# MEETING MINUTES
# MEETING OF SPECIAL COMMITTEE 231

## Terrain Awareness Warning System (TAWS)

RTCA Paper No. 119-19/SC231-028

**Date:** May 14-15, 2019

**Time:** 0900 EST to 1700 EST

**Place:** RTCA Office, Washington DC

**Co-Chairs:** Yasuo Ishihara Rick Ridenour

**Government Authorized Representative:** Charisse Green

**Attendees:**

| Name | Company/Agency | Attendance Day 1 | Attendance Day 2 |
|---|---|---|---|
| Adler, Richard | Federal Aviation Administration (FAA) | **Attended in person** | **Attended in person** |
| Baker, James (Kirk) | Federal Aviation Administration (FAA) | | |
| Bleakley, Timothy | General Atomics Aeronautical Systems, Inc. | **Attended in person** | **Attended in person** |
| Blom, Stefan | Saab Group | **Attended in person** | **Attended in person** |
| Bradley, Capt. Mark | Delta Air Lines, Inc. | | |
| Bulger, Chip | Federal Aviation Administration (FAA) | | |
| Burgeles, Mr. Brett | The Boeing Company | | |
| Bykov, Vladimir | International Aeronavigation Systems (IANS Inc.) | | |
| Caruhel, Mrs. Camille | Airbus | | |
| Chism, Linda | Alaska Airlines | **Attended in person** | **Attended in person** |
| Cros, Xavier | Airbus | | |
| Dean, Mr. Garfield | EUROCONTROL | **Attended on phone** | |
| Dhulipudi, Mr. Durga | Honeywell International, Inc. | | |
| Duke, Rune | Aircraft Owners and Pilots Association | **Attended on phone** | |
| Dunagan, Mr. Joseph | Raytheon | | |

| Name | Company/Agency | Attendance Day 1 | Attendance Day 2 |
|---|---|---|---|
| Fisch, Wayne | Universal Avionics Systems Corp. | | |
| Fleury, Stephane | Thales Group | | |
| Forrest, Joseph | Collins Aerospace | | |
| Franzen, Mr. Paal | Astronautics Corporation of America | | |
| Geoghagan, William L | National Air Traffic Controllers Association (NATCA) | | |
| Goddard, David | Garmin Ltd. | | |
| Gosselin, Eustis | Jacobs Technology | | |
| Green, Charisse | Federal Aviation Administration (FAA) | **Attended in person** | **Attended in person** |
| Hogestad, Marie | Federal Aviation Administration (FAA) | | |
| Ishihara, Yasuo | Honeywell International, Inc. | **Attended in person** | **Attended in person** |
| Johnson, Steve | Honeywell International, Inc. | | |
| Judge, John | Lockheed Martin Corporation | **Attended on phone** | |
| Kapytov, Vasily | International Aeronavigation Systems (IANS Inc.) | | |
| Kindred, Rob | National Air Traffic Controllers Association (NATCA) | | |
| King, Mr. Matt | Alaska Airlines | | |
| Kirtz, Jon | Collins Aerospace | **Attended on phone** | **Attended on phone** |
| Koffink, Michael | Intertek Testing Services NA | | |
| Korns, Peter | National Business Aviation Association | | **Attended in person** |
| Labay, Mr. Marcus | Federal Aviation Administration (FAA) | **Attended on phone** | **Attended on phone** |
| Lawrence, Mr. Tom | Universal Avionics Systems Corp. | **Attended in person** | **Attended in person** |
| LE CANN, Mr. Alexandre | Airbus | | |
| Lorey, Janiece | Gulfstream Aerospace Corporation | **Attended in person** | **Attended in person** |
| Meunier, Hugues | Thales Group | | |
| Morrison, Rebecca | RTCA, Inc. | **Attended in person** | **Attended in person** |
| Mulkins, Jim | Honeywell International, Inc. | | |

