

ADS-B Avionics Check

Explanation of Data Associated with ADS-B Compliance Reports



Flight Standards Service

Aircraft Maintenance Division (AFS-300)

Avionics Branch (AFS-360)

October, 2014

Background - ADS-B Avionics Check

The purpose of the ADS-B Avionics Check is to provide requesting aircraft owners, operators, and maintainers with an additional method of verifying proper operation and performance of ADS-B equipment required by 14 CFR §91.225. Requests for ADS-B Avionics Checks are processed in the order received with results provided electronically (pdf) in the form of a Compliance Report (CR).

The purpose of this document is to provide information to aid in the interpretation of data associated with a CR. CR data provides information on the performance of an aircraft's ADS-B system for a specific flight and will either verify proper ADS-B system operation or identify specific functions/parameters of the system which failed to meet established standards. ADS-B function/parameter failures identified within a CR may be useful to aircraft and avionics maintainers when performing fault isolation and troubleshooting of ADS-B systems.

14 CFR §91.227 specifies the avionics performance required for operation in the airspace identified in §91.225 after January 1, 2020. However, ATC and other ADS-B IN equipped aircraft will use your ADS-B Out data whenever the system is transmitting. Therefore, aircraft with ADS-B Out systems installed prior to January 1, 2020 and compliant to TSO-C166b and/or TSO-C154c must maintain the required avionics performance standards associated with the system's intended function (ref. 14 CFR §23.1301 and §23.1309) once installed and used (transmitting).

Note: The FAA does not provide certification of portable ADS-B transmitters/transceivers and the data quality and integrity of these units are unknown. Per FAA policy, all portable ADS-B transmitters/transceivers must be configured to transmit a SIL = 0 (zero) to prevent their data from being processed by ATC and other ADS-B In equipped aircraft.

Questions related to information provided within ADS-B Compliance Reports should be directed to the FAA Flight Standards Service, Aircraft Maintenance Division Avionics Branch (AFS-360) via email at the following address: 9-AWA-AFS-300-ADSB-AvionicsCheck@faa.gov

ADS-B Compliance Report (CR) Explanation

Page 1: Provides information about the aircraft, registered owner, flight identification, and a high-level overview of the ADS-B avionics performance observed during the associated flight.



U.S. Department of Transportation Federal Aviation Administration ADS-B Compliance Monitor

ADS-B Aircraft Operation Compliance Report

ICAO: 12345678

Tail Number: N123Y

Flight Id: ABC123

Period: 10-02-2014 00:34:04 to 10-02-2014 01:42:52

Aircraft: 1986 - Rutan Model 76 Voyager (w/o winglets)

Year - Make / Model

Non-Compliance Issues Identified

Items high-lighted in red within this report indicate the ADS-B Out system installed on this aircraft failed to meet the corresponding performance requirement as specified in § 91.227. Prior to January 1, 2020, the owner/operator must take action to correct identified system performance deficiencies as soon as practical. After January 1, 2020, system performance issues must be corrected prior to operation of the aircraft in the airspace specified in §91.225. Requests for authorization to deviate from §91.225 to support movement of the aircraft to effect ADS-B Out system repairs and testing may be made to the appropriate ATC facilities per §91.225(g).

	Analysis	Exceptions
Airborne 1090	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Surface 1090	<input type="checkbox"/>	<input type="checkbox"/>
Surface RWY/Taxi 1090	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Airborne UAT	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Surface UAT	<input type="checkbox"/>	<input type="checkbox"/>
Surface RWY/Taxi UAT	<input checked="" type="checkbox"/>	<input type="checkbox"/>

The Compliance Monitor collects and displays aircraft data in the following categories:

1. Airborne & Data Link 1090
2. Surface & Data Link 1090
3. Surface RWY/Taxi & Data Link 1090
4. Airborne & Data Link UAT
5. Surface & Data Link UAT
6. Surface RWY/Taxi & Data Link UAT

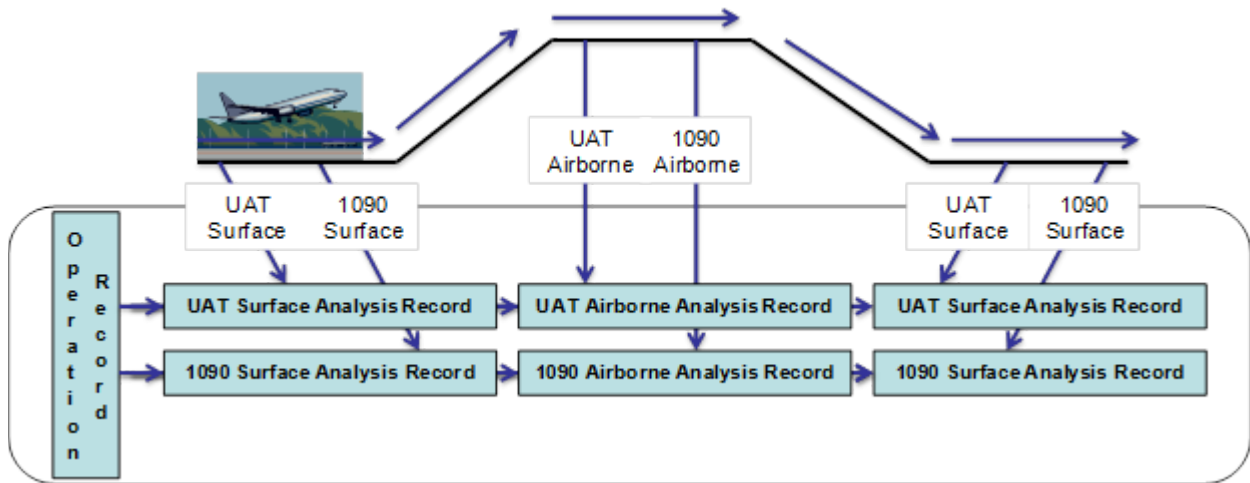


Illustration of how data is collected in operation and analysis records

Non-Compliance Issues are divided into 4 major categories:

1. **Required Message Elements Checks:** 14 CFR §91.227 (d) specifies 19 message elements that must be broadcast by ADS-B Out avionics. Note that §91.227(d) (9) is only broadcast when identifying an emergency. This box will be checked if applicable message elements are missing.
2. **Integrity and Accuracy Checks:** 14 CFR §91.227(c) identifies ADS-B Out performance requirements for NIC/NACp/NACv/SDA/SIL. This box will be checked if avionics performance fails to meet specified requirements.
3. **Kinematics:** The Compliance Monitor performs reasonableness checks on changes in Baro/Geo altitude, position, and velocity. This box will be checked if changes in these parameters were outside that for normal aircraft performance.
4. **Other Checks:** The Compliance Monitor checks certain parameters for values outside an expected range and fields that are improperly formatted (ICAO address, Mode 3A, emitter category, etc).

Note: It is not the FAA’s intent to assess avionics performance on the surface of airports not listed in §91, Appendix D due to inherent multipath interference within these environments. Therefore, the Compliance Monitor is configured to omit surface data (as reported by ADS-B avionics) from its compliance assessment analysis at these locations. An ADS-B installation with issues in determining proper air/ground state will increase the likelihood of a non-compliant report with red flags associated with Missing Ele and Int & Acc compliance categories for approximately 3-5% of the total flight operation. When possible, aircraft exhibiting issues with air/ground determination will be identified in responses to requests for ADS-B avionics compliance checks.

Page 2: Provides an Operation Summary for the associated flight

Operation Summary			
Operation Id:	1A2B	Start Time:	10-02-2014 00:34:04
ICAO Reported:	ABCDE (12345678)	End Time:	10-02-2014 01:42:52
ICAO Assigned:	ABCDE (12345678)	Duration (s):	01:08:48
Tail Number:	NXYXY	Total Reports:	43202
Country:	United States - Civil		
<hr/>			
Detection:	<input checked="" type="checkbox"/> Airborne <input type="checkbox"/> Surface	Service Area(s):	<input checked="" type="checkbox"/> Western <input type="checkbox"/> Central <input type="checkbox"/> Eastern
Service Volume Initial:	166 - Los Angeles		
Service Volume Final:	214 - John Wayne-Orange County Surface		
<hr/>			
Link Version:	2	Out Capability:	DUAL
Flight Id:	NXYXY	In Capability:	DUAL
Operator:		<input type="checkbox"/> Military	
Exceptions:	Airborne 1090 in rule airspace <input type="checkbox"/>	<input type="checkbox"/> Anonymous	
	Airborne 1090 <input checked="" type="checkbox"/> Surface 1090 <input type="checkbox"/>	Airborne UAT in rule airspace <input type="checkbox"/>	
		Airborne UAT <input checked="" type="checkbox"/> Surface UAT <input type="checkbox"/>	

Operation Id: Number assigned to the flight operation by the Compliance Monitor.

Start/End time: The start and stop time of the flight as observed by ground monitoring.

Reported ICAO: The 24 bit ICAO address transmitted from the aircraft.

Assigned ICAO: Each aircraft has a unique 24 bit address assigned during registration. However, it is possible for an aircraft to operate in an Anonymous mode where it sends out a randomly generated 24 bit address. The Compliance Monitor uses the Assigned ICAO field to record and report the unique ICAO address for that aircraft. If the aircraft is not operating in Anonymous mode, the Compliance Monitor will put the 24 bit address received from the aircraft in both the Reported and Assigned ICAO address fields. If the aircraft is operating in Anonymous mode only the Reported ICAO address field will be populated.

Duration: Duration of the monitored flight in hours, minutes & seconds.

Total reports: Number of ADS-B downlinks transmitted during monitoring.

Tail Number: The N-number associated with the aircraft registration.

Country: Country associated with aircraft registration.

Detection: Flight mode(s) where aircraft was monitored (airborne and/or on the surface).

Service area(s): FAA ADS-B service area(s) where aircraft was monitored.

Service Volume Initial/Final: Location of initial and final service volumes where aircraft was monitored.

Link Version: Link version of ADS-B transmitter. A "2" indicates rule compliant versions (i.e., TSO-C166b or TSO-C154c).

Out Capability: Data link used i.e., 1090, UAT and/or Dual.

In Capability: Indication of ADS-B receive capability i.e., 1090, UAT and/or Dual.

Military/Anonymous: Military flight or ADS-B system transmitting in anonymous mode.

Flight Id: Flight identification number (must match flight plan if filed) transmitted.

Operator: Aircraft operator information when available.

Exceptions: Boxes are marked if exceptions were found.

<i>Aircraft Summary</i>			
Type Aircraft: Fixed-Wing Single Engine		Type Engine: Reciprocating	
Certification: Type Certified		Airworthiness Date: 12/01/1986	
Cert Date: 05/24/1986	Expiration 05/31/2020	Classification: Standard	
Make: RUTAN		Year: 1986	
Model: 76 Voyager		Serial: Long Flight	
<hr/>			
Type Registration: Individual			
Owner: MR. SMITH SONIAN			
Street: INDEPENDENCE AVE			
Street:			
City: WASHINGTON DC		State: DC	Zip: 20560

Aircraft Summary Information obtained from FAA Registry is summarized in above table

Page 3 through end of report: Provides Information on the ADS-B System: Message Elements; Integrity & Accuracy; Kinematics; and Other checks for each of the Data Link and Airborne/Surface categories where applicable.

Airborne 1090 Analysis Summary

Start Time: 10-02-2014 00:34:09 **End Time:** 10-02-2014 01:40:05
Duration (s): 01:05:55 **Processed Reports:** 2341 **Total Reports:** 20047

Service Volume Initial: 2007 - Southern California TRACON CTV
Service Volume Final: 2007 - Southern California TRACON CTV

Link Version: 2 **Out Capability:** 1090 **In Capability:** UAT
Emitter Category: 1 - Light (<15,500lbs) **Antenna(s):** 1 - Single **SILsupp:** 0 - Per Hour
Flight Id: N171L Vert Velocity Baro
Mode 3A: 0204 Vert Velocity Geo
Exceptions:

Rule	Miss Ele	Int \ Acc	Kin	Other	NIC	NACp	NACv	SIL	SDA
Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No

Class A	Class B	Class C	Class D	Class E	Part91AppD
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Missing Elements

Category	NACp	NACv	Vel	Baro Alt	Geo Alt	Flight Id	Mode 3A	Emit Cat
% Fail	0.73%	0.04%	0.13%	0.00%	0.26%	0.17%	0.17%	0.17%
Max dT(s)	00:03:52	00:00:00	00:00:00	00:00:00	00:00:29	00:00:03	00:00:03	00:00:03
MCF	6	1	1	0	3	3	4	3

Start/End time: The start and stop time the flight was observed by ground monitoring.

Duration: Duration of the monitored flight in hours, minutes & seconds.

Processed Reports: Number of ADS-B downlinks processed by ATC automation.

Total Reports: Number of ADS-B downlinks transmitted during monitoring.

Service Volume Initial/Final: Location of initial and final service volumes where aircraft was monitored.

Link Version: Link version of ADS-B transmitter. A “2” indicates rule compliant versions (i.e., TSO-C166b or TSO-C154c).

Out Capability: Data link used i.e., 1090 and/or UAT

In Capability: Indication of ADS-B receive capability.

Emitter Category: Indication of the aircraft size/weight (ref. AC 20-165).

Antenna(s): Indication of the number of antenna installed.

SILsupp: SILsupp calculated on a per-hour or per-sample basis.

Flight Id: Flight identification number transmitted.

Mode 3A: Mode 3A code transmitted.

Vert Velocity Baro/Geo: Method used to provide the aircraft’s vertical velocity (barometric/geodetic)

Exceptions:

Rule/Miss(ing) Element/Integrity/Accuracy/Kinematics/Other values: Indication that ADS-B system met or did not meet (red) the corresponding requirement.

NIC/NACp/SIL/SDA value: Percentage of operation that ADS-B system met the corresponding performance requirement. Note: Reference [AC 20-165A](#) for detailed information on these parameters.

Missing Elements: Missing elements will be highlighted in red by category.

% Fail: Percentage of flight that corresponding element failed to be transmitted.

Max dT(s): Maximum time period the element was missing.

Maximum Consecutive Failures (MCF): Maximum consecutive messages in which the element was missing.

Integrity & Accuracy

Category	NIC	NACp	NACv	SIL	SIL Sup	SDA	NIC_SVT	NACp_SVT	Val	eVAL	eVal NIC
% Fail	100.00%	100.00%	100.00%	100.00%	0.00%	0.73%	100.00%	100.00%	0.00%	0.00%	0.00%
Max dT(s)	00:57:16	00:57:09	00:57:16	00:57:16	00:00:00	00:03:52	00:57:16	00:57:09	00:00:00	00:00:00	00:00:00
MCF	2341	2324	2340	2341	0	6	2341	2324	0	0	0

Category	NIC	NACp	NACv	SIL	SDA
Avg	0.0	0.0	0.0	1.0	2.0
Min	0	0	0	0	0
Max	0	0	0	1	2

Integrity & Accuracy: Failed Integrity & Accuracy categories will be highlighted in red.

Upper Table:

% Fail: Percentage of operation that corresponding category element failed requirements.

Note: *If using an uncertified GPS (or portable transmitter) the system must report as SIL = zero and result in a 100% Fail in the SIL category box above.*

VAL: Validation is the process of performing a check on whether or not the position information reported in an ADS-B Message from a particular aircraft could reasonably have been transmitted from the reported location. Validation processing is optional for the ADS-B Service. When the option is exercised, the ADS-B Service will perform validation processing. The Compliance Monitor will flag exceptions for aircraft where the ADS-B Service is reporting validation errors.

eVAL: Enhanced Validation is an independent check of the ADS-B reported position that is used to support avionics compliance monitoring. This check is made to a tighter tolerance than the “standard” validation described above. Due to the tighter tolerance requirement, Enhanced Validation airspace is limited to that within 15 NM of operational terminal radar sensors. The Compliance Monitor will flag exceptions for aircraft where the ADS-B Service is reporting enhanced validation errors.

NIC_SVT, NACp_SVT & eVal NIC: Not relevant to compliance until mandate.

Lower Table:

Average/Minimum/Maximum NIC/NACp/NAVv/SIL/SDA values transmitted.

Kinematics

	Baro Alt	Baro Alt Δ	Geo Alt	Geo Alt Δ	Velocity	Position Δ
% Fail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MCF	0	0	0	0	0	0

Kinematics: The Compliance Monitor performs a reasonableness check on changes in Baro/Geo Altitude, Position, and Velocity. Items highlighted in red were identified with parameter changes outside the range of normal aircraft performance. MCF = Maximum Consecutive Failures.

Other Checks

	Link Version	Emitter Cat	Flight ID	Mode 3A
% Fail	0.00%	0.00%	0.00%	0.39%
MCF	0	0	0	6

	ICAO Duplicate	Anonymous	UAT Only above 18K
% Fail	0.00%	0.00%	0%
Max dT (s)	00:00:00	00:00:00	00:00:00
MCF	0	0	0

Other Checks:

Upper table:

The Compliance Monitor will identify a percentage (total operation) and the maximum consecutive failures that ADS-B avionics failed to broadcast these message elements.

Lower table:

ICAO Duplicate - The CM performs a check of all active US flights to determine if the ICAO address being broadcast is also being broadcast by another aircraft. If so, % Fail, Max dT(s) and MCF are included.

Anonymous: Percentage, time (in seconds), and MCF associated of the operation that the ADS-B system was operated in anonymous mode.

Distribution Tables: The following distribution tables provide a percentage of operation for the corresponding parameter value and the number of downlinks associated with that value.

Distributions

NIC - Horizontal Containment Bound

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unkn	< 20NM	< 8NM	< 4NM	< 2NM	< 1NM	< .6NM	< .2NM	< .1NM	< 75m	< 25m	< 7.5m	XXX	XXX	XXX	XXX
100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NACp - 95% Horizontal Accuracy Bound (EPU)

NA	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	$\geq 10\text{NM}$	$< 10\text{NM}$	< 4NM	< 2NM	< 1NM	< .5NM	< .3NM	< .1NM	$< .05\text{NM}$	< 30m	< 10m	< 3m	XXX	XXX	XXX	XXX
0.7%	99.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
17	2324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NACv - 95% Horizontal Velocity Error

NA	0	1	2	3	4	5	6	7
	$\geq 10\text{m/s}$	< 10m/s	< 3m/s	< 1m/s	< .3m/s	Reserved	Reserved	Reserved
0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	2340	0	0	0	0	0	0	0

SIL - Source Integrity Level

0	1	2	3
$> 1 \times 10^{-3}$	$\leq 1 \times 10^{-3}$	$\leq 1 \times 10^{-5}$	$\leq 1 \times 10^{-7}$
0.7%	99.3%	0.0%	0.0%
17	2324	0	0

SILs - SIL Supplement

0	1
/Hour	/Sample
100.0%	0.0%
2341	0

SDA - System Design Assurance

0	1	2	3
$> 1 \times 10^{-3}$	$\leq 1 \times 10^{-3}$	$\leq 1 \times 10^{-5}$	$\leq 1 \times 10^{-7}$
0.7%	0.0%	99.3%	0.0%
17	0	2324	0

GVA - Geometric Velocity Accuracy

0	1	2	3
>150m	$\leq 150\text{m}$	$\leq 45\text{m}$	Reserved
100.0%	0.0%	0.0%	0.0%
2341	0	0	0

Validation

0	1	2	3
Unknown	Invalid	Reserved	Valid
0.3%	0.0%	0.0%	99.7%
8	0	0	2333

Enhanced Validation

0	1	2	3
Unknown	Invalid	Reserved	Valid
84.7%	0.0%	1.2%	14.1%
1983	0	27	331

NIC Baro

0	1	2	3
Not XCheck	X Check	Reserved	Reserved
0.4%	99.6%	0.0%	0.0%
9	2332	0	0

SQL - Signal Quality Level

Category	0	1	2	3	4	5	6	7
1090 ES	≤ -90dBm	≤ -87dBm	≤ -84dBm	≤ -81dBm	≤ -78dBm	≤ -72dBm	≤ -66dBm	> -66dBm
UAT	≤ -96dBm	≤ -93dBm	≤ -90dBm	≤ -87dBm	≤ -84dBm	≤ -78dBm	≤ -72dBm	> -72dBm
	1.2%	1.7%	2.8%	3.5%	8.4%	22.0%	18.9%	41.5%
	28	40	66	82	196	516	442	971