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SIL and SDA Encoding Values
Revision 1

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Summary
This Working Paper addresses resolution of the final definitions of revised SIL language. SIL, SDA, and SIL Supplement are defined and discussed.

1. Introduction:

During the 6/17/2009 meeting several Action Items were generated to help finalize the definitions and formatting of SIL

2. Summary of Agreements:

a. The new, split, SIL values will be called

> **SIL**: Source Integrity Level. Defines the probability of exceeding the NIC containment radius
> **SIL Supplement**: Defines whether SIL is based on a per hour or per sample probability
> **SDA**: System Design Assurance: Defines the probability of an avionics failure causing false or misleading position information to be transmitted.

b. The **SIL** field will be a two bit field to be backwards compatible. A third field will be added to represent the per hour per sample differentiation. This field was named **SIL Supplement**.

c. SIL and NIC will be defined as a containment radius versus a containment region as SIL and NIC only apply to the horizontal.

d. We still have to find bits for SDA and SIL supplement.

3. Proposed Changes to DO-260A

2.2.3.2.7.1.1X Source Integrity Level (SIL)

The "SIL" (Source Integrity Level) subfield is a 2-bit ("ME" bits 45 and 46, Message bits 77 and 78) field that shall be used to define the probability of the reported horizontal position exceeding the containment radius defined by the NIC, without alerting, assuming no avionics faults. The SIL will address the Signal-in-Space (SIS), and will be the higher of the faulted or fault free probability of the Signal-In-Space causing the NIC containment radius to be exceeded.

> *Note: The faulted SIS case will represent the highest probability for GNSS position sources while the fault free SIS case will represent the highest probability for DME/DME or DME/DME/LOC position sources because the SIS is monitored and for IRU position sources because there is no SIS.*

The SIL probability can be defined as either per sample or per hour as defined in the SIL Supplement (SIL_{SUPP}) in Para 2.2.3.2.7.1Y.

The SIL subfield shall be encoded in accordance with Table 2-72, as specified in the Aircraft Operational Status Message. For installations where the SIL value is being dynamically updated, if an update has not been received from an on-board data source for SIL within the past 5 seconds, then the SIL subfield shall be encoded as a value of ZERO (0), indicating unknown.

> *Note: The SIL and NIC should be set to unknown if the ADS-B position source does not supply an output certified to provide an indication of the integrity of the reported position (e.g. such as HPL from GNSS systems.)*

SIL Value	Bit	Probability of exceeding the NIC containment radius
3	11	$\leq 1X10^{-7}$ Per Hour or Sample
2	10	$\leq 1X10^{-5}$ Per Hour or Sample
1	01	$\leq 1X10^{-3}$ Per Hour or Sample
0	00	$> 1X10^{-3}$ Per Hour or Sample or Unknown

Table 2-72

Recommendations for 260A Table 2-72 Change 2 Notes:

Note 1: Delete Entirely

Note 2: Change to:

The DO-242A definition of SIL has been updated in these MOPS. These updates will be incorporated in the next revision of the DO-242A.

Note 3: Delete Entirely

Note 4: Delete Entirely

Note 5: Delete Entirely

Note 6: Streamline to:

Implementers should not arbitrarily set the SIL to ZERO (0) just because SIL is not provided by the position source. Implementers should perform an off-line analysis of the installed position source to determine the appropriate SIL.

Historical DO-260A Change 2 Notes (For Reference):

1. The NIC parameter is broadcast partly in the TYPE subfield of the Airborne Position and Surface Position messages, and partly in the NIC supplement subfield of the Aircraft Operational Status Messages (2.2.3.2.7.2.6)

2. "An indication" may include, for example, a flag for invalid position reports or a change in NIC, or switching to another data source. See 2.1.2.15 of the ADS-B MASPS RTCA DO-242A for a more complete description of SIL.

3. The vertical integrity containment column only applies to NIC values greater than 8.

4. The SIL encoding is the most stringent of the horizontal or vertical values

5. At the time of publication of these MOPS, it is recognized that there are three possible derivations of SIL:

(a) the integrity value provided by the navigation sensors with self monitoring capability. (eg GPS)
(b) the reliability of aircraft systems given as indicated by a failure rate commensurate with the equipment design assurance
(c) the integrity of other navigation systems (e.g. RNP) that rely on ground based self monitoring equipment for integrity assurance, and for which no specific hourly integrity value can be ascribed.
These three values are not readily interchangeable. Selection of the largets of the values as specified in Table 2-72 is felt to provide a reasonable bound on the order of magnitude of the probability of possible failures affecting ADS-B applications. Future revisions of these MOPS may refine the SIL definition as more is understood.

6. Since the SIL is intended to reflect the integrity of the navigation source of the position information broadcast, the SIL value transmitted should be indicative of the true integrity of the ADS-B position data. A problem for installations that include currently available GNSS receivers and FMS systems is that SIL is not output by these systems. With a lack of SIL information being provided by the position source, implementers should not arbitrarily set a SIL value of ZERO (0) indicating unknown integrity. It is suggested, unless there is a tightly coupled navigation source where SIL can be unambiguously determined and set dynamically, that the ADS-B transmitting subsystem should provide for the static setting of SIL as part of the installation procedure. Most implementers are expected to determine SIL by off-line analysis of the installed configuration. This off-line analysis can be performed on the various primary and alternate means of determining the reported position. SIL is a static value for each of these configurations.

2.2.3.2.7.1.1Y Source Integrity Level Supplement (SIL_{SUPP})

The "SIL_{SUPP}" (Source Integrity Level Supplement) subfield is a 1-bit ("ME" bits A, Message bits C) field that shall define whether the reported SIL probability is based on a per hour probability or a per sample probability as defined in table 2.yy.

SIL Supplement	Bit	Basis for SIL Probability
1	1	Probability of exceeding NIC containment radius is based on per sample
0	0	Probability of exceeding NIC containment radius is based on per hour

Table 2.yy

• **Per Hour:** The probability of the reported geometric position laying outside the NIC containment radius in any given hour without an alert or an alert longer than the allowable time-to-alert. The per hour representation will typically be used when the probability of exceeding the NIC is greater for the faulted versus fault-free Signal-in-Space case. (When the SIS fault rate is defined as hourly)

Note: The probability of exceeding the integrity containment radius for GNSS position sources are based on a per hour basis, as the NIC will be derived from the GNSS Horizontal Protection Level (HPL) which is based on a probability of $1X10^{-7}$ per hour.

• **Per Sample**: The probability of a reported geometric position laying outside the NIC containment radius. The per sample representation will typically be used when the probability of exceeding the NIC is greater for the fault-free Signal-in-Space case or when the position source does not depend on a SIS.

Note: The probability of exceeding the integrity containment radius for IRU, DME/DME and DME/DME/LOC position sources may be based on a per sample basis.

2.2.3.2.7.1.13 System Design Assurance (SDA)

The "SDA" (System Design Assurance) subfield is a 2-bit ("ME" bits XX -YY, Message bits ZZ - TT) field that shall define the failure condition that the ADS-B system is designed to support as defined in Table 2.x.

The supported failure condition will indicate the probability of an ADS-B system malfunction causing false or misleading information to be transmitted. The definitions and probabilities associated with the supported failure effect are defined in AC 25.1309-1A, AC 23-1309-1C, and AC 29-2C. All relevant systems attributes should be considered including software and complex hardware in accordance with RTCA/DO-178B or RTCA/DO-254.

The ADS-B system includes the ADS-B transmission equipment, ADS-B processing equipment, position source, and any other equipment that processes the position data transmitted by the ADS-B system.

SDA Value	Bit	Supported Failure Condition Note 2	Probability of Failure causing transmission of False or Misleading Information Note 3,4	Software & Hardware Design Assurance Level Note 1,3
3	11	Hazardous	$\leq 1X10^{-7}$ Per Hour	B
2	10	Major	$\leq 1X10^{-5}$ Per Hour	C
1	01	Minor	$\leq 1X10^{-3}$ Per Hour	D
0	00	Unknown/ No safety effect	$> 1X10^{-3}$ Per Hour or Unknown	N/A

Table 2.x

Note 1: Software Design Assurance per DO-178B. Airborne Electronic Hardware Design Assurance per DO-254
Note 2: Supported Failure Classification defined in AC-23.1309-1C, AC-25.1309-1A, and AC 29-2C
Note 3: Because the broadcast position can be used by any other ADS-B equipped aircraft or by ATC, the provisions in AC 23-1309-1C that allow reduction in failure probabilities and design assurance level for aircraft under 6,000 pounds do not apply.
Note 4: Includes probability of transmitting false or misleading latitude, longitude, velocity, or associated accuracy and integrity metrics.