| Name | Company/Agency | Attendance Day 1 | Attendance Day 2 |
|---|---|---|---|
| Ostrom, Gary | Honeywell International, Inc. | **Attended on phone** | |
| Parikh, Mr. Ajay | Ligado Networks | | |
| Philbin, Mr. John | Northrop Grumman Corporation | | |
| Pippard, Mr. Nigel | Saab Group | | |
| Prosser, Kevin | Gulfstream Aerospace Corporation | **Attended in person** | **Attended in person** |
| Resnick, Mr. Boris | International Aeronavigation Systems (IANS Inc.) | | |
| Reynolds, Zach | L3 Technologies | **Attended in person** | **Attended in person** |
| Ridenour, Rick | L3 Technologies | **Attended in person** | **Attended in person** |
| Ringnes, Mr. Erik | Honeywell International, Inc. | | |
| Rossi, Mr. Angelo | The MITRE Corporation | | |
| Sadilov, Mr. Vsevolod | International Aeronavigation Systems (IANS Inc.) | | |
| Sauter, Michael | Lufthansa | | |
| Sheng, Randy | Honeywell International, Inc. | | |
| Stevens, Aubrey | Delta Air Lines, Inc. | | |
| Stone, Capt. Rocky | United Airlines, Inc. | **Attended in person** | |
| Sun, Hui | Honeywell International, Inc. | | |
| Tubb, Nick | The Boeing Company | **Attended in person** | **Attended in person** |
| Vafiades, Monica | U.S. Air Force | | |
| Williams, Shaun | NTSB | **Attended in person** | **Attended in person** |
| Wilson, Garry | Gulfstream Aerospace Corporation | **Attended on phone** | **Attended on phone** |
| Zapoluch, Steve | Garmin Ltd. | **Attended on phone** | **Attended on phone** |

**Plenary Discussion:**

**Tuesday, May 14:**

A slide presentation was provided to the group to develop on the initial agenda. This is attached.

Rebecca Morrison walked through 3 RTCA policies:

- Anti-trust policy
- Proprietary policy
- Committee participation membership policy

Rick Ridenour and Yasuo Ishihara (co-chair) led the remainder of the slides. Yasuo pointed out that he participates in the General Aviation Joint Steering Committee (GAJSC), including Class C operations where a Safety Enhancement (SE) proposal has been developed.

Introductions were made both in the room and on the phone.

The RTCA Process was discussed by Rebecca. She pointed out that the TOR does not include a document release (or FRAC process), but instead a recommendation to be provided to the PMC. There is a template for the recommendation that Rebecca has provided on the SC-231 workspace. She indicated that a peer review form will then be used for markups of the recommendations. She has also provided a link to a past recommendation from the SC-228 (UAV) committee which did not map to the template. See below:
https://workspace.rtca.org/apps/org/workgroup/sc-213/download.php/36753/213agn41.pdf

A review of the TOR then took place. The emphasis in the TOR is for part 135 operations and in particular for Alaskan operators. We will ask Rocky Stone and/or Linda Chism to work with their contacts to get greater part 135 participation. To that end, Yasuo is trying to arrange a meeting with the Alaskan operators at their location later in the fall or winter, as the Alaska summer season is too busy to get good attendance. Shaun Williams stated that on September 6th, a roundtable discussion of Part 135 operations in general will be hosted by the NTSB in Alaska with Robert Sumwalt. This agenda will include TAWS but also operations, time pressures, route standards and safety management in the Alaska area. Yasuo indicated that this is a conflict with Charisse and himself for a separate HTAWS committee.

A recommendation is due on May 2020. While the committee does not need to go through FRAC, dates of the completion of the recommendation are likely needed by around January 2020 to allow review time. Rebecca stated that depending on the submittal date to RTCA, the presentation to the PMC may be affected – for example, an early May 2020 or earlier submittal will be presented to the PMC in June. A late May 2020 submittal will be presented to the PMC in September.

