SE 120 CAST Safety Enhancement (SE)
TAWS IMPROVED FUNCTIONALITY

STUDY TOPIC
TAWS
TERRAIN AWARENESS AND WARNING SYSTEM

CICTT RISK AREAS
CFIT

SECTION I: SE OVERVIEW

Study Topic Overview Summary

Controlled Flight Into Terrain (CFIT) accidents, where a properly functioning aircraft under the control of a fully qualified and certificated flightcrew is flown into terrain with no apparent awareness on the part of the flightcrew, could be substantially reduced or eliminated with the addition of Global Positioning System (GPS) navigation data to the TAWS equipment. GPS sensors are also critical to achieving the full potential of CAST SE 1, Terrain Awareness Warning System (TAWS), in a limited ground-based navigation aid (NAVAID) environment. Additionally, timely revisions to TAWS terrain databases, alerting algorithms, and optional features should be incorporated into the TAWS equipment to ensure the accuracy and timeliness of the TAWS warnings and displays.

Existing aircraft used in commercial operations worldwide have varying operational capabilities and limitations. These various capabilities and limitations require the development and employment of a variety of strategies to improve the overall safety of approach operations.

The operational capabilities of the worldwide fleet may be represented as a continuum; however, for the purpose of this SE the aircraft have been categorized as "Classic," "Standard," and "Advanced."

- Classic: Aircraft typically equipped with electro-mechanical flight instruments and basic navigation capability, such as very-high-frequency omnidirectional range (VOR), distance measuring equipment (DME), automatic direction finders (ADF), and possibly GPS navigators (flight management systems (FMS)). (Most inertial navigation systems (INS) have been removed because of high maintenance costs.)
- Standard: Aircraft with multi-sensor area navigation (RNAV) FMS, electronic flight instruments, and electronic map displays (the majority of aircraft produced during the past 15 years). These aircraft may have DME/DME or triple INS positioning capability rather than GPS.
- Advanced: Aircraft equipped similar to "Standard" aircraft but with advanced navigation capabilities (such as GPS sensors and required navigation performance (RNP) capabilities) and possibly enhanced situational awareness systems such as TAWS.

SE Objective

CAST recommends current production models, new type design aircraft, and existing aircraft, where appropriate, include GPS equipment to allow incorporation of certain TAWS enhancements. Standard operating procedures (SOP) should be established to help flightcrews operate in areas with limited NAVAIDs.

Primary Risks Mitigated

Controlled Flight Into or Toward Terrain (CFIT)

Action	Organization(s)	Strategy	Description	Due Date
Action 1	Air Carriers	Procedures	Establish SOPs explaining increased risk in areas with limited ground-based NAVAIDs.	N/A
	Comments: CAST closed this action.			
Action 2	Aircraft Manufacturers	Equipment	Install GPS sensors in all current production model aircraft and new type designs.	N/A
	Comments: CAST closed this action.			

SECTION I: SE OVERVIEW

Action	Organization(s)	Strategy	Description	Due Date
Action 3	Air Carriers	Equipment	Install GPS capability on all "Standard" aircraft.	N/A
	Comments: CAST closed this action.			
Action 4	Air Carriers	Procedures	Establish procedures to ensure proper updating of TAWS terrain databases.	N/A
	Comments: CAST closed this action.			
Action 5	AIA, Air Carrier Industry Assns., Air Carriers	Procedures, Equipment	Establish procedures to review TAWS manufacturers' recommended updates.	N/A
	Comments: CAST closed this action.			
Action 6	AIA, Air Carrier Industry Assns., Air Carriers	Procedures, Equipment	Establish procedures to review available optional TAWS features not currently in use.	N/A
	Comments: CAST closed this action.			

See section II of this SE for detailed action descriptions.

References:

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SECTION II: DETAILED ACTION INFORMATION

Action 1: Establish SOPs explaining increased risk in areas with limited ground-based NAVAIDs

Primary Implementer	**Air Carriers**
Action Objective	Air carriers should establish, as appropriate, standard operating procedures (SOP) that advise flightcrews of the possible increased risk of operating into areas with limited ground-based navigation aids (NAVAID) and that help verify the aircraft's actual position relative to displayed ground track when appropriate. Air carriers should also develop policies that match aircraft capability to the NAVAID environment at the expected arrival location.
Action Timeline	Flow Time: 12 months Due Date: N/A
Timeline/Flow for Future Adopters	TBD
CAST Lead	Airlines for America (A4A)

#	Organization(s)	Detailed Steps
1a	Air Carriers	Develop SOPs.
	Complete.	
1b	Air Carriers	Communicate the rationale behind the necessity for these SOPs (reference events involving map shifts and/or ground-based navigation equipment failures).
	Complete.	

