Federal Aviation Administration
Alaskan Region

Capstone Program Management Office
801 B Street, Suite 500
Anchorage Alaska 99501

Capstone Test and Evaluation Master Plan

for

ADS-B Radar-Like Services

Final

30 January 2001

ALASKAN REGION
Capstone
Investment in Safety

Preamble

The Capstone Program is sponsored by the Federal Aviation Administration's (FAA's) Alaskan Region and is in cooperation with the FAA Safe Flight 21 Program. The Capstone Program accelerates nationwide efforts to improve aviation safety and efficiency through a multi-year introduction of current and emerging concepts and technologies. Initial validation plans include the installation of government-furnished Global Positioning System (GPS) driven avionics suites in up to 150 commercial aircraft serving the Bethel/Yukon-Kuskokwim delta area in and around Bethel, Alaska. For the first year and beyond, compatible data link transceivers installed at strategically located ground sites are designed to facilitate Air Traffic Control and flight information services.

The Capstone Test and Evaluation Master Plan (TEMP) for ADS-B Radar-Like Services outlines the activities for use of the Capstone ADS-B system for radar-like services in airspace in and around Bethel, Alaska. These activities are based on a transition from aircraft supplemental VFR use of Capstone avionics to authorizing air traffic control use of ADS-B in applying procedures for separation, sequencing, and other VFR & IFR radar-like services. Operational feedback during this initial period will lead to system refinements, requirement validation, and risk mitigation prior to ADS-B use for radar-like services. The scheduled operational date for ADS-B radar-like services is 1 January 2001.

The Capstone Program Office in coordination with other participating organizations is producing this document. It presents program background; system descriptions; and test management, organization, planning, and documentation activities. The Capstone TEMP for ADS-B Radar-Like Services is not intended as a Public Relations document; inquiries into such should be directed to the appropriate offices of the participating organizations.

Acknowledgements

FAA Alaskan Region
FAA Safe Flight 21 Program
Alaska Air Carrier Association
Alaska Aviation Safety Foundation
Aircraft Owners and Pilots Association (AOPA)
University of Alaska Anchorage
Alaska Airman's Association, Inc.
NAS Implementation Support Contract (NISC)
The MITRE Corporation Center for Advanced Aviation System Development (CAASD)
UPS Aviation Technologies
Lockheed Martin

Table of Contents

1. Program Overview 1

1.1. Capstone Background 1

1.2. Capstone ADS-B Radar-Like Services 2
1.2.1. Objective 3
1.2.2. Description of Operational Use 3
1.2.3. Potential Advantages 4
1.2.4. ATC Procedures and Phraseology 4

1.3. Purpose of TEMP 5

1.4. Implementation and Operational Evaluation Activities 5

1.5. Schedule 7

1.6. System Description 8
1.6.1. Capstone Ground System 8
1.6.2. Capstone Avionics 9

2. Capstone Deliverables 12

2.1. Capstone ADS-B System End-to-End Performance Analysis 12

2.2. Safety Engineering Report 12

2.3. Safety Benefit Study 12

2.4. Performance and Operational Data 13

3. Developmental Test and Evaluation 16

3.1. Ground System 16
3.1.1. Equipment 16
3.1.2. Procedures and Training 18
3.1.3. Approvals 19

3.2. Airborne System 20
3.2.1. Equipment 20
3.2.2. Procedures and Training 22
3.2.3. Approvals 23

4. Operational Evaluation 24

4.1. Ground System 24
4.1.1. Data Collection Methodology 24
4.1.2. Performance Measures 25

4.2. Airborne System 25
4.2.1. Data Collection Methodology 25

4.2.2. Performance Measures 25
4.3. Safety Effects and Benefits 25
4.3.1. Data Collection Methodology 26
4.3.2. Performance Measures 26

5. Capstone System Safety 27

5.1. System Safety 27

5.2. Capstone System Safety Program Plan 28
5.2.1. Program Scope and Objectives 28
5.2.2. Capstone System Safety Organization 28
5.2.3. Capstone Program Milestones 29
5.2.4. Capstone System Safety Requirements 29
5.2.5. Hazard Analysis 34
5.2.6. Capstone System Safety Data 34
5.2.7. Safety Verification 35
5.2.8. Audit Program 35
5.2.9. Training 35
5.2.10. Incident Reporting 36
5.2.11. Capstone System Safety Interfaces 36

6. Resources Summary 37

Appendix A: FAA Administrator's Letter on Capstone ADS-B Radar-Like Services 1

Appendix B: Detailed Capstone ADS-B Radar-Like Services Schedule 1

Appendix C: Capstone Avionics Supplemental Type Certificate 1

Appendix D: WJHTC Micro-EARTS Acceptance Testing Memo 1

Appendix E: Interim Ground System Certification Procedures and Requirements 1

Appendix F: WJHTC B727 Alaska Flight Test Plan 1

Appendix G: ATC Procedures and NATCA MOU 1

Appendix H: AFS Separation Standards Recommendations and Pilot Training: 1

Appendix I: Capstone ADS-B Acceptability Evaluation 1

Appendix J: Air Traffic Controller Questionnaires 1

Appendix K: Pilot Questionnaires and Surveys **1**

Appendix L: Acronyms **1**

1. Program Overview

1.1. Capstone Background

The Capstone Program accelerates nationwide efforts to improve aviation safety and efficiency through a multi-year introduction of current and emerging concepts and technologies. Initial validation plans include the installation of government-furnished Global Positioning System (GPS) driven avionics suites in up to 150 commercial aircraft serving the Bethel/Yukon-Kuskokwim Delta area. For the first year and beyond, compatible data link transceivers installed at strategically located ground sites are designed to facilitate Air Traffic Control (ATC) and flight information services.

The name "Capstone" is derived from the program's effect of drawing and holding together concepts and recommendations contained in reports from the RTCA, the National Transportation Safety Board (NTSB), and the Alaskan aviation community. Each of these groups works in partnership with the FAA to identify and mitigate risks associated with a transition toward modernization of the National Airspace System (NAS). The program incorporates guidance from internal, external, national, and local organizations to facilitate safety improvements and validation work under a single program.

Elevated accidents rates and the absence of airspace services such as radar make Alaska the ideal location to evaluate key new communications, navigation, and surveillance (CNS) technologies. Increased pilot situational awareness is a critical area of possible safety improvements through the introduction of state-of-the-art avionics suites and ground stations. Aircraft chosen to participate in the avionics validation are equipped with:

- An IFR-certified GPS receiver for new and / or enhanced navigation capabilities,
- A Universal Access Transceiver (UAT) data link radio to provide the pilot with timely decision making information via Automatic Dependent Surveillance-Broadcast (ADS-B), Traffic Information Service-Broadcast (TIS-B), and Flight Information Services (FIS) (e.g., graphical weather maps, METARs, TAFs),
- A panel mounted multiple function color display to present traffic, weather, and navigation information from the above components and to present a terrain advisory database to help prevent collisions with terrain.

The initial ground station network unites new data link technologies with existing telecommunications facilities at up to twelve (12) locations in the Bethel/Yukon-Kuskokwim Delta area. As technologies are validated, more sites are planned in future years to allow for coverage area growth. The sites create a connection between FAA air traffic control facilities and participating aircraft. The major components of the ground system are:

- Modification to the Anchorage Air Route Traffic Control Center (ARTCC) Micro En Route Automated Radar Tracking System (Micro-EARTS) automation system to incorporate ADS-B data for processing and display at Anchorage ARTCC and potentially Bethel Tower;

- Capstone Server that establishes the relationships that control the flow of information (e.g., ADS-B, FIS, TIS-B) within the Capstone ground system architecture, and
- Ground broadcast transceivers (GBT) that are remote ground stations with communication and router capability to Anchorage ARTCC.

Other major parts of the Capstone Program include:

- Flight following/locating capabilities for aircraft operators/dispatch offices,
- GPS non-precision instrument approach procedures developed for runways at remote village airports within the Capstone area, and
- FAA-certified automated weather observation systems III (AWOS III) with radio broadcast capability provides the required weather information to enable air carrier use of the new non-precision GPS instrument approach procedures.

Capstone is working with the Safe Flight 21 Program Office at FAA Headquarters to document the operational benefits of these systems, the impact on safety, and the cost / benefit of equipage. While the Capstone Program Office demonstrates and documents the operational benefits that are to be gained through 2001, planning for statewide implementation is also occurring for 2002 – 2005 and beyond.

The Capstone Program Office will continue to work with the Alaska aviation industry to build on the lessons learned in the Bethel/Yukon-Kuskokwim area and expand the use of these technologies to improve aviation in other areas of Alaska.

The Capstone Program Office reports to the Alaskan Regional Administrator, and serves to plan and coordinate implementation. The office is staffed by individuals detailed from various "straight lined" divisions within the Region. Oversight of the program is provided by a Management Review Board, made up of Senior Executive and FAA managers from participating organizations, providing periodic review of the Capstone Program.

1.2. Capstone ADS-B Radar-Like Services[1]

While radar surveillance capability accounts for significant operational efficiency, safety, and improved services in the NAS, not all NAS airspace is under radar surveillance coverage. The effective coverage of ground-based radar systems is subject to line-of-sight and shadowing effects, and though radar coverage does exist down to near the surface in the vicinity of radar sites (such as in busier terminal areas), many outlying areas are without coverage. As a result, many flights operated at the lower altitudes or away from terminal areas will likely traverse non-radar airspace. The adverse impact this has on flight operations is best illustrated by considering the procedures and services that radar surveillance makes possible.

[1] The following section is largely derived from the SafeFlight21 Ops/Procedures Subgroup, High-Level Concepts of Operational, DRAFT September 2000.

Where radar coverage does exist, for example, the air traffic controller can use a wide range of techniques to maintain IFR separation, such as aircraft vectoring and speed control. When coupled with the accuracy of radar-derived position data (as compared to pilot position reporting in a non-radar environment), these techniques allow much smaller separation minima to be applied, thereby increasing traffic throughput. In addition, radar surveillance capability makes it possible to offer a wide range of services to VFR and IFR aircraft, including flight following and traffic advisories, minimum safe altitude warning (MSAW), and navigational assistance, for example. Search-and-rescue activities can also be better focused if radar data are available for a flight presumed missing. All of these techniques and services require the accurate position information from radar to be operationally effective.

In spite of its importance in the provision of separation and other services, it is not cost-effective to site and install ground-based radar systems to achieve complete radar coverage of NAS airspace. As a result, operations in non-radar airspace are conducted using less-efficient separation techniques, and some services are not possible. IFR operations at many airports that are below radar coverage, for example, are subject to what is known as "one-in-one-out" procedures. Under such procedures, only one IFR aircraft at a time is allowed to enter the non-radar airspace, and no other aircraft can enter until the preceding aircraft either reports clear of the runway (in the case of a landing), or becomes radar-identified upon entering radar coverage after takeoff. As a result, aircraft awaiting takeoff or approach clearances while a preceding aircraft is completing an operation can encounter significant delays.

1.2.1. Objective

The objective of this application, simply stated, is to provide a cost-effective means to make the techniques and services associated with radar surveillance also available in non-radar airspace. This would include addressing those situations in non-radar airspace that pose the most significant constraints to IFR operations, such as "one-in-one-out" airports. An important aspect of the application is to ensure that controller and pilot workload is not adversely affected. While it is envisioned that radar services can be effectively replicated with new systems, it is not intended that these new systems be limited to mimic only what ground-based radar can support.

The objective of Capstone ADS-B radar-like services is to enable ATC to use ADS-B surveillance information to provide better services to pilots initially in the Bethel, Alaska area in order to increase safety, efficiency, and capacity.

1.2.2. Description of Operational Use

This application makes use of ADS-B to provide the controller with position and other information on ADS-B-equipped aircraft. The application assumes a network of strategically placed ground-based listening stations that passively monitor the ADS-B frequency for ADS-B messages from equipped aircraft flying in the area. These messages are forwarded to the cognizant ATC facility for processing and to be displayed to the controller.

Where appropriate, ADS-B-supplied position information for aircraft in the area should be displayed to the controller on the same device used to depict conventional radar data. Such would be the case for sectors having non-radar airspace lying below airspace with radar coverage

(due to shadowing or line-of-sight limitations, for example). In situations where there is no overlying radar airspace, a display dedicated to ADS-B-derived surveillance information would be used. Also, depending on how operational procedures are worked out, it may be desirable to provide the controller an indication or display of a "clear-of-runway" condition for aircraft completing an approach and landing.

Depiction of ADS-B-derived information on the display would be similar to what the controller sees for aircraft under conventional ground-based surveillance. In addition, the same services and procedures would be used for both ADS-B-derived and conventional radar data. These services include ensuring aircraft separation, flight following and traffic advisories, MSAW, navigational assistance, and search-and-rescue, for example. To keep controller and pilot workload manageable in this application, procedures used under an ADS-B-derived system should be similar to those applied under conventional radar - including separation minima. (Note: this is not intended to limit potential reductions in separation minima made possible by ADS-B in other applications).

1.2.3. Potential Advantages

Several benefits are anticipated with this application. First, it will effectively permit application of radar-based techniques and services in airspace that does not have radar coverage. Experience has reliably shown that these techniques yield efficiency, capacity, and safety benefits whenever radar capability and associated techniques are introduced to non-radar airspace. These improvements would be especially noticeable in airspace that is now constrained to one-in-one-out operations.

In addition to more efficient use of the airspace, the ATC system will be able to offer more services to pilots, including flight following and traffic advisories, MSAW, navigational assistance, and enhanced search-and-rescue. Because it is intended to replicate the features of familiar ground-based radar, both the controller and pilot should be able to take advantage of the application without the need for extensive training. Users will not have to incur incremental costs to derive a benefit from this application because the same ADS-B capability is integral to several other applications. Finally, because the ground system is far-less costly than conventional radar, this ADS-B-based system should permit radar-like services to be available in considerably more NAS airspace.

1.2.4. ATC Procedures and Phraseology

Per FAA Notice N7110 dated 21 Dec 2000, when aircraft are appropriately equipped, ADS-B can be used as a source for aircraft position beyond or below radar coverage or when primary and/or secondary radar surveillance systems are unusable or unavailable. ADS-B is a tertiary form of surveillance, with raw radar remaining primary and beacon system remaining secondary. For the purpose of this Notice, "radar" is defined as information displayed on the Micro-En Route Automated Radar Tracking System controller display which is derived from primary radar, Mode 3/A secondary radar, and ADS-B. Phraseology for transfer of radar identification, i.e., "handoff", "radar contact", "point out", and "traffic", apply.

1.3. Purpose of TEMP

The Capstone Program Office in coordination with the participating organizations is producing this Capstone Test and Evaluation Master Plan (TEMP) for ADS-B Radar-Like Services. The purpose of the TEMP is to document all the required tasks and activities to meet an operational date of 1 January 2001, for the use of the Capstone ADS-B system for radar-like services in airspace in and around Bethel, Alaska. Progress on these various activities will be reflected via updates to the appendices. The TEMP presents program background, system descriptions, and test management, organization, planning, and documentation activities. These activities are based on a transition from aircraft supplemental VFR use of Capstone avionics to authorizing air traffic control use of ADS-B in applying procedures for separation, sequencing, and other VFR & IFR radar-like services. Operational feedback during this initial period will lead to system refinements, requirement validation, and risk mitigation prior to ADS-B use for radar-like services.

There are 6 parts to this TEMP. Part 1 provides a program overview, including ADS-B radar-like services operational concept, schedule, and system descriptions. Part 2 defines the Capstone deliverables for ADS-B radar-like services. Parts 3 and 4 describe the developmental and operational evaluation activities for the ground and airborne systems. Part 5 summarizes Capstone System Safety activities and Part 6 summarizes resources. Appendices follow the body of the document.

1.4. Implementation and Operational Evaluation Activities

Capstone integrates the planning of resources required to implement Capstone technologies and procedures. Operational and technical performance data will be collected and analyzed during developmental and operational tests and evaluations to support transition to full ADS-B radar-like services. The following tasks for establishing radar-like services using ADS-B in the Bethel area were outlined by the FAA Administrator[2] and this TEMP documents how each is being completed.

- Approve airborne equipment including the global positioning system and data link equipment that transmits the ADS-B signals,
- Approve ground-based systems and ensure that adequate radio spectrum is available and certified to meet identified user requirements,
- Ensure compatibility of systems transmitting ADS-B information to the appropriate air traffic control facility,
- Approve ground system equipment that will be used to display ADS-B information and establish procedures for the use of ADS-B,

[2] FAA Administrator Capstone letter to Alaska Air Carriers Association, 3 January 2000

- Approve operational standards and associated operations specifications permitting use of radar-like services based on ADS-B equipment, and

- Perform an operational safety review and determine that the Capstone ADS-B system is at least equivalent to radar in terms of reliability and system performance.

See Appendix A for a copy of the FAA Administrator's 3 January 2000 letter on Capstone ADS-B Radar-Like Services.

1.5. Schedule

ID		Task Name	Start	Finish	Resource Names
1		**Approve Airborne Equipment**	**Tue 6/15/99**	**Mon 1/1/01**	**ACE-115N,AIR-130**
2		**Avionics STC (Supplemental VFR)**	**Tue 6/15/99**	**Wed 2/2/00**	**ACE-115N,UPSAT**
5		**Functional Hazard Assessment**	**Wed 9/1/99**	**Mon 4/17/00**	**ACE-115N,AIR-130**
8		**UAT Design Specification**	**Tue 2/29/00**	**Fri 5/5/00**	**UPSAT,ACE-115N,MITRE**
11		**Avionics Amended STC for Radar-Like Services & Freq Cl**	**Mon 2/21/00**	**Fri 12/15/00**	**ACE-115N**
17		**Avionics Installations**	**Fri 2/11/00**	**Mon 1/1/01**	**ACE-115N**
21		**Approve Ground-Based System and Radio Spectrum**	**Wed 12/1/99**	**Mon 1/1/01**	**AAL-400,ASR**
22		**Spectrum and Frequency Change**	**Wed 12/1/99**	**Mon 1/1/01**	**ASR-1**
32		**Maintenance (Documentation & Training)**	**Fri 2/25/00**	**Fri 10/6/00**	**AAL-400**
45		**Installation Network - ZAN**	**Mon 1/3/00**	**Wed 6/28/00**	**"**
52		**Installation MEARTS - ZAN**	**Wed 3/22/00**	**Fri 6/23/00**	**"**
59		**Installation GBT - Bethel**	**Tue 2/29/00**	**Fri 6/16/00**	**"**
65		**GBT Retrofit for Radar-Like Services (e.g., RMM) & Freq C**	**Thu 5/18/00**	**Wed 12/20/00**	**AAL-400**
72		**Ground System Compatibility & Certification**	**Tue 3/23/99**	**Mon 1/1/01**	**AAL-400.AOS**
73		**MEARTS ADS-B Development**	**Tue 3/23/99**	**Tue 1/18/00**	**AUA-600**
79		**MEARTS Acceptance Testing (WJHTC)**	**Wed 11/17/99**	**Fri 4/28/00**	**AUA-600**
90		Acceptance Testing Test Report	Mon 5/1/00	Thu 6/1/00	AUA-600
91		**Key Site Testing (AK)**	**Mon 6/26/00**	**Wed 11/22/00**	**AAL-400**
98		**Capstone ADS-B Ground System Certification**	**Wed 6/21/00**	**Mon 1/1/01**	**AOS**
106		**Air Traffic Planning and Procedures**	**Wed 2/9/00**	**Fri 1/5/01**	**ATP,ZAN,NATCA,AAL-500**
107		ATP Request to AFS-400 for validation of 5 mile Radar-Like S	Wed 7/19/00	Wed 7/19/00	ATP-1
108		**Define Specific ATC Procedures (ZAN & BET)**	**Wed 2/9/00**	**Tue 10/17/00**	**NATCA,ATP-100,ZAN-20,AAL**
112		**NATCA Article 7 Brief**	**Wed 5/10/00**	**Fri 12/15/00**	**ATX-500,ZAN-20,NATCA,ATP**
119		**Controller Training**	**Mon 9/11/00**	**Fri 1/5/01**	**AAL-500,ZAN-30**
124		**ATP-100 ADS-B Notice to ZAN/AAL-500**	**Fri 12/15/00**	**Fri 12/22/00**	**ATP-1**
127		**Controller Operational Feedback Analysis**	**Wed 9/13/00**	**Tue 10/17/00**	**ZAN,NATCA**
130		**Approve Ops Standards and Ops Specs**	**Wed 12/1/99**	**Mon 1/1/01**	**AFS**
131		Analyze/review ADS-B data for IFR sep standard	Thu 7/13/00	Wed 11/22/00	AFS-400
132		**AFS-400 Concurrence Memo to ATP-1 for 5-mile radar-like**	**Wed 11/15/00**	**Wed 11/22/00**	**"**
135		Air Transport Handbook Bulletin (HBAT) & Other Inspector Gu	Mon 2/28/00	Wed 11/22/00	"
136		Avionics Cert Coordination	Tue 1/11/00	Fri 12/15/00	"
137		ATC Procedures Coordination	Tue 1/11/00	Fri 12/22/00	"
138		**Pilot Training**	**Tue 12/7/99**	**Sat 12/30/00**	**ANC FSDO,AFS-400,UAA**
142		**UAA Safety Study and Pilot Ops Feedback**	**Wed 12/1/99**	**Mon 1/1/01**	**UAA**
147		**End-to-End Safety Review**	**Wed 1/12/00**	**Wed 11/15/00**	**AAL-1SC,ASY**
148		Form Capstone Safety Review Team	Wed 1/12/00	Wed 1/12/00	UAA,ACE-115N,MITRE,ASY-3
149		System Safety Program Plan	Wed 1/12/00	Mon 8/7/00	"
150		Operating & Support Preliminary Hazard Analysis	Mon 1/17/00	Thu 7/6/00	"
151		Hazard Tracking & Risk Resolution	Fri 6/30/00	Wed 11/15/00	"
152		Safety Engineering Report - Final	Wed 11/15/00	Wed 11/15/00	"
153		Operational Capstone ADS-B Radar-Like Services	Mon 1/1/01	Mon 1/1/01	

See Appendix B for detailed schedule.

1.6. System Description

1.6.1. Capstone Ground System

The Capstone ground system architecture supports multiple services with emphasis on products (e.g., ADS-B, FIS-B, TIS-B) that meet the needs of the aviation community. The ground system architecture will provide ADS-B information to the Micro-EARTS, and information such as textual/graphical weather (i.e., FIS-B). The ground system architecture will also broadcast radar-tracked targets (i.e., TIS-B) to the aircraft. To ensure all services provided meet the required level of certification (Critical for surveillance, Essential for information) the Capstone ground system architecture will have phased certification. The Phase 1 ADS-B architecture (shown in Figure 1) is designed to meet the Administrators commitment and schedule for ADS-B radar-like services. The phased design goal is to allow development of FIS-B and TIS-B products without impact to the operational Micro-EARTS ADS-B services and to field initial operational infrastructure capable of meeting AOS requirements with the ability to move into Airway Facilities support.

The Phase 1 Capstone ADS-B Ground system includes the Micro-EARTS to process and display ADS-B information, and a telecommunications system architecture that includes remotely located GBTs, ADS-B fixed parrots, long haul telecommunications (Alaska NAS Interfacility Communications System (ANICS) and/or leased telecommunications), and routers to the Micro-EARTS gateway. Figure 2 depicts this fully redundant Phase 1 operational architecture. Note that the Capstone Server is not part of initial operational architecture, but will be included in a developmental system (fielded in parallel) to allow for FIS-B and TIS-B testing.

The ADS-B modifications to the Micro-EARTS will be certified through a NAS Change Proposal (NCP) process (Capstone Case File NCP-AL512-Micro-EARTS-013), that involves software changes to the currently certified Micro-EARTS baseline to incorporate processing of ADS-B data. The Capstone telecommunications architecture must support surveillance (i.e., critical level) services in accordance with NAS performance requirements. Design goals for these requirements are specified in the FAA's NAS System Requirements Specification (NAS-SR-1000). The Capstone ground system communication architecture will be tested via a FAA AOS-500/AAL-500/400 agreed upon NCP process.

Phase 1 will allow operational use of ADS-B in both Anchorage ARTCC and potentially Bethel Tower. Anchorage Center controllers will use it to perform VFR and IFR radar-like services. Bethel Tower, currently being a VFR-only tower, will be able to use the ADS-B information for VFR services. ADS-B traffic information processed through the Anchorage Center Micro-EARTS will also be made available to aircraft operators/dispatchers for flight following/locating activities.

