
# PILOT PERCEPTION AND USE OF ADS-B TRAFFIC AND WEATHER SERVICES (TIS-B & FIS-B)

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# Pilot Perception and Use of

# ADS-B Traffic and Weather Services (TIS-B and FIS-B)

by

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## Executive Summary

Automatic Dependent Surveillance – Broadcast (ADS-B) is a central component of the NextGen air traffic control modernization program. It is intended to improve traffic surveillance capabilities by sharing accurate aircraft position information between pilots and air traffic controllers. In addition, "**ADS-B In**" capability provides pilots with traffic information for nearby flights along with relevant weather and airspace information. Pilots can access these products using a variety of installed and portable avionics systems. This study was intended to evaluate potential benefits of **ADS-B In** traffic and weather services. Goals included identifying the factors that influence the decision whether to equip with **ADS-B In** as well as evaluating current pilot usage of traffic and flight information uplink services.

A total of 1407 pilots responded to an online survey that was announced through several general aviation media outlets. Respondents were solicited regardless of previous ADS-B experience. A majority of respondents had used **ADS-B In**, with 56% of respondents reporting having experience with either an installed or portable system. Of the group who had experience with **ADS-B In**, 85% used portable systems and 30% used installed systems.

A perceived safety benefit from **ADS-B In** traffic information was clearly apparent based on feedback from several questions in the survey. Among pilots who use ADS-B traffic on a regular basis, 42% of respondents indicated that it had helped them avoid a mid-air collision. The perceived usefulness of ADS-B traffic was strongly dependent on equipage with **ADS-B Out**. A full 51% of respondents with both **ADS-B In** and **ADS-B Out** reported that ADS-B traffic had helped them avoid a mid-air collision, while only

19% of respondents without **ADS-B Out** agreed. This, along with other responses, suggested a safety benefit from improved traffic avoidance for respondents who also fly with **ADS-B Out** installed in their aircraft. While there was an apparent safety benefit from **ADS-B In** traffic information for all respondents, limitations in coverage area was an issue for many pilots who were not equipped with **ADS-B Out**. While this issue is anticipated to dissipate as a greater percentage of the general aviation fleet equips with **ADS-B Out**, the coverage limitations clearly limit the usefulness of ADS-B traffic information as it is currently implemented.

Respondents commonly used **ADS-B In** flight information (weather, airspace, and other system information) as a resource when changing altitude or rerouting. Some respondents also reported occasions where the knowledge that they would receive this information in the air influenced their decision to take off (in situations where they otherwise might not have). Therefore, for at least some pilots, **ADS-B In** flight information services appeared to influence the traditional go/no-go decision process.

For respondents who had not flown with **ADS-B In**, 53% indicated that they were planning to equip in the future. Common reasons for not equipping included the high cost of the technology and the availability of alternative services. As the technology becomes more widespread, it expected that the cost of equipment will decrease. Based on these survey results, not all pilots are simply holding out for lower prices - 10% of respondents with no **ADS-B In** experience cited mistrust of the technology or general lack of interest as reasons for not using the services.

This study showed that **ADS-B In** traffic has provided increased situational awareness for pilots operating in VFR environments, such as congested traffic patterns, as well as in IFR environments as a backup for ATC separation services and traffic advisories. **ADS-B In** flight information services have clearly impacted pilot decision making in the air, with occasional benefits prior to takeoff by impacting go/no-go decisions. The availability of ADS-B uplink services is changing the way that pilots fly. It is a push toward independence in the cockpit, enabling pilots to use state-of-the-art technology to enhance flight safety.

# Acknowledgements

This project was funded by the U.S. Department of Transportation - Federal Aviation Administration through the Consortium in Aviation Operations Research (NEXTOR II) Center of Excellence.

The authors wish to thank AOPA, EAA, Flying Magazine, and GA News for their help in disseminating the survey announcement to a wide segment of the general aviation community. Without this promotional assistance, the enthusiastic nationwide response to the survey would not have been possible. In addition, the authors thank the pilots who volunteered their time and offered valuable feedback by participating in the survey. Finally, the authors thank Joshua Emig for his assistance in creating and administering the survey.

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# Acronyms

| | |
|---|---|
| AC | Advisory Circular |
| A/C | Aircraft |
| ADS-B | Automatic Dependent Surveillance - Broadcast |
| ADS-R | Automatic Dependent Surveillance – Rebroadcast |
| AIRMET | Airmen's Meteorological Information |
| ATC | Air Traffic Control |
| ATP | Airline Transport Pilot |
| CDTI | Cockpit Display of Traffic Information |
| CFI | Certified Flight Instructor |
| CFII | Certified Flight Instructor – Instrument |
| DOT | Department of Transportation |
| ES | Extended Squitter |
| FAA | Federal Aviation Administration |
| FIS-B | Flight Information Service – Broadcast |
| FL | Flight Level |
| GA | General Aviation |
| GPS | Global Positioning System |
| IMC | Instrument Meteorological Conditions |
| IFR | Instrument Flight Rules |
| MEI | Multi-Engine Instructor |
| METAR | Meteorological Terminal Routine Weather Report |
| MFD | Multi-Function Display |
| MHz | Mega Hertz |
| NAS | National Airspace System |
| NEXRAD | Next Generation Radar |
| NextGen | Next Generation Air Transportation System |
| NOTAM | Notice to Airmen |
| PIREP | Pilot Report |
| SIGMET | Significant Meteorological Information |
| SUA | Special Use Airspace |
| TAF | Terminal Aerodrome Forecast |
| TAS | Traffic Advisory System |
| TCAS | Traffic Collision Avoidance System |
| TIS-B | Traffic Information Service – Broadcast |
| TFR | Temporary Flight Restriction |
| UAT | Universal Access Transceiver |
| VFR | Visual Flight Rules |
| VMC | Visual Meteorological Conditions |

# 1 Introduction

## 1.1 Introduction

ADS-B (Automatic Dependent Surveillance – Broadcast) is a precise surveillance system based on Global Positioning System (GPS) location information transmitted by participating aircraft. The system also introduces the capability to uplink traffic, weather, and other relevant information to properly equipped aircraft (FAA, 2010). There are two components to ADS-B.

1. **ADS-B Out** is the transmission of identity and position information from an aircraft. This broadcast is received by other aircraft, ground stations, and air traffic controllers. (Blue arrows in Figure 1-1)
2. **ADS-B In** is the reception of other traffic, weather, and flight information services transmitted by ground stations and other aircraft. (Green arrows in Figure 1-1)

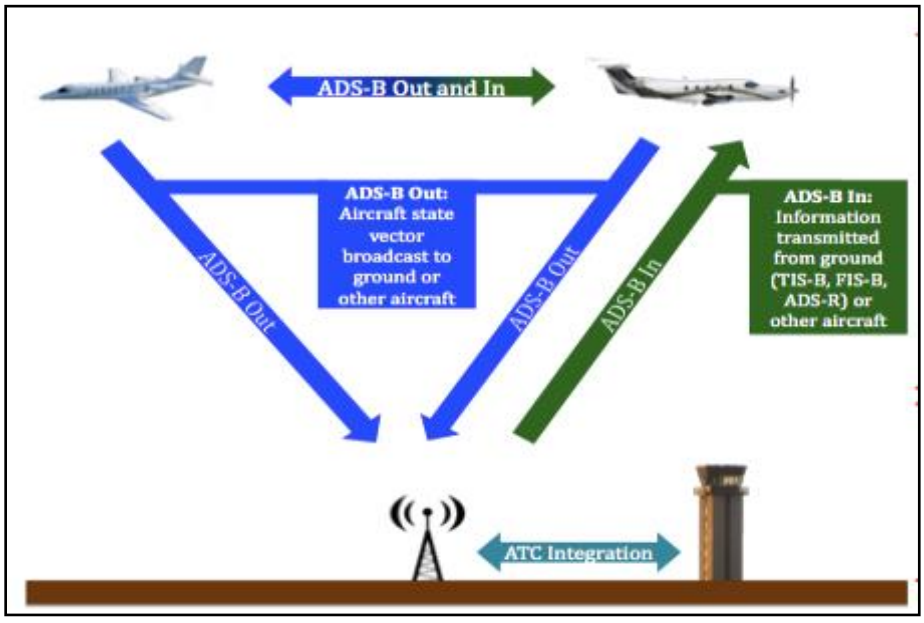


**Figure 1-1. Schematic Representation of ADS-B (Kunzi, 2011)**

The avionics and other hardware that are onboard an aircraft determine whether it is equipped for **ADS-B Out**, **ADS-B In**, or both. The FAA has mandated that all aircraft

be equipped with **ADS-B Out** capability as part of the Next Generation Air Transportation System (NextGen). However, outfitting an aircraft with **ADS-B In** is voluntary and independent of **ADS-B Out** equipage. This has led to the growth of an industry that manufactures relatively low-cost **ADS-B In** devices for pilots not currently equipped with **ADS-B Out**.

**ADS-B In** information is available in either installed or portable form. Installed systems are permanently affixed to the instrument panel or avionics rack of an aircraft and are powered by the onboard electrical system. All installed systems include an ADS-B receiver/antenna and connect to some form of display (either directly to a MFD or wirelessly to a tablet). Different receivers have different interface capabilities. Technical specifications for hardware and software supporting **ADS-B In** are less restrictive than those for **ADS-B Out**, so a variety of interfaces and software solutions have been marketed. Some of these interface with a wide variety of MFDs and tablets, while others are designed for specific and proprietary installation packages.

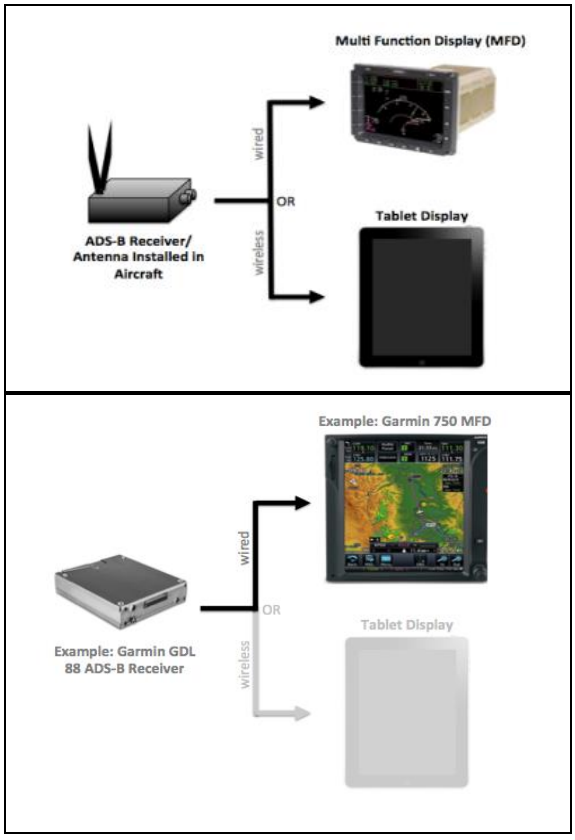


**Figure 1-2. Example of installed ADS-B In hardware**

Portable systems, about the size of a television remote, are battery-powered and require a Bluetooth or wireless connection to a tablet in order to display **ADS-B In** information. Portable ADS-B receivers can be powered either by a battery or a power source in the cockpit. Pilots may select the mounting location for the receiver (normally on the glare shield, dashboard, or cockpit windows). The display device, whether a tablet computer or other form of electronic flight bag, is normally powered internally by batteries. A wide variety of applications have been developed to display **ADS-B In** information to pilots for inflight use. Many of these applications can also be used for pre-flight planning, location tracking, attitude reference backup, and other flight-related functions. Weather and traffic information from **ADS-B In** is generally presented as an additional "layer" of the application's graphical interface.

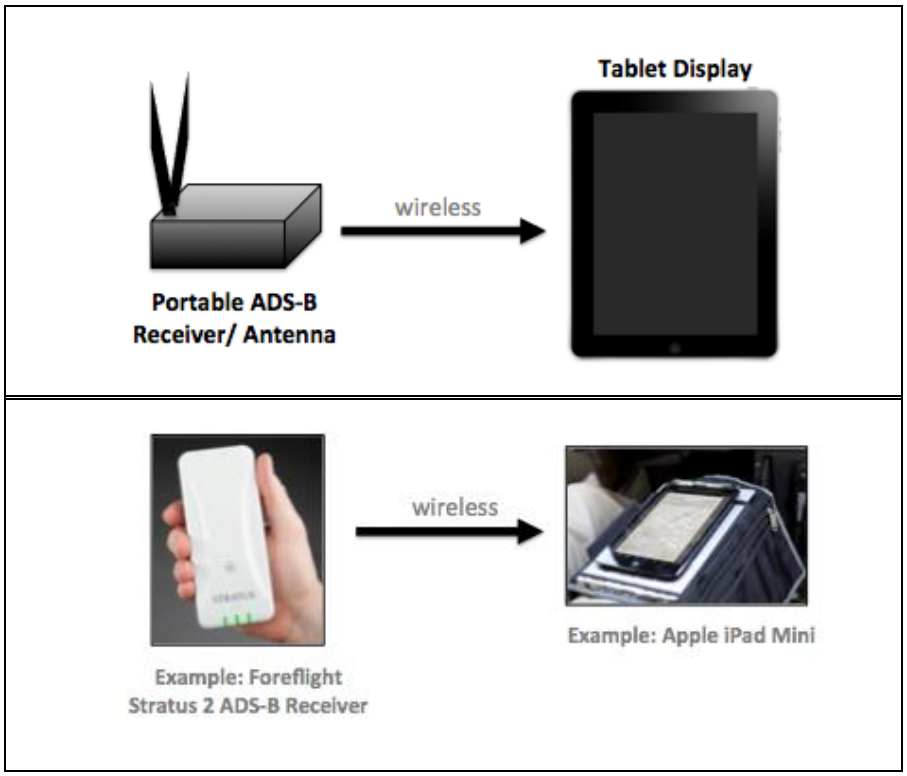


**Figure 1-3. Example of portable ADS-B In hardware**

An aircraft equipped for **ADS-B In** receives traffic information from other aircraft and from the ground station network. **ADS-B In** traffic services provide location information for other aircraft with a transponder in the vicinity of the equipped aircraft. ADS-B traffic incorporates direct ADS-B transmissions from other aircraft as well as uplinked traffic from radar and ADS-B ground systems (TIS-B and ADS-R).

Flight Information System-Broadcast (FIS-B) is a component of **ADS-B In** that allows pilots to receive important inflight information such as weather and airspace restrictions. It was designed for use primarily by the general aviation community. The service aggregates information for transmission using ADS-B ground stations. Systems onboard the aircraft decode the FIS-B data package for display to the pilot. The exact display format and content varies between devices, but generally includes weather imagery, forecasts, and relevant notices to airmen.

## 1.2 Motivation

Increased safety and efficiency are primary motivations for the transition to ADS-B surveillance in the National Airspace System (NAS). Traffic and weather uplink services were implemented with the intention of improving the inflight resources available to general aviation pilots and incentivizing ADS-B equipage and use. The success of these objectives cannot be gauged without soliciting direct feedback about **ADS-B In** traffic and weather services from the general aviation community, as **ADS-B Out** equipage rates do not provide information about pilot adoption or perception of the associated services.

The main goal of the study was to evaluate the use and potential benefits of **ADS-B In** uplink services (traffic and FIS-B). In order to evaluate this, the following sub-goals were defined.

- Determine level of experience with **ADS-B In** equipment for the current pilot population
- Understand barriers to **ADS-B In** equipage
- Identify different ways in which FIS-B and traffic services are used by the GA community including:
  - Impacts on Go/No-Go decisions
  - Avoidance of weather
  - Avoidance of mid-air collisions
- Gain insight on strengths and weaknesses of current traffic uplink and FIS-B implementation as perceived by pilots

# 2 Methodology

## 2.1 Survey Design

The survey was designed with the overall structure presented in Figure 2-1. The entire survey is included in the Appendix.

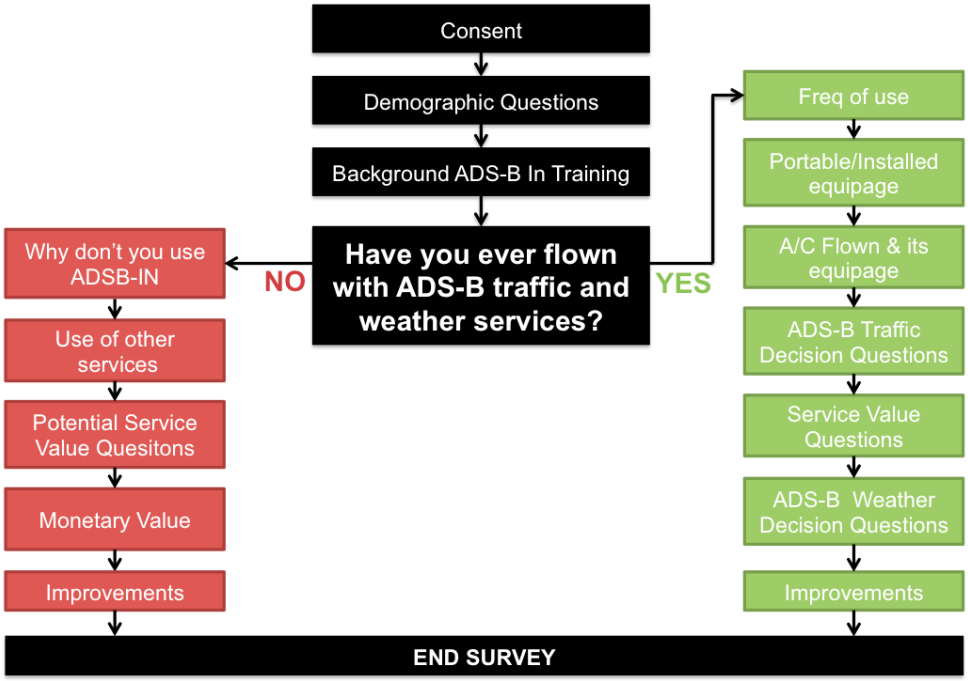


**Figure 2-1. Survey architecture**

The survey began with demographic questions detailing pilot flight experience. Background training materials were then presented in order to provide participants with a baseline for ADS-B terminology in the survey. The remainder of the survey was split based on whether the participant had experience flying with any ADS-B traffic (provided by ADS-B direct, TIS-B, and ADS-R) or flight information (weather and airspace status uplink from FIS-B). If pilots had never flown with **ADS-B In**, questions were presented to understand why a pilot had not equipped and to determine a hypothetical valuation of the information that is available with **ADS-B In**.

If pilots had flown with ADS-B traffic uplink and FIS-B, questions were posed to capture the frequency of use, type of systems used, impact on inflight decisions, and general perception of the system. Questions were also asked regarding the impact of ADS-B traffic information on visual acquisition and conflict resolution with other traffic. FIS-B decision questions were included to determine how weather and other flight information services had influenced vital flight decisions such as route planning, diversion to alternate airports, and general impact on go/no go decisions. In addition, questions regarding each service were posed to find out how pilots valued the information provided by **ADS-B In**.

Some of the questions included the use of the 5 point Likert scale shown in Figure 2-2. For the purposes of analysis, "Always/Frequently" or "Extremely/Very" responses were considered "strong" results.

| **"Strong" Responses** | | **"Weak" Responses** | | |
|---|---|---|---|---|
| ○ Always | ○ Frequently | ○ Occasionally | ○ Rarely | ○ Never |
| ○ Extremely (Useful, Satisfied, Important) | ○ Very (Useful, Satisfied, Important) | ○ Somewhat (Useful, Satisfied, Important) | ○ Slightly (Useful, Satisfied, Important) | ○ Not (Useful, Satisfied, Important) |

**Figure 2-2. Likert scales used in survey**

During post-processing of results, responses for the subset of survey participants who had "always" or "frequently" used **ADS-B In** were analyzed to evaluate potential differences with infrequent users. In other situations, the survey responses were segmented in order to shed further insight on responses (such as separating instrument-rated pilots or pilots with **ADS-B Out** equipage). In all cases, the response percentages reported in the results are with respect to a sample subset defined in the figure title and textual description. In some cases, the sample includes pilots who did not respond to the question under examination. This results in the sum of response percentages being less than 100% in those cases.

Finally, for all respondents, free response questions were presented regarding potential improvements to the system as well as other general comments. These were used to capture information regarding strengths and weaknesses in the current implementation of **ADS-B In** as perceived by pilots.

## 2.2 Survey Promotion and Distribution

The survey database and front-end was powered by Google Forms and hosted on an MIT web server. The survey was initially beta-tested with 80 pilots to verify correct survey flow, content display, and website technical performance.

In order to distribute the survey to a wide segment of the general aviation pilot population, several industry organizations and media outlets agreed to publish a survey announcement. The call for participants was distributed to over 400,000 readers in the following publications:

- AOPA e-Pilot and e-Brief
- EAA e-Hotline
- Flying Magazine e-Newsletter
- GA News e-Newsletter and GA News in print

The survey website was activated for data collection between March 17, 2014 and April 21, 2014.

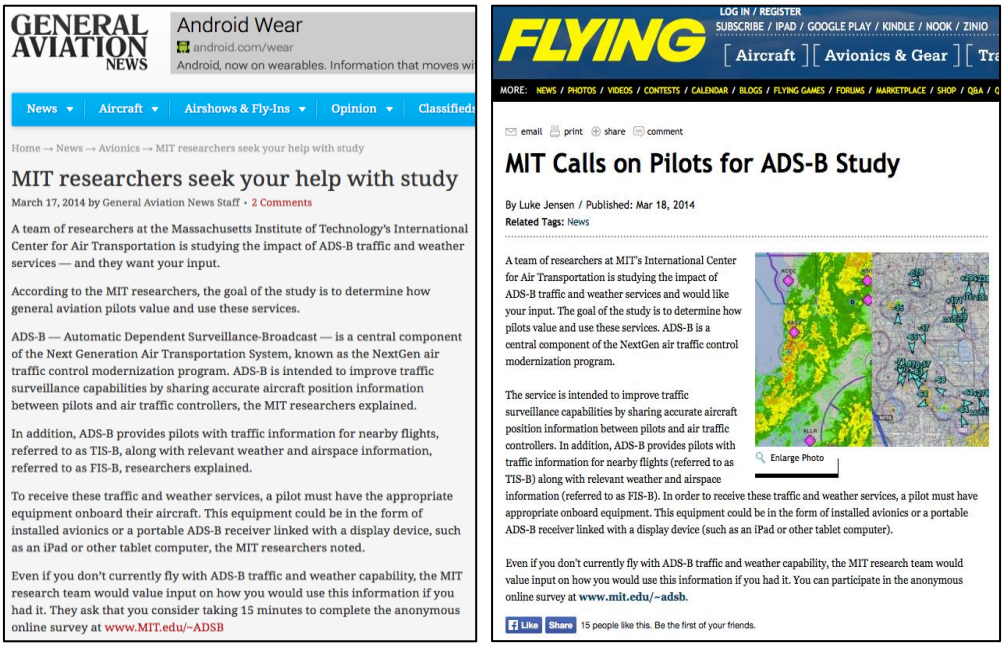


**Figure** 2-3 **Examples of survey advertisement in General Aviation News (left) and Flying Magazine (right)**

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# 3 Demographic and Background Information

Pilots were solicited using articles and advertisements posted in a number of high profile aviation publications. The results were filtered to exclude blank submissions and participants who did not consent to participate in the survey. Filtering was also done to identify any implausible entries based on stated pilot certifications and flight experience. Following the filtering process, 1407 valid responses remained for analysis.

