Honeywell

TCAS Tracking Performance Requirements

Don Walker
Flight Safety COE
913-712-2193
don.walker@honeywell.com

TCAS Track Requirements

- How does TCAS decide what to start/establish a track on?
  - Replies must be consistent
  - TCAS starts track initialization on Mode S when a Squitter is received.
  - ATCRBS tracks are started when replies correlate.
  - Aircraft +/- 10000 ft altitude whose received signal strength is above -74 dBm
  - Targets closer than existing tracks must be able to replace them
  - DO-185A Paragraph 2.2.4.6.2.2.2 requires 2 Mode S Replies to establish a track in consecutive update periods
  - DO-185A Paragraph 2.2.4.6.2.1.2 requires 4 ATCRBS Replies to establish tracks (3 consecutive and 1 in the next 5 update periods)
- What is the track limit?
  - DO-185A Paragraph 2.2.4.6.1 The TCAS track requirement is 30 targets.
- How does TCAS decide to drop a track?
  - When the limit is reached, TCAS drops the farthest track.
  - TCAS also drops tracks based on a timeout.

TCAS Track File Priority

- **How are the targets in a TCAS track file prioritized?**
  - **Tracks are ordered by threat priority for the first 30 targets.**
  - **DO-185A, Attachment A, 7-P18 (high level pcode)**

PROCESS Traffic_score;
Calculate score multiplier according to altitude reporting capability;
IF (Traffic code indicates Resolution Advisory)
THEN assign high score value;
ELSEIF (Traffic code indicates Traffic Advisory)<includes non-alt.>
THEN IF (range is less than incremental volume)
THEN assign medium high score, sorted by range;
ELSEIF (intruder range is converging)
THEN assign medium score, sorted by range tau, but not less than medium low score;
OTHERWISE assign medium low score, sorted by range;
<altitude reporting intruders get higher score>
ELSEIF (Traffic code indicates Proximity advisory)
THEN assign low score, sorted by range;
OTHERWISE assign very low score, sorted by range;
END Traffic_score;

Track Maintenance

- **How is track maintenance specified in the TCAS MOPS?**
  - **ATCRBS DO-185A Paragraph 2.2.4.6.2.1.3**

Established tracks shall be updated using replies that meet the following criteria as a minimum:

a. The reply range occurs within a range window centered on the range predicted from previous reply history.

b. The reply altitude occurs within an altitude window of +/-200 ft centered on the altitude predicted from previous reply history.

TCAS II shall not use a reply to satisfy a. and b. above if the direction of arrival for that reply is outside of the required interrogation beamwidth as defined in subparagraph 2.2.4.5.4.2.1 for a maximum suppression transponder.

The TCAS II equipment shall delete the established track on a Mode C transponder-equipped aircraft after the sixth surveillance update interval following receipt of the last valid correlating reply.

Appendix A, Section A.6 describes one acceptable set of algorithms for maintenance of Mode C target tracks.

Track Maintenance

- **MODE S DO-185A Paragraph 2.2.4.6.2.2.3**

  Established tracks shall be updated using replies that meet the following criteria as a minimum:

  a. The Mode S address following the error correction decoding process of subparagraph 2.2.4.4.2.2d is correct.

  b. The reply range occurs within a range window centered on a range predicted from previous reply history.

  c. The reply altitude occurs within an altitude window centered on the altitude predicted from previous reply history. In no case shall the altitude window be larger than ±500 ft.

  Note: The altitude reporting status of a track may change from non-altitude reporting to altitude reporting and from altitude reporting to non-altitude reporting. Item c applies only if the established track is an altitude reporting track and the reply contains altitude data.

  If own aircraft is on the ground, Mode S intruders with established tracks shall continue to be tracked as long as the intruder is airborne according to 2.2.4.6.1.3.

  The range and altitude correlation window process described in Appendix A, Section A.6 for Mode C targets is acceptable for Mode S targets.

  In the event that two or more surveillance tracks are associated with the same Mode S address, only the track that is closest in range shall be retained.

Track Maintenance

- **MODE S DO-185A Paragraph 2.2.4.6.2.2.3 (cont.)**

  The range of the target shall be used with its estimated range-rate relative to TCAS to determine its potential threat to TCAS and whether it can be interrogated less frequently than the nominal 1-second rate. Each scan, the potential threat level (TAU) of the target shall be calculated as follows:

  TAU = (r – (SMOD^2/r))/ min(-6 kt, rdot)

  where r is the tracked range, r dot is the estimated relative range rate and SMOD is a surveillance distance modifier which for this purpose shall be equivalent to 3 nmi. This value of SMOD ensures that TCAS will always use the nominal 1-second update rate in situations where tau can change rapidly, such as in a parallel approach. The denominator ensures use of the reduced rate for diverging intruders beyond SMOD.

