Report No.

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

VOLUME 2

End –to- End System
Preliminary Hazard Analysis
Matrix of Scenarios

MIL-STD-882C/D Methodology

02 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.

CSSWG Members:

Michael Allocco, ASY-300
August Asay, ACE-115N
Lari Belisle, ZAN-530
Kevin Brandon, NATCA
James Call, AAL-1SC
James Cieplak, MITRE/CAASD
Leonard Kirk, University of Alaska Anchorage
Michael Lenz, ASY-300
Jim Patchett, ZAN-20
Brad Wacker, Lt. Col. USAF

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**1**	Two ADS-B aircraft on approach IFR. Inadvertent loss of ADS-B on one aircraft occurs due to Capstone avionics failure.	Loss of ADS-B on aircraft and loss of separation	IIIC	R3	4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 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. 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 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 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.	Aircraft GPS and other means of navigation still available

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**2**	Two ADS-B aircraft on approach IFR. Inadvertent loss of single aircraft ADS-B target on ATC display occurs due to ground system failure.	Loss of aircraft position on controller's display and potential loss of separation	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations 4c Ensure GBT coverage is adequate for providing ATC radar-like services 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	Aircraft GPS and other means of navigation still available ATC procedures and training being developed by ZAN/NATCA team and coord with ATP. Maintenance personnel procedures and training being developed by AAL-400 and AOP. Acceptance testing conducted at WJHTC accomplished 4/00.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
20	**3**	Two ADS-B aircraft on approach IFR. Inadvertent loss of ADS-B on single aircraft occurs due to environmental effects.	Loss of ADS-B on aircraft and loss of separation	IIIC	R3	5. Controller situational awareness. 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 loss of target. Controller will apply another means of separation. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 25b. Pilot ability to see-and-avoid in VMC. 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. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**4**	Two aircraft, light and large, on approach. Light is equipped with ADS-B and large is not. Inadvertent loss of ADS-B on light aircraft occurs due to avionics failure.	Loss of ADS-B on aircraft Slight increase in controller workload	IIID	R4	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. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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. 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. 74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	If new procedural separation rules are developed between ADS-B and non-ADS-B aircraft (e.g., ADS-B flight corridor), this scenario needs to be re-examined.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**5**	Two aircraft, light and large, on approach. Light is equipped with ADS-B and large is not. Inadvertent loss of ADS-B on light aircraft occurs due to ground system failure.	Loss of aircraft position on controller's display Slight increase in controller workload	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 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. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	If new procedural separation rules are developed between ADS-B and non-ADS-B aircraft (e.g., ADS-B flight corridor), this scenario needs to be re-examined.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
20	**6**	Two aircraft, light and large, on approach. Light is equipped with ADS-B and large is not. Inadvertent loss of ADS-B on light aircraft occurs due to environmental effects.	Loss of ADS-B on aircraft Slight increase in controller workload	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 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. 5. Controller situational awareness. 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 loss of target. Controller will apply another means of separation. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 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. 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. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 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. 74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**7**	Two ADS-B aircraft on approach IFR. Inadvertent loss of voice communication occurs to single aircraft due to comm failure.	Loss of voice communication single aircraft Slight increase in controller workload	IIIC	R3	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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 25b. Pilot ability to see-and-avoid in VMC. 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. 29 Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft 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.	
32	**8**	Two ADS-B aircraft on approach IFR. Inadvertent loss of voice communication due to ground system malfunction.	Loss of voice communication with one or both aircraft and slight increase in controller workload Possible NMAC	IIIC IIE	R3 R4	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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 25b. Pilot ability to see-and-avoid in VMC. 29 Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
20	**9**	Two ADS-B aircraft on approach IFR. Inadvertent loss of voice communication occurs to single aircraft due to environmental effects.	Loss of voice communication single aircraft Slight increase in controller workload.	IIIE	R4	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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 25b. Pilot ability to see-and-avoid in VMC. 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. 29 Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**10**	Two aircraft, light and large, on approach. Light is equipped with ADS-B and large is not. Inadvertent loss of ADS-B and voice communication occurs to light aircraft due to electrical system failure.	Loss of ADS-B on aircraft Slight increase in controller workload	IE IIID	R4 R4	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. 4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 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. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
32	**11**	Two aircraft, light and large, on approach. Light is equipped with ADS-B and large is not. Inadvertent loss of ADS-B and voice communication due to ground system failure.	Loss of voice communication with one or both aircraft and slight increase in controller workload	IIIC	R3	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 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.	If new procedural separation rules are developed between ADS-B and non-ADS-B aircraft (e.g., ADS-B flight corridor), this scenario needs to be re-examined
			Possible NMAC	IIE	R4	3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 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. 59. Verification and validation of critical software during testing for avionics and/or ground system.	
				12			

