



# **Capstone Safety Engineering Report #1 ADS-B Radar-Like Services**

**VOLUME 3**

**List of Precautions, Controls and Mitigation**

**MIL-STD-882C/D Methodology**

**20 December 2000**

The Capstone System Safety Working Group (CSSWG) prepared this report and conducted the analysis. The CSSWG also utilized expertise from other personnel involved in Capstone as needed. The Capstone Program Manager has primary responsibility for implementing system safety within Capstone. This analysis was performed in coordination with the FAA Office of System Safety (ASY) and follows standard safety practices.

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The following Capstone Control List is a table of the controls identified in the Volume 2 Preliminary Hazard Analysis Matrix of Scenarios with corresponding status of verification. This list will be updated periodically as part of the CSSWG hazard tracking and risk resolution activities.

## CAPSTONE CONTROL LIST

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
<p>1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000.</p>	<p>Both system and service level certification procedures are in place for Capstone ADS-B ground system that follow the FAA Order 6000.15 certification process. Reference memo: FAA AAL-470, INFORMATION: Interim ADS Procedures – Certification, Restoration, and Logging, Memorandum 18 August 2000.</p> <p>“CERTIFICATION: Three documents have been issued to describe the certification parameters and entries.</p> <ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>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.”</li> </ol>
<p>1a. Ground system certification, installation, and approval process in place for equipment external to Capstone to meet critical-level services in accordance with NAS-SR-1000.</p>	<p>The Capstone ADS-B ground system is being incorporated into the currently certified Alaska ground system architecture. This includes the computer network within Anchorage Center as well as remote communications links such as ANICS.</p>
<p>1b. Certification, installation, and approval process in place for equipment external to Capstone to meet critical-level services in accordance with NAS-SR-1000.</p>	<p>Capstone equipment is being incorporated within the currently certified NAS infrastructure, which includes both aircraft and ground system certified equipment, e.g. GPS. The SSWG reviewed the NAS-SR-1000, Capstone architecture, and relevant equipment external to Capstone and noted no situations of concern.</p>

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
<p>2. If in non-radar environment, current procedural separation rules are being applied, given the large is not ADS-B equipped. No change to current operations.</p>	<p>Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.</p> <p>“f. Within CAPSTONE airspace, standard non-radar separation procedures shall be applied between non-ADS-B equipped aircraft and ADS-B equipped aircraft.”</p>
<p>3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot.</p>	<p>The Maintenance Control Center monitors the ground system with regard to standards and tolerances defined in FAA ORDER: FAA AOS-440, Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En Route Automated Radar Tracking System (MEARTS), ORDER 6190.16B, 17 July 2000. Paragraph 166 ESTDD Service Level Certification Procedures.</p>
<p>4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations.</p>	<p>Controller and maintenance procedures are in place for Capstone ADS-B ground system that follow the FAA Order 6000.15 certification process. Reference memo: FAA AAL-470, INFORMATION: Interim ADS Procedures – Certification, Restoration, and Logging, Memorandum 18 August 2000.</p> <p>“CERTIFICATION: Three documents have been issued to describe the certification parameters and entries.</p> <ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>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.”</li> </ol>
<p>4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately.</p>	<p>Maintenance and installation instructions are included as part of the STC submission. Reference: Capstone System Installation Instructions (UPSAT 560-1024-02), Apollo GX60 Installation Instructions (UPSAT 560-0959-03), Apollo MX20 Installation Instructions (UPSAT 560-1025-02) – see Capstone STC Master Drawing List (UPSAT 560-1027-01) for others.</p>

