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Survey of Potential ADS-B Benefits for the Soaring Community

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As part of the FAA's plans for the modernization of the Air Traffic Control (ATC) system, Automatic Dependent Surveillance – Broadcast (ADS-B) will be the basis of the future surveillance system in the US and other countries worldwide. Since the benefit of ADS-B is co-dependent on the overall equipage of the nationwide fleet of aircraft, creating incentives for aircraft operators to equip with ADS-B is crucial.

Sailplanes are exempt from the US requirement to equip with ADS-B avionics by 2020. However, in light of recent mid-air collisions involving sailplanes, there is interest to determine how ADS-B could be used for the Soaring Community. In order to determine how ADS-B could be beneficial to the Soaring Community, an internet based survey of US sailplane pilots was conducted. 272 participants ranked thirteen ADS-B applications as low, medium or high benefit to the soaring community. The survey also collected information about the equipment currently present in sailplanes, the willingness to pay for new equipment and pilot background such as certification level and yearly hours flown.

All survey participants were sailplane pilots. Each of the 13 applications surveyed had at least 50% of the participants rank it as medium benefit or higher. Traffic information/conflict avoidance as well as Search and Rescue are among the application categories that are ranked the highest. Namely, the five applications that were ranked the highest are Airborne Conflict Management, Enhanced Visual Acquisition, ADS-B Based Emergency Locator Transmitter (ELT), Traffic Information Service Broadcast (TIS-B) and Improved Search and Rescue. Applications that were ranked lower are applications that provide additional flight information or that are specific to air traffic control. Of the survey participants, 53.8% were willing to pay between $1000 and $3000 for new equipment while 43.8% were willing to pay less than $1000. Current ADS-B avionics prices begin at $5000. Since the certification of ADS-B avionics is a major cost driver, one way to reduce cost would be to lower the certification standards for sailplane ADS-B avionics.

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Nomenclature

ADS-B	Automatic Dependent Surveillance – Broadcast	*FAA*	Federal Aviation Administration
FIS-B	Flight Information Service Broadcast	*SSA*	Soaring Society of America
TIS-B	Traffic Information Service – Broadcast	*VFR*	Visual Flight Rules

I. Introduction and Background

A. Automatic Dependent Surveillance – Broadcast (ADS-B)

As part of the FAA's plans for modernization of the Air Traffic Control (ATC) system, Automatic Dependent Surveillance - Broadcast (ADS-B) will be the basis of the future surveillance system in the US, supplemented by the current Radar system. In 2010, the FAA published a rule that requires any aircraft operating in certain airspace after 2020 to be equipped with ADS-B avionics.[7] Much of the benefit delivered from ADS-B is dependent on the overall equipage of all the aircraft in the airspace system. Unless a majority of aircraft transmit ADS-B, ATC will have to continue using Radar surveillance. Also, benefit from aircraft-to-aircraft ADS-B applications would be reduced. Therefore, creating incentives for aircraft operators to equip with ADS-B is crucial.

To achieve early benefit from ADS-B, aircraft have to be equipped with ADS-B avionics *as well as* the navigation system that provides the information to be broadcast via ADS-B. For operators to equip early and voluntarily, the benefit received from the system has to be equal or greater than the cost of the equipment. Therefore, implementing elements of the system that are of high benefit can create incentives for users to equip voluntarily and early.

B. ADS-B and the Soaring Community

The FAA does not require sailplanes to carry transponders. Correspondingly, sailplanes will also be exempt from the requirement to equip with ADS-B avionics. However, in light of recent mid-air collisions that involved sailplanes, interest exists to determine how ADS-B could potentially be used by the soaring community. One example of such a mid-air collision is the collision above Minden, NV, where a Hawker business jet collided with an ASW-27 at 11,000ft. In response to this accident, the NTSB made the following recommendations to the FAA:

> "Remove the glider exemptions from the Federal Aviation Regulations that pertain to transponder requirements and use. (A-08-10)
>
> Establish a national transponder code for glider operations, as low in the transponder code range as feasible, that would notify air traffic controllers of glider operation/position. (A-08-12)
>
> Upon establishment of a national transponder code for glider operations, as per Safety Recommendation A-08-12, ensure that air traffic control personnel are informed of the code, what it represents, and under what limitations the users are typically operating. (A-08-13)"[8]