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
20	**12**	Two aircraft, light and large, on approach. Light is equipped with ADS-B and large is not. Inadvertent loss of ADS-B and communication occurs to light aircraft due to environmental effects.	Loss of ADS-B on aircraft Slight increase in controller workload	IE IIID	R4 R4	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. 4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 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. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**13**	Two ADS-B aircraft on approach IFR. Single aircraft transmits erroneous altitude information due to avionics failure (e.g., altitude encoder). Aircraft altimeter reads correctly.	Mid-Air collision	IE	R4	5. Controller situational awareness. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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. 74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	Pilot has correct altitude via altimeter to report to ATC. Future avionics enhancement could be to automatically cross check barometric and GPS altitude. If ADS-B starts using GPS altitude, this needs to be re-examined.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**15**	Two ADS-B aircraft on approach IFR. Single aircraft transmits erroneous ADS-B position information due to avionics malfunction.	Mid-air collision	IE	R4	5. Controller situational awareness. 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. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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.	

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**16**	Two ADS-B aircraft on approach IFR. Single aircraft position is erroneously indicated to controller due to ground system failure.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**17**	Two aircraft, light and large. Light is equipped with ADS-B and large is not. ADS-B aircraft transmits erroneous ADS-B position information due to avionics failure.	Mid-air collision	IE	R4	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. 5. Controller situational awareness. 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. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**18**	Two aircraft, light and large. Light is equipped with ADS-B and large is not. Light in ADS-B environment and Large is in radar. Targets merged on the controller's display, only indicating one target.	Near midair collision	IID	R3	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 21. Conduct MEARTS tracker testing, to evaluate the calibration between radar and ADS-B. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**19**	Pilot takes inappropriate action as a result of erroneous information on MFD.	Mid-air collision	IE	R4	17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 34. Capstone avionics includes an integrity monitor to display the most accurate (valid) GPS position. 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). 39a. Avionics are placarded with warnings to prevent inappropriate use. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding 57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment. 59. Verification and validation of critical software during testing for avionics and/or ground system. 60. Human factors evaluation was conducted and conforms to appropriate standards. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	Can be further mitigated if operator has a defined safety program.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**20**	Misleading information displayed on controller display (e.g., position indication, flight ID, altitude) due to system malfunction.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 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. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	Detection of other than ADS-B mis-leading info?