The part 135 operations in Alaska were then noted. Although Alaska is the location of these most recent CFIT incidents, these incidents are not isolated to Alaska. A common theme in these accidents and other similar cases is the use of the terrain inhibit switch to avoid the continuous alerting condition that can occur during low altitude operations.

TAWS Class differences were noted. Ten or greater passenger seats comprise Class A. Class B covers aircraft with 6-9 passenger seats. Class C covers smaller aircraft. The differences between Class B and C include definitions of Flight Environment and in particular, RTC (Required Terrain Clearance) levels. The TSO-151d (DO-367) RTC level is 500 feet for Class B systems while enroute and 200 feet while in cruise for Class C systems.

Shaun Williams pointed out that with TSO-151c, the Class B RTC levels had been set to 700 feet while operations in Alaska and other locations are routinely flown at 500 feet AGL. It is only now with TSO-151d (DO-367) released in 2017 where the RTC has been reduced to 500 feet

(Class B) which would still provide unwanted alerts, though perhaps to a lesser extent. While the reduction in RTC is matching flight levels in Alaska, this DO-367 Class B change was based on TERPS procedures, not tying to the Alaskan operational cases.

Yasuo points out that if the 200 foot Class C RTC were the basis for FLTA operations in Alaska, this is only of benefit when flying over relatively flat terrain or over rolling hills. With operations at low AGL altitude (500 feet) in areas of mountainous regions, such as southeastern Alaska, the forward looking sensor and swath is intersecting the higher surrounding terrain and driving the undesired alerting. The point is that the lower RTC in isolation does not provide blanket capability to fly at these lower AGLs, due to the surrounding terrain.

Kevin Prosser asked if the nuisances were limited to the FLTA and therefore excluded the GPWS modes. Yasuo, who was personally involved in several of these cases, agreed. He did not feel that the GPWS modes were the cause of nuisance alerts.

The NTSB recommendations were then discussed. In particular, the recommendation A-18-015 was walked through. Yasuo pointed out that in his experience, there are many instances where these Part 135 operations have shown that a terrain inhibit was set on the ground before the flight began. While the inhibition is not continuously being used, numbers of ~80 % of flight time (9,000 out of 11,000 flight hours as cited by Shaun) having inhibition have been seen in the field for these Alaskan operators. While the A-18-015 recommendation may imply a TAWS SW change, we should point out that mechanical options such as a timer based switch itself may also be considered. These are typically latched switches. Shaun pointed out that the Alaska operations have seen two types of switches – the alternate position switch with annunciation lamp but also a simple toggle switch where the switch position itself is the only indication (no lamp annunciation).

This alternative of changing the switch type might be appealing given that a forward fit solution with a SW change can be cost prohibitive for the majority of operators who have had their TAWS solutions in place for many years.

Questions on the effect of the Terrain Inhibit were then raised. Both the aural and visual alert are typically inhibited. In addition, the terrain display (optional for Class B and C) is also sometimes removed, where the presumption is that if the position or data base are not credible and therefore drive inhibition, that the remaining terrain depiction may also be misleading. A visual annunciation or indication must be provided when a Terrain Inhibit is present.

Rocky Stone asks if any of the military systems that already have terrain sensitivity differences might be applicable here. The concept of desensitizing the TAWS system as has been done in some HTAWS is also open for discussion.

A PFD and MFD simulated replay video was shown of the AAR-17/02 Ketchikan CFIT entire flight. This allowed a side-by-side comparison of Class B vs. Class C thresholds. There were 200 alerts present in the TSO-151c Class B TAWS and 160 alerts present in the TSO-151c Class C TAWS with around 6.5 minutes of alerting during the 10-15 minute flight before the CFIT occurred. As there are no operations today with TSO-151d Class C, this was not simulated.

However, knowing the nearby terrain and the location of the flight in a canyon area, even the lower TSO-151d thresholds would still have frequent alerts. There was a question on the resolution of the database – it appears that the terrain was high resolution (6 arc-sec or less) though no confirmed number is known. So, even the combination of high resolution terrain and low RTC thresholds associated with Class C DO-367 would still result in frequent alerts in this type of operation.

