PRELIMINARY ANALYSIS OF POTENTIAL ADS-B USER BENEFITS FOR HAWAIIAN HELICOPTER AIR TOUR OPERATORS

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Motivation

In response to the September 24, 2004 crash of a Bell 206B helicopter being operated under CFAR Part 91 by Bali Hai Helicopter Tours, Inc on the island of Kauai in Hawaii the National Transportation and Safety Board (NTSB) issued nine recommendations to the Federal Aviation Administration (FAA). [1] Several of those recommendations relate to Automatic Dependent Surveillance-Broadcast (ADS-B) technology including:

> *Accelerate the implementation of automatic dependent surveillance-broadcast (ADS-B) infrastructure in the State of Hawaii to include high-quality ADS-B services to low-flying aircraft along heavily traveled commercial air tour routes.* (A-07-25)

ADS-B ground infrastructure is currently planned to be installed in Hawaii between 2010 and 2013 as part of the National Airspace System (NAS) wide implementation of ADS-B. Current plans call for ADS-B coverage to be focused on areas of existing radar coverage. However, a large majority of the commercial air tour routes are conducted in regions outside of existing radar coverage due to mountainous terrain and limited radar facilities. The NTSB recommendation would therefore require a change to the ADS-B implementation plans.

In addition the NTSB recommended mandating ADS-B equipment for air tour operators:

> *Require that Hawaii air tour operators equip tour aircraft with compatible automatic dependent surveillance-broadcast (ADS-B) technology within 1 year of the installation of a functional National ADS-B Program infrastructure in Hawaii.* (A-07-26)

This would also require a change in ADS-B implementation. Currently, the FAA does not plan on mandating ADS-B out equipage until around 2020, and then only in class A, B, and C airspace. In Hawaii, only Oahu and Maui have class B or class C airspaces, thus many air tour operators would not be required to equip with ADS-B out under the existing plan.

An alternative approach to address the NTSB recommendations outside an early mandate would be to establish a Memorandum of Agreement (MOA) similar to that currently established for the Gulf of Mexico with Helicopter Association International (HAI). The MOA established a collaborative agreement, where the FAA will provide ADS-B ground infrastructure and separation services for offshore helicopters, while the HAI operators agreed to equip their helicopters and grant use of off-shore oil platform space for ADS-B equipment. If a similar agreement could be reached between the FAA and Hawaiian air tour operators, the ground infrastructure could be in place and operators equipped sooner than 2020, and the ADS-B implementation could attempt to provide focused benefits for Helicopter air tour operators.

The objective of this study is to identify helicopter air tour operator requirements and potential ADS-B applications which would provide user benefits sufficient to justify early equipage with ADS-B technology. In order to identify user requirements a series of focused interviews, surveys and a flight observation were conducted during a joint FAA / HAI Helicopter Air Tour safety summit in Honolulu on May 22-23, 2007.

Method

User input was obtained through a survey instrument and focused interviews with participants in the Joint FAA / HAI Helicopter Air Tour safety summit.

The conference was attended by over 50 representatives from 19 Hawaiian air tour operators, representing a significant majority of the helicopter air tour operators in Hawaii (80% of the operators listed on the Hawaii Visitors and Convention Bureau website [2] attended, plus an additional 9 operators). The participants consisted of Chief Pilots, Directors of Operations, Maintenance Directors, Presidents, and CEOs.

ADS-B was briefed to the participants by the FAA Surveillance Broadcast Systems program office. In conjunction with the briefing, written surveys were distributed to the air tour operators. A copy of the survey instrument is presented in Appendix 1. Surveys were completed by 44% of the Hawaiian helicopter air tour operators in attendance as well as two surveys completed by fixed-wing air tour operators in Hawaii, and one completed by a Hawaiian FSDO inspector who is also a commercially rated helicopter and fixed-wing pilot.

Focused interviews were conducted with sixteen representatives of air tour operators using the interview question protocol in Appendix 2 as a guide. Due to intensive nature of the summit and the limited time to interview many of these interviews were conducted in groups. As part of the interviews, operators were asked to trace their typical flight routes on FAA sectional charts. A compilation of these sketched routes can be found in Appendix 3.

In total, feedback was collected from 84% of the Hawaiian air tour operators present at the safety summit. The survey and interview participants are listed in Appendix 4.

In order to assess operational considerations, a site visit and flight observations were conduced during a typical air tour flight around the island of Oahu. The flight was conducted on an Aerospatiale AS350BA "A-Star" helicopter, operated by Makani Kai Helicopters departing from Honolulu International Airport (Figure 1). During this site visit additional input was solicited from the president and operations manager. The flight route was typical of a normal tour and is shown in Figure 2.