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**21**	Misleading information displayed on controller display, i.e. position indication, due to avionics failure.	Mid-air collision	IE	R4	5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
31	**22**	Misleading information - position indication - displayed on controller display due to calibration malfunction.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 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. 21. Conduct MEARTS tracker testing, to evaluate the calibration between radar and ADS-B. 25b. Pilot ability to see-and-avoid in VMC. 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). 73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**24**	Misleading altitude information displayed on controller display due to avionics failure.	Mid-air collision	IE	R4	5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
31	**25**	Misleading altitude information displayed on controller display due to calibration malfunction.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 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. 21. Conduct MEARTS tracker testing, to evaluate the calibration between radar and ADS-B. 25b. Pilot ability to see-and-avoid in VMC. 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). 73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	Pilot has correct altitude via altimeter to report to ATC. Future avionics enhancement could be to automatically cross check barometric and GPS altitude. If ADS-B starts using GPS altitude, this needs to be re-examined.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
72	**26**	Misleading information displayed on controller display due to spoofing.	Minor degradation	IIID	R4	56. Provide security controls to minimize the potential for spoofing risk.	
72	**27**	Misleading information displayed on MFD due to spoofing.	Minor degradation	IIID	R4	56. Provide security controls to minimize the potential for spoofing risk.	
15	**28**	Pilot loses situational awareness due to excessive heads down time reading MFD.	Collision risk Loss of aircraft control	ID	R2	5. Controller situational awareness. 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. 25b. Pilot ability to see-and-avoid in VMC. 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). 42. Evaluate the avionics package for design enhancements to prevent erroneous pilot action. 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. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Can be further mitigated if operator has a defined safety program.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
14	**29**	Pilot loses situational awareness due to less than adequate proficiency and/or currency.	Collision risk Loss of aircraft control	ID	R2	5. Controller situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 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. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Can be further mitigated if operator has a defined safety program.
15	**30**	Excessive glare on MFD.	Decreased situational awareness	IVB	R4	47. Photo-sensor is provided within the GX60 and MFD designs. 60. Human factors evaluation was conducted and conforms to appropriate standards.	
12	**31**	Inappropriate use of ADS-B. Pilots attempt aircraft to aircraft separation via MFD. Aircraft not under ATC separation.	Mid-air collision	ID	R2	25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 39a. Avionics are placarded with warnings to prevent inappropriate use. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding. 57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Can be further mitigated if operator has a defined safety program.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
12	**32**	Inappropriate use of ADS-B. Pilots attempt aircraft to aircraft separation via MFD. Possible increased collision risk between ADS-B and non-ADS-B aircraft. Only ADS-B targets displayed on MFD.	Mid-air collision	ID	R2	5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 39a. Avionics are placarded with warnings to prevent inappropriate use. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding. 57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Can be further mitigated if operator has a defined safety program. Can be under ATC control.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
12	**33**	Inappropriate use of MFD. Pilot attempts aircraft to fixed object or terrain separation via MFD and collision occurs due to secondary hazards for example: • Incorrect altitude setting - human error, environmental effect, system malfunction; • Inaccurate terrain data due to software malfunction, error, failure; • Uncharted obstructions.	Collision risk	IE	R4	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. 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). 39a. Avionics are placarded with warnings to prevent inappropriate use. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding. 57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system. 64. Establish database update revision cycle requirements for Capstone, including changes between revision cycles, and annunciation to pilot if outdated. 71. Review and validate terrain databases to minimize conflicting, inaccurate, and inappropriate data that could result in hazardous, misleading information.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
15	**34**	Pilot loss of situational awareness due to MFD clutter.	Increased pilot workload	IIID	R4	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). 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. 42. Evaluate the avionics package for design enhancements to prevent erroneous pilot action. 52. Provide display declutter capability. 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. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Display is supplemental, clutter causes pilot not to use it
12	**35**	Controller loss of situational awareness due to display clutter.	Loss of separation and near mid-air	IID	R3	41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational awareness. 42a. Evaluate the ground system package for design enhancements to prevent erroneous controller action. 52. Provide display declutter capability. 60. Human factors evaluation was conducted and conforms to appropriate standards.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**37**	Loss of controller display due to system malfunction.	Near mid-air collision	IID	R3	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system. 74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**39**	Loss of single target on controller display due to ground system malfunction (Similar to scenario 2 above, with exception that this scenario considers situations in addition to approach.)	Loss of aircraft position on controller's display and potential loss of separation	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations 4c Ensure GBT coverage is adequate for providing ATC radar-like services 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	Aircraft GPS and other means of navigation still available ATC procedures and training being developed by ZAN/NATCA team and coord with ATP. Maintenance personnel procedures and training being developed by AAL-400 and AOP. Acceptance testing conducted at WJHTC accomplished 4/00.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
31	**42a**	MEARTS simultaneously tracking aircraft with ADS-B and radar. Inadequate calibration between Radar and ADS-B tracks result in 2 aircraft being displayed as single target.	Near midair collision	IID	R3	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 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. 21. Conduct MEARTS tracker testing, to evaluate the calibration between radar and ADS-B. 22. Real-time tracker processing of radar and ADS-B tracks is conducted to determine if tracks are valid (e.g., 3 good hits). 23. Real-time monitoring of ground system through use of ADS-B fixed parrot and radar parrot 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. 73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
31	**42b**	MEARTS tracking one aircraft with ADS-B and one with radar. Inadequate calibration between Radar and ADS-B tracks result targets being displayed as having adequate lateral separation, when it does not exist.	Near midair collision	IID	R3	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 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. 21. Conduct MEARTS tracker testing, to evaluate the calibration between radar and ADS-B. 22. Real-time tracker processing of radar and ADS-B tracks is conducted to determine if tracks are valid (e.g., 3 good hits). 23. Real-time monitoring of ground system through use of ADS-B fixed parrot and radar parrot 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 73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	ADS-B has position GPS drift, while radar has azimuth/range errors.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
20	**44a**	Loss of, or malfunction of, ADS-B due to electro-static discharge damage to ground equipment.	Loss of aircraft position on controller's display and potential loss of separation	IIID	R4	5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
20	**44b**	Loss of, or malfunction of, ADS-B due to electro-static discharge damage to avionics.	Loss of ADS-B on aircraft and loss of separation	IIIC	R3	5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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. 33. Electrical load analysis required for Capstone installation.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
16	**47**	Miscommunication occurs between controller and aircraft, due to ADS-B system malfunction, i.e. inappropriate clearance or clearance given to wrong aircraft.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