If sailplanes were equipped with transponders, aircraft that have TCAS would receive traffic and resolution advisories (TA's and RA's) in case of a predicted conflict. Partially due to the cost of the technology, TCAS is currently only present on commercial aircraft and some high-end GA aircraft. A lower cost solution that has been introduced in Europe, New Zealand and other parts of the world is FLARM. A proprietary technology, FLARM uses an integral GPS and barometric sensor to determine position and altitude then broadcasts that information in addition to a predicted future 3D flight path. FLARM uses a different frequency than transponders or ADS-B and can thus only work between appropriately equipped aircraft. Nonetheless, the low cost and low power draw of a FLARM system makes it a very attractive option for sailplane pilots. If the soaring community were to adopt FLARM as the standard, ATC or other aircraft would not be able to "see" those targets while sailplanes would not be able to "see" ADS-B or transponder

equipped aircraft. As mentioned, ADS-B will be the primary surveillance technology for powered aircraft by the end of this decade. Any aircraft equipped with ADS-B avionics will be able to transmit ADS-B messages that can be used by ATC on the ground as well as other aircraft to perform ADS-B applications, including traffic alerting.

If ADS-B avionics are installed in sailplanes, an element in the transmitted ADS-B message uniquely identifies the sailplane as such. This capability could be used to meet NTSB recommendation A-08-12. Since many sailplanes do not have an electrical system and have small cockpits, any potential ADS-B avionics would be required to be small in size as well as have a low power draw. Also, the lower the cost, the more likely an operator is to invest in the technology. The cost of recently announced ADS-B avionics for powered aircraft is estimated to begin at $5000 (installed) and increases depending on additional functionalities. Such avionics are certified to FAA standards DO–260B or DO-282B. Certain performance levels are then set by the ADS-B rule published in 2010.[7] These certification standards are driven by IFR operations and assume a power system is available in the aircraft. Since most soaring operations take place in VFR conditions, performance and power requirements of such avionics are not well suited for a sailplane.

One possible way of reducing the size, cost and power draw of avionics is to implement ADS-B avionics that are certified to lower standards (such as lower transmission power or GPS integrity). For example, each ADS-B avionics system uses a navigation unit that provides the position information as well as the integrity of that information. This navigation unit is a main driver for the cost; reducing the integrity requirement of the navigation unit reduces it's cost significantly and has the potential to reduce the power draw as well. However, under the current implementation of the overall ADS-B system, aircraft that transmit position information that does not meet the integrity standards will not be tracked by the system. As a result, in order to get the full benefit, the development of low cost, low power avionics for the sailplane community would have to be accompanied by the introduction of a VFR sailplane tracking mode for ADS-B avionics as well as ATC (as recommended by the NTSB). Additionally, as ADS-B applications and their procedures are developed, consideration needs to be given to how such targets would interact with and be used by ADS-B applications onboard other aircraft.

In light of this, the work presented here identifies what applications are of interest to the soaring community. Implementing these applications has the potential to create incentives for the soaring community to equip with ADS-B.

II. Methodology

In order to evaluate which ADS-B applications are most beneficial to the soaring community and how willing the community is to adopt this new technology, a survey was created to collect pilot input. First, applicable ADS-B applications were identified.

A. Identifying Applicable ADS-B Applications

An ADS-B application is a functionality in the National Airspace System (NAS) that is enabled by ADS-B. ADS-B applications are the primary means by which the system delivers benefit to the operators. Based on a literature review, 41 applications were identified.[5] Documents included in the literature review were references 1-4. From the perspective of the glider community, however, many of those applications were not applicable and therefore omitted (such as ADS-B based high altitude flow corridors). Also, far term applications (planned for 2025 and after) were omitted. This resulted in a list of thirteen applications listed below. In the list, each application is identified as being a Traffic Awareness (T), a Search and Rescue (S&R), Air Traffic Control (ATC) or Information Application (I):

ADS-B Based Emergency Locator Transmitter (ELT) The ADS-B message has the capability to transmit a "Downed Aircraft" message. This could double as an ELT functionality. (S&A)