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
4c Ensure GBT coverage is adequate for providing ATC radar-like services	Service area coverage charts have been calculated. In August the FAA B727 flew defined flight profiles to test and verify coverage areas. Analysis of that data and target of opportunity aircraft tracks is planned to be completed by end of November 2000. During November-December 2000 controllers are conducting realtime evaluation of Capstone ADS-B system for providing ATC radar-like services.
5. Controller situational awareness.	During November-December 2000 controllers are conducting real-time evaluation of Capstone ADS-B system for providing ATC radar-like services. Capstone controller procedures have been developed Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.
6. ADS-B track loss is detected and indicated to controller. If available primary or secondary radar targets will be indicated, or lost track will automatically coast.	This functionality is described in the Micro-EARTS Capstone Functional Description Narrative (FDN) (CCD 21270 / NCP AL512-MEART-013), formal acceptance testing of this functionality was conducted successfully at the FAA Technical Center April 2000.
7. Standard 7110.65 controller procedures for validating aircraft ID, position, and altitude when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source. Controller will apply another means of separation.	Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.
7a. Standard 7110.65 controller procedures for validating aircraft ID, position, and altitude when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source. Including procedures for <u>loss of target</u> . Controller will apply another means of separation.	Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.
7b. Standard 7110.65 controller procedures for validating aircraft ID, position, and altitude when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source. Including procedures for <u>erroneous indication of target</u> . Controller will apply another means of separation.	Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.
7c. Standard 7110.65 controller procedures for <u>validating speed</u> when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source.	Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.

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<p>8. ADS-B radar-like separation standard (e.g., 5 nmi, MEAs) is defined to allow intervention time for ATC and pilot to respond safely in case of system failure or other contingencies.</p>	<p>AFS-400 memorandum supporting 5 nmi ADS-B separation standard has been drafted, is currently under review, and planned to be signed the beginning of December 2000.</p> <p>Capstone ADS-B controller procedures use this separation standard. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.</p>
<p>9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure.</p>	<p>Pilot operational feedback through the Univ of Alaska has indicated pilots enhanced situational awareness with the use of the MFD.</p>
<p>10. ADS-B erroneous position is detected via MEARTS track processing and indicated to controller. If available primary or secondary radar targets will be indicated, or lost track will automatically coast.</p>	<p>Malfunctions and erroneous position reports are tracked via the Maintenance Control Center and if out of standards and tolerances as defined in FAA ORDER: FAA AOS-440, Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En Route Automated Radar Tracking System (MEARTS), ORDER 6190.16B, 17 July 2000 – this will be indicated to controller. The track processing and coasting functionality is described in the Micro-EARTS Capstone Functional Description Narrative (FDN) (CCD 21270 / NCP AL512-MEART-013), formal acceptance testing of this functionality was conducted successfully at the FAA Technical Center April 2000.</p>
<p>11. Design to minimize risk due to transmission delay</p>	<p>The system is designed with a 1 second update rate that will compensate for transmission delay – GBT and avionics don't hang onto old data (i.e., they are pass throughs) – will have new update the next second. The GBTs timestamp received aircraft data and the MEARTS processor considers that timestamp for validity of data.</p>
<p>12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews.</p>	<p>Failures and malfunctions are tracked via the Maintenance Control Center and if out of standards and tolerances as defined in FAA ORDER: FAA AOS-440, Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En Route Automated Radar Tracking System (MEARTS), ORDER 6190.16B, 17 July 2000 – this will be reported to the controller. Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.</p>