31	**49**	MEARTS tracking aircraft with ADS-B only and there is an ADS-B system calibration deviation resulting in possible increase in collision risk (i.e., ADS-B drifts out of calibration) NOTE: Scenario includes avionics ADS-B drift.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 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. 22. Real-time tracker processing of radar and ADS-B tracks is conducted to determine if tracks are valid (e.g., 3 good hits). 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
10	**51**	ADS-B system malfunction occurs and controller does not detect it due to lack of recognition.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 14. Failure /malfunction indication shall be designed to conform to appropriate standards (e.g., FARs, Human Factors design guide FAA CT-96/1). 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational awareness. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 59. Verification and validation of critical software during testing for avionics and/or ground system. 60. Human factors evaluation was conducted and conforms to appropriate standards. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
10	**52**	ADS-B system malfunction occurs and pilot and controller do not detect it.	Mid-air collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 14. Failure /malfunction indication shall be designed to conform to appropriate standards (e.g., FARs, Human Factors design guide FAA CT-96/1). 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**53**	Erroneous malfunction indication to pilot.	Increased pilot workload	IIID	R4	5. Controller situational awareness. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 13. Design the system to minimize the potential for false alarms. 14. Failure /malfunction indication shall be designed to conform to appropriate standards (e.g., FARs, Human Factors design guide FAA CT-96/1). 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**54**	Erroneous malfunction indication to maintenance control center	Increased controller workload	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 13. Design the system to minimize the potential for false alarms. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**55**	Display information conflict between ground displays and MFD, due to ADS-B system malfunction. Inaccuracy occurs on: - controller's display, or - pilot's MFD	Possible near midair collision	IID	R3	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. Air-to-air ADS-B surveillance allows a cockpit situational awareness back up for ground system failures. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with DO-178B for avionics. STC should be amended for radar-like services. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (MX20 (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**60**	Loss of separation due to time delay in ground processing system (update rate).	Loss of separation	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 11. Design to minimize risk due to transmission delay 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
10	**61a**	Collision between ADS-B IFR aircraft with terrain/fixed object due to human error.	Collision risk	ID	R2	5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 16. Implement aircraft maintenance training/procedures to assure appropriate Capstone database updates are conducted 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 35b. Provide training on operational uses of the Capstone equipment to include terrain avoidance, weather avoidance, contingencies, and other flight planning functions. 41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational awareness. 60. Human factors evaluation was conducted and conforms to appropriate standards. 64. Establish database update revision cycle requirements for Capstone, including changes between revision cycles, and annunciation to pilot if outdated. 71. Review and validate terrain databases to minimize conflicting, inaccurate, and inappropriate data that could result in hazardous, misleading information.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
10	**64**	Collision between ADS-B IFR aircraft with other airborne ADS-B IFR aircraft due to human error.	Collision	IE	R4	4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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). 60. Human factors evaluation was conducted and conforms to appropriate standards.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
10	**65**	Collision between ADS-B IFR aircraft with other airborne non-equipped aircraft due to human error.	Collision	IE	R4	4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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). 60. Human factors evaluation was conducted and conforms to appropriate standards.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
10	**66**	Collision between ADS-B IFR aircraft with other aircraft on ground due to human error.	Collision	IE	R4	4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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). 60. Human factors evaluation was conducted and conforms to appropriate standards.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
13	**67**	Physical hazards associated with Capstone installation posing risks to personnel, i.e. electrical shock, falls.	Single fatality	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 32. Capstone installation and maintenance manuals are provided. 36. Conduct a review of Capstone ground system manuals to ensure that appropriate cautions and warnings are provided. 40. Provide foreign object damage (FOD) control and visual inspection procedures during installation and use 60. Human factors evaluation was conducted and conforms to appropriate standards. 61. Evaluate physical hazards associated with Capstone and provide appropriate controls.	
71	**69**	Loss of ADS-B due to “jamming”.	Minor degradation	IIID	R4	55. Provide security controls to minimize the potential for jamming risk	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**70**	MFD/GPS advisory flags and other annunciation i.e., traffic, terrain, position, route, and altitude not indicated due to malfunction.	Possible loss of situational awareness	IIID	R4	5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 14. Failure /malfunction indication shall be designed to conform to appropriate standards (e.g., FARs, Human Factors design guide FAA CT-96/1). 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft.	
40	**71a**	Some aircraft ADS-B not received due to frequency saturation of airborne receiver, i.e., is their sufficient bandwidth to accommodate all aircraft in a terminal environment.	Not all ADS-B targets displayed	IIIE	R4	18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 77. Evaluate and design the Capstone system to minimize the potential for bandwidth saturation.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**71b**	Loss of separation due to frequency saturation of ground receiver (GBT ADS-B receiver, remote site to ANC transmitter/receiver, ANC receiver) i.e., is their sufficient bandwidth to accommodate all aircraft.	Loss of separation	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 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 loss of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 77. Evaluate and design the Capstone system to minimize the potential for bandwidth saturation.	
10	**76**	Human error results in tagging of wrong target on controller display, resulting in inappropriate clearance or communication.	Inappropriate vectoring results in collision.	IE	R4	5. Controller situational awareness. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational awareness. 42a. Evaluate the ground system package for design enhancements to prevent erroneous controller action. 60. Human factors evaluation was conducted and conforms to appropriate standards..	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
40	**77a**	Installation errors result in ADS-B malfunction - avionics	Minor system damage (i.e., system inoperative)	IIIC	R3	4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 5. Controller situational awareness. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 32. Capstone installation and maintenance manuals are provided. 33. Electrical load analysis required for Capstone installation. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
30	**77b**	Installation errors result in ADS-B malfunction – ground system	Possible collision risk	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 32. Capstone installation and maintenance manuals are provided. 36. Conduct a review of Capstone ground system manuals to ensure that appropriate cautions and warnings are provided. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding 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. 61. Evaluate physical hazards associated with Capstone and provide appropriate controls. 74. Assure that the ground system conforms to the specifications for electronic equipment (e.g., general requirements in FAA-G-2100g).	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**78**	Malfunctions of systems outside of Capstone, that interfaces with Capstone equipment (e.g., ANICS, MEARTS processing other than ADS-B processing), results in Capstone equipment processing erroneous data (This could result in an undetected error within Capstone.)	Mid-air collision Major system damage	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 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. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
12	**79**	ADS-B Capstone pilots not following procedures.	Collision risk with terrain, other aircraft, ground equipment.	ID	R2	5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 39a. Avionics are placarded with warnings to prevent inappropriate use. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding. 57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Can be further mitigated if operator has a defined safety program.