The details of the respondent population sampled are provided in this section, along with comparative information regarding the actual U.S. pilot population as tabulated by the FAA Civil Airmen Statistics report for 2013. Because the respondents were self-selected, it is important to exercise care in interpreting the data as they may not fully represent the general pilot population.

Responses spanned the full spectrum of pilot experience levels. Figure 3-1 shows the number of total flight hours held by the participants. Just under half of the respondents had fewer than 1000 flight hours. The response pool also contained many pilots with a great deal of experience, with about 12% of participants reporting more than 8000 hours of flight time.

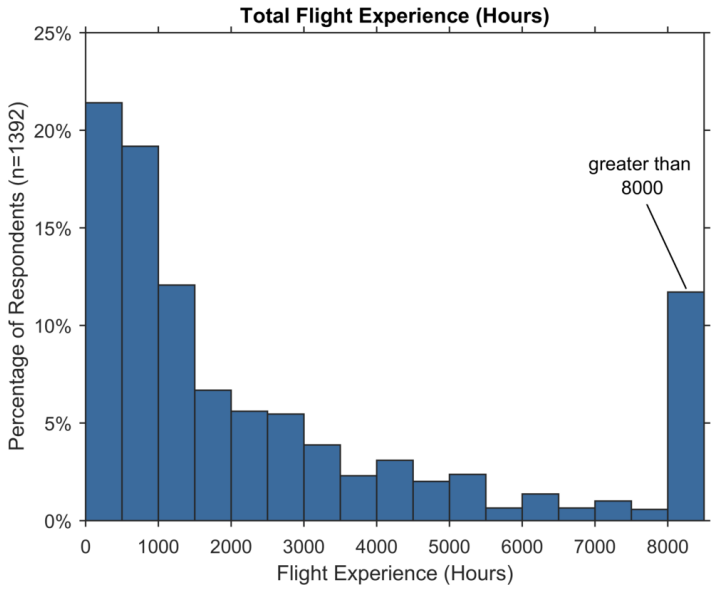


**Figure 3-1. Total flight experience of respondents**

In terms of highest achieved pilot certification levels, survey responses included a larger segment of private pilots than in the overall pilot population. This is because the survey was primarily promoted to general aviation pilots rather than commercial operators. Figure 3-2 shows the distribution of pilot certification level among respondents. Student pilot responses were less numerous than expected.

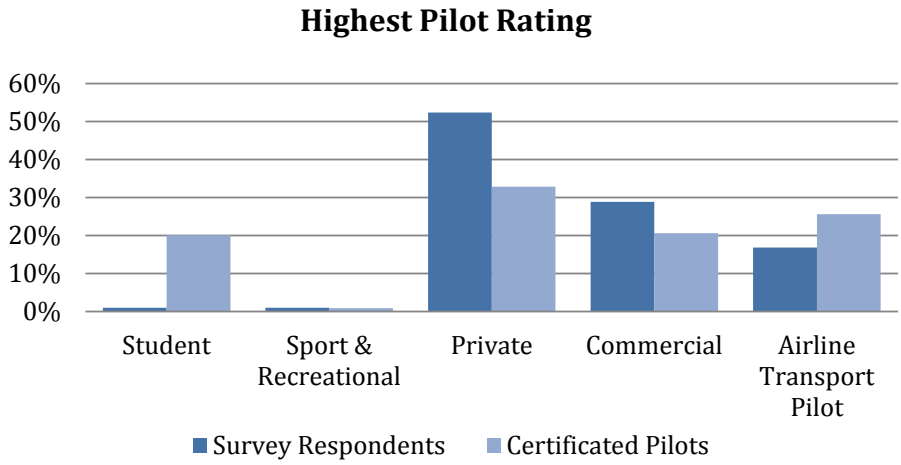


**Figure 3-2. Highest pilot ratings for respondents and U.S. pilot population (FAA, 2013)**

Respondents reported the airport code of their primary home airport. The distribution of these home airports is generally aligned with the geographic distribution of the 2013 pilot population. However, Figure 3-3 shows that the highest response rate per certificated pilot in New England, along the East Coast, and in certain other states distributed throughout the country. In terms of exposure to congested airspace, 90.3% of respondents stated that they flew regularly within 30 nm of Class B or C airspace.

In terms of distribution between instrument and visual flying, 71.6% of all respondents reported flying most frequently under visual flight rules (VFR) and 28.1% most frequently under instrument flight rules (IFR). The majority of the respondents (85.9%) flew single engine aircraft most often. The majority of respondents (77.8%) also owned the aircraft they typically flew, while 18.2% rented and 14.0% flew professionally.

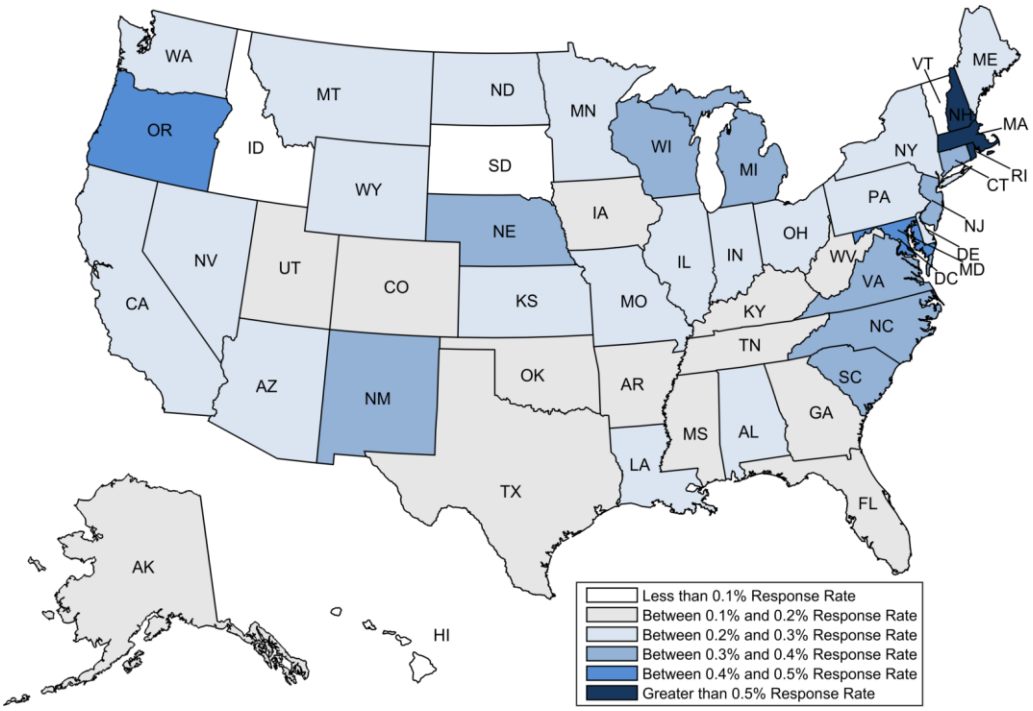


**Figure 3-3. Response rate by state (relative to FAA Airmen Statistics, 2013)**

The average age of respondents was 57.1 years, higher than the general pilot population's average age of 44.9 years (FAA, 2013). However, results indicate that usage rates for **ADS-B In** are similar for every age group of respondents. This means that any "age bias" in the pilot sample is likely unimportant with respect to technological adoption rates. Females were underrepresented in the survey, comprising 1.6% of total respondents compared to 6.6% of certificated pilots (FAA, 2013).

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# 4 Use of ADS-B In

While exposure and market penetration of **ADS-B In** products is increasing around the country, not all pilots have experience with the system for a variety of reasons. Of the 1407 respondents to this survey, 56% stated that they had used **ADS-B In** services in flight. In terms of equipage timeline, 89% of respondents who had flown with **ADS-B In** began flying with the services within the previous 2 years. Recent adopters make up a large portion of respondents, with 23% starting to use **ADS-B In** uplink services within the previous 6 months measured from the date of the survey response. These results are driven by the increase in availability of cockpit technology and ground station infrastructure within the past 2 years.

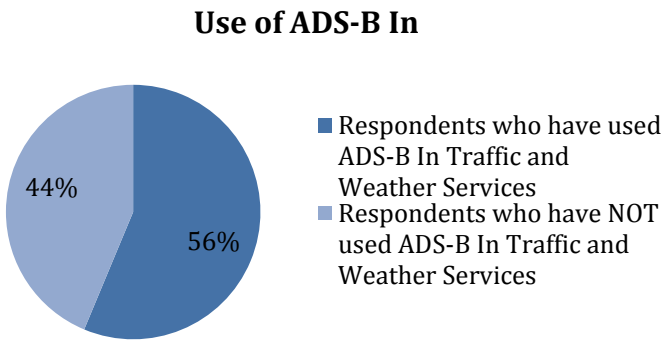



**Figure 4-1. Percentage of respondents who have used ADS-B In**

Of respondents who reported experience with **ADS-B In** traffic and weather systems, the majority obtained that experience with portable rather than installed systems. Figure 4-2 shows that 85% of respondents reporting experience with **ADS-B In** have used a *portable* system, while only 30% of the same group have experience with *installed* systems.

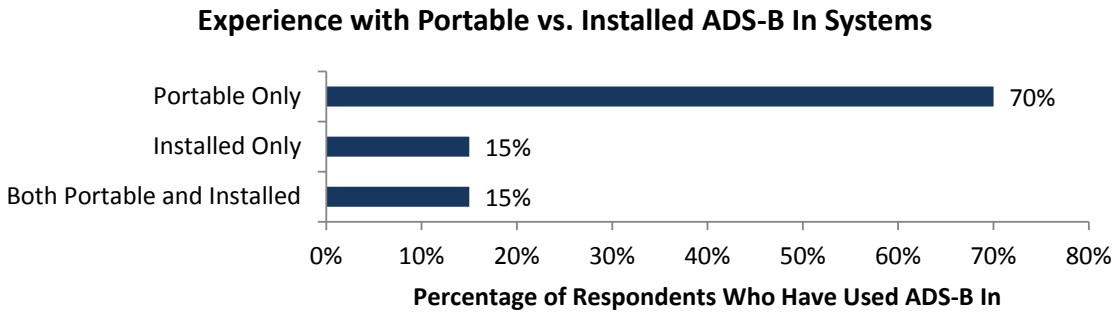



**Figure 4-2 Percentage of respondents who have used installed and portable ADS-B systems.**

The FAA has mandated **ADS-B Out** as part of their Next Gen efforts, and 27.5% of respondents who have used **ADS-B In** reported the corresponding aircraft being equipped with **ADS-B Out** as well.

The factors that influenced the choice of ADS-B equipment is presented in Figure 4-3. The results indicate that weather services are somewhat more important than traffic services in equipment choice. This may be due to the variety of data products included in FIS-B broadcasts, resulting in significant variability in how the information can be displayed. Therefore, graphical presentation of weather and airspace information can be a significant differentiator between competing products. Respondents also indicated that compatibility with existing equipment was a strong factor in deciding which equipment to buy. In a typical response, one commercial pilot wrote that, “Although we have not yet installed ADS-B in our C210, when we do [equip], the price and compatibility with our installed [avionics] will be crucial.”

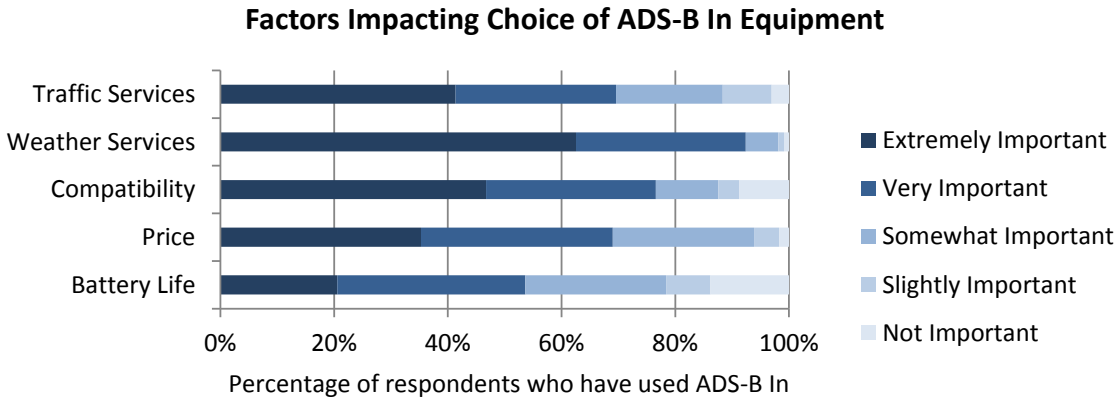



**Figure 4-3. Factors that contributed to choice of ADS-B In equipment for all respondents who have used ADS-B In (n=792)**

For the pilots who reported that they had never used **ADS-B In** services, Figure 4-4 shows that a majority indicated that they were planning to equip with **ADS-B In** in the future. The reasons for this delayed equipage vary. The survey indicated that 44.1% of respondents who have not yet equipped consider the equipment too expensive, while 26.8% already had alternate services in the cockpit. Example alternative traffic services include active transponder interrogation systems, such as the Traffic Alerting System (TAS) and Traffic Collision Avoidance System (TCAS), and a variety of passive systems such as the Traffic Information Service (TIS). Example alternative weather services include XM subscription weather, lightning detection, and onboard weather radar. One respondent summarized many of the most common reasons for not yet equipping with **ADS-B In**, stating that he, "…already [had] and iPad with [a popular flight planning application] that would influence the decision on what ADS-B system to purchase." He continued that he, "…had not already purchased because of the cost and the concern that the technology will change, so the very expensive [portable receiver] will become outdated shortly."

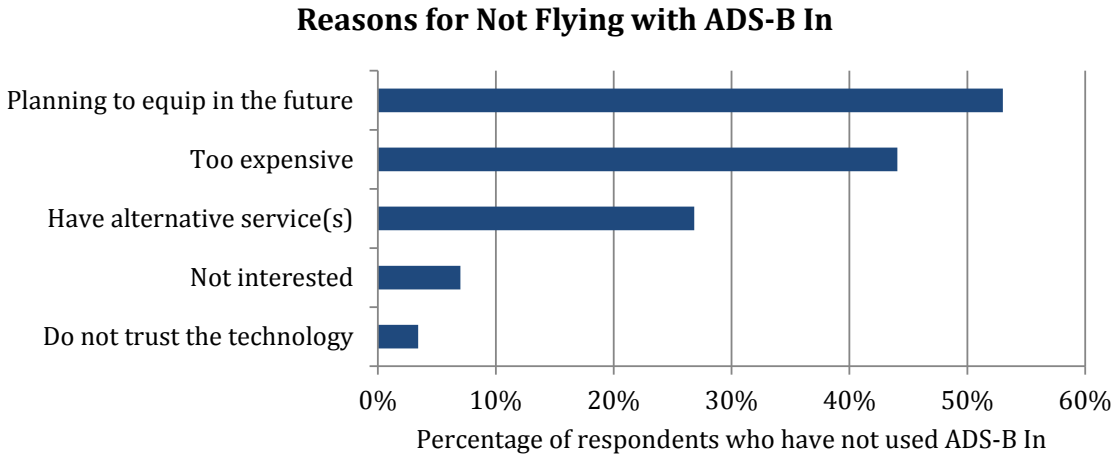



**Figure 4-4. Reasons for not flying with ADS-B In**

Questions were also asked to pilots who had not equipped with **ADS-B In** systems to assess their approximate willingness to pay for the systems. Willingness to pay was assessed separately for owner pilots and renter pilots. Responses from both groups are provided in the Appendix.

The remainder of the results focuses on the group who indicated having used **ADS-B In** services inflight.

## 4.1 Overall Use of ADS-B Traffic Services

In terms of the overall perception of respondents, 63% of those who had used ADS-B traffic services report it to be “very” or “extremely” useful. In addition, as can be seen in Figure 4-5, 57% of those who use **ADS-B In** traffic use it at least “frequently”. That is, the majority of pilots who use the service appear to use it regularly.

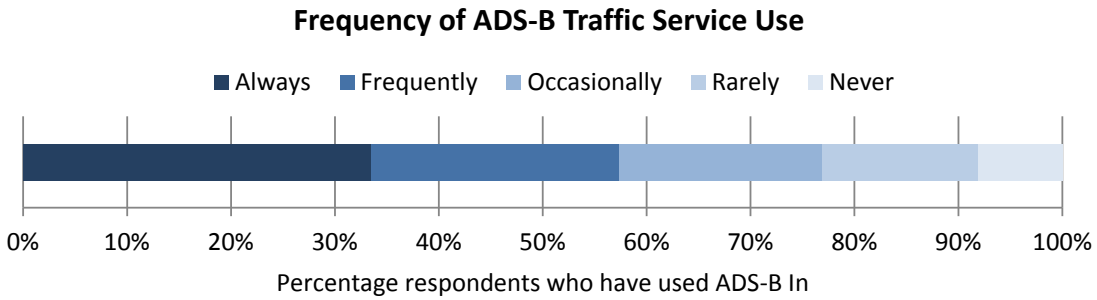



**Figure 4-5. Frequency of use of ADS-B Traffic services**

Figure 4-6 shows the relative perceived usefulness of **ADS-B In** traffic services in VFR and IFR operations for instrument rated pilots. These pilots are most likely to have experience operating the **ADS-B In** equipment in both environments. Among this group, 63% stated they found **ADS-B In** traffic to be equally valuable in both IFR and VFR, 31% stated it was most valuable during IFR operations, and 5% of stated it was most valuable during VFR operations. The large number of pilots indicating ADS-B traffic usefulness in both IFR and VFR (among pilots who operate in both environments) indicates a high level of perceived usefulness for improved traffic information in general. Respondents stated that ADS-B aided in “seeing and avoiding” other aircraft by providing greater situational awareness, particularly in congested airport environments. When operating IFR, pilots indicated that ADS-B traffic added situational awareness as well as a backup for ATC traffic monitoring and advisory services. One pilot reported that “any aid to situational awareness enhances safety in both VFR and IFR environments,” summarizing the general sentiment of the many respondents who viewed **ADS-B In** services as equally valuable in all flight conditions.

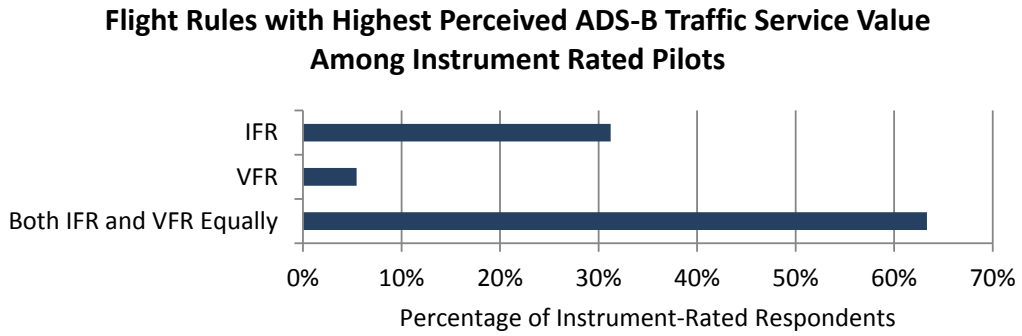



**Figure 4-6. Flight rules with highest perceived ADS-B traffic service value among instrument rated pilots (n=581)**

### 4.1.1 Safety Benefits of ADS-B In Traffic Services

Figure 4-7 shows the percentages of pilots who reported that ADS-B traffic services had helped to avoid a mid-air collision. In terms of pilot-reported collision avoidance valuation, 29% of all respondents who had used **ADS-B In** services reported that the traffic services had helped them avoid a mid-air collision. This indicates that there is a significant safety benefit from **ADS-B In** services. For pilots who "always" or "frequently" used **ADS-B In** traffic, the value grew to 42%, indicating that the value of these services increased with use ($z=4.64$, $p<0.001$). One respondent stated that the system had "saved [his] life twice in 3 years" and urged an accelerated deployment schedule.

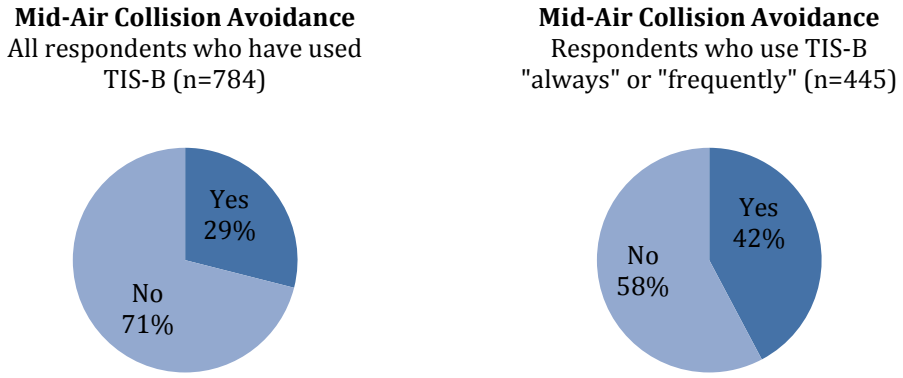



**Figure 4-7. Mid-air collision avoidance**

The cases described by respondents in their free responses indicate the benefit is primarily due to earlier awareness of potential conflicts. A Mooney M20 pilot from

Missouri stated, “I've had 2 near traffic encounters in which I can honestly say I would never have noticed the other traffic without the ADS-B information.” Only 7% of respondents who use the system “frequently” or “always” reported maneuvering aggressively for traffic, indicating that pilots are using the information for early resolution of conflict situations rather than for last-minute abrupt avoidance maneuvers. These results are supported by the fact that 64% of respondents who use the system often indicated that ADS-B traffic has “always” or “frequently” helped them visually acquire other aircraft. Figure 4-8 shows the relative perceived value of **ADS-B In** traffic information for heavy users of the system compared to occasional users. As was the case for midair collision avoidance, the perceived value of **ADS-B In** traffic information increases with use ($z=3.64$, $p<0.001$).