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13. Design the system to minimize the potential for false alarms.	<p>Site adaptable parameters for safety function processing (e.g., Minimum Safe Altitude Warning, Conflict Alert) are being evaluated by controllers during November-December 2000 to minimize the potential for false alarms.</p> <p>The avionics have been evaluated to meet FAR 23.1322 (Warning, caution and advisory lights), to include a review by aircraft certification human factors specialist October 2000.</p>
14. Failure/malfunction indication shall be designed to conform to appropriate standards (e.g., FARs, Human Factors design guide FAA CT-96/1).	<p>MEARTS went through a human factors evaluation upon initial certification several years ago. Ongoing controller feedback has refined the interface. Controller input has been utilized throughout the ADS-B upgrade process, both during WJHTC and Anchorage ARTCC testing.</p> <p>The avionics have been evaluated to meet FAR 23.1322 (Warning, caution and advisory lights), to include a review by aircraft certification human factors specialist October 2000. Reference UPSAT's Capstone "Radar-Like Services" Certification Plan (UPSAT PD6000, 7 November 2000) section 4.2.3/</p>
15. Standard 7110.65 controller procedures for validating aircraft altitude will be applied when using ADS-B as a surveillance source, the same as when using radar beacon system as a surveillance source.	Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.
16. Implement aircraft maintenance training/procedures to assure appropriate Capstone database updates are conducted.	Avionics at start-up automatically check for out-of-date databases and indicates status to pilot.
17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard aircraft certification procedures (e.g., TSO-129C, DO-178B (software) and AC-23.1309-1C (hardware)). STC will be amended for ADS-B radar-like services.	Capstone avionics are certified (No, SA02149AK) under standard STC procedures. UPSAT's Capstone "Radar-Like Services" Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK has been submitted for amended STC.
18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification.	UPSAT's Capstone "Radar-Like Services" Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK states in section 2.2.2 Certification Approach, "the Capstone IDS [Capstone Interim Design Specification (IDS) for the Universal Access Transceiver] will be used as the minimum performance specification in the absence of an FAA coordinated RTCA MOPS for UAT datalink."

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
<p>18b. Avionics include safety monitor (e.g., integrity, old data) to alert of avionics failure (i.e., automatic shutdown/blue screen). 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification.</p>	<p>UPSAT's Capstone "Radar-Like Services" Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK states in section 3.2 Safety Monitor, "a Safety Monitoring system has been incorporated into the MX20 design that protects the parsing of GPS data, the packing of the ADS-B message and validates feedback from the UAT datalink transmissions." Also under section 2.2.2 Certification Approach, "the Capstone IDS [Capstone Interim Design Specification (IDS) for the Universal Access Transceiver] will be used as the minimum performance specification in the absence of an FAA coordinated RTCA MOPS for UAT datalink."</p>
<p>19. Conduct reliability analysis of Capstone ADS-B system.</p>	<p>UPSAT is conducting a continuous reliability analysis on the avionics and GBTs as part of their internal quality assurance program. Periodic reports are given to the Capstone Office. During the October/November 2000 timeframe the Capstone ADS-B Acceptability Evaluation was conducted that included reliability of the system. During normal operations, the BDAT (beacon data service will be used to log all facility and service information (same as used for Radar Beacon System) Reference memo: FAA AAL-470, INFORMATION: Interim ADS Procedures – Certification, Restoration, and Logging, Memorandum 18 August 2000.</p>
<p>20. Standard 7110.65 controller procedures for validating calibrating system (e.g., parrot) when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source.</p>	<p>Standard procedures contained in FAA 7110.65 apply per Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.</p>
<p>21. Conduct MEARTS tracker testing, to evaluate the calibration between radar and ADS-B.</p>	<p>MEARTS tracker testing was successfully conducted during formal acceptance testing at the FAA Technical Center April 2000. In August 2000 the FAA B727 flew defined flight profiles to test and verify calibration between radar and ADS-B. Analysis of that data and target of opportunity aircraft tracks is planned to be completed by end of November 2000. During November-December 2000 controllers are conducting realtime evaluation of Capstone ADS-B system for providing ATC radar-like services.</p>
<p>22. Real-time tracker processing of radar and ADS-B tracks is conducted to determine if tracks are valid (e.g., 3 good hits).</p>	<p>MEARTS tracker testing was successfully conducted during formal acceptance testing at the FAA Technical Center April 2000. In August 2000 the FAA B727 flew defined flight profiles to test and verify calibration between radar and ADS-B. Analysis of that data and target of opportunity aircraft tracks is planned to be completed by end of November 2000. During November-December 2000 controllers are conducting realtime evaluation of Capstone ADS-B system for providing ATC radar-like services.</p>



Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
23. Real-time monitoring of ground system through use of ADS-B fixed parrot and radar parrot.	The Maintenance Control Center monitors the ground system with regard to standards and tolerances defined in FAA ORDER: FAA AOS-440, Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En Route Automated Radar Tracking System (MEARTS), ORDER 6190.16B, 17 July 2000. Paragraph 166 ESTDD Service Level Certification Procedures.
24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide).	The MX20 and GX60 User Guides (UPSAT 560-1026-00 and 560-0961-02) describes this functionality. The MX20 Multi-Function Display System Safety Assessment (UPSAT PD1415) also references this functionality.
25a. Pilot situational awareness.	Pilot operational feedback through the Univ of Alaska has indicated pilots enhanced situational awareness with the use of the MFD.
25b. Pilot ability to see-and-avoid in VMC.	When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see-and-avoid other aircraft (FAR 91.113).
26. Real-time monitoring of ground system through use of ADS-B fixed parrot. Real-time tracker processing of ADS-B tracks is conducted, to determine if tracks are valid (e.g., 3 good hits).	The Maintenance Control Center monitors the ground system with regard to standards and tolerances defined in FAA ORDER: FAA AOS-440, Maintenance of Radar Bright Display Equipment Replacement (RBDER)/Micro-En Route Automated Radar Tracking System (MEARTS), ORDER 6190.16B, 17 July 2000. Paragraph 166 ESTDD Service Level Certification Procedures.
27. Standard pilot and controller procedures (e.g., AIM and 7110.65) for lost voice communications will be applied when using ADS-B as a surveillance source, the same as when using radar beacon system as a surveillance source.	<p>Capstone ADS-B procedures utilize standard 7110.65 controller procedures. Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000.</p> <p>“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)” – reference Airline Training Supplement SUBJ: Procedures and Phraseology associated with Capstone ADS-B for aircraft flown by ____ Airline in Alaska.</p>

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
28. Standard controller procedures and NAS-SR-1000 requirements for loss of display are in place for the contingency and will be applied when using ADS-B as a surveillance source, the same as when using radar beacon system as a surveillance source.	Standard procedures contained in FAA 7110.65 apply per Reference FAA NOTICE: FAA ATP, SUBJ: ATC Procedures and Phraseology Associated with ADS-B for Visual and Instrument Flight Rules Aircraft at Anchorage ARTCC (Capstone Procedures), NOTICE N xxxx.xx, xx November 2000. Standard Airway Facility procedures also apply – these will be refined as necessary between IOC and ORD for the ADS-B system per reference memo INFORMATION: Interim ADS Procedures-Certification, Restoration, and Logging, Aug 18, 2000.
29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft.	Pilot operational feedback through the Univ of Alaska has indicated pilots enhanced situational awareness with the use of the MFD and air-to-air ADS-B traffic.
30. The avionics have been tested, per procedures defined in RTCA/DO-160D, to environmental categories as listed in the various Capstone avionics installation manuals.	Capstone avionics are certified (No, SA02149AK) under standard STC procedures. UPSAT’s Capstone “Radar-Like Services” Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK has been submitted for amended STC, section 4.3 deals with Environmental testing.
31. Use of standard pilot procedures for loss of radar contact as stated in the Aeronautical Information Manual, including applying standard position reporting procedures for non-radar operations.	“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)” – reference Airline Training Supplement SUBJ: Procedures and Phraseology associated with Capstone ADS-B for aircraft flown by ____ Airline in Alaska.
32. Capstone installation and maintenance manuals are provided.	Capstone avionics are certified (No, SA02149AK) under standard STC procedures. The Capstone STC Master Drawing List (UPSAT 560-1027-01) list the installation and maintenance manuals required for the avionics. UPSAT’s Capstone “Radar-Like Services” Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK has been submitted for amended STC.  FAA AAL-470 Memorandum, INFORMATION: Interim ADS Procedures – Certification, Restoration, and Logging, 18 August 2000 lists the ground system maintenance manuals that include GBT handbook, Order AL6368.1 (describes the maintenance of the remote sites) and Order 6190.16B (provide and update for the MicroEARTS system).
33. Electrical load analysis required for Capstone installation.	Capstone avionics are certified (No, SA02149AK) under standard STC procedures. UPSAT’s Capstone “Radar-Like Services” Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK has been submitted for amended STC.