Figure 1: AS350 Helicopter Operated by Makani Kai Helicopters

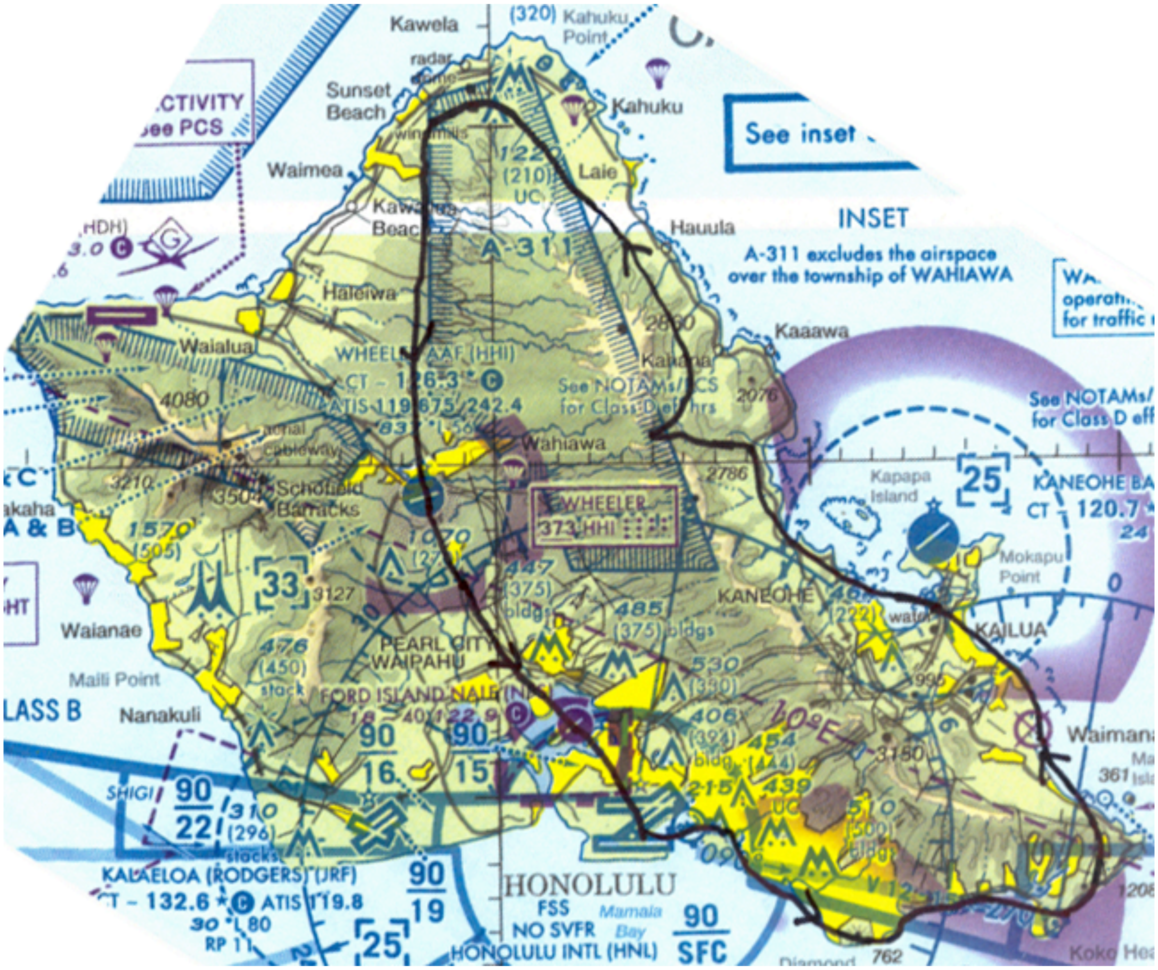

Figure 2: Standard Oahu tour route flown during the observational flight

Operational Environment

Air tour operators in Hawaii conduct their business in a unique operating environment, based on details obtained during the interviews and field observations. The air tours usually consist of flights of fifteen minutes to an hour, departing and arriving from the same airport or heliport with upwards of 6 passengers. The tours are conducted primarily in Aerospatiale ES350 "A-Star" and Bell 206 single turbine helicopters, however at least one operator uses piston powered R44s and another uses Augusta A109 twin turbine engine helicopters.

The tours are conducted over the coast, over mountainous terrain, and in small canyons. A sample route map for the island of Kauai can be seen in Figure 3. A complete set of maps for routes flown by the interviewees is in Appendix 3. The operators must also deal with the low clouds and rain which are common with the Pacific trade-wind driven weather patterns on the Hawaiian Islands, where moist air from the ocean is driven up the windward slopes creating a cloud layer below a larger scale temperature inversion. [3] This causes larges amounts of rain in some areas of the islands, with the rainiest part being Mt. Waialeale on Kauai with an annual average rainfall of about 450 inches. This contrasts greatly with the leeward coasts and high slopes which can see an annual rainfall of less than 10 inches.

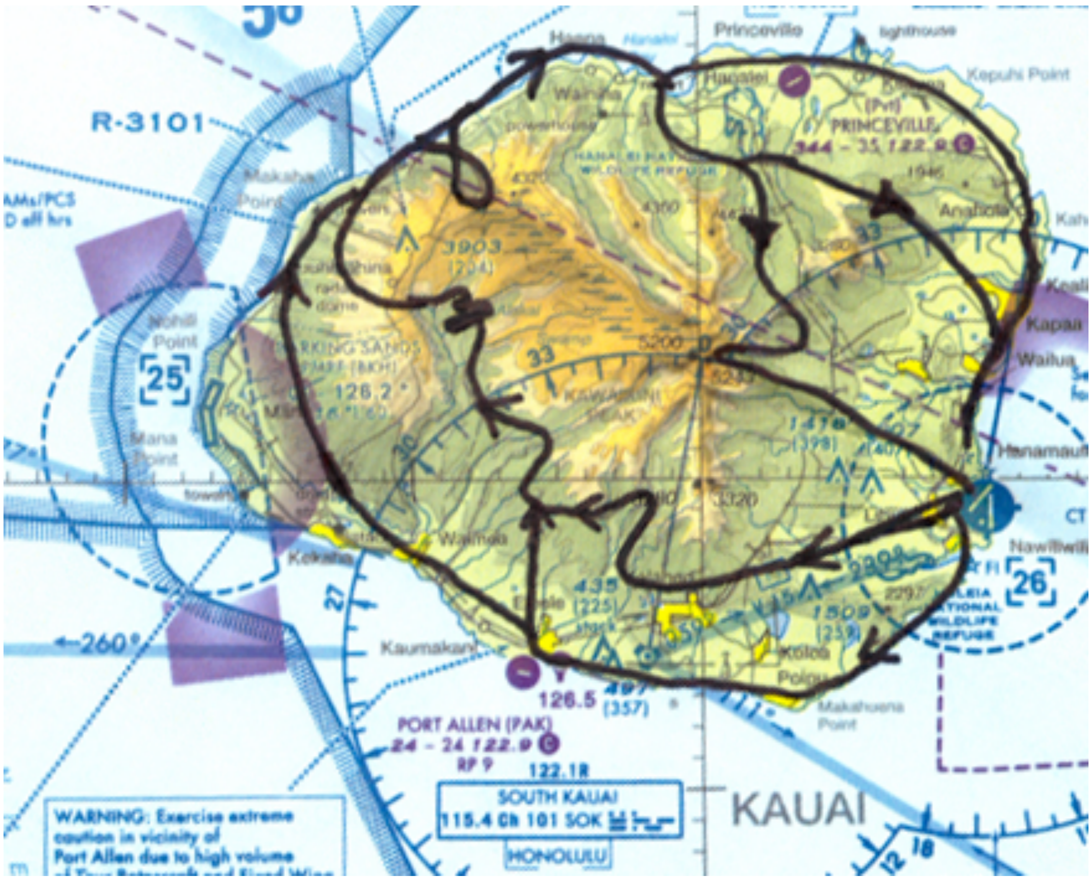

Figure 3: Variety of air tour routes on Kauai. The coastal routes are used during periods of low ceilings, while the inland routes are preferred.

Compounding the weather impacts on Hawaiian helicopter operators is the minimum altitude restriction placed on Hawaiian air tour operators under CFAR Part 136 Appendix A (formally SFAR 71). This restriction, in effect since 1996, restricts air tour operators to a minimum altitude of 1500 feet, as opposed to the standard minimum altitude of 300 feet for Part 135 helicopter operators (CFAR 135.203 b). While the full grounds for this rule creation were not investigated, anecdotal accounts indicate that it was driven by both safety and noise abatement concerns. This restriction limits the ability of tour operators to launch with low clouds. Unfortunately the 1500′ rule may actually increase noise impact since when the weather deteriorates, operators fly over the low, populated coastal areas.

Based on the interviews and comments during the safety summit question and answer period, most operators have FSDO-granted deviations from the 1500′

rule in certain places, allowing 1000′ or 500′ ground clearance. However, the standard is still 1500′ for non-scenic segments of the route.

The NTSB has concerns that the "SFAR 71 altitude restrictions may increase the potential for inadvertent encounters with could layers", yet the NTSB determined that there is not enough data to asses the significance of this relationship. One operator noted that there have been 19 fatalities on the island of Kauai alone since the enactment of SFAR 71, and directly attributes them to the altitude restriction and the increased chance of VFR into IMC encounters. While this obviously stretches the diverse causes of the accidents, it illustrates the operators strong safety concerns with the 1500′ rule.

Survey Results

Benefits

In general helicopters air tour operators in Hawaii were receptive to the implementation of ADS-B technology in Hawaii, especially after they learned more about the technology. 100% of the survey respondents saw value in ADS-B services (question 7, Appendix 1), but 22% wrote that the benefits would be "limited" or "little."