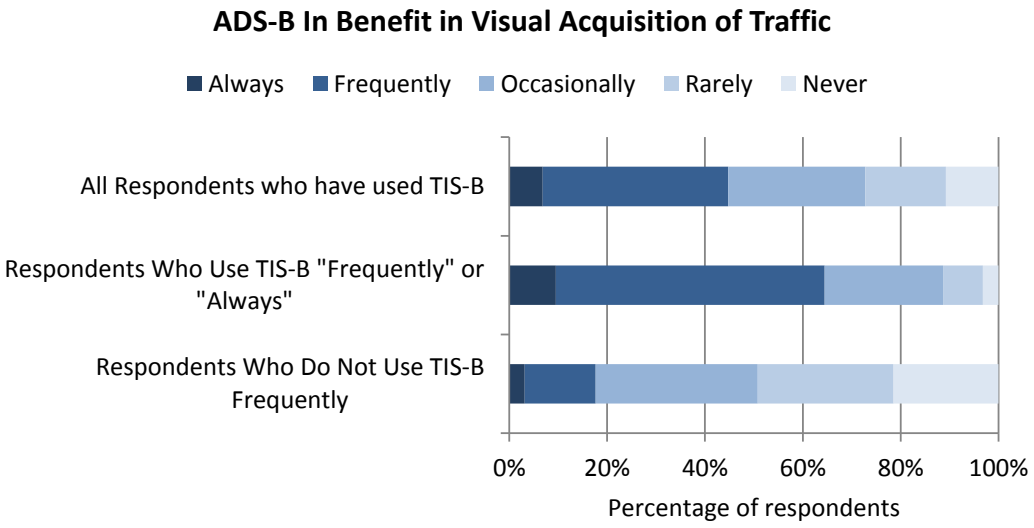



**Figure 4-8. Benefit in visual acquisition with ADS-B In traffic services**

It was apparent that respondents with installed **ADS-B In** systems were reporting higher safety benefit in terms of traffic awareness and avoidance compared to respondents with only portable systems. Since most respondents with installed systems also have **ADS-B Out**, further analysis was conducted for respondents who also fly with **ADS-B Out** in comparison to those who do not. These results are shown in Figure 4-9. A marked perceived safety benefit is apparent for respondents who fly with **ADS-B Out** in terms of traffic avoidance ($z=8.79$, $p<0.001$). 51% of total respondents *with* **ADS-B Out** reported that ADS-B traffic had helped them avoid a mid-air collision, where only 19% of

respondents *without* **ADS-B Out** agreed. Pilots who use the system regularly see even more benefits.

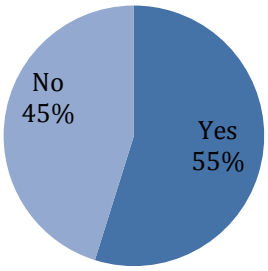
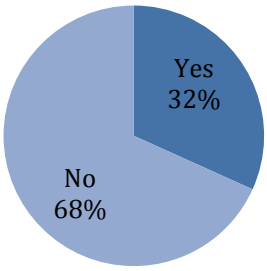
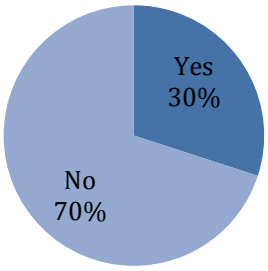
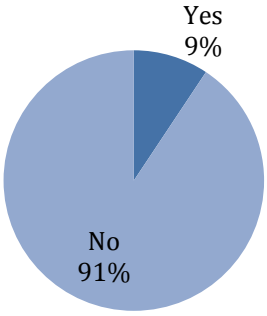
| | Respondents who *are* Equipped with **ADS-B Out** | Respondents who *are not* Equipped with **ADS-B Out** |
|---|---|---|
| Respondents who use **ADS-B In** Traffic Services "Always" or "Frequently" |  n=186 |  n=230 |
| Respondents who use **ADS-B In** Traffic Services less than "Frequently" |  n=30 |  n=289 |

**Figure 4-9. Mid-air collision avoidance for respondents who are equipped with ADS-B Out and respondents who are not equipped with ADS-B Out**

The safety benefit from **ADS-B In** traffic extended beyond the perceived threat of collision. Pilots report that the system helps to visually acquire other traffic earlier than they might have without the system, thus allowing pilots to plan according to current traffic conditions. Figure 4-10 shows that 78% percentage of respondents *with* **ADS-B Out** reported that **ADS-B In** "frequently" or "always" helps them visually acquire traffic, whereas only 29% of respondents *without* **ADS-B Out** agreed (z=3.32, p=0.001).

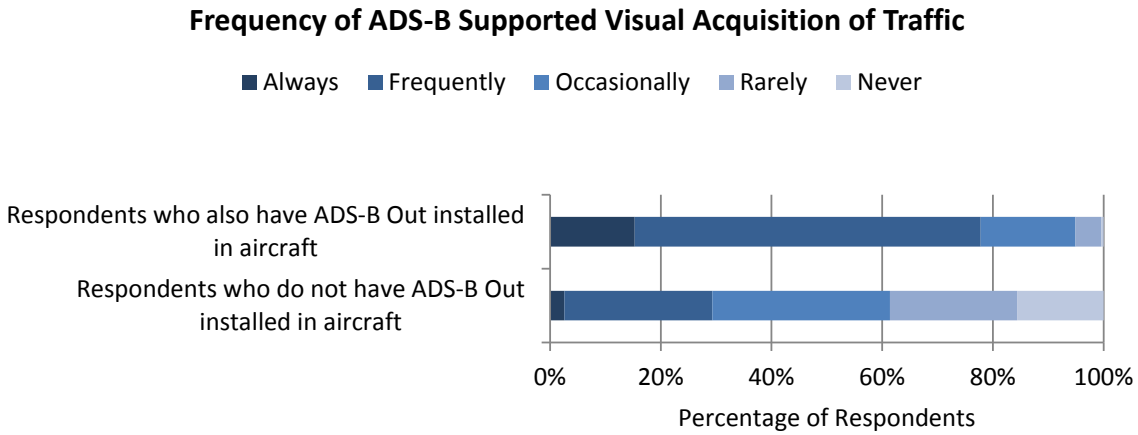



**Figure 4-10. Frequency of ADS-B supported visual acquisition of traffic for respondents who fly with ADS-B Out (n=216) and respondents who do not fly with ADS-B Out (n=503)**

### 4.1.2 Coverage Limitations of ADS-B In Traffic Services

Feedback on the traffic awareness implications of **ADS-B In** was not entirely positive. This was primarily due to concerns over coverage area limitations and resulting information inconsistency. In the current implementation, TIS-B and ADS-R information is only broadcast to airspace regions immediately surrounding an **ADS-B Out** equipped aircraft. Aircraft with only **ADS-B In** can "piggyback" on TIS-B broadcasts when an **ADS-B Out** aircraft is nearby, but this coverage is highly unpredictable. This explains the relatively low safety valuation by pilots *without* **ADS-B Out** compared to those *with* **ADS-B Out**. Respondents with **ADS-B Out** receive the full suite of **ADS-B In** uplink services at all times, increasing predictability of the traffic services. Reduced overall satisfaction with **ADS-B In** traffic was expressed by pilots who were not also equipped with **ADS-B Out**. One private pilot who was not equipped with **ADS-B Out** remarked that "the coverage is [spotty] and if one is [flying] low to stay out of high winds or weather, it is highly unreliable. Nothing worse in an airplane than an instrument you can't rely on." Another pilot in a similar situation responded, "ADS-B traffic information helps me spot **ADS-B Out** equipped aircraft and some other aircraft, but it doesn't give me that advantage in seeing and avoiding some other non-equipped aircraft." Figure 4-11 shows that, when asked directly, respondents who are equipped with **ADS-B Out** indicated a considerably higher level of satisfaction than respondents who do not ($z=2.85$, $p=0.004$).

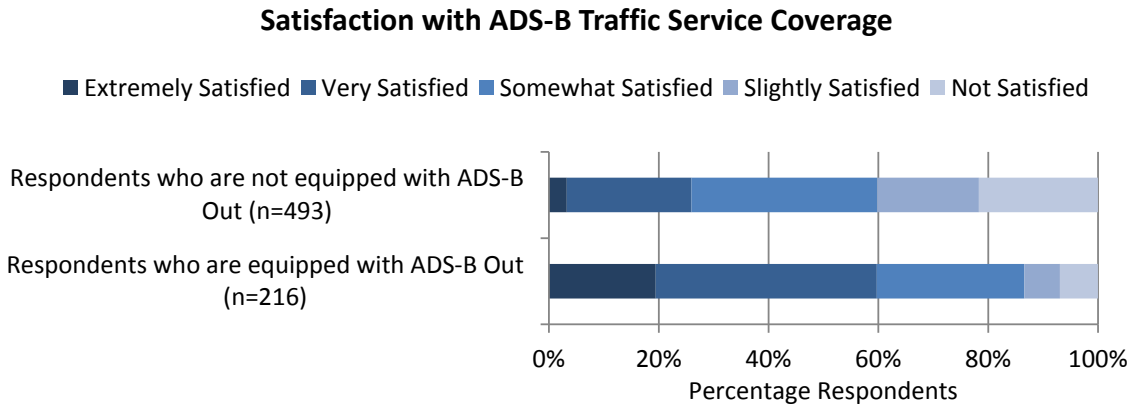



**Figure 4-11. Satisfaction with ADS-B traffic service coverage for respondents who are not equipped with ADS-B Out (n=493) and those who are equipped with ADS-B Out (n=216)**

## 4.2 Use of ADS-B Weather and Flight Information Services

Figure 4-12 shows that among pilots who have used **ADS-B In**, the service is used "frequently" or "always" by 72% of respondents. Once pilots have access to **ADS-B In** weather services, they appear to use them heavily. This trend of comprehensive adoption was even more clear for FIS-B information than it was for **ADS-B In** traffic.

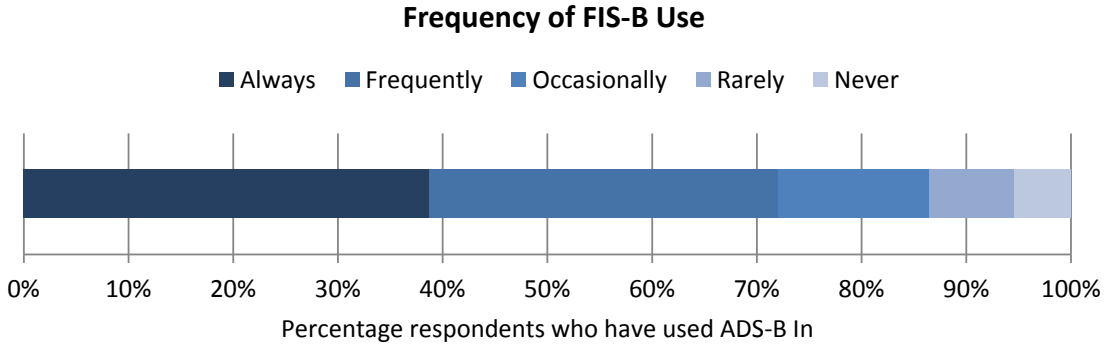



**Figure 4-12. Frequency of ADS-B weather service use (n=792)**

Figure 4-13 shows that 74% of instrument-rated users consider FIS-B to be useful in both IFR and VFR environments. In free response entries, pilots cited the value of FIS-B for VFR route planning to avoid regions of instrument conditions. One private pilot respondent indicated that he used "ADS-B weather for enroute planning, altitudes and knowing wind conditions at destination airports. It is highly valuable while enroute." IFR pilots focused on improved destination weather monitoring capabilities and

monitoring of convective weather activity. The common use of FIS-B information was slightly different in instrument and visual conditionals, although pilots commented on the value of both. One instrument-rated pilot wrote that, “In the soup it's nice to have an idea of what's next […] When flying VFR it's nice to know how things are looking a few hundred miles out if I'm on a long trip so I can deviate around cells.”

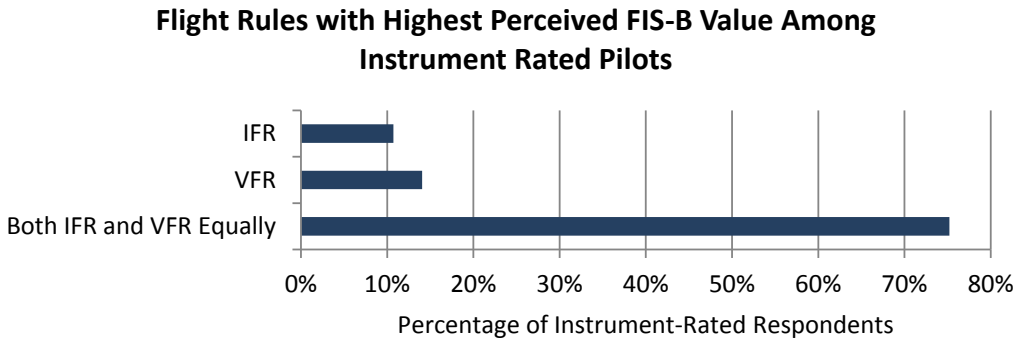



**Figure 4-13. Flight rules with highest perceived ADS-B weather service value among instrument rated pilots (n=581)**

Pilots use inflight information from FIS-B for different types of decisions that impact the safety of flight. Figure 4-14 shows that pilots commonly use ADS-B weather services to select appropriate altitudes and routes. The low reported frequency of use of **ADS-B In** weather information for diversion decision is likely due to the relative infrequency of diversion situations. However, by the nature of diversions, the times when such decisions are required are normally quite important from a safety standpoint. A commercially-rated pilot wrote that, “FIS-B radar and TAF information in flight helped me decide to stop for the night to let a line of thunderstorms pass.”

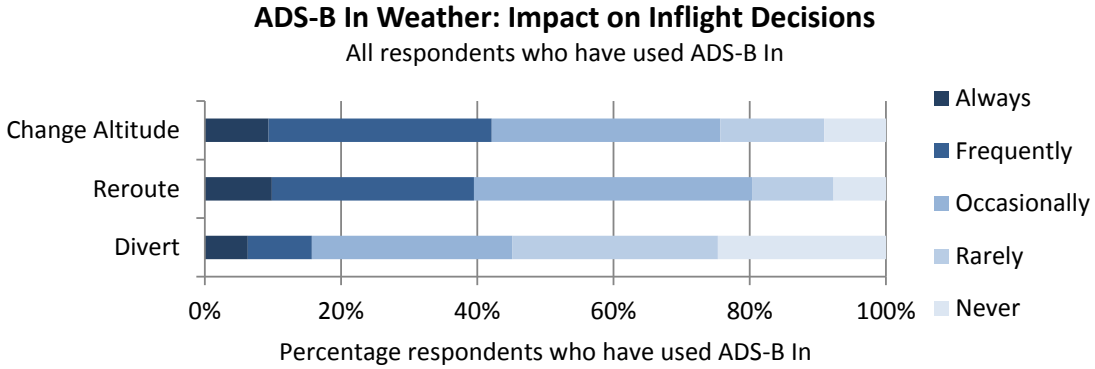



**Figure 4-14. Inflight decision impact (all ADSB-In respondents) (n=792)**

The impact of **ADS-B In** on preflight decision making was investigated by asking respondents "how often has the fact that you will receive ADS-B weather in the air influenced your decision to takeoff in situations where you otherwise may not have?" Of the pilots who always or frequently use ADS-B weather, 17% stated that the knowledge that they will have FIS-B in the air has affected their go/no go decision. For example, one private pilot wrote, "I wouldn't take off into adverse conditions, though I might take off knowing that I could make an informed decision to land before adverse weather starts."

The perceived usefulness of the available FIS-B information is shown in Figure 4-15. Overall, respondents valued all services included in FIS-B. In particularly, the respondents considered METAR and radar information to be the most useful out of the services provided. The same valuation question was posed to the group who had not used **ADS-B In**, in hypothetical form, such as "How useful would you find METAR information inflight?" These trends are similar to the group that had used **ADS-B In**, details of which are provided in the Appendix.

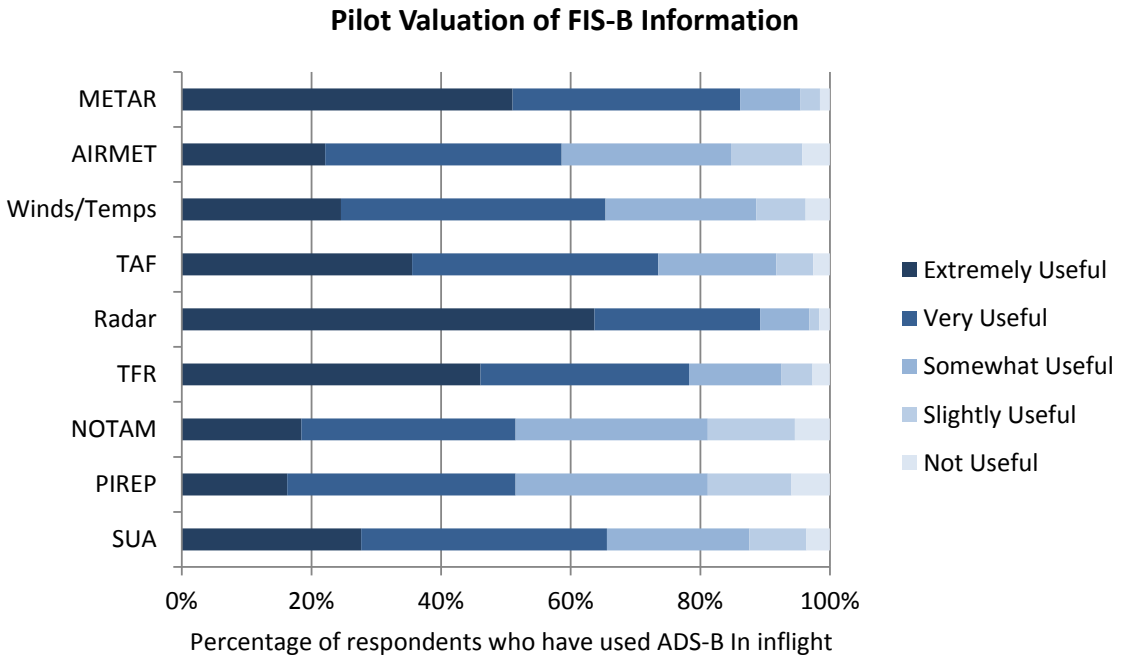



**Figure 4-15. Perceived usefulness of each ADS-B In service for respondents who had used ADS-B In services. (n=792)**

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# 5 Summary and Conclusions

This study shows that most pilots currently using **ADS-B In** traffic and flight information services, including weather and airspace information, perceive an increased safety of flight and improved decision-making capability as a result of the services. Traffic and flight information uplink services are important components of the ADS-B system at the heart of NextGen, complementing the precise surveillance capability introduced by **ADS-B Out**. Thus, the benefits of ADS-B for general aviation pilots fall into two broad categories: improved information availability from uplink services (**ADS-B In**) and improved ATC system services from precise surveillance (**ADS-B Out**). This study focuses on the first category of benefits, probing pilot perceptions and current usage of **ADS-B In** broadcast services. Goals also included identifying the factors that influence the decision whether to equip with **ADS-B In**.

A total of 1407 pilots responded to an online survey that was announced through several general aviation media outlets. A majority of respondents had used **ADS-B In**, with 56% of respondents reporting having experience with either an installed or portable system. Of the group who had experience with **ADS-B In**, 85% had used portable systems and 30% had used installed systems.

Overall, a perceived safety benefit from **ADS-B In** traffic information was clearly apparent based on the feedback from several questions in the survey. Among pilots who use ADS-B traffic on a regular basis, 42% of respondents indicated that it had helped them avoid a mid-air collision. The perceived usefulness of ADS-B traffic was also strongly dependent on equipage with **ADS-B Out**. A full 51% of respondents with both **ADS-B In** and **ADS-B Out** reported that ADS-B traffic had helped them avoid a mid-air collision, while only 19% of respondents without **ADS-B Out** agreed. This, along with other responses, suggested a safety benefit from improved traffic avoidance for respondents who also fly with **ADS-B Out** installed in their aircraft. While there was an apparent safety benefit from **ADS-B In** traffic information for all respondents, limitations

in coverage area was an issue for many pilots who were not equipped with **ADS-B Out**. While this issue is anticipated to dissipate as a greater percentage of the general aviation fleet equips with **ADS-B Out**, the coverage limitations clearly limit the usefulness of ADS-B traffic information as it is currently implemented.

Respondents commonly used **ADS-B In** flight information (weather, airspace, and other system information) as a resource when changing altitude or rerouting. Some respondents also reported occasions where the knowledge that they would receive this information in the air influenced their decision to take off (in situations where they otherwise might not have). Therefore, for at least some pilots, **ADS-B In** flight information services appeared to influence the traditional go/no-go decision process.

For respondents who had not flown with **ADS-B In**, 53% indicated that they were planning to equip in the future. Common reasons for not equipping included the high cost of the technology and the availability of alternative services. As the technology becomes more widespread, it expected that the cost of equipment will decrease. Based on these survey results, not all pilots are simply holding out for lower prices - 10% of respondents with no **ADS-B In** experience cited mistrust of the technology or general lack of interest as reasons for not using the services.

This study showed that **ADS-B In** traffic has provided increased situational awareness for pilots operating in VFR environments, such as congested traffic patterns, as well as in IFR environments as a backup for ATC separation services and traffic advisories. **ADS-B In** flight information services have clearly impacted pilot decision making in the air, with occasional benefits prior to takeoff by impacting go/no-go decisions. The availability of ADS-B uplink services is changing the way that pilots fly. It is a push toward independence in the cockpit, enabling pilots to use state-of-the-art technology to enhance flight safety.

# Bibliography

Federal Aviation Administration. (2010). Automatic Dependent Surveillance – Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service; Final Rule. Federal Register. Retrieved from http://www.gpo.gov/fdsys/pkg/FR-2010-05-28/pdf/2010-12645.pdf

Federal Aviation Administration. (2011). National Airspace System Capital Investment Plan FY 2012-2016. Retrieved from http://www.faa.gov/air_traffic /publications/cip/files/FY12-16/FY12-16_CIP_Complete_May_2011.pdf

Federal Aviation Administration. (2011). Airworthiness Approval for ADS-B In Systems and Applications. AC 20-172.

Federal Aviation Administration (2013). FAA Civil Airmen Statistics. Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/

General Aviation News (2014). MIT researchers seek your help with study. Retreived from http://generalaviationnews.com/2014/03/17/mit-researchers-seek-your-help-with-study/

Jensen, Luke (2014). MIT Calls on Pilots for ADS-B Study. Flying Magazine. Retrieved from http:// www.flyingmag.com/news/mit-calls-pilots-ads-b-study

Kunzi. Fabrice. (2011). Benefits and Incentives for ADS-B Equipage in the National Airspace System. Masters Thesis, Cambridge: MIT.

RTCA. (2011). Aircraft Surveillance Application System (ASAS) MOPS for Aircraft Surveillance Application (ASA) Systems. RTCA DO-317A.

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# Appendices

## Survey Part I (Consent, Demographics, & Training)

***Please use navigation buttons at the BOTTOM of this page to go back to previous pages in this survey. DO NOT use your browser navigation buttons.***

* Required


MIT International Center for Air Transportation

### ADS-B Traffic and Weather Services

The International Center for Air Transportation at the Massachusetts Institute of Technology is studying the impact of ADS-B traffic and weather services. The goal of this study is to gain better understanding of how pilots use ADS-B In services.

We are interested in collecting the experiences and opinions of pilots like you. This research is in support of the FAA's NextGen program, and your participation and invaluable insight will further the understanding of usage and issues associated with these NextGen services. Ultimately this research will shed more light on what can be done to support the pilot community.

