INTRODUCTION:

Based on past ADS-B testing at the Louisville airport, the traffic accuracy and integrity requirements for ASSA/FAROA in the ASA MASPS (RTCA DO-289) are causing a majority of ADS-B equipped ground traffic to be either degraded or not displayed. Ground traffic situational awareness applications should consider lower thresholds in-order to accommodate the current ADS-B equipage of aircraft. Considering lower thresholds will result in more ground traffic on the CDTI display enhancing ground situational awareness and therefore improving safety and confidence in the system. This evaluation will analyze the performance requirements needed for ground traffic situational awareness without compromising (improving) safety and performance. The criteria used for the evaluation are (1) current ADS-B equipage of aircraft and (2) safety implications of misleading position relative to airport map elements (e.g. runways, taxi-ways, etc).

CURRENT REQUIREMENTS FOR ASSA/FAROA:

Table 1 represents the current traffic accuracy and integrity requirements for ASSA/FAROA. Based on an approximate traffic distribution at Louisville, about 80% of all ADS-B equipped aircraft are either invalid (not displayed) or degraded. Note: The following traffic NAC_P, NIC, and SIL values were derived from their reported NUC_P values (DO-260 Ver. 0 reports). The majority of aircraft that have a $NAC_P \geq 9$ are from UPS aircraft that are equipped with WAAS GPSs; therefore, other locations (away from UPS's main hub in Louisville) may have even less valid ground traffic.

Table 1: Current Requirements for ASSA/FAROA

Accuracy Thresholds:

All SDF Traffic%	60%								20%	20% (2/3 are UPS with WAAS)		
CDTI Symbol	Invalid (Not Displayed)								Degraded	Valid		
NAC_P (95%)	0	1	2	3	4	5	6	7	8	9	10	11
	10 NM	4 NM	2 NM	1 NM	0.5 NM	0.3 NM	185.2 m	92.6 m	30 m	10 m	3 m	

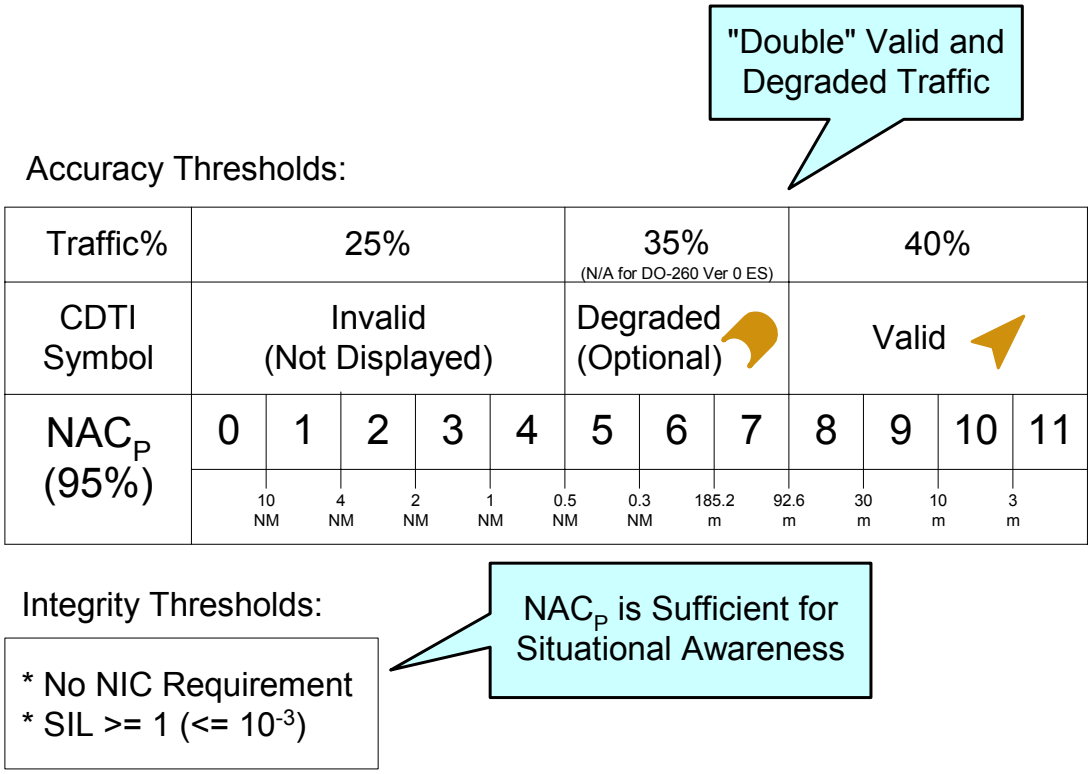
Integrity Thresholds:

All SDF Traffic%	80%									20% (2/3 are UPS with WAAS)		
CDTI Symbol	Degraded									Valid		
NIC	0	1	2	3	4	5	6	7	8	9	10	11
	20 NM	8 NM	4 NM	2 NM	1 NM	0.6 NM	370.4 m	185.2 m	75 m	25 m	7.5 m	
SIL	0									>=1 (<=10^{-3})		

PROPOSED REQUIREMENTS FOR ASSA/FAROA:

A $NAC_P \geq 8$ (< 92.6 m) is an acceptable threshold to accurately identify the location of traffic overlaid an airport map. Table 2 contains acceptable accuracy and integrity requirements for ground traffic situational awareness. These applications are for basic situational awareness and do not involve separation or spacing. NAC_P (95% confidence) should be sufficient (no need for NIC) for situational awareness purposes; but ground applications that consider alerting may require more stringent requirements since crew action may be required. These new thresholds should double the amount of valid traffic displayed on the CDTI. If degraded traffic is considered, then 30% more traffic can be displayed for situational awareness. Unfortunately, traffic that transmits values of NAC_P between 5 and 7 are most likely due to old GPS installations that assume Selective Availability (SA) on. Also, ground traffic that have a $NAC_P < 8$ (equivalent to $NUC_P < 7$) will be considered equal to 0 since DO-260 (Version 0) surface position squitters don't encode below an inferred NAC_P value of 8. Only DO-260A (Version 1) transponders are capable of transmitting NAC_P values below 8 for ground traffic. ADS-B traffic with a $NAC_P < 5$ most likely are not equipped with GPS position sources. A SIL ≥ 1 (≤ 10^{-3}) is suitable for ground traffic situational awareness applications that are considered as a fault category of Minor.

Table 2: Proposed Requirements for Ground Traffic Situational Awareness



EVALUATION:

The following sections contain the performance evaluation for ground traffic situational awareness.

Current ADS-B Equipage of Aircraft:

Figure 1 shows a NAC_P sample of ADS-B equipped aircraft on 8/16/07 & 8/22/07 at Louisville airport (SDF). The majority of this sample is from aircraft that transmit NUC_P therefore these inferred NAC_P values were derived per DO-260A.

The outer rings in Figure 1 represent the traffic accuracy/integrity states based on the new proposed requirements for ground traffic situational awareness.

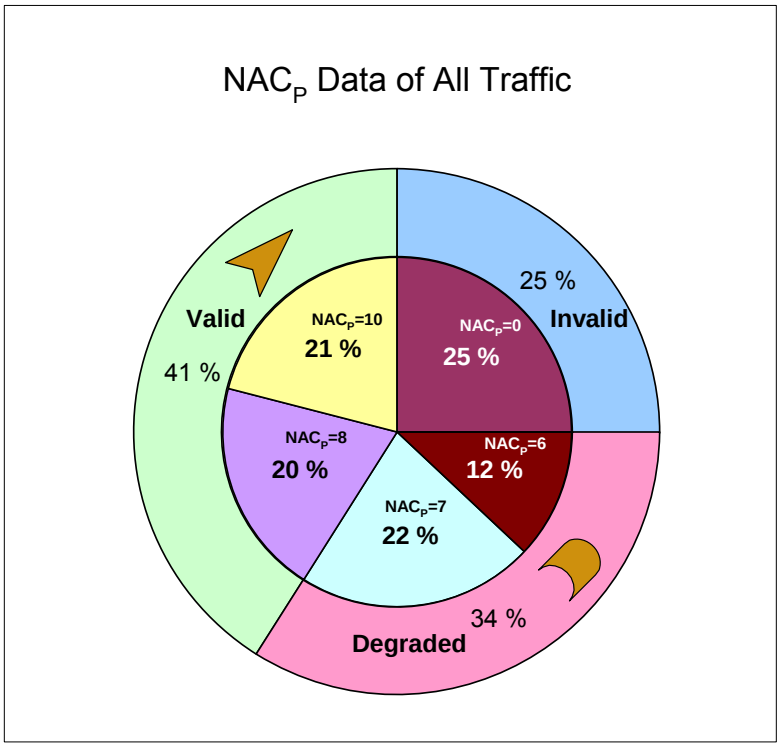


Figure 1: NAC_P Data of Traffic at SDF (with New Proposed Requirements)

The majority of installations that don't meet the performance criteria are due to non-augmented GPSs that assume Selective Availability (SA) on or due to installations that get their positions from sources such as FMS that don't provide quality/integrity metrics.

