure without primary surveillance by radar, all planes must be equipped with both ADS-B Out and In. This is a long-term objective, simple location is with some additional information is the short-term objective.

The issues addressed here focus on three interrelated areas:

- The pros and cons of ADS-B
- Payment for the system
- The phasing-in of ADS-B

THE PROS AND CONS OF ADS-B

The ADS-B concept is at the core of both the $40 billion Next Generation Air Transportation System (NextGen) which was initiated in 2009 in the United States and of Single European Sky ATM Research (SESAR) in Europe that was initiated in 1999.

The European Single Sky initiative has a somewhat different objective to NextGen. The United States challenge is to replace a unified radar based system that has grown in a rather *ad hoc* way and thus in need of serious efficiency improvement to handle traffic growth. The Federal Aviation Administration, for example, has estimate that increasing congestion in the air transportation system of the United States, if unchanged, would cost the American economy $22 billion annually in lost economic activity by 2022. In addition to addressing this, NextGen is specifically seen as reducing aviation fuel consumption and emissions. In contrast, the European challenge is to initially reduce the large number of air navigation service providers from nearly forty to a one; i.e. structurally to make it akin to the American system. Despite difference in motives, there

[2] Strictly the ADS-B system relies on two avionics components—a high-integrity GPS navigation source and a data link. The current transponder or RVSM maintenance requirements are not changed or affected by the ADS-B rule

is agreement between the United States and EUROCONTROL over broad approaches towards interoperable satellite based systems.

The issue of general aviation, while of considerable importance in the United States, has attracted little attention in Europe with its Single European Sky initiative quite simply because it is of a far smaller order of magnitude. For example, while there were 209,034 registered general aviation planes in the United States in 2012, there were 21,462 in Germany in 2013, 32,410 in France in 2011, 19,850 in the United Kingdom in 2013, and 3,657 in Switzerland in 2012. [3]

The United States will require the majority of aircraft operating within its airspace to be equipped with ADS-B Out by 1 January 2020; the specific categories of airspace involved are seen in TABLE 1. These are airspaces where a more basic transponder is already required.[4] There is no requirement for aircraft to have ADS-B In capabilities by January 1st 2020. [5] In terms of general aviation the requirement has been variously estimated to affect between 157,000 to 165,000 aircraft[6].

TABLE 1

Airspace	**Altitude**
A	All aircraft equipped
B	All aircraft equipped
C	All aircraft equipped
E	Above 10,000ft MSL but not below 2,500ft AGL

One of the major challenges of NextGen is to develop a system that caters for the requirements of a diverse range of air transport users, often with quite distinct characteristics and needs. At one level are large civil scheduled commercial airlines that in 2013 had 642 million passenger enplanements in the United States and carried 19,729 million lbs of cargo and mail. The scheduled passenger carriers currently operating with wafer thin financial margins and with a legacy of inabilities to even recover their operating costs, often see the burden of even the small cost per revenue passenger mile as difficult to justify at the operational level. At the longer-term, strategic level, however, the ability to increase the reliability and capacity of services across large networks is generally seen as a significant development. In contrast, the scheduled cargo/express

[3] GENERAL AVIATION MANUFACTURERS ASSOCIATION, *2013 General Aviation Statistical Databook & 2014 Industry Outlook*, Washington DC, 2014.

[4] They are also required at all altitudes within 30 miles of some airports and some other flights over water.

[5] The Federal Aviation Administration in publishing its final rule justified this; "Standards for ADS-B In air-to-air applications are still in their infancy…it is premature to require operators to equip with ADS-B In at this time."

[6] General aviation includes businesses engaged in on-demand passenger or cargo charter flying; corporate flight departments; owner-flown aircraft; flight schools; companies offering aircraft fuel, storage, maintenance and parts; and aircraft sales, brokerage and rental firms.

carriers that tended to enjoy higher margins, have largely been more enthusiastic about the change with; for example, UPS, has adopted it because it is seen as a tool for improving fleet operations with it knowing exactly where planes are (and *de facto* where consignments are) when outside of radar surveillance and for managing their flights in real time.[7] FedEx has supported it for similar reasons.

More generally, the recent events involving commercial scheduled passenger flights AF477 and MH370 has brought a heightened public awareness of the inadequacies of modern air navigation systems, or at least their deployment, and in the inability to locate flights all of the time. The costs of trying to locate a crashed plane are high both in economic and human terms; something that extends to general aviation. General aviation crashes are more common than for scheduled flights, which is not surprising because they represent about 96% of the United States air fleet, but involve fewer deaths and injuries per incident; e.g. there were 1,471 accidents in 2012 resulting in 432 fatalities.

While it is important to be wary of making comparisons, particularly when data is collected in different ways, this situation can be put in the context of commercial aviation being about 50 times safer and car travel 20 times safer than general aviation in terms of fatalities per hour traveled between 2002 and 2012. (The use of alternative matrices, such as accidents or serious injury, changes the picture slightly ADS-B should reduce the accident rates for general aviation and make research and rescue operations more effective and less costly. While most general aviation accidents occur at or near airfields, some, often weather related, are in more remote locations. The extent to which the types of flights involved would come under the 2020 ADS-B regulation is, however, unclear.[8] A full ADS-B strategy may well produce far greater benefits for the marginal costs it would entail.

Even large planes get lost. The most tragic and best know cases are perhaps the Uruguayan Air Force Flight 571 that crashed in the Andes in 1972 because of bad navigation, and AF477 into the South Atlantic partly because of poor information on altitude, but there are regular instances of aircraft landing by mistake at the wrong airports in the United States; luckily accidents are rare.[9] ADS-B Out, and ADS-B In more so, provides a mechanism for pilots and ground control to have greater awareness of aircraft locations. ADS-B In, for example, reduces the risk of runway incursions with cockpit and controller displays that show the location of aircraft and equipped ground vehicles on airport surfaces. In addition, ADS-B Out can provide local information regarding real-time weather conditions.

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[7] The more efficient use of aircraft and the consequential lower fuel burn is also likely to have environmentally beneficial effects, see US GOVERNMENT ACCOUNTABILITY OFFICE, *Aviation and the Environment: NextGen and Research and Development Are Keys to Reducing Emissions and Their Impact on Health and Climate*, GAO-08-706T, 2008.

[8] There seems to be no single gathering of information of the search costs involved when a general aviation plane goes missing, a simple search of the Web, however, provides numerous examples.

[9] http://www.iasa.com.au/folders/Safety_Issues/others/wrong-ways.html provides a list of commercial aircraft landing at the wrong airport. There appears to be no complete record of general aviation incidents of a similar kind,

Putting a money value on these benefits, and others that are general aviation specific is difficult. There will be savings in fuel, weather information will be better, and provided automatically, and flying should be safer beside other things. Putting a price on such changes is not easy. The Federal Aviation Administration has put a value of $200 million on the identifiable benefits to the sector, but argues that wider benefits are extensive. Additionally, given the massive heterogeneity of the general aviation fleet, there will inevitably be wide variations across beneficiaries. What this should also be set against, and to my knowledge has not been to date, is the current situation whereby general aviation uses approximately 16 percent of air traffic control services but contributes only 3 percent of the costs[10].

But what is often missed in these types of very static calculations is the allocation of costs during a transition when operating both radar and satellite based systems. As transfer takes place the amount of traffic using primary surveillance will decline while that using ADS-B based systems, and especially when ADS-B In is widely adopted, will increased implying a much higher cost burden being placed on those using radar surveillance. The burden, for example, of the radar-based system on general aviation would increase significantly if scheduled airlines moved to comprehensive ADS-B navigation systems.

PAYMENT FOR THE SYSTEM

There is no-such thing as free lunch, and moving to satellite based air navigation requires resources. In particular, unlike primary radar-based surveillance, full ADS-B requires equipping aircraft so that they can interact with other aircraft and ground installations in much wider range of ways. This means that its use involves two distinct costs to users; one to reflect the infrastructure costs involved and another the costs of the on-board equipment.

The costs of equipping a plane varies according to such things as whether it is a retrofit, whether it includes both ADS-B Out and In, or just the former, and the extent to which equipment offers information beyond that required for certification. Given these facts, the estimated costs range from $4,000 to $17,000 to equip an aircraft with ADS-B Out, although in the case of new aircraft there is the off-setting cost of a saving from not having a separate transponder fitted. The costs of ABS Out and In equipment has been estimated to cost up to $30,000. In addition, there are annual costs associated with the ground infrastructure of the system and, in the short-term, of operating the current radar surveillance system. There is certainly no consensus on the aggregate costs in involved; e.g. a Federal Aviation Administration estimate suggests that the cost to equip general aviation aircraft from 2012 to 2035 could range anywhere from $1.2 to $4.5 billion.

There has been little market-based incentive for early adoption of a new technology like ADS-B where many of the benefits are not immediate. Indeed, the reverse is almost the case because the main gains come after widespread adoption and “first movers” have the

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[10] US DEPARTMENT OF TRANSPORTATION’S INSPECTOR GENERAL OFFICE, *Use of the National Air Space System*, CR-2008-028, Washington DC, 2008.

burden of having equipped with only partially useful equipment; the network economies take time to be realiazed.

There is some intended financial support for general aviation from the NextGen GA Fund[11] to help up-grade existing aircraft to meet the Federal Aviation Administration's 2020 deadline. The fund is a public-private partnership between the United States Congress, the aerospace industry and the private-sector investment community. It began with a capital base of $550 million with the intention of eventually provide some $1.3 billion in financing to the general aviation sector over 10 years. It is focused on the more costly retrofits; those of over $10,000. This measure, however, has come some time after the notification of the 2020 requirement, and thus has done little to stimulate early adoption of the necessary avionics.

