DAP / ADD Handbook

Guidelines for use of DAP/ADD in ATS

Operational Excellence Program – WST 13.6 and 01.07

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1. INTRODUCTION

1.1. DOCUMENT SCOPE AND OBJECTIVE

The present document is a deliverable of the Operational Excellence Programme (OEP) Work Stream 13.6 Harmonised Downlinked Aircraft Parameters and Work Stream 01.07 Utilisation of Mode S DAP/CAP. It includes guidance material and recommendations to support the implementation of the use of Downlinked Aircraft Parameters (DAP) and Aircraft Derived Data (ADD). The recommendations provided in the document have to be adapted to the local environment and characteristics. Local safety and performance analysis should be performed to validate that the recommendations are applicable to the local environment.

This document covers the aircraft parameters downlinked through mode S, named Downlinked Aircraft Parameters (DAP), and the aircraft parameters downlinked through ADS-B, named Aircraft Derived Data (ADD). For many data items it is the same information in both DAP and ADD, however there are also differences. In order to ease the readability of the document, the term DAP is used in the other sections of the document to refer to both DAP and ADD.

1.1.1. Operational benefits associated to the use of the daps

The possible ATS operational benefits and targets associated with the implementation of the DAPs are assessed separately for each DAP, in Chapter 2. From a general perspective the following kind of ATC operational benefits can be expected from the use of DAPs:

- Easier monitoring of compliance with ATC clearance reducing workload for both ATCO and pilots.
- Detection of pilot read back errors, based on crosscheck between the DAP provided value and the issued instruction (e.g., erroneous flight level selection).
- Reduction of air-ground voice or data communication, e.g., the availability of DAPs reduce the need for ATC to make a request to the flight crew to report the speed, Mach number or heading, before issuing an ATC instruction.
- Improved situational awareness for the ATCO.

It is noted that DAPs support many additional use cases and provides related benefits in areas such as safety nets, weather, tracking etc.

1.2. DOCUMENT STRUCTURE

Chapter 1 includes the introduction of the document.

Chapter 2 is structured per data item, for which each data item it includes description of scenarios, usage analysis, guidance material, and recommendations for operational use of DAPs.

ANNEX A Includes guidance material for the detection of incorrect DAP values at the CWP.

ANNEX B Includes guidance material for handling of rounding errors.

ANNEX C Includes description of the logical model assumed for the derivation of the recommendations.

ANNEX D Includes an overview of the DAPs.

ANNEX E Includes ANSP feedback regarding performance requirements for IAS, MHDG and SAL.

Definitions and Abbreviations

1.3. DEFINITION OF TERMS

Alert	Alert is a stimulus displayed on ATCO interface in case of detection of an abnormal situation. Alert requires an acknowledgment from the ATCO, contrary to indication (see definition below).
TCO interface option	"ATCO interface option" is used in this document to designate the options of the ATCO interface that will allow the ATCO to activate or de-activate the display of a given DAP. This activation / deactivation of the display can be done for one flight on the ATCO interface (track specific) or for all flights on the ATCO interface (global)
Barometric Pressure Setting	Barometric Pressure Setting is a parameter provided by the aircraft through ADS-B and mode S transponder. This parameter reflects the Barometric Pressure Setting set by the pilot in the aircraft.
Cruise Climb	An aeroplane cruising technique resulting in a net increase in altitude as the aeroplane mass decreases. This kind of procedure is mainly used in oceanic airspace. ATC need to protect all intermediate levels above the current altitude to the cleared upper limit.
Indicated Air Speed	Indicated Air Speed is a parameter provided by the aircraft through mode S transponder and conditionally through ADS-B version 3. This parameter reflects the actual Indicated Air Speed of the aircraft.
Indication	Indication is a stimulus displayed on ATCO interface in case of detection of an abnormal situation. Indication is only for information and does not require an acknowledgment from the ATCO, contrary to alert.
Level	Level is a generic term relating to the vertical position of an aircraft in flight and meaning variously, height, altitude, or flight level.(Ref. ICAO Annex 2)
Mach Number	Mach Number is a parameter automatically sent by aircraft through mode S transponder. This parameter reflects the actual Mach Number of the aircraft.
Magnetic Heading	Magnetic Heading is a parameter provided by the aircraft through mode S transponder and conditionally through ADS-B version 3. This parameter reflects the actual Magnetic Heading of the aircraft.
Selected altitude	Selected altitude is a parameter provided by the aircraft through ADS-B and mode S transponder. This parameter reflects the value selected by the pilots on the Mode Control Panel / Flight Control Unit (MCP / FCU) or equivalent equipment.
Situation Display	Situation display. An electronic display depicting the position and movement of aircraft and other information as required.
Warning	Warning is a generic term used in this document to refer either to alert or indication (defined above). For each use case the needed level of stimulus should be assessed locally.

