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Rachel Borsa

Professor Brian G. Dillman

Professor Timothy D. Ropp

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EXPLORING THE IMPACT OF ADS-B NEXTGEN TECHNOLOGY REQUIREMENTS FOR GENERAL AVIATION

Rachel Borsa
Purdue University
West Lafayette, Indiana
Professor Brian G. Dillman
Dept. of Aviation - Purdue University
West Lafayette, Indiana
Professor Timothy D. Ropp
Dept. of Aviation - Purdue University
West Lafayette, Indiana

The Next Generation Air Transportation System, or NextGen, represents the modernization of the United States air transportation system. It is a shift from legacy computer and radar based technologies to an integrated set of technologies, connected into a real time data sharing "system," shared by air traffic control, pilots and airports. This upgrade to our National Airspace System (NAS) involves potentially significant changes and financial considerations for many air operators. The upgrade and integration of one of these technologies, the Automatic Dependent Surveillance – Broadcast (ADS-B) transmitter, is among the mandatory upgrades being required by the Federal Aviation Administration within a few years. This paper explores the cost and benefits of this specific NextGen technology for general aviation owner/operators, takes a specific look at the implications for flight training schools, and details the many ways that general aviation pilots can access and use the new information in the cockpit.

Air transportation is a major economic engine for the United States, accounting for 5.2 percent of the United States Gross Domestic Product and contributing over $1 trillion annually to the national economy, and 11 million jobs (FAA, 2011b). The required growth and modernization of United States civil aviation is therefore paramount in order to sustain this benefit while meeting anticipated future demand for air travel. Growth and sustainability will be constrained if modern day issues related to safety, data sharing capabilities, aircraft noise, emissions, and fuel economy – as targeted by the NextGen initiative - are not addressed (US Government, 2003). The underlying nature of NextGen seeks to address issues of safety, capacity and efficiency which could jeopardize sustainable air transportation in the 21st century if these outcomes are not maintained as the NextGen system evolves. Without a major improvement to the current air transportation system, the United States risks falling behind in safety, efficiency and overall competitiveness within the global air transportation system.

Graduates from FAA approved flight programs must enter the industry familiar with the emerging technologies as well as the issues that are inherent within their utilization. This report explores background information for Automatic Dependent Surveillance – Broadcast (ADS-B), an onboard technology that will be required for aircraft including general aviation in most airspaces by the year 2020 (FAA-AC 90-114, 2011). This report looks at the implications for training schools with general aviation fleets and potential benefits of investing in and learning ADS-B technology early on in the deployment schedule for the technology. A purposeful early investment sooner rather than later (closer to an FAA mandated deadline) is believed to provide greater benefit to training programs and their students, the future NextGen professionals.

Background

The modernization of the United States National Airspace System (NAS) into the Next Generation Air Transportation System (NextGen) has been an ongoing process since its mandate by Congress in 2003 under the Vision 100 Aviation Reauthorization Act (US Government, 2003). This upgrade is being rolled out by the Federal Aviation Administration (FAA) pursuing convenient, dependable and hassle-free air travel that will also accommodate projected levels of increased demand for air travel worldwide in the coming decade (NextGen, 2011).

NextGen involves all levels of the aviation industry including, air traffic control, commercial air carriers, and general aviation. Premier among innovations on the flight operations side are new satellite and Global Positioning System (GPS) technologies in place of traditional ground based radar, and flight deck upgrades enabling more autonomous, real time fact-based decision making with the pilot in command of an aircraft in flight. As a result of this holistic 'systems' approach of shared data and more pilot autonomy (see Table 1), the industry is evolving from the traditional concept of air traffic control to a more relaxed concept of *air traffic management* (2011), although the term 'relaxed' may perhaps, in the view of the authors, be a misnomer.

There has been little significant change in air traffic control and airspace systems since the end of WWII, or the Jet Age (FAA Implementation, 2012). At one time the NextGen concept was relegated to "forward thinkers" looking to intangible future technology capabilities. However, with technology already demonstrating its capabilities and real deadlines quickly approaching, action must be taken. NextGen leverages both new technology as well as technologies that already exist (NextGen, 2011). For aircraft applications, the goal is to provide flight crews greater situational awareness and more control over what is happening in the aircraft, and to reduce time on the ground waiting for air traffic control instructions. Data acquisition and decision making traditionally assembled and relayed from the ground to the aircraft will occur much more substantially in the flight deck, with controllers assuming the role of traffic flow managers rather than ground controllers (FAA, 2011a).

Table 1.
NextGen is split into six different components (FAA, 2011a). They are:

- Automatic Dependent Surveillance-Broadcast (ADS-B) (the focus of this report)
- System Wide Information Management
- NextGen Network Enabled Weather
- NAS Voice System
- Collaborative Air Traffic Management Technologies, and
- DataComm Data Communications.

There are several different aims that the FAA has for NextGen. The FAA wants to keep delays low and give the pilots more flexibility to maneuver around weather problems. In addition, the system is being designed to make a smaller carbon footprint with more precise flights, to establish "one seamless sky," create more jobs in more cities, and to keep travelers safe (FAA, 2011).

The Role of ADS-B

ADS-B continues to play a prominent role in NextGen and is one of the flagship technologies highlighted by the FAA. By the year 2020, the FAA will be implementing the rule that all aircraft must be equipped with onboard position reporting and identification technology called ADS-B (FAA-AC 90-114, 2011; FAA Final Rule, 2010). In September of 2010, the FAA approved satellite-based technology for air traffic controllers in areas with the coverage (FAA, 2012). Although planning has been underway for nearly a decade, the pending requirement for ADS-B remains problematic, especially for general aviation operators. Questions range from "*What is it and how do I use it?* to *"How much does it cost and what's the real benefit?"*

ADS-B System Description. Each word in Automatic Dependent Surveillance-Broadcast is descriptive of the overall system (ADS-B Technologies, 2011):

Automatic: always on and requires no operator intervention.

Dependent: system is dependent on an accurate Global Navigation Satellite System (GNSS) signal (also known as Global Positioning System GPS),

Surveillance: the method used for determining position of aircraft, vehicles or other assets.

Broadcast: continuously broadcasts aircraft position and other data to any ADS-B equipped aircraft, or ground station equipped to receive ADS-B.

ADS-B Out provides information similar to what the Transponder/Decoder system provides (secondary radar), but the way information is received is completely new. Ground stations and aircraft both require ADS-B Out for this technology to work. ADS-B Out will be the requirement that the FAA will mandate. Aircraft receive position data from a GPS satellite constellation in space and then simultaneously broadcast their position and all other data to any aircraft equipped with ADS-B In technology and ground station equipped to receive it (ADS-B Technologies, 2011).

As stated earlier, the only ADS-B standard required by 2020 for all aircraft is to have ADS-B Out installed for flight in ADS-B airspace (FAA-AC 90-114, 2011). Specifically, ADS-B Out will be required in (FAA, 2010a):

- Class A, B, and C airspace
- Class E airspace within the 48 contiguous states and District of Columbia at and above 10,000 feet MSL, excluding the airspace at and below 2500 feet above the surface
- Class E airspace at and above 3000 feet MSL over the Gulf of Mexico from the coastline of the US out to 12 nautical miles
- Around those airports identified in 14 CFR part 91, Appendix D

The ADS-B Out rule does not apply to an aircraft that was not originally certificated with an electrical system or that has not been certified with such a system installed, including balloons and gliders (FAA, 2010b).

It would appear that simple. Radar could degrade with range, atmospheric conditions, or target altitude. Also, update intervals do not depend on the rotational speed or reliability of mechanical antennas. ADS-B will be faster than radar and more fail-resistant. When ADS-B Out technologies are paired with ADS-B In technologies in the aircraft, the result will be information that can be utilized with almost complete situational awareness. ADS-B Out can tell us aircraft speed, position, direction, relative altitude, and aircraft tail numbers (Dillman, 2012). There will be virtually no more blind spots and if utilized correctly, pilots will be much safer and more aware in the air.

ADS-B Out can be equipped one of two ways. The owner can install a 1090 megahertz (MHz) extended squitter broadcast link, or the Universal Access Transceiver (UAT) broadcast link (2010). The extended squitter and the UAT are both certified by Technical Standard Orders, TSO-C166b and TSO-C154C, respectively (2010). Purdue University acquired a fleet of Cirrus SR-20's in 2010. With those airplanes, the University bought the GTX 33ES transponder (Dillman). The ES stands for extended squitter and Purdue bought that transponder because it already had ADS-B Out capability and it is currently being utilized in the aircraft.

A steep learning curve remains for pilots utilizing ADS-B to fully realize the potential benefits available. While ADS-B Out will be required by the FAA, the true benefit for pilots operating within the system will be the information provided by ADS-B In. ADS-B In will contain Flight Information Services-Broadcast (FIS-B) and Traffic Information Services- Broadcast (TIS-B) (2010). This will be an excellent resource for pilots because certain aspects of the information available will be free, and pilots can access this information from in the cockpit (2010). If the weather begins to deteriorate, the pilot can scroll across her screen and find where the weather is good enough to land, or the pilot can fly above or around the weather. Some other benefits of having ADS-B In are: enhanced visual acquisition, enhanced visual approaches, final approach and runway occupancy awareness, airport surface situational awareness, conflict detection, merging and spacing, Cockpit Display of Traffic Information (CDTI), and Cockpit Assisted Visual Separation (CAVS) (2010). This is where having a compatible display, like the glass cockpit design of the Cirrus SR-20's, will be required to fully benefit from the technology. The pilot will need a big enough screen so that she can see all of the information provided. An alternative platform is the incorporation of tablet technologies such as the Apple IPad. For a somewhat small investment, the ADS-B In information can be accessed with relative ease. The options for compliance of the ADS-B Out mandate are widespread and the available access to the ADS-B In information is available from a variety of resources as well. Because of this fact, it is imperative that the pilots operating a given aircraft be familiar with the resources available and, more importantly, how they will access the desired information.