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
34. Capstone avionics includes an integrity monitor to display the most accurate (valid) GPS position.	UPSAT's Capstone "Radar-Like Services" Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK states in section 3.2 Safety Monitor, "a Safety Monitoring system has been incorporated into the MX20 design that protects the parsing of GPS data, the packing of the ADS-B message and validates feedback from the UAT datalink transmissions". In addition the GX60 includes an integrity monitor (RAIM) per certification requirements in TSO-129a.
35a. Pilot training/procedures in place for Capstone – approved Part 135 training curriculum, 2-day ground school, flight training, and line check. Includes preflight set-up/procedures to make as simple use as possible during normal instrument scan and proper CRM for cross check of erroneous info (e.g., setting baro, target and navigation info) with other information in cockpit as well as coordinating with ATC (e.g., ATC gives altimeter setting).	UAA has been providing Capstone training classes periodically in Anchorage and in Bethel. Recurrent training is now being offered. Specific training has been developed for ADS-B radar-like services - reference Airline Training Supplement SUBJ: Procedures and Phraseology associated with Capstone ADS-B for aircraft flown by ____ Airline in Alaska. The original training is being enhanced by use of video taped classes and other means are also being sought.
35b. Provide training on operational uses of the Capstone equipment to include terrain avoidance, weather avoidance, contingencies, and other flight planning functions.	UAA has been providing Capstone training classes periodically in Anchorage and in Bethel. Recurrent training is now being offered. Specific training has been developed for ADS-B radar-like services - reference Airline Training Supplement SUBJ: Procedures and Phraseology associated with Capstone ADS-B for aircraft flown by ____ Airline in Alaska. The original training is being enhanced by use of video taped classes and other means are also being sought.
36. Conduct a review of Capstone ground system manuals to ensure that appropriate cautions and warnings are provided.	Ground system manual review is conducted by various organizations (e.g., AAL-400, ZAN AF, AOS, contractor support) as part of normal certification process.
37. Provide correlation procedures, and design requirements to verify accuracy between controller's display and MFD. If similar information is displayed it must be accurate and consistent.	<p><i>** do not have consensus if this control is required – still under consideration during IOC **</i></p> <p>ATC's requirement is to correlate ground system – no requirement to correlate with MFD. MFD is supplemental.</p> <p>Deleted by Alaska in June, Lower 48 in July put back in- Keep this control and scenario 55 in, re-discuss risk – no require correlation, but procedural control to advise that that MFD and ATC display are not correlated as well as different operational perspective (e.g., TCAS traffic display pilot/controller comm)</p> <p>Can be conducted manually - Suggest when system is periodically self checked for position accuracy, also correlate target on MFD with controller.</p>