Notes

SECTION II

Note: See section III for detailed costs and resources.

SECTION II: DETAILED ACTION INFORMATION

Action 2: Install GPS sensors in all current production model aircraft and new type designs

Primary Implementer	**Aircraft Manufacturers**
Action Objective	Aircraft manufacturers should install, or provide options to install, Global Positioning System (GPS) sensors in all current production model aircraft and new type designs.
Action Timeline	Flow Time: 6 months Due Date: N/A
Timeline/Flow for Future Adopters	TBD
CAST Lead	Aerospace Industries Association (AIA)

#	Organization(s)	Detailed Steps
2a	AIA	Communicate with manufacturers and obtain commitment to install, or provide options to install, GPS on all current production model aircraft and all new type designs.
	Complete.	
2b	Aircraft Manufacturers	Provide information outlining the safety benefits of GPS to customers if GPS is an option.
	Complete.	

Notes

Note: See section III for detailed costs and resources.

SECTION II: DETAILED ACTION INFORMATION

Action 3: Install GPS capability on all "Standard" aircraft

Primary Implementer	**Air Carriers**
Action Objective	Air carriers should install Global Positioning System (GPS) capability on all "Standard" aircraft. At a minimum, air carriers should modify TAWS to GPS TAWS. For any air carriers not installing GPS at this time, CAST recommends implementing Action 1 to minimize Controlled Flight Into Terrain (CFIT) risk. In addition, CAST recommends all air carriers enable GPS to the TAWS box at any applicable maintenance opportunities.
Action Timeline	Flow Time: 36 months Due Date: N/A
Timeline/Flow for Future Adopters	TBD
CAST Lead	Airlines for America (A4A)

#	Organization(s)	Detailed Steps
3a	A4A	Communicate with all air carriers the rationale for the incorporation of GPS equipment for TAWS functionality.
	Complete.	
3b	Air Carriers	Air carriers that fly standard aircraft equipped with non-GPS TAWS into regions with minimal navigation aids (NAVAID) (for example, no dual distance measuring equipment (DME) or poor ground-based NAVAID reliability) should modify standard TAWS to GPS TAWS or conduct a risk assessment and develop and implement effective risk mitigation.
	Complete.	

Notes

- "Classic" aircraft are currently equipped with GPS TAWS and additional change is not required.
- GPS-updated TAWS improves TAWS alerting and display functionality by enabling use of geometric altitude and higher precision alerting terrain clearance floor profiles. GPS-updated TAWS also ensures the TAWS terrain display and alerts remain accurate when operating into areas with minimal NAVAIDs.

Note: See section III for detailed costs and resources.

SECTION II: DETAILED ACTION INFORMATION

Action 4: Establish procedures to ensure proper updating of TAWS terrain databases

Primary Implementer	**Air Carriers**
Action Objective	Air carriers should establish procedures to ensure TAWS terrain databases are updated in accordance with the manufacturer's recommendations.
Action Timeline	Flow Time: 6 months Due Date: N/A
Timeline/Flow for Future Adopters	TBD
CAST Lead	Airlines for America (A4A)

#	Organization(s)	Detailed Steps
4a	TAWS Manufacturers	Provide recommendations for incorporation of TAWS terrain database updates to air carriers.
	Complete.	
4b	Air Carriers	Develop and implement procedures for updating TAWS terrain databases on all aircraft in accordance with the manufacturer's recommendations.
	Complete.	

Notes

Note: See section III for detailed costs and resources.

SECTION II: DETAILED ACTION INFORMATION

Action 5: Establish procedures to review TAWS manufacturers' recommended updates

Primary Implementer	**AIA, Air Carrier Industry Associations, Air Carriers**
Action Objective	The Aerospace Industries Association (AIA), air carrier industry associations,[1] and air carriers should establish procedures to review and form a consensus on TAWS manufacturers' recommended updates associated with the underlying TAWS alerting algorithms. Manufacturers, air carriers, and regulators should work together to incorporate those updates considered beneficial to enhancing Controlled Flight Into Terrain (CFIT) protection.
Action Timeline	Flow Time: 18 months Due Date: N/A
Timeline/Flow for Future Adopters	TBD
CAST Lead	AIA

#	Organization(s)	Detailed Steps
5a	Air Carriers	In conjunction with manufacturers, review, form a consensus on, and implement updates to TAWS operating algorithms that are considered beneficial to enhancing CFIT protection.
	Complete.	
5b	Air Carrier Industry Assns.	Communicate to members the rationale for keeping TAWS equipment updated to the latest applicable configuration of operating algorithms respective to CFIT protection.
	Complete.	
5c	Aircraft Manufacturers	Incorporate those TAWS alerting algorithm updates into production aircraft.
	Complete.	
5d	AIA	Encourage manufacturers to develop service bulletins for upgrading existing TAWS on in-service aircraft.
	Complete.	
5e	Manufacturers, Air Carriers, FAA	Coordinate/work together to enable desired changes to be incorporated efficiently.
	Complete.	

Notes

[1] Airlines for America (A4A), Regional Airline Association (RAA), and National Air Carrier Association (NACA).

Note: See section III for detailed costs and resources.

SECTION II: DETAILED ACTION INFORMATION

Action 6: Establish procedures to review available optional TAWS features not currently in use

Primary Implementer	**AIA, Air Carrier Industry Associations, Air Carriers**
Action Objective	The Aerospace Industries Association (AIA), air carrier industry associations,[2] and air carriers should establish procedures to review available optional/selectable TAWS features not currently used by an air carrier and form a consensus on those features that would enhance Controlled Flight Into Terrain (CFIT) protection for its operation. Manufacturers, air carriers, and regulators should work together to facilitate efficient incorporation of those desired optional/selectable TAWS features.
Action Timeline	Flow Time: 12 months Due Date: N/A
Timeline/Flow for Future Adopters	TBD
CAST Lead	AIA

#	Organization(s)	Detailed Steps
6a	AIA, Air Carrier Industry Assns., Air Carriers	Establish procedures to review available optional/selectable TAWS features (such as peaks and obstacles) if not currently active to form a consensus on those features that would enhance CFIT protection for air carrier operations (obstacles exist and are mapped).
	Complete.	
6b	Aircraft Manufacturers	Develop service bulletins for the retrofit of existing aircraft where applicable.
	Complete.	
6c	Aircraft Manufacturers	Work to encourage customers to select such options on production aircraft and new type designs.
	Complete.	
6d	Manufacturers, Air Carriers, FAA	Coordinate/work together to enable efficient activation of those TAWS features that air carriers desire to enhance CFIT protection.
	Complete.	

Notes

[2] Airlines for America (A4A), Regional Airline Association (RAA), and National Air Carrier Association (NACA).

Note: See section III for detailed costs and resources.

SECTION III: SUPPLEMENTAL INFORMATION

Source Study	Controlled Flight Into Terrain (CFIT) Joint Safety Implementation Team (JSIT)
Related Initiatives	• Most aircraft manufacturers, including Boeing and Airbus, now include GPS as standard equipment on new production aircraft. • Equipment is available to upgrade existing TAWS equipment to add GPS capability. • RTCA, Inc., Special Committee (SC)–159: GPS (Global Positioning System)/GLONASS. • International Civil Aviation Organization (ICAO) Global Navigation Satellite System Panel.

Total Cost	**$39,600,000**	*Note: All dollar amounts are approximate.*
Action 1	$100,000	
Action 2	$0	
Action 3	$17,200,000	
Action 4	$0	
Action 5	$4,800,000	
Action 6	$17,500,000	

	Organization	Resources Needed
Direct Resource Overview – Government	N/A	N/A

	Organization	Resources Needed
Direct Resource Overview – Industry	Air Carriers	• Action 3: o ~$10,100/aircraft to equip GPS TAWS. o ~$100,000/aircraft (with GPS provisions) to equip GPS into navigation systems and TAWS. o ~$120,000/aircraft (without GPS provisions) to equip GPS into navigation systems and TAWS. o For GPS TAWS, 1,700 airplanes max x ~$10,100 = ~$17.2 million. • Action 5: o Certification activity: ~$30,000 per model per revision x 53 part 121 models = $1.6 million/revision. o Estimate 1 revision every 4 years. o Cost through 2020 = 3 x $1.6 million = ~$4.8 million. • Action 6: Retrofit: ~$5,700/aircraft x 0.45 x 6,838 = ~$17.5 million.

Indirect Resource Overview

The organizations identified in this section are not expected to incur direct costs associated with implementing this SE, but they may incur indirect costs within their normal line of work.

Organization	Description
Aircraft Manufacturers	Action 5: Service bulletin for software load only; no cost.

SECTION IV: REVISION LOG

Major revisions (whole numbers) represent CAST-approved changes to SE language. Minor revisions (decimals) represent minor changes to target dates or completion notes that do not affect implementer actions.

Revision	Date	Description
2.0	09/17/2018	New SE format. Content reorganized and terminology updated. No substantive changes.
1.0	12/01/2011	
Original	10/05/2006	CAST adopted SE 120.