Abbreviation	Definition
ADD	Aircraft Derived Data
APM	Approach Path Monitor
ATCO	Air Traffic Controller
BPS	Barometric Pressure Setting
CAP	Control Access Parameter
CFIT	Controlled Flight Into Terrain
CWP	Controller Working Position
DAP	Downlinked Aircraft Parameters
FISO	Flight Information Service Officer
HMI	Human Machine Interface
IAS	Indicated Airspeed
ISA	International Standard Atmosphere
MCP / FCU	Mode Control Panel / Flight Control Unit
MHDG	Magnetic Heading
MSAW	Minimum Safe Altitude Warning
SAL	Selected Altitude
SFL	Selected Flight Level
STCA	Short Term Conflict Alert

1.4. REFERENCES

[RD 1] EUROCONTROL - EUROCONTROL Specification for ATM Surveillance System Performance – ESASSP, edition: 1.3, March 2021

[RD 2] ICAO - Procedures for Air Navigation Services – Air traffic management, ICAO PANS-ATM (Doc 4444), edition: 16 Amendment 10, November 2021, or later.

[RD 3] EUROCONTROL Guidelines – Operational Use of Downlink Airborne Parameters -High Level Considerations, EUROCONTROL Edition Number : 1.0, November 2012

[RD 4] ICAO - Technical Provisions for Mode S Services and Extended Squitter, Doc 9871, edition: 2, 2012, or later.

[RD 5] EUROCAE - Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground System –ED-129B, March 2016

[RD 6] EUROCAE - MOPS for Secondary Surveillance Radar Mode S Transponders – ED-73F, December 2020

[RD 7] EASA - EUROCAE Study: Cooperative Surveillance DAPs/Registers, EASA.2016.FC19 SC.002, edition: 1.0, July 2017

[RD 8] EUROCONTROL –Use of Downlink Aircraft Parameters and aircraft derived data – SPR, DRAFT edition: 1.4 , September 2020 (pending publication)

2. GUIDANCE AND RECOMMENDATIONS

The recommendations provided in the document have to be adapted to the local environment and characteristics. Local safety and performance analysis should be performed to validate that the recommendations are applicable to the local environment.

The procedures defined in this document are intended to be applicable for DAP-equipped aircraft. As such, the DAP related recommendations are only applicable for DAP-equipped aircraft for which the DAP item is used operationally.

2.1. INDICATED AIRSPEED AND MACH NUMBER

2.1.1. Scenario description

Although IAS and Mach Number are two different downlinked parameters, they are described together within the same scenario because the content and sequence of ATCO and Flight Crew actions during speed control are the same, regardless of expressing the speed as IAS in knots or as Mach Number.

The IAS and Mach are used in horizontal speed control of aircraft. Usually, speed control is achieved by issuing speed adjustment instructions to the aircraft, when necessary to establish and/or maintain a desired separation minima or spacing between two or more aircraft.

The Indicated Air Speed (IAS) and Mach Number (Mach) are automatically received through the surveillance processing system and presented to the ATCO on a situation display at the CWP. The IAS or Mach may be selected for display by the ATCO (global or track specific selection) or by default (always displayed and not selectable by the ATCO), as decided and prescribed by the ANSP. The display option depends on the intended use. However, for the purpose of these guidelines, it is assumed that the DAP IAS/Mach is systematically used in the assessment to determine the need for speed control instead of pilot's report. Consequently, this parameter should be readily accessible to the ATCO[1].