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
39a. Avionics are placarded with warnings to prevent inappropriate use.	Placard requirements are defined in the appropriate avionics installation manuals (e.g., MX-20 Installation Manual (PD 560-1025-02) section 2.5.3). Avionics certification, Capstone, and Principal Inspectors personnel have at various times inspected avionics installs.
39b. Installation personal will check installed Capstone equipment to verify appropriate placarding.	Installation personal are required to follow the appropriate installation manuals (e.g., MX-20 Installation Manual (PD 560-1025-02) section 2.5.3). Avionics certification, Capstone, and Principal Inspectors personnel have at various times inspected avionics installs.
40. Provide foreign object damage (FOD) control and visual inspection procedures during installation and use.	Part of standard installation procedures for avionics and ground system.
41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational awareness.	Draft procedures have been developed, finalized training will be completed prior to radar-like services implementation. Reference training material
42. Evaluate the avionics package for design enhancements to prevent erroneous pilot action.	Various mechanisms are in place to evaluate the avionics for design enhancements. These include University of Alaska Pilot surveys, formal/informal feedback to UPS AT, ANC ACO, and Capstone Program Office monthly pilot meetings. "Initial Results – Data Collection Effectiveness Pilot Comments and Interviewer Notes" was completed September 2000 by Univ of Alaska, FAA aircraft certification Small Airplane Directorate, and CAMI.
42a. Evaluate the ground system package for design enhancements to prevent erroneous controller action.	A Capstone ADS-B Action Request System (ZAN N1800.2, 7 Nov 2000) has been established for reporting, correcting, and tracking Capstone ADS-B problems, anomalies, and suggestions at Anchorage ARTCC.
45. Develop procedures for issuance of NOTAMS affecting Capstone related services.	Standard procedures for issuing NOTAMs will be applied to Capstone related services. Coordination with the AFSS has taken place through AAL-500.
47. Photo sensor is provided within the GX60 and MFD designs.	A photo sensor is provided within the GX60 and MX20. See MX20 and GX60 Users Guide (UPS AT doc. 560-1026-00 and 560-0961-02)
48. Review of maintenance plan, manuals, instructions, procedures, and design to minimize the potential that no single error or combination of two errors will result in a catastrophic event.	Review of avionics manuals and procedures is completed as part of the STC process. The appropriate Airways Facility national and local personnel as part of system and service certification complete review of ground system manuals and procedures. Members of the Capstone System Safety Working Group have also reviewed various plans, manuals, and procedures.

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
49. Pilots are trained to fly predominantly in the Track-up 360 mode.	The University of Alaska developed training material recommends using Track-up 360 mode. A Caution was added to the Airplane Flight Manual Supplement for Capstone System Installation (UPS AT doc # 560-1028-01). “Caution must be exercised when viewing the map function page in the North-Up mode to avoid disorientation when transferring to a function page presented in the Track-UP mode.”
52. Provide display declutter capability.	<p>The MX-20 and GX-60 have declutter capabilities such as display range control, traffic altitude filter, independent selection of various features (airways, boundaries, navigation aids). See MX20 and GX60 Users Guide (UPS AT doc. 560-1026-00 and 560-0961-02)</p> <p>The MEARTS controller display have standard declutter capabilities such as display range control, limited data blocks, and configurable menus. Altitude sectorization is a planned declutter upgrade.</p>
53. Minimum proficiency requirements have been established for Capstone equipment, flight procedures, and refresher training; based upon inputs from lessons-learned and pilot survey information.	Through inputs from pilot surveys and interviews (see “Initial Results – Data Collection Effectiveness Pilot Comments and Interviewer Notes” September 2000 by Univ of Alaska, FAA aircraft certification Small Airplane Directorate, and CAMI) there is indication of a lack of consistency in training by operators. Additional recommendations are being worked to improve training proficiency.
55. Provide security controls to minimize the potential for jamming risk.	<p>Security review per current procedures is being accomplished</p> <p>CRC checks between avionics and GBT and between GBT and ZAN</p> <p>Revert to non-radar procedures, if system is not functioning or targets not displayed.</p>
56. Provide security controls to minimize the potential for spoofing risk.	<p>Security review per current procedures is being done</p> <p>CRC checks between avionics and GBT and between GBT and ZAN</p> <p>Revert to non-radar procedures.</p> <p>Design of ADS-B message and CRC check prevent corrupting information. If additional aircraft is projected, standard 7110.65 positive ID procedures will detect. Radar separation only applied between identified IFR aircraft.</p>