Survey participants were presented with a list of potential applications to indicate if they would have "significant benefits", "limited benefits", "no benefits" from the given application for their operation considering financial, efficiency, safety, and other operational benefits. As can be seen in Figure 4, the applications with strongest benefits from surveys, with 44% or more of the respondents indicating significant benefits, are Company Flight Tracking, Increased VFR Flight Following, Enhanced Visual Acquisition, Cockpit Assisted Visual Separation (CAVS), and Cockpit Datalink Weather.

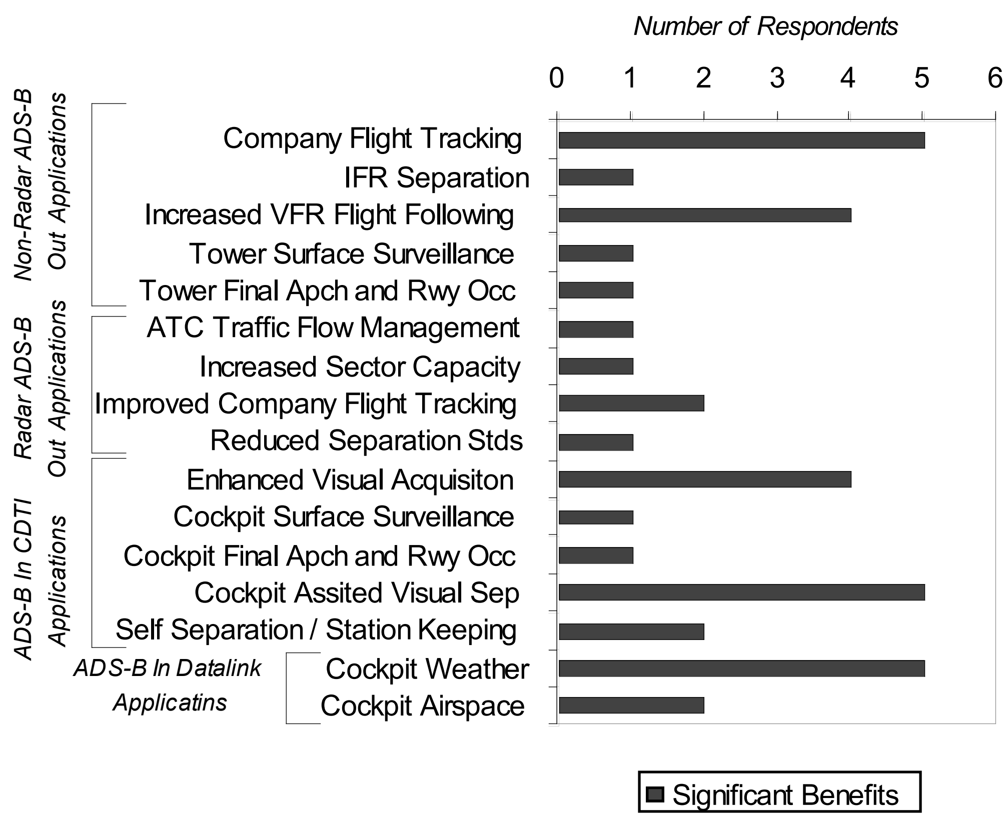

Figure 4: Survey results listing the number of respondents who marked significant benefits for each application

As expected, categories with IFR-only benefits, such as ATC traffic flow management and increased sector capacity, had little appeal to the helicopter air tour operators who operate in a VFR-only environment. Additionally, airport applications for surface surveillance or final approach awareness are of little use to helicopter operators.

In addition, when asked what other applications would provide benefits to the air tour operations, respondents listed NOTAMs via datalink, two way communications with the office (brought up by two survey respondents), make and model of aircraft ahead for wake turbulence (from a fixed wing operator), and tracking of aircraft for search and rescue and precautionary landings (brought up by both an interviewee and another operator during the open question and answer period). The communication and flight tracking applications are analyzed in detail below in the Primary Focused Interview Findings section.

Equipage

Approximately two thirds of operators have GPS equipped aircraft, but a majority of those are VFR panel mounted units. The helicopter used for the observational flight had VFR GPS, but it was not used at all by the pilot during the air tour. No operators currently have MFDs, EFBs, or datalink weather capabilities. Half of the operators have Mode-S transponders. Therefore, there is almost no latent capacity to equip with ADS-B technology, besides the possible upgrades to the Mode-S transponders for 1090-ES ADS-B out. Operators will need to equip with GPS receivers certified to IFR standards in order to meet the accuracy and integrity ADS-B performance requirements. Additionally, operators will need to install certified displays for ADS-B in applications.

When asked "What are the factors which would affect your decision to voluntarily equip with ADS-B or other avionics equipment?", 75% of the respondents for the question listed price or cost of avionics. In addition, 50% listed weight as a concern. Similar responses were given to the question, "What are the obstacles you see in equipping your fleet with ADS-B equipment?" Cost (66% or respondents), Weight (55% or respondents), and Panel Space (55% or respondents) were the key concerns. One participant wrote, "How much the pilot weighs is already an issue".

These concerns highlight the fact that operators will consider cost, size, and weight of avionics in addition to benefits when deciding whether or not to equip.

Other

A majority of the survey respondents projected that the number of air tour operations would continue to increase in Hawaii, agreeing with the NTSB statement that, "As Hawaii's air tour industry continues to grow, increasing numbers of aircraft will be flying over rugged, scenic terrain in a finite airspace." However, one operator noted that the number of passengers will always be finite and the air tour industry will reach a limit. Another commented that he wasn't sure the number of aircraft will continue to climb. This also conflicts with a statement by the president of a Maui-based tour operator, who wrote that the "numbers indicate air tour in Hawaii are on the decrease not growing." Finally, the owner of a seaplane business in Honolulu for many years indicated that there are a decreasing number of air tours in Oahu and fewer operators than 10 to 20 years ago. Further investigation is needed on the trends of the air tour industry in Hawaii.

Primary Focused Interview Findings

Based on the focused interviews, the following four findings were consistent across the all interviews and identified by at least 50% of the Hawaiian helicopter operators interviewed.

1. *Hawaii specific weather products.*

   Weather information is the greatest benefit of ADS-B technology cited by operators. One Director of Operations claimed that weather and lack of weather information are the leading causes of flight cancellations. This is consistent with the survey results, where all of the respondents found significant or limited benefits to cockpit weather information, with a majority selecting significant benefits.

   However, during the interviews it became apparent that the weather information needed by the helicopter air tour operators is not the same information needed for enroute fixed wing operations and reflected in the current ADS-B UAT datalink weather products. The METAR, TAF, and area forecast do not reflect the diverse and rapidly changing weather patterns in Hawaii. Radar and satellite images are useful for seeing approaching or building storms, but alone they do not provide enough data for a go/no go decision or in-flight decision making.

   Operators need to be able to identify weather around the corner and on the opposite side of an island, especially ceiling and visibility. Currently operators rely on sources outside of official National Weather Service products for obtaining weather information, obtaining a briefing from the flight service station, which usually consists of "VFR Not Recommended", as a formality. From the ground, the operators call civilians living or working in key sites to ask about cloud heights and visibilities in relation to known mountains and passes or call both military and civilian air traffic control towers to speak with the controllers about the current local weather.

Once airborne, pilots relay informal pilot reports (PIREPs) over the common traffic advisory frequency (CTAF), to other operators. However, these CTAF communications are limited to line of sight communication, so reports of weather on the other side of an island cannot be heard by the helicopters' base of operations or even from a helicopter on one side of a ridge to the other. This voiced based weather reporting system was observed during the observational flight, along with details of an operator ahead waiting for a pass to clear due to low clouds. The complex weather of the Hawaiian Islands was also observed on the flight, with some areas of Oahu covered with low clouds and rain (Figure 5) while others just a 15 minute flight away (about 15 nm) had only scattered clouds (Figure 6).

Numerous operators expressed interest in the possibility of weather cameras located in key sites for observing the weather. This came after a presentation at the air safety summit on the FAA's Weathercam project in Alaska, where low cost weather cameras have been placed at key sites such as passes across the state and the feeds are available free on the internet. Operators in Hawaii claimed that a similar system would be invaluable in Hawaii due to the quickly changing weather patterns and lack of weather reporting stations along the air tour routes. Operators also suggested that if feeds from these weather cameras could be made available to pilots in the cockpit through an ADS-B datalink, the pilots could make better decisions about when to continue a flight during marginal weather conditions. However, further research needs to be done to see if there is bandwidth available on an ADS-B datalink for transmission of images with sufficient resolution to identify ceilings and visibilities at the weather camera locations.

Figure 5: Low clouds and rain during the observational flight

Figure 6: Scattered clouds 15 minutes later and 15 nm away on the observational flight

2. *Voice communication enhancements installed with the ADS-B ground infrastructure would be beneficial.*

After weather information, the second most cited benefit of an ADS-B infrastructure by operators was the potential for enhanced communication coverage provided by ADS-B ground station installations. If ground stations were installed to cover the low level tour routes, communication equipment would also need to be installed to allow air traffic control (ATC) services.

Operators were less interested in talking with ATC as they were interested in extending CTAF VHF coverage beyond line of sight in the rugged terrain to allow communications with other helicopters for informal weather reports and communication with the operator's base of operations. VHF radio repeaters could be installed at ADS-B ground stations allowing communication beyond line of sight.

One operator was considering a satellite phone system for their helicopters and thought that a service charge of $120 per month was reasonable for this service. However, technical issues prevented the equipage. This indicates the willingness of operators to find ways to communicate continuously with their helicopters.

3. *Flight tracking provides targeted benefits to air tour operators.*

There is interest in the ability to track company helicopters through ADS-B technology at the base of operations. This data could be used for flight scheduling and observing deviations due to weather. One operator pointed out during the question and answer period and another noted on the survey the importance of locating helicopters quickly during precautionary or forced off-airport landings. This search and rescue capability of ADS-B is especially useful for helicopter operators who are not required to have Emergency Locator Transmitters (ELTs) on board.

As the NTSB points out, ADS-B data could also be used for internal or FAA investigations of potential altitude violations. The use of ADS-B reports by the FAA for enforcement actions troubled at least two operators since they claimed that pilots may just turn off the equipment to avoid enforcement.

4. *Cockpit traffic displays only useful in regions of mixed flight activity with fixed wing operators.*

Hawaiian operators indicated less interest in cockpit traffic information than cockpit weather information and enhanced voice communications. Currently separation is based on standard air tour routes and conducted visually through aided by of pilot position reports broadcast on the CTAF. This voluntary voice based coordination of positions was observed during the observational flight. No operators currently utilize a Traffic Collision Avoidance System (TCAS) or a Traffic Awareness System (TAS) on their helicopters. The air tour operators maintain order by flying similar routes in the same direction, maintaining a single file line.

The primary interest in traffic displays is in areas of mixed flight activity. As one large operator put it, "The concern is not with other helicopter air tour traffic but with fixed wing and military flights." Occasionally, the helicopters will be orderly orbiting over a scenic location like a crater, when a small single engine fixed wing aircraft will fly right over the scenic location causing the helicopters to "scatter". Operators usually attribute this fixed wing behavior to student pilots and pilots unfamiliar with the area, who don't use the CTAF position reporting. Operators also commented that military flights occasionally transition the air tour routes without announcing since military aircraft are usually only equipped with UHF communications equipment. Military and fixed wing ADS-B equipage must be considered integral for an ADS-B system in Hawaii to work for traffic awareness and separation.

Further study should be conducted to see if regions of mixed flight activity, such as training areas and military routes, are under existing secondary radar coverage so that TIS-B could be utilized to provide benefits to early adopters of ADS-B in technology.

Other Focused Interview Observations

- *Applications should be tailored to VFR not IFR operations.*

  Helicopter operators in Hawaii operate exclusively under visual flight rules (VFR). Thus many of the applications and benefits, such as merging and spacing, that are proposed for fixed-wing operators in the IFR-based ATC system, are not applicable to the VFR operations in Hawaii. This consideration of VFR operations must be taken into account when developing and ADS-B system in Hawaii that is of use to helicopter air tour operators.

  Both in the surveys and in the interviews, respondents, especially chief pilots, expressed concern that the ADS-B technology would reduce the amount of time pilots spend with their heads "out of the cockpit" maintaining attitude, terrain separation, traffic separation, and weather separation visually, since they would be looking at displays on the helicopter panel. Another concern, cited by the director of the TOPS safety program for helicopters, is that advanced cockpit technologies send the wrong message to pilots by allowing them to get closer to IFR conditions with a false sense of comfort.

- *Select technologies should be bundled with ADS-B to encourage operator equipage.*

  While there does not appear to be sufficient support for voluntary ADS-B equipage alone, when combined with other cockpit avionics, operators were more receptive to ADS-B equipage. Based on question 15 of the survey (Appendix 1) 44% of respondents would combine ADS-B with weather datalink, CDTI, GPS navigation and a moving map. This is consistent with the existing general aviation ADS-B installations done for the Capstone project in Hawaii. A Terrain Awareness and Warning System (TAWS) was also indicated as a bundled technology in the surveys, by only 33% of respondents. This result is constant with interview results that found only one operator currently has TAWS in their helicopters.

  One important finding from the site visit was that many operators provide live video footage to passengers on an instrument panel display as seen in Figure 7. This footage comes from multiple cameras placed around the helicopter, and is recorded for sale as a DVD to passengers after their flight. Since panel space is so restricted in the cockpit, ADS-B moving map or weather displays must be able to share a display with these video monitors. The Hawaiian operator that has already equipped their helicopters with TAWS, uses a display that can switch between video and the TAWS alerting screen.

  No operators indicated interest in Enhanced Vision System (EVS) such as Forward-Looking InfraRed (FLIR) or with a 3D synthetic vision system. This reflects the VFR-only operating environment of the air tours.

Figure 7: Air tour helicopter panel with video monitor

- *Operator concerns must be addressed prior to expecting any equipage.*

  Interview participants had a number of concerns. Like in the survey, size, weight, and cost concerns were brought up. As pointed out earlier, some are worried that additional avionics will keep pilots' heads in the cockpit. One chief pilot suggest that the avionics should be voice activated and that PIREPs could be recorded and transmitted to other helicopters via the datalink so that no time is spent heads down typing or reading written PIREPs. While this may not be feasible with existing ADS-B technology, the concept deserves researching for possible integration with future communication technologies.