A sample of a popular MMR GPS that assumes SA on reported HPLs between 131 – 465 meters (NIC = 6 - 8). Two other popular GPSs with SA on that we sampled had similar results. The government has turned SA off for a number of years now; therefore, the quality and integrity values from GPSs that still assume that SA is on may be over conservative up to a factor of 5.

Unfortunately, ground traffic that have a NIC < 8 (equivalent to NUC_P < 7) will be considered equal to 0 since surface position squitters don't encode below a NIC value of 8. Table 3 shows what would be typically transmitted for ground traffic based on these HPL levels. Note: Many current DO-260 (Version 0) transponders with GPS SA on transmit inferred values of NIC and NAC_P of 8 because they are based on HFOM which have values much less than HPL. Transponders that use HPL will have potential issues with GPS SA on installations.

Table 3: Surface Position NIC & NAC_P Values

HPL	Type Code for (Surface Position Message)	NIC (Gnd Traffic)	DO-260 (Ver 0) NAC_P (Gnd Traffic)
< 7.2 m	5	11	11
< 25 m	6	10	10
< 185.2 m	7	8	8
≥ 185.2 m	8	0	0

Allowing traffic with a NAC_P = 8 (< 92.6 m) would double the amount of valid traffic displayed on the CDTI improving situational awareness.

Safety Implications of Misleading Position:

Since aircraft are overlaid an airport map, GPS position errors need to be considered which may lead to misleading aircraft positions relative to airport map elements such as runways and taxiways. This evaluation will consider the probability that an aircraft could be misinterpreted as being on either a runway or a taxiway. Also the safety implications will be evaluated if an aircraft's position was misinterpreted on the airport map.