ADS-B coordinated cross country flying When flying cross country in a group of multiple sailplanes, ADS-B could enable better coordination between the pilots. As such, ADS-B could be used to mark or communicate locations of good lift, way points, etc. (I)

ADS-B enhanced close proximity operations When multiple aircraft are operating in a confined space (such as a narrow thermal), ADS-B could enable pilots to coordinate maneuvers safely. (T)

Airborne Conflict Management This application uses ADS-B traffic information to detect potential

threat aircraft. As an improvement over enhanced visual acquisition (described below), it could provide traffic advisories. (T)

ATC Surveillance in Non-Radar Airspace This application will provide ATC surveillance in non-Radar areas such as below current Radar coverage. Current radar procedures would be applied using ADS-B surveillance. (ATC)

Communication of in-flight weather to other aircraft or ground If aircraft are equipped accordingly, weather specific information via an electronic pilot report could be transmitted via the ADS-B message and thus, improving forecasting and preflight weather briefings to pilots. (I)

Enhanced ATC (Tower) Situational Awareness in Reduced Visibility Using ADS-B, a virtual image could be created to aid situational awareness for controllers at airports. (ATC)

Enhanced ATC Flight Following Due to the more comprehensive coverage and the increased surveillance quality of ADS-B surveillance, ATC will be able to better advise pilots of nearby traffic, minimum safe altitude warnings (MSAW), etc. (ATC)

Enhanced Visual Acquisition Using a CDTI (Cockpit Display of Traffic Information), ADS-B information from other aircraft as well as TIS-B (described below) is displayed in the cockpit and used to detect and track aircraft more effectively in visual conditions. (T)

Flight Information Service Broadcast (FIS-B) Using ADS-B In, flight relevant information such as current weather, NOTAM's and TFR's are linked from the ground directly to the cockpit and displayed on a CDTI. This results in Enhanced Weather Situational Awareness as well as Enhanced Airspace Status Situational Awareness. Conceivably, this datalink could be used as a secondary means of communicating emergency information in case of VHF outage. (I)

Improved Flight Tracking (club specific, online, race tracking, etc.) Current flight tracking is limited to areas with ATC Radar coverage and often VFR targets are not available. ADS-B would enable clubs to keep track of their aircraft, display flight information online, improve real time race tracking, allow operators or companies to improve their fleet scheduling, etc. (I)

Improved Search and Rescue Flight Track data serves as an input to search and rescue operations. ADS-B has a better accuracy of the last known position, a higher update rate and historical track and would thus enable more efficient and more accurate responses to emergency situations. (S&R)

Traffic Information Service Broadcast (TIS-B) Using ADS-B In, traffic information is linked directly to the cockpit from the ground. This traffic information is in addition to the ADS-B messages received directly from other ADS-B aircraft – it contains traffic targets that were determined using ground Radar. This traffic information can then be displayed on the traffic display (CDTI). (I)

B. Online Survey

In order to gather input from the soaring community on these applications, an online survey with three sections was created. The first section contained an introduction to ADS-B to ensure that all participants were answering the questions in the survey based on the same knowledge. Second, the ADS-B applications were introduced and the participants were asked to rank the potential benefits of each application. In giving their rankings, they were asked to consider safety, efficiency, financial, and other operational benefits to themselves or the sailplane community as a whole. The ranking scale was a five point scale where 1 was low benefit, 3 was medium benefit and 5 was high benefit. 2 and 4 were for "low to medium" or "medium to high", respectively. Participants were also asked how much they would be willing to pay for this equipment and were given a field where they could suggest other potential ADS-B applications. In the last section, the participants were asked to anonymously provide information about their background and flying activity as well as any other comments they might have. Figure 1 shows a screenshot of the application ranking section.

The link to the survey was published via the Soaring Society of America's (SSA) online newsletter on March 15th. It was also advertised at the beginning of April 2010 in the monthly magazine of the SSA. A later invitation was sent out to the national headquarters of the Civil Air Patrol where it was forwarded to its glider wing.