  There are also concerns that ADS-B out would be used as a surveillance tool to monitor and violate operators for CFAR 136 Appendix A minimum altitude limit violations. It is difficult for operators to know altitude above ground level or horizontal distance from terrain, thus the potential for strict enforcement may cause an unwillingness of operators to equip.

Conclusions

There are ADS-B benefits to Hawaiian air tour operators, which center on useful weather information and enhanced communication. Flight tracking and cockpit traffic displays provide additional benefits for air tour operators. The major concerns for operators are equipment price and the potential for FAA enforcement actions based on surveillance data. When weighed with the concerns, the benefits of ADS-B out or in are not enough by themselves for widespread air tour operator voluntary equipage in Hawaii. However, operators would be interested in voluntarily equipping with ADS-B technology if it enabled relief from the CFAR 136 Appendix A restrictions or if it allowed the general limit to be moved from 1500' to 300'-500'.

Acknowledgements

The authors would like to thank all those who took the time to discuss air tour operations and complete the survey. This study would not have been possible without their honest comments and feedback.

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Appendix 1: Helicopter Operator Survey

Massachusetts Institute of Technology

International Center for Air Transportation

MIT ICAT

ADS-B Helicopter Operator Survey

Name: ______________________________ **Email:** ______________________________

Organization or business: ____

MIT ICAT is investigating applications and benefits of ADS-B technology in order to provide input to the FAA regarding the implementation roll-out plan of ADS-B in the National Airspace System. We are seeking input from a variety of operators and pilots throughout the country.

This survey is voluntary. You have the right not to answer any question, and to stop the survey at any time. You will not be compensated for this survey. Data from this survey will be used by the MIT ICAT for ongoing research on technology in the National Airspace System.

1. What is your role in your organization?

2. Pilot qualifications *(circle all that apply):*

   None Private Commercial ATP Fixed Wing Rotorcraft Instrument Rated

3. What airports/heliports do you normally operate from (use ICAO identifier if known)?

Assuming that all necessary infrastructure were in place and your aircraft were equipped, please consider the following applications of ADS-B technology and identify the potential benefits of the application **to your operations** considering financial, efficiency, safety, and other operational benefits.

Non-Radar Airspace ADS-B Out Applications

The first set of applications relates to **ADS-B Out** technology where each aircraft broadcasts its position, altitude, airspeed, trend information, and aircraft ID to ground stations in areas where there is **no existing ATC radar coverage** (at low altitudes and in mountainous, remote, and over water areas). This data is fed to ATC to produce radar-like displays of traffic information for controllers and interested parties.

Check one for each application

Application	N/A	No benefits	Limited benefits	Significant benefits
Operation Center/Company/Online flight tracking of aircraft in the non-radar environment				
IFR separation in the non-radar enroute environment				
Increased VFR flight following coverage outside of radar coverage				
Increased airport surface awareness from the air traffic control tower				
Increased final approach and runway occupancy awareness from the air traffic control tower				

(continued on back)

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Radar Airspace ADS-B Out Applications

The second set of applications derives from the fact that the **ADS-B Out** information from each aircraft sent to air traffic controllers is better than existing radar-based information in **existing radar airspace**. ADS-B has a faster update rate (1 sec), more accurate position reporting, heading, and velocity as well as aircraft ID.

Check one for each application

Application	N/A	No benefits	Limited benefits	Significant benefits
Better air traffic control traffic flow management of enroute sectors and busy terminal areas				
Increased enroute sector capacity				
Improved Operation Center/Company/Online flight tracking in the existing radar environment				
Reduced separation standards				

4. Are there any other applications of **ADS-B Out** (both in and out of existing radar airspace) not listed above that could benefit your organization?

ADS-B In Traffic Display Applications

The third set of ADS-B applications is enabled by **ADS-B In** technology where the **ADS-B Out** information described above is received by individual aircraft in addition to ground stations, so that **traffic information is displayed in the cockpit** on a dedicated display, a multifunction display (MFD), or an electronic flight bag (EFB).

Application	N/A	No benefits	Limited benefits	Significant benefits
Enhanced visual acquisition allowing pilots to identify other aircraft visually in VFR or marginal VFR conditions				
Airport surface surveillance, allowing pilots to view all other vehicles operating on the airport surface				
Final approach and runway occupancy awareness				
Increased ability to maintain visual separation in VFR or Marginal VFR conditions				
Self-separation or station keeping				

5. Are there any other applications of **ADS-B In** Traffic Displays not listed above that could benefit your organization?

ADS-B In Datalink Applications

The final set of **ADS-B In** applications relate to **data uplink** enabled applications, where data from the ground can be uplinked to the cockpit for display.

Check one for each application

Application	N/A	No benefits	Limited benefits	Significant benefits
Display of real-time weather information				
Display of real-time airspace information				

6. Are there any other applications of **ADS-B In** Datalink not listed above that could benefit your organization?

7. Do you see value in these ADS-B services as a whole? Why or why not?

Current Equipage

8. Are any of the aircraft you operate currently equipped with a … (*check all that apply*)
   IFR Certified GPS? ☐ Panel Mounted VFR GPS? ☐ Portable GPS? ☐
   What model(s)?

9. Are any of the aircraft you operate currently equipped with a… (*check all that apply*)
   Multifunction Display (MFD)? ☐ Electronic Flight Bag (EFB)? ☐
   What model(s)?

10. Are any of the aircraft you operate currently equipped with datalink weather receivers? If yes, what models(s)?

(continued on back)

11. Are any of the aircraft you operate currently equipped with Mode-S transponders? If yes, what models(s)?

Operating Patterns and Avionics

12. What are the constraints on your business? (helicopters, tourists, pilots, competition, weather, regulations, etc.)

13. Do you agree with the following statement from the NTSB on Hawaiian helicopter operations, "As Hawaii's air tour industry continues to grow, increasing numbers of aircraft will be flying over rugged, scenic terrain in a finite airspace"?
    Yes ☐ No ☐ Why or why not?

14. Rank the following potential avionics upgrades from 1 to 8 based on operational benefits (safety, efficiency, cost savings, etc) with 1 being the most beneficial and 8 being the least beneficial:

    ___ ADS-B Out transponder
    ___ ADS-B In cockpit traffic display
    ___ ADS-B Datalink in-cockpit weather
    ___ Enhanced Vision System (EVS), like Forward Looking Infrared (FLIR)
    ___ GPS navigation
    ___ Moving map display
    ___ 3D Synthetic Vision System
    ___ Terrain Avoidance and Warning System (TAWS)

15. ADS-B Out capabilities may be combined with other avionics to create a single system for helicopter installations. What capabilities would you combine with ADS-B Out to create an affordable system which benefits your operations? *(check all that apply)*

- ☐ ADS-B In cockpit traffic display
- ☐ ADS-B In datalink weather
- ☐ Moving map display
- ☐ Terrain Display and Alerting
- ☐ Enhanced Vision System
- ☐ GPS navigation
- ☐ 3D Synthetic Vision System
- ☐ Other: ______________________

16. For the combined system you created above, how much would you be willing to pay?
    $

17. For the combined system you created above, how much would you expect to pay, given the current prices of avionics?
    $

18. What are the factors which would affect your decision to voluntarily equip with ADS-B or other avionics equipment?

19. What are the obstacles you see in equipping your fleet with ADS-B equipment?

20. If you decided to equip your entire fleet with a simple ADS-B Out system how long would it take if the installations were part of the normal maintenance cycle to minimize out of service costs?

    For an ADS-B In system with cockpit displays?

21. Any other comments regarding ADS-B?

Thank you for taking the time to complete this survey. We are interested in getting more detailed insight about operations in Hawaii. Please stop by the MIT booth (at the FAA booth) where several students and faculty will be taking detailed comments.

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Appendix 2: Focused Interview Questions

Massachusetts Institute of Technology

International Center for Air Transportation

ADS-B Hawaii Focused Interview Questions

John Hansman, Ted Lester, MIT International Center for Air Transportation

Interviewee: ______________________ **Date:** ________________

Organization: ____

☐ Part 91 Helicopter Air Tour ☐ Part 135 Helicopter Air Tour

☐ Other: ___________________________

Inform subject that participation is voluntary, they may refuse to answer any and all questions, and they may decline further participation, at any time, without adverse consequences. All answers will be anonymous, unless further permission is requested.

Part I: Background

1. What is your role in your organization?

2. What is your experience with ADS-B?

3. Are you a pilot? ☐Helicopter ☐Fixed Wing
   If so, what is the highest certificate you hold?
   ☐Private ☐Commercial ☐ATP

   Number of total hours?

Part II: Operational Patterns

4. What percent of your organization's pilots are instrumented rated?

5. What airports/heliports do you utilize (ICAO identifiers if known)?

6. What routes do you travel? (trace on color maps)

7. What are your low visibility or low ceiling procedures? Do the routes change?

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8. How has the Hawaiian helicopter air tour 1500' rule affected your flight patterns and business?

9. What are the areas lacking radar coverage? (indicate on color maps)

10. Do you have operational problems entering or leaving radar controlled airspace? What are they?

11. What are the leading causes of your flight cancellations?

12. What are other constraints on your business? (helicopters, tourists, pilots, competition, weather, FARs…)

13. Do you agree with the following statement from the NTSB on Hawaiian helicopter operations, "As Hawaii's air tour industry continues to grow, increasing numbers of aircraft will be flying over rugged, scenic terrain in a finite airspace"? Why or why not?

Part II: Applications and Benefits

14. What do you see as the most beneficial applications of **ADS-B Out** to your business?

15. What do you see as the most beneficial applications of **ADS-B In** and Cockpit Traffic displays to your business?

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16. What do you see as the major barriers or concerns regarding ADS-B implementation and operational use?

17. If you had in-cockpit datalink weather and airspace data, what weather and airspace information would you want?

Part III: Current Equipage.

18. Do you currently have ADS-B out equipment on any of your aircraft (both TSO'd or latent capacity to upgrade)? *(What models?)*
    a. Mode-S Transponders?
    b. ADS-B processing?
    c. Position sources (GPS)?

Specifically, which aircraft models are equipped?

19. Do you currently have the ability to display ADS-B information (traffic and/or weather) on any aircraft through MFDs or EFBs? If so, what systems?

20. What are your current sources of in-cockpit weather information (text, graphics, forecasts, communication with dispatch, communication with FSS, etc.)? Do you pay for these services?

Part IV: Future Fleet Equipage

21. What are the factors which would affect your decision to voluntarily equip with ADS-B or other avionics equipment?

22. Do you currently have plans for future ADS-B equipment retrofit? New aircraft equipage? EFB (or MFD) equipage?

23. What are the obstacles you see in equipping your fleet with ADS-B equipment?

24. If you decided to equip your entire fleet with "ADS-B out" how long would it take if the installations were part of the normal maintenance cycle to minimize out of service costs?

For "ADS-B in" with cockpit displays?

25. Do you see any major ongoing maintenance issues associated with ADS-B?

Part V: Costs

26. How much per aircraft would you be willing to pay for the following capabilities installed, and how much would you expect to pay for them installed?

	Willing to pay	Expect to pay
ADS-B Out transponder		
ADS-B In cockpit traffic display		
ADS-B Datalink in-cockpit weather		
Enhanced Vision System (EVS)		
GPS navigation		
Moving map display		
3D Synthetic Vision System		
Terrain Avoidance and Warning System (TAWS)		

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27. ADS-B Out capabilities may be combined with other avionics to create a single system for helicopter installations. What capabilities would you combine with ADS-B Out to create an affordable system which benefits your operations?

How much would you expect to pay for such a system? How much would you be willing to pay?