• PARTICIPATION AND WITHDRAWAL

Your participation in this study is completely voluntary, and you may subsequently withdraw from it at any time without penalty or consequences of any kind.

• CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be directly or indirectly identified with you will remain confidential.

The results of the survey will not be linked to you or your IP address. Any demographic information and information about your pilot certification that is collected is for research purposes only and will not be used to identify you.

• CONTACT

If you have any questions or concerns about the research, please contact any of the following personnel Sathya Silva at adsb@mit.edu or R. John Hansman at rjhans@mit.edu.

*

- ○ I agree with these terms (Continue Survey)
- ○ I disagree (Terminate Survey)

## Pilot Certifications

**What is your highest pilot certification?**

- ○ Student
- ○ Sport
- ○ Recreational
- ○ Private
- ○ Commercial
- ○ Airline Transport Pilot

**What ratings do you hold?**
Select all that apply

- ☐ Airplane Single Engine Land
- ☐ Airplane Multi Engine Land
- ☐ Airplane Single Engine Sea
- ☐ Airplane Multi Engine Sea
- ☐ Rotorcraft Helicopter
- ☐ Instrument Airplane
- ☐ Instrument Rotorcraft

**Are you a certified instructor?**

- ☐ CFI (Certified Flight Instructor)
- ☐ CFII (Certified Flight Instructor - Instrument)
- ☐ MEI (Multi Engine Instructor)
- ☐ Other:

**Please list any other certificates or ratings which you hold:**

## Pilot information

**Total flight hours**
(approximate)

## Within previous 12 months:

**Total hours**

**Cross-country hours**

**Instrument hours**
(actual + simulated instrument)

**Night hours**

## Demographics

**What is your age?**

**In what year did you earn your first pilot certificate?**

**What is your gender?**

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

**In what region(s) do you normally fly?**
Select all that apply

- ☐ Alaskan Region
- ☐ Central Region
- ☐ Eastern Region
- ☐ Great Lakes Region
- ☐ New England Region
- ☐ Northwest Mountain Region
- ☐ Southern Region
- ☐ Southwest Region
- ☐ Western Pacific Region

**Do you regularly fly within 30nm of Class B or C airspace?**
Select all that apply

- ☐ Yes, I fly regularly within 30nm of Class B airspace
- ☐ Yes, I fly regularly within 30nm of Class C airspace
- ☐ No, I do not regularly fly within 30nm of Class B or C airspace

## What 2 airports do you fly out of most often?

Specify airport code if possible (example: KBED, KOSH)

**Airport 1**

**Airport 2**

## What make/model aircraft do you fly most often?

Specify flight plan type designator if possible (example: C172, B737)

**Most often**

**Second most often**

**How do you typically gain access to aircraft?**
Select all that apply

- [ ] Own
- [ ] Rent
- [ ] Fly Professionally
- [ ] Other:

**Under what flight rules do you most frequently operate?**

- ( ) VFR
- ( ) IFR

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## "ADS-B In" Technology

Background Outline:
1. General Background
2. Installed Systems
3. Portable Systems
4. Traffic Services
5. Weather Services

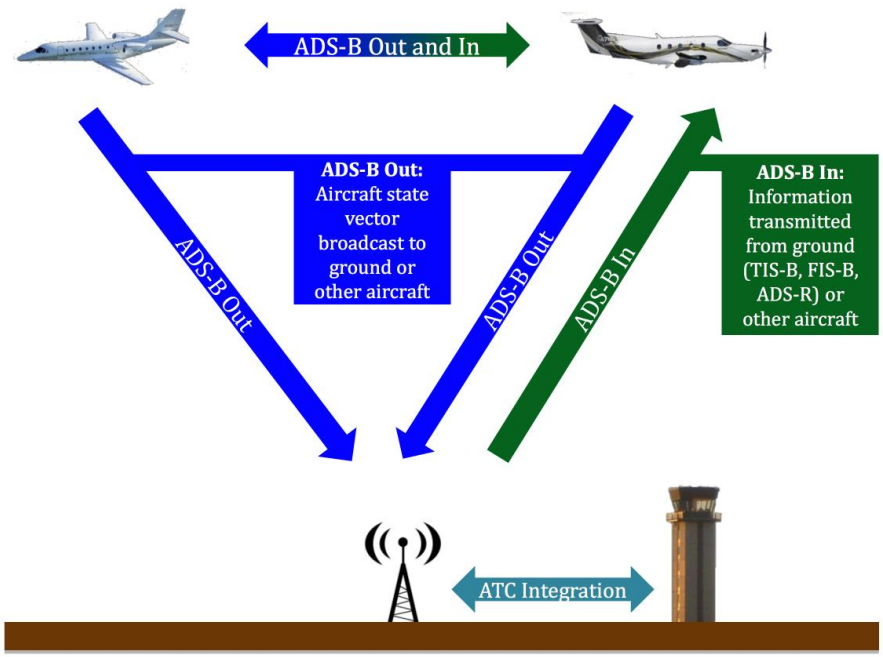
## General Background

ADS-B (Automatic Dependent Surveillance – Broadcast) is a Global Positioning Service (GPS) based surveillance system that provides more precision than radar and introduces the capability to transmit weather (FIS-B) and traffic (TIS-B) information to aircraft in flight. There are two components to ADS-B.

1. “ADS-B Out” is the transmission of position and other information out of the aircraft to other aircraft, ground stations, and ATC. (Blue arrows in figure below)

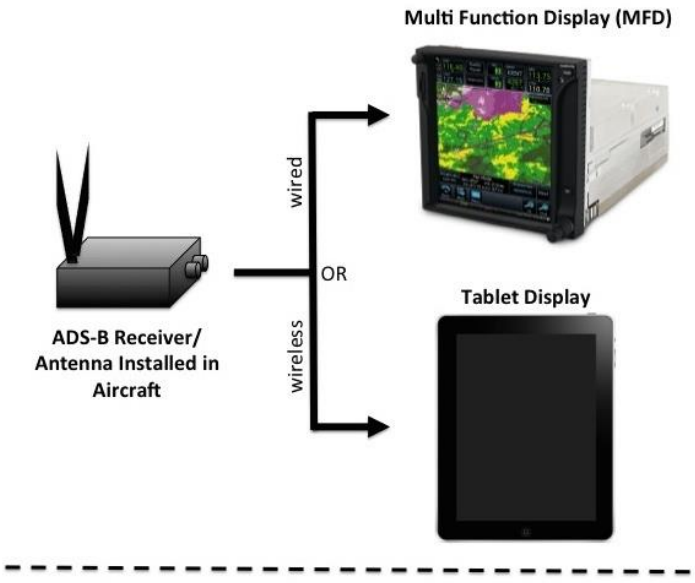
2. “ADS-B In” is the reception of other traffic information and weather information in flight. (Green arrows in figure below)

Depending on the equipment you fly with, you could have “ADS-B Out”, “ADS-B In”, or both. The focus of this survey is on “ADS-B In” weather and traffic services only, using portable or installed equipment.




## Installed "ADS-B In" Systems

Installed systems are powered by the aircraft and installed in the cockpit. All installed systems include an ADS-B receiver/antenna and connect to some form of display (either directly to a MFD or via bluetooth/wifi to a tablet). Different receivers have different interface capabilities. For example the Garmin GDL 88 receiver, will only interface to an installed multi function display.




Example: Garmin GDL 88 ADS-B Receiver

Example: Garmin 750 MFD

## Portable "ADS-B In" Systems

Portable systems are battery-powered, about the size of a TV remote, and require a bluetooth or wi-fi connection to an existing tablet to display ADS-B In information (example: Apple iPad with ForeFlight Mobile application).


Example: Foreflight Stratus 2 ADS-B Receiver

Example: Apple iPad Air

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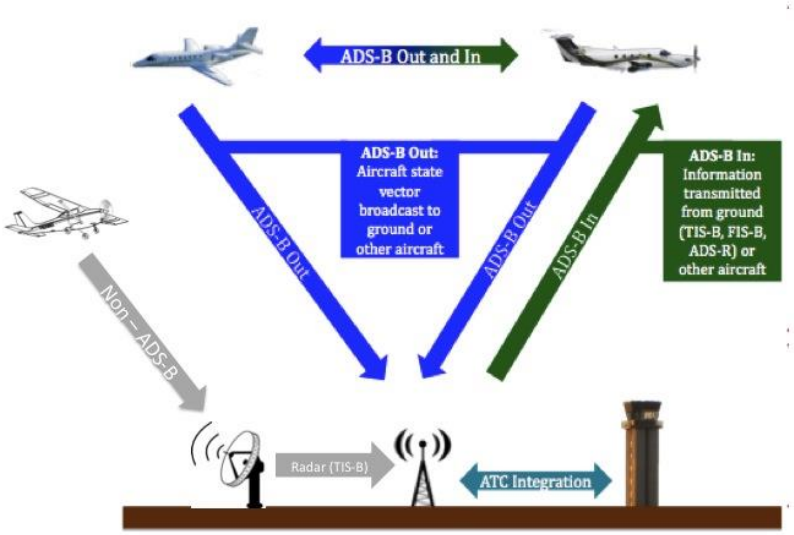
## "ADS-B In" Background: Traffic Services

ADS-B provides the capability to receive traffic information from any aircraft with a transponder, whether they are equipped with ADS-B or not.

1. Aircraft who are not equipped with ADS-B will be interrogated via radar. This radar information is then fed through the ground station and transmitted to you via TIS-B. (Note: TIS-B will only be broadcasted when an aircraft broadcasting ADS-B Out is also within range of the ground station)

2. Aircraft who are equipped with ADS-B will be sending their information to other aircraft and ground stations. You will be able to receive this information either directly via ADS-B or through a ground station via ADS-R.

In some systems, it is not possible for the pilot to determine whether the traffic shown is ADS-B, ADS-R, or TIS-B traffic. For the purpose of this survey, please consider ALL of the above sources of traffic information.

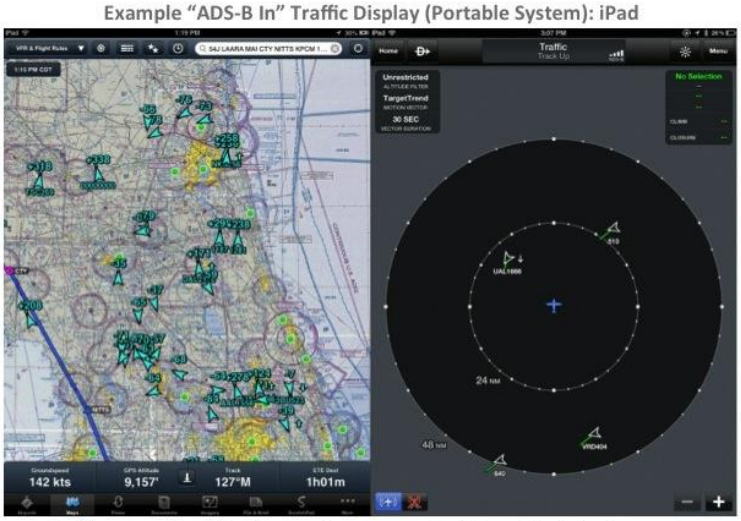



Example "ADS-B In" Display (Installed System): Garmin 750 MFD


Traffic on map background

Traffic on black background

Example “ADS-B In” Traffic Display (Portable System): iPad



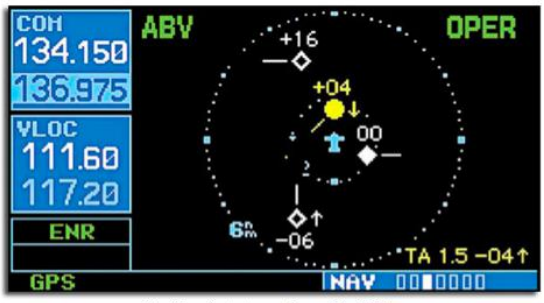

Traffic on sectional background  Traffic on black background

## Other NON ADS-B Traffic Systems

Traffic Advisory System (TAS)

TAS actively interrogates aircraft, through transponder range interrogation, that are located in a given proximity, displays the location and trend information on a MFD, and provides aural alerts to help pilots locate conflicting traffic. TAS does not provide resolution advisories. These systems are becoming more common on general aviation aircraft.

**Example TAS Display:**




http://exxelavionics.com/images/Traffic_3.jpg

Traffic Collision and Alerting (TCAS)

TCAS also actively interrogates aircraft that are located in a given proximity, displays the location and trend information on a MFD, and provides traffic alerts and resolution advisories to pilots. TCAS is typically more often found in commercial aircraft.

**Example TCAS Display:**


http://upload.wikimedia.org/wikipedia/commons/thumb/8/87/Tcas_EU-Flysafe.jpg/250px-Tcas_EU-Flysafe.jpg

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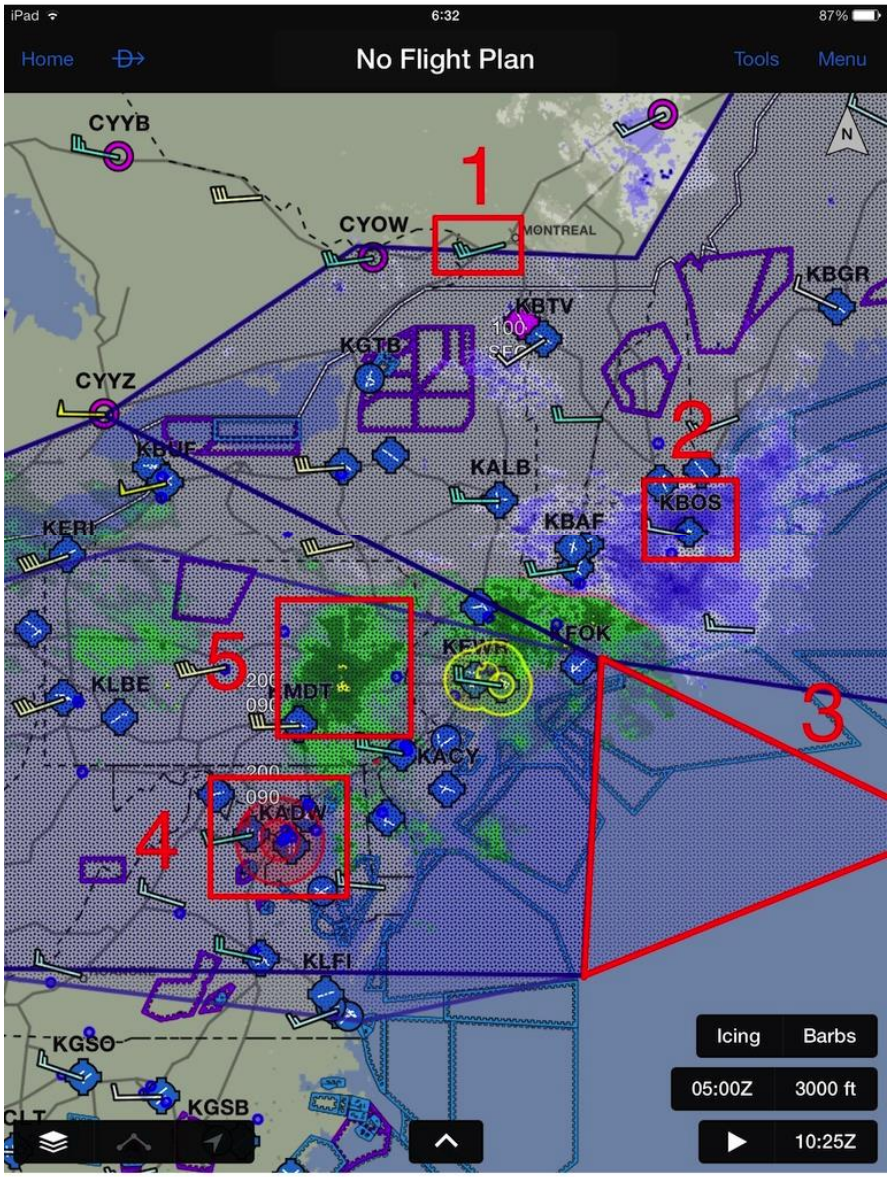
## "ADS-B In" Background: Weather Services

Flight Information System-Broadcast (FIS-B), is a data broadcasting service that works with ADS-B In to allow pilots to receive important flight information such as weather and airspace restrictions inflight.

The system gathers information through the use of ADS-B ground stations and delivers that data to an aircraft's onboard cockpit display in the form of weather alerts, airport information and various other reports. FIS-B information is broadcast every 5 minutes and each specific service is updated as they are published.

FIS-B provides pilots with the following information:
- Aviation Routine Weather Reports (METARs)
- Terminal Area Forecasts (TAFs)
- NEXRAD Precipitation maps
- Notices to Airmen (NOTAMs)
- AIRMETs
- SIGMETs
- Status of Special Use Airspace (SUA)
- Temporary Flight Restrictions (TFRs)
- Winds and Temperatures Aloft
- Pilot Reports (PIREPs)

Example ADS-B Weather Information: Garmin GDL 39




1. Winds Aloft
2. Airport Information
3. AIRMET
4. TFR
5. Weather Radar

## Other NON ADS-B Weather Systems

The following weather systems are common in aviation, however are NOT ADS-B based. This survey will NOT focus on these traffic systems.

XM Weather

Provides weather information to pilots via satellite communication to onboard XM receivers. XM can interface to pilots via MFDs, electronic flight bags, or pocket PCs.

**Example XM Weather Display:**


http://www.sportys.com/morepics/5355a.jpg

Onboard Weather Radar

Includes equipment typically installed in the radome of an aircraft. Pilots have control over the tilt of the radar and can map precipitation ahead of the aircraft. The information is displayed on a cockpit display.

**Example Onboard Weather Radar Display:**


http://sportysnetwork.com/airfacts/wp-content/blogs.dir/13/files/2013/09/onboard.jpg

Lightning Detection

Includes a receiver to identify lightning strikes within range of the aircraft. These strikes are then displayed in the cockpit. Examples include Stormscope and Strikefinder.

**Example Stormscope Display:**


http://www.avweb.com/newspics/ stormscope_fuzzy_sm.jpg

Flight Watch/EFAS (Enroute Flight Advisory System)

EFAS is operated by US Flight Service Stations (FSS) and provide enroute weather updates as well as collect PIREPs. Flight Watch can be reached on 122.0 MHz when flying below 18,000 ft MSL. Flight watch is a radio based system and does not include any required equipment (except for a 2 way radio) nor does it require a cockpit display.

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# Survey Part IIa (have used ADS-B services)

* Required

***Please use navigation buttons at the BOTTOM of this page to go back to previous pages in this survey. DO NOT use your browser navigation buttons.***

## ADS-B In Experience

**Have you ever used ADS-B In weather and/or traffic services while operating an aircraft?** *
Either portable or installed FIS-B/TIS-B

- ◯ Yes
- ◯ No

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## Weather and Traffic System Usage

**When did you begin flying with ADS-B In services?**

- ◯ Less than 6 months ago
- ◯ 6 - 12 months ago
- ◯ 1 - 2 years ago
- ◯ More than 2 years ago

**How often have you used the following traffic services?**

| | Always | Frequently | Occasionally | Rarely | Never | Don't Know |
|---|---|---|---|---|---|---|
| ADS-B Traffic Services | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| TAS (Traffic Advisory System) | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| TCAS (Traffic Collision Avoidance System) | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Other (specify below) | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**If you selected "Other" above, which traffic service(s) have you used?**

**In which flight rules do you find ADS-B traffic services most valuable?**

- ◯ VFR
- ◯ IFR
- ◯ Both VFR and IFR equally

**Please explain**

**How often have you used the following weather services?**

| | Always | Frequently | Occasionally | Rarely | Never | Don't Know |
|---|---|---|---|---|---|---|
| ADS-B Weather Services | ○ | ○ | ○ | ○ | ○ | ○ |
| XM Weather | ○ | ○ | ○ | ○ | ○ | ○ |
| Onboard weather radar | ○ | ○ | ○ | ○ | ○ | ○ |
| Lightning detection (example: stormscope) | ○ | ○ | ○ | ○ | ○ | ○ |
| Flight Watch/EFAS (En Route Flight Advisory Service) | ○ | ○ | ○ | ○ | ○ | ○ |
| Other (specify below) | ○ | ○ | ○ | ○ | ○ | ○ |

**If you selected "Other" above, which weather service(s) have you used?**

**In which flight rules do you find ADS-B weather services most valuable?**

- ○ VFR
- ○ IFR
- ○ Both VFR and IFR equally

**Please explain**

## ADS-B In Experience

**Have you ever used an INSTALLED ADS-B In system?**

- ○ Yes
- ○ No

**If you have used an INSTALLED system, how often have you used the following systems?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| Garmin GDL 88 | ○ | ○ | ○ | ○ | ○ |
| Garmin GDL 90 | ○ | ○ | ○ | ○ | ○ |
| Avidyne TAS600 ADS-B | ○ | ○ | ○ | ○ | ○ |
| FreeFlight RANGR XVR / RX | ○ | ○ | ○ | ○ | ○ |
| FreeFlight XPLORER | ○ | ○ | ○ | ○ | ○ |
| NavWorx ADS600 / ADS600-B / ADS600-BG | ○ | ○ | ○ | ○ | ○ |
| SkyVision Xtreme ADS-B-Gen2 | ○ | ○ | ○ | ○ | ○ |
| SkyVision Xtreme ADS-B-Sys1i /2i | ○ | ○ | ○ | ○ | ○ |
| Other (specify below) | ○ | ○ | ○ | ○ | ○ |
| Do not know system model | ○ | ○ | ○ | ○ | ○ |

**If you selected "Other" above, which system(s) have you used?**

**Have you ever used a PORTABLE ADS-B In system?**

○ Yes

○ No

**If you have used a PORTABLE system, how often have you used the following systems?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| Garmin GDL 39 | ○ | ○ | ○ | ○ | ○ |
| SkyVision Xtreme ADS-B-GenX/2 | ○ | ○ | ○ | ○ | ○ |
| Foreflight Stratus/Stratus 2 | ○ | ○ | ○ | ○ | ○ |
| Dual Electronics XGPS170 | ○ | ○ | ○ | ○ | ○ |
| SkyRadar DX | ○ | ○ | ○ | ○ | ○ |
| Sagetech Clarity | ○ | ○ | ○ | ○ | ○ |
| Other (specify below) | ○ | ○ | ○ | ○ | ○ |
| Do not know system model | ○ | ○ | ○ | ○ | ○ |

**If you selected "Other" above, which system(s) have you used?**

## Equipage

**In what make/model aircraft have you primarily used ADS-B In services?**
Please use flight plan type designators if possible (example: C172, B737)

**What ADS-B In system have you used when you fly that aircraft?**

- [ ] Installed - Garmin GDL 88
- [ ] Installed - Garmin GDL 90
- [ ] Installed - FreeFlight RANGR XVR / RX
- [ ] Installed - FreeFlight XPLORER
- [ ] Installed - Avidyne TAS600 ADS-B
- [ ] Installed - NavWorx ADS600 / 600-B / 600-BG
- [ ] Installed - SkyVision Xtreme ADS-B-Sys1i / 2i
- [ ] Installed - SkyVision Xtreme ADS-B-Gen2
- [ ] Portable - SkyVision Xtreme ADS-B-GenX/2
- [ ] Portable - Sagetech Clarity
- [ ] Portable - Garmin GDL 39
- [ ] Portable - Dual Electronics XGPS170
- [ ] Portable - SkyRadar DX
- [ ] Portable - ForeFlight Stratus/Stratus 2
- [ ] Do not know
- [ ] Other:

**What display device have you used when you fly that aircraft?**

- ( ) iPad
- ( ) Android tablet
- ( ) Windows tablet
- ( ) Multi-Function Display (MFD)
- ( ) Electronic Flight Bag
- ( ) Other:

**If you personally chose the ADS-B In equipment that you fly with, what factors contributed to your choice of the above equipment?**

| | Extremely Important | Very Important | Somewhat Important | Slightly Important | Not Important |
|---|---|---|---|---|---|
| Price | ( ) | ( ) | ( ) | ( ) | ( ) |
| Weather services | ( ) | ( ) | ( ) | ( ) | ( ) |
| Traffic services | ( ) | ( ) | ( ) | ( ) | ( ) |
| Compatibility with existing equipment | ( ) | ( ) | ( ) | ( ) | ( ) |
| Battery life | ( ) | ( ) | ( ) | ( ) | ( ) |
| Other (specify below) | ( ) | ( ) | ( ) | ( ) | ( ) |

**If you selected "Other" above, what other factor(s) contributed to your choice of equipment?**

**Please use this space to elaborate on your reasons for choosing this/these ADS-B In system(s).**

**Is there also an ADS-B OUT system installed in that aircraft?**

- ○ Yes
- ○ No
- ○ Do not know

**If you have an ADS-B Out system installed, please specify type.**

## ADS-B Traffic Service Usage

**Have ADS-B traffic services ever helped you avoid a mid-air collision?**

- ○ Yes
- ○ No

**For flights where you flew with ADS-B In services, how often has ADS-B traffic information helped you to visually acquire another aircraft?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

**For flights where you have flown with ADS-B In services, how often have you maneuvered aggressively where ADS-B traffic information was a factor in your decision to maneuver?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

**On your last flight, was ADS-B traffic information a factor in your decision to maneuver for traffic at any point during the flight?**

- ○ Yes
- ○ No
- ○ Did not maneuver for traffic

**How satisfied are you with ADS-B traffic service coverage?**

| | Extremely Satisfied | Very Satisfied | Somewhat Satisfied | Slightly Satisfied | Not Satisfied |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

**Please describe any situations where service coverage was an issue.**

**Has limited ADS-B traffic information coverage ever influenced safety of flight?**

- ○ Yes
- ○ No

**If yes, please describe the situation(s) where this occurred.**

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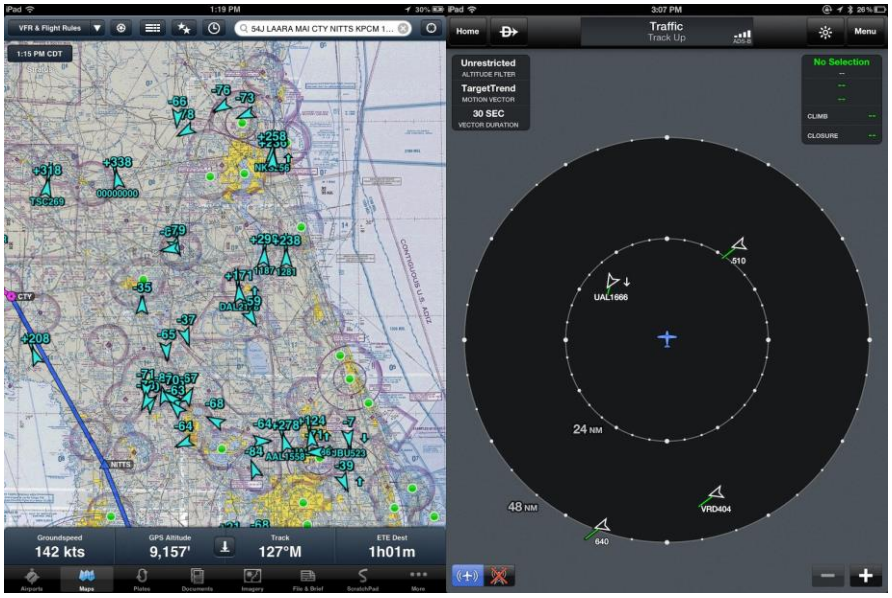
## ADS-B Traffic Information Display

**How useful have you found an ADS-B cockpit display of traffic information?**
If you have not used ADS-B traffic information inflight, please specify how useful such inflight information would be to you.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example traffic information: ForeFlight Stratus and Garmin GDL 39

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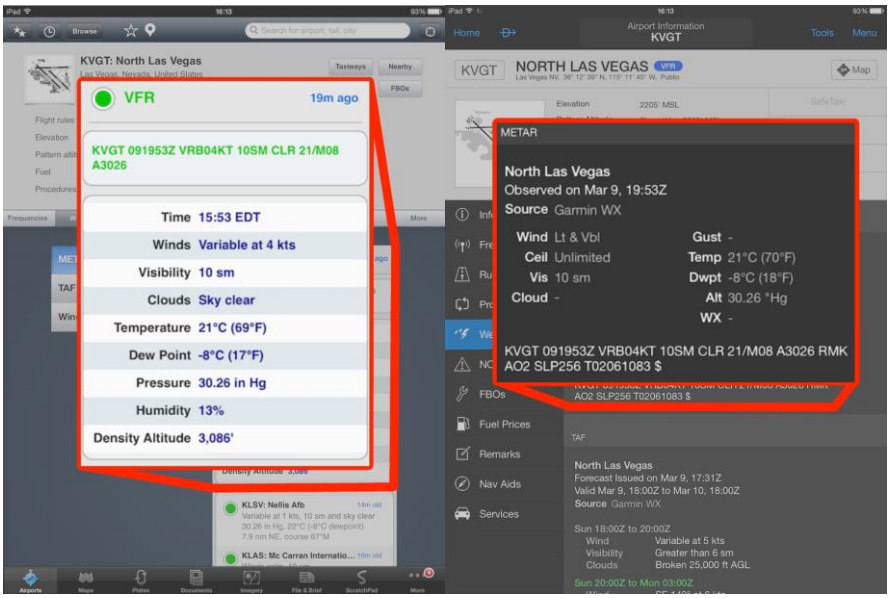
## METARs: Aviation Routine Weather Reports

**How useful have you found surface observation information (METARs) inflight?**
If you have not used FIS-B inflight, please specify how useful you would find METAR information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example METAR: ForeFlight Stratus and Garmin GDL 39

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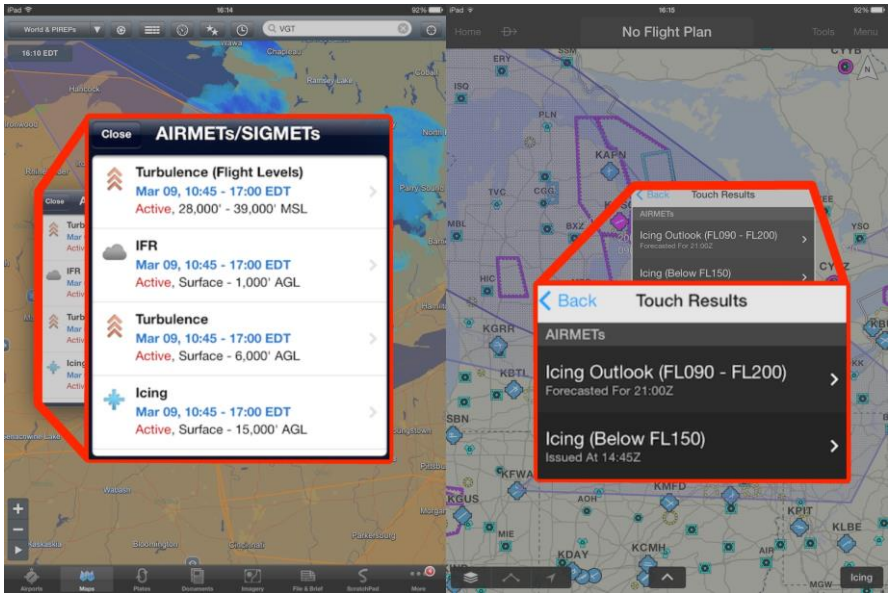
## AIRMET/SIGMET

**How useful have you found AIRMET/SIGMET information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find AIRMET/SIGMET information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example AIRMET/SIGMET: ForeFlight Stratus and Garmin GDL 39

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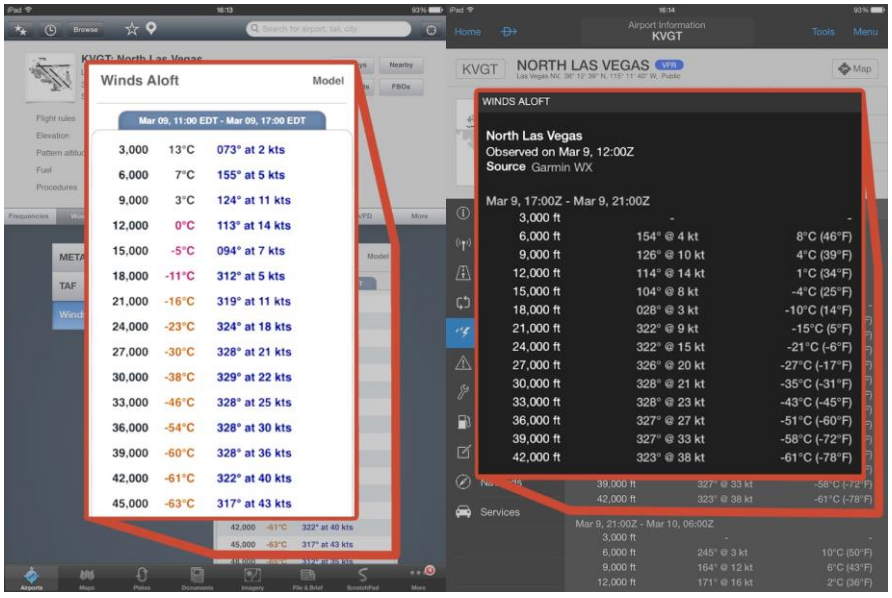
## Winds & Temperatures Aloft

**How useful have you found Winds & Temperatures Aloft information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find Winds & Temperatures Aloft information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example Winds & Temps Aloft: ForeFlight Stratus and Garmin GDL 39

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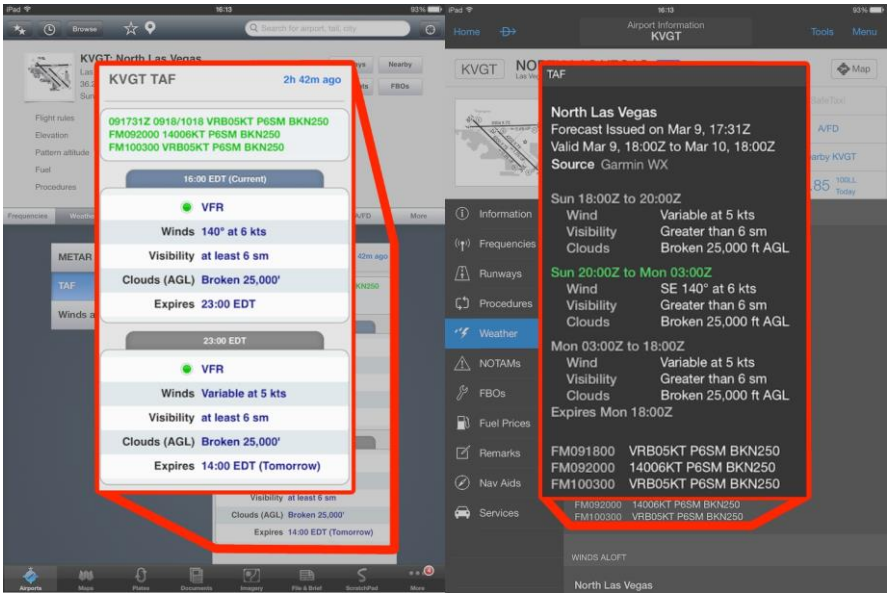
## TAFs: Terminal Area Forecasts

**How useful have you found Terminal Area Forecast (TAF) information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find TAF information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example TAF: ForeFlight Stratus and Garmin GDL 39

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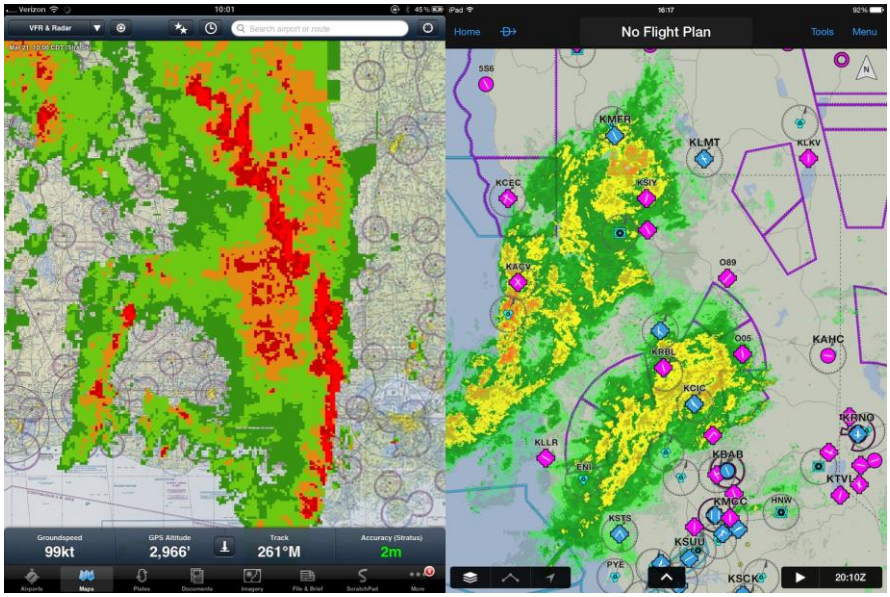
## NEXRAD Precipitation Maps

**How useful have you found weather radar information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find weather radar information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example Weather Radar: ForeFlight Stratus and Garmin GDL 39

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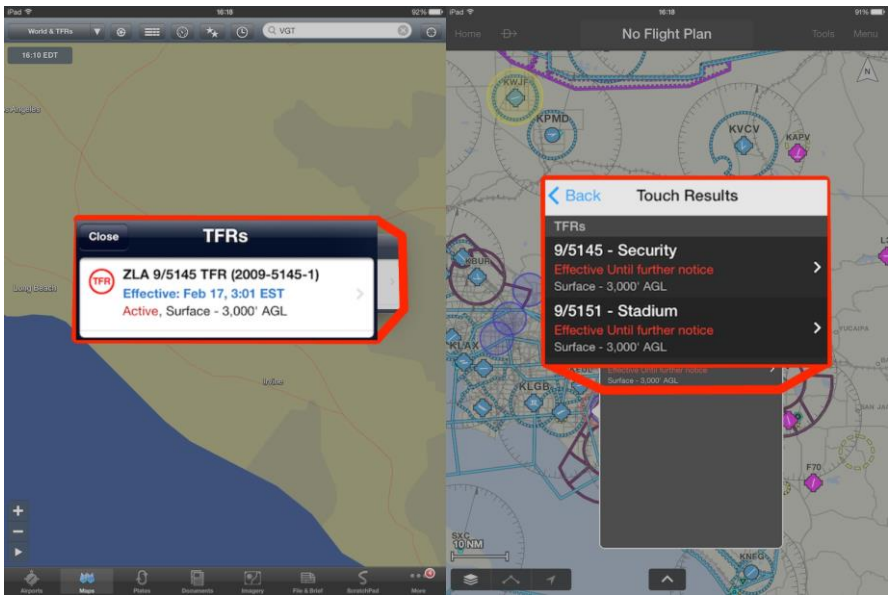
## TFRs: Temporary Flight Restrictions

**How useful have you found Temporary Flight Restriction (TFR) information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find TFR information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example TFR: ForeFlight Stratus and Garmin GDL 39

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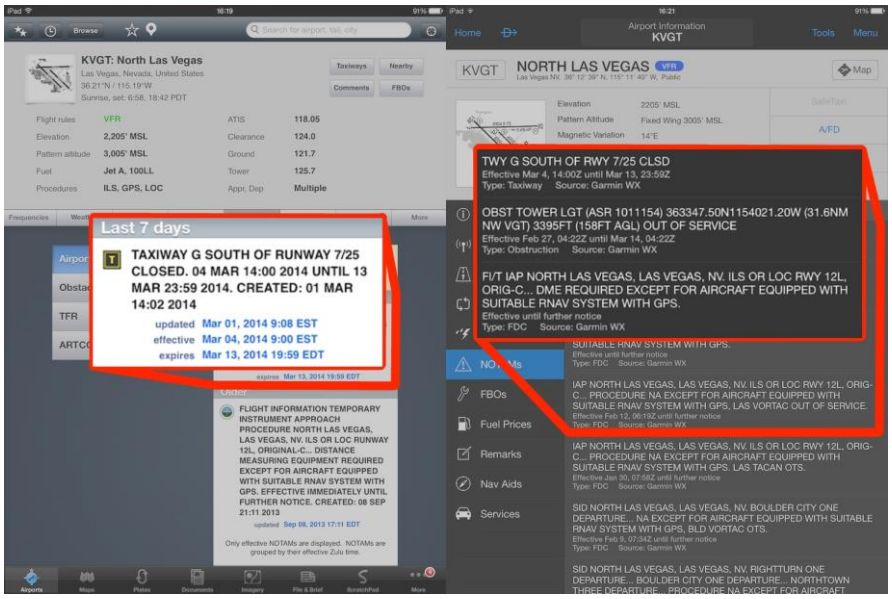
## NOTAMs: Notices To Airmen

**How useful have you found Notice to Airmen (NOTAM) information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find NOTAM information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example NOTAM: ForeFlight Stratus and Garmin GDL 39

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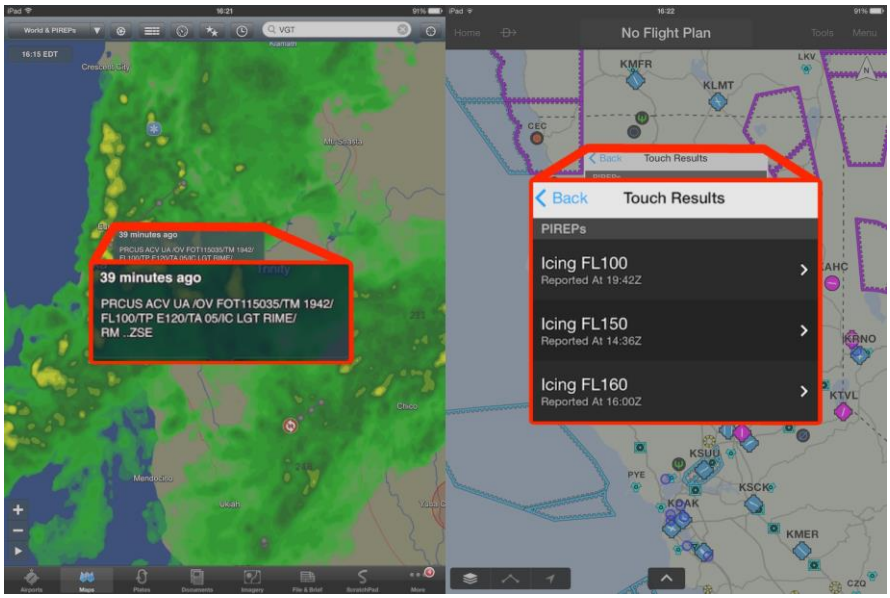
## PIREPs: Pilot Reports

**How useful have you found Pilot Report (PIREP) information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find PIREP information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example PIREP: ForeFlight Stratus and Garmin GDL 39

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## SUA: Status of Special Use Airspace

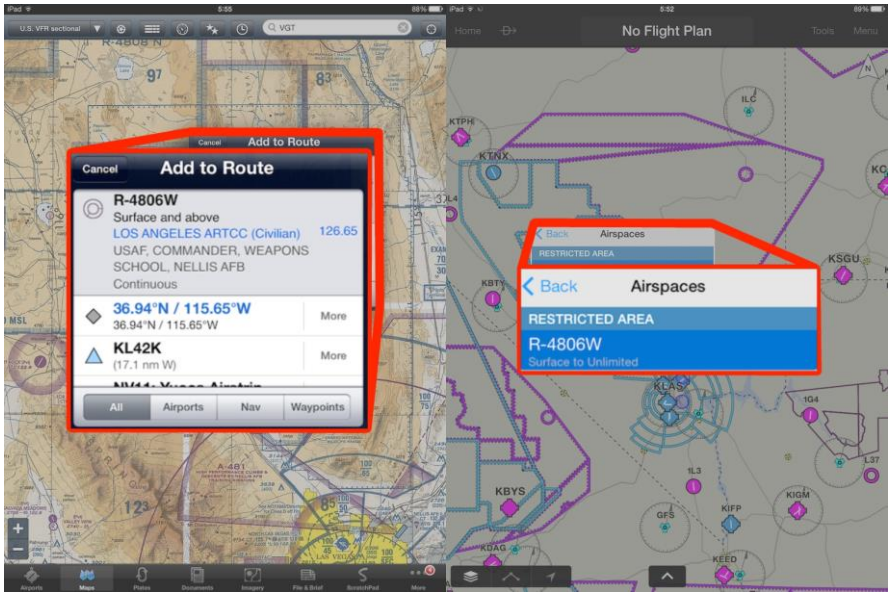
Examples of special use airspace:

-Prohibited Areas
-Restricted Areas
-Warning Areas
-Military Operations Areas
-Alert Areas
-Controlled Firing Areas
-National Security Areas

**How useful have you found Special Use Airspace (SUA) information inflight?**
If you have not used FIS-B inflight, please specify how useful you would find SUA information inflight.

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example SUA: ForeFlight Stratus and Garmin GDL 39

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## ADS-B Weather Service Usage

**For trips when you have used ADS-B In equipment, how often has ADS-B weather information influenced your in-flight decisions?**
Select all that apply

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| Altitude selection | ○ | ○ | ○ | ○ | ○ |
| Rerouting | ○ | ○ | ○ | ○ | ○ |
| Diverting to alternate airport | ○ | ○ | ○ | ○ | ○ |
| Other (specify below) | ○ | ○ | ○ | ○ | ○ |

**If you selected "Other" above, what other in-flight decisions have been influenced by ADS-B weather information?**

**On your LAST TRIP with ADS-B In equipment, did ADS-B weather information influence your in-flight decisions?**

- ☐ Yes, selected different altitude
- ☐ Yes, rerouted
- ☐ Yes, diverted to alternate airport
- ☐ No
- ☐ Other:

**What information services do you use for pre-flight planning?**
Check all that apply

- ☐ Tablet/Smartphone application (ex: ForeFlight, Garmin Pilot, WingX)
- ☐ Websites (ex: Aviation Weather Center, AOPA Flight Planner)
- ☐ Flight Service Station (telephone 1-800-WXBRIEF)
- ☐ DUATS (computer)
- ☐ DUATS (telephone)
- ☐ Other:

**How often has the fact that you will receive ADS-B weather in the air influenced your decision to takeoff in situations where you otherwise may not have?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

**Please describe any situations where this was the case.**

## Suggested Improvements for ADS-B traffic and weather services

**How would you improve the existing ADS-B traffic and weather services?**

**Please provide any additional comments here:**


MIT International Center for Air Transportation

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# Survey Part IIb (have not used ADS-B services)

* Required

***Please use navigation buttons at the BOTTOM of this page to go back to previous pages in this survey. DO NOT use your browser navigation buttons.***

## ADS-B In Experience

**Have you ever used ADS-B In weather and/or traffic services while operating an aircraft?** *
Either portable or installed FIS-B/TIS-B

- ◯ Yes
- ◯ No

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## Please explain why you do not fly with ADS-B traffic or weather services.

- ☐ Planning to equip in the future
- ☐ Have alternative service(s)
- ☐ Not interested
- ☐ Too expensive
- ☐ Do not trust the technology
- ☐ Other:

**Please expand on your reason(s) for not using ADS-B traffic or weather services.**

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## Traffic and Weather Service Usage

**How often have you used the following traffic services?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| TAS (Traffic Advisory System) | ○ | ○ | ○ | ○ | ○ |
| TCAS (Traffic Collision Avoidance System) | ○ | ○ | ○ | ○ | ○ |
| Other (specify below) | ○ | ○ | ○ | ○ | ○ |

**If you selected "Other" above, what other traffic service(s) have you used?**

**How often have you used the following weather services?**

| | Always | Frequently | Occasionally | Rarely | Never |
|---|---|---|---|---|---|
| XM Weather | ○ | ○ | ○ | ○ | ○ |
| Onboard weather radar | ○ | ○ | ○ | ○ | ○ |
| Lightning detection (Example: Stormscope) | ○ | ○ | ○ | ○ | ○ |
| Flight Watch/EFAS (En Route Flight Advisory Service) | ○ | ○ | ○ | ○ | ○ |
| Other (specify below) | ○ | ○ | ○ | ○ | ○ |

**If you selected "Other" above, what other weather service(s) have you used?**

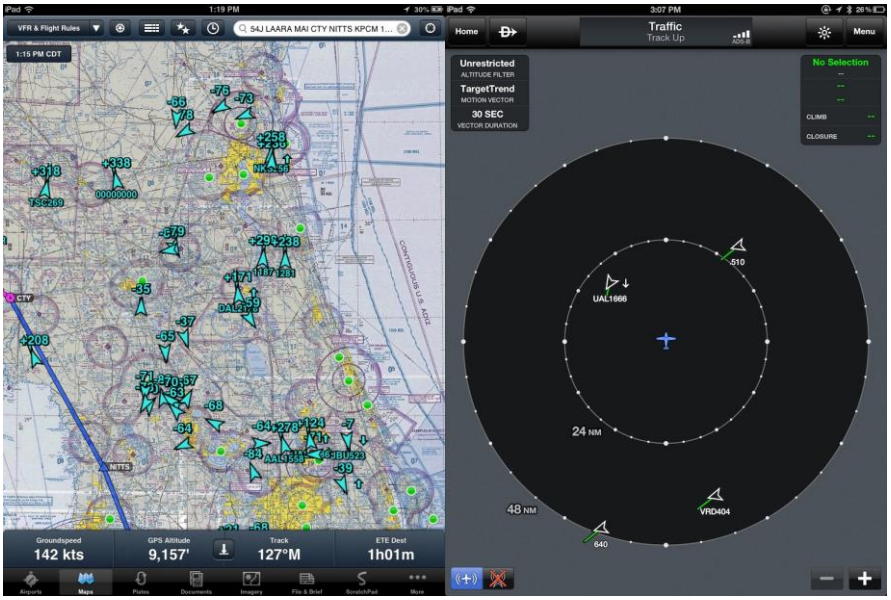
***Please use navigation buttons at the BOTTOM of this page to go back to previous pages in this survey. DO NOT use your browser navigation buttons.***

## ADS-B Traffic Information Display

**How useful would you find a ADS-B cockpit display of traffic information?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example traffic information: ForeFlight Stratus and Garmin GDL 39

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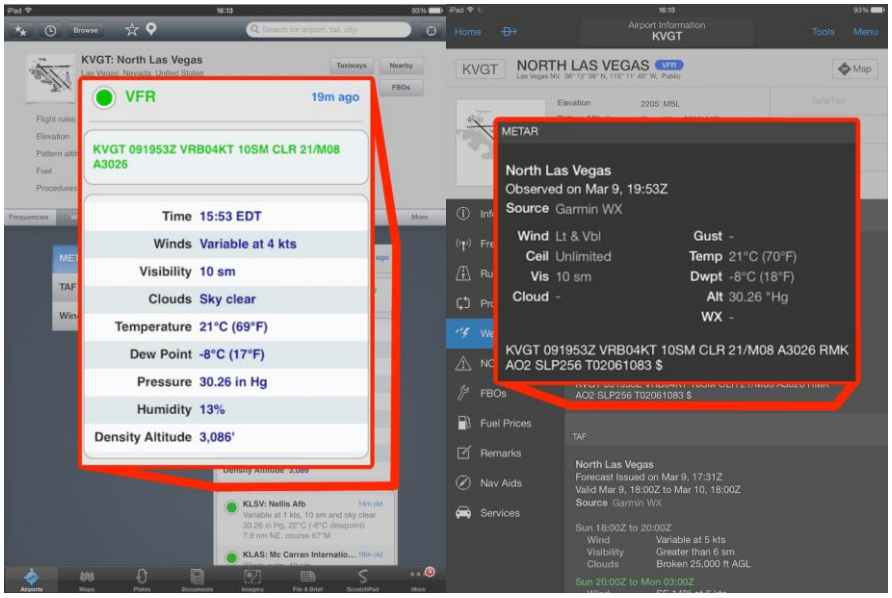
## METARs: Aviation Routine Weather Reports

**How useful would you find surface observation information (METARs) inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example METAR: ForeFlight Stratus and Garmin GDL 39

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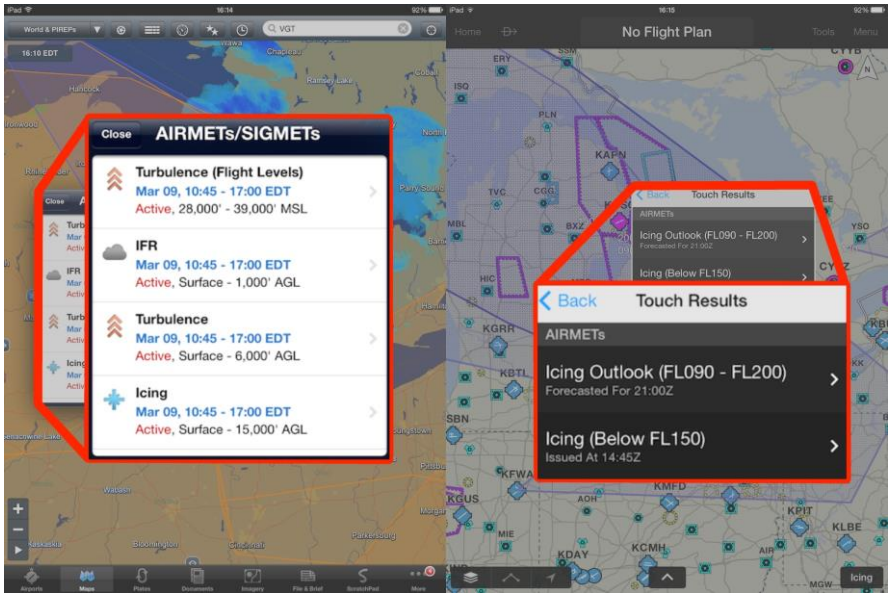
***Please use navigation buttons at the BOTTOM of this page to go back to previous pages in this survey. DO NOT use your browser navigation buttons.***

## AIRMETs/SIGMETs

**How useful would you find AIRMET/SIGMET information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example AIRMET/SIGMET: ForeFlight Stratus and Garmin GDL 39

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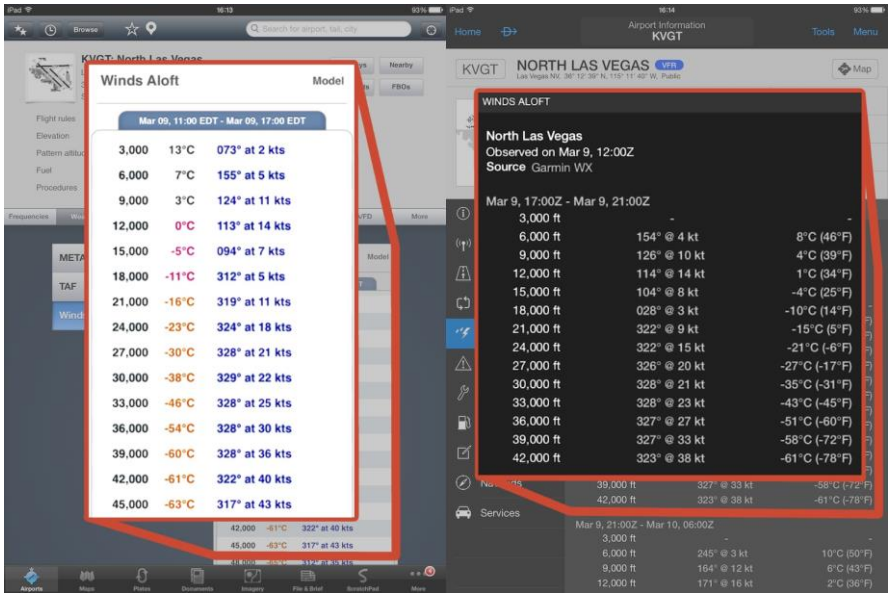
## Winds & Temperatures Aloft

**How useful would you find Winds & Temperatures Aloft information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example Winds & Temps Aloft: ForeFlight Stratus and Garmin GDL 39

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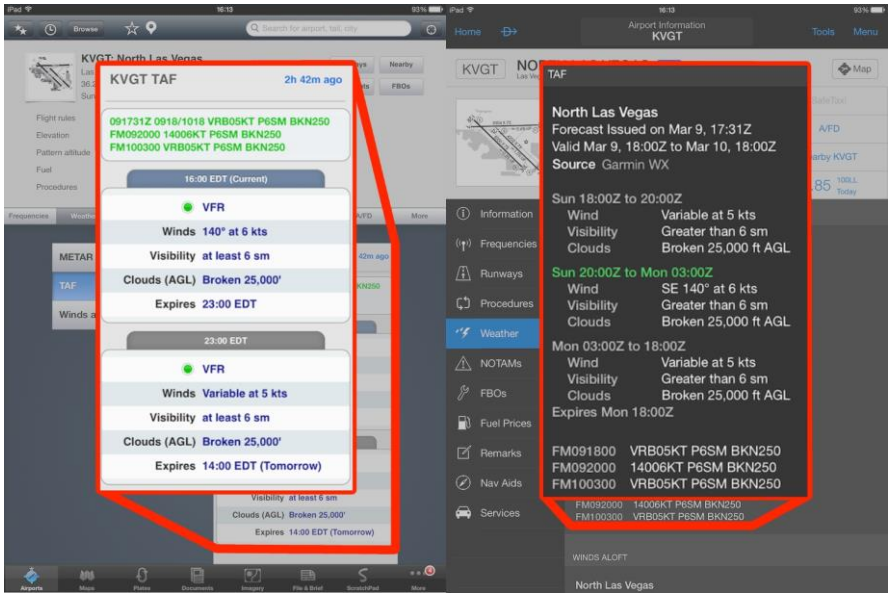
## TAFs: Terminal Area Forecasts

**How useful would you find terminal area forecast (TAF) information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example TAF: ForeFlight Stratus and GDL 39




« Back Continue »

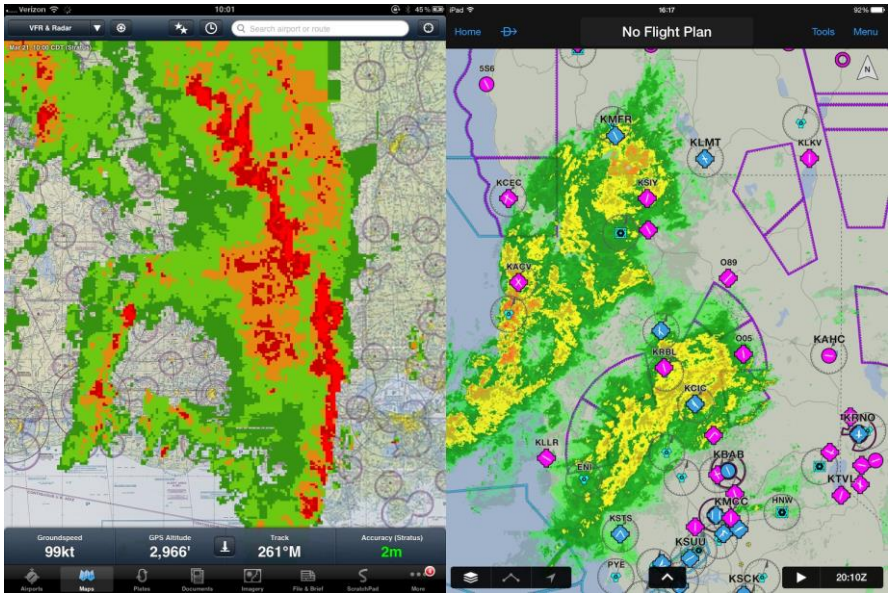
***Please use navigation buttons at the BOTTOM of this page to go back to previous pages in this survey. DO NOT use your browser navigation buttons.***

## NEXRAD Precipitation Maps

**How useful would you find weather radar information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example Weather Radar: ForeFlight Stratus and GDL 39

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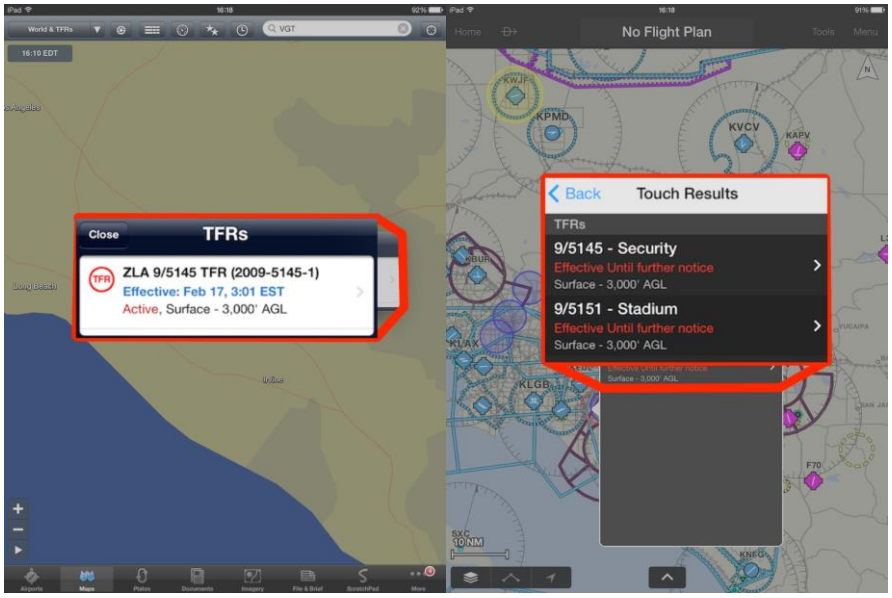
## TFR: Temporary Flight Restrictions

**How useful would you find Temporary Flight Restriction (TFR) information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example TFR: ForeFlight Stratus and Garmin GDL 39

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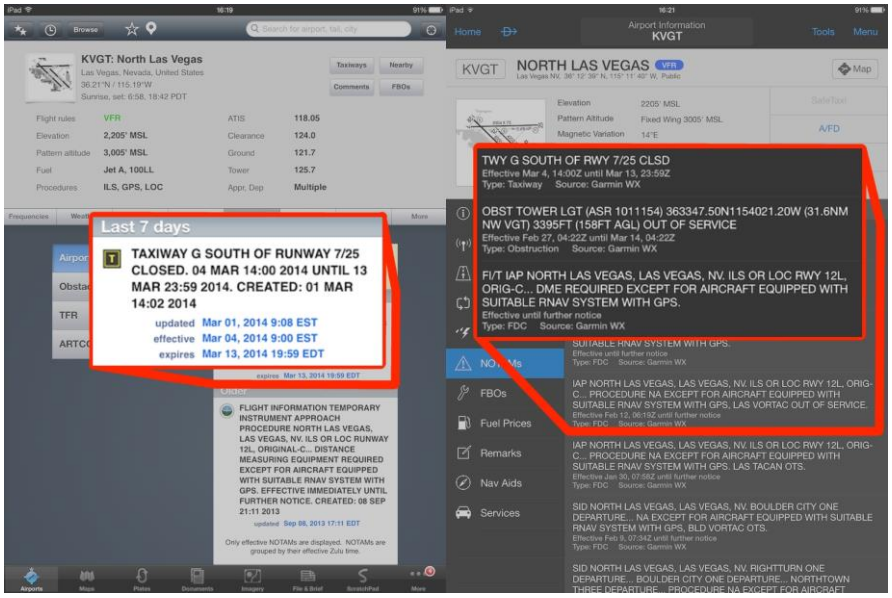
## NOTAMs: Notices To Airmen

**How useful would you find Notice to Airmen (NOTAM) information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example NOTAM: ForeFlight Stratus and Garmin GDL 39

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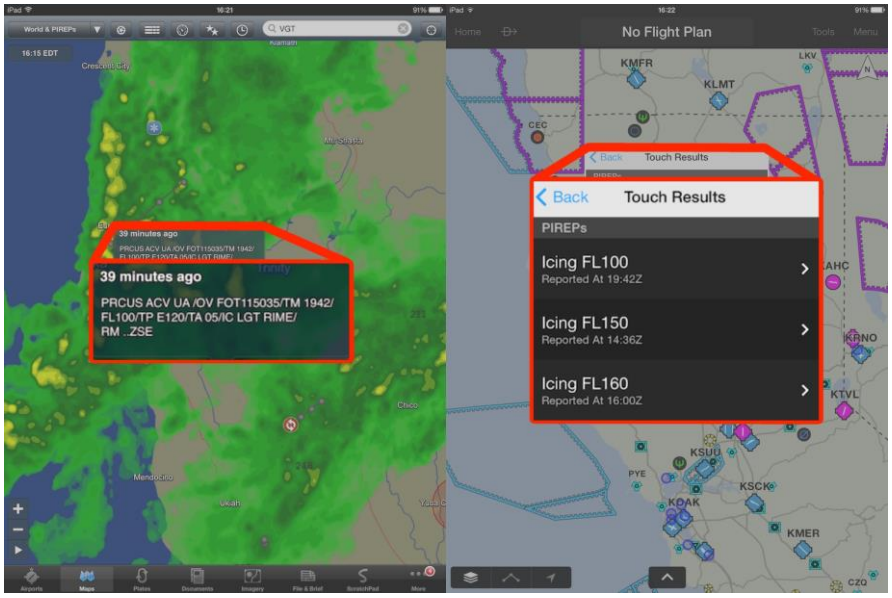
## PIREPs: Pilot Reports

**How useful would you find Pilot Report (PIREP) information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example PIREP: ForeFlight Stratus and Garmin GDL 39

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## SUA: Status of Special Use Airspace

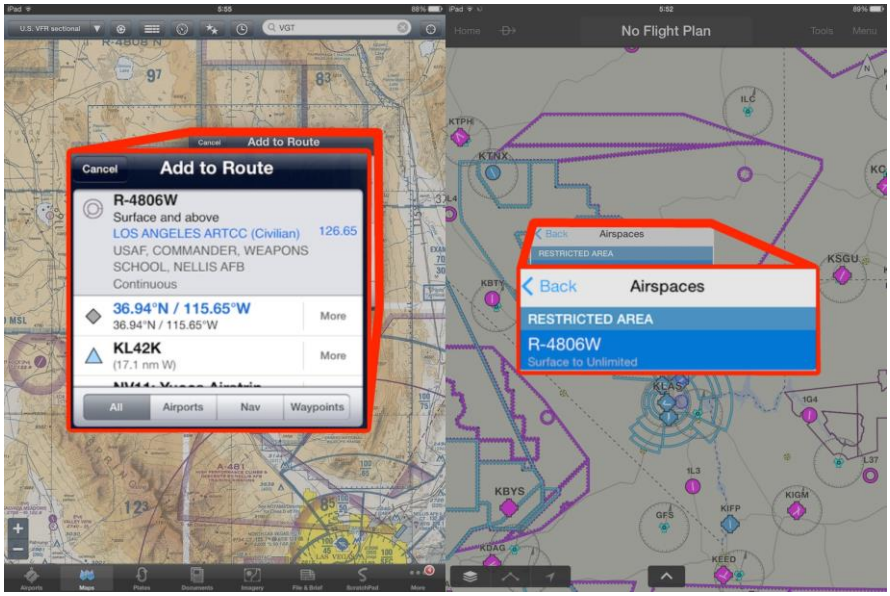
Examples of special use airspace:

-Prohibited Areas
-Restricted Areas
-Warning Areas
-Military Operations Areas
-Alert Areas
-Controlled Firing Areas
-National Security Areas

**How useful would you find Special Use Airspace (SUA) information inflight?**

| | Extremely Useful | Very Useful | Somewhat Useful | Slightly Useful | Not Useful |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

## Example SUA: ForeFlight Stratus and Garmin GDL 39

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## Value of ADS-B Traffic and Weather Services

The following questions will be used to gauge user value of ADS-B traffic and weather information.