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
<p>57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment.</p>	<p>The University of Alaska developed training material defines both appropriate and inappropriate uses of the Capstone system and equipment. Normal operating procedures as well as limitations are in the Airplane Flight Manual Supplement for Capstone System Installation (UPS AT doc # 560-1028-01). The avionics are also placarded with “GPS and MFD limited to VFR use only”. A similar message comes up at MX20 start-up.</p>
<p>58. Provide for a design means to verify time synchronization between ADS-B and GPS inputs.</p>	<p>UPSAT’s Capstone “Radar-Like Services” Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK states in section 3.2 Safety Monitor, “a Safety Monitoring system has been incorporated into the MX20 design that protects the parsing of GPS data, the packing of the ADS-B message and validates feedback from the UAT datalink transmissions.”</p>
<p>59. Verification and validation of critical software during testing for avionics and/or ground system.</p>	<p>Capstone avionics are certified (No, SA02149AK) under standard STC procedures, which include verification and validation of critical software. The software criticality is defined in UPSAT’s Capstone “Radar-Like Services” Certification Plan (UPSAT PD6000, 7 November 2000) under FAA Project Number ST0433AK and has been submitted for amended STC. This is covered under control 17.</p> <p>Ground system software verification and validation is completed as part of the standard ground system certification, installation, and approval process (see Control 1). The MEARTSWJHTC acceptance testing Capstone test plan provides a description of some of these verification and validation activities (11 February 2000).</p>
<p>60. Human factors evaluation was conducted and conforms to appropriate standards.</p>	<p>Human factors analysis was completed with initial. An aircraft Certification human factors specialist has been working with the University of Alaska on follow-on usability survey.</p> <p>MEARTS went through a human factors evaluation upon initial certification several years ago. Ongoing controller feedback has refined the interface. Controller input has been utilized throughout the ADS-B upgrade process, both during WJHTC and Anchorage ARTCC testing.</p>
<p>61. Evaluate physical hazards associated with Capstone and provide appropriate controls.</p>	<p>Control of physical hazards associated with Capstone is accomplished during installation of equipment and is described in the installation manuals.</p>

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
62. Conduct thorough review of manuals to ensure compatibility and consistency of information, and make appropriate changes if necessary.	Review of avionics manuals and procedures is completed as part of the STC process. The appropriate Airways Facility national and local personnel as part of system and service certification complete review of ground system manuals and procedures. Members of the Capstone System Safety Working Group have also reviewed various plans, manuals, and procedures.
63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	<p>Various mechanisms are in place to track and evaluate the avionics for anomalies. These include University of Alaska Pilot surveys, formal/informal feedback to UPS AT, ANC ACO, and Capstone Program Office monthly pilot meetings. "Initial Results – Data Collection Effectiveness Pilot Comments and Interviewer Notes" was completed September 2000 by Univ of Alaska, FAA aircraft certification Small Airplane Directorate, and CAMI.</p> <p>A daily ground system ADS-B service certification is accomplished with appropriate maintenance log entries. A Capstone ADS-B Action Request System (ZAN N1800.2, 7 Nov 2000) has been established for reporting, correcting, and tracking Capstone ADS-B problems, anomalies, and suggestions at Anchorage ARTCC.</p>
64. Establish database update revision cycle requirements for Capstone, including changes between revision cycles, and annunciation to pilot if outdated.	The GPS and MX20 database revision cycle is ?? days. At start-up the avionics system check also checks database version and annunciates out of date versions.
71. Review and validate terrain databases to minimize conflicting, inaccurate, and inappropriate data that could result in hazardous, misleading information.	Several dedicated flight tests were conducted (e.g., STC flight test, FAA B727) that that included terrain database validation. In addition, various mechanisms are in place to evaluate the avionics for design enhancements. These include University of Alaska Pilot surveys, formal/informal feedback to UPS AT, ANC ACO, and Capstone Program Office monthly pilot meetings. Any anomalies in terrain database will be fed back into database revision cycle.
73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	System settings and site adaptive parameters testing was successfully conducted during formal acceptance testing at the FAA Technical Center April 2000. In August 2000 the FAA B727 flew defined flight profiles to further test these parameters in Anchorage ARTCC. Analysis of that data and target of opportunity aircraft tracks is planned to be completed by end of November 2000. During November-December 2000 controllers are conducting realtime evaluation of Capstone ADS-B system for providing ATC radar-like services. This controller evaluation will continue between IOC and ORD.
74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	Conformance to electronic equipment specifications is accomplished during initial certification, installation, and periodic inspections as defined in appropriate installation and maintenance manuals (e.g., GBT maintenance Order AL6368.1, GBT Installation-UPSAT doc #560-1024-02).