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
41	**80a**	Total loss of GPS and ADS-B capability due to system malfunction on single aircraft.	Loss of ADS-B and GPS Navigation capabilities on aircraft and loss of separation	IIIC	R3	1b. Certification, installation, and approval process in place for equipment external to Capstone to meet critical-level services in accordance with NAS-SR-1000. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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 45. Develop procedures for issuance of NOTAMS affecting Capstone related services. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system. 79. Other means of navigation available on aircraft	

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
41	**80b**	Total loss of GPS and ADS-B capability on all aircraft due to GPS system malfunction.	Loss of ADS-B and GPS Navigation capabilities on all aircraft and loss of separation	IIIE	R4	1b. Certification, installation, and approval process in place for equipment external to Capstone to meet critical-level services in accordance with NAS-SR-1000. 5. Controller situational awareness. 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. 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 loss of target. Controller will apply another means of separation. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 29. Air-to-air ADS-B traffic depiction can provide an additional means of detection of ADS-B aircraft. 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 45. Develop procedures for issuance of NOTAMS affecting Capstone related services 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**87**	Error in ground speed indication on controller's display due to ground system malfunction.	Undetected conflict alert Erroneous conflict alert Loss of separation	IIIE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 7c. Standard 7110.65 controller procedures for validating speed when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**88**	ADS-B tracks are inadvertently "coasted" on controller display due to system malfunction therefore coasted target is inaccurate.	Coasted position is less accurate Possible dropped track. Loss of separation	IIID	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 7c. Standard 7110.65 controller procedures for validating speed when using radar beacon system as a surveillance source will be applied when using ADS-B as a surveillance source. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 12. Design system to automatically report system failure /malfunction to ATC and apply existing procedures to notify affected aircrews. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**89**	Inappropriate ICAO addresses or tail numbers are posted on ADS-B MEARTS tracks due to system malfunction.	Inappropriate ATC control action	IIIE	R4	5. Controller situational awareness. 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. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 59. Verification and validation of critical software during testing for avionics and/or ground system. 63. Continue tracking and evaluation of software anomalies for avionics and/or ground system. 78. Evaluate and design the Capstone system to minimize the potential for erroneous or inappropriate ICAO address posting on ADS-B tracks.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
12	**91**	Inappropriate use of terrain function for surface or primary navigation results in collision	Collision risk	ID	R2	5. Controller situational awareness. 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 erroneous indication of target. Controller will apply another means of separation. 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. 16. Implement aircraft maintenance training/procedures to assure appropriate Capstone database updates are conducted. 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC. 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). 35b. Provide training on operational uses of the Capstone equipment to include terrain avoidance, weather avoidance, contingencies, and other flight planning functions. 39a. Avionics are placarded with warnings to prevent inappropriate use. 39b. Installation personal will check installed Capstone equipment to verify appropriate placarding. 41. Assure that controller training and procedures are in place for Capstone, to minimize human error and increase situational awareness. 57. Ensure the Capstone training specifically defines both appropriate and inappropriate uses of the Capstone system and equipment. 60. Human factors evaluation was conducted and conforms to appropriate standards. 64. Establish database update revision cycle requirements for Capstone, including changes between revision cycles, and annunciation to pilot if outdated. 71. Review and validate terrain databases to minimize conflicting, inaccurate, and inappropriate data that could result in hazardous, misleading information.	Can be further mitigated if operator has a defined safety program.
				60			