Viewing ADS-B as an Educational Tool

NextGen impacts General Aviation on several levels. General aviation training and operators will need to do more research about ADS-B technology than the average airline pilot. GA pilots will, in a sense be more in charge of deciding what device they receive their information on, where the original information comes from, understanding the different limitations, and when and where to best use the information. Owner/operators have expense and transitional training to consider and rightfully so. Similarly, from a GA training fleet perspective, while initial cost structure can be high, the positive outcome is a better equipped student.

As an example, Purdue's fleet of Cirrus SR-20s represents an excellent platform for the new ADS-B technology. While the cost of this fleet ultimately adds to student fee structure, the student also is introduced to NextGen style technologies from the beginning of training. The Cirrus aircraft are glass cockpit and contain two screens; the Primary Flight Display (PFD) and the Multi-Function Display (MFD). The PFD has all of the information that traditional round style instrumentation provide on older aircraft. The MFD is where the majority of the information pertinent to ADS-B is located. The Traffic Avoidance System (TAS) shows the position of other airplanes with transponders and ADS-B Out equipment. The ADS-B allows pilots to see the direction of flight of conflicting traffic, allows the determination if the aircraft is ascending or descending, and can identify the tail number of the other ADS-B aircraft. Seeing all of that additional information only occurs when the planes have ADS-B Out. ADS-B is a useful tool in facilitating pilots to see and understand more of what is going on around the pilot. When utilized correctly, situational awareness increases exponentially.

Again, it is recognized that the cost of a fully equipped ADS-B can be steep for the individual aircraft owner/operator. Market price at the time of this report for ADS-B capability is $8395US (Garmin, 2012). Then, the owner has to pay for the maintenance to install the transponder with ADS-B capability; which is usually an extra $1000. Just ADS-B Out can cost anywhere from $2000 to upwards of $10,000. However, there are other options and alternate routes that owners can take to create a cheaper purchase. The FAA is currently providing benefits and price cuts to those who install the equipment now. Also, the FAA is more lenient on what way the owner installs the ADS-B capable equipment. It can be in the form of the transponder or in the form of an antenna, but if it is on the plane, then it counts. In the future, the FAA could become stricter about what equipment can and cannot be used to transmit ADS-B Out.

ADS-B In is received in a different way than ADS-B Out. Purdue has a GTS 800 which is capable of receiving TIS-B and FIS-B when that becomes functional to pilots (Garmin, 2012). With the MFD, the pilot can scroll to different screens and she will see weather on one page, including METARs, TAFs, Sigmets, Airmets, TFRs, and Radar (Lawrence, 2011). In conjunction with the TAS system, the ADS-B allows the pilot can see all of the traffic in the area. ADS-B In can "see" an area of 100 nm (2011). The most common distance to set the distance is eight miles. When ADS-B In locates an aircraft within those eight miles, or however the pilot changes the settings, a warning will sound; saying, for example, "Traffic, two 'o'clock, seven point five miles, three hundred feet below" (2011). This feature makes the pilot's job easier by finding the potentially harmful traffic and avoiding it. ADS-B In really is a remarkable piece of technology for those that have the ability to access the information.

There are many different ways to illustrate that ADS-B technology is worth the money, time, and practice, especially at a training school like Purdue. Other than verifying that the aircraft you're operating is equipped with ADS-B Out and an awareness of which airspace it is required to operate, there is nothing really to learn involving ADS-B Out. It is an automatic signal and cannot be controlled by the pilot. However ADS-B In, once it is functional, will be an invaluable resource for the student aviators at Purdue and something that will need to be incorporated into the plethora of other information sources that are available. Unlike aircraft from decades ago, there are virtually unlimited possibilities for obtaining source material to complete the pilot's responsibilities. They will be seeing and reading the same information that airline pilots utilize in flight. The technology should be streamlined across the industry so that every system is somewhat alike which will allow for seamless transitions between various aircraft and operators. Other data sources include constant weather updates on days that are marginal VFR, enabling more precise predictions and flight plan decision making including weather avoidance and go/no-go scenarios.

Conclusion

Regardless of cost concern or learning curves, NextGen technology integration continues, and it is time to move from the questions of "why and when" to the next question of "how". ADS-B In offers a consistent format of information, albeit through varied mechanisms and systems. As the NAS evolves, opportunity exists at the educational level to shape novice aviators into better systems thinkers by learning the requisite methods and approaches necessary to interact with a complex air transportation system before they enter it. This in turn will facilitate a more informed human operator and achieve crucial future safety outcomes.

At the university level, ADS-B is seen as a significant enabler for sharpening 21st century flight deck command, awareness and decision-making skills. This in turn prepares students to assimilate into airline careers already being transformed by NextGen. On top of all that, proper utilization of ADS-B makes the skies safer. Soon we will not think of ADS-B as an expensive luxury, but as a necessary human-in-the-loop technology in the flight deck.

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