28. Any other comments regarding ADS-B?

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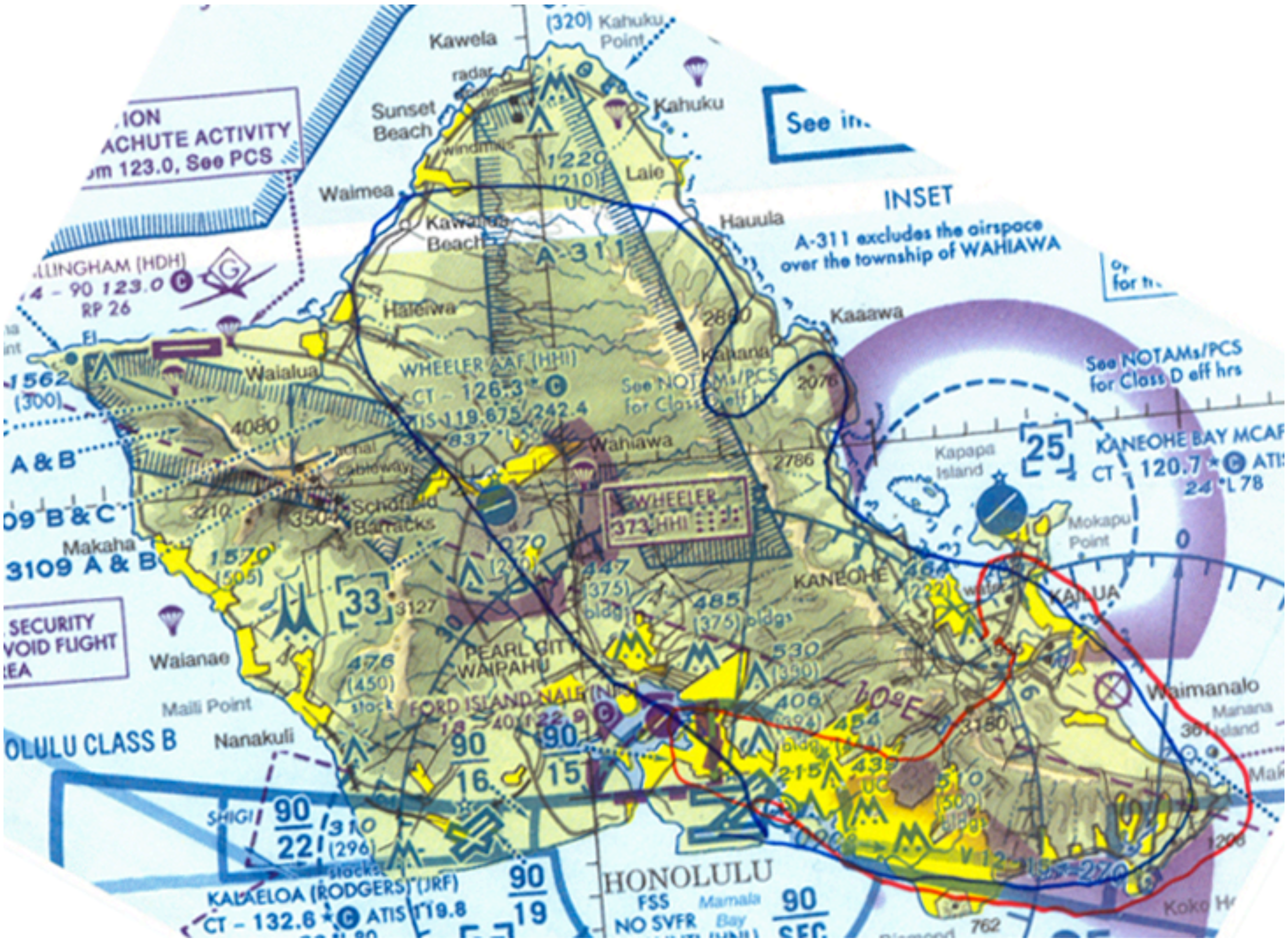
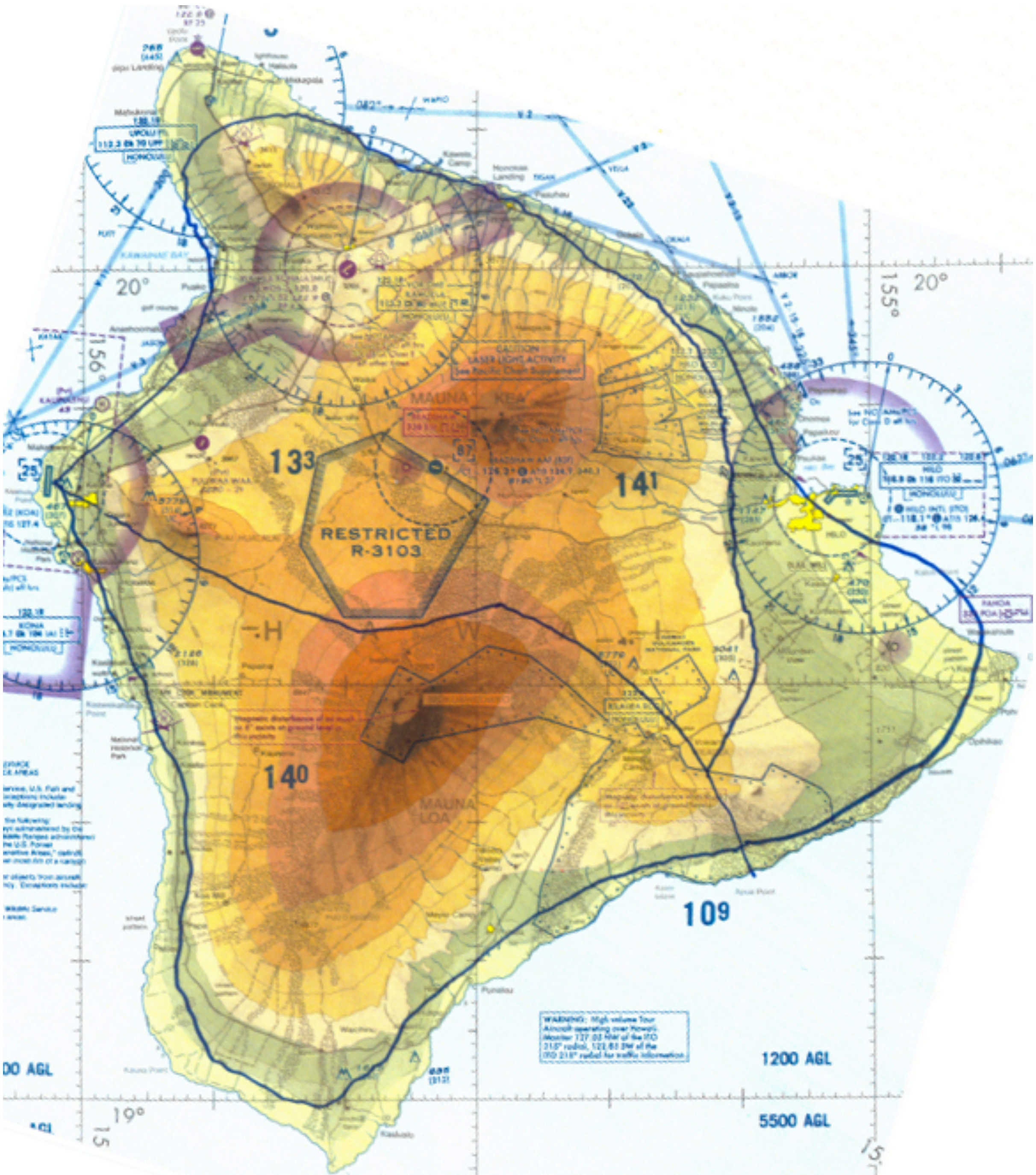
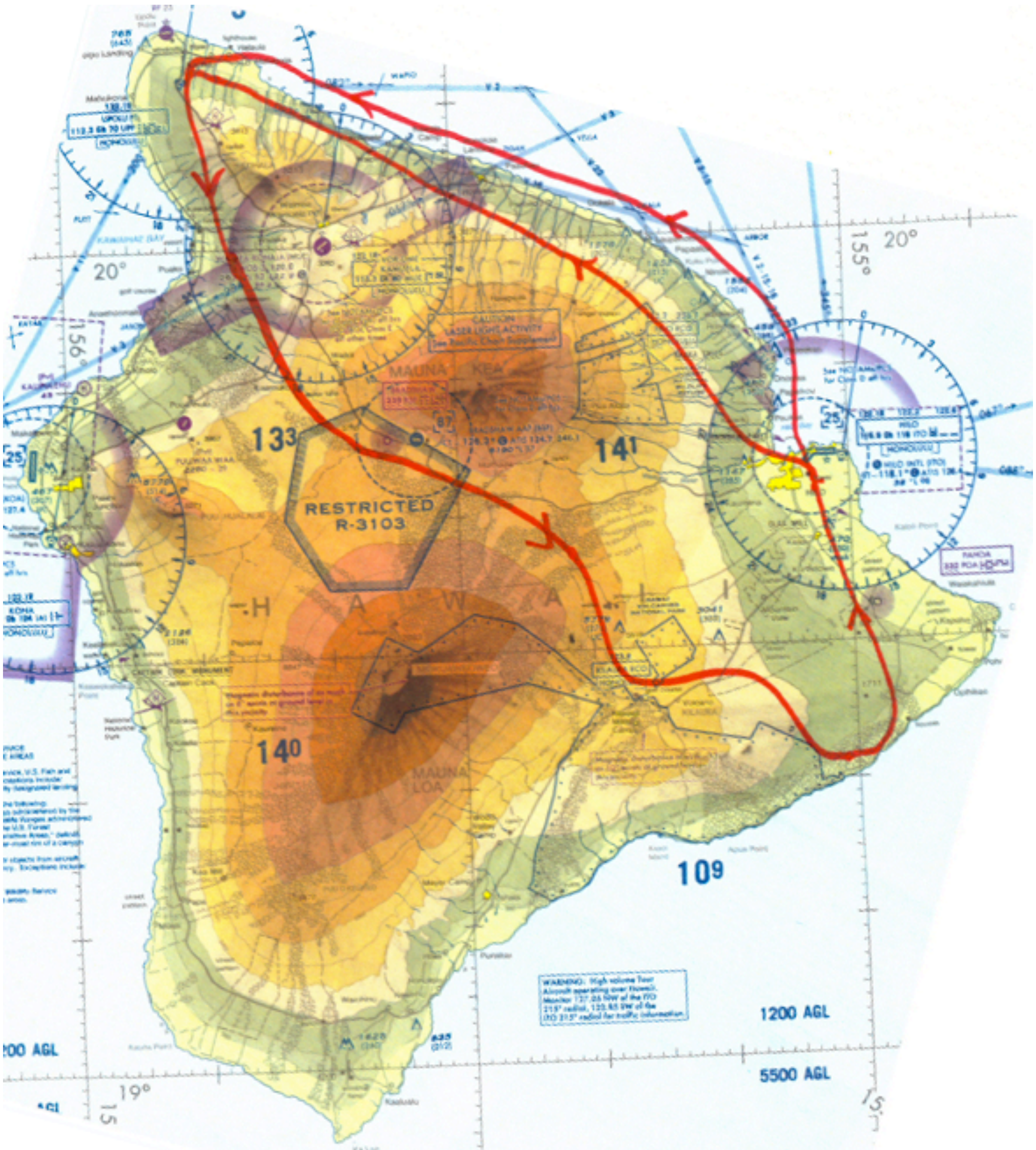
Appendix 3: Route Maps