In addition to the money costs of fitting ADS-B In there is in the case of the existing general aviation fleet, the time costs of retrofitting that can take from a day or so to more than a week. For those elements of the fleet that are used for such as training, taxi, charter, and business travel this is a *de facto* financial cost as aircraft are out of action. Additionally, while many flights may fall outside of the Federal Aviation Administration's 2020 requirement, there will inevitably occasions when planes that are normally used at lower altitudes will be brought within the ADS-B threshold. This means that for users of these aircraft there will be a requirement for ADS-B Out equipment that is not always needed, and maybe seldom needed; "portable" equipment is not really an option.

THE PHASING-IN OF ADS-B

The United States has chosen a particular path for phasing in ADS-B, it is not the only possible way of doing this and some other countries have taken different routes; the differences may be due the underlying objectives sought, the nature of the traffic, or the broader institutional structures involved.

While NextGen entails large scale infrastructures investment, the United States aircraft fleet is both large and diverse and the Federal Aviation Administration has sought to embrace a large part of this fleets' use of airspace as one action by mandating it can make use of the ADS-B system. The creation of the ground infrastructure began in August 2007 when the FAA awarded ITT Corp. a contract to develop and build a nationwide network of 794 ADS-B ground stations. This is also essentially what is happening in Europe, with planes with a weight above 12,600lb or a max cruise of over 250 knots being required to carry ADS-B from 2017, and new planes from 2015 (originally this was 2015 and 2013 respectively but there has been slippage). This has all the pros-and-cons of any big-bang strategy (actually more of a medium bang because ADS-B In is not included.) with high set-up costs but a relatively quick flow of benefits and more solid information to help individual actors make decisions.

[11] http://www.nextgenfund.com/

The approach helps shorten the transition to the satellite based system, and gives a clear target for those involved. The latter is not just important for aircraft users but also for those that manufacture the hard and software that is required on the plane and ground, and those that conduct the equipage of the existing fleet. It removes some of the production uncertainties and allows the build-up of necessary equipage capacity. In the long-run it is likely that all aircraft will require to be fitted with at least ADS-B Out, and possibly ADS-B In, equipment and advanced notice would allow new aircraft to be prepared for this, and lessen the costs of retrofitting. This latter factor can reduce the costs of producing the hardware and lead to greater diversity in the products offered; a number of alternative models become financially viable to produce. Added to this, a substantial market has room for a large number of suppliers thus keeping up competitive pressures and minimizing prices.

The evidence of retrofitting the United States general aviation fleet is that to-date progress has been slow. Data from the Federal Aviation Administration suggest that by early 2014 less than 1,500 aircraft met certification requirements. This is well below the trend required to meet the 2020 target, although some caveats should be taken into account. First, not all the planes that are ultimately likely to fly in the designated ADS-B Out required airspace will need to do so by January 1st 2020, and some of the existing fleet will be out of service by that date anyway for other reasons.[12] Second, the existing equipage facilities are likely to be expanded as demand increases for retrofitting; this is, after all, a commercial activity with financial rewards coming from the equipage service. Third, there is some general evidence from other areas that when there are mandatory requirements, economies of experience have some effect with both money and time costs of installing a new technology at the micro-level falling as more operations are completed.

Other countries have adopted slightly different road maps for change. Canada has essentially adopted more of what may be called a “geographical spread system” under which ADS-B capacity has been provided over some areas that have no radar surveillance, e.g. the Hudson Bay where separation has been reduced from 80 nautical miles to five. A variation on this them is to spread the technology vertically, beginning say with A and B airspace, this similar to the Australian approach. The underlying problem with all these approaches is that underlying any significant change in air navigation, and indeed in any transportation sector, namely that users are not static and many move between parts of the overall system.

CONCLUSIONS

Changing any air navigation system is difficult, not least because the existing structure cannot be closed down while the new is introduced. The United States, with the world’s largest air transportation system, typifies the sorts of compromise that have to be made in

[12] The United States active general aviation fleet fell from 223,700 to 209,034 between 2010 and 2013, although the Federal Aviation Administration forecasts growth as economic recovery takes place. The degree to which this growth will involve the new entry of aircraft to the United States fleet will affect retrofitting needs.

piecemeal change. The hope is that NextGen will, once fully in place, provide a more flexible long-term framework within which air traffic can grow efficiently to the benefit of the country. Nevertheless, the change has not been proving easy, and never seemed likely to be.

The move to the use of satellite surveillance represents a significant improvement to air navigation, filling gaps in the existing radar based systems and offering enhanced and faster information flows. While the initial adoption of ADS-Out in the United States will provide only some of the potential benefits of a full ADS system it, nevertheless, will impact positively in terms of safety and more efficient use of air space; there seems to be general agreement on this. The costs to both the aviation sector and taxpayer are not small, and the expenses of retrofitting part of the general aviation fleet to meet new certification standards by 2020 are equally far from negligible. It is perhaps unfortunate that incentives for early adoption have been slow to transpire, but firm mandates have been shown to stimulate market responses that allow targets to be met.