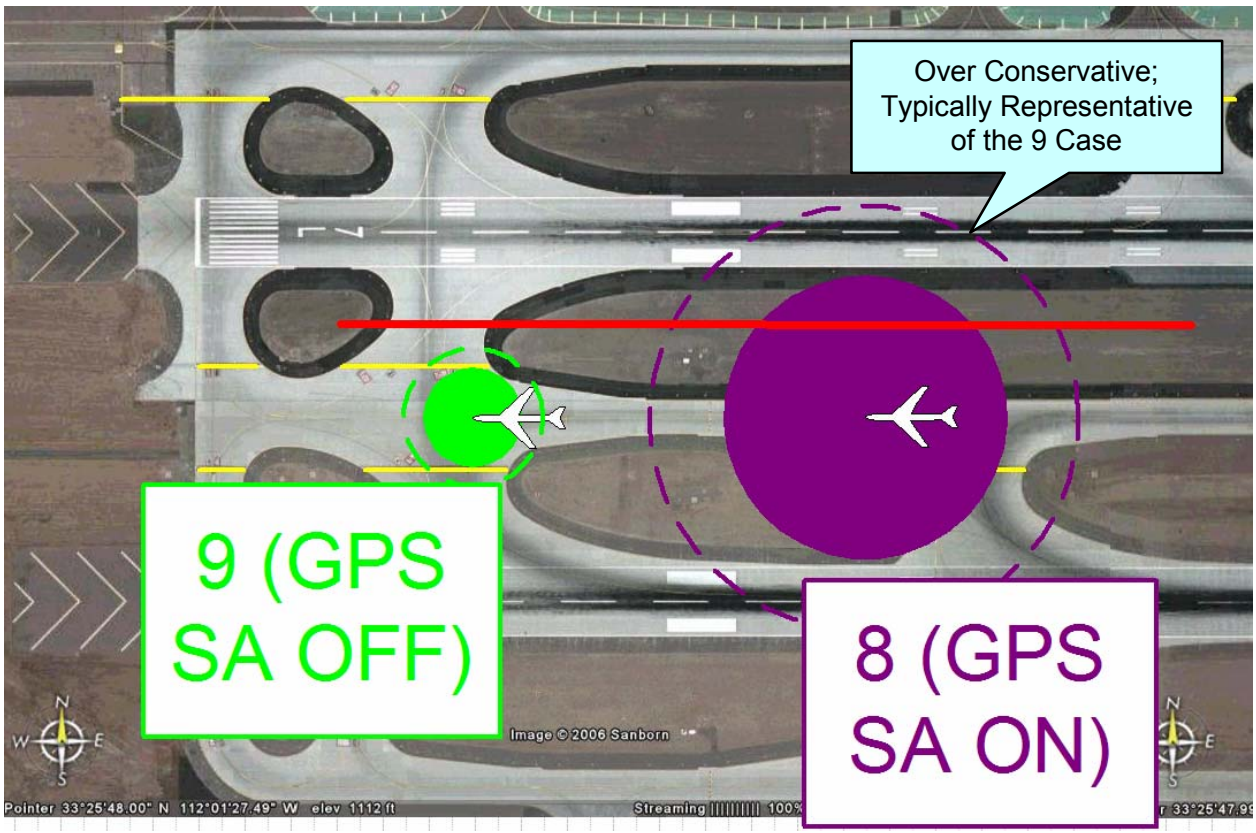


Figure 2: Position Uncertainty

Figure 2 illustrates circles of position uncertainty for aircraft with typical NACp values for non-augmented GPS sensors that assume either Selective Availability (SA) is on and off. A drawn to scale photo of a portion of Phoenix Sky Harbor airport (KPHX) is used with 150ft wide runways and runway centerlines separated by 800ft.

The solid inner circle reflects the accuracy error of 95% probability based on the aircraft's reported NACp value. The dashed ring represents an estimated 10^{-3} probability based on the given NACp and assuming a Rayleigh type of distribution. The red line represents the halfway point between the runway and taxiway.

With an accuracy error of NACp = 8 (95% containment), there is a chance that the aircraft may be past the halfway point between the runway and taxiway, but not on the runway. There is a 10^{-3} probability that the aircraft may be misinterpreted as being on the runway.

With an accuracy error of NACp = 9 (95% containment) and a 10^{-3} probability, the aircraft will not be past the halfway point between the runway and taxiway; and will not be misinterpreted as being on the runway.

Aircraft with accuracy errors of NACp = 8 typically have GPSs that are still accounting for SA being on which is over conservative since the government has turned SA off for a number of years. Therefore, aircraft reporting a NACp = 8 most likely have accuracy errors similar to those that have a NACp = 9. Our flight test experience at Louisville airport has also verified that these aircraft are being shown right on the center line of the runways and taxiways. NACp values below 8 should be considered invalid or degraded since the probability of misleading position is much higher even with GPS sources that assume SA is on.

These applications are for basic situational awareness and do not involve separation or spacing. The flight crew is still responsible for out-the-window acquisition of other traffic and airport elements (e.g. see and avoid) and should not rely solely on the supplemental display information. Ground traffic situational awareness provides an effective means to aid the flight crew in the out-the-window visual scan and correlation of other traffic and airport elements. In an event of a misleading aircraft position on the airport map, the following safety implications are considered ("potential operational consequences" of surface movement per DO-289 ASA MASPS):

1. Surface collision: The flight crew is still responsible for out-the-window acquisition of other traffic and should not rely on the display. The display is intended to actually reduce surface collisions by providing prior awareness of potential collisions and the potential for creating a surface collision due to misleading traffic positions should be very minimal with the new proposed quality/integrity thresholds. Additionally, the flight crew maintains vigilance to see and avoid of all traffic per current procedures.

2. Leaving prepared surface: The flight crew is still responsible for out-the-window acquisition of other traffic and should not rely on the display. The display should actually improve and supplement the flight crew's judgment before leaving the prepared surface.

3. Erroneous maneuvers: The flight crew is still responsible for out-the-window acquisition of other traffic and should not rely on the display. The flight crew must not maneuver solely based on the display information but they must use the information in a supplemental manner to their existing safe movement procedures. The flight crew performs cross checking with other information sources (e.g. visual out the window, paper maps, electronic charts, and controller). Also, there is a limitation to not use the display for navigation purposes (e.g. Placard or AFM).

4. Increased work load (confusion/distraction): The flight crew is expected to visually scan out-the-window for other traffic with a cross check on the display. Flight crew work load can be reduced by seeing other traffic prior to visually acquiring the aircraft but must not be used as a primary means of acquiring aircraft. The supplemental display information is intended to improve the flight crew's surface movement efficiency and the potential for creating confusion or distraction due to misleading traffic positions should be very minimal with the new proposed quality/integrity thresholds.

The display of misleading information on an aerodrome moving map display is considered a minor failure condition (see references below).

1. AC 120-86, Section 5.3: For Airborne systems that are developed only for enhanced traffic awareness operations, the failure condition classification for misleading information is considered "minor".

2. TSO-165, Section 3.b.: Malfunctions resulting in display of misleading information used on the airport surface (ground applications) are considered a minor failure.

3. RTCA DO-257A Section 2.1.8: The display of misleading information on an aerodrome moving map display is considered a minor failure condition.

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