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
11	**93**	Confusion/incompatibility between the actual design and the operator's, maintenance, training, and/or installation manuals results in confusion or erroneous equipment use.	Collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 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. 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). 62. Conduct thorough review of manuals to ensure compatibility and consistency of information, and make appropriate changes if necessary.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
33	**95**	Track processing inaccuracies due to system malfunction and/or design.	Erroneous or misleading information Possible collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 5. Controller situational awareness. 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. 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 erroneous indication of target. Controller will apply another means of separation. 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. 9. MFD could enhance pilot situational awareness in the event of a ground system and/or avionics failure. 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. 18a. Avionics ADS-B integrity, availability, reliability will meet the requirements specified in the UAT Interim Design Specification.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
11	**97**	Pilot misinterprets a "red" terrain warning as non-threatening, due to previous experience with the system's 300 ft warning buffer, and the user manual's lack of reference to the buffer.	Collision with terrain	IE	R4	35b. Provide training on operational uses of the Capstone equipment to include terrain avoidance, weather avoidance, contingencies, and other flight planning functions. 60. Human factors evaluation was conducted and conforms to appropriate standards. 71. Review and validate terrain databases to minimize conflicting, inaccurate, and inappropriate data that could result in hazardous, misleading information.	Suggest to add the following note to the user's guide discussion of Terrain (TER) Function: "Due to a combination of system tolerances, terrain up to 300 feet below your current altitude may be displayed in RED. WARNING: Treat all terrain depicted in RED as if it is at, or above, your current altitude."
13	**99**	Erroneous controller information due to inappropriate ATC facility adaptive parameter settings.	Misleading information on controller's display Possible collision	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 5. Controller situational awareness. 73. Evaluate system settings and site adaptive parameters and monitor between IOC and ORD.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
14	**108**	Over-reliance on Capstone equipment results in flight crews failure to maintain currency/proficiency at pilotage/dead reckoning skills.	Loss of pilot situational awareness	IIID	R4	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). 35b. Provide training on operational uses of the Capstone equipment to include terrain avoidance, weather avoidance, contingencies, and other flight planning functions 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.	

