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Public ADS-B Performance Report (PAPR) User Guide

Background

The purpose of the Public ADS-B Performance Report (PAPR) is to provide aircraft owners, operators, and avionics installers/maintainers with an additional method of verifying proper operation of ADS-B Out equipment.

The purpose of this User's Guide is to provide information to aid in the interpretation of data associated with a PAPR and to provide general guidance to help resolve avionics issues identified within a PAPR.

PAPR data provides information on the performance of an aircraft's ADS-B system for a specific flight. It will verify proper ADS-B system operation or identify specific parameters received by the NAV CANADA's system which failed to comply with established standards. ADS-B system performance data identified within a PAPR may be useful to aircraft avionics maintainers when performing post-installation compliance/configuration checks and fault isolation.

A PAPR is typically available on the NAV CANADA website two hours after flight termination. After a PAPR request has been submitted, the user will receive an acknowledgement email within a few minutes. Once the request has been completed, the user will receive a second email within 60 minutes containing the PAPR report. If the time period provided in the request covers multiple flights (legs), separate reports will be provided for each of the flight. The time period should not exceed one day.

Version 2.0 - December 2023

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Example of a PAPR

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Public ADS-B Performance Report | Rapport public sur le rendement de l'ADS-B

This report outlines the performance of ADS-B Out equipment installed on aircraft. Find more information on NAV CANADA's website.

Le présent rapport décrit la performance de l'équipement ADS-B émission dont est doté un aéronef. Consulter le site Web de NAV CANADA pour obtenir des détails.

Operation Summary | Résumé des opérations

ICAO 24-bit address **Adresse 24 bits de l'OACI**	C06921	Aircraft Registration Immatriculation d'aéronef	C-GNVC	Report Date Date du rapport	2023-09-07 15:37
Request ID ID de demande	PAPR- 0001835	Req Start Time Heure de début de la demande	2023-07-10 17:50 Z	Req End Time Heure de fin de la demande	2023-07-10 23:30 Z
Duration Durée	05:26:44	Detect Start Time Heure de début de détection	2023-07-10 17:59 Z	Detect End Time Heure de fin de détection	2023-07-10 23:26 Z
# of Reports Nombre de rapports	4314	Link Version Version de liaison	[2]	Emitter Category Catégorie d'émetteur	2
Flight ID ID de vol	NVC201	Baro Alt (ft) Altitude barométrique (pieds)	-100 - 36025	PUI – 5 seconds (%) PUI – 5 secondes (%)	96

Integrity and Accuracy | Intégrité et exactitude

Category | Catégorie	NIC	NACp	SIL	SDA
% Fail | Échec (%)	0	0	0	0
MCF	0	0	0	0
Average | Moyenne	7.99	10	3	2
Minimum	7	8	3	2
Maximum	8	11	3	2
Acceptable	Yes	Yes	Yes	Yes

Missing Elements | Éléments manquants

Category | Catégorie	Flight ID | ID de vol	Mode 3A	Baro Alt | Altitude barométrique	Geo Alt | Altitude géographique
% Missing | Manquant (%)	0.41724618	0	0	0

Public ADS-B Performance Report
Rapport public sur le rendement de l'ADS-B

Flight ID Validation | Validation de l'ID de vol

Category Catégorie	Invalid Character Caractère invalide	Intervening Spaces Espaces d'intervention	All Spaces Tous les espaces	Blank Char Caractère vide	Word Test Mot d'essai	Word XPDR Mot XPDR	Character N Caractère N	ICAO Address Adresse de l'OACI
% Fail | Échec (%)	0	0	0	0	0	0	0	0
MCF	0	0	0	0	0	0	0	0
Acceptable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note : Items marked as not acceptable within this report indicate the ADS-B Out Equipment installed on this aircraft failed to meet the corresponding performance requirement as specified in CARS#551.103.

For more information on this report, reference the User's Guide.

For more information, please contact NAV CANADA customer service.

Nota : Les éléments marqués comme non acceptables dans le présent rapport indiquent que l'équipement de l'ADS-B émission installé sur l'aéronef en question n'a pas satisfait aux exigences de performance correspondantes, comme le stipule le RAC 551.103.