Oahu



Hawaii (Big Island)

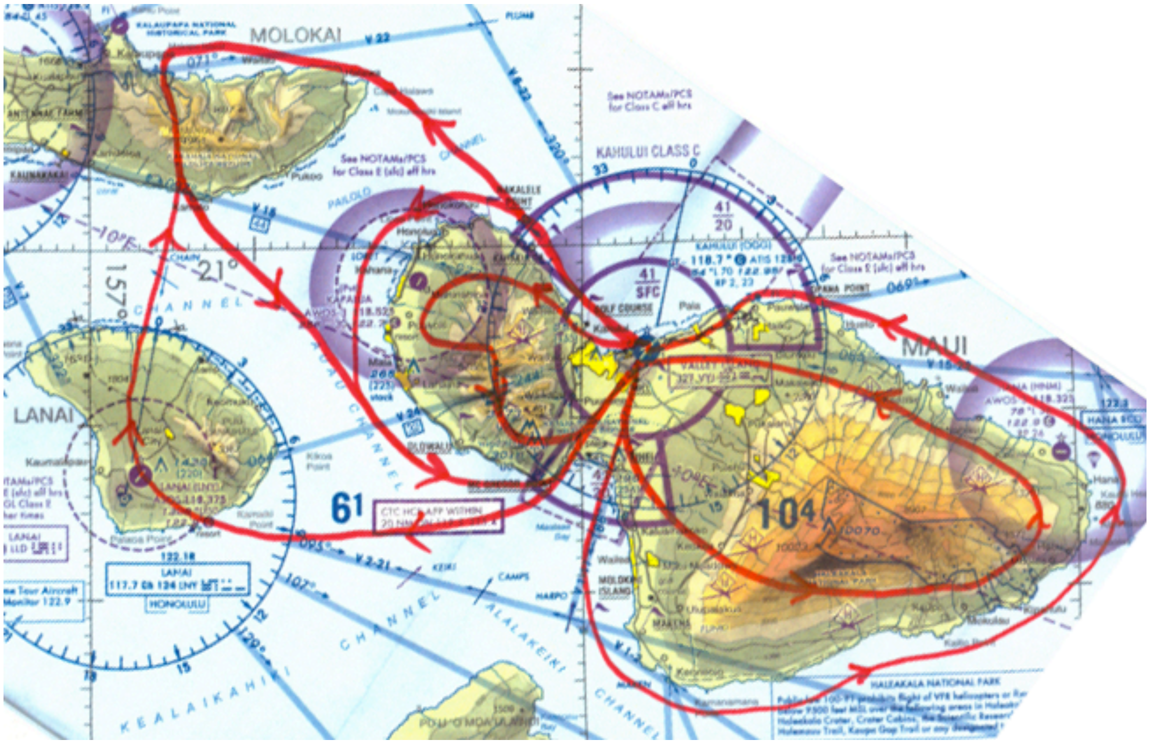



RESTRICTED
R-3103
MAUNA KEA
MAUNA LOA
133
141
140
109
1200 AGL
5500 AGL
20°
19°
155°
156°

Kauai


56
Haena
Princeville
Hanalei
Kilauea
Kepuhi Point
PRINCEVILLE
344 – 35 122.9
Anahola
Kealia
Kapaa
Wailua
Hanamaulu
Lihue
Nawiliwili
26
Makaha Point
Puuhinahina
radar dome
BARKING SANDS
126.2
Mana
3903
(204)
5200
5243
KAWAIKINI PEAK
33
30
27
1416
(398)
3280
3120
Waimea
Kekaha
Eleele
Kalaheo
Koloa
Poipu
Makahuena Point
Kaumakani
126.5
497
(357)
435
(225)
1509
(259)
HULEIA NATIONAL WILDLIFE REFUGE
HANALEI NATIONAL WILDLIFE REFUGE
lighthouse
HONOLULU
PORT ALLEN (PAK)
24 – 24 122.9
RP 9
122.1R
SOUTH KAUAI
115.4 Ch 101 SOK
KAUAI
See NOTAM for Class

Maui



Appendix 4: Study Participants

Survey Participants

Name	Title	Organization
Benjamin Fouts	President	Mauna Loa Helicopters
Cary Mendes	Former Chief Pilot	AlexAir
David Ryon	FAA Inspector	Hawaii FSDO
Gardner Brown	Director of Operations	Will Squyers Helicopter Service
Katsuhiro Takahashi	Pilot, CFI	Above It All, Inc
Paul Morris		Sunshine Helicopters
Rick Johnson	General Manager	Heli USA
Steve Egger	President/Owner	Air Maui helicopter tours
Steve Gould	President/Director of Operations	Mauiscape Helicopters

Name	Title	Organization
Anthony Fink	Pilot, Safety Director	Above It All, Inc
Casey Pauer		
Chuck DiPiazza	President/ Director of Operations	Air Kauai Helicopters
Chuck Lanza	Operations Manager	Makani Kai Helicopters
Curt Lofstedt	President	Island Helicopters Kauai
Dan Betencourt	Lawyer	
Dana Rosendal	Chief Pilot	Niihau Hilicopters
Darl Evans	Chief Pilot	Blue Hawaiian Helicopters
David Chevalier	President	Blue Hawaiian Helicopters
David Ryon	FAA Inspector	Hawaii FSDO
Eric Lincoln	Director of Operations	Blue Hawaiian Helicopters
Nigel Turner	President/CEO	Heli USA Airways
Preston Myers		Safari Helicopters
Rich Johnson	General Manager, Hawaii	Heli USA Airways
Richard Schuman	President	Makani Kai Helicopters
Robert Butler	Directors	TOPS Program
Tom Yessman	President	Liberty Helicopters