"NIC/NAC/SIL"

Proposed Changes in the
Revised DO-242A ADS-B MASPS

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Definitions

- **HPL (Horizontal Protection Limit)**
  HPL is a measure of the integrity of the position being reported. It is the radius of a circle, centred on an aircraft's reported position, such that the probability is 10^{-7} per flight hour or less that the aircraft's actual position is outside that circle without that fact being detected at the transmitting aircraft.* To determine the HPL, some redundancy in measurements is required (e.g., pseudoranges from more than 4 satellites in a GPS fix).

* This definition isn't exactly right, but it's close enough for an introductory overview of the subject.

Definitions

- **HFOM (Horizontal Figure of Merit)**
  HFOM is a measure of the accuracy of an aircraft's reported position. It is the radius of a circle, centred on an aircraft's reported position, such that the probability of the true position lying outside that circle is 5% or less. Redundant measurements are not needed to estimate HFOM; the HFOM computation assumes that everything is working as it should.
- HFOM is also known (in DO-236A, the RNP MASPS) as **EPU (Estimated Position Uncertainty)**

Old (DO-242) Design

- NUC_P (Navigation Uncertainty Category for Position) encodes an integrity bound (HPL) for $NUC_P = 0, 1, 2, \ldots, 7$
- NUC_P encodes a 95% accuracy bound (HFOM) for $NUC_P = 8$ or 9

Old (DO-242) Design

NUC_P	HPL [Integrity Radius]	95% Horizontal Accuracy Radius	95% Vertical Accuracy Bound
0	No Integrity	Unknown	Unknown
1	HPL < 20 NM	HFOM < 10 NM	(Use Baro Pressure Altitude)
2	HPL < 10 NM	HFOM < 5 NM	(Use Baro Pressure Altitude)
3	HPL < 2 NM	HFOM < 1 NM	(Use Baro Pressure Altitude)
4	HPL < 1 NM	HFOM < 0.5 NM	(Use Baro Pressure Altitude)
5	HPL < 0.5 NM	HFOM < 0.25 NM	(Use Baro Pressure Altitude)
6	HPL < 0.2 NM	HFOM < 0.1 NM	(Use Baro Pressure Altitude)
7	HPL < 0.1 NM	HFOM< 0.05 NM	(Use Baro Pressure Altitude)
8	TBD	HFOM < 10 m	VFOM < 15 m
9	TBD	HFOM < 3 m	VFOM < 4 m
…	TBD	TBD	TBD

Old (DO-260) Design

NUC_P	Type Code in Airborne Position Message	Type Code in Surface Position Message	HPL, VPL (if known)	HFOM, VFOM (if HPL, VPL unknown)
0	0 or 18	0	Unknown	Unknown
1	17	Not used	HPL < 20 NM	HFOM < 10 NM
2	16	Not used	HPL < 10 NM	HFOM < 5 NM
3	15	Not used	HPL < 2 NM	HFOM < 1 NM
4	14	Not used	HPL < 1 NM	HFOM < 0.5 NM
5	13	Not used	HPL < 0.5 NM	HFOM < 0.25 NM
6	12	8	HPL < 0.2 NM	HFOM < 0.1 NM
7	11	7	HPL < 0.1 NM	HFOM < 0.05 NM
8	10	6	HPL < 25 m	HFOM < 10 m and VFOM < 15 m
9	9	5	HPL < 7.5 m	HFOM < 3 m and VFOM < 4 m
…	TBD	TBD	TBD	TBD

Problems with Old (DO-242) Design

- Accuracy bounds and integrity bounds are different, and are used for different purposes.
- Integrity bounds (HPL, VPL) are used in separation algorithms. They help to define how far apart two aircrafts' reported positions must be in order not to have a safety issue.
- Accuracy bounds (HFOM, VFOM) are used for alerting algorithms. They help to define how close aircraft may be before the pilot is alerted to pay attention to a possible intruder.
- But NUC_P sometimes specifies an accuracy limit (HFOM) and sometimes specifies an integrity limit (HPL).