**What information services do you use for pre-flight planning?**
Check all that apply

- ☐ Tablet/Smartphone application (ex: ForeFlight, Garmin Pilot, WingX)
- ☐ Websites (ex: Aviation Weather Center, AOPA Flight Planner)
- ☐ Flight Service Station (telephone 1-800-WXBRIEF)
- ☐ DUATS (computer)
- ☐ DUATS (telephone)
- ☐ Other:

**If you own a tablet computer, please specify type.**

- ☐ iPad
- ☐ Android tablet
- ☐ Windows tablet
- ☐ Do not own
- ☐ Other:

**How much would you be willing to pay for a PORTABLE ADS-B In system?**
(not including tablet)

- ○ Would not purchase
- ○ Less than $300
- ○ $300 - $599
- ○ $600 - $899
- ○ $900 - $1,199
- ○ $1,200 - $1,500
- ○ More than $1,500
- ○ Prefer not answer

**If you rent an aircraft, how much extra would you pay (per hour) for INSTALLED ADS-B In services?**

- ○ Would not pay extra
- ○ Less than $5 per hour
- ○ $6 - $10 per hour
- ○ $11 - $15 per hour
- ○ More than $15 per hour
- ○ Do not rent
- ○ Prefer not to answer

**If you own an aircraft WITH a Multi-Function Display (MFD), how much would you be willing to pay for an INSTALLED ADS-B In system that interfaces with your existing MFD?**

- ○ Would not purchase
- ○ Less than $1,000
- ○ $1,000 - $2,999
- ○ $3,000 - $4,999
- ○ $5,000 - $7,000
- ○ More than $7,000
- ○ Do not own such an aircraft
- ○ Prefer not to answer

**If you own an aircraft WITHOUT A MFD, how much would you be willing to pay for an INSTALLED ADS-B In (FIS-B/TIS-B) system for tablet use?**
(not including required tablet)

- ○ Would not purchase
- ○ Less than $1,000
- ○ $1,000 - $2,999
- ○ $3,000 - $4,999
- ○ $5,000 - $7,000
- ○ More than $7,000
- ○ Do not own such an aircraft
- ○ Prefer not to answer

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## Suggested Improvements for ADS-B traffic and weather services

**How would you improve the existing ADS-B traffic and weather services?**

**Please provide any additional comments here:**

MIT ICAT MIT International Center for Air Transportation

« Back Submit

Never submit passwords through Google Forms.

## Background: ADS-B In Services

**ADS-B In** services are comprised of ADS-B traffic services, including Traffic Information Service - Broadcast (TIS-B) and ADS-B weather services, including Flight Information Service - Broadcast (FIS-B). This information is transmitted to the aircraft and depicted on a multi-function display or tablet device.

The **ADS-B In** implementation was influenced by the dual-link strategy proposed for **ADS-B Out** broadcasts. **ADS-B Out** can broadcast on either a 1090MHz ES link or a 978 UAT link. The 1090MHz ES link is used internationally and required above FL 180, thus primarily used by commercial operators. There was concern for frequency congestion on the 1090MHz ES link if general aviation aircraft were required to equip with 1090 MHz ES; thus, the 978 UAT link was proposed to add the capability of broadcasting FIS-B and provide added safety benefit to the general aviation community equipping with ADS-B. The dual link system was found necessary by the FAA to meet the needs of all NAS operators, including general aviation pilots.

### ADS-B In Traffic Services

An aircraft equipped for **ADS-B In** receives traffic information from other aircraft and from the ground station network. **ADS-B In** traffic services provide location information for other aircraft with a transponder in the vicinity of the equipped aircraft, regardless of whether the traffic target aircraft are equipped with ADS-B. Traffic can be received over three channels for display to the pilot:

1. ADS-B: Traffic information is transmitted by **ADS-B Out** equipped aircraft. These transmissions are received directly by **ADS-B In** equipped aircraft within range of the initial transmission. No ground network is necessary for this channel of traffic information.
2. ADS-R: Automatic Dependent Surveillance – Rebroadcast (ADS-R) transmits ADS-B traffic information through a ground network to aircraft equipped with **ADS-B In**. This is required for two scenarios:
    a. Provides location information for traffic outside of direct aircraft-to-aircraft ADS-B range.

b. Provides location information for traffic equipped with **ADS-B Out** on a different ADS-B link that cannot be received directly - 1090 MHz Extended Squitter (1090ES) or 978 MHz Universal Access Transceiver (UAT)

3. TIS-B: Traffic information from secondary surveillance radars (SSRs) is processed by the ADS-B ground network and transmitted to aircraft equipped with **ADS-B In**. This capability allows aircraft not yet equipped with **ADS-B Out** to appear on **ADS-B In** traffic displays for participating aircraft. It should be mentioned that TIS-B is only broadcasted when an aircraft broadcasting **ADS-B Out** is also within range of the ground station.

In some systems, it is not possible for the pilot to determine whether the traffic shown is ADS-B, ADS-R, or TIS-B traffic. For the purpose of this survey, pilots were asked to consider all of the above sources of traffic information. Examples of traffic displays are shown below for installed and portable systems.


**Example of traffic information display (installed)**


**Example of traffic information display (portable)**

### ADS-B In Weather Services

Flight Information System-Broadcast (FIS-B) is a data broadcasting service that works with **ADS-B In** to allow pilots to receive important flight information such as weather and airspace restrictions inflight. The service is only available on the UAT ADS-B link. It was designed for use primarily by the general aviation community.

The system gathers information through the use of ADS-B ground stations and delivers that data to an aircraft's onboard cockpit display in the form of weather alerts, airport information and various other reports. FIS-B information is broadcast every 5 minutes and each specific service is updated as they are published. There is no industry standard for FIS-B information display format, so a wide variety of presentations are available in current installed and portable displays.

FIS-B provides pilots with the following information:

- Aviation Routine Weather Reports (METARs)
- Terminal Area Forecasts (TAFs)
- NEXRAD Precipitation maps
- Notices to Airmen (NOTAMs)

- AIRMETs
- SIGMETs
- Status of Special Use Airspace (SUA)
- Temporary Flight Restrictions (TFRs)
- Winds and Temperatures Aloft
- Pilot Reports (PIREPs)

An example of some information displayed on a portable system is shown in Figure 0-1.

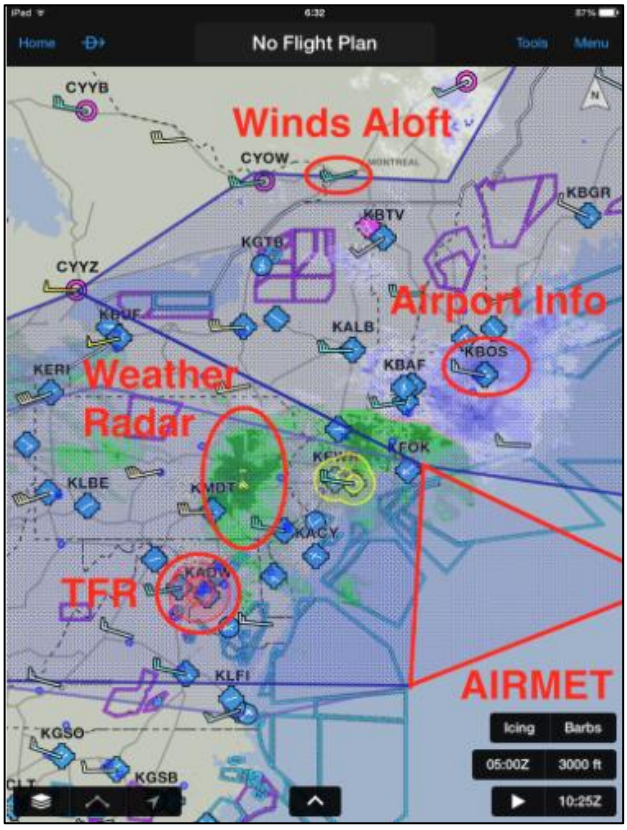
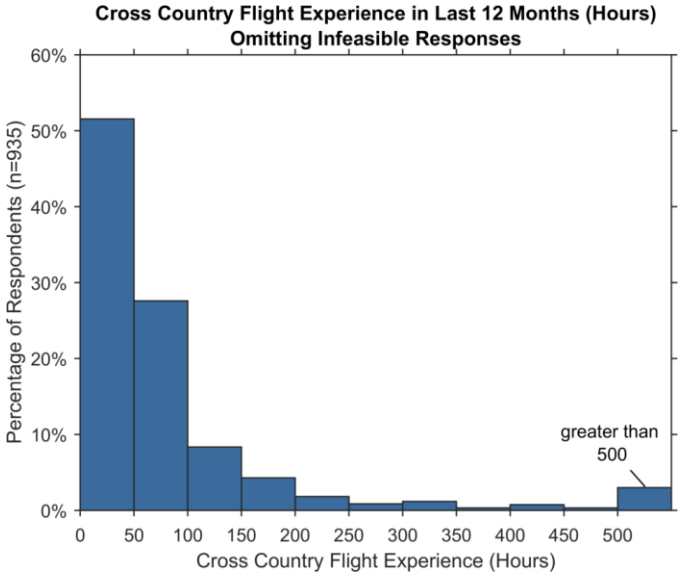



**Figure 0-1, Example of flight information display (portable)**

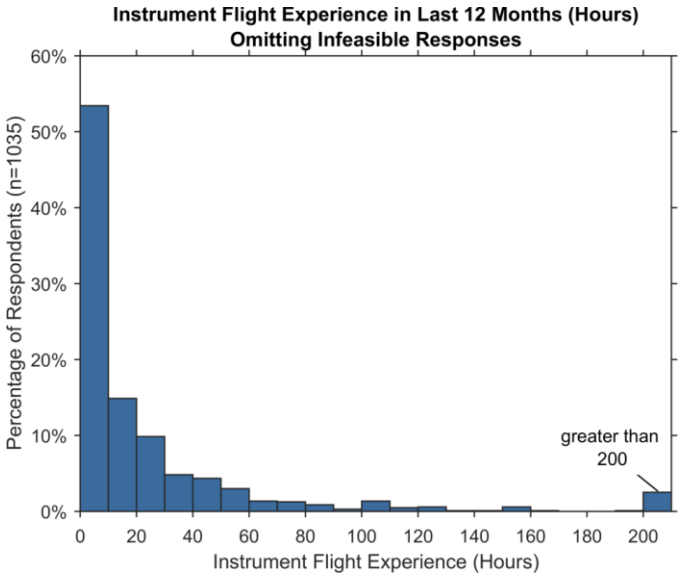
# Additional Data

## Flight Experience – Detailed

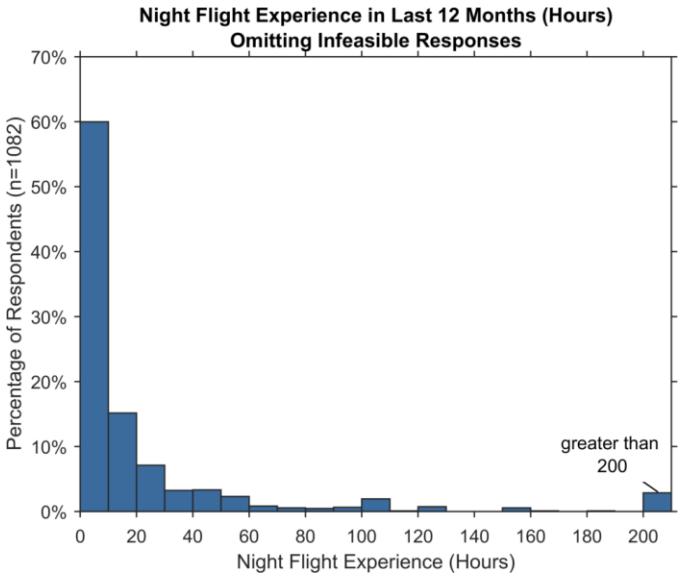
Respondents were asked to report cross country (XC) flight experience within previous 12 months. 442 respondents appear to have reported total XC time rather than within previous 12 months. The results were filtered to exclude the cases where the previous year's XC flight time was greater than the total previous year's flight hours.



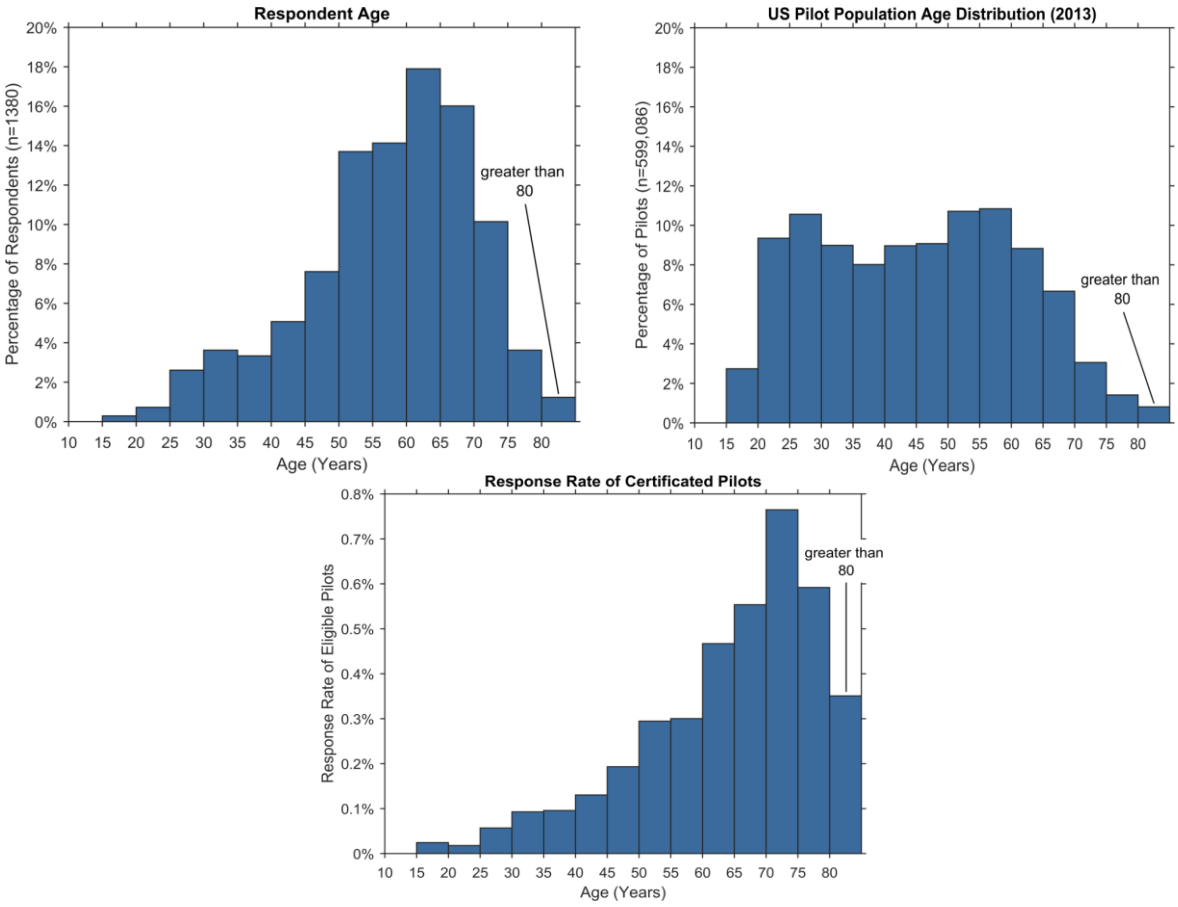

Respondents were asked to report total instrument time, including both actual and simulated instrument experience, within the previous 12 months. 295 respondents appear to have reported total instrument time rather than within previous 12 months. The results were filtered to exclude the cases where the previous year's instrument time was greater than the total previous year's flight hours.

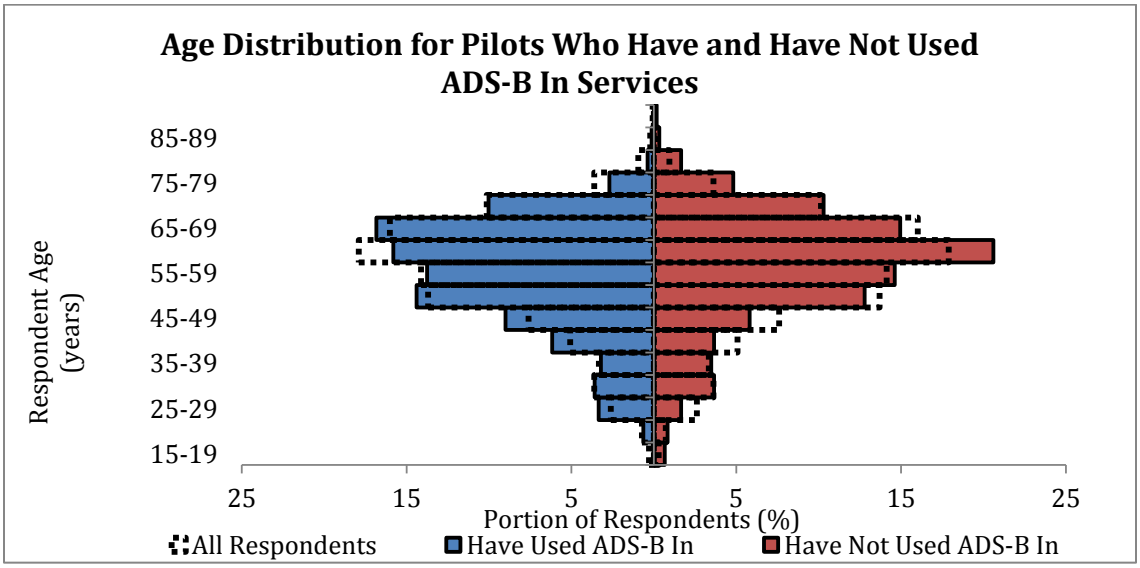



Respondents were asked to report night hours within the previous 12 months. 269 respondents appear to have reported total night time instead. The results were filtered to exclude the cases where the previous year's night time was greater than the total previous year's flight hours.



## Age of Respondents



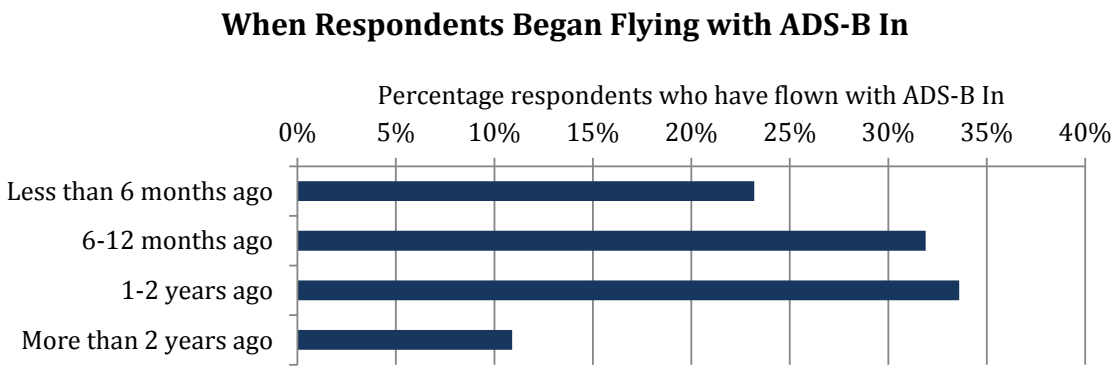



## Primary Aircraft Flown by Respondents & Method of Access

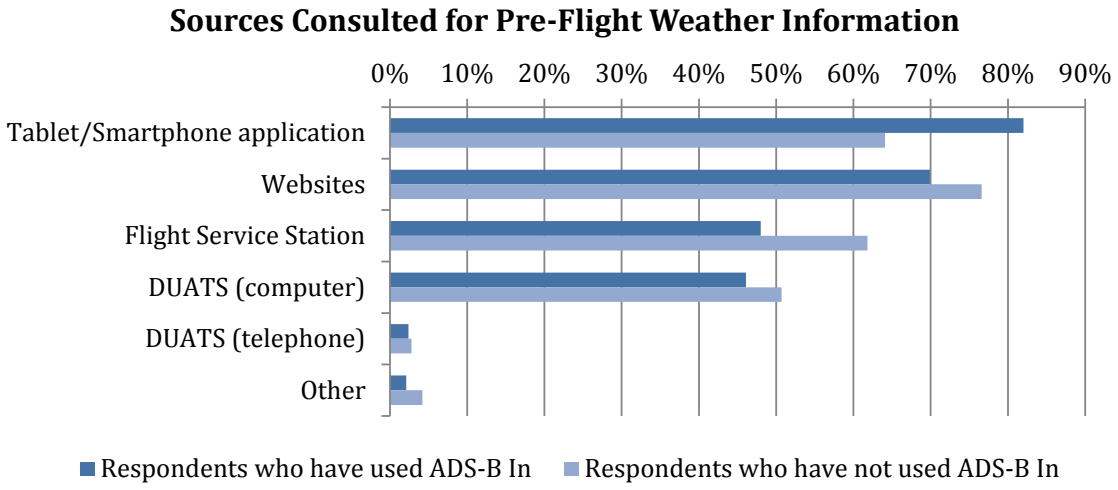
| Aircraft | # Responses | Percentage |
|---|---|---|
| Single Engine (less than 200 HP) | 616 | 44.2% |
| Single Engine (greater than 200 HP) | 593 | 42.6% |
| Turbine | 79 | 5.7% |
| Multi Engine Piston Propeller | 72 | 5.2% |
| Helicopter | 25 | 1.8% |
| Glider | 6 | 0.4% |
| Airship | 1 | 0.1% |
| Military | 1 | 0.1% |

| | # Responses | Percentage |
|---|---|---|
| Own | 1095 | 68.4% |
| Rent | 256 | 16.0% |
| Fly Professionally | 197 | 12.3% |
| Flying Club/Partial Ownership | 53 | 3.3% |

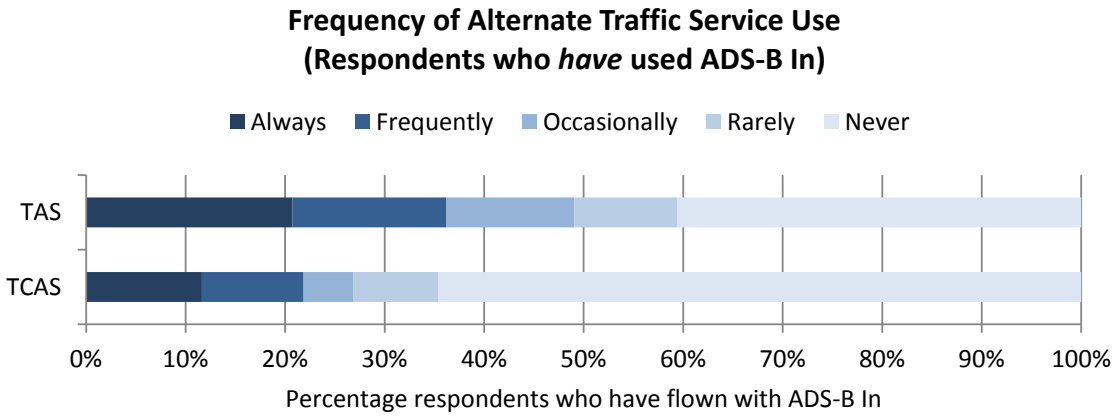
## When Respondents Began Flying with ADS-B In