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
41	**109**	Enhanced navigational accuracy of GPS places two aircraft, flying between same points, on precisely the same tracks, resulting in possible collision.	Mid-air collision.	IE	R4	5. Controller situational awareness. 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. 9a Pilot situational awareness of traffic is enhanced by MFD display of ADS-B targets 25a. Pilot situational awareness. 25b. Pilot ability to see-and-avoid in VMC.	Procedural recommendations for VFR operations such as use of minor random track/altitude offsets should be studied for future implementation. No change to current operations, therefore current practices apply, such as prescribed altitudes for direction of flight/route, ATC traffic advisories or CTAF enroute advisories. Alaska environment (e.g., icing, low ceilings) may reduce available VFR altitudes
13	**114**	Foreign object damage to Capstone equipment during installation results in system damage or degradation.	Major system damage. Inadvertent loss of Capstone equipment and/or functionality.	IID	R3	4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 40. Provide FOD control and visual inspection procedures during installation and use.	This scenario considers both aircraft and ground systems.

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
17	**116**	Inappropriate GX60 selection made due to erroneous pilot action. Situation results in loss of situational awareness and confusion.	Loss of separation	IIID	R4	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). 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. 42. Evaluate the avionics package for design enhancements to prevent erroneous pilot action. 60. Human factors evaluation was conducted and conforms to appropriate standards.	
15	**119**	Pilot loses situational awareness due to excessive heads down time reading GX60.	Collision risk Loss of aircraft control	ID	R2	5. Controller situational awareness. 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). 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. 25b. Pilot ability to see-and-avoid in VMC. 42. Evaluate the avionics package for design enhancements to prevent erroneous pilot action. 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. 60. Human factors evaluation was conducted and conforms to appropriate standards.	Can be further mitigated if operator has a defined safety program.

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
15	**122**	Excessive glare on GX60.	Decreased situational awareness	IVB	R4	47. Photo-sensor is provided within the GX60 and MFD designs. 60. Human factors evaluation was conducted and conforms to appropriate standards.	
10	**126a**	When in the North-UP mode, and flying in a direction other than north, critical terrain/target information along track maybe masked by the "Info" window.	Collision with terrain	IE	R4	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). 49. Pilots are trained to fly predominantly in the Track-up 360 mode. 60. Human factors evaluation was conducted and conforms to appropriate standards.	
10	**126b**	When in the North-UP mode, and flying in a direction other than north, loss of pilot situational awareness due to translation errors	Loss of pilot situational awareness Collision with terrain	IE	R4	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). 49. Pilots are trained to fly predominantly in the Track-up 360 mode. 60. Human factors evaluation was conducted and conforms to appropriate standards.	
13	**128**	Maintenance error in ground equipment results in Capstone equipment damage, and/or loss of system, and/or misleading information.	Capstone system loss	IE	R4	1. Ground system certification, installation, and approval process in place for Capstone to meet critical-level services in accordance with NAS-SR-1000. 3. Real-time monitoring of ground system through use of GBT status message and ADS-B fixed parrot. 4a. Controller and maintenance procedures (proactive and reactive) and training are in place for ground system equipment failures/malfunctions/limitations. 32. Capstone installation and maintenance manuals are provided. 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.	

Preliminary Hazard Analysis
For Capstone ADS-B Radar-Like Services

Type	Scenario#	Scenario Description	Possible Effect	Risk	R#	Recommendations for Precautions, Controls and Mitigation	Comments
13	**129**	Maintenance error in avionics equipment results in Capstone equipment damage, and/or loss of system, and/or misleading information.	Major system damage	IID	R3	4b. Ensure applicable avionics maintenance procedures and training are in place, to assure avionics maintenance is conducted appropriately. 17. Avionics certification, installation, and approval process in place for Capstone, in conformance with standard 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. 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. 24. Avionics include data flag annunciation to pilot, automatically indicating various avionics system failures (see MX20 User Guide, GX60 Users Guide). 32. Capstone installation and maintenance manuals are provided. 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.	