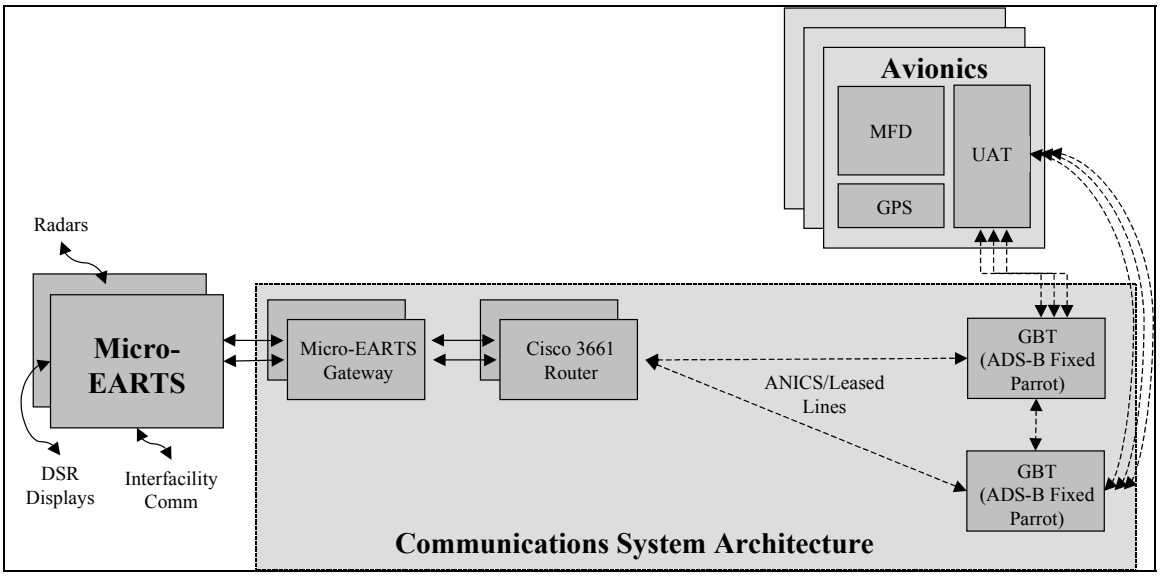


Figure 1. Phase 1 Capstone ADS-B System Block Diagram

1.6.2. Capstone Avionics

During CY2000, installation of government provided avionics began for approximately 150 commercially operated aircraft. The Capstone program provides three UPS Aviation Technologies avionics products: the Apollo GX60 TSO-C129A certified GPS navigator/VHF communication radio (or GX50 TSO-C129A certified GPS navigator - Figure 2), the Apollo MX20 multi-function cockpit display (Capstone configured - Figure 3), and the Universal Access Transceiver (UAT - Figure 4).

Installation of these avionics is covered under a multiple make, model, and series FAA Supplemental Type Certificate (see Appendix C for STC No. SA02149AK) in accordance with UPS Aviation Technologies' Capstone STC Master Drawing List. The current avionics are limited to supplemental VFR operations via the FAA approved Airplane Flight Manual Supplement or Supplemental Airplane Flight Manual for Capstone System Installation. This system will be placarded “GPS and MFD limited to VFR use only”, and the aircraft/pilot must have other navigation capabilities appropriate to the route of flight. A description of the avionics is provided below with a block diagram depicted in Figure 5. The avionics will be upgraded and STC amended to meet requirements for radar-like services.

Figure 2. GX60 GPS Navigator/Comm

Figure 3. MX20 Multi-Function Display

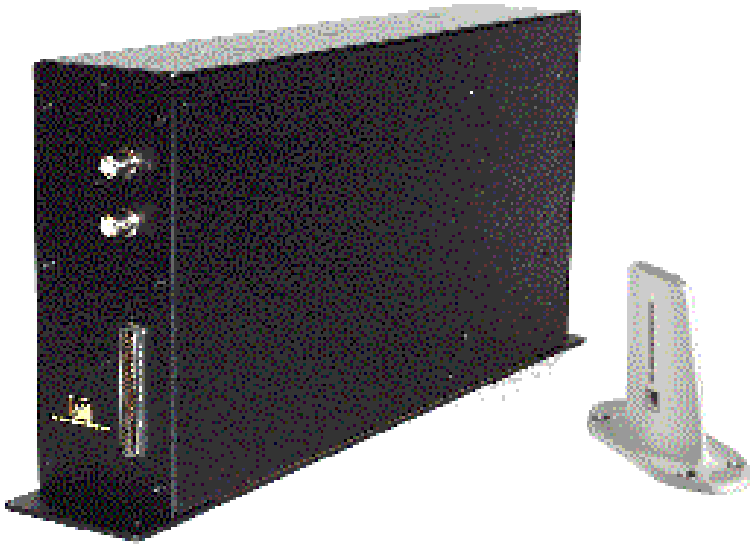


Figure 4. UAT DataLink Radio

- GX60 GPS/VHF Communication System is TSO-C129A Class A1 approved for IFR non-precision approach operation and also TSO-C37d, TSO-C38d and TSO-C128 approved 760-channel VHF communication transceiver. The Apollo GX60 will provide navigational data to the pilot. The Capstone installation limits the GX60 for VFR operation only. (Note the GX50, provided on a few Capstone aircraft, is equivalent to a GX60 without the VHF communication transceiver.)

- MX20 Multi-Function Display is capable of displaying ADS-B traffic, flight information service, moving map, terrain awareness information, and VFR/IFR charting functions. The Capstone version of the MX20 display has an internal GPS receiver to provide timing and positioning for the UAT datalink. Further, the MX20 uses the internal GPS for own-ship display.

- Universal Access Transceiver (UAT) radio will transmit the ADS-B position reports as generated by the MX20 (via the internal GPS receiver). The transceiver will receive data from other aircraft as well as data transmitted by ground stations (i.e., FIS-B and TIS-B) and transfer it to the MX20. Dual antennas are installed to resolve shadows created from various mounting configurations. One antenna is top mounted; the second antenna is bottom mounted.

FAA certified technicians, in accordance with the manufacturer's instructions, install the avionics equipment and perform post installation checkouts.

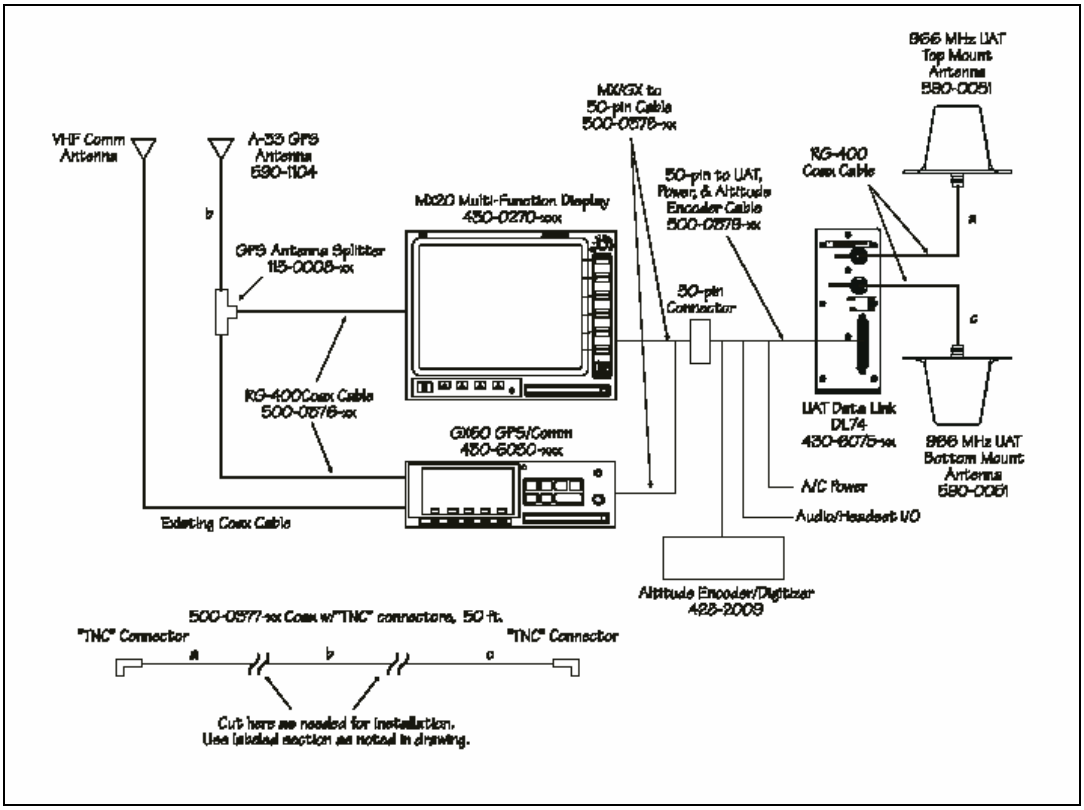


Figure 5. Capstone Avionics Block Diagram

2. Capstone Deliverables

2.1. Capstone ADS-B System End-to-End Performance Analysis

The Capstone ADS-B ground system will be certified through a NCP process. Ground system certification will include Micro-EARTS and the GBTs. The technical report produced by AUA-600 from this testing and certification process will provide "a satisfactory determination that the Capstone ADS-B system is at least equivalent to radar". This includes evaluating the Capstone ADS-B system to the NAS requirements for surveillance information.

The certification process will include acceptance testing at the William J. Hughes Technical Center (WJHTC) and key site operational and maintainability testing in Alaska. During the key site testing, data will be archived during targets of opportunity (i.e., aircraft flying VFR with installed avionics) and during dedicated evaluation flights. Review of this data will be consistent with the Airway Facilities and Air Traffic commissioning process. This data will also be used for Flight Standards approval of Capstone ADS-B data for use as surveillance information for radar-like services. Controller operational feedback will also be gathered during this period for reporting, correcting, and tracking Capstone ADS-B problems, anomalies and suggestions.

2.2. Safety Engineering Report

An end-to-end system-level operational safety review for Capstone ADS-B radar-like services is being performed by the Capstone Program Office and the Alaskan Region in coordination with the FAA Office of System Safety (ASY-300). A Capstone system safety working group has been formed that includes Alaskan operations and safety specialists. This analysis will include hazard identification, risk assessment, severity and probability determination, and controls and mitigation documentation specific to Capstone avionics, ground systems and procedures. The Capstone Radar-Like Services Using ADS-B Safety Engineering Report will be available in November 2000.

2.3. Safety Benefit Study

The University of Alaska – Anchorage (UAA) is under contract to perform a three-year study addressing the safety and benefits that result from the Capstone Program and associated new flight procedures in the Bethel/Yukon-Kuskokwim Delta area. The safety study includes:

- Documenting a baseline of Capstone area operations (e.g., accidents/incidents/near mid-air collisions, carriers/operators, pilots, airports, approaches, navaids and all facilities to include weather, communication, and navigation)

- Monitoring and documenting infrastructure changes within Capstone area (e.g., IFR approaches established, ADS-B ground system coverage, Capstone avionics acceptance/usability, operator reliance on avionics, equipment failure rate, training, accidents/incidents/near mid-air collisions, human factors relating to usefulness and acceptance)

- Preparing annual and final reports on safety change measured (e.g., review of accidents/incidents/near mid-air collisions, analysis of pre-Capstone/post-Capstone safety posture, survey of Capstone users)

The draft baseline study can be found at http://www.alaska.faa.gov/capstone/docs/docs.htm. Twice yearly follow-on surveys, including pilot Capstone avionics usability data, will cover each year of the Capstone program. This study will be used by the Capstone Program Office and organizations such as FAA Aircraft Certification and FAA Civil AeroMedical Institute (CAMI) to assist in future policy decisions for this type of technology, and the FAA System Architecture and Investment Analysis (ASD) to support NAS implementation.

2.4. Performance and Operational Data

An important Capstone product is the data and operational experience gained through Capstone activities that other organizations (e.g., RTCA, ASD, FAA Air Traffic System Requirements (ARS)) and decision-makers can use in a variety of on-going regulatory and industry activities. Table 1 summarizes the activity areas defined in the RTCA Development and Implementation Planning Guide for ADS-B Applications[3], Capstone data sources, and potential users of that data. For example, Capstone data will support and help address issues identified by FAA ARR-100 in their Requirements Evaluation Plan for ADS-B (Phase #1: Identification of Research Needs) and Operational Demonstration Requirements Document for ADS-B Applications in Support of Requirements Evaluation Plan Phase II and III activities. Input to NAS Architecture, cost/benefit, and industry standards development is also expected.

[3] RTCA, Development and Implementation Planning Guide for ADS-B Applications, DO-249, 1999.

Table 1. Example Capstone Data Sources Categorized to RTCA Planning Guide Activities[4]

Activity Area	Capstone Data Sources	Potential Users of the Data
Operational Concept	Pilot and controller training material, pilot and controller questionnaires and operational feedback	RTCA and other standards committees, FAA Air Traffic System Requirements (ARS), SF21 Ops/Procedures SG
Benefits and Constraints	UAA Safety Study, actual equipment costs	SF21 Cost/Benefit WG, FAA System Architecture and Investment Analysis (ASD)
Maturity of Concept and Technology	Certification and operational approvals of equipment and procedures	RTCA and other standards committees, FAA Air Traffic System Requirements (ARS), SF21 Ops/Procedures SG
Operational Procedures	Pilot and controller training material. ADS-B procedures as adopted from current ATC (e.g., 7110.65) and pilot (e.g., FARs, AIM) procedures	RTCA and other standards committees, FAA Air Traffic System Requirements (ARS), SF21 Ops/Procedures SG
Human Factors Issues	Controller operational feedback, UAA Pilot Training and Safety Study	RTCA and other standards committees, Airway Facilities, Air Traffic, Flight Standards, Aircraft Certification, SF21 Ops/Procedures SG
End-to-End Performance and Technical Requirements	AOS-600 report, ADS-B and radar track data	RTCA and other standards committees, FAA Air Traffic System Requirements (ARS), FAA System Architecture

[4] RTCA, Development and Implementation Planning Guide for ADS-B Applications, RTCA/D0-249, October 1999.

		and Investment Analysis (ASD), SF21 Tech/Cert SG
Interoperability Requirements for Air and Ground Systems	Certification test data, interface requirements document (IRD) and ground system architecture documentation	RTCA, FAA Air Traffic System Requirements (ARS), SF21 Ops/Procedures SG
Operational Safety Assessment	Safety Engineering Report, certification test data	System Safety (ASY), Air Traffic, Flight Standards, Aircraft Certification
Equipment Development, Test, and Evaluation (Aircraft and Ground)	AOS-600 report, ADS-B and radar track data. Controller operational feedback, UAA Training and Safety Study	RTCA and other standards committees, Airway Facilities, Air Traffic, Flight Standards, Aircraft Certification, SF21 Tech/Cert SG
Operational Test and Evaluation	AOS-600 report, ADS-B and radar track data. Controller operational feedback, UAA Pilot Training and Safety Study	RTCA and other standards committees, Airway Facilities, Air Traffic, Flight Standards, Aircraft Certification, SF21 Ops/Procedures SG, SF21 Cost/Benefit, SF21 Tech/Cert

3. Developmental Test and Evaluation

Developmental Test and Evaluation (DT&E) will be used to identify and resolve critical technical and operational issues leading toward certifications and approvals of the ground and airborne systems.

3.1. Ground System

3.1.1. Equipment

Various DT&E activities were performed by the ground equipment manufacturers (Lockheed Martin for Micro-EARTS, UPS Aviation Technologies for the GBT), both in their facilities as well as in conjunction with the FAA. The bulk of the ground system DT&E activities as they relate to radar-like services were conducted at the WJHTC for acceptance testing in April 2000 and has continued in Alaska for key site testing. The following sections detail the DT&E activities.

3.1.1.1.Micro-EARTS Acceptance Testing

The Micro-EARTS acceptance testing at the WJHTC included AUA-640 for overall test process management, AOS-400 as Micro-EARTS test director, ACT-300 for flight tests, AAL/Anchorage Center for regional coordination, and Lockheed Martin as test manager. Various other organizations were involved, including, the CNS Engineering and Test Division (AOS-300), NAS System Engineering and Analysis Division (AOS-500), and the Facility Services and Engineering Division (AOS-600). These tests included end-to-end testing of ADS-B targets on the Micro-EARTS using a test configuration of the Capstone ground system and WJHTC aircraft equipped with Capstone avionics.

The Lockheed Martin Micro-EARTS test plan[5] established the plans for all testing to be conducted by Lockheed Martin Air Traffic Management (LMATM) on the Capstone Case File (NCP-AL512-MEART-013). The Capstone Case File involves software changes to the Micro-EARTS baseline to incorporate processing of ADS-A and ADS-B data (Note ADS-A is not part of Capstone). The LMATM Micro-EARTS support team had the responsibility to develop the test procedures, dry run these procedures, and conduct the formal acceptance test at WJHTC. The test activities involved verification of the Capstone requirements as defined in the Functional Description Narrative (FDN)[6] for the Capstone Case File.

One purpose of the Capstone Case File was to add the capability to the Micro-EARTS to process ADS-B surveillance data and present this to the controller on the situation display. The data are also processed by the safety functions with any resulting warnings displayed for the controller.

---

[5] Lockheed Martin Air Traffic Management, Capstone Test Plan, Draft February 11, 2000

[6] Lockheed Martin Air Traffic Management, Final Draft Micro-EARTS Capstone Functional Description Narrative (FDN), CCD 21270 / NCP AL512-MEART-013, 02/03/2000

ADS-B testing was limited to the functions performed by the Micro-EARTS using ADS-B inputs as specified in the Capstone Interface Control Document (ICD) for the Capstone Communication Control Server (CCCS) to Micro-EARTS Gateway interface[7].

Testing for Capstone was comprised of two major categories: regression testing and functional testing. Regression testing is primarily done using existing test procedures from some of the more significant case files added to Micro-EARTS. Functional testing was done with new test procedures written to validate the requirements specified in the FDN for Capstone. The new test procedures were written using the same format as the test procedures currently developed as part of the Micro-EARTS support activities.

At the completion of each test case, the test results were analyzed and evaluated by test personnel according to the success criteria listed in the test procedures. The test procedure shall be marked accordingly, P (Pass) or F (Fail). Each failure shall be documented in the test log. At the end of each day of testing, a debriefing was held. After completion of system testing a Post-Test Debriefing was held. Issues that arose during the test period were reviewed and an appropriate resolution plan developed.

Appendix D provides a memo pertaining to Capstone ADS-B acceptance testing and data accuracy, and provides a recommendation to support separation minima for Capstone ADS-B.

3.1.1.2.Capstone Communications System Architecture Testing

The Capstone Communications system architecture will go through appropriate level of system testing in order to meet the requirements as specified in the System Architecture Description for Capstone Communications[8]. The Capstone telecommunications architecture must support surveillance (i.e., critical level) services in accordance with NAS performance requirements. Design goals for these requirements are specified in the FAA's NAS System Requirements Specification (NAS-SR-1000). The Capstone ground system communication architecture will be tested via a FAA AOS-500/AAL-500/400 agreed upon NCP process and will include WJHTC and Anchorage Center testing (see Appendix E).

GBTs are not included in any existing orders that contain certification parameters. However, the National Airways System Engineering Division, AOS-200, is in the process of writing certifications parameters to be used once test equipment is available for the GBTs. Test equipment will not be available until after the IOC date established by the program office. The notice in Appendix E provides interim certification criteria to be used until GBT test equipment is available.

---

[7] FAA AAL-512, CAPSTONE INTERFACE CONTROL DOCUMENT (ICD) FOR THE CAPSTONE COMMUNICATIONS CONTROL SERVER(CCCS) THE Micro-EARTS Gateway, Final, document Control Number: NAS-IC-82298228**,** Case File Number (CFN): AL512-Micro-EARTS-014 December 09, 1999

[8] FAA AAL-512, SYSTEM ARCHITECTURE DESCRIPTION FOR CAPSTONE COMMUNICATIONS FINAL DRAFT, March 24, 2000

3.1.1.3.Spectrum

Operationally protected spectrum is a requirement for ATC use of ADS-B for radar-like services. The FAA Spectrum Management Office (ASR) is in the process of coordination with the US Department of Defense to ensure that the UAT frequency is protected. The current UAT avionics and the corresponding GBTs are operating on a frequency of 966 MHz that has temporary experimental approval in the state of Alaska. This is adequate for supplemental uses of ADS-B (e.g., enhanced air-to-air visual acquisition). However, for the more demanding ATC IFR separation services a frequency of 981 MHz is being sought. The only Navigation Aid in Alaska that could have caused interference was the Fairbanks VOR, and that has been retuned. There is an issue with the Department of Defense JTIDS interference and that is being coordinated. Note the retrofitting of the avionics and the GBTs to 981 MHz will be scheduled simultaneously in the December 2000 – January 2001 timeframe.

An interim authorization for Capstone use of 981MHz and JTIDS operations in Alaska has been accomplished and is reflected in the Government Master File for frequency assignments. Coordination for long term agreement on use of this spectrum range for NAS modernization and JTIDS is ongoing.

3.1.1.4.Key-Site Testing

Following the acceptance testing process at the WJHTC, AUA-600, AAL-500 and AAL-400 conducted key site installation testing for the Micro-EARTS and GBTs at the Anchorage Center. During this testing, data was collected using targets of opportunity (i.e., aircraft flying VFR with installed avionics). Air Traffic (AT) and Airway Facilities (AF) maintenance and operations will use this data to support commissioning of the ground system.

During August 2000, the FAA B727 from the WJHTC performed dedicated flight profiles (see Appendix F) to validate previously documented performance of ADS-B to determine and confirm signal coverage for ground installations at Bethel, Cape Newenham, and Cape Romanzof. The test included system interaction performance between ADS-B airborne and ground transceivers and the hard and soft connections to the Micro-EARTS. The testing was designed to collect coverage and performance information related to the ADS-B ground station and airborne avionics; Test coverage area integrity and signal availability of ADS-B transmissions at various altitude and specific locations in the Capstone area; Observe and document performance of radar at Newenham and Romanzof and ADS-B ground stations at Bethel, Newenham and Romanzof while tracking the test aircraft.

3.1.2. Procedures and Training

3.1.2.1.Air Traffic Controller

Air traffic specialists from both Anchorage Center and ATP-100 have reviewed the controller's handbook (Order 7110.65, Air Traffic Control) and various other FAA documents (e.g., 7210.3, 7610.4, Aeronautical Information Manual, Letters of Agreements, Alaska Flight Information Supplement) to adopt and apply current radar separation rules and procedures (e.g., alignment

check, positive identification and validation, separation standards) for ADS-B radar-like services. The intent was to apply “ADS-B” wherever the term "radar" appears, permitting full use/acceptance of ADS-B for both VFR and IFR services. This work, as well as development of a controller training package, is being performed. Formal NATCA coordination and controller training will be completed prior to initial operational capability.

See Appendix G for the ATP Notice and NATCA Memorandum of Understanding regarding Capstone ADS-B Radar-Like Services.

3.1.2.2.Technician

Both Maintenance Control Center and System Management Office technical training will occur based on manufacturer provided installation manuals and other appropriate documentation. As equipment is upgraded so will the corresponding manuals and training materials. Trained technicians with certification authority are responsible for certification and corresponding facility maintenance log entries regarding the GBTs, Micro-EARTS, and other parts of the Capstone ADS-B ground system.

3.1.3. Approvals

Standard approval and authorization processes will certify the ground systems for operational use. This will include service and system level certifications. This certification is based on performance and reliability results from DT&E activities and operational testing explained in the next section. Approval for the use of ADS-B for 5-mile radar-like separation will require data showing that the Capstone ADS-B system is at least equivalent to radar in terms of reliability and system performance. This includes data from the WJHTC acceptance testing, key-site testing (e.g., WJHTC FAA B727), and operational testing. This approval process will be a collaborative effort between flight standards (AFS), air traffic procedures (ATP), airways facility (AF), Micro-EARTS Integrated Product Team (AUA), and the Alaskan Region.

The service level certification encompasses all lower certification levels and indicates that the overall service can be used by air traffic control for the safe, efficient movement of aircraft within the area served by the service. As part of the service certification, the certifying engineer/technician must ensure that all certifiable systems in the sensor to the display path have current certifications. System level certification verifies that the hardware components of the system and the operational program are functioning together as a unit. This level of certification also ensures that the correct version of software is installed on each processor utilized in the system.

Certification is required for components of the NAS that provide moment-by-moment positional information, per Order 6000.15C, para 504. A service level certification will be required at ZAN ARTCC. That service level certification will be based, in part, on the source facility (GBT) and satisfactory system operation, reference Order 6000.15C, para 505 & 506. FAA Order 6190.16B, Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En

Route Automated Radar Tracking System (MEARTS)[9] provides guidance and prescribes technical standards, tolerances, and procedures applicable to the maintenance and inspection of the RBDER and the MEARTS. It also contains certification requirements for surveillance services (e.g., ADS-B) in the en route ATC environment, and certification requirements for constituent systems used to provide these services. General guidance on ground system certification of systems, subsystems, and equipment can be found in FAA Order 6000.15 and has been followed for the Capstone ADS-B ground system installation.