With no ADS-B information, Spider track simulations were performed on this AAR-18/02 (Togiak) case to determine the aircraft track at the time leading up to the accident. The caution alert occurred 46 seconds ahead of the CFIT and a warning alert occurred 36 seconds ahead. Though the accident recovery showed the terrain switch set to the uninhibited position, there is a reasonable belief that the terrain inhibit was set, compared to the likelihood that the flight crew tolerated the continuous alerting without a pull up response until very late.

The Togiak CFIT incident showed that 2 separate routes had been flown. The second aircraft took off after the accident aircraft and chose a different route. Another operational constraint idea would be to avoid the 500 foot AGL operations by flying IFR and therefore maintain higher altitude levels. But one needs to recognize that the VFR operations are greatly preferred where icing conditions are often present and IFR infrastructure for radar and comm coverage are unavailable.

Linda asked for MOPS differences between HTAWS and TAWS in these scenarios. Yasuo described that the HTAWS does have several key differences as found in TSO-C194 and DO-309. There is a "reduced protection" mode in HTAWS systems per the MOPS. There is a pilot acknowledgement of alert function where alerting is suppressed when the conflict is still active.

Rocky asked if the HTAWS systems included other lateral guidance maneuvers. The HTAWS regulations do not address lateral guidance. Rick pointed to other TAWS systems that include an Avoid Terrain aural alert, but without lateral guidance due to the Level C software, not allowed to provide guidance information.

A 2015 CFIT, ANC15FA049 was studied next, a Cessna 207 in Juneau. The terrain inhibit was on for this portion of the flight. Paal noted that this system had a separate Aural mute beyond the Terrain Inhibit and asked if this was standard. Yasuo felt that this is a manufacturer option as to how the aural inhibition takes place. As there were no nuisance alert opportunities prior to this CFIT, Yasuo expressed the opinion that terrain need not have been inhibited and therefore alerting could have been heard properly.

GAJSC recommendations were discussed next. A chair of this committee is in Washington and should join this committee on Wednesday. There are 4 such recommendations shown on slide 24 of the presentation.

1. Class C usage for unique operations. While there is little benefit in Ketchikan (still would have many nuisance alerts), the operators in conditions such as the CFITs in Togiak or St. Mary's could benefit. It is assumed that in some or most cases, the existing system can be configured for Class C with no SW loading or hardware changes, although a regulatory action would be required.

2. Specifically driven by the Ketchikan case, FAA encourages alternative TAWS envelopes to provide some low sensitivity alerting. This could lead to a change to DO-367 also and the accompanying TSO-151.
3. Specifically driven by the Togiak case, FAA encourages an uninhibit function. As stated earlier, this could also be provided as a mechanical timer based switch to replace the manual inhibit. This would be a quicker implementation, where some future SW change could still be provided. This switch would be configurable in the order of minutes, not hours and would not be dynamic. This could be an FAA 337 alteration and could be done outside of OEM and TAWS manufacturer changes. This may be covered under Non Required Safety Enhancing Equipment (NORSEE) approval.
4. GAMA is encouraging enhanced lateral and vertical terrain escape guidance for Part 23 aircraft. The group is unclear on whether this enhancement is (a) an addition to the existing TAWS system or (b) a separate system meant to be used instead of the TAWS system. There was then further discussion on whether lateral guidance could be used in additional to vertical guidance. First, the DO-367 requirements do not allow for any TAWS to provide navigation – at least one existing system that provides lateral alerting has an aural of "Avoid Terrain". Also, even though there are improving database resolutions, there can still be errors significant enough to potentially provide misleading data. Also within the recommendation was the use of satellite based ADS-B to obtain ATC IFR clearance otherwise not possible due to lack of conventional radar coverage when inadvertent IMC conditions occur.

The Ketchikan CFIT case prompting the TOR guidance was then reviewed.

A brainstorming session then began with several ideas discussed. Below are comments occurring during the discussion. Please see attached power point for the entire list of brainstormed ideas.

Stefan Bloom had a suggestion of providing lateral information when the terrain system is inhibited. At the point in the flight where the vertical terrain height / sensor swath is not trustworthy, lateral guidance may still be of value.

Linda felt that the GPS altitude may not be reliable enough for use in remote areas. However, the committee expressed that the WAAS corrected position is more consistently accurate due to the cold temperature conditions and baro missets that can occur with pressure altitude. The greater worry in remote Alaska operations is the lack of roll data or radio altitude data.

Timothy and Paal expressed the need to address the RTC levels which seem mismatched to the types of operation and, via the inhibit being pressed, causing the most dangerous situations to have the least protection. The better alternative to inhibit would be a low sensitivity mode, to provide at least some level of protection in these situations.

Linda asked if there were reversionary modes for the inhibit switch at power on; would a cold start pull the unit out of inhibition? The mechanical switch does not offer a reversion to uninhibited. However, electronic displays may offer this feature.

Gary asked how many aircraft are equipped with displays. Most of the turbine Otters, Caravans have displays. However, the Beavers do not typically have a display.

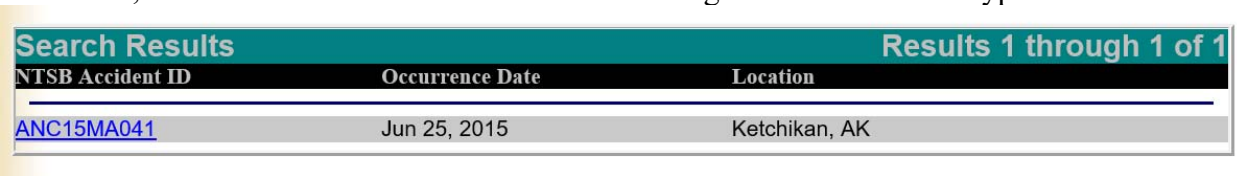
Tom Lawrence expressed the concern that pilots are likely to keep doing what they've been doing for years. Even if we have timers on the inhibit, they will adapt to their current practices and just press the timer every 10 minutes (or whatever the duration is). Rich Adler felt that there is merit in the auto-uninhibit but when coupled with other recommendations, less opportunity for the CFIT window will still exist. Rhetorically, is the purpose of whatever solution we are developing intended to adjust to how these operators fly (where passengers are disturbed by aural alerting) or are we assuming that after training, operators will change their behavior? The former seems more likely.

An additional idea from Paal, was to evaluate after every alert, if a pilot adjustment is made (flight path angle, track angle), discontinue the alert until the alert conditions change.

There has been a discussion on a hypothetical Class D TAWS as a result of these discussions. This would be an exemption that the FAA would then allow for these special low altitude operations. Rich Adler suggested reductions of the lateral width of the sensors to avoid what are perhaps unwanted alerts.

From here, a brainstorm list of potential solutions have been developed, well beyond those listed above. These have been recorded in the slide presentation.

A path of how to get to the Ketchikan CFIT docket which provides spreadsheet data of onboard GPS sensor data from this case was discussed. One would start at the below NTSB site:
https://www.ntsb.gov/investigations/SitePages/dms.aspx
From here, a selection of "ANC15MA041" and clicking on "find" shows a hyperlink below:



Search Results — Results 1 through 1 of 1

| NTSB Accident ID | Occurrence Date | Location |
|---|---|---|
| ANC15MA041 | Jun 25, 2015 | Ketchikan, AK |

Clicking on the hyperlink reveals a series of docket items, where the tabular data has the csv download:

| | | |
|---|---|---|
| 6 | Mar 09, 2017 | Cockpit Displays – Recorded Flight Data - Attachment 5 (Tabular Data) |

**Wednesday, May 15:**

Peter Korns was introduced to the committee today, where he had been meeting with the GAJSC on May 14 which he provided some summary of. Within the GAJSC, 183 CFITs were studied and from these, 63 accident cases were studied in depth with 9 Safety Enhancement recommendations developed from these. Most of these were in the areas of communication or other issues. However, of these, SE-55 was selected on the technology side for the TAWS Class C systems. Within SE-55, there were 4 outputs that have been discussed in the SC-231

committee as shown in power point slides 25-28. Output 3 was considered the minimum action to be taken where Output 4 is more of an enhancement.