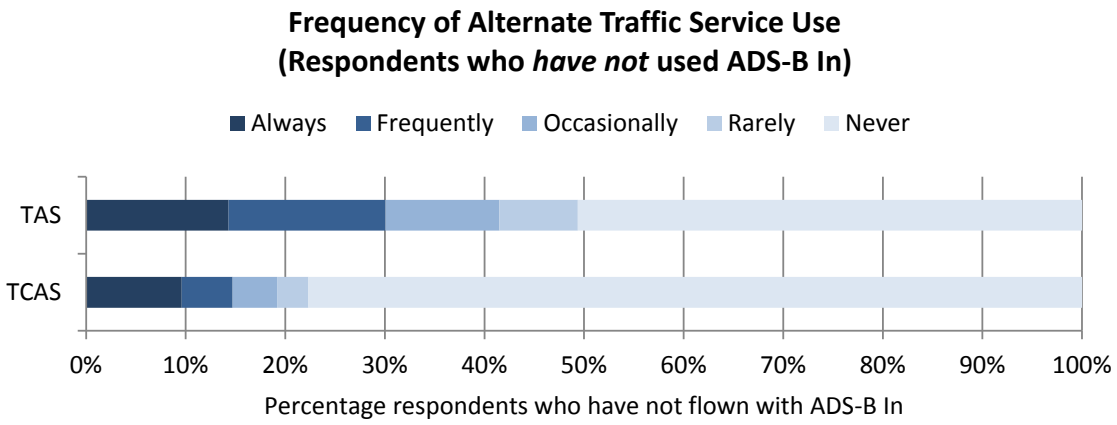


## Pre-flight Sources of Information




## List of alternate traffic services used (not including ADS-B)

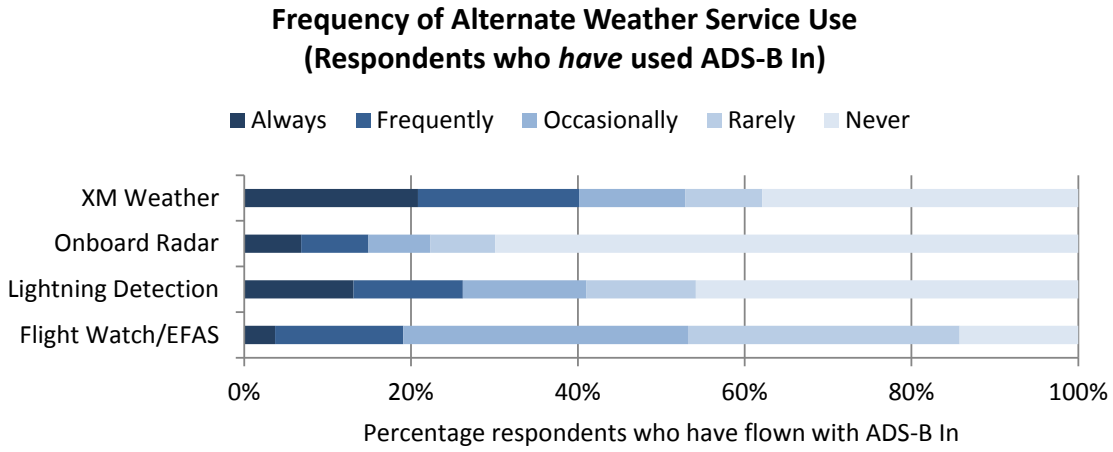


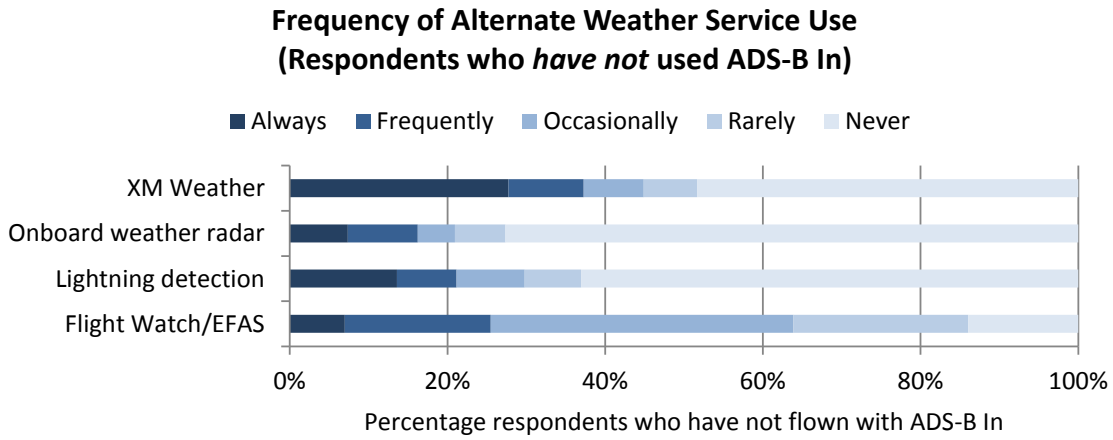



"Other" Services Used:

- Airborne Identify Friend or Foe (IFF)
- Eyes
- FLARM
- L-3 Avionics SkyWatch
- Monroy ATD-300 Traffic Watch
- Naval Air Craft Collision Warning System (NACWS)
- Proximity Warning Device (PWD)
- Ryan Traffic Collision Avoidance Device (TCAD)
- Traffic Information Service (TIS)
- VFR Flight Following
- Weapon Fire control radars
- Zaon Portable Collision Avoidance System (PCAS)/Traffic Proximity Alert System (TPAS)

## List of alternate weather services used (not including ADS-B)

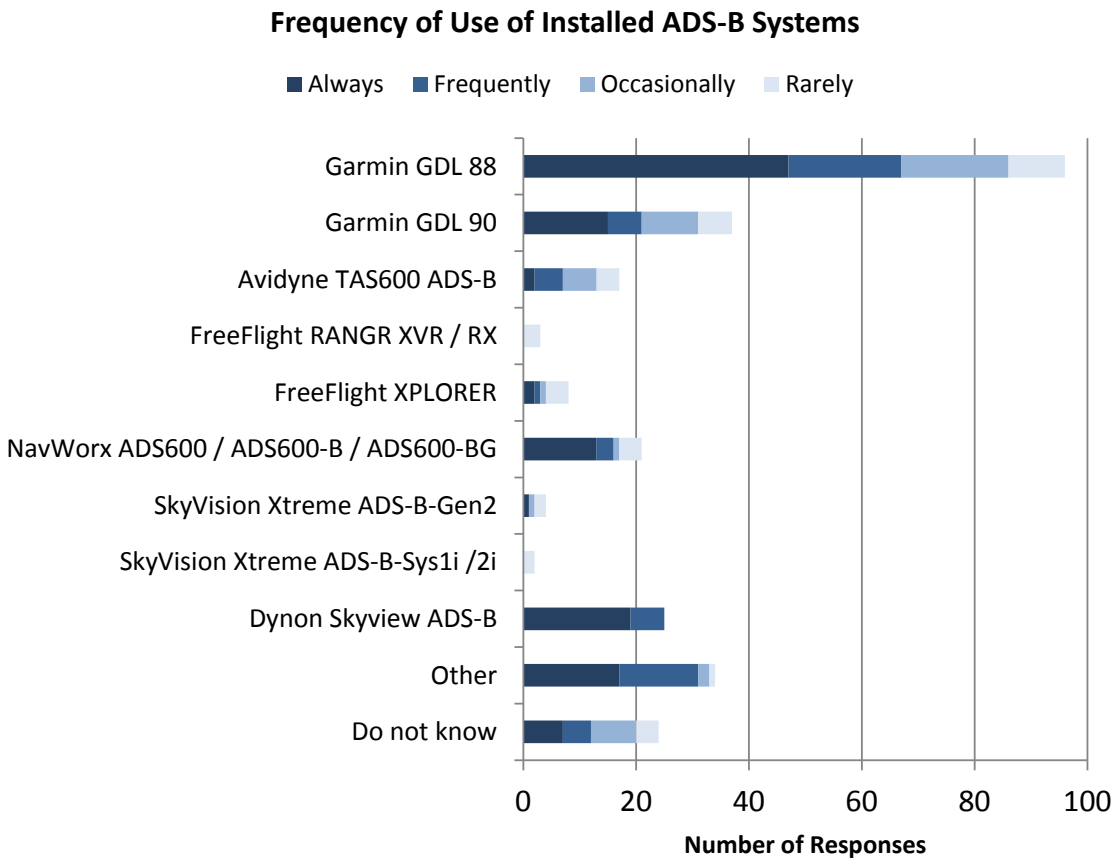



"Other" services used:

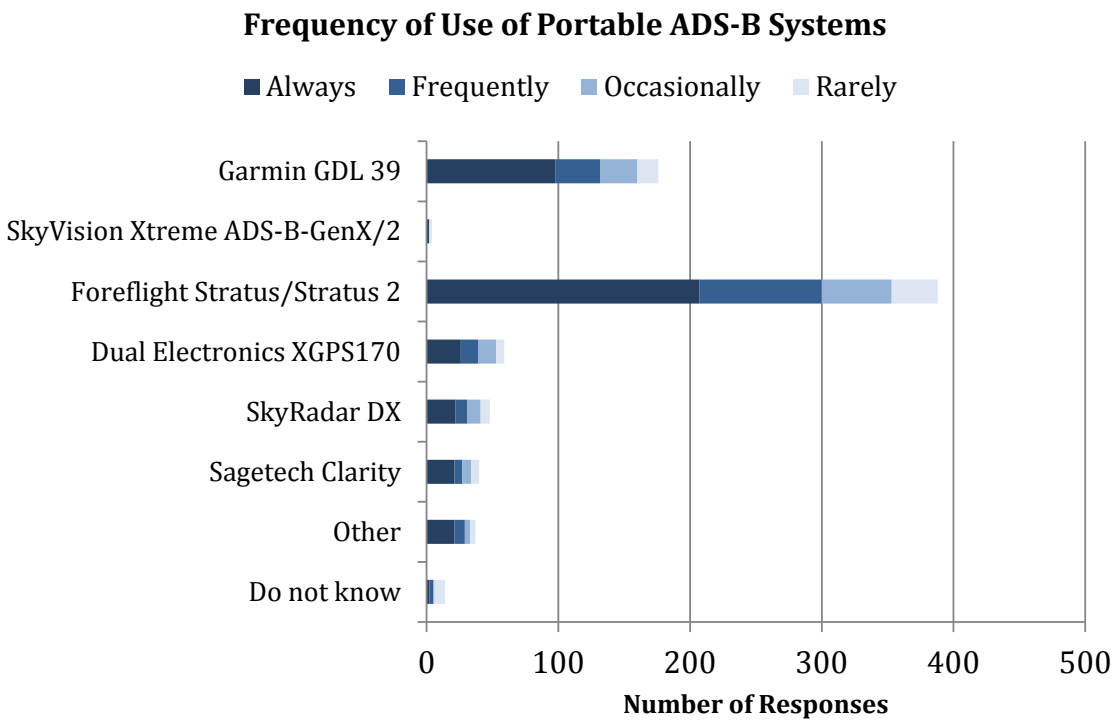
- Airborne Flight Information System (AFIS)
- Alaska flight service
- ATC weather advisories
- ATIS, AWOS, ASOS en-route by VHF radio
- Cloud tops info w/ icing detection
- DUATS
- FSS Briefing
- Hazardous Inflight Weather Advisory Service (HIWAS)
- METARs on G-1000
- MyRadarPro
- NOAA Aviation Digital Data Service (ADDS)
- Tablet/phone w/ cell signal, no ADS-B (Foreflight, Garmin Pilot, Etc)
- Visual monitoring of wx inflight
- The Weather Channel
- Weather displays in company operations centers
- Weather Services International (WSI) Inflight
- Weather websites via airborne WIFI
- Weather website before flight

## ADS-B Equipment Models




List of “other” installed systems used:

- 2004 Capstone II system
- Chilton
- Collins ADS-B Out
- Dual 170/GRT Sport EFIS
- Dynon Skyview/SV-ADSB-470/SV-XPNDR-261
- FLARM
- Flight Data Systems Pathfinder_R
- Garmin G1000
- Garmin GDL 39 as a permanent installation
- Garmin GTN 750 w GX 35 Transponder
- Garmin GTS800
- Garmin GTX 330 ES
- Gmx 200
- gtx3300 and Garmin 400W
- PowerFLARM Core
- Radenna Skyradar
- Radenna Skyradar D2
- Sky Guard TWX
- Skyguard ADS-B In/out
- SkyRadar
- SkyRadar for in and Trig TT31 for Mode S out
- Strauss ll
- Trig TT31 1090ES out with TIS in




List of "other" portable systems used:

- AnyWhere Map / XM
- Clarity SV
- Dual GPs 170
- FLARM
- Flight Data Systems Pathfinder
- FreeFlight with WingX
- Garmin 496
- Garmin 696
- Garmin Pilot
- iFly/SkyRadar-L
- iLevil
- PADS WXBOX
- PowerFlarm
- SkyguardTWX ADS-B in-out
- SkyRadar (1st gen)
- SkyRadar D2
- SkyRadar Dual band
- SkyRadar L
- Voyager by Seattle Avionics
- Wing X
- Wing-x by Hilton with nexrad
- WingXPro
- Zaon XRX
- ZAON XRX w/MX1090

## Details on ADS-B Use in Primary Aircraft

Respondents were asked about the make/model aircraft with which they primarily used ADS-B services. The data for the 792 respondents who had used ADS-B is provided below.

| Aircraft | Number of Responses | Percentage of Responses |
|---|---|---|
| Piston Single | 576 | 72.7% |
| Experimental | 78 | 9.8% |
| Piston Twin | 40 | 5.1% |
| Corporate | 17 | 2.1% |
| Helicopter | 11 | 1.4% |
| Airliner | 6 | 0.8% |
| Did not answer | 64 | 8.1% |

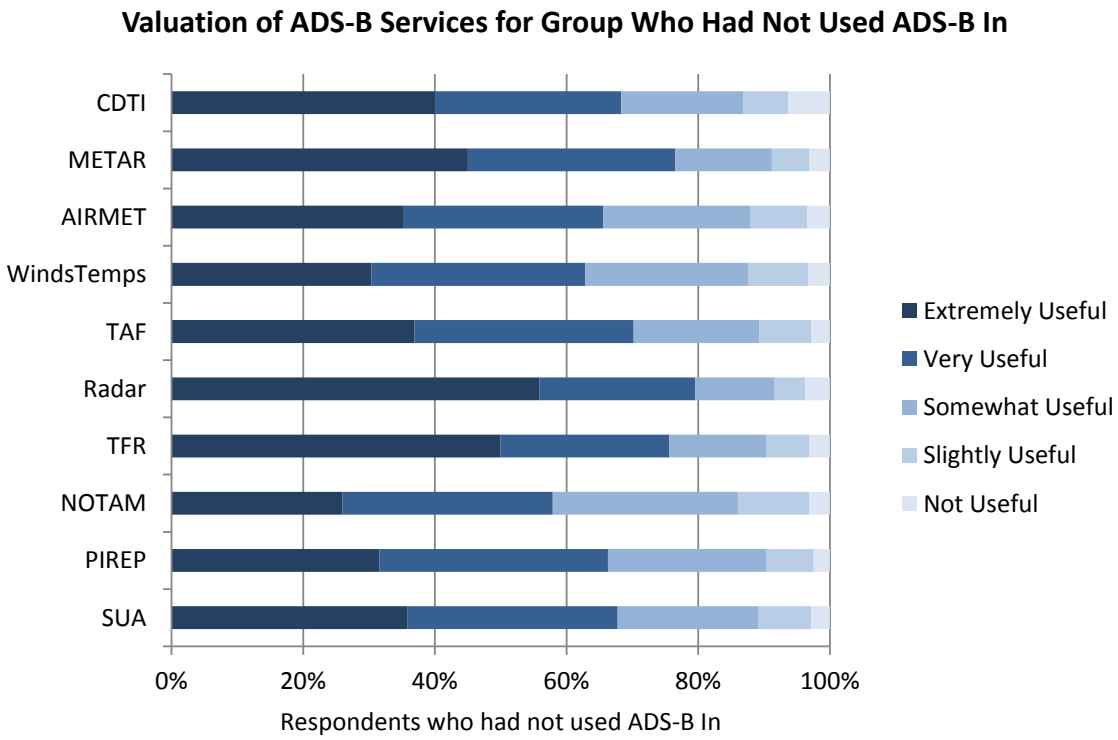
Respondents were then probed regarding what kind of system they use when they fly the aircraft reported above. The data for the 792 respondents who had used ADS-B is provided below.

| System | Number of Responses | Percentage of Responses |
|---|---|---|
| Portable | 581 | 73.4% |
| Installed | 159 | 20.1% |
| Do not know or left blank | 84 | 10.6% |

Finally, respondents were asked what display device they use when they fly that aircraft. The data for the 792 respondents who had used ADS-B is provided below.

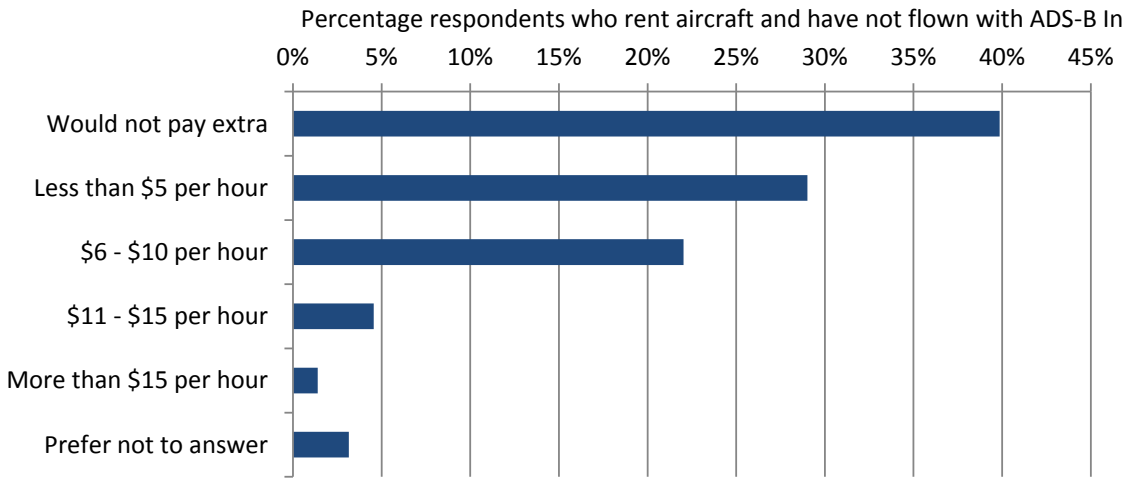
| Display Device | Number of Responses | Percentage of Responses |
|---|---|---|
| Apple tablet or phone | 516 | 65.2% |
| Android tablet or phone | 41 | 5.2% |
| Other tablet, phone, or EFB | 42 | 5.3% |
| MFD or other installed display | 149 | 18.8% |
| Did not answer | 51 | 6.4% |

## Valuation of ADS-B In Services (Have Not Used ADS-B In)

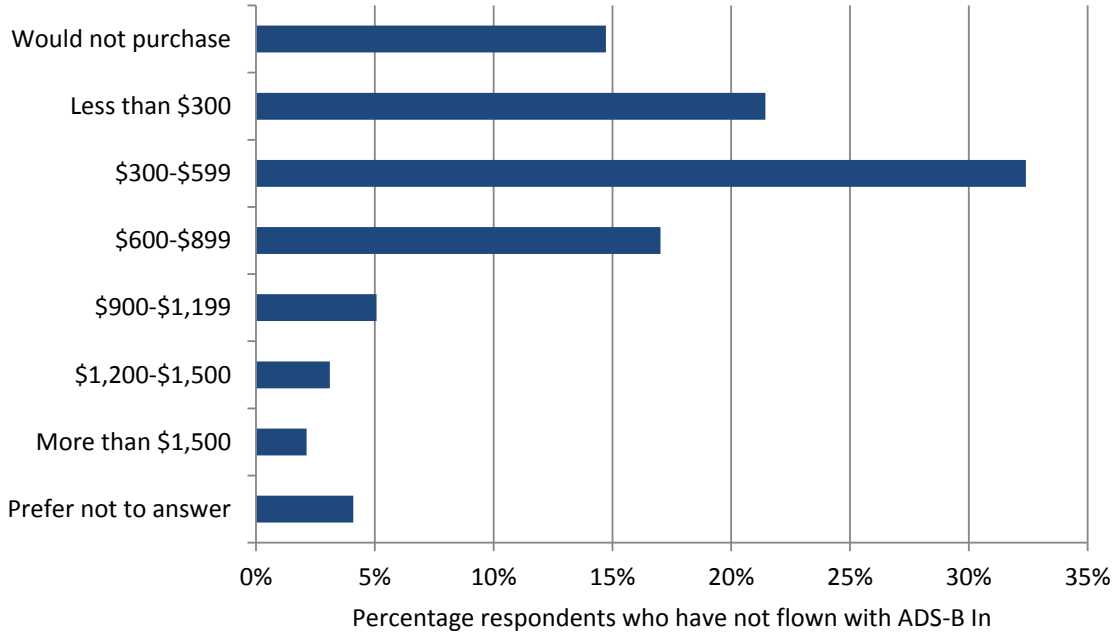


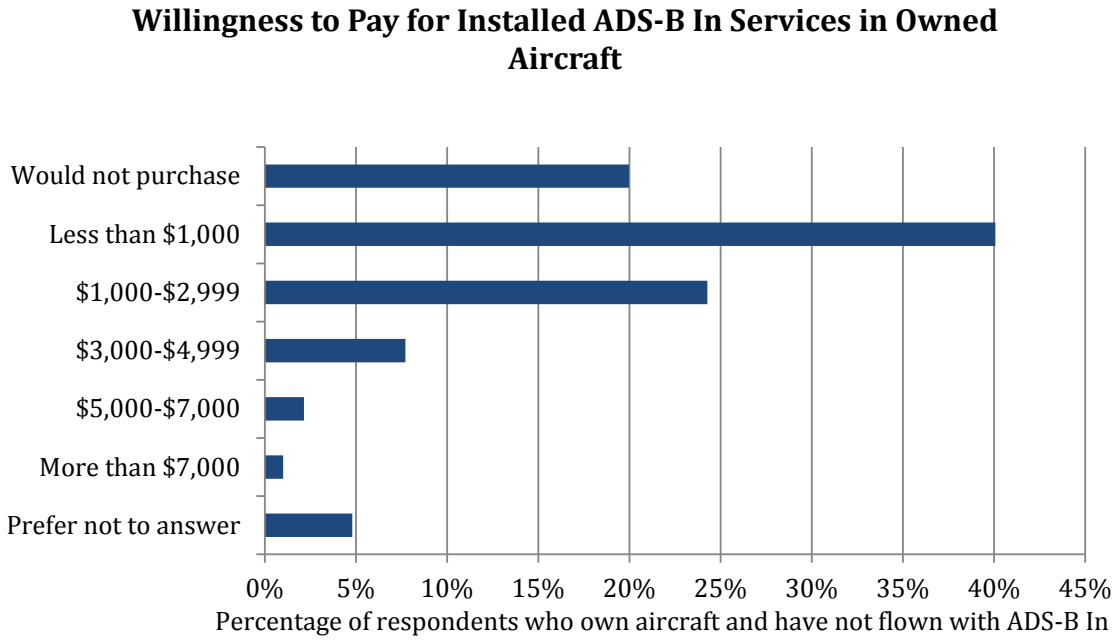
## Willingness to Pay for ADS-B In Devices

**Willingness to pay (per hour) for Installed ADS-B In Services in Rental Aircraft**




**Willingness to Pay for a Portable ADS-B In System (Not Including Tablet)**






## ADS-B Weather: Impact on Go/No Go Decision