Honeywell

Enhanced Visual Acquisition Integrity Discussion

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DO-289 MASPS Highlights

- Table C-2 EVAcq Information Requirements
  - Target Accuracy
    - NACp ≥ 5, HFOM < 0.5 Nm (926m)
  - Target Integrity
    - NIC ≥ 5, Rc < 1 Nm (1852m)
    - Integrity Containment Risk 10^{-2}/hr
    - Note 2: It is expected that the 0.01 integrity risk will be supported without explicit integrity monitoring; the 1 Nm requirement is intended to be consistent with 0.5 Nm accuracy.
- SIL Definition §3.1.5.17
  - The Surveillance Integrity Level (SIL) defines the probability of the integrity containment region used in the NIC parameter being exceeded, without alerting, including the effects of airborne equipment condition, which airborne equipment is in use, and which signals are used by the navigation source.

Fielded Equipment Highlights

- **Legacy Position Source**
  - GPS protected by RAIM is commonly accepted to have 10^{-7} PMD
  - TSO C129 GPS typically certified to 10^{-5} HW/SW PMD
- **Capstone UAT Equipment EVAcq Implementation**
  - No NAC Requirement
  - Chevron displayed for Targets with NIC >= 5 (HPL < 1.0)
  - Bullet displayed for Targets with NIC <= 4

Availability Study

- **Probability that HPL is > 1.0 Nm**
  - **2.7669e-5**
  - **Conservative to use the probability as a per hour risk**

- **GPS Model**
  - **Analysis computed on the 180 Nm grid specified in RTCA/DO-208**
  - **Almanac specified in RTCA/DO-208 (21 Satellite Model)**
  - **Visibility mask angle of 5 degrees**
  - **SA On Assumption**
  - **5 minute intervals over a 12 hour period**

DO-260A/DO-282A Equipment Concerns

- **Human Factors Concern with Availability**
  - Can't completely eliminate availability issue.
  - Strike a balance between Pilot Trust and Risk
- **Validate a way to Scale Containment Radius from 10^{-5} Integrity to 10^{-2}**
  - This can buy availability back.
  - Stan Jones prepared a paper for STP MOPS
    - The gist of the paper is that, by scaling the Radius of containment from a 10-7 value to a 10-5 value, you buy back 22 percent.
- **Alternatively Validate a Containment Radius at 10^{-5} Required for EVAcq**

NRA Interop Risk Assessment

- **FRAC Copy of NRA Interop Document Appendix G**
  - **Asserts that the risk of an undetected containment failure when using DO-260 NUC is on the order of 10^{-7} assuming that HPL is available on the aircraft.**
  - **The HPL assumption is being enforced by the regulator in Australian airspace.**
  - **No guarantee that this assumption will be enforced in other airspace. Have to assume that it isn't.**