System level certification of the GBT is accomplished through WJHTC testing and installation test requirements (See Appendix E). A Facilities and Equipment Maintenance Handbook for the GBT[10] provides guidance and prescribes technical standards, tolerances, and procedures applicable to the maintenance and inspection of the Apollo GBT2000 Ground-Based Transceiver which is the remotely located, data link portion of the ADS-B service. It also provides information on special methods and techniques that will enable maintenance personnel to achieve optimum performance from the equipment. This information augments information available in instruction books and other handbooks, and complements the latest edition of Order 6000.15, General Maintenance Handbook for Airway Facilities.

Installations at ZAN and Bethel followed a standard AF process that included a site survey, developing a design package, reviewing the site design, installation using appropriate certification criteria, and a Joint Acceptance Inspection.

3.2. Airborne System

3.2.1. Equipment

DT&E activities (e.g., bench and flight tests) at UPS Aviation Technologies' Salem, Oregon facilities and activities in Alaska led to the issuance of a STC (No. SA02149AK) for the Capstone avionics (See appendix C). This STC for the provisioning of wiring, antenna, and mounting hardware was issued in November 1999. An amended STC was issued following flight tests of the multi-function display and UAT in February 2000 that covers the Capstone avionics to support navigation, terrain, and traffic awareness (using ADS-B) for supplemental VFR operations. The upgrade to these avionics for radar-like services is scheduled for December 2000 and the STC will be once again amended. Continued DT&E activities will support the certification of this upgrade.

The avionics upgrade for ATC's use for radar-like services mainly effects the UAT radio (i.e., certification of the broadcast signal). It does not change the pilot's use of the avionics, i.e., the MX20 and GPS will still be limited to supplemental VFR operations via the FAA approved Airplane Flight Manual Supplement or Supplemental Airplane Flight Manual for Capstone System Installation. The system will still be placarded "GPS and MFD limited to VFR use only", and the aircraft/pilot must have other navigation capability appropriate to the route of

---

[9] Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En Route Automated Radar Tracking System (MEARTS), FAA Order 6190.16B.

[10] FAA Facilities and Equipment Maintenance Handbook – GBT, DRAFT Order Al 6368.1, 6/30/00

flight. (Note that some operators may upgrade their GPS and other navigation systems for IFR operations, but this is not a part of Capstone.)

3.2.1.1.UAT

The intended function of the Capstone ADS-B system is to provide aircraft identification, position, and status information to other aircraft and to ATC to enable surveillance capabilities in an area not serviced by radar.

A Capstone UAT Interim Design Specification[11] has been developed to document avionics requirements for the application of ATC's use for radar-like services. In addition a frequency change to 981MHz will be required to enable operationally protected spectrum – a requirement for operational use by ATC. A certification plan to ensure the UAT meets the above requirements is being developed and DT&E activities such as prototype builds, engineering evaluations, flight and environmental testing will take place in 2000. This will result in an amended STC for ADS-B radar-like services.

The Capstone UAT Interim Design Specification is not an RTCA-developed Minimum Operational Performance Standard (MOPS); it is an Interim Design Specification (IDS) specifically developed to support the FAA's Capstone Program. A critical requirement for Capstone is for standards defining the aircraft-based ADS-B transmit function. This is required to support the program's near-term objective of providing ATC "radar-like" services to equipped aircraft in non-radar airspace. The primary objective of this IDS is to provide certification guidance for the ADS-B transmit function. Figure 6 shows the services and connectivity supported by UAT.

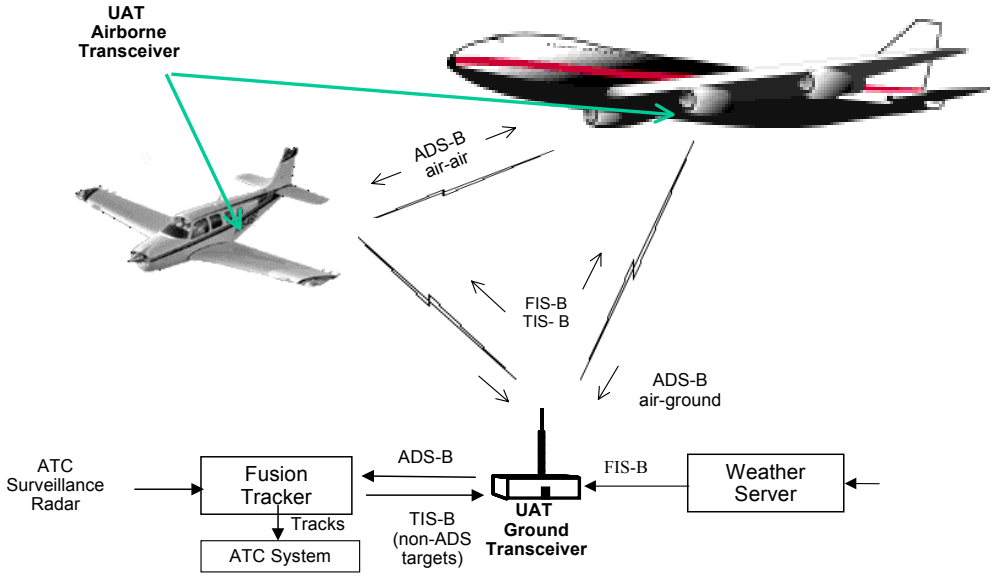


Figure 6. UAT Services and Connectivity

[11] FAA Capstone Program Office, Capstone UAT Interim Design Specification, DRAFT 18 May 2000

A functional hazard assessment was performed by aircraft certification and helped define the requirements in the IDS. The following are examples of requirements from the IDS that are applicable to the intended function of "Radar-Like Services", and which are in addition to what was required for VFR advisory services.

- Navigation equipment independent of the avionics supporting Radar-Like Services must be retained.

- Avionics equipment supporting Radar-Like Services are subject to periodic airworthiness inspections.

The installation process for the upgraded radar-like service avionics will consist of a box-swap of the UAT i.e., disconnect the antennas, wiring harness, and mounting bracket from the existing UAT unit and install the new unit. The current wiring harness, antennas, and mounting bracket will be used with the upgraded UAT unit. There will also be an accompanying software upgrade for the MX20, consisting of replacing the current flash card memory with a new flash card, similar to a database update. The entire process is expected to take 1 hour, including proper maintenance log entries.

3.2.2. Procedures and Training

The University of Alaska at Anchorage (UAA) is contracted by the Capstone Program Office to develop and administer FAR Part 135 approved initial and recurrent pilot training on the Capstone avionics. Training will be made available in Anchorage at the UAA's Aviation Complex and in Bethel. Beta-testing of the training was accomplished in December 1999 and January 2000. Initial classes began in February 2000. The training program will be updated, as appropriate, to include new functionality in the avionics and reflect pilot operational feedback. This includes training, as determined by FAA Flight Standards, for use of ADS-B when radar-like services become available.

For the Capstone avionics training, 2-day initial ground training is followed by initial operational experience with the equipment. The optimum scheduling of this training per operator corresponds with their aircraft becoming equipped. The training includes equipment familiarization and practice exercises relating to real world flight operations in the Bethel Y-K Delta. The MX20 and GX60 units are available during training and operated in a demonstration mode centering on Bethel.

As appropriate, each pilot involved in Capstone will receive additional training, developed by UAA and approved by Flight Standards, on the use of ADS-B for radar-like services (see Appendix H). From the pilot's perspective ADS-B radar-like services will be similar to receiving normal radar services from ATC. As experience is gained and operational feedback is documented, specific procedures (e.g., special VFR) for the airspace around Bethel may be developed and implemented.

3.2.3. Approvals

The FAA Flight Standards Principal Inspectors (operations, maintenance, avionics) for the participating operators have approved the training and procedures for the supplemental VFR avionics. Appropriate oversight will continue as new avionics functionality is introduced.

A Joint Flight Standards Handbook Bulletin for Air Transportation (HBAT) and Continuous Airworthiness (HBAW) (HBAT 00-06, HBAW 00-05) has been issued for operational approval to conduct operations using ADS-B avionics systems (OpSpecs A002 and A052). Per this HBAT/HBAW, the application of ATC's use of ADS-B for separating aircraft in a non-radar environment does not require an issuance of OpSpec paragraph A052 given it will not require the pilot to share separation responsibility (maintain separation from other air traffic using a cockpit display of traffic). Therefore, operations are conducted as they are today in a radar environment.

AFS-400 has the responsibility to review and approve the use of ADS-B data as surveillance information. This is a concurrence process between air traffic, airways facilities, aircraft certification, and flight standards. See Appendix H, for memos regarding separation standards for ADS-B and a recommendation to authorize ATC services to Capstone ADS-B equipped aircraft.

4. Operational Evaluation

Implementation and operational evaluation during normal revenue service flying will be conducted to monitor Capstone systems performance and to collect operational feedback from the pilots and controllers. The implementation and operational evaluation for the airborne systems started in February 2000 with the initial avionics installations, and will largely be accomplished by UAA, using pilot surveys and questionnaires. Operational feedback during supplemental VFR operations is a required step towards full radar-like services and is therefore included in this document. Operational evaluation of the ground systems will commence in September 2000. Acceptable levels of performance, reliability, integrity and pilot/controller operational feedback will permit the transition to radar-like services.

4.1. Ground System

The objective of this effort is to verify that the Capstone ADS-B ground system is acceptable for use in providing radar-like services and that the Capstone ADS-B ground system equipment performs in accordance with applicable specifications. The accuracy of the Capstone ADS-B Global Positioning System (GPS) receiver was tested at the WJHTC in April, 2000 and found to provide position information in accordance with the published GPS specification.

Since the ZAN Microprocessor Enroute Automated Radar Tracking System (Micro-EARTS) will be used to collect most of the data necessary for this evaluation and both ADS-B and radar data are needed, the data collection will not begin until at least one Capstone Ground Based Transceiver (GBT) has been certified in accordance with FAA certification procedures. Following this, ADS-B and radar data will be recorded via the Micro-EARTS Continuous Data Recording (CDR) function for a period of at least 30 days using targets of opportunity and dedicated test flights. The geographical test area is defined as that airspace defined in Airspace Docket 99-AAL-24. Each day's data will be reduced to Microsoft Excel format to facilitate analysis and charting.

See Appendix I for the Capstone ADS-B Acceptability Evaluation Test Plan and a memo from AUA-600 summarizing results.

4.1.1. Data Collection Methodology

The ZAN Micro-EARTS will be used to collect most of the data necessary for this evaluation, and both ADS-B and radar data are needed. FAA maintenance logs and controller comments will also be used.

A controller Capstone ADS-B Action Request System has been developed by Anchorage ARTCC and will be used for reporting, correcting, and tracking Capstone ADS-B problems, anomalies and suggestions at Anchorage ARTCC (Appendix J). Once operations begin an additional questionnaire, developed by AND-500, can be administered to capture controller feedback relating to benefits, workload implications, and procedure development (Appendix J)

4.1.2. Performance Measures

The design system requirements as stated in applicable government and manufacturer specifications will be used to determine that the system is functioning properly. These are referenced in the Capstone ADS-B Acceptability Evaluation Test Plan (Appendix I). In addition, the system performance measures for use of surveillance information in providing aircraft separation are described in NAS-SR-1000[12] requirements. The Capstone ADS-B system was designed to meet and in many cases exceed these requirements for enroute surveillance. Care should be taken not to confuse design versus minimum performance measures. Just because the system is designed to exceed the NAS performance standards, should not make the design specifications the minimum performance specifications for a new technology/implementation.

4.2. Airborne System

Pilots began flying Capstone equipment as a supplemental aid to VFR operations in February 2000. The operational evaluation for the airborne systems has been ongoing since then and is largely being accomplished by UAA, using pilot surveys and questionnaires. Operational feedback during supplemental VFR operations as well as with the introduction of radar-like services is required to identify system anomalies and potential refinements.

4.2.1. Data Collection Methodology

The UAA has been contracted to provide a training and safety study that will baseline the current operations as well as monitor pilot acceptance, usability, and usefulness of avionics, and collect feedback on training and Capstone avionics use through a series of questionnaires and surveys (Appendix K). In addition other mechanisms are in place, such as FAA Flight Standards Program Tracking and Reporting Subsystem (PTRS) and UPS AT technical support hotline/tracking system. Data collection and analysis will help validate pilots increased situational awareness and improved flight safety.

4.2.2. Performance Measures

The Capstone program office, Aircraft Certification, and Flight Standards have requirements to continually review operations of the Capstone avionics for continued airworthiness on any unanticipated design anomalies as well as to improve the next generation designs. Aircraft certification looks at human factor data such as functionality, integration, and operational interface ease of use. Flight Standards looks at similar items and also at air carrier training, manuals/procedures, and operational specifications. Performance measures for these types of requirements can be subjective and are therefore not expanded upon here.

4.3. Safety Effects and Benefits

To quantify the safety effects and benefits of Capstone, the UAA has been contracted to provide a Training and Safety Study that will baseline the current operations and periodically update that

---

[12] Federal Aviation Administration, National Airspace System – System Requirements Specification (NAS-SR-1000), paragraph 3.2.3 Aircraft Separation, Change 14 December 1995.

baseline to measure Capstone's effect on operations. It must be noted that uncontrolled changes (e.g., increase/decrease in IFR traffic, increase/decrease in pilot experience) within the Bethel/Y-K delta will also effect operations – so these must be considered in the analysis. This training and safety study will be used to track the impact of radar-like services.

4.3.1. Data Collection Methodology

Appendix K has copies of the Capstone Evaluation Feedback Form and a Usability Analysis. A Capstone baseline survey can be found in the Capstone Baseline Safety Report. These various forms are used to track such things as:

- Pilot background, experience, and training, opinions about safety and Capstone
- Equipment malfunctions
- Usability of the MFD and GPS

4.3.2. Performance Measures

The performance measures for the airborne system operational evaluation is defined largely by the baseline survey results. Follow-on surveys will be compared to the baseline results to see how Capstone, in this case specifically the introduction of radar-like services, has impacted operations in the Bethel Y-K delta region. Items such as equipment malfunctions will be fed back to the manufacturer for their analysis and consideration for product improvement.

5. Capstone System Safety

The development of Capstone ADS-B radar-like services is following defined system safety practices in order to facilitate a safe and risk managed implementation. This operational safety review process is intended to meet the safety review requirement stated in the Administrator's letter.

System Safety is a specialty within systems engineering that supports program risk management. It is the application of engineering and management principles, criteria, and techniques to optimize safety. The tasks and activities of system safety management and engineering being used by Capstone are defined in this section and can be considered the Capstone System Safety Program Plan (CSSPP). The specific elements include Scope and Objectives, System Safety Organization, Program Milestones, System Safety Requirements, Hazard Analysis, System Safety Data, Safety Verification, Audit Program, Training, Incident Reporting, and System Safety Interfaces.

5.1. System Safety

The inputs to the system safety process are the design concepts of the Capstone Program, formal documents, and design discussions during formal meetings and informal communications. The on-going outputs of the system safety process are hazard analysis, risk assessment, risk mitigation, risk management, and optimized safety.

Inputs:

- Concept of Operations
- Interface Control Documents
- Operational Requirements Document
- System / Subsystem Specification
- Management and System Engineering Plans (e.g., Test and Evaluation Master Plan)
- Design details

Outputs:

- Hazard Analysis:
  - Identifying safety related risks (contributory hazards) throughout Capstone life cycle
  - Conducting system hazard analysis evaluating human, hardware, software, and environmental exposures
  - Identifying and incorporating hazard (risk) controls
- Risk Assessment
  - Defining risk criteria (severity and likelihood)
  - Conducting risk assessment (risk acceptability and ranking)
- Risk Management
  - Conducting Hazard Tracking and Risk Resolution
- Optimize safety (assure acceptable safety related risks)
- Monitor controls

5.2. Capstone System Safety Program Plan

This Plan includes appropriate system safety tasks and activities to be conducted within the program. It includes integrated efforts of other participants, management, team members, and subcontractors. The CSSPP elements listed below are to be monitored specifically by the Capstone System Safety Working Group as implemented.

Ensuring Capstone system safety is a consensus process with participation from operational personnel implementing Capstone and appropriate system safety representatives from the FAA Office of System Safety. This group has had various telecons and meetings to perform the safety analysis and review process. An important aspect of this process is having the people performing the implementation (e.g., providing training) also involved in the review in order to put into practice the identified controls and mitigations.

Specific for radar-like services a "lower 48 team" produced an initial draft preliminary hazard analysis and then through a series of review meetings in Alaska the Capstone implementation experts refined it.

5.2.1. Program Scope and Objectives

The objective of System Safety is to optimize safety by the identification of safety related risks, their elimination, and/or control via design and/or procedures, based on acceptable system safety precedence.

Capstone is a program implementing new technologies and procedures to specifically address safety and capacity/efficiency issues in Alaska. Lessons learned during the initial implementation in the Bethel Yukon-Kuskokwim Delta area can then be applied to the rest of the NAS. Hazard tracking and risk resolution activities are to continue throughout the Capstone Program life cycle. As Capstone evolves so should the system safety efforts. This plan defines important activities associated with Capstone System Safety and it is to be formally endorsed by the program manager.

5.2.2. Capstone System Safety Organization

As a result of the January 2000 Capstone radar-like services coordination meeting in Washington DC, a Capstone System Safety Working Group was formed. This is the primary group responsible for the Capstone system safety review.

In general, the FAA Administrator is accountable and has the authority for safety. The agency management has the responsibility for carrying out the programs. The primary responsibility for the Capstone program is with the program manager and the Capstone staff personnel delegated day to day system activities.

5.2.2.1.Capstone System Safety Working Group

Activities of the Capstone System Safety Working Group (CSSWG) are defined in this plan. The CSSWG includes cognizant personnel who are involved in the Capstone program.

Primary Working Group members include:

Mike Allocco, ASY-300
August Asay, ACE-115N
Lari Belisle, ZAN-20
Kevin Brandon, NATCA
James Call, AAL-1SC
Jim Cieplak, MITRE/CAASD
Leonard Kirk, UAA
Michael Lenz, ASY-300
Jim Patchett, ZAN-20
Brad Wacker, ASY-300

CSSWG activities may include:

- Monitoring Capstone System Safety interface activities to assure that system safety is adequately demonstrated; all identified risks that have not been eliminated are adequately controlled and risk controls (mitigation) have been formally verified as being implemented.
- Review activities, analysis, assessments, and studies appropriate to system safety.
- Conducting the hazard tracking and risk resolution activities.

5.2.3. Capstone Program Milestones

The Capstone System Safety process schedule is defined within this plan. The schedule indicates specific events and activities along with program milestones.

- Generate System Safety Program Plan
- Conduct Preliminary Hazard Analysis (PHA)
- Generate Safety Engineering Reports (SER)
- Complete end-to-end Safety Review
- Complete Hazard Tracking and Risk Resolution activities
- Conduct CSSWG Meetings

5.2.4. Capstone System Safety Requirements

The general engineering and administrative requirements for Capstone System Safety are described within this CSSPP. As the design and the preliminary hazard analysis matures specific system safety standards and requirements are to be developed by the program in concert with the Capstone System Safety Working Group. The PHA indicates the mitigations for the identified risks. These mitigations are to be formally verified and validated. Every accepted mitigation, precaution, hazard control or risk control is to be formally incorporated into the design and/or administrative procedures. This effort involves hazard tracking and risk resolution.

5.2.4.1. Hazard Tracking and Risk Resolution

Hazard Tracking and Risk Resolution is a procedure to document and track risks, contributory hazards, and their associated controls by providing an audit trail of risk resolution that will be documented in the safety engineering report. The controls are to be formally verified and the

specific risks and/or contributory hazards are to be closed during safety reviews. This verification process is discussed below in section 5.2.7 Safety Verification.

5.2.4.2.Risk Assessment Measurement

The measurement for risk assessment is defined below. Risk is associated with a specific accident (event); it is an expression of the credible worst case severity and likelihood related to the scenario under study. Capstone program management, with input from the CSSWG, is to define acceptable risk levels. The CSSWG will define the current levels of risk without Capstone implementation, the transitional risks during implementation, and the residual risks after Capstone implementation and acceptance.

The definitions shown in the tables below (Tables 2, 3, 4) are appropriate to support system hazard analysis activities, in that events can occur at any time considering possible exposure within the system and life cycle. Consider events occurring on the ground, during maintenance, within a facility, within an individual aircraft, or between a number of aircraft. The PHA is conducted at a system level. The system considers interfaces and interactions of humans, hardware, software, firmware, and/or the environment. The PHA is the first analytical step that will develop into a full system hazard analysis.

Table 2. Event Severity Definitions

Description	**Category**	**Definition**
Catastrophic	I	Fatality, and/or system loss, and/or severe environmental damage, and/or collision with aircraft, and/or structure, and/or ground
Critical	II	Severe injury, severe occupational illness, major system, and/or environmental damage, and/or near midair collision, and / or service termination.
Marginal	III	Minor injury, minor occupational illness, and/or minor system damage, and/or environmental damage, and/or loss of separation of aircraft, and/or loss of communication single aircraft, and/or service interruption.
Negligible	IV	Less then minor injury, occupational illness, and/or less then minor system damage, and/or environmental damage

Table 3. Event Likelihood

DESCRIPTION	LEVEL	CAPSTONE GROUND EQUIPMENT	CAPSTONE AIRCRAFT FLEET
Frequent	**A**	Likely to occur frequently	Continuously experienced
Reasonably Probable	**B**	Will occur several times in the life of item	Will occur frequently
Remote	**C**	Likely to occur sometime in life of exposure	Will occur several times
Extremely Remote	**D**	Unlikely, but possible to occur in life of an item	Unlikely but can reasonably be expected to occur
Extremely Improbable	**E**	So unlikely, it can be assumed occurrence may not be experienced	Unlikely to occur, but possible

Notes:

1. Event Likelihood is an estimation of the probability of a specific potential event under study, based upon best judgment.
2. Consider that potential events will have many contributors, i.e., human errors, software malfunctions, deviations, failures. The system reliability/availability approximation may only be a part of this overall estimation of the scenario likelihood. System risks can occur even with perfect system reliability and availability.
3. Consider worst case severity and likelihood, when evaluating system safety related risks.
4. A contributory hazard is the potential for harm, i.e., unsafe acts and/or unsafe conditions. Contributory hazards may be associated with the potential events under study.
5. The Risks associated with any changes within the system must be reevaluated.

Table 4. Severity versus Likelihood

SEVERITY LEVEL	LIKELIHOOD OF OCCURRENCE				
	A Frequent	*B* Reasonably Probable	*C* Remote	*D* Extremely Remote	*E* Extremely Improbable
I CATASTROPHIC Collision, Fatality, System Loss, Severe Damage	R1		R2		
II CRITICAL NMAC, Severe Injury, Severe Illness, Major System Damage, Service Termination			R3		R4
III MARGINAL Loss of Separation, Minor Injury, Minor Illness, Minor System Damage, Loss of Comm (single aircraft), Service Interruption					
IV NEGLIGIBLE Less Than Minor Injury or Illness, Less Than Minor System Damage	R4			R5	

Risk Assessment Code	Criteria
R1	Risk must be eliminated or controlled to an acceptable level. Residual risk is extremely high, and additional mitigation will be required.
R2	Risk is still considered very high because of the nature of Alaska operations. Risk must be controlled to an acceptable level.
R3	Risk is considered moderate.
R4	Risk is considered low.
R5	Risk is considered very low.

5.2.4.3.Capstone System Safety Precedence

The order of precedence for satisfying system safety requirements and resolving identified risks is listed in Table 5.

Table 5. Capstone System Safety Precedence

Description	Priority	Definition
Design for minimum risk	1	From the first design to eliminate risks. If the identified risk cannot be eliminated, reduce it to an acceptable level through design selection.
Incorporate safety devices	2	If identified risks cannot be eliminated through design selection, reduce the risk via the use of fixed, automatic, or other safety design features or devices. Provisions shall be made for periodic functional checks of safety devices.
Provide warning devices	3	When neither design nor safety devices can effectively eliminate identified risks or adequately reduce risk, devices shall be used to detect the condition and to produce an adequate warning signal. Warning signals and their application shall be designed to minimize the likelihood of inappropriate human reaction and response.
Develop procedures and training	4	Where it is impractical to eliminate risks through design selection or specific safety and warning devices, procedures and training are used. However, concurrence of authority is usually required when procedures and training are applied to reduce risks of catastrophic or critical severity.

5.2.4.4.General Capstone System Safety Objectives

The CSSWG are following these general system safety objectives. The CSSWG recommends that to the maximum extent possible, all participants in the Capstone Program follow these objectives.

- Eliminate risks early via design, material selection and/or substitution.
- When hazardous components must be used, select those with the least risk throughout the life cycle of the Program.
- Design software controlled or monitored functions to minimize initiation of hazardous events, through software controls i.e., error source detection, modular design, firewalls, command control response, failure detection.