Recommendations for Precautions, Controls and Mitigation	Status of Control Verification
76. Evaluate and design the Capstone system to minimize the potential for latency errors/malfunctions.	Specific objectives in the Capstone ADS-B Acceptability Evaluation conducted during September-October 2000 included latency errors and malfunctions (objective 3). Analysis of that data is planned to be completed by end of November 2000.
77. Evaluate and design the Capstone system to minimize the potential for bandwidth saturation.	Bandwidth saturation modeling has been accomplished and is satisfactory for upto approximately 60 aircraft processed simultaneously by Anchorage ARTCC. Upgrades to the Anchorage ARTCC network and GBTs are being investigated to allow for additional bandwidth.
78. Evaluate and design the Capstone system to minimize the potential for erroneous or inappropriate ICAO address posting on ADS-B tracks.	MX20 software mod 1.2 scans for an ICAO address of "1" (i.e., inappropriate) and gives an annunciation on startup. During the Capstone ADS-B Acceptability evaluation, inappropriate ICAO addresses were looked for. Setting the proper ICAO address installation address has been stressed at Bethel Pilot meetings and Capstone Program Office and Anchorage Certification office have followed-up with installers. MEARTS track processing also considers the possibility of multiple aircraft reporting the same ICAO address.
79. Other means of navigation available on aircraft.	The Airplane Flight Manual Supplement for Capstone System Installation (UPS AT doc # 560-1028-01) section 2.1.4 states that "the aircraft/pilot must have other navigation capability appropriate to the route of flight." In addition, the Capstone Interim Design Specification (IDS) for the Universal Access Transceiver states section 2.18 states that "navigation equipment independent of the avionics supporting Radar-Like Services must be retained." These certification requirements for the Capstone system.



### Other CAPSTONE Safety Recommendations

Recommendations for Precautions, Controls and Mitigation	Remarks
44. Implement Remote Communications Outlets to eliminate time constraints of clearance void times.	Capstone not installing RCOs. Scenario this control applied to was deleted.
46. Establish a phased approach to Capstone implementation for IFR, with increase weather minimums.	Applicable to future transition of Capstone IFR equipment – include in next step appendix.
50. Assure ATC, FSS, and pilots continue the appropriate use of PIREPs (voice and data link) to augment weather updates.	Not applicable to ADS-B radar-like services
51. Procedural recommendations such as use of minor random track offsets are advisable for Bethel specific operations.	Changed to a comment for future implementation in scenario 109 (only scenario this control is in)
54. Consider a feature to provide full text METAR/TAFs on FIS.	Not applicable to ADS-B radar-like services
65. Encourage aircraft to aircraft communication to convey weather-related information.	Not applicable to ADS-B radar-like services
67. ATC should update weather when aircraft enters data link coverage, especially when weather at the destination is near minimums or is deteriorating rapidly.	Standard as today
68. Develop pilot procedures to update destination weather when the destination is out of data-link range.	Standard as today

Recommendations for Precautions, Controls and Mitigation	Remarks
69. Evaluate site locations to provide additional AWOS III weather coverage.	Not applicable to ADS-B radar-like services
70. Capstone will provide up-to-date weather data.	Not applicable to ADS-B radar-like services
72. Evaluate data link coverage requirements based on lessons-learned, pilot surveys, etc.	This was considering uplink of TIS-B and FIS-B information. Not applicable to ADS-B radar-like services.
75. Pilots should obtain an updated telephone weather briefing during stops at stations outside of data link coverage.	Not applicable to ADS-B radar-like services