As both IAS and Mach are downlinked (via mode S) from the aircraft at all altitudes and no information is provided by the aircraft on which parameter is currently being flown, the rules specified in PANS-ATM should be used in the settings of the ATS system to determine which of the two parameters will be displayed to the ATCO:

a) Except where otherwise approved by the competent authority, speed is expressed in:
   i) Mach Number at or above 7 600 m (FL 250), where speed adjustments are expressed in multiples of 0.01 Mach.
   ii) IAS (knots) below 7 600 m (FL 250), where speed adjustments are expressed in multiples of 10 kt based on IAS.
b) Within TMA airspace speed is always expressed in IAS (knots).
c) Display of both parameters may also be acceptable.

ATCO should refrain from issuing speed instructions expressed in increments from the current speed of the aircraft, this is because the speed reference for controller and pilot might be different. Speed instructions should therefore be given to a specific speed in multiples of 10 kts or in multiples of 0.01 Mach e.g., INCREASE SPEED TO 180 KNOTS.

The following sequence of actions is performed by the ATCO and the Flight Crew:

a) The ATCO reads the current downlinked IAS or Mach to determine the appropriate speed adjustment to be issued to an aircraft (increase, maintain or reduce) without asking the Flight Crew to report the current speed of the aircraft.

[1] E.g. when IAS/Mach is only used for situational awareness as an information that still requires a pilot's report before applying a speed control, the display of it can be optional.

b) The ATCO issues the speed adjustment instruction to the aircraft and enters the assigned IAS/Mach in the system (ATCO HMI or paper strip). Speed adjustments are limited to those necessary to establish and/or maintain a desired separation minimum or spacing (usually about up to 20-30 kt/Mach 0.05). If the speed adjustment is too large or goes beyond certain values e.g., below 250 kt for turbojet aircraft during initial descent from cruising level, prior acceptance of a pilot is required.
c) The Flight Crew reads back the speed instruction, assigned by ATCO, and adjusts the speed accordingly (IAS or Mach).
d) The ATCO listens to the readback to ascertain correct acknowledgement of assigned speed by the flight crew.
e) The aircraft speed is expected to evolve towards the assigned IAS/Mach Number.
f) When the IAS/Mach DAP is used for checking compliance with an ATC instruction, the implementation should pursue an automated system (see however technical consideration IAS-MACH-REC-14 below) to detect discrepancies between the assigned speed and the IAS/Mach DAP. When a discrepancy is detected, the system issues a warning to the ATCO. In such cases, the ATCO contacts the Flight Crew to verify the speed flown and to obtain the reason for non-compliance (e.g., turbulence penetration), or to ensure compliance with the assigned speed.
g) When the discrepancy in point f) above is caused by the pilot's error, the pilot will readjust to comply with the assigned speed.
h) When the observed discrepancy in point f) above is not the result of pilot non-compliance and the actual speed flown is compliant with the assigned speed (while the IAS/Mach DAP differs from it), and unless the discrepancy is caused by a nuisance warning, the ATCO will not rely on the DAP value and will initiate steps to report the corrupted DAP to the technical department.

2.1.2. Benefits

The expected benefits of the operational use of the IAS /Mach Number are:

- Improved accuracy in assessment of speed difference between aircraft.
- Improved understanding of the spacing evolution between aircraft (closing/increasing rate).
- Reduction of air-ground voice or data communication, when ATC does not request the flight crew to report IAS/Mach, before issuing an ATC instruction to adjust the speed.
- Improved situational awareness.
- Early detection of discrepancies between the assigned and the flown speed.
- Support improved calculation of wind direction and speed by the ground systems.
- Improved accuracy of trajectories calculation.

2.1.3. Performance

Extraction parameter

The IAS and Mach number are available as follows:

Table 1 IAS and MACH availability and Transmission rates

Availability and Transmission rates					
Data Item