- Design to minimize risk created by human error in the operation and support of the Program.
- Consider alternate approaches to minimize risk, such as interlocks, fail safe design, and redundancy.
- Provide design protection from uncontrolled energy sources, e.g. physical protection, shielding, grounding, and bonding.
- Locate equipment so that access during operations, servicing, maintenance, installation, repair, minimizes exposure to associated risks.
- Categorize risks associated with the system and its performance.
- Identify the allocation of requirements to specification traceability and assess the effectiveness of this allocation on risk control.

5.2.5. Hazard Analysis

Hazard analysis is the process of examining a system throughout its life cycle to identify inherent safety related risks. The CSSWG has developed a Preliminary Hazard List (PHL). The PHL was used as the basis for continuing analysis to convert into a Preliminary Hazard Analysis. A list of potential accident scenarios that can occur throughout the life cycle of the Capstone Program are being developed. The scenarios along with their worse case effects, their risks, and their mitigations are being defined.

Other safety assessments, safety studies, and related analyses are being reviewed by the CSSWG for inclusion within the PHA. As the Capstone Program design matures, analysis efforts should progress and the PHA will be refined and enhanced.

5.2.6. Capstone System Safety Data

Historical system safety related data and specific lessons learned are to be used to enhance hazard analysis efforts. Specific knowledge concerning past contingencies, incidents, and accidents are also being evaluated to refine analysis activities. The University of Alaska, Institute of Social and Economic Research, is documenting a baseline of Capstone area operations (e.g., accidents/incidents/near mid-air collisions, carriers/operators, pilots, airports, approaches, navigational aids and all facilities to include weather, communication, and navigation), prior to Capstone implementation.[13] The CSSWG will use information from these studies to help identify risk levels.

In coordination with the Capstone Program office, the University of Alaska is collecting operational feedback. The feedback results will be used to monitor and document infrastructure changes within the Capstone area (e.g., IFR approaches established, ADS-B ground system coverage, Capstone avionics acceptance/usability, operator reliance on avionics, equipment failure rate, training, accidents/incidents/near mid-air collisions, human factors relating to usefulness and acceptance).[14] This information will also be used to refine the hazard analysis.

---

[13] Berman, M., Hill, A., Martin, S. University of Alaska, Institute of Social and Economic Research, "Air Safety in Southwest Alaska; Capstone Baseline Safety Report," DRAFT, January 31, 2000.

[14] Ibid, 2.

5.2.7. Safety Verification

Safety verification is needed to assure that system safety is adequately demonstrated and all identified risks that have not been eliminated are controlled. Risk controls (mitigation) must be formally verified as being implemented. Safety verification is accomplished by the following methods:

- Inspection
- Analysis
- Demonstration
- Test
- Implicit Verification
- Operational Feedback

It should be noted that no single method of verification indicated above provides total system safety assurance. Safety verification is conducted in support of the closed-loop hazard tracking and risk resolution process.

The mitigations within the PHA will be verified as they are implemented. The verification methods will be indicated within the analysis. After verification, the associated scenario will be considered closed. This implies that the risk is either eliminated or it has been controlled to an acceptable level defined by Program Management.

5.2.8. Audit Program

All activities in support of system safety are subject to a qualified peer review and/or audit as necessary. All system safety documentation including this system safety program plan and draft safety engineering report will be distributed and reviewed by the CSSWG, Capstone Program Office, applicable FAA lines of business, and appropriate Capstone users. This includes internal efforts and all external activities in support of closed-loop Hazard Tracking and Risk Resolution.

5.2.9. Training

When required, CSSPP participants are to receive specific training (e.g. briefings, safety talks, meetings, and presentations) in system safety to conduct hazard analysis, hazard tracking and risk resolution. Additional training will be provided for CSSWG members and other participants to assure awareness of the system safety concepts discussed herein.

Specific training is to be conducted for system users, controllers, systems engineers, and technicians. Training considers normal operations with standard operating procedures, maintenance with appropriate precautions, test and simulation training, and contingency response. Specific hazard control procedures will be recommended as a result of hazard analysis efforts.

5.2.10. Incident Reporting

The objective is to identify abnormal conditions or situations that can adversely affect the system safety of the Capstone Program and to be proactive in resolving them. The CSSWG will be working with the University of Alaska in the area of accident and incident reporting and analysis.

Any incident, accident, malfunction, or failure affecting Capstone System Safety is to be investigated to determine causes and to enhance hazard analysis. Causes will be eliminated. Testing and certification activities are also to be monitored; anomalies, malfunctions, failures that affect system safety are to be corrected.

5.2.11. Capstone System Safety Interfaces

System Safety has interfaces with other applicable disciplines both internally to systems engineering and externally. System Safety is involved within all Organizations and Program Offices, i.e., Airways Facilities, Air Traffic, Aircraft Certification, Software Development, Certification, Testing, Contract Administration, and Human Factors as examples. These disciplines may be directly involved in the hazard analysis, hazard control, hazard tracking, and risk resolution activities.

6. Resources Summary

See Capstone Program Plan version 2 for a summary of Capstone resources. That document can be found on the Capstone website at http://www.alaska.faa.gov/capstone/docs/.

Appendix A: FAA Administrator's Letter on Capstone ADS-B Radar-Like Services

Directors
+
Above

CONCURRENCES	
RTG. SYMBOL	ANI-1
INITIALS/SIG.	JHm222
DATE	12/13/99
RTG. SYMBOL	ART-1
INITIALS/SIG.	RMn92N
DATE	11/30/99
RTG. SYMBOL	AVR-1
INITIALS/SIG.	MGilligan
DATE	12/7/99
RTG. SYMBOL	for ARA
INITIALS/SIG.	D. Kerr
DATE	12/15/99
RTG. SYMBOL	AOA-3
INITIALS/SIG.	Bruce
DATE	12/27/99
RTG. SYMBOL	AAF-1
INITIALS/SIG.	R. Enoch
DATE	9/1/99
RTG. SYMBOL	for ADA-1
INITIALS/SIG.	AM
DATE	12/20/99
RTG. SYMBOL	ADA-2
INITIALS/SIG.	Cb R
DATE	12 3

KR 12/27/99

JAN 3 2000

Mr. John Eckels
President, Alaska Air Carriers Association
929 East 81st
Anchorage, AK 99518

Dear Mr. Eckels:

Thank you for your letter in support of Safe Flight 21 and the Capstone initiative. I agree with your assessment of the benefits that can be gained from an endeavor like Capstone in Alaska, and I share your enthusiasm to make this program a success.

To that end, the tasks identified in your letter have been delegated to the program office having lead responsibility. Specifically, these are:

a. Aircraft Certification has responsibility for approving the airborne equipment, including the global positioning system and data link equipment, that transmits the automatic dependent surveillance-broadcast (ADS-B) signals. 12/27/99

b. Airway Facilities has responsibility for approving ground-based systems and for ensuring that adequate radio spectrum is available and certified to meet identified user requirements.

c. Airway Facilities, together with the Air Traffic Service, must ensure compatibility of systems transmitting ADS-B information to the appropriate air traffic control facility.

d. Air Traffic Planning and Procedures must approve equipment that will be used to display ADS-B information and establish procedures for the use of ADS-B.

e. Flight Standards must approve operational standards and associated operations specifications permitting use of radar-like services based on ADS-B equipment.

Form DOT F 1320.65A (Rev. 5/83)
Supersedes previous edition

OFFICIAL FILE COPY

A991008022

These tasks and others are being orchestrated jointly by the Safe Flight 21 (headquarters) and Capstone (Alaskan Region) program offices. Each of the required tasks, including an operational safety review, has been scheduled to meet an operational date of January 1, 2001, for use of the Capstone ADS-B system for radar-like services in airspace in and around Bethel, Alaska.

It is important to note, however, that there are some hurdles ahead that could keep this goal from being met. These include, but are not limited to, a satisfactory determination that the Capstone ADS-B system is at least equivalent to radar in terms of reliability and system performance and the satisfactory completion of an "end-to-end" safety review. Although these issues present risk to the program, the status of this effort is being tracked at our associate administrator level to preclude unforeseen delay.

I would ask you, as one of our partners in improving the safety and efficiency of the National Airspace System, to commit your support to our program offices by assisting in the above tasks. Industry support is critical in an initiative of this type. Working together, we can meet the goals of this program.

Sincerely,

ORIGINAL SIGNED BY
JANE GARVEY

Jane F. Garvey
Administrator

cc: AND-1/500/510, ARA-1, AOA-3(2)
AND-510:HBELL:kr:X34396:10/286/99
Revised per ASR & ATP:kr:11/23/99
Revised per AOA-3:kr:12/27/99
Controls: AOA-3: A991008022; ARA-1: 740-99
Document: A99-Eckels

Appendix B: Detailed Capstone ADS-B Radar-Like Services Schedule

Capstone Radar-Like Services Using ADS-B Schedule DRAFT v5.4

Project Start Date: Tue 1/18/00
Project Finish Date: Mon 1/1/01

ID	Task_Name	Duration	Start Date	Finish Date	Resource_Names
1					
2	**Approve Airborne Equipment**	413 days	Tue 6/15/99	Sat 12/30/00	ACE-115N,AIR-130
3	**Avionics STC (Supplemental VFR)**	167 days	Tue 6/15/99	Wed 2/2/00	ACE-115N,UPSAT
4	Provisions	111 days	Tue 6/15/99	Tue 11/16/99	"
5	MFD & UAT	57 days	Tue 11/16/99	Wed 2/2/00	"
6	**Functional Hazard Assessment**	164 days	Wed 9/1/99	Fri 4/14/00	ACE-115N,AIR-130
7	Supplemental VFR	1 day	Wed 9/1/99	Wed 9/1/99	"
8	Radar-Like Services	33 days	Thu 3/2/00	Fri 4/14/00	"
9	**UAT Design Specification**	49 days	Tue 2/29/00	Wed 5/3/00	UPSAT,ACE-115N,MITRE
10	Capstone UAT Interim Design Specification	49 days	Tue 2/29/00	Wed 5/3/00	"
11	Capstone Proposed Initial Draft Standard for UAT	49 days	Tue 2/29/00	Wed 5/3/00	"
12	**Avionics Amended STC for Radar-Like Services & Freq Change**	222 days	Mon 2/21/00	Fri 12/15/00	ACE-115N
13	RFP to UPSAT for Freq Change	11 days	Mon 2/21/00	Mon 3/6/00	Capstone Program Office
14	RFP to UPSAT for Radar-Like Services	28 days	Thu 5/4/00	Fri 6/9/00	"
15	UPSAT Contract Mod for Freq Change	1 day	Mon 5/15/00	Mon 5/15/00	"
16	UPSAT Contract Mod for Radar-Like Services	1 day	Fri 6/30/00	Fri 6/30/00	"
17	Amended STC	1 day	Fri 12/15/00	Fri 12/15/00	ACE-115N,UPSAT
18	**Avionics Installations**	232 days	Wed 2/23/00	Sat 12/30/00	ACE-115N

19	Initial Installations (Supplemental VFR)	228 days	Wed 2/23/00	Tue 12/26/00	Installers
20	Deliver 1st Radar-Like Services & Freq Change Avionics	2 days	Tue 12/26/00	Wed 12/27/00	UPSAT
21	Install 1st Radar-Like Services & Freq Change Avionics	3 days	Thu 12/28/00	Sat 12/30/00	Installers,ACE-115N
22					
23	**Approve Ground-Based System and Radio Spectrum**	293 days	Wed 12/1/99	Sun 12/31/00	AAL-400,ASR
24	**Spectrum and Frequency Change**	293 days	Wed 12/1/99	Sun 12/31/00	ASR-1
25	966MHz Temp Experimental Approval (BET, ANC)	1 day	Wed 12/1/99	Wed 12/1/99	"
26	966MHz Temp Experimental Approval (expanded box)	11 days	Tue 1/18/00	Tue 2/1/00	"
27	981MHz Temp Experimental Approval (AK)	1 day	Wed 1/12/00	Wed 1/12/00	"
28	981MHz Prelim Protected Ops Approval (YK Delta)	69 days	Thu 1/13/00	Mon 4/17/00	"
29	**981MHz Protected Ops Approval (YK Delta)**	138 days	Fri 6/30/00	Sun 12/31/00	ASR-1,AAL-1S
30	JTIDS/UAT Interference Tech Analysis	58 days	Fri 6/30/00	Fri 9/15/00	MITRE,ASR
31	DOD/FAA 981MHz Agreement thru NTIA for BET	1 day	Fri 9/22/00	Fri 9/22/00	NTIA,ASR,DOD
32	ASR Final Authorization	1 day	Sun 12/31/00	Sun 12/31/00	ASR-1
33	FAI VOR/DME Freq Change	76 days	Fri 4/21/00	Mon 7/31/00	AAL-400
34	**Maintenance (Documentation & Training)**	167 days	Fri 2/25/00	Fri 10/6/00	AAL-400
35	Develop Maintenance Concept	6 days	Fri 3/10/00	Fri 3/17/00	"
36	Write and Deliver PASS Notification Letter	23 days	Thu 3/16/00	Fri 4/14/00	"
37	I & I	44 days	Mon 4/17/00	Tue 6/13/00	"
38	Develop Training Program (System Architecture/Overview)	22 days	Sat 4/1/00	Sun 4/30/00	"
39	Obtain Manufacturer Hardware Documentation	52 days	Fri 2/25/00	Thu 5/4/00	"
40	Initial Cadre Training	5 days	Fri 5/5/00	Thu 5/11/00	"

41	Draft Maintenance Handbook and ILSP	34 days	Tue 5/2/00	Thu 6/15/00	,,
42	Final Maintenance Handbook and ILSP	11 days	Fri 6/16/00	Fri 6/30/00	,,
43	Develop Training Program (Technical Training)	26 days	Wed 7/5/00	Mon 8/7/00	,,
44	Signed PASS MOA	1 day	Fri 8/25/00	Fri 8/25/00	
45	MCC Training	20 days	Mon 8/21/00	Fri 9/15/00	,,
46	SSC & SMO Technician Training	10 days	Mon 9/25/00	Fri 10/6/00	,,
47	**Installation Network - ZAN**	131 days	Mon 1/3/00	Wed 6/28/00	,,
48	Develop Architecture/Design	44 days	Mon 1/3/00	Thu 3/2/00	,,
49	ZAN Site Survey/Design Package	27 days	Tue 3/28/00	Mon 5/1/00	,,
50	Review ZAN Design	5 days	Tue 5/2/00	Mon 5/8/00	,,
51	ZAN FAA Site Prep	4 days	Tue 5/9/00	Fri 5/12/00	,,
52	ZAN Install	28 days	Mon 5/22/00	Wed 6/28/00	,,
53	Site Acceptance Test	9 days	Fri 5/19/00	Wed 5/31/00	,,
54	**Installation MEARTS - ZAN**	71 days	Wed 3/22/00	Fri 6/23/00	,,
55	MEARTS Site Survey	2 days	Wed 3/22/00	Thu 3/23/00	,,
56	MEARTS Design Package	26 days	Fri 3/24/00	Thu 4/27/00	,,
57	MEARTS FAA Site Prep	4 days	Fri 4/28/00	Tue 5/2/00	,,
58	MEARTS Install	5 days	Mon 6/12/00	Fri 6/16/00	,,
59	Software Delivery	1 day	Mon 6/19/00	Mon 6/19/00	LMCO
60	MEARTS Hardware/Software On-Site Testing	4 days	Tue 6/20/00	Fri 6/23/00	AAL-400
61	**Installation GBT - Bethel**	82 days	Tue 2/29/00	Fri 6/16/00	,,
62	BET Site Survey	0	Tue	Tue	AAL-400

		days	2/29/00	2/29/00	
63	BET Design Package	15 days	Mon 4/3/00	Fri 4/21/00	"
64	Review BET Site Design	5 days	Mon 4/24/00	Fri 4/28/00	"
65	2nd Site Survey/Design Package	0 days	Sat 6/10/00	Sat 6/10/00	"
66	BET Install	2 days	Thu 6/15/00	Fri 6/16/00	"
67	**GBT Retrofit for Radar-Like Services (e.g., RMM) & Freq Change**	159 days	Thu 5/18/00	Wed 12/20/00	AAL-400
68	RFP to UPSAT for Radar-Like Services Upgrade & Freq Change	44 days	Thu 5/18/00	Tue 7/18/00	Capstone Program Office
69	UPSAT Contract Mod for Radar-Like Services and Freq Change	1 day	Thu 6/1/00	Thu 6/1/00	"
70	Deliver GBT Test Equipment	1 day	Fri 9/29/00	Fri 9/29/00	UPSAT
71	Deliver Modified GBTs (RMM/981Mhz/Ver 31.1)	1 day	Wed 11/22/00	Wed 11/22/00	UPSAT
72	Modified GBT to AOS for testing	19 days	Thu 11/23/00	Tue 12/19/00	AOS
73	Swap GBTs at BET (Install and re-certify)	1 day	Wed 12/20/00	Wed 12/20/00	AAL-400
74					
75	**Ground System Compatibility & Certification**	473 days	Tue 3/23/99	Sat 12/30/00	AAL-400.AOS
76	**MEARTS ADS-B Development**	216 days	Tue 3/23/99	Tue 1/18/00	AUA-600
77	MEARTS System Requirements Review	4 days	Tue 3/23/99	Fri 3/26/99	"
78	MEARTS Preliminary Design Review	3 days	Tue 7/20/99	Thu 7/22/99	"
79	Support Bethel Demo	5 days	Mon 8/23/99	Fri 8/27/99	"
80	MEARTS Critical Design Review	4 days	Mon 10/25/99	Thu 10/28/99	"
81	Capstone ICD to MEARTS Gateway	29 days	Thu 12/9/99	Tue 1/18/00	AAL-512
82	**MEARTS Acceptance Testing (WJHTC)**	119 days	Wed 11/17/99	Fri 4/28/00	AUA-600
83	MEARTS Acceptance Test Plan	65 days	Wed 11/17/99	Tue 2/15/00	LMCO
84	Acceptance Testing Review Mtg	4	Tue	Fri	AUA-600

	(WJHTC)	days	2/15/00	2/18/00	
85	Testbed Equipment Installation (WJHTC)	30 days	Mon 1/10/00	Fri 2/18/00	ACT-300
86	Deliver Draft MEARTS Software to AOS-630	1 day	Wed 3/15/00	Wed 3/15/00	LMCO
87	MEARTS Acceptance Test Procedures	20 days	Wed 3/15/00	Mon 4/10/00	LMCO
88	Dry Run Flight Tests	3 days	Tue 3/28/00	Thu 3/30/00	ACT-300
89	Deliver Final MEARTS Software to AOS-630	1 day	Fri 4/7/00	Fri 4/7/00	LMCO
90	Dry Run Flight Tests	3 days	Tue 4/11/00	Thu 4/13/00	ACT-300
91	Acceptance Testing and Flight Tests	10 days	Mon 4/17/00	Fri 4/28/00	AOS-400,AOS-500,ACT-300,ACT-400,LMCO,AAL-500,ZAN,AUA-600
92	STR Resolution Testing	5 days	Mon 4/24/00	Fri 4/28/00	AOS-400,AOS-500,ACT-300,ACT-400,LMCO,AAL-500,ZAN,AUA-600
93	Acceptance Testing Test Report	24 days	Tue 5/2/00	Thu 6/1/00	AUA-600
94	**Key Site Testing (AK)**	112 days	Mon 6/26/00	Wed 11/22/00	AAL-400
95	MEARTS/GBT On-Site Testing	1 day	Mon 6/26/00	Mon 6/26/00	"
96	**End-to-End 30 Day Ops Data Collection and Analysis**	51 days	Fri 9/15/00	Wed 11/22/00	AUA-600
97	Test Plan	1 day	Fri 9/15/00	Fri 9/15/00	"
98	30 day Ops Data Collection & Interim Reports (performance and controller feedback)	23 days	Fri 9/15/00	Sun 10/15/00	"
99	AUA-600 Analyze and Interim Reports	23 days	Mon 10/16/00	Wed 11/15/00	"
100	Final Report on ADS-B is at least equivalent to radar	1 day	Wed 11/22/00	Wed 11/22/00	"
101	**Capstone ADS-B Ground System Certification**	144 days	Wed 6/21/00	Sat 12/30/00	AOS
102	**Joint Acceptance Inspection (JAI)/Contractor Acceptance Inspection (CAI)**	4 days	Wed 6/21/00	Mon 6/26/00	"

103	ZAN MEARTS	1 day	Mon 6/26/00	Mon 6/26/00	"
104	BET GBT	1 day	Wed 6/21/00	Wed 6/21/00	"
105	Notice AL6360.1 Interim GBT Cert Parameters	1 day	Wed 8/16/00	Wed 8/16/00	AAL-400
106	Order AL6368.1 GBT Handbook	1 day	Wed 12/20/00	Wed 12/20/00	"
107	Order 6190.16B Micro-EARTS Handbook	1 day	Mon 7/17/00	Mon 7/17/00	AOS
108	Commissioning NOTAMs	1 day	Sat 12/30/00	Sat 12/30/00	AAL
109					
110	**Air Traffic Planning and Procedures**	243 days	Wed 2/9/00	Sun 12/31/00	ATP,ZAN,NATCA,AAL-500
111	ATP Request to AFS-400 for validation of 5 mile Radar-Like Sep Std	1 day	Wed 7/19/00	Wed 7/19/00	ATP-1
112	**Define Specific ATC Procedures (ZAN & BET)**	185 days	Wed 2/9/00	Sun 10/15/00	NATCA,ATP-100,ZAN-20,AAL-500
113	7110.65 scrub for Doc Change Proposal	25 days	Wed 2/9/00	Tue 3/14/00	"
114	Initial Procedures Draft	1 day	Fri 9/15/00	Fri 9/15/00	"
115	Review during 30-day Ops Data Collection	23 days	Fri 9/15/00	Sun 10/15/00	"
116	**NATCA Article 7 Brief**	163 days	Wed 5/10/00	Fri 12/15/00	ATX-500,ZAN-20,NATCA,ATP-100
117	Initial Brief	1 day	Wed 5/10/00	Wed 5/10/00	"
118	Follow-on Brief	1 day	Mon 8/7/00	Mon 8/7/00	"
119	NATCA National/ZAN Meetings	4 days	Tue 8/22/00	Fri 8/25/00	"
120	Evaluation MOU	1 day	Fri 9/15/00	Fri 9/15/00	"
121	Complete NATCA Informational Items for Radar-Services MOU	1 day	Thu 12/14/00	Thu 12/14/00	"
122	Radar-Services MOU	1 day	Fri 12/15/00	Fri 12/15/00	"
123	**Controller Training**	85 days	Mon 9/11/00	Sun 12/31/00	AAL-500,ZAN-30
124	ZAN Training Package	78 days	Mon 9/11/00	Sun 12/24/00	"

125	BET ATCT Training Package	78 days	Mon 9/11/00	Sun 12/24/00	"
126	ZAN Training Complete	7 days	Mon 12/25/00	Sun 12/31/00	"
127	BET ATCT Complete	7 days	Mon 12/25/00	Sun 12/31/00	"
128	**ATP-100 ADS-B Notice to ZAN/AAL-500**	6 days	Fri 12/15/00	Fri 12/22/00	ATP-1
129	Final DRAFT	1 day	Fri 12/15/00	Fri 12/15/00	ATP-100
130	ATP-100 Authorization Notice to AAL500/ZAN for 5 mile Radar-Like Sep Std	1 day	Fri 12/22/00	Fri 12/22/00	"
131	**Controller Operational Feedback Analysis**	23 days	Fri 9/15/00	Sun 10/15/00	ZAN,NATCA
132	Capstone ADS-B Action Request System during 30-day Ops Data Collection	23 days	Fri 9/15/00	Sun 10/15/00	ZAN,NATCA
133	Operational Feedback Controller Questionaire Dry-Run	23 days	Fri 9/15/00	Sun 10/15/00	ZAN,NATCA,AND
134					
135	**Approve Ops Standards and Ops Specs**	294 days	Wed 12/1/99	Mon 1/1/01	AFS
136	Analyze/review ADS-B data for IFR sep standard	95 days	Wed 7/19/00	Wed 11/22/00	AFS-400
137	**AFS-400 Concurrence Memo to ATP-1 for 5-mile radar-like sep standard**	6 days	Wed 11/15/00	Wed 11/22/00	"
138	Draft	1 day	Wed 11/15/00	Wed 11/15/00	"
139	Final	1 day	Wed 11/22/00	Wed 11/22/00	"
140	Air Transport Handbook Bulletin (HBAT) & Other Inspector Guidance	193 days	Wed 3/8/00	Wed 11/22/00	"
141	Avionics Cert Coordination	244 days	Thu 1/20/00	Fri 12/15/00	"
142	ATC Procedures Coordination	249 days	Thu 1/20/00	Fri 12/22/00	"
143	**Pilot Training**	288 days	Tue 12/7/99	Sat 12/30/00	ANC FSDO,AFS-400,UAA
144	Beta Test Classes	24 days	Tue 12/7/99	Fri 1/7/00	"
145	Initial	233 days	Tue 2/22/00	Sat 12/30/00	"

146	Ops Bulletin Radar-Like Services	1 day	Fri 12/15/00	Fri 12/15/00	"
147	**UAA Safety Study and Pilot Ops Feedback**	294 days	Wed 12/1/99	Mon 1/1/01	UAA
148	Baseline Survey and Report	156 days	Wed 12/1/99	Sat 7/1/00	"
149	Pilot Feedback Forms	219 days	Fri 3/10/00	Fri 12/29/00	"
150	Follow-On Survey	10 days	Mon 8/14/00	Fri 8/25/00	"
151	CY00 Report	1 day	Mon 1/1/01	Mon 1/1/01	"
152					
153	**End-to-End Safety Review**	228 days	Wed 1/12/00	Wed 11/15/00	AAL-1SC,ASY
154	Form Capstone Safety Review Team	1 day	Wed 1/12/00	Wed 1/12/00	UAA,ACE-115N,MITRE,ASY-300,AAL-1SC,ZAN-20,NATCA
155	System Safety Program Plan	148 days	Wed 1/12/00	Mon 7/31/00	"
156	Operating & Support Preliminary Hazard Analysis	124 days	Mon 1/17/00	Mon 7/3/00	"
157	Hazard Tracking & Risk Resolution	99 days	Thu 7/6/00	Wed 11/15/00	"
158	Safety Engineering Report - Final	1 day	Wed 11/15/00	Wed 11/15/00	"
159					
160	**Operational Capstone ADS-B Radar-Like Services**	**1 day**	**Mon 1/1/01**	**Mon 1/1/01**	

Appendix C: Capstone Avionics Supplemental Type Certificate

United States Of America

Department of Transportation - Federal Aviation Administration

Supplemental Type Certificate

Number SA02149AK

This Certificate issued to UPS Aviation Technologies, Inc.
2345 Turner Road, S.E.
Salem, OR 97309

*certifies that the change in the type design for the following product with the limitations and conditions therefor as specified hereon meets the airworthiness requirements of Part * of the * Regulations.*

Original Product Type Certificate Number: * * UPS Aviation Model List No. UPS-AT-01, Rev 1, dated February 2, 2000, or later FAA approved revision for list of approved airplane models, Type Certification numbers, and applicable airworthiness regulations.