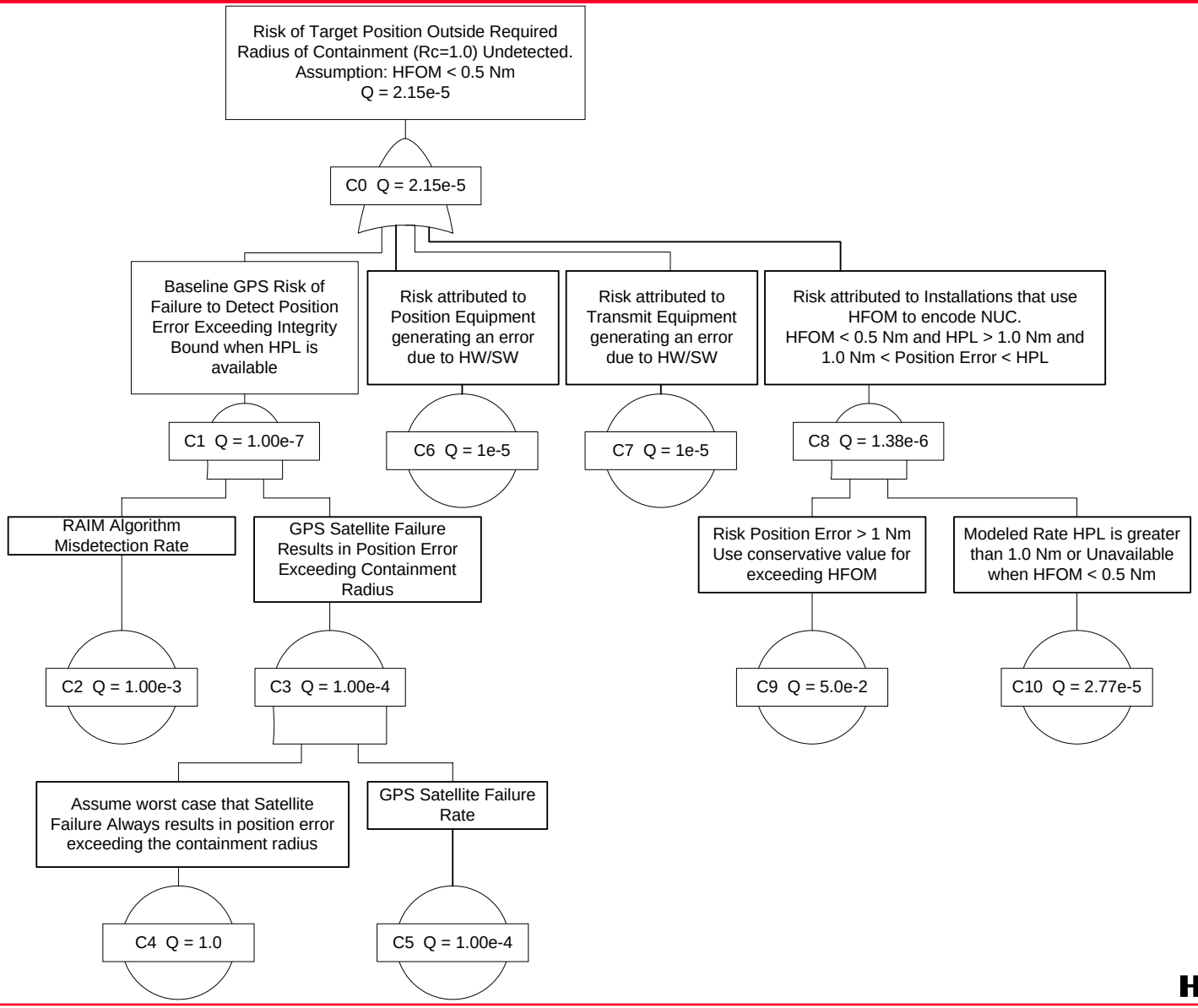
Risk Incurred by DO-260 Equipment

- Existing DO-260 Installations allow the use of HFOM when HPL is not available to encode NUC
- Some installations may not have HPL on the bus
  - All Honeywell GPS transmit either HPL or an indication that RAIM is unavailable
  - Unknown what is available from other vendors
  - Honeywell FMS do not transmit Label 130 (HIL) or Label 247 (HFOM) so FMS solutions will always transmit NUC=0
- NUC of 4 is interpreted as NIC=5, NAC=5, SIL=2 refer to DO-289 Table AE-3
- NUC of 4 may be encoded by HPL < 1.0 Nm or HFOM < 0.5 Nm refer to DO-260 Table 2-11

Risk Assessment Assumptions

- Assume HPL value is never available to Transmitter
  - NUC is being encoded from HFOM
- No risk associated with HFOM > 0.5 Nm
  - Results in NUC < 4, Target not used by application
- No risk associated with RAIM Alert, detected error
  - Results in NUC = 0, Target not used by application
- Modeled Availability of HPL
  - Model is somewhat sensitive to receiver design on the order of 1 order of magnitude
  - No modeling of local interference, e.g. terrain masking, multi-path, antenna shadowing
- Risk Exposure is on a per hour basis
- Risk Assessment for GPS Source Only

Risk Fault Tree



Fault Mitigations

- Did not aggressively characterize the probability that the position error exceeded 0.5 Nm but did not exceed 1.0 Nm.
  - Used conservative value of 5e-2.
  - Separately Modeled a Rayleigh distribution
    - Assuming that 0.5 Nm is the 95% point, the CDF shows that 1 Nm is 0.99999375.
    - This suggests that, in the fault free case, the probability that the error > 1.0 Nm when HFOM < 0.5 Nm is approximately 6e-6
- Modeled probability of HPL > 1.0 Nm uses a conservative Satellite Almanac
- HPL or RAIM unavailable is transmit by all Honeywell GPS
  - We believe that this statement is true for most other vendors as well

Conclusion

- Enhanced Visual Acquisition Requirements
  - Target Integrity
    - NIC ≥ 5, Rc < 1 Nm (1852m)
    - Integrity Containment Risk 10^{-2}/hr
- Risk Associated with DO-260 Equipment
  - From the fault tree
    - Risk (Undetected Error > 1.0 Nm) = 2.15e-5/hr
- Enhanced Visual Acquisition Requirements are met by DO-260 installations
  - At least for Honeywell Equipment
  - Other vendors should look into their risk
- Need to Validate a method for scaling Rc Requirements for Availability