Problems with Old (DO-242) Design

- Some applications are likely to need an accuracy bound (HFOM). If an aircraft announces $NUC_P = 1$, 2, 3, 4, 5, 6, or 7, these applications cannot be used with that aircraft, because HFOM is not specified for $NUC_P < 8$.
- Other applications are likely to need an integrity bound (e.g., HPL). If an aircraft announces $NUC_P =$ 8 or 9, these applications either cannot be used at all with that aircraft (because HPL is not specified) or must use an overly conservative accuracy radius.

Problems with Old (DO-260) Design

- A receiving ADS-B subsystem cannot tell whether the NUC_P value encoded in the message type code is based on an integrity bound (HPL) or a 95% accuracy bound (HFOM or EPU).
- Applications that need an integrity bound cannot be used, because the transmitting aircraft might have based its NUC_P value on HFOM, the 95% accuracy bound, rather than HPL.
- Applications that need an accuracy bound would be ill served by an integrity bound, because the integrity bound would be excessively large.

New (DO-242A) Approach

Split the NUC_P parameter into three new parameters:

- **NIC** (Navigation Integrity Code) – based on integrity bounds [e.g., HPL and VPL]
- **NAC_P** (Navigation Accuracy Code for position) – based on accuracy bounds [e.g., HFOM (or EPU) and VFOM)]
- **SIL** (Surveillance Integrity Level) – defines the level of integrity: the probability of being outside the NIC radius without equipment at the transmitting aircraft detecting that might be the case: 10^{-3}, 10^{-5}, or 10^{-7} per flight hour

ADS-B MASPS Changes

Old (DO-242)

NUC_P	Integrity	Accuracy
0	--	--
1	HPL < 20 NM	HFOM < 10 NM
2	HPL < 10 NM	HFOM < 5 NM
3	HPL < 2 NM	HFOM < 1 NM
4	HPL < 1 NM	HFOM < 0.5 NM
5	HPL < 0.5 NM	HFOM < 0.25 NM
6	HPL < 0.2 NM	HFOM < 0.1 NM
7	HPL < 0.1 NM	HFOM < 0.05 NM
8		HFOM < 10 m, VFOM < 15 m
9		HFOM < 3 m, VFOM < 4 m
…	TBD	TBD

New (DO-242A)

NIC	Integrity Containment Limits
0	--
1	R_C < 20 NM
2	R_C < 8 NM
3	R_C < 4 NM
4	R_C < 2 NM
5	R_C < 1 NM
6	R_C < 0.6 NM
7	R_C < 0.2 NM
8	R_C < 0.1 NM
9	R_C < 75 m, VPL < TBD
10	R_C < 25 m, VPL < TBD
11	R_C < 7.5 m, VPL < TBD

ADS-B MASPS Changes

Old (DO-242)

NUC_P	Integrity	Accuracy
0	--	--
1	HPL < 20 NM	HFOM < 10 NM
2	HPL < 10 NM	HFOM < 5 NM
3	HPL < 2 NM	HFOM < 1 NM
4	HPL < 1 NM	HFOM < 0.5 NM
5	HPL < 0.5 NM	HFOM < 0.25 NM
6	HPL < 0.2 NM	HFOM < 0.1 NM
7	HPL < 0.1 NM	HFOM < 0.05 NM
8		HFOM < 10 m, VFOM < 15 m
9		HFOM < 3 m, VFOM < 4 m
…	TBD	TBD

New (DO-242A)

NAC_P	Accuracy
0	--
1	EPU < 10 NM
2	EPU < 4 NM
3	EPU < 2 NM
4	EPU < 1 NM
5	EPU < 0.5 NM
6	EPU < 0.3 NM
7	EPU < 0.1 NM
8	EPU < 0.05 NM
9	EPU < 30 m, VFOM < 45 m
10	EPU < 10 m, VFOM < 15 m
11	EPU < 3 m, VFOM < 4 m

ADS-B MASPS Changes

New (DO-242A)

SIL	Probability of Exceeding Containment Bounds for NIC Without Being Notified
0	(No Integrity)
1	$< 10^{-3}$ per flight hour
2	$< 10^{-5}$ per flight hour
3	$< 10^{-7}$ per flight hour

Forward/Backward Compatibility

- Issues of compatibility between different versions of a data link MOPS need to be addressed.
- This has been addressed by WG-3 in developing DO-260A. (It's also described in the appendix of the WG-6 White Paper on NIC/NAC/SIL.)