Make: *

Model: *

Description of Type Design Change: Installation of GX50/60 GPS Navigator, Capstone configured MX20 Multi-Function Display, and UAT transceiver, in accordance with UPS Aviation Technologies Capstone Supplemental Type Certificate Master Drawing List, P/N 560-1027-( ), dated January 27, 2000, or later FAA approved revision.

Limitations and Conditions: Compatibility of this design change with previously approved modifications must be determined by the installer. FAA approved Airplane Flight Manual Supplement or Supplemental Airplane Flight Manual, P/N 560-1028-( ), FAA approved February 2, 2000, or later FAA approved revision is a required part of this installation. Installation of the Capstone configured MX20 Multi-Function Display and UAT transceiver limited to aircraft participating in FAA ADS-B Demonstration programs. Transmission of the UAT signal limited to FAA approved demonstration areas. Refer to the Capstone System Installation Manual, P/N 560-1024-( ), and Capstone System Instructions for Continued Airworthiness, Document Number 560-1040-( ), dated December 11, 2000, or later FAA approved revision for continued airworthiness of the Capstone Avionics System.

If the holder agrees to permit another person to use this certificate to alter the product, the holder shall give the other person written evidence of that permission.

This certificate and the supporting data which is the basis for approval shall remain in effect until surrendered, suspended, revoked or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: June 15, 1999

Date reissued:

Date of issuance: November 16, 1999

Date amended: February 02, 2000; August 2, 2000; December 19, 2000

By direction of the Administrator

Gregory J. Holt

(Signature)

Gregory J. Holt
Manager
Anchorage Aircraft Certification Office

(Title)

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

FAA Form 8110-2(10-68) Page 1 of 3

This certificate may be transferred in accordance with FAR 21.47.

Appendix D: WJHTC Micro-EARTS Acceptance Testing Memo

U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject: **INFORMATION:** Capstone Automatic Dependent Surveillance-B (ADS-B) Accuracy

Date: June 12, 2000

From: Product Team Lead for Micro-Processor En Route Automated Radar Tracking System (Micro-EARTS), AUA-650

Reply to Attn of:

To: Free Flight Program Manager-Capstone Lead AFS-410

This purpose of this memorandum is two-fold:

-Provide background data pertaining to Capstone ADS-B acceptance testing and accuracy;

-Provide a recommendation to support 3 NMI and 5 NMI separation minima for Capstone ADS-B.

The Global Positioning System (GPS), maintained and operated by the U.S. Department of Defense, can be used as a reference for determining three dimensional global positions to an accuracy of +/- 100 meters 95 percent of the time. This accuracy is better than the worse case radar error, +/- 1/8 NMI and +/- 3 ACPs (0.92 NMI at 200 NMI from the sensor; 0.184 NMI at 40 NMI from the sensor) used to support 3 NMI and 5 NMI separation minima.

The avionics equipment supplied by UPS AT to equip aircraft participating in the Alaskan Region Project Capstone computes and reports aircraft position derived from the GPS. As a part of the Capstone acceptance testing at the WJHTC, 4/13-27/2000, several ADS-B flight tests were performed. During a test on 4/19 display observations were logged at various times to verify map and display accuracy. From 16:50:00 to 17:12:00 Zulu, the aircraft was positioned on the runway at the WJHTC. The aircraft's position on the display coincided exactly with the geo-map line depicting the runway during this time. The aircraft then flew a profile designed to verify Micro-EARTS functionality. During the flight, the aircraft flew along a line of longitude that was depicted in the geomap. The position of the aircraft coincided exactly with the line of longitude. As the airplane touched down following the flight check, its position on the display coincided exactly with the geo-map line depicting the runway.

Recordings of ADS-B position reports made during the flight check were compared with data from extremely accurate Nike and laser tracking radars. The ADS-B positions were compared with post corrected data from an on-board Ashtech GPS receiver. Preliminary evaluation of these comparisons indicates that the ADS-B reported aircraft positions fell within the published horizontal GPS tolerance (+/- 100 meters).

Questions have arisen concerning the accuracy of ADS-B altitude, the relative display of ADS-B and radar positions to the controller, and the processing of erroneous ADS-B messages.

Altitude information reported by ADS-B equipped aircraft is derived in the same manner as that reported in response to Mode C beacon interrogations. An encoding altimeter is referenced to atmospheric pressure via an external port on the aircraft and the readings are reported relative to standard atmospheric pressure or Mean Sea Level (MSL). The altitude data are processed identically for beacon Mode C reports and ADS-B reports and displayed to the controller exactly the same. The reader should note that GPS derived height values, if reported, are not used for ADS-B track maintenance or for Minimum Safe Altitude Warning (MSAW) or Conflict Alert (CA) processing.

Erroneous ADS-B information is detected at time of calculation by the avionics equipment and during transmission by a message integrity assurance algorithm, i.e. Cyclical Redundancy Check (CRC). The verification performed by the avionics consists of computing Dilution of Precision (DOP) figures based on satellite geometry in accordance with published Receiver Autonomous Integrity Monitoring (RAIM) requirements. The figure of merit is reported in the ADS-B message as a Numerical Uncertainty Computation - Position (NUC-p) value. Unusable position calculations are eliminated by only use of messages with a NUC-p value of 4 or higher.

Messages corrupted during transmission are detected by use of a CRC calculation by the Micro-EARTS. Any message failing the CRC check is discarded prior to track processing.

Since the accuracy of the ADS-B data used by the Micro-EARTS is better than the worse case accuracy of FAA certified radar data and the display processing used for both radar and ADS-B data is identical, the relative errors in display of ADS-B tracks and radar tracks on a common display are less than the relative errors between tracks from two or more radars. Application of radar separation criteria, 3 nmi. or 5 nmi., should, therefore, be acceptable for ADS-B aircraft.

The display priority for selection of aircraft position information is such that the positions of aircraft detected by operational radars will always be those reported by the

operational radar. This display data restriction will prevent inadvertent use of ADS-B data in areas in which the controller has chosen to use data from only one radar sensor or for interfacility processing of aircraft tracks not detected by operational radar.

If you have any questions, please contact Jack A. Neuberger at 202-366-5152.

Jack A. Neuberger
Jack A. Neuberger

Appendix E: Interim Ground System Certification Procedures and Requirements

1) Interim ADS Procedures – Certification, Restoration, and Logging
2) Interim Certification Requirements for ADS-B GBT

MEMORANDUM

U.S. Department
of Transportation
Federal Aviation
Administration

Subject: INFORMATION: Interim ADS Procedures -- Certification, Restoration, and Logging

Date: AUG 18 2000

From: Manager, Operations Branch, AAL-470

Reply to Attn of:

To: Manager, NA-SMO
Manager, SA-SMO
Manager, MCC

The Automatic Dependant Surveillance (ADS) system is scheduled to become operational in a shakedown mode in the September 2000 timeframe. The actual date of declaring Initial Operating Capability (IOC) depends on several factors, including the establishment of all procedures for its use.

During the shakedown period, between IOC and ORD, we will be testing our own Airway Facilities procedures and refining them as necessary. Your input is critical during this timeframe to refine these procedures. The initial administrative procedures are listed below.

IDENT: Initially, we intend on utilizing BDAT as the service to log all facility and service information. A request to establish new facilities and services in the national FSEP has been submitted. Once approved, we intend to add "GBT" as the official facility type for each remote location. We also intend to add "ADS" as the official service type for each remote service. Until that time, please utilize the appropriate XYZ BDAT service to log all maintenance, interruption, and certification entries. The following BDAT services have been established in the FSEP (Y-Test status, Cost Center Code AL1JH):

BET BDAT	Bethel	GBT JAI complete July, 2000
EHMZ BDAT	Cape Newenham	GBT JAI pending
CZFZ BDAT	Cape Romanzof	GBT JAI pending
KSM BDAT	St. Marys	Site survey complete 8/00
ANI BDAT	Aniak	Site survey complete 8/00
DLG BDAT	Dillingham	*future*
AKNZ BDAT	King Salmon	*future*
SVWZ BDAT	Sparrevohn	*future*
TLJZ BDAT	Tatalina	*future*
UNK BDAT	Unalakleet	*future*

CERTIFICATION: Three documents have been issued to describe the certification parameters and entries.

1. The GBT handbook, Order AL6368.1, describes the maintenance of the remote sites. The certification entry is "GBT Certified" and is made by the remote site technician on a semi-annual basis.
2. A notice, AL6360.02, has been issued, that provides interim certification parameters until test equipment and RMM software is available. This notice is currently being revised and will be reissued as AL-N6360.1.
3. Order 6190.16B, has been issued to provide and update for the MicroEarts system, and will also provide certification guidelines for the ADS service. The "ESTDD certified" entry is required on a daily basis.

Certification of the GBT's and the service is required before IOC can be declared.

SHORT NAMES: As part of the logging system, it is desirable to standardize the short names that are used in various LCM and LIR entries. The following list depicts the most common short names that should be used.

GBTP Primary GBT or path between the remote site and the MicroEarts
GBTA Alternate GBT or path between the remote site and the MicroEarts
CCCS Capstone Communications Control Server

LOGGING: Until GBT and ADS are established in the FSEP as valid facility and service types, all log entries shall be made against the BDAT service. The following guidelines apply:

1. Complete loss of services from a remote GBT site:
   XYZ BDAT 8x FL

2. Failure of one GBT at a remote site:
   XYZ BDAT 8x RS, short name = GBTP for primary, GBTA for alternate unit, Location = Remote

3. Failure of one path from a remote site:
   XYZ BDAT 88 RS, short name = GBTP for primary, GBTA for alternate unit, Location = Remote

4. Failure of software in the Communications Server at ZAN causing loss of all ADS services:
   ZAN ETARS 86 RS, short name = CCCS, Location = Control

5. Failure of hardware in the Communications Server at ZAN:
   ZAN MEARTS 80 RS, short name = CCCS, Location = Control

RESTORATION: Initially before IOC, restoration is established as 1A, Next Work Day. This is essentially to facilitate testing of the ADS system prior to declaring an Initial Operating Capability. When IOC is declared, the restoration code is established as 1B. Next Day. During this time period (IOC to ORD), the expectation is the system is being used for short periods of time during administrative times, Monday through Friday. Upon completion of the shakedown period, the entire system will be commissioned, including the remote sites, the new hardware at the ARTCC, and the services, by declaring ORD (operational readiness demonstration). It is currently envisioned that the Capstone system will be used for VFR advisories. At a later phase, it will be utilized for IFR procedures. At the time that is used for IFR procedures, the restoration code will be established as 1K, Immediate Response. Please note that for all these restoration codes (1A, 1B, 1K), the first response is from the MCC. The immediate response means that the MCC specialist utilizes all available tools to analyze and restore the system prior to callout. Callout to a remote site is normally expected to occur within a 72-hour window, similar to MAR Restoration levels.

LOGISTICS SUPPORT: Supply support for the GBT's is through the manufacturer, UPS Aviation Technology, for a period of three years. In the event of a failure, the failed item is returned to UPS Aviation Technology after receiving an authorization number from the Contracting Officer. Spares provided include one GBT, one UAT antenna, and one GPS antenna. The UAT antenna is depot supported. An individual remote site can function on one GBT while the failed unit is being repaired and replaced by the factory. The CISCO routers are off-the-shelf equipment and are supported by Cisco. The warranty provides for delivery of replacement parts the next business day. The CCCS is a Sun Enterprise 250, and is supported by Sun. One spare is provided for both the routers and the CCCS. The ILSP document and the Capstone Site Implementation document describes more detail.

POINTS OF CONTACT: The following points of contact are established for the operation and maintenance of the Capstone System.

Ron Webb, 451-5723, First Level Technical Support, Certified on GBT equipment.

Hugh Barber, 271-2371, Program Manager, Overall Program Management with detail support to the remote sites.

Tom Elledge, 269-2503, Program Manager for the ARTCC Hardware and Software. Certified on GBT equipment.

Mark Olson, 271-1376, NISC Support

Verne Jensen, 271-2205, SSC Manager

TRAINING: Several training sessions are scheduled for the Capstone system. Initially, an MCC overview course is planned for August 22, 2000, with two other 4-hour sessions provided. Additionally, an equipment course will be offered for the SSC specialists and Technical Support Staff personnel starting September 11, 2000. Contact the AFTT for exact course dates.

Alan D. Falkenstein

Alan D. Falkenstein

cc:
AAL-401
AAL-410
AAL-420
AAL-500

NOTICE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
ALASKAN REGION

AL N 6360.1

August 16, 2000

Cancellation
Date: 6/1/2001

SUBJ: INTERIM CERTIFICATION REQUIREMENTS FOR AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST (ADS-B) GROUND-BASED TRANSCEIVER (GBT) APOLLO MODEL GBT 2000

1. PURPOSE.

a. GBTs are not included in any existing orders that contain certification parameters. National Airways System Engineering Division, AOS-200, is in the process of writing certification parameters to be used once test equipment is available for the GBTs. Test equipment will not be available until after the IOC date established by the program office. This notice provides interim certification criteria to be used until GBT test equipment is available (approximately October 2, 2000).

b. This notice has been reviewed and evaluated for impacts upon year 2000 (Y2K) functionality and has no detrimental effect upon Y2K compliance.

2. DISTRIBUTION. This notice is distributed to branch level in the Airways Facilities Division and to all AF field offices and facilities.

3. CANCELLATION. This Notice replaces earlier issued interim certification requirements contained in documents numbered AL6360.01 dated June 15, 2000, and AL6360.02 dated June 26, 2000.

4. ACTION. Facilities having Apollo GBT 2000s shall use the following certification criteria:

Parameter	Standard	Reference Paragraph
Electrical Power 28Vdc	+18.0 Vdc to +40.0 Vdc	UPSAT GBT Installation Manual 560-0406-01, Para. 4.1 & 6.9, AL6368. 1, 506
GPS Lock	Front Panel GPS LED solid green In less than 15 min. (Normal time less than 2 min)	UPSAT GBT Installation Manual 560-0406-01, Para. 4.3, 1.7.2 & 7.3, AL6368.1,504e
UAT RX	Receives ADS-B equipped aircraft in calculated coverage area	AL6368.1, 504
UAT TX	Carrier Freq. = Assigned +/-0.003% Freq. Deviation = Same as Std. Output Power = 25W – 80W	Requires Spectrum Analyzer with Hold feature. Use test equipment handbook for test procedure. AL6368.1, 503
UAT Antenna	Impedance less than 10 Ohms VSWR less than 1.7:1	UPSAT GBT Installation Manual 560-0406-01, Para. 4.2.1, AL6368. 1, 502.e
GPS Antenna	Voltage 5VDC +/- 0.25VDC at GPS antenna connector, 0.6V – 1.2V cable end of antenna coax using diode test mode on DVM.	UPSAT GBT Installation Manual 560-0406-01, Para. 4.2.2 AL6368. 1, 502.d
Beacon	GPS Lat. & Long. = Surveyed NAD 83 Position +/- 100m Fixed Lat. & Long. = Actual Altitude = Lower than 160 feet AGL or Greater than 59,000 feet MSL	Interagency GPS Executive Board NOAA National Geodetic Survey update 5/26/00 UPSAT GBT Installation Manual 560-0406-01, Para. 3.7.3.1, AL6368.1, 505 Handbook 6360.14A, 33b.(12)

NORMAL CERTIFICATION INTERVAL: Semi-annually
MAXIMUM CERTIFICATION INTERVAL: 210 days
PERSON RESPONSIBLE FOR CERTIFICATION: Electronics Technician at GBT Facility
CERTIFICATION ENTRY IN FACILITY MAINTENANCE LOG: ADS-B Ground-Based Transceiver Certified

Distribution: A-X-(AF)3; FAF-0(LTD)

Initiated by: AAL-470

5. BACKGROUND.

a. Under the FAA Administrator's letter of January 3, 2000, the Capstone office is deploying an ADS-B system for radar-like services in airspace in and around Bethel by January 1, 2001. As part of this deployment GBTs are being installed to link the airborne avionics to the communications system which carries the ADS-B data back to the Anchorage Air Route Traffic Control Center.

b. Certification is required for components of the NAS that provide moment-by-moment positional information, per Order 6000.15C, para 504. A service level certification (ETARS) will be required at ZAN ARTCC. That service level certification will be based, in part, on the source facility (the GBT) and satisfactory system operation, reference Order 6000.15C, para 505 & 506.

for Dennis H. Powell
Manager, Airway Facilities Division

Appendix F: WJHTC B727 Alaska Flight Test Plan

Capstone

Flight Test Plan

August 21, 22, 23, 24 2000

Final Draft 8-12-00

Offices coordinated with and who provided flight profile information.

AAL-200

ACE-115N

AAL-500

AAL-ZAN

AAL-400

MITRE/CAASD

AAL-1SC

ACT-12

NATCA

AUA-650

Contents

General flight test information	**Pages 1-7**
Flight profiles	**Pages 8-12**
Personnel locator	**Page 13**
ADS and Radar coverage projections (not included)	**Page 14-22**

Capstone Flight Test Plan

August 21, 22, 23, 24 2000

General: This plan involves validation of previously documented performance of ADS-B to determine and confirm signal coverage for ground installations at Bethel, Cape Newenham, and Romanzof. The test will confirm system interaction performance between ADS-B airborne and ground transceivers and the hard and soft connections to the M-EARTS. Accuracy of the terrain data is also part of the plan.

Objectives: The testing is designed to collect coverage and performance information related to the ADS-B ground station and airborne avionics; Test coverage area integrity and signal availability of ADS-B transmissions at various altitude and specific locations in the Capstone area; Observe and document performance of radar at Newenham and Romanzof and ADS-B ground stations at Bethel, Newenham and Romanzof while tracking the test aircraft; Validate Micro-EARTS and OCS software functionality. Completion of at least two of the three flight profiles in the four-day period is the success criteria threshold for testing.

Secondary objectives include providing the collected data to also support ADS-B R&D activities outside of Capstone. See section on Suggested Additional Test Data Collection.

Some portions of the plan require VMC flight. Due the nature of the weather in the lower Kuskokwin Delta, some portion of the profiles may not be accomplished during the demonstration. August 21, 22, 2000 are back up weather days. Weather permitting all three profiles are planned to be completed. The B-727 crew is the final authority concerning the flight portion of the test. The crew will modify profiles as needed to ensure the safe operation of the aircraft and optimize test results.

Test Method:

Test Item Description: A Boeing 727 will be equipped with Capstone avionics which include an MFD incorporating GPS, ADS-B, and terrain data. Flights will be conducted in the area with the test aircraft operating at a variety of altitudes and routes.

Test Approach: The approach is to operate the B-727 through a series of clearly defined flight profiles at various ranges and altitudes from ADS-B ground stations. These flight profiles are designed to cover the operational areas for typical GA aircraft flight paths. There is also the desire to coincide these test flights with high aircraft activity at and around Bethel. A Capstone coordinator at a central site on the ground will report times, locations and altitudes the aircraft enters and leaves ADS-B coverage areas. (Note: descent/ascent rates need to ensure going in and out of coverage as planned.) Observers on the aircraft will record locations, times and altitudes that both terrain and traffic were noted. M-EARTS ADS-B update rates will be recorded during one half standard rate through one and one half-standard rate turns. Effects of high-speed passes directly over ground stations will be noted for possible future testing. And flights directly over latitude and longitude lines will help answer accuracy questions.

Test Procedures: The test procedures are included in the flight profiles. During each test the aircraft crew will interact by radio with the Air Traffic Controller on sector viewing the aircraft identifier on a ground based display. A Capstone coordinator will attend the pre-flight briefing each morning will be in the control room to help with any non ATC procedural issues encountered. Some portions of the test require radio contact for the crew to know when to change altitudes etc. The script for interaction between all parties will be provided at the time of the test. The test includes passenger compartment observers noting the location and time terrain and traffic information was observed. This data will be analyzed after the exercise.

Test Schedule: The test schedule is included in the flight profiles.

Airspace: The testing will be conduct with the route structure described in the flight profiles below.

Safety: All flights will be conducted inside the appropriate FAR's. The area involved does not contain a high volume of traffic; approximately 100 aircraft operate daily to 50 plus airports within a 90, 000 square mile area. Some risk is associated with operating a large jet aircraft below 10000 MSL in an area populated primarily by small reciprocating and turbine engine aircraft. Local flight crews are accustom to mixing with large commercial jet traffic which serves the Bethel Airport 3 to 5 time daily. Notam's will be issued to alert aviation operators and pilots of the specific dates, times, routes and altitudes the test will cover. Issuing NOTAMS covering the specific flight profiles will mitigate this risk. Large numbers of migratory waterfowl will be flying in the area during the test. Flight test crew awareness and increased external vigilance will help mitigate this hazard.

Instrumentation: The Capstone avionics suite will be installed in the passenger compartment of the B-727 for use by airborne observers. Appropriate equipment to ensure meeting the data collection requirements described below will be installed on the B-727 and at Anchorage Center (note most/all data collection at ZAN is through standard archiving processes).

Data Collection:

Data collection should include both sensor (source) inputs (raw position data) as well as outputs to the controller display (display position reports) and tracker outputs. In addition to ADS-B position reports received on the ground, data may be collected from airborne systems. Recordings should be made available for analysis of air-to-air performance and to record position references for comparison with data received on the ground. Every data element should be time tagged and synchronized to a common clock. Procedures for logging and labeling collected data need to be defined. It is better to have more data than what is needed and discard the excess rather than find out something was not collected.

Record the following data:

- Ownship state vector (e.g., horizontal position, altitude, ground track, groundspeed) – position truth data independent from ADS-B report is desired
- Raw data input to M-EARTS from en route radars: CZF, EHM, TLJ, SVW, AKN, and ENA

- M-EARTS displayed aircraft state vectors
- M-EARTS track position reports
- ADS-B state vector data input to M-EARTS
- ADS-B state vector data collected at CCCS
- ADS-B state vector data collected in test aircraft
- ownship generated reports
- reports received over ADS-B channel (for each received address, log number of receptions in each (say) 30 sec interval and the state vector of the received unit at the time of each logged interval. Since we know broadcast rates, this will enable us to pairwise plot probability of message reception vs separation range – may be done real-time if possible or through post processing)
- TCAS surveillance data collected in test aircraft

Record (manually) start and stop times for data collection. Coordinate data recording activities. Manually record significant events that occur during the demo.

Suggested Additional Test Data Collection when and where possible

1. Simultaneous Collection of Multiple Radar and ADS-B Data in support of SC-186 WG4 (Jonathan Hammer, MITRE/CAASD)

Purposes:

Evaluate and Compare ADS-B performance with NAS surveillance system requirements

Evaluate ability to correlate ADS-B data with multi-radar data

Analyze TIS-B requirements

Analyze ADS-B / Radar Correlation Requirements

Assess registration bias errors between ADS-B and radar

Justification: Multi-Radar integration, ADS-B, and required surveillance performance (RSP) have been identified by RTCA as a necessary step in the direction of future surveillance systems. It is necessary to evaluate multi-radar integration and, in addition, to evaluate the combination of multi-radar data with ADS-B. This will enable us to answer many important questions, for example:

- What are the ground system requirements for TIS-B? For example, is multi-radar integration required to support envisioned procedures:
- What are reasonable attributes of RSP as supported by the existing infrastructure? What level of RSP can be supported through the integration of multiple sensor sites and through integration of ADS-B?

- What difficulties might we find in attempting to integrate multi-sensor and ADS-B data (e.g., registration errors).

Data Collection

For the purposes of this experiment, ADS-B data and radar data should be collected at ground sites.

Data to be collected should consist of raw radar range, azimuth, and time from multiple radar sites simultaneously observing the ADS-B equipped aircraft. Aircraft identity code, Mode C, and all other measured data from each radar should be recorded. If possible, a common clock should be used to time stamp the radar data and the ADS-B data as close to the time of receipt as possible. Recorded ADS-B data should consist of all ADS-B fields in the ADS-B state vector reports (as defined in DO-242).

2. Simultaneous Collection of TCAS and ADS-B Data in support future SF21 Analyses (Jonathan Hammer, MITRE/CAASD)

(Note many aircraft in the Bethel Y-K Delta area are not required to have transponders and therefore would not be tracked by TCAS.)

Purposes:

A. Develop requirements for cross-correlating TCAS and ADS-B data.

B. Assess whether TCAS can provide a means of validating or augmenting ADS-B data integrity.

<u>Justification:</u>

Integration of TCAS and ADS-B data has been the subject of significant debates within the US and international standards communities. On one side, concerns have been raised with regard to diminishing the TCAS safety function by combining ADS-B and TCAS data. On another side, the combination of TCAS and ADS-B data is claimed to be a method of monitoring ADS-B performance and enhancing ADS-B data integrity. Resolution of these questions are of crucial importance to the standards community. This data collection effort will help to assess the possibilities for data validation / integrity monitoring, and will help to address these issues.

Data Collection

Simultaneous collection of TCAS range, bearing, and Mode C data with ADS-B data should be performed on targets of opportunity by the airborne FAA aircraft. Message receipt time tags should be synchronized between the two systems so that registration bias errors can be assessed. All data fields for ADS-B state vector reports should be recorded.

3. UAT ADS-B Performance in support of SF21 Link Evaluation Team Analysis (Stan Jones, MITRE/CAASD)

Purposes:

Apply operational data to UAT ADS-B models developed under the SF21 Link Evaluation Team

Justification:

This will provide a data collection opportunity in a GA aircraft environment with multiple aircraft equipped with UAT ADS-B.

Data Collection

Log ownship state vector data periodically with time tags. Also for each received address, log number of receptions in each (say)30 sec interval and the state vector of the received unit at the time of each logged interval. Since we know broadcast rates, this will enable us to pairwise plot probability of message reception vs separation range. Closing encounters are of most interest. We should also have any available calibration data. Please see additional Data Collection

Data Analysis (suggested)

A. Coverage: Compare in and out of coverage with estimated coverage.

B. Blip/Scan: Compute for periods when in good and marginal coverage. Compare with radar for periods when both have coverage.

C. Raw Sensor Position Accuracy: Select straight line segments of reported straight (non-accelerating) flight and perform regression analysis. Compare results of data recorded on aircraft, radar data, and ADS-B pseudo radar. Select both radial and crossing trajectories.

D. Steady State Track Accuracy: Analyze tracker position estimates and velocity for same segments used for sensor raw position analysis. Compare results with observations made on aircraft for designated periods (heading, speed)—factor in winds (record weather data for some test periods).

E. Steady State ATC Display Accuracy: Analyze data sent to controller display for same segments.

F. Maneuvering Accuracy: Analyze tracker and displayed position data for periods where aircraft are maneuvering—constant turn rate.

G. Resolution Test: Evaluate all performance measures during periods of close approach of two aircraft. Compare with radar performance during the same period.

Flight Profile 1

Aircraft: B-727
Date: August 21, or 22, 2000
Pre-departure briefing: 0800 ADT
Departure Time: 0900 ADT
Route: ANC J501 BET EHM CZF BET J501 ANC.
Post Flight debrief: 1600 ADT
Notes: An advisory will be issued to Air Traffic facilities announcing this profile.

Depart Ted Stevens Anchorage International airport via J-501 to SQA (117.2), descend to 12000 MSL, Maintain 12000 MSL until reported in ADS-B coverage, descend to 10000 MSL until reported into ADS-B coverage, descend to 8000 MSL until reported into ADS-B coverage, cross Scalp intersection at 6000 MSL Maintain 6000 MSL until reported in ADS-B coverage, continue toward the BET VORTAC (114.1), fly to the Bethel airport by executing an instrument approach to a missed approach to allow for observer ADS-B target acquisition. Land at the Bethel airport and shutdown if observers are on board, low or missed approach if observers are not on board.

Depart Bethel airport, Climb to 4000 MSL (weather permitting) crossing over the BET VORTAC, turn to fly direct headed approximately 200 degrees.

Fly direct to EHM NDB(385), descend, as terrain, traffic and weather permit to 500 AGL (to allow observation and terrain data base accuracy) at a point 60nm south of the BET VORTAC. Climb to cross EHM at 12000 feet MSL to allow radar an ADS-B comparison. (Could be 10,000ft and still be in BET ADS-B coverage, 12,000ft has greater cone of silence above radar)

Turn right fly direct to CZF NDB(275), descend, until reported out of ADS-B coverage, and then as terrain, traffic and weather permit to as low as 500 feet AGL (To allow observation and terrain data base accuracy) at a point 110nm Northwest of the EHM NDB. Climb to be level at 12000 feet MSL and denote altitude reported in ADS-B coverage, maintain 12000 MSL until crossing over the CZF NDB to allow radar and ADS-B comparison. (Could be 10,000ft and still be in BET ADS-B coverage, 12,000ft has greater cone of silence above radar)

Turn right fly direct BET VORTAC(114.1), descend, as terrain, traffic and weather permit to as low as 500 feet agl at a point 70nm Southwest of the CZF NDB to detect and report the location and altitude of any loss of ADS-B coverage and allow for observation and accuracy of terrain data base. Climb to be level at 12000 feet MSL crossing over the BET VORTAC to allow radar and ADS-B comparison.

Turn left, join V319/J501 maintain 7000 feet until reported out of ADS-B coverage. Climb to 9000 MSL until reported out of ADS-B coverage climb to 11000 MSL until reported out of ADS-B coverage cross SQA at or above 12000 MSL. Return to Anchorage; weather permitting, during the arrival into the Anchorage area, observe terrain displayed on the MFD.

Flight Profile 2

Aircraft: B-727
Date: August 22, or 23, 2000
Pre Departure briefing 0800 ADT
Departure Time: 0900 ADT
Route: ANC J501 BET Bethel airport.
Departure time: 1300 ADT
Route: BET V-453 Altey Intersection, TOG(393) EHM (385) V333 IIK(115.9) J120 BET(114.1) J501 ANC(114.3).
Post flight Debrief 1600 ADT
Notes: : An advisory will be issued to Air Traffic facilities announcing this profile

Depart Ted Stevens Anchorage International airport via J-501 to SQA. (117.2) Descend to 12000 MSL. Maintain 12000 MSL until reported in ADS-B coverage, descend to 10000 MSL until reported into ADS-B coverage. Descend to 8000 MSL until reported into ADS-B coverage, cross Scalp intersection at 6000 MSL Maintain 6000 MSL until reported in ADS-B coverage. Continue toward the BET VORTAC (114.1), fly to the Bethel airport by executing an instrument approach to a missed approach to allow for observer ADS-B target acquisition. Fly an instrument approach (land and shutdown at the Bethel airport when observers are on board, low or missed approach if observers are not on board).

Depart Bethel airport via V453, climb to and level off at 11000 MSL.

At Altey intersection, using one half-standard rate, turn right through a full 360 degree turn and than fly direct Togiak (TOG) NDB (393) to compare turning update rate comparison between ADS-B and radar.

At TOG climb and maintain 12000, using a standard rate, turn left through a full 360 degree turn and than fly direct to the Cape Newenham (EHM) NDB(385)) for turning update rate comparison between ADS-B and radar.

Accelerate to maximum safe operating speed and pass over the EHM NDB; decelerate to normal cruising speed to detect any anomalies associated with high speed . Using one and one half times standard rate, turn right through a full 360 degree turn and than intercept V333 to the IIK(115.9)) to compare turning update rate comparison between ADS-B and radar.

AT IIK VOR, using a standard rate turn fly V480 to BET, fly an instrument approach to t the Bethel airport land and shutdown.

Depart Bethel airport, join V319/J501 climb and maintain 7000 feet until reported out of ADS-B coverage, climb to 9000 MSL until reported out of ADS-B coverage climb to 11000 MSL until reported out of ADS-B coverage cross SQA at or above 12000 MSL, climb to cruising altitude and return to Anchorage; weather permitting, during the arrival into the Anchorage area, observe terrain displayed on the MFD.

Flight Profile 3

Aircraft: B-727
Date: August 23, or 24, 2000
Pre Departure briefing: 0800 ADT
Departure Time: 0900 ADT
Route: ANC J501 BET Bethel airport.
Departure time: 1300 ADT
Route: BET to 61degrees N 163 degrees W, to 62 degrees N 163 degrees W to 62 degrees N 160 degrees W to 60 degrees N 160 degrees W to 60 degrees N 163 degrees W to BET J501 ANC
Post flight debrief 1600 ADT
Notes: An advisory will be issued to Air Traffic facilities announcing this

Depart Ted Stevens Anchorage International airport via J-501 to SQA (117.2), descend to 12000 MSL, Maintain 12000 MSL until reported in ADS-B coverage, descend to 10000 MSL until reported into ADS-B coverage, descend to 8000 MSL until reported into ADS-B coverage, cross Scalp intersection at 6000 MSL Maintain 6000 MSL until reported in ADS-B coverage, continue toward the BET VORTAC (114.1), fly to the Bethel airport by executing an instrument approach to a missed approach to allow for observer ADS-B target acquisition, fly an instrument approach, land and shutdown.

Depart Bethel airport via direct 61N 163 W, climb to 12000 MSL

Turn Northwest and descend to arrive at 62 N 163 W at 500 feet AGL.

Turn east and climb to arrive at 62 N 160 W at 11000 MSL.

Turn Southeast and descend to arrive over 60 N 160 W at 500 AGL.

Turn Southwest and descend to arrive over 60 N 163 W at 12000 MSL.

Fly direct to BET and execute an instrument approach to a missed approach. Land at the Bethel Airport.

Depart Bethel airport, join V319/J501 climb and maintain 7000 feet until reported out of ADS-B coverage, climb to 9000 MSL until reported out of ADS-B coverage climb to 11000 MSL until reported out of ADS-B coverage cross SQA at or above 12000 MSL, climb to cruising altitude and return to Anchorage; weather permitting, during the arrival into the Anchorage area, observe terrain displayed on the MFD.

Flight Profile 4

Aircraft: B-727
Date: August 21, 22, 23, or 24, 2000
Pre Departure briefing: 0800 ADT
Departure Time: 0900 ADT
Route: ANC J501 BET Bethel airport, from Bethel airport a 30 DME arc around the BET VOR
Post flight debrief 1600 ADT
Notes: An advisory will be issued to Air Traffic controllers and specialists announcing this profile.

Depart Ted Stevens Anchorage International airport via J-501 to SQA (117.2), descend to 12000 MSL, Maintain 12000 MSL until reported in ADS-B coverage, descend to 10000 MSL until reported into ADS-B coverage, descend to 8000 MSL until reported into ADS-B coverage, cross Scalp intersection at 6000 MSL Maintain 6000 MSL until reported in ADS-B coverage, continue toward the BET VORTAC (114.1), fly to the Bethel airport by executing an instrument approach to a missed approach to allow for observer ADS-B target acquisition, fly an instrument approach, land and shutdown.

Depart Bethel airport, intercept the 270 degree radial from the BET VOR and fly toward the 30 mile DME fix, and climb to 8000 MSL. Approaching the 30 mile DME fix, turn right to intercept a 30 mile arc around the Bethel VOR. While maintaining a 30 mile DME arc, using cardinal compass points, 360, 090, 180, climb and descend between 2000 and 8000 feet MSL. This will porpoise the aircraft into and out of Radar coverage allowing M-EARTS equipment to track transitions from radar to ADS-B and back to radar. (Coordination with Anchorage Center controllers may allow altitude variances, the objective is to descend/ascend in and out of Radar coverage while remaining ADS-B coverage.) After completing the 30 arc, intercept the 270 degree radial inbound to the Bethel VOR, conduct an instrument approach to the Bethel airport, land and shutdown

Depart Bethel airport, join V319/J501 climb and maintain 7000 feet until reported out of ADS-B coverage, climb to 9000 MSL until reported out of ADS-B coverage climb to 11000 MSL until reported out of ADS-B coverage cross SQA at or above 12000 MSL, climb to cruising altitude and return to Anchorage; weather permitting, during the arrival into the Anchorage area, observe terrain displayed on the MFD.

Flight Profile 5

Capstone/NATCA Demonstration Flight
Aircraft: B-727
Date: August 21, 22, 23, or 24, 2000
Pre Departure briefing: 0800 ADT
Departure Time: 0900 ADT
Route: ANC J501 BET Bethel airport, from Bethel airport to a series of intersections and return.
Notes: An advisory will be issued to Air Traffic controllers and specialists announcing this profile.

Depart Ted Stevens Anchorage International airport via J-501 to SQA (117.2), descend to 12000 MSL, Maintain 12000 MSL until reported in ADS-B coverage, descend to 10000 MSL until reported into ADS-B coverage, descend to 8000 MSL until reported into ADS-B coverage, cross Scalp intersection at 6000 MSL Maintain 6000 MSL until reported in ADS-B coverage, continue toward the BET VORTAC (114.1), fly to the Bethel airport by executing an instrument approach to a missed approach to allow for observer ADS-B target acquisition, fly an instrument approach, land and shutdown.

Aircraft must be equipped with Capstone ADS-B avionics with a properly coded ICAO address. A flight plan must be filed through Kenai AFSS using the profile below as the route of flight. The remark section of the flight plan will contain "ADSB/*(ICAO Code)*. This will enable Anchorage Center to verify software functions within the Micro-EARTS and OCS.

Action	Observations
Depart Bethel Airport. Proceed eastbound at 1,500AGL to WEEKE intersection. Report WEEKE intersection.	Depart aircraft in OCS. Verify aircraft is over WEEKE intersection.
Fly direct to VIDDA intersection while climbing to 5,500.	Watch for change from ADS-B to RBD, note altitude and distance from Bethel.
Fly direct FISHH, climb to 6,500.	Begin process of alternating between radar and ADS inputs. Note any track fluctuation.
Fly direct CABOT, maintain 6,500.	Continue switching inputs as required. Have pilot turn MFD off then on. Have pilot turn transponder off then on.
Fly direct DAHLS, maintain 8,500.	Continue switching inputs as required.
Proceed direct Bethel at an appropriate VFR altitude. Contact Anchorage Center (125.2) for any instructions Land and shutdown at the Bethel airport.	If enough data has been received, release aircraft. If more data is needed and weather permits, provide instructions to aircraft.

Depart Bethel airport, join V319/J501 climb and maintain 7000 feet until reported out of ADS-B coverage, climb to 9000 MSL until reported out of ADS-B coverage climb to 11000 MSL until reported out of ADS-B coverage cross SQA at or above 12000 MSL, climb to cruising altitude and return to Anchorage; weather permitting, during the arrival into the Anchorage area, observe terrain displayed on the MFD.

Attachment A: Key personnel locators during the open house.

ALASKA CAPSTONE PROJECT

N40 INFORMATION

N40: B727 (100QC)

Flight Crew:	John Geyser, Keith Beihl, John Tatham
Maintenance:	John Birney
Safety/Mods:	Ralph Pohl
Project Personnel:	Dot Buckanin, Paul Quick, Carl Jezierski

Telephone Numbers

FAA Tech Center Flight Operations:	609-485-6492/6482 (24hrs)
John Geyser	609-485-6468
Keith Biehl	609-485-6480
John Tatham	609-485-6004
Paul Quick	609-485-6309
N40 Crew Mobile Phone	609-513-0716
N40 Satellite Phone	Outgoing only
Regal Alaskan	907-243-2300
ERA Aviation (KANC)	907-248-4422
KBET Airport Manager	907-543-2495
KBET Hangar 1 FBO	907-543-4001
KGTF Holman Aviation FBO	406-453-7613
Rick Girard Capstone B-727 coordinator	907-271-2003
Bruce Walker Capstone B-727 alt coordinator	907-271-2050
Lari Belisle Anchorage Center coordinator	907-269-1124
Gary Childers Capstone POC	907-271-6304
Cell phone	907-223-3509
Ellis McElroy Open House coordinator	907-271-5943
Traci Huron Open House alt. coordinator	907-271-1338

.

Appendix G: ATC Procedures and NATCA MOU

1) ATP Notice: ATC Procedures and Phraseology associated with ADS-B in Anchorage FIR at Anchorage ARTCC

2) Capstone NATCA MOU

NOTICE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

N 7110.

DEC 21 2000

Cancellation
Date: 12/31/01

SUBJ: **ATC Procedures and Phraseology Associated With Use of ADS-B in Anchorage FIR at Anchorage ARTCC**

1. PURPOSE. This notice prescribes air traffic control (ATC) procedures and phraseology for use by controllers at the Anchorage Air Route Traffic Control Center (ARTCC) in Anchorage, Alaska, providing ATC services in the Anchorage Flight Information Region (FIR) using automatic dependent surveillance-broadcast (ADS-B).

2. DISTRIBUTION. This notice is distributed to select offices in Washington headquarters, the Alaskan Regional Office, William J. Hughes Technical Center, Mike Monroney Aeronautical Center, and Anchorage ARTCC.

3. EFFECTIVE. January 1, 2001.

4. BACKGROUND. ADS-B is a new source for surveillance. Surveillance data derived from ADS-B can be used in a manner similar to surveillance data derived from primary or secondary radar surveillance systems. When aircraft are appropriately equipped, ADS-B data can be used as a source for aircraft position beyond or below radar coverage or when primary and/or secondary radar surveillance systems are unusable or unavailable.

5. RELATED PUBLICATIONS. Order 7110.65, Air Traffic Control.

6. DEFINITIONS/ABBREVIATIONS.

a. Automatic dependent surveillance-broadcast (ADS-B). ADS-B is a surveillance application transmitting parameters, such as position track and ground speed, via a broadcast mode data link and at specified intervals, for utilization by any air and/or ground users requiring it. ADS-B is a tertiary form of surveillance, with raw radar remaining primary and beacon system remaining secondary. ADS-B surveillance may be used when primary and secondary radar are unusable or unavailable.

b. Radar. For the purpose of this supplement, "radar" is defined as information displayed on the Micro-En Route Automated Radar Tracking System controller display which is derived from primary radar, Mode 3/A secondary radar, and ADS-B. Phraseology for transfer of radar identification, i.e., "handoff," "radar contact," "point out," and "traffic," apply.

c. Ground-based transceiver (GBT). GBT is an ADS-B transmitter/receiver.

Distribution:

Initiated By: ATP-110

7. **PROCEDURES.** The procedures contained in FAA Order 7110.65 apply, except as noted below.

a. Separation standards for ADS-B displayed targets are below flight level (FL) 600 (5 miles) and at or above FL 600 (10 miles) in the en route operating environment, only.

b. Controllers must receive training on ADS-B procedures and phraseology prior to conducting ADS-B operations.

c. Radar identification and status of ADS-B aircraft shall be in accordance with Order 7110.65, Paragraphs 5-3-2, Primary Radar Identification Methods, and 5-3-7, Identification Status.

d. Inform an aircraft when its ADS-B transmitter appears to be inoperative or malfunctioning.

PHRASEOLOGY–
ADS-B.
(Identification) YOUR ADS-B TRANSMITTER APPEARS TO BE INOPERATIVE/MALFUNCTIONING.
STOP ADS-B TRANSMIT.

e. Inform aircraft concerned when the ground interrogator or GBT appears to be inoperative or malfunctioning.

PHRASEOLOGY–
INTERROGATOR.
(Name of facility or control function) BEACON INTERROGATOR INOPERATIVE/MALFUNCTIONING.

PHRASEOLOGY–
GBT.
(Name of facility) GROUND BASED TRANSCEIVER INOPERATIVE/MALFUNCTIONING.

f. Inform an aircraft when you want it to turn off its ADS-B transmitter.

PHRASEOLOGY–
STOP ADS-B TRANSMIT.

8. **CERTIFICATION AND PERFORMANCE CRITERIA.** ADS-B equipment is certified as a surveillance source that meets the 5-mile separation criteria equivalent utilized in the en route radar environment.

ORIGINAL SIGNED BY
JEFF GRIFFITH

Jeff Griffith
Program Director
for Air Traffic Planning and Procedures

Memorandum of Understanding
between the
National Air Traffic Controllers Association
and the
Federal Aviation Administration

This Agreement is made by and between the National Air Traffic Controllers Association (hereinafter "NATCA" or "the Union") and the Federal Aviation Administration (hereinafter "the FAA" or "the Agency"), collectively known as the "Parties." It represents the Parties' agreement concerning the Implementation of the Capstone Demonstration Project at the Anchorage Air Route Traffic Control Center ("ARTCC").

Section 1. Prior to Initial Operating Capability ("IOC"), the Agency shall resolve to the satisfaction of the Union at the national level, Issue #3 as described in the "ATS Capstone Review for the implementation of Radar-like Services White paper," dated December 15, 2000, attached hereto.

Section 2. Prior to IOC, the Parties at the facility level shall jointly develop a transition plan and brief all affected bargaining unit employees ("BUE") on the plan.

Section 3. Prior to January 16, 2001, the Agency shall resolve, to the satisfaction of the Union at the national level, Issue #1 as described in the Capstone Review White Paper. The Agency shall discontinue the use of Capstone equipment and procedures if the issue is not resolved by that date.

Section 4. Prior to May 30, 2001, the Agency shall resolve, to the satisfaction of the Union at the national level, Issue #4, as described in the Capstone Review White Paper. The Agency shall discontinue the use of Capstone equipment and procedures if the issue is not resolved by that date. Additionally, if the issue is not resolved by that date, the Agency shall establish a work group consisting of two BUEs from each area of operation at ZAN to determine and resolve the impact on the facility, including, but not limited to, traffic management initiatives and staffing. The Agency shall provide "one-for-one" backfill overtime to replace the two BUEs from each area. Capstone equipment or procedures shall not be re-implemented at ZAN until all work group identified issues are resolved to the satisfaction of the work group.

Section 5. All BUEs shall be granted immunity for operational errors and/or operational deviations if the use of the Capstone procedures and services cause a distraction from the primary responsibility of separation of aircraft from other aircraft or airspace, from IOC to 60 days after operational readiness demonstration ("ORD").

Section 6. The Agency shall not install and/or activate any additional Ground Based Transceivers beyond the three (3) that are presently certified in the Bethel area without prior notification to and negotiation with the Union at the national level. The Agency shall not expand the geographical area in which Capstone equipment and/or procedures are utilized without prior notification to and negotiation with the Union at the national level.

Section 7. Within sixty (60) days of the execution of this Agreement, the Agency shall convene a meeting in a mutually agreeable location for the purpose of addressing and resolving existing and future automation enhancements at ZAN; including but not limited to, how ZAN receives, funds, and implements National Airspace System products such as the Enhanced Stams Information System. The Agency shall provide duty time, travel and per diem for up to four (4) ZAN BUEs and up to four (4) other national Union representatives to attend the meeting. The Union shall designate its meeting attendees.

Section 8. The Parties at the facility level shall jointly develop DYSIM training problems that include radar/non-radar mixed environment operations. All affected BUEs shall complete said training within thirty (30) days of IOC. For employees unavailable due to leave or other absences from the facility, this training shall be completed not later than sixty (60) days after IOC. Said training shall not be pass/fail in nature.

Section 9. If either party at the facility level determines there is a safety or operational impact, they may terminate the use of Capstone equipment and procedures at any time.