1. Traffic Information Service Broadcast (TIS-B)

Description:
Using ADS-B In, traffic information is linked directly to the cockpit from the ground. This traffic information is in addition to the ADS-B messages received directly from other ADS-B aircraft -- it contains traffic targets that were determined using ground radar. This traffic information can then be displayed on the traffic display (see Figure 1).

- 1 - Low Benefit
- 2
- 3 - Medium Benefit
- 4
- 5 - High Benefit

Figure 1: ADS-B Traffic Display

Figure 1. Screenshot of application ranking section in survey

III. Participant Background

Over a period of three months (March 15th until June 15th, 2010), 272 individuals responded to the survey. Since participation was voluntary, the participants are more likely to have an interest in ADS-B than the general soaring community which may influence the results. Some participants ranked the ADS-B applications but provided incomplete or no information about their flying background. While their rankings were used during the application analysis, their responses were removed for the analysis of the background. As a result, the background information is based on 266 responses. The certifications of the pilots are shown in Table 1.

Table 1. Pilot Statistics: Certificates

Certification	# of Participants	Certification	# of Participants
Student Pilot	2	CPL	115
Sport Pilots Certification	3	CP+Instrument	49
PP + Glider only	63	ATP	32
PP	115	CPL + CFI	56
PP + Instrument	18	ATP + CFI	24

A large percentage (55%) of the participants have certifications that are more advanced than the Private Pilots License. This indicates that the participants were some of the more trained and experienced individuals of the soaring community. This same pattern is also noticeable in Table 2 which shows the statistics of the

participants' operations. Many participants fly in excess of 100 hours per year while using high performance gliders (L/D > 30). As a result, some care needs to be taken when extrapolating these results to the whole of the soaring community.

Table 2. Operation Statistics: Average Yearly Hours, Flying Environment and Type of Glider

	Hours
Average Yearly Total	140.2
Median Yearly Total	100.0
Average Yearly Sailplane	79.0
Median Yearly Sailplane	60.0
Type of Flying Environment	**Percentage**
Training	42.7%
X-Country	44.3%
Competition	10.0%
Wave	3.2%
Type of Glider	**Percentage**
L/D<30	21.5%
L/D>30	72.6%
Motorglider	8.4%

Table 3 shows the equipment that the participants have on the sailplanes they most often fly. They were asked to separately select the equipment that is present on the best equipped as well as the least equipped aircraft. The numbers in the columns represent the percentage of aircraft that were indicated to have the specific equipment. 14.2% said that they only fly one aircraft.

Table 3. Average equipage of low and high end sailplanes

	Best Equipped Aircraft	**Least Equipped Aircraft**
Altimeter	100.0%	80.2%
Airspeed Indicator	100.0%	80.5%
Compass	97.6%	74.9%
Variometer	99.3%	78.3%
Electrical System	77.9%	35.2%
Mode C Transponder	34.5%	7.1%
VHF Radio	95.5% (2% hand-held)	56.6% (20% hand-held)
GPS System	88.0% (37% hand-held)	12.0% (5% hand-held)
Flight Data Logger	74.5%	8.2%
Glide Computer	69.7%	4.5%

A follow up question to what the specifics of the electrical system were showed that most aircraft use an electrical system that has 8-10 A-hours and uses two 12V Batteries. Some have a third battery usually dedicated to a sole purpose (such as a transponder).

IV. Results

Figure 2 shows the benefit ranking of the 13 applications. In this figure, only the percentages for participant rankings of medium or higher are shown. The numbers in the bars represent the percentage that a given ranking was chosen by the participants for that application. For example, for the Airborne Conflict Management Application, 19% selected medium to high benefit. It can be seen that for every application,

at least half of the participants perceived it to deliver at least medium benefit. The five applications that had more than 80% of participants rank them as medium or high benefit are all either Traffic Awareness or Search and Rescue Applications. The rest of the applications are specific to flight information or ATC and not as directly tied to increasing flight safety. Also, the answers to the question of how much the survey participants would be willing to pay for this technology can be seen in Table 4.