Linda had additional brainstorm concepts that she had developed with a colleague overnight. A GPS altitude compared to terrain altitude "height sensor" set to say 100 or 200 feet might have an additional protection beyond the FLTA system (while the latter is inhibited). Shaun cited the use of this radio altimeter is typically set to 0 feet in every crash case he has investigated. Yasuo has worked with a similar height based alerting with helicopter operators. The feedback he had from Helo operators was that these were nuisance prone and would often get set so close to zero to make this ineffective. Rich is concerned that this type of alert is the GPWS alert and the lack of the predictive element removes allowances for reaction time that a predictive system provides.

Janiece suggested that we are providing a lot of solutions but have not yet established a problem statement. Yasuo acknowledged that the evaluation of brainstorm solutions would likely be first, but that we would return to objectives.

Timelines for the GAJSC were discussed. After this committee approval, these recommendations are expected in 2 years for recommendations 1 and 2 (Class C and auto-uninhibit), and 3-4 years for recommendation 4 which is the enhanced vertical and lateral guidance, sometimes referred to as Ground Collision Avoidance System (GCAS). However, given that the SC-231 committee won't complete a recommendation until next year and then would get PMC approval in Fall 2020, this would only leave one year for the DO-367 update which would be challenging. Peter indicated that these time frames are notional and could be adapted to the SC-231 committee time frames.

Rich Adler went through a briefing of a GCAS system being developed by NASA/FAA. A future meeting will have a fuller presentation, but the current briefing showed the combination of lateral and vertical maneuver depictions for the audience to better appreciate the benefits and potential drawbacks of such a system. An example slide is shown below.


Each of the brainstormed ideas were then classified in 4-5 general classes as shown in the slides. The committee then created slides of concerns/risks and advantages associated with each category.

**NEXT STEPS**

**Action:** Zach to provide template for the assigned brainstorming concepts shown below.

**Actions:** Assignments are being made to describe the brainstormed concepts in greater detail. The due date for posting these is end of day Friday, July 12.

Lateral Escape – Stefan, Kevin, Paal

Envelope Change – Tom, Yasuo, Charisse

Inhibition Changes – Janiece, Rick

Additional Functionality – John Kirtz

Nuisance alerts less annoying - Zach

New TAWS Class – Yasuo

Allowing Class C settings for Class B operations - Yasuo

Higher integrity, accuracy, resolution databases – Rick

SVS addition - Rick

Topics to include for each concept include:

- Top level block diagram where applicable
- Purpose
- Operational effect
- Training associated with the concept
- Implementation effort
- Regulatory implications
- Description of advantages (as developed on 15 May – see slides)
- Description of disadvantages (as developed on 15 May – see slides)

A telecon is planned for Monday, July 29 at 11:00 AM to 1:00 PM Washington time. An agenda will be provided approximately 2 weeks before this (~ July 15).

For the next planned meeting, an NTSB roundtable meeting (not affiliated with SC-231) in Anchorage is planned for 6 September with Shaun Williams and Peter Korns. We will see if another SC-231 committee member can attend, though HTAWS MOPS participants can not.

The next plenary meeting is planned for 24-25 September, Tuesday/Wednesday in Washington DC. The goal will be to provide recommendations in a some power point form in order to describe to the operators in Alaska in late fall or winter.

The following meeting is likely to take place in either Anchorage or Ketchikan in late October or November/December to meet with operators in Alaska. Linda and Peter have begun coordinating this. At this same meeting the SC-231 committee is projected to walk through recommendations.

Plenary section closed with this remark.