  All intruders shall be interrogated at least once every five surveillance update intervals. An intruder with a TAU value of equal to or less than 60 seconds shall be interrogated at the nominal surveillance update rate of once every surveillance update interval. An intruder with a TAU value greater than 60 seconds shall be interrogated at a rate of no more than once every five surveillance update intervals if:

  a. the tracked barometric altitude of own aircraft is less than 18,000 ft, and

  b. the tracked altitude of the intruder aircraft is less than 18,000 ft.

  A hysteresis of +/- 500 ft shall be applied to the above 18,000-ft altitude boundary in order to prevent rapid oscillations between two different interrogation rates.
  Note: The above statement is not intended to prohibit re-interrogation(s). If a tracking interrogation fails to elicit a valid reply from a target being updated at a 5-second rate, additional interrogations are transmitted as specified below, i.e., surveillance should not wait five seconds to re-interrogate.

Track Maintenance

- **MODE S DO-185A Paragraph 2.2.4.6.2.2.3 (cont.)**

  Each scan, surveillance shall make available to the CAS logic a valid track report for each established track which includes the Mode S address, range and altitude position, altitude quantization bit, a 1-second or 5-second update indication, whether the tracked range or altitude was coasted this scan, and, for newly established tracks, the previous history associated with track establishment.

  Appendix A, Section A.11 describes one acceptable algorithm for tracking of aircraft with a 5-second interrogation rate.

  If, during active surveillance, a tracking interrogation fails to elicit a valid reply, additional interrogations shall be transmitted. The total number of tracking interrogations addressed to a single target shall not exceed five during a single surveillance update interval or twenty six distributed over ten successive surveillance update intervals. The first tracking interrogation shall be transmitted using the antenna that was used in the last successful interrogation of that target. If two successive tracking interrogations fail to elicit valid replies from a target, the next two interrogations to that target shall be transmitted using the other antenna.

  The TCAS II equipment shall delete the established track on a Mode S transponder-equipped aircraft after the sixth surveillance update interval (5 coasts) following receipt of the last valid correlating reply if the track was maintained with interrogations transmitted once every surveillance update interval, or after the tenth surveillance update interval (9 coasts) following receipt of the last valid correlating reply if the track was maintained with interrogations transmitted once every five surveillance update intervals. The TCAS II equipment shall also delete the established track on a Mode S transponder-equipped aircraft following five consecutive replies in which the VS field indicated the aircraft to be on the ground. Any subsequent squitters and replies from that aircraft are subject to the squitter processing requirements of subparagraph 2.2.4.6.2.2.1. The Mode S address associated with the deleted surveillance track shall be retained an additional four surveillance update intervals so as to enable immediate reacquisition if a squitter is received within that period.

Demonstrated Track Performance

- Track performance is specified by flight test
  - DO-185A Paragraphs 3.4.4.1, 3.4.4.2
  - Target of Interest Defined
    - ATCRBS, 5 Nm front quadrant, 3.5 Nm side quadrants, 2 Nm aft quadrant, 5 degree lookup/lookdown angle
    - MODE S, 10 Nm Range, 10 degree lookup/lookdown angle
    - Altitude Reporting and In Air
  - Track Probability
    - ATCRBS surveillance probability for targets-of-interest > 95%
    - Mode S surveillance probability for targets-of-interest > 95%
  - False Tracks
    - No false tracks allowed on Mode S targets
    - ATCRBS allows 1.2 percentage of total tracks

TCAS Slant Range Correction

- **Does TCAS make a correction from Slant Range to Horizontal Range during tracking?**
  - **MOPS does not require slant range correction during tracking**
  - **CAS logic expects slant range.**

- **Is Slant Range corrected in the track file?**
  - **Slant range is corrected to horizontal range in the track file.**

ASSAP Tracking Recommendations

- No Design Specified
- Max Number of Tracks 100
  - Required Track Capacity Specified per Application
- Volume Specified per Application
- Track Maintenance Requirements
  - Max allowed coasting time
  - Max velocity specified
  - Max accelerations specified