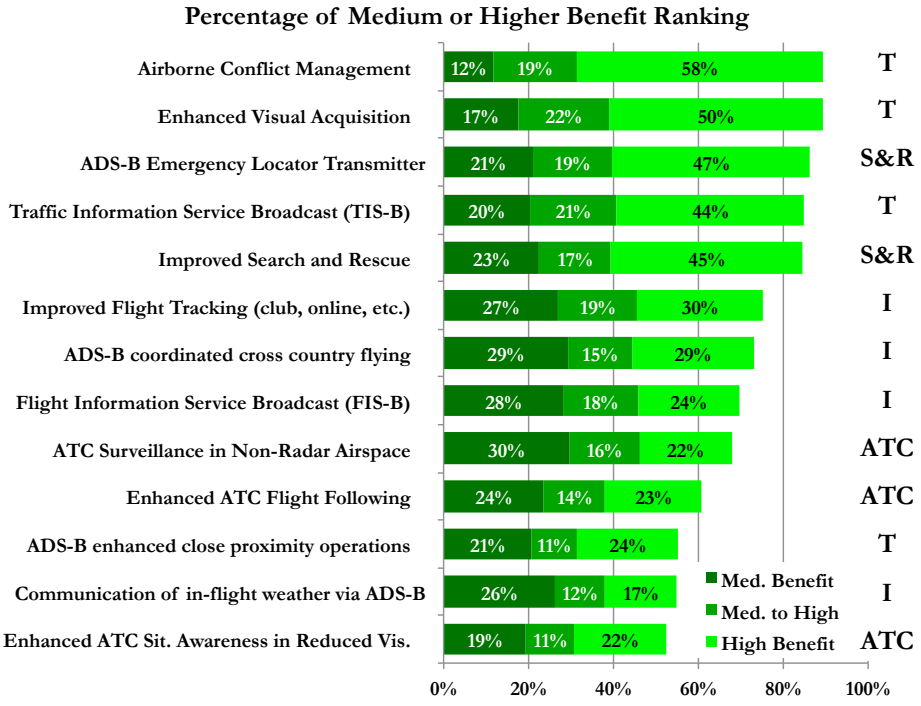

Figure 2. Percentage of participants that ranked the respective application at medium benefit or higher

Table 4. Willingness of survey participants to pay for ADS-B technology

Price Range	Percentage
Less than $1000	43.75%
$1000 to $3000	53.75%
More than $3000	2.5%

V. Discussion and Conclusions

Traffic information/conflict avoidance as well as Search and Rescue are among the application categories ranked the highest. Namely, the five applications ranked the highest are Airborne Conflict Management, Enhanced Visual Acquisition, ADS-B Based Emergency Locator Transmitter (ELT), Traffic Information Service Broadcast (TIS-B) and Improved Search and Rescue. Applications that were ranked lower are applications that provide additional flight information or that are specific to Air Traffic Control. Also, judging from the written comments, the majority of participants are in favor of introducing ADS-B to the soaring community and see it as a potentially large benefit.

Looking at the willingness to pay, an interesting finding was that the majority of participants had a willingness to pay $1000 to $3000 for ADS-B equipment. The researchers had expected the participants to strongly favor the"Less than $1000" category. Nonetheless, the range of current ADS-B avionics for powered

aircraft begins at $5000 and is thus still higher than the willingness to pay of the survey participants.

Therefore, In order to achieve wide-spread acceptance of ADS-B avionics in the soaring community, low cost ADS-B avionics are required. As mentioned, integrity requirements for the navigation units in powered aircraft were set for IFR flight operations and have a large impact on cost. Since sailplanes operate mainly in VFR conditions, one possible way of reducing the cost as well as the size and power draw of avionics is to implement ADS-B avionics that are certified to lower standards. The ADS-B message already has the capability to identify sailplanes as such, thus communicating to ATC and other aircraft that it might be using a system with different levels of integrity, as recommended by the NTSB (A-08-13). Also, glider operations most often take place in VFR weather conditions – this allows other aircraft to verify position information received via ADS-B using standard visual scanning techniques.

Compared to FLARM, using ADS-B for sailplanes has an additional benefit that it would introduce them to the same link as other NAS users. FLARM uses a different frequency than transponders or ADS-B and can only work between appropriately equipped aircraft. Since ADS-B will be the standard NAS wide by the end of this decade, equipping sailplanes with ADS-B can improve safety among sailplanes as well as between sailplanes and powered aircraft.

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