Section 10. The Agency shall implement altitude sectorization Phase I (do not display traffic above x altitude) no later than August 30, 2001. Phase II (those items not covered in Phase I) will be implemented no later than January 30, 2002, per attached schedule. By February 28, 2001, the Agency shall convene a work group of no less than two (2) BUE from each Micro-EARTS facility and no less than two (2) other national Union representatives to complete the functional description narrative for this enhancement. The Agency shall provide duty time, travel and per diem for Union representatives to attend the meeting. This work group will also prioritize the national Micro-EARTS site delivery schedule (attached).

Section 11. The Agency shall provide duty time, travel and per diem for up to four (4) national Union representatives for a site visit to ZAN to observe ADS-B/Capstone operations and LAN upgrades. The Union shall designate its' representatives. This site visit shall occur no later than September 30, 2001.

Section 12. The Agency shall adhere to the attached "Micro-EARTS Site Deliveries" schedule. All upgrades described in the DSR CHI Upgrade MOU Addendum, dated January 22, 1999, shall be incorporated into DSR at ZAN beginning no later than October 31, 2001, with completion by August 30, 2002, unless otherwise determined by the work group in Section 10.

Section 13. If the Agency fails to meet any required date(s) in this agreement, the Agency shall convene a meeting, one for each missed date, within 7 days of each required date, at ZAN for the purpose of personally explaining to bargaining unit representatives why the Agency was unable to meet their obligations as agreed to in this agreement. ATP-1, AOS-1 and AUA-600 shall personally attend each meeting.

Section 14. All issues expressly delegated to the Parties at the facility level by this Agreement for negotiation shall be negotiated and resolved in accordance with the provisions of Article 7 of the CBA.

Section 15. This agreement constitutes no waiver by either Party of any right guaranteed by law, rule, regulation, or contract.

Section 16. This Agreement may be re-opened by mutual agreement of the Parties in accordance with the provisions of Article 7 of the CBA.

Section 17. The Parties shall meet at the end of the Capstone Demonstration Project to determine the feasibility of continuing this MOU.

FOR THE UNION:	FOR THE AGENCY:
Wade Stanfield	Jim Griffith

Date: 12/27/00

Appendix H: AFS Separation Standards Recommendations and Pilot Training:

1) Separation Standards for the Use of ADS-B by Anchorage ARTCC

2) Flight Standards Service Recommendation to Authorize Anchorage ARTCC to provide Air Traffic Control Service to Capstone ADS-B Equipped Aircraft Conducting Operations in Non Radar Airspace in the Bethel, Alaska Area.

3) Airline Training Supplement

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: **INFORMATION:** Separation Standards for the Use of Automatic Dependent Surveillance-Broadcast (ADS-B) by Anchorage Air Route Traffic Control Center (ARTCC)

Date: JUL 20 2000

From: Manager, Flight Technologies and Procedures Division, AFS-400

Reply to Attn. of:

To: Program Director for Air Traffic Planning and Procedures, ATP-1

We are in receipt of your July 19 memorandum. Your memorandum requested our formal validation of using ADS-B for providing "radar" services for the following operations in the Anchorage ARTCC airspace:

1. Between IFR aircraft and IFR aircraft.
2. Between IFR aircraft and VFR aircraft; and
3. Between VFR aircraft and VFR aircraft.

Your memorandum also requested the specific separation certification levels that our office has developed for the use of ADS-B, and any contingencies, if known.

We have determined, based on data provided from AUA-650, that the ADS-B signal transmitted from Alaska Capstone avionics equipped aircraft to the Anchorage ARTCC can be used to provide "radar" services between VFR aircraft and VFR aircraft.

We believe that additional data and experience using ADS-B for VFR "radar" advisories will validate future use of ADS-B by Anchorage ARTCC for providing "radar" services between IFR aircraft and IFR aircraft or between IFR aircraft and VFR aircraft. Our goal is to meet the January 1, 2001 timeframe for use of ADS-B by Anchorage ARTCC for 5-mile en route IFR separation.

When additional data is provided to us by AUA-650 validating that the ADS-B target data provided to the controller is as accurate as existing en-route and terminal radar used for aircraft to aircraft separation and the airborne ADS-B avionics is certified for IFR use, we should be able to concur with using ADS-B for "radar" services in the Anchorage ARTCC airspace. These follow-on services would initially include 5-mile separation services to Capstone ADS-B equipped aircraft in the Anchorage ARTCC en route airspace and, may allow future 3-mile separation standards in terminal airspace.

The following limitations apply for the use by Anchorage ARTCC of ADS-B to provide "radar" services between VFR aircraft and VFR aircraft.

- These limitations and procedures will remain in effect until the Capstone avionics achieves an amended Supplemental Type Certificate (STC) IAW RTCA DO-178. The present avionics configuration and software can only support ATC procedures and services requiring an aircraft identification and positional accuracy determination. The procedures and services identified below fall within this scope.

- Anchorage ARTCC will use ADS-B reports broadcast by properly equipped aircraft and received by certified ground stations to display an aircraft's position on the controller's DSR workstation.

- Controllers may use displayed information to provide the following limited ATC services as described in the following FAA Order 7110.65 paragraphs:

  a. Specifically, controllers may use ADS-B position information to issue Safety Alerts, paragraph 2-1-6, Wake Turbulence Cautionary Advisories, paragraph 2-1-20, Traffic Advisories, paragraph 2-1-21, Bird Activity Information, paragraph 2-1-22, and Pilot Deviation Notification, paragraph 2-1-26

  b. Controllers may also use ADS-B position information to provide limited radar services. These would be limited to radar monitoring for Merging Target Procedures, paragraph 5-1-8, Holding Pattern Surveillance, paragraph 5-1-9, Deviation Advisories, paragraph 5-1-10, and Validation of Mode C Readout, paragraph 5-2-17.

- Controller procedures such as Radar Identification and Termination, and Transfer of Control would be the same as currently used for traditional radar, with minor modifications to ensure that radar separation minima will not be utilized. Pilots will also be informed that radar separation, sequencing, or spacing is not being provided.

- Radar vectoring will not be provided, except as a suggestion to VFR aircraft.

Please contact the AFS-400 Free Flight Program Manager at (202) 267-9093 if additional information is needed.

Robert A. Wright

Robert A. Wright

U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject: **ACTION:** Flight Standards Service Recommendation to Authorize Anchorage Air Route Traffic Control Center (ARTCC) to provide Air Traffic Control Service to Capstone ADS-B Equipped Aircraft Conducting Operations in Non Radar Airspace in the Bethel, Alaska Area.

Date: December 7, 2000

From: Director, Flight Standards Service, AFS-1

Reply to Attn of:

To: TO: Director, Air Traffic Service, AAT-1

We have reviewed the results of the attached Capstone ADS-B Acceptability Evaluation completed by the Oceanic and Offshore Integrated Product Team and provided to the FAA Flight Technologies Division on November 30, 2000.

Our review of the Capstone Equipped Aircraft Operational Data and the Acceptability Evaluation indicates that the accuracy of the Capstone ADS-B positional information transmitted to Anchorage ARTCC is as good or better than surveillance radar.

We concur with certifying and approving the use of ADS-B equipment used by Anchorage ARTCC as a surveillance source that meets the 5-mile separation criteria equivalent utilized in the en route radar environment with the following conditions and limitations:

- Separation standards for ADS-B displayed targets are: Below FL600-5 miles and at or above FL600-10 miles in the en route operating environment only
- ADS-B service is limited to the Anchorage FIR area when primary and secondary radar are unusable or unavailable
- All Pilots and Controllers must receive training on ADS-B procedures and phraseology prior to conducting ADS-B operations
- Performance of the ADS-B signal must be continuously monitored using ADS-B fixed parrot
- Supplemental Type Certificate or applicable follow on STC approval is issued for the installed airborne Capstone avionics system
- Radar identification of ADS-B aircraft shall be in accordance with FAA Order 7110.65, paragraph 5-3-2, Primary Radar Identification Methods

Please contact the AFS-400 Free Flight Program Manager at (202) 267-9093 if additional information is needed. information is needed.

(Original signed by)

L. Nicholas Lacey

Attachment
AUA-600 Capstone ADS-B Evaluation Acceptability Memo

Airline Training supplement

SUBJ: PROCEDURES AND PHRASEOLOGY ASSOCIATED WITH CAPSTONE AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST (ADS-B) FOR AIRCRAFT FLOWN BY _____AIRLINE IN ALASKA.

1. PURPOSE. This training supplement prescribes procedures and phraseology for pilots using Automatic Dependent Surveillance-Broadcast (ADS-B) for Radar services.

2. DISTRIBUTION. This training supplement is distributed to all participating carriers, Alaskan Region Air Traffic control facilities and Flight Standards offices.

3. SCHEDULE: Training must be completed by each pilot on the procedures and phraseology associated with Automatic Dependent Surveillance-Broadcast prior to accepting IFR clearances which rely upon ADS-B for ATC surveillance.

4. BACKGROUND. As new source for surveillance, ADS-B, is used in the manner similar to surveillance data derived from primary or secondary radar surveillance systems. When aircraft are appropriately equipped, and within range of a ground based transceiver, ADS-B will become a source for aircraft position beyond or below radar coverage or when primary and/or secondary radar surveillance systems are unusable.

4. DEFINITIONS/ABBREVIATIONS.

a. ADS-B (Automatic Dependent Surveillance-Broadcast): ADS-B is a surveillance application transmitting parameters, such as position track and ground speed, via a broadcast mode data link, and at specified intervals, for utilization by any air and/or ground users requiring it. ADS-B is a tertiary form of surveillance, with raw radar remaining primary and beacon system remaining secondary. ADS-B surveillance may be use when primary and secondary radar are unusable or unavailable.

b. GBT- (Ground Based Transceiver) A data link which transmits ADS-B information to the Air route traffic control facilities.

c. Radar: For the purpose of this document, “radar” is defined as information displayed on the Micro-En Route Automated Radar Tracking System controller display which is derived from primary radar, Mode 3/A secondary radar, and ADS-B. Phraseology for the transfer of radar identification by controllers, i.e., “handoff,” “radar contact,” “point out,” and “traffic,” apply.

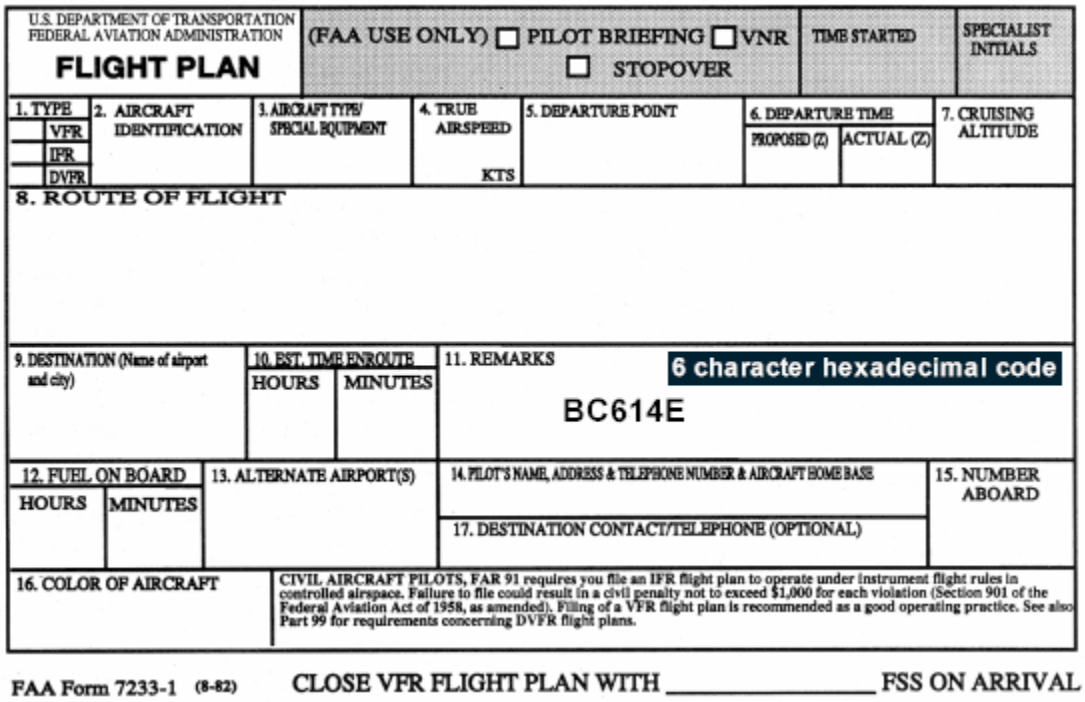
d. ICAO Address- An eight (8) bit numeric address programmed into each specific aircraft’s ADS-B system during installation. This numeric address provides the functional equivalent of a transponder code when received by Air Traffic Control (ATC).

e. Hexadecimal code- The aircraft specific 8 bit numeric address is converted by the ATC system to a six character alphanumeric designation for display on ATC controllers screens for aircraft identification.

6. PROCEDURES: Radar procedures, with the exceptions found in this supplement, are identical to procedures prescribed for radar in Chapters 4 and 5 of the Airman's Information Manual (AIM).

a. **PREFLIGHT**: If a request for ATC services predicated on ADS-B is anticipated when a flight plan is filed, the aircraft's "N" number as filed in Block 2 shall be entered in the in the MX-20(press FN key twice, select the function key "traf", select menu enter, select "enter FID", in the drop down box enter the "N" number using the arrow keys, select "menu enter", verify the broadcast Flight ID in the lower right corner of the MFD). The hexadecimal address shall be included in Block 11 (remarks section) of the FAA Flight Plan at the time of filing.

Note: Each aircraft's unique hexidecimal alphanumeric can be determined by entering the 8 bit (octal) ICAO code into a scientific calculator (the calculator incorporated into most personal computers has a scientific view) push "OCT", type in the 8 numbers, push HEX and record the 6 alphanumeric figure.


U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
FLIGHT PLAN
(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER
TIME STARTED
SPECIALIST INITIALS
1. TYPE VFR IFR DVFR
2. AIRCRAFT IDENTIFICATION
3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT
4. TRUE AIRSPEED KTS
5. DEPARTURE POINT
6. DEPARTURE TIME PROPOSED (Z) ACTUAL (Z)
7. CRUISING ALTITUDE
8. ROUTE OF FLIGHT
9. DESTINATION (Name of airport and city)
10. EST. TIME ENROUTE HOURS MINUTES
11. REMARKS
6 character hexadecimal code
BC614E
12. FUEL ON BOARD HOURS MINUTES
13. ALTERNATE AIRPORT(S)
14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE
15. NUMBER ABOARD
17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)
16. COLOR OF AIRCRAFT
CIVIL AIRCRAFT PILOTS, FAR 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.
FAA Form 7233-1 (8-82)
CLOSE VFR FLIGHT PLAN WITH _____ FSS ON ARRIVAL

b. **IN FLIGHT**: When requesting ADS-B services in-flight ("pop-up"), it may be necessary to provide both your aircraft call sign and hexadecimal code.

PHRASEOLOGY- N12345 code BC614E

Pilots desiring ATC service should ensure their equipment is transmitting their aircraft specific "N" number prior to contacting ATC. On the traffic page of the MX-20 (Multi Function Display, (MFD) the pilot will select the "broadcast flight ID" function. (Note: The broadcast VFR or Standby mode will not provide ATC the aircraft identification information.)

After initial radar contact is established, the controllers and flight crews should use the normal aircraft call sign during subsequent communications.

ADS-B equipment does not employ an "ident" feature similar to that found on transponders at this time. If a hexadecimal code is in doubt, ATC may request a flight crew to momentarily "stop ADS-B transmit" to ensure positive identification. For this reason, pilots should be thoroughly familiar with this capability in their equipment. (Note: to "stop ADS-B transmit" the pilot should select the traffic page on the MX-20 and then select the standby function

c. **SEPARATION STANDARDS:** Separation standards for ADS-B displayed targets are below flight level (FL) 600 (5 miles) and at or above FL 600 (10 miles) in the enroute operating environment only.

d. **INOPERATIVE/MALFUNCTIONING ADS-B TRANSMITTER OR GBT**

1. ATC will inform the flight crew when the aircraft's ADS-B transmitter appears to be inoperative or malfunctioning.

   PHRASEOLOGY –

   (Identification) YOUR ADS-B TRANSMITTER APPEARS TO BE INOPERATIVE/MALFUNCTIONING. STOP ADS-B TRANSMITS.

   Note: In the event of ADS-B malfunction the flight crew will select the traffic page on the MX-20 and select the "broadcast VFR" function to maintain a cockpit display of other traffic information.

2. ATC will inform the flight crew when the GBT transceiver becomes inoperative or malfunctioning.

   PHRASEOLOGY –

   (Name of facility) GROUND BASED TRANSCEIVER INOPERATIVE/MALFUNCTIONING. (And if appropriate) RADAR CONTACT LOST.

   Note: Inoperative or malfunctioning GBT may cause the lost of Radar services.

3. ATC will inform the flight crew if it becomes necessary to turn off the aircraft's ADS-B transmitter.

PHRASEOLOGY –

STOP ADS-B TRANSMIT.

4. Other Malfunctions and considerations

Loss of automatic altitude reporting capabilities (encoder failure) will result in lost of ATC altitude advisory services.

7. ADS-B RADAR SERVICE LIMITATIONS.

a. ADS-B will become a source for aircraft position beyond or below radar coverage or when primary and/or secondary radar surveillance systems are unusable.

b. Use of ADS-B radar services is limited to service volume of the GBT.

Note: GBT's are line of sight facilities.

8. CERTIFICATION AND PERFORMANCE CRITERIA.

a. ADS-B equipment is certified as a surveillance source that meets the 5-mile separation criteria equivalent utilized in the en route radar environment.

Appendix I: Capstone ADS-B Acceptability Evaluation

1) Test Plan
2) AUA Results Memo

The FAA Administrator has charged FAA Flight Standards with the task of approving "operational standards and associated operations specifications permitting use of radar-like services based on ADS-B equipment". AUA-600 has agreed to support Flight Standards in this task by collecting and analyzing Capstone ADS-B performance data.

The objective of this effort is to verify that the Capstone ADS-B ground system is acceptable for use in providing radar-like services and that the Capstone ADS-B ground system equipment performs in accordance with applicable specifications. The accuracy of the Capstone ADS-B Global Positioning System (GPS) receiver was tested at the WJHTC in April, 2000 and found to provide position information in accordance with the published GPS specification. ADS-B accuracy will therefore not be addressed in this task.

Since the ZAN Microprocessor Enroute Automated Radar Tracking System (Micro-EARTS) will be used to collect most of the data necessary for this evaluation and both ADS-B and radar data are needed, the data collection will not begin until at least one Capstone Ground Based Transceiver (GBT) has been certified in accordance with FAA certification procedures. Following this, ADS-B and radar data will be recorded via the Micro-EARTS Continuous Data Recording (CDR) function for a period of at least 30 days using targets of opportunity and dedicated test flights. The geographical test area is defined as that airspace defined in Airspace Docket 99-AAL-24. Each day's data will be reduced to Microsoft Excel format to facilitate analysis and charting.

The specific objectives, necessary data, expectations, and data collection methods to begin this evaluation are delineated below.

Objective 1. Evaluate ADS-B message content anomalies and transmission anomalies to determine error rates and origin of suspected data corruption and to identify necessary equipment and/or software corrections

Necessary Data: A 30 day collection of ADS-B messages and transmission error information

Expected Results: Less than 0.1 percent of all messages contain detectable message content errors. Data transmission error rates due to all causes are less than 0.01 percent.

Required Performance: All system components meet documented standards and tolerances as contained in applicable government and manufacturer specifications for the Capstone avionics and ground equipment, the ANICS, and the Cisco router.

Data Source and Collection Method: Capstone equipped aircraft messages recorded by the Micro-EARTS.

Objective 2. Evaluate all equipment outages and apparent equipment outages to determine cause, impact on service availability, and restoration time.

Necessary Data: A 30 day collection of FAA maintenance log entries, controller comments, and ADS-B messages.

Expected Results: No undetected ground equipment failures, no unscheduled equipment outages, no disruption of ADS-B service during the data collection period. An equipment failure is deemed to have been undetected if no FAA maintenance log entry is made to document the failure, no equipment or system status message is found that indicates the failure, and the applicable ADS-B fixed parrot, if any, is received periodically after the failure.

Required Performance: Service availability no less than 99.5 percent of the time during which data are collected. Availability will be based upon equipment and/or software failures and will not include scheduled outages or outages due to external causes.

Data Source and Collection Method: FAA Maintenance logs collected and compiled at least once per seven day data collection period, Controller comments collected and compiled weekly, and ADS-B messages recorded by the MicroEARTS.

Objective 3. Determination of ADS-B position latency when received at the MicroEARTS.

Necessary Data: A minimum of 3,000 Capstone ADS-B messages representing a random sampling from all Capstone equipped aircraft and Capstone ground system data transmission components. A 30 day collection of ADS-B messages received at the MicroEARTS is expected to fulfill this requirement.

Expected Results: Minimum position latency of no less than 475 ms, maximum position latency of not more than 1.35 seconds, average message latency of approximately 900 ms.

Required Performance: Minimum position latency not less than 350 ms, maximum position latency not more than 1.45 seconds, average position latency 800 to 1000 ms.

Data Source and Collection Method: ADS-B messages from Capstone equipped aircraft and Capstone GBTs recorded at the MicroEARTS.

Objective 4. Evaluate MicroEARTS ADS-B functionality for compliance with the Capstone MicroEARTS NCP and FDNs.

Necessary Data: MicroEARTS and airborne recorded data from controlled flight profiles flown between 8/21/00 and 8/24/00, a 30 day collection of ADS-B messages representing 30 days of system operation with equipment in a certified status, air traffic controller comments for a 30 day period, FAA maintenance logs

Expected Results: The MicroEARTS provides all functionality required by the Capstone NCP and FDNs.

Required Performance: The MicroEARTS meets all requirements specified in the Capstone NCP, all additional MicroEARTS enhancements required to meet the goals stated in the FAA Administrator's letter of 1/3/00 are scheduled to be completed by 1/1/01, all MicroEARTS enhancements required or desired subsequent to 1/1/01 are documented.

Data Source and Collection Methods: Air traffic controller comments compiled weekly, FAA maintenance log entries compiled weekly, internal MicroEARTS surveillance data and display data processing results as recorded by the MicroEARTS, controller keyboard entries recorded by the MicroEARTS, interfacility message data recorded by the MicroEARTS, MicroEARTS CGW recordings.

Objective 5. Evaluate the performance of the Capstone ADS-B fixed parrots

Necessary Data: ADS-B fixed parrot messages from all Capstone ADS-B fixed parrots for a minimum of 3 hours each day for a contiguous 30 day period. The messages must include a minimum of 600 messages from each GBT for every contiguous one hour time period in a 24 hour day; a total of no less than 14400 messages per parrot spread over the 30 day period.

Expected Results: Messages with time stamps at even 5 second intervals from the start of each minute, an average of no less than 10 messages per minute in any contiguous one hour period, average GPS position solution within 20 meters of surveyed position adapted in the MicroEARTS.

Required Performance: Fewer than 0.5 percent of all received messages contain timestamps other than at zero seconds past a minute tick or a multiple of 5 seconds following a minute tick, an average of no less than 10 messages per minute when the Capstone ground equipment is fully operational.

Data Source and Collection Methods: Capstone ADS-B fixed parrot messages from certified Capstone ADS-B fixed parrots as recorded by the MicroEARTS.

Objective 6. Compare the displayed position of ADS-B aircraft with that of radar detected aircraft.

Necessary Data: A minimum of three aircraft tracks from each overlapping radar and ADS-B coverage area each containing a minimum of 10 secondary radar detections and a minimum of 85 percent ADS-B position report rate within the 10 secondary radar detections. The tracks must not contain any coast intervals as defined by the MicroEARTS CPFS. If the overlapping radar is a MAR, the 10 radar detections must be primary radar reinforced.

Expected Results: Maximum time corrected difference between the displayed position of ADS-B and radar tracks not more than +/- 1.5 nmi for any track. No significant evidence of track stitching in ADS-B tracks.

Required Performance: Computed average difference in the time corrected displayed position of aircraft reported by both ADS-B and radar not more than the applicable radar reporting error +/- 0.25 nmi after correcting for radar registration errors. No more than +/- 100 meter per second change in report to report position interval for ADS-B tracks.

Data Source and Collection Methods: ADS-B messages from Capstone equipped aircraft operating in areas of radar coverage within 175 nmi of a Capstone GBT as recorded by the MicroEARTS.

Objective 7. Evaluate MicroEARTS ADS-B and radar data fusion

Necessary Data: A minimum of 200 hours of ADS-B and radar aircraft track data over a 30 day period for aircraft operating within 175 nmi of a Capstone GBT, a minimum of two hours of data from Capstone equipped aircraft flying defined paths within Capstone GBT coverage areas, and controller comments concerning displayed radar and ADS-B aircraft positions.

Expected Results: No false radar and ADS-B track bonds of more than 30 seconds duration, no controller detectable change in radar data display, fewer than 3 conflict alerts per hour due to unbonded radar and ADS-B tracks from common aircraft, no false MSAWs due to use of erroneous ADS-B altitude information, no false conflict alerts due to erroneous ADS-B position information, no failures to display radar detected aircraft position due to ADS-B track bonds

Required Performance: Same as Expected Results except that conflict alerts due to failure to bond track data from a common aircraft must not exceed 5 within any one hour period.

Data Source and Collection Methods: ADS-B messages from Capstone equipped aircraft and radar reports for all aircraft operating within 175 nmi of each certified Capstone GBT, ADS-B messages and radar reports from all aircraft flying defined paths in support of this evaluation as recorded by the MicroEARTS, air traffic controller logs compiled weekly, MicroEARTS SMC messages, and MicroEARTS CAs and MSAWs.

Objective 8. Evaluate the operation of the MicroEARTS Kalman Filter to assure no detrimental effect on MicroEARTS safety functions.

Necessary Data: A minimum of 200 hours of ADS-B and radar aircraft track data over a 30 day period for aircraft operating within 175 nmi of certified Capstone GBTs, a minimum of two hours of data from Capstone equipped aircraft flying defined paths within Capstone GBT coverage areas, and controller comments concerning CAs and MSAWs.

Expected Results: No false MSAWs for aircraft in radar coverage due to erroneous use of ADS-B information, no false conflict alerts between aircraft in radar coverage due to erroneous use of ADS-B information.

Required Performance: Same as Expected Results.

Data Source and Collection Methods: ADS-B messages from Capstone equipped aircraft and radar reports for all aircraft operating within 175 nmi of certified Capstone GBTs, air traffic controller logs compiled weekly, MicroEARTS SMC messages, and MicroEARTS CAs and MSAWs. All MicroEARTS data to be extracted from MicroEARTS recordings.

Objective 9. Evaluate operational GBT coverage to determine if significant holes exist in areas of frequent travel by Capstone equipped aircraft or along paths frequently used by air traffic controllers to vector aircraft.

Necessary Data: A minimum of 200 hours of ADS-B and radar position reports from Capstone equipped aircraft operating in and within 175 nmi of certified Capstone GBTs, a minimum of 2 hours of ADS-B and radar data from Capstone equipped aircraft flying defined paths in Capstone

operational GBT coverage areas, and controller comments concerning loss of displayed position of Capstone equipped aircraft.

Expected Results: No significant gaps in aircraft tracks within the designed coverage area of any FAA certified Capstone GBT due to failure to receive ADS-B messages at the GBT.

Required Performance: Documentation and publication, if necessary, of all areas, if present, in the designed coverage boundaries of each FAA certified operational GBT in which ADS-B aircraft tracks are coasted by the MicroEARTS due to uncorrectable loss of messages from aircraft operating in those areas. i.e. Documentation of all uncorrectable holes in GBT coverage areas. Minimum documentation will be the report of the results of this test. Additional one time documentation of initial system performance may be required by the FAA for distribution to air traffic control personnel or maintenance personal.

Data Source and Collection Methods: ADS-B messages and radar reports from Capstone equipped aircraft operating within 175 nmi of certified operational Capstone GBTs and ADS-B messages and radar reports from all aircraft flying defined paths in support of this evaluation, air traffic controller logs compiled weekly as recorded by the MicroEARTS.

U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject: INFORMATION: Capstone Automatic Dependent Surveillance-B (ADS-B) Acceptability Evaluation

Date: Nov. 30, 2000

From: Leader, Oceanic & Offshore Integrated Product Team, AUA-600

Reply to Attn of:

To: Manager, Flight Technologies and Procedures Division, AFS-400

With all varying systems in place to provide radar-like services using ADS-B, the next step was to demonstrate that ADS-B, as currently implemented, is suitable for use in providing these services. AUA and the Alaskan Region have gathered data during the period of late September to early November. The initial evaluation and analysis of anomalies has been completed and appropriate equipment and/or software corrections have been made or documented. Follow on analysis is expected to continue through IOC.

After a thorough review of the data, I am pleased to advise you that the ADS-B reported positions displayed to the air traffic controller appear to be as good as or better than the Anchorage radar data for determining aircraft position, speed, and direction of flight. Furthermore, there is no significant evidence of track stitching in ADS-B target reports by comparison with radar target reports.

There is one anomaly that is of concern. The Navigation Uncertainty Category for Position (NUCp) value is not presently usable as an ADS-B message filter because it does not correlate to the applicable message. However, an equivalent method for monitoring GPS performance using the ADS-B fixed parrots and published GPS performance charts has been evaluated as acceptable and this data is presented in Section 23 of the evaluation report. The ADS-B fixed parrot is displayed at the controller's workstation when an out of tolerance condition is detected. This action is similar to the procedure used for monitoring radar parrots. Until the NUCp problem is corrected our analysis indicates that the Capstone system is safe for use with this defined and agreed to procedure.

Micro-EARTS functionality changes and enhancements required prior to the planned January IOC have been coordinated with cognizant parties and thoroughly tested. The Airways Facility Operational Support Service will deliver the final changes in December 2000. Additional enhancements to Micro-EARTS ADS-B continuous data recording, data extraction and other desired functionality were not considered mandatory for initial operational use of the Capstone ADS-B data for air traffic control, but have been

documented and are considered desirable for earliest possible implementation. It should be noted, however, that further expansion of the Capstone technology beyond the Bethel area will require additional modifications to the Micro-EARTS and additional investment in the Micro-EARTS hardware infrastructure.

In summary, based on the results of the attached evaluation, the accuracy, frequency, and reliability of the ADS-B data appear to be superior to radar as a source of aircraft surveillance information. I recommend Flight Standards consider issuing a notice approving use of Capstone ADS-B data as an aircraft surveillance source as good as or better than radar for the Bethel, Alaska area.

If you have any questions, please contact me on 65316, or Jack Neuberger at 65152.

(Original Signed by)

Nancy J. Graham

Attachment:
Capstone ADS-B Evaluation Report

Copy Furnished: AFS-410 (Don Streeter)

Appendix J: Air Traffic Controller Questionnaires

1) Capstone ADS-B Action Request System (Anchorage ARTCC)

2) Controller Questionnaire Anchorage ARTCC (AND-500)

NOTICE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ZAN N1800.2

Anchorage Air Route Traffic Control Center

Cancellation
Date:

SUBJ: Capstone ADS-B Action Request System

1. PURPOSE This document describes the system for reporting, correcting, and tracking Capstone ADS-B problems, anomalies and suggestions at Anchorage ARTCC. The procedures outlined in this document shall be used in processing Capstone ADS-B Action Requests.

2. DISTRIBUTION. This Notice is distributed to all Anchorage Air Route Traffic Control Center Operations Managers, Operations Supervisors, NAS Plans and Programs Support Manager, Airspace and Procedures Manager and Quality Assurance/Training Manager and local representatives of the National Air Traffic Controllers Association.

3. EFFECTIVE DATE. August 21, 2000

4. BACKGROUND. The air traffic control system is constantly changing to meet new demands. The need for system, procedural and operational improvements is usually most perceptively identified by those who must apply operational solutions to the problems. In order to respond more efficiently and effectively to Capstone ADS-B problems, especially those identified by controller personnel, a means of reporting, recording and reacting to problems is needed. The problems specified are those that cannot be solved utilizing less formal means (speed memo or verbal coordination). The Capstone ADS-B Action Request System has been designed to serve this purpose.

5. DEFINITIONS.

a. Action Office. The line of business (Training, Automation, etc.) responsible for action to resolve the problem identified on the Capstone ADS-B Feedback Form, ZAN Form 1800-2.

b. Capstone ADS-B Feedback Form (CAFF). The form used by the originator and action personnel for reporting Capstone ADS-B problems, anomalies and suggestions and the corrective action taken.

c. Capstone ADS-B Action Request Coordinator. The NAS Plans and Programs Support Manager, ZAN-510, is responsible for control numbering and monitoring the flow of CAFF's.

d. Originator. The specialist who submits the CAFF to the supervisor on duty.

6. FORMS. Capstone ADS-B Feedback Form, ZAN Form 1800-2 (Appendix 1) shall be used to document any discrepancies and/or suggestions related to Capstone ADS-B.

7, REPORTS. The CAFF will be routed back to the originator through supervisory levels with comments as to the action taken. If a suitable solution has not been determined, an interim answer as to the status of the CAFF will be returned to the originator. Copies of all completed CAFF's will be routed to the Facility Manager, the Operations Managers, and the NATCA facility representative. The NAS Plans and Programs Support Manager shall maintain a central file on all CAFF's and responses submitted. In addition, an operational CAFF binder shall be established to allow ATCS review of reported Capstone ADS-B problems, anomalies and suggestions and the action taken. The binder will be located in the West area.

8. PROCEDURES.

a. Originator. The specialist who becomes aware of operational, procedural or equipment deficiencies and/or problems will complete the CAFF. Describe the problem with as much detail as possible. This expedites the troubleshooting process. Give the completed CAFF to the supervisor on duty.

b. First Level Supervisor. The Supervisor is responsible for reviewing the CAFF to determine that sufficient information is included. Date, sign, and forward the CAFF to ZAN-510 for processing action.

c. NAS Plans & Programs Support Manager.

(1) ZAN-510 is responsible for reviewing CAFF's and identifying which line of business listed below will have the primary responsibility for researching, answering and/or correcting the problem. ZAN-510 is also responsible for maintaining a central control log and assigning a sequential number to the CAFF followed by a one-letter designator, which identifies the line of business primarily, responsible for acting on the CAFF. (Example: CAFF003T) The letter designators are:

A Airspace and Procedures

D Automation

F Airway Facilities

M Traffic Management

T Training

Q Quality Assurance

N NAS Plans and Programs

I International

L Military

X Other

(2) After assigning the CAFF a number, ZAN-510 will deliver the CAFF to the designated department. A copy of the CAFF shall be posted to the binder in operations with the action(s) taken and/or the office assigned. If Airway Facilities is designated, ZAN-510 will coordinate with the sector staff.

9. RESPONSIBILITIES. The line of business having responsibility (as determined above) completes the action taken and forwards the CAFF back to ZAN-510. If the action required to correct a valid problem is beyond the facility's authority and/or ability to solve, the problem will be forwarded to the proper FAA office using standard agency procedures (NCP, Memorandum, etc.).

Stephen P. Creamer
Air Traffic Manager

Capstone ADS-B Feedback Form

Tracking # *(ZAN-510 use)*	
1. Originator's Name/Initials:	
2. Date/Time of Occurrence:	
3. Type of Feedback: *(Please check the appropriate box)* Problem ☐ Anomaly ☐ Suggestion ☐	
4. Aircraft ID:	
5. Title of Feedback:	
6. Full Description: *(Attach additional pages if necessary)*	
7. Originator's Signature:	**8. Date:**
9. Supervisor's Signature:	**10. Date:**
REMAINDER OF FORM FOR ZAN-510 USE	
11 Date Received:	**12. Assignment:**
13. Action Taken: *(Attach additional pages if necessary)*	
14. Completed by:	**15. Date:**

Instructions for Completing the Capstone ADS-B Feedback Form (ZAN Form 1800-2):

Introduction: The form has been established to provide a formal method to report problems, anomalies, and/or suggestions relating to Capstone ADS-B implementation at the Anchorage ARTCC.

Using the Form: Complete the following items. Block numbers correspond to the numbered blocks on the form.

Tracking # ***For ZAN-510 use only.*** *Leave Blank. Tracking # is assigned by ZAN-510 for control, distribution, and follow-up.*

Block 1 **Originator's Name/Initials.** Print originator's name and operating initials.

Block 2 **Date/Time of Occurrence.** Enter actual UTC date and time of ADS-B occurrence.

Block 3 **Type of Feedback.**

- Problem – Recurring or consistent software or hardware error
- Anomaly – One-time or unusual software or hardware error
- Suggestion – Any recommended changes to software, hardware, or procedural aspect of Capstone ADS-B implementation

Block 4 **Aircraft ID.** Aircraft ID may include any of the following:

- Call Sign
- Tail Number
- ICAO address
- Beacon Code
- Computer Identification (CID)

Block 5 **Title of Feedback.** Brief title of feedback being submitted. To be used for tracking purposes.

Block 6 **Full Description.** Describe the problem, anomaly, or suggestion as completely as possible. The following items serve as examples of the description.

- Location
- Range Setting
- Altitude
- IFR or VFR
- Ever on Radar?
- Receiving ATC Service? If so, what type(s).
- Sector Operations Impact
- Suggested Solution

Block 7 **Originator's Signature.** Signature of Originator

Block 8 **Date.** Date of Originator's signature

Block 9 **Supervisor's Signature.** Signature of Supervisor on watch.

Block 10 **Date.** Date of Supervisor's signature

Blocks 11-15 ***ZAN-510 use only.***

Block 11 ***Date Received.*** *Date of receipt in ZAN-510.*

Block 12 ***Assignment.*** *ZAN-510 identification of office with primary responsibility for researching and response for identified problem, anomaly, or suggestion.*

Block 13 ***Action Taken.*** *Response taken by Office of Assignment.*

Block 14 ***Completed by.*** *Signature of Support Manager, NAS Plans and Programs.*

CONTROLLER QUESTIONNAIRE

ANCHORAGE ARTCC

1. What effect, if any, did the additional surveillance coverage provided by ADS-B data have on maintaining situational awareness?

1	2	3	4	5	6	7
Very Negative			No Effect			Very Positive

COMMENTS: _____

_____

_____

2. What effect, if any, did the increased surveillance coverage provided by ADS-B data enhance your ability to issue safety alerts and provide other services, including traffic advisories?

1	2	3	4	5	6	7
Very Negative			No Effect			Very Positive

COMMENTS: _____

_____

_____

3. What effect, if any, did the mixture of ADS-B equipped aircraft and non-equipped aircraft have on your ability to issue safety alerts and provide other services, including traffic advisories?

1	2	3	4	5	6	7
Very Negative			No Effect			Very Positive

COMMENTS: _____

_____

_____

4. Keeping in mind that the display of ADS-B data was surpressed within areas of radar coverage (see note below), what effect, if any, did the addition of ADS-B data add to your ability to issue safety alerts and provide other services, including traffic advisories?

NOTE: In areas where both radar coverage and ADS-B data are available, the radar target has priority. That is, the radar target will be presented and the ADS-B data will be surpressed. There is no merging of data such that a consolidated target is presented.

1	2	3	4	5	6	7
Very Negative			No Effect			Very Positive

COMMENTS: _____

_____

_____

5. What effect, if any, did the additional surveillance coverage have on the quality of communications with ADS-B equipped aircraft (common understanding of the situation)?

1	2	3	4	5	6	7
Very Negative			No Effect			Very Positive

COMMENTS: _____

_____

_____

6. What effect, if any, did the additional surveillance coverage have on the quantity of communications with ADS-B equipped aircraft?

1	2	3	4	5	6	7
Very Negative			No Effect			Very Positive

COMMENTS: _____

_____

_____

7. Could you foresee any advantages to displaying ADS-B data within areas of radar coverage (that is, advantages to displaying ADS-B data while surpressing the radar data)? If so, what?

_____

_____

_____

8. Did you experience any situations where the use of ADS-B data increased your workload? If so, how?

_____

_____

_____

9. Did you experience any situations where the use of ADS-B data decreased your workload? If so, how?

_____

_____

_____

10. Do you have any suggested changes to the presentation of ADS-B target data (data block, color, icon, etc.)?

_____

_____

_____

11. Do you have any suggested changes to the procedures or phraseology that were established for controlling ADS-B equipped aircraft?

_____

_____

_____

Appendix K: Pilot Questionnaires and Surveys

1) Capstone Evaluation Feedback

2) Capstone Usability Survey

Capstone Evaluation Feedback

Dear Capstone Participant:

The evaluation of the Capstone avionics is essential to continued development of the technology. The University of Alaska Anchorage Aviation Technology is involved in a 3-year study of Capstone and would appreciate your assistance.

This letter is made available to the pilot/crew to report Capstone avionics related events for a specific flight. The backside of this letter is a brief form for reporting Capstone related events (good or not so good) and equipment reliability. We want your feedback!

The essential elements of the report are date/time, route of flight (e.g., 2/25/2000 BET, HPB, VAK, BET), did the equipment work properly YES or NO, did the Capstone avionics hinder/help, and if the Capstone avionics helped your pilot decision making. If you have time for a few additional details, especially on any NO answer, they would be appreciated.

The report can be anonymous and still be helpful. However, a name and contact will get you direct feedback to any problems you have encountered. If each operator would bundle their reports and send them to me at UAA/AT on a weekly basis in the prepaid envelopes provided I would appreciate it.

Thank You

Leonard F. Kirk UAA/AT Capstone (907) 264-7436

Fax: (907) 264-7444 E-Mail: anlfk@uaa.alaska.edu

If you would like a direct response include:

Name: _____ E-Mail: _____

Phone: _____ Fax: _____

Date/Time of Flight: _____ Aircraft Tail # (optional): _____
Route of Flight: ____, ____, ____, ____, ____, ____, ____, ____, ____, ____, ____, ____, ____, ____
Weather: _____

Did the equipment function properly? YES ☐ NO ☐
If NO, indicate which equipment malfunctioned and explain in detail.
GPS ☐ → which mode? NAV ☐; MAP☐ ; NRST ☐; Information ☐; SEL ☐;
DIRECT TO ☐, ENTER ☐; Smart keys☐; Large/small knob ☐;
PHOTO CELL ☐; ON/OFF ☐; Other_____
MFD ☐ → which mode? TRAF ☐; TERR ☐; Custom MAP ☐; IFR ☐; VFR ☐;
SYS ☐; Photo cell ☐; Menu enter key ☐; Editing keys "declutter" ☐;
Function key ☐; Other_____
COMM ☐ → which mode? Squelch/Volume ☐; Voice quality ☐;
Reception ☐; Active or standby frequencies ☐; Other_____
UAT ☐ → Unable to see other traffic ☐; Other traffic unable to see my aircraft ☐
Explain, including location (e.g., BET110@32.1nmi or lat/long) and setup of Capstone Avionics (e.g., custom map, 20nm range, relative terrain, other applicable functions and settings): _____
_____
_____
_____

During this flight did the Capstone Avionics hinder/help your:

1= **Hinder** Greatly→ 5= **Help** Greatly

• Navigation Awareness (***GPS***):	1	2	3	4	5	N/A
• Navigation Awareness (***MFD***):	1	2	3	4	5	N/A
• Terrain Awareness:	1	2	3	4	5	N/A
• Traffic Awareness:	1	2	3	4	5	N/A

Explain: _____
_____

Place an X in the box for each function that influenced you to change:

	Route	**Altitude**	**Go/No Go Decision**	**Other**	**N/A**
• Navigation Awareness (***GPS***):	☐	☐	☐	☐	☐
• Navigation Awareness (***MFD***):	☐	☐	☐	☐	☐
• Terrain Awareness:	☐	☐	☐	☐	☐
• Traffic Awareness:	☐	☐	☐	☐	☐

Explain: _____
_____

General Comments (e.g., suggested training, procedures, other recommendations): _____
_____
_____
_____

Capstone Usability Survey

Instructions: For each of the following statements, rate how much you agree or disagree with the statement on a scale of 1 to 6, where 1 = completely disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = moderately agree, and 6 = completely agree. Each statement should be answered in relation to various aspects of both the GPS unit and the multi-function display unit.

GPS Usability for Specific Tasks

Statement	Startup	Creating Flight Plan	Editing Flight Plan	En Route Navigation	Responding to System Messages	Accessing Airport Information
1. The equipment is easy to use.						
2. The equipment operating procedures are easy to remember.						
3. The equipment performed the functions necessary for my flying operations.						
4. The GPS provides most of the navigation information I need to conduct my flight.						
5. The GPS provides the majority of navigation information needed without reference to other navigation information sources.						
6. The equipment provides easy access to the functions necessary for my flight.						
7. The equipment operating manual clearly explains procedures.						
8. When I press the wrong button, it is easy to undo.						
9. I am never confused about which display page is active.						

MFD Usability for Specific Tasks

Statement	Accessing and Using Sectional Display	Accessing and Using Terrain Display	Accessing and Using Traffic Display	Accessing and Using Flight Plan	Accessing and Using Custom Map Display
11. The equipment is easy to use.					
12. The equipment operating procedures are easy to remember.					
13. The equipment performed the functions necessary for my flying operations.					
14. The MFD provides most of the information I need to conduct my flight.					
15. The MFD contains most of the information I need without referring to additional sources of information.					
16. The equipment provides easy access to the functions necessary for my flight.					
17. The equipment operating manual clearly explains procedures.					
18. When I press the wrong button, it is easy to undo.					
19. I am never confused about which display page is active.					

GPS and MFD User-Interface Issues

Statement	**GPS**	**MFD**
21. The response time of the equipment is adequate.		
22. The equipment provides adequate feedback.		
23. The display does not wash out in direct sunlight.		
24. The display does not wash out in indirect sunlight.		
25. The display is legible in night conditions.		
26. The controls are easy to operate.		
27. Control labels are easy to understand and remember.		

28. The equipment allows for easy detection of alerting messages.		
29. Alerting messages are appropriate and easily understood.		
30. The equipment operating manual is easy to use.		
31. I feel confident using the equipment for VFR navigation.		
32. I feel confident using the equipment to aid in the visual acquisition of other aircraft.		
33. I feel confident using the equipment to aid in separation from terrain during VFR flight.		
34. The equipment is helpful as a supplemental system during IFR flight.		

MFD Specific Features and Modes

Statement	Accessing and Using Sectional Display	Accessing and Using Terrain Display	Accessing and Using Traffic Display	Accessing and Using Flight Plan	Accessing and Using Custom Map Display
36. The PAN feature is highly desirable and easy to use.					
37. The INFO mode is very useful.					
38. The North-Up mode is highly preferred.					
39. The Track-up mode is highly preferred.					
40. The scaling on the map/display is highly desirable and easy to manipulate.					
41. The advisory flags (terrain or traffic) are easy to respond to.					
42. The 360 mode is highly preferred.					
43. Arc mode is highly preferred.					
44. The INVERT function is highly desirable.					
45. The NAV data function is highly desirable.					
46. The range and display formats are highly preferred.					
47. Text message displays are highly preferred.					

GPS Menu Organization and Functions

Statement	Startup	Creating Flight Plan	Editing Flight Plan	En Route Navigation	Responding to System Messages	Accessing Airport Information
49. The equipment accommodates canned flight plans.	N/A					
50. The menu choices or button formats are highly preferred.	N/A					
51. The menus are easy to find.	N/A					

Appendix L: Acronyms

ADS-A	Automatic Dependence Surveillance-Addressed
ADS-B	Automatic Dependence Surveillance-Broadcast
AF	Airways Facilities
AIM	Aeronautical Information Manual
ANICS	Alaska NAS Interfacility Communications System
AOPA	Aircraft Owners and Pilots Association
ARINC	Aeronautical Radio Inc.
ARTCC	Air Route Traffic Control Center
AT	Air Traffic
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
AWOS	Automated Weather Observation System
CCCS	Capstone Communication Control Server
CNS	Communications, Navigation, and Surveillance
CSSPP	Capstone System Safety Program Plan
CSSWG	Capstone System Safety Working Group
DT&E	Developmental Test and Evaluation
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FDN	Functional Description Narrative
FIS-B	Flight Information Services-Broadcast
GBT	Ground Broadcast Transceiver
GPS	Global Positioning System
HBAT	Handbook Bulletin for Air Transportation
HBAW	Handbook Bulletin for Air Transportation and Continuous Airworthiness

ICD	Interface Control Document
IDS	Interim Design Specification
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IOC	Initial Operational Capability
LMATM	Lockheed Martin Air Traffic Management
MASPS	Minimum Aviation System Performance Standards
MFD	Multi Function Display
Micro-EARTS	Micro Enroute Automated Radar Tracking System
MOPS	Minimum Operational Performance Standards
MOU	Memorandum of Understanding
MSAW	Minimum Safe Altitude Warning
NAS	National Airspace System
NATCA	National Air Traffic Controllers Association
NCP	NAS Change Proposal
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
OT&E	Operational Test and Evaluation
PHA	Preliminary Hazard Assessment
PTRS	Problem Trouble Reporting System
SER	Safety Engineering Report
SF21	Safe Flight 21
STC	Supplemental Type Certificate
TEMP	Test and Evaluation Master Plan
TIS-B	Traffic Information Services-Broadcast

TSO	Technical Standard Order
UAA	University of Alaska-Anchorage
UAT	Universal Access Transceiver
UPS AT	United Parcel Service Aviation Technologies
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
WJHTC	William J. Hughes Technical Center
Y-K	Yukon-Kuskokwim
ZAN	Anchorage Air Route Traffic Control Center