Pour obtenir de plus amples renseignements sur ce rapport, consulter le guide d'utilisation.

Communiquer avec le Service à la clientèle de NAV CANADA pour obtenir plus de renseignements.

PAPR Explanation

Operational Summary

The Operation Summary section provides general information of the user request and the corresponding detected flight.

Operation Summary | Résumé des opérations

ICAO 24-bit address **Adresse 24 bits de l'OACI**	C06921	Aircraft Registration Immatriculation d'aéronef	C-GNVC	Report Date Date du rapport	2023-09-07 15:37
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# of Reports Nombre de rapports	4314	Link Version Version de liaison	[2]	Emitter Category Catégorie d'émetteur	2
Flight ID ID de vol	NVC201	Baro Alt (ft) Altitude barométrique (pieds)	-100 - 36025	PUI – 5 seconds (%) PUI – 5 secondes (%)	96

ICAO 24-bit address	The 24-bit ICAO address (hexadecimal format) received from the aircraft.
Aircraft Registration	The aircraft registration associated with the aircraft's 24-bit ICAO address. Only provided for Canadian registered aircrafts.
Report Date	Date and Time (UTC) of the creation of the report.
Request ID	Request ID assigned by the PAPR service, associated to the user request for future reference.
Req Start Time	Start Date/Time (UTC) of the requested flight.
Req End Time	End Date/Time (UTC) of the requested flight.
Duration	Duration (hours:minutes:seconds) of the detected flight .
Detect Start Time	Date/Time (UTC) of the first detection.
Detect End Time	Date/Time (UTC) of the last detection.
# of Reports	Number of ADS-B target reports received for the detected flight in Asterix CAT21 format. Asterix CAT21 is a specification for surveillance data exchange used by air navigation service providers.
Link Version	Link version of the ADS-B transmitter.
Emitter Category	Emitter category of the aircraft.
Flight ID	Last Flight Identification code received. The Flight ID should be identical to the aircraft call sign used during the flight.
Baro Alt (ft)	The minimum and maximum Barometric Pressure altitude reported by the aircraft.
PUI – 5 seconds (%)	The Probability of Update for an Interval (PUI) is the probability of generating a valid Target Report during the defined Update Interval (5 seconds) where the Target Report has derived the target position from at least one detection occurring within the Update Interval as defined in EUROCAE's ED-129B.

Integrity and Accuracy

The Integrity and Accuracy section provides integrity and accuracy values detected throughout the flight. Failure to meet the minimum requirement will result in the ADS-B data being unusable for air traffic control.

Integrity and Accuracy | Intégrité et exactitude

Category | Catégorie	NIC	NACp	SIL	SDA
% Fail | Échec (%)	0	0	0	0
MCF	0	0	0	0
Average | Moyenne	7.99	10	3	2
Minimum	7	8	3	2
Maximum	8	11	3	2
Acceptable	Yes	Yes	Yes	Yes

% Fail	Percentage of the flight the corresponding category element failed performance assessment.
MCF	Maximum number of consecutive received ADS-B (Asterix CAT21) messages in which the element failed performance assessment.
Average	Average value of the corresponding category element.
Minimum	Minimum value of the corresponding category element.
Maximum	Maximum value of the corresponding category element.
Acceptable	Assessment of the category element.
NIC	Navigation Integrity Category
NACp	Navigation Accuracy Category for Position
SIL	Surveillance or Source Integrity Level
SDA	Horizontal Position System Design Assurance Level

Missing Elements

The Missing Elements section provides statistics of missing elements.

Missing Elements | Éléments manquants

Category | Catégorie	Flight ID | ID de vol	Mode 3A	Baro Alt | Altitude barométrique	Geo Alt | Altitude géographique
% Missing | Manquant (%)	0.41724618	0	0	0

% Missing	Percentage of the flight the corresponding category element was missing.
Flight ID	Flight identification
Mode 3A	Mode 3A – SSR Code
Baro Alt	Barometric altitude
Geo Alt	Geometric altitude

Flight ID Validation

The Flight ID Validation section provides details of errors in the Flight ID.

Flight ID Validation | Validation de l'ID de vol

Category Catégorie	Invalid Character Caractère invalide	Intervening Spaces Espaces d'intervention	All Spaces Tous les espaces	Blank Char Caractère vide	Word Test Mot d'essai	Word XPDR Mot XPDR	Character N Caractère N	ICAO Address Adresse de l'OACI
% Fail | Échec (%)	0	0	0	0	0	0	0	0
MCF	0	0	0	0	0	0	0	0
Acceptable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

% Fail	Percentage of the flight the corresponding category element failed validation assessment.
MCF	Maximum number of consecutive received ADS-B (Asterix CAT21) messages in which the element failed validation assessment.
Acceptable	Assessment of the category element.

Invalid Character	Flight ID with an Invalid character
All Spaces	Flight ID with eight spaces
Blank Char	Flight ID with an intervening space
Word Test	Flight ID containing the word TEST
Word XPDR	Flight ID containing the word XPDR
Character N	Flight ID containing the letter N followed with seven spaces
ICAO Address	Flight ID containing the ICAO 24-bit address

Guidance for PAPR Not Acceptable Elements

Element	Possible Causes
Integrity and Accuracy	
NIC, NACp, SIL and SDA (100% not acceptable)	Component and/or software compatibility with position source Improper system configuration
NIC, NACp, SIL and SDA (partial not acceptable)	Intermittent loss of GNSS service Antenna masking caused by maneuvering Portion(s) of flight in areas where ADS-B coverage may not be available Component software issue
Missing Element	
Flight ID (100% Missing)	Flight ID not configured in avionics or Flight ID transmit is inhibited

Flight ID (partial Missing)	Portion(s) of flight in areas where ADS-B coverage may not be available
Mode 3A	Mode 3/A code input device not providing data
Baro Alt	Loss of data from barometric pressure altitude source (encoder)
Geo Alt	Loss of geometric altitude data from GPS
Flight ID Validation	
Flight ID incorrect	Flight ID not properly entered

Terms Description

Field Name	Description
Emitter Category	Identification of aircraft characteristics: 0 = No ADS-B Emitter Category Information 1 = light aircraft <= 15500 lbs 2 = 15500 lbs < small aircraft <75000 lbs 3 = 75000 lbs < medium a/c < 300000 lbs 4 = High Vortex Large 5 = 300000 lbs <= heavy aircraft 6 = highly manoeuvrable (5g acceleration capability) and high speed (>400 knots cruise) 7 to 9 = reserved 10 = rotocraft
Link Version	Identification of the link version. CAR 551.103 requires version 2

<table>
<tr><td></td><td>0 = DO-260

1 = DO-260A

2 = DO260B</td></tr>
<tr><td>NACp</td><td>Navigation Accuracy Category for Position is used to indicate the accuracy of the aircraft horizontal position being transmitted.

CAR 551.103 requires a minimum value of 8. NACp values of <8 will be flagged as not acceptable within PAPR when the % Fail threshold is exceeded.

<table>
<tr><th colspan="2">Coding</th><th>95% Horizontal Accuracy Bounds (EPU)</th><th>Comment</th></tr>
<tr><th>(Binary)</th><th>(Decimal)</th><th></th><th></th></tr>
<tr><td>0000</td><td>0</td><td>EPU ≥ 18.52 km (≥10 NM)</td><td>Unknown accuracy</td></tr>
<tr><td>0001</td><td>1</td><td>EPU < 18.52 km (10 NM)</td><td>RNP-10 accuracy</td></tr>
<tr><td>0010</td><td>2</td><td>EPU < 7.408 km (4 NM)</td><td>RNP-4 accuracy</td></tr>
<tr><td>0011</td><td>3</td><td>EPU < 3.704 km (2 NM)</td><td>RNP-2 accuracy</td></tr>
<tr><td>0100</td><td>4</td><td>EPU < 1852 m (1 NM)</td><td>RNP-1 accuracy</td></tr>
<tr><td>0101</td><td>5</td><td>EPU < 926 m (0.5 NM)</td><td>RNP-0.5 accuracy</td></tr>
<tr><td>0110</td><td>6</td><td>EPU < 555.6 m (0.3 NM)</td><td>RNP-0.3 accuracy</td></tr>
<tr><td>0111</td><td>7</td><td>EPU < 185.2 m (0.1 NM)</td><td>RNP-0.1 accuracy</td></tr>
<tr><td>1000</td><td>8</td><td>EPU <92.6 m (0.05 NM)</td><td>e.g., GPS (with SA on)</td></tr>
<tr><td>1001</td><td>9</td><td>EPU < 30 m</td><td>e.g., GPS (SA off)</td></tr>
<tr><td>1010</td><td>10</td><td>EPU < 10 m</td><td>e.g., WAAS</td></tr>
<tr><td>1011</td><td>11</td><td>EPU < 3 m</td><td>e.g., LAAS</td></tr>
<tr><td>1100</td><td>12</td><td>Reserved</td><td></td></tr>
<tr><td>1101</td><td>13</td><td>Reserved</td><td></td></tr>
<tr><td>1110</td><td>14</td><td>Reserved</td><td></td></tr>
<tr><td>1111</td><td>15</td><td>Reserved</td><td></td></tr>
</table>
</td></tr>
</table>

NIC

Navigation Integrity Category is used to indicate the radius of containment around the aircraft. CAR 551.103 requires a minimum value of 7. NIC values of <7 will be flagged as not acceptable within PAPR when the % Fail threshold is exceeded.

NIC Value	Radius of Containment (R_C)	Airborne			Surface		
		Airborne Position TYPE Code	NIC Supplement Codes		Surface Position TYPE Code	NIC Supplement Codes	
			A	B		A	C
0	R_C unknown	0, 18 or 22	0	0	0, 8	0	0
1	R_C < 20 NM (37.04 km)	17	0	0	N/A	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	0	N/A	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	1	N/A	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	0	N/A	N/A	N/A
5	R_C < 1 NM (1852 m)	14	0	0	N/A	N/A	N/A
6	R_C < 0.6 NM (1111.2 m)	13	1	1	8	0	1
	R_C <0.5 NM (926 m)	13	0	0	N/A	N/A	N/A
	R_C < 0.3 NM (555.6 m)	13	0	1	8	1	0
7	R_C < 0.2 NM (370.4 m)	12	0	0	8	1	1
8	R_C < 0.1 NM (185.2 m)	11	0	0	7	0	0
9	R_C < 75 m	11	1	1	7	1	0
10	R_C < 25 m	10 or 21	0	0	6	0	0
11	R_C < 7.5 m	9 or 20	0	0	5	0	0
12	Reserved						
13	Reserved						
14	Reserved						
15	Reserved						

SDA

System Design Assurance is used to indicate the failure condition that the position transmission chain is designed to support.

CAR 551.103 requires a minimum value of 2. SDA values of <2 will be flagged as not acceptable within PAPR when the % Fail threshold is exceeded.

SDA Value		Supported Failure Condition	Probability of Undetected Fault causing transmission of False or Misleading Information	Software & Hardware Design Assurance Level
(decimal)	(binary)			
0	00	Unknown / No safety effect	> $1x10^{-3}$ per flight hour or Unknown	N/A
1	01	Minor	≤ $1x10^{-3}$ per flight hour	D
2	10	Major	≤ $1x10^{-5}$ per flight hour	C
3	11	Hazardous	≤ $1x10^{-7}$ per flight hour	B

SIL

Source Integrity Level is used to indicate the probability of the transmitted horizontal position exceeding the radius of containment defined by the NIC.

CAR 551.103 requires a minimum value of 3. SIL values of <3 will be flagged as not acceptable within PAPR when the % Fail threshold is exceeded.

SIL Coding		Probability of Exceeding the NIC Containment Radius (R_C)
(Binary)	(Decimal)	
00	0	Unknown or > 1×10^{-3} per flight hour or per sample
01	1	≤ 1×10^{-3} per flight hour or per sample
10	2	≤ 1×10^{-5} per flight hour or per sample
11	3	≤ 1×10^{-7} per flight hour or per sample

Troubleshooting

Result variations for different flights

ADS-B systems typically operate on the 1090 MHz radio frequency band. This frequency is a critical aviation resource shared by various aeronautical systems, each designed for a slightly different purpose. When multiple transmissions occur simultaneously on 1090 MHz, some of those transmissions may not always be able to reach the intended recipients due to the resulting frequency congestion. The various surveillance services deployed by air navigation service providers take this potential congestion into account.

NAV CANADA deploys surveillance services that are commensurate with different requirements within specific airspace volumes, understanding that not all airspaces require the same services. For example, terminal airspace service enables smaller separations specifically targeted for use in areas surrounding busier airports, with the expectation that aircraft are to be closely spaced at the minimum prescribed separation for efficiency purposes. By their nature, these applications anticipate airspace to be busy and therefore the airspace has the requirement for redundant ATS surveillance systems, that ensure safety of operations at all times.

Outside of busy terminal airspace and the associated aircraft traffic, the capability for full time aircraft position monitoring, tracking and alerting remains both preferential and optimal for medium and lower density enroute airspace. For that reason, the deployment of a satellite solution to ensure all aircraft are detectable while operating over Canada's vast and diverse geographical area brings significant value in air traffic management and safety for operators in Canadian Domestic Airspace.

Surveillance technologies in use by NAV CANADA include:

- Primary Surveillance Radar (PSR)
- Secondary Surveillance Radar (SSR)
- Ground Based Automatic Dependent Surveillance Broadcast (ADS-B)
- Space Based ADS-B
- Wide Area Multilateration (WAM)

These sources are fed into a surveillance data processing system which uses algorithms that actively applies weighting which is assigned to each sensor report for its contribution to the position displayed to the air traffic controller, based on accuracy and integrity.

SSR, ADS-B, and WAM all rely on 1090 MHz, and the number of transmissions on that frequency at any given time is dependent on the number of systems actively responding to interrogations, and the number of aircraft in a given region. ADS-B transmits a message twice per second regardless of being interrogated. Due to the combination of these transmissions in congested airspace, the 1090 MHz band can experience a degradation in performance when:

- Transponders are interrogated beyond their capability (due to the number of, or configuration of, interrogating systems)
- There are too many transmissions on the frequencies (number of aircraft)

- There are unexpected transmissions on the frequencies (e.g., non-surveillance “noise”)

Frequency congestion on 1090 MHz can potentially result in a degradation of aircraft surveillance, and the need to deploy additional surveillance sensors to be able to maintain the required level of performance.

To support Canada’s ADS-B Mandate, NAV CANADA partnered with Aireon to develop a Public ADS-B Performance Report, referred to as ‘PAPR’, which provides an assessment of the operating status of ADS-B transponders in aircraft during flights across Canadian airspace. The system uses space-based ADS-B data to generate the performance report.

To manage the significant amount of data that ADS-B transmits, and still deliver the required statistical analysis, PAPR uses four second throttled data to generate the report and acts as a tool to aid in the trending of aircraft performance.

Due to the congestion on 1090 MHz and the large coverage area of the Aireon satellites’ receivers, aircraft that fly in congested areas are likely to experience variations in PAPR report parameters. Congestion on 1090 MHz cannot be fully mitigated, therefore to receive consistent PAPR reports, aircraft would need to fly outside 1090 MHz congested areas, or alternatively flying at off-peak hours in the normally congested areas can also help to minimize impact on PAPR reports.

A specific measurement that PAPR looks to report on, and which is impacted by the frequency congestion, is the Probability of Update Interval (5 seconds) – PUI(5); which can be used to trend over time whether an aircraft’s performance is consistently meeting that reporting standard. While flying in airspace experiencing congestion, PUI(5) will be impacted due to the additional loss of data at the satellite’s receivers, which will impact the overall PUI.

NAV CANADA ensures safety and efficiency of airspace in areas that experience 1090 MHz congestion through the use of the multiple sensor types stated above, however when seeking ADS-B performance reports from PAPR, aircraft operators should consider the impact of congestion on the 1090 MHz frequency band.

1090 Mhz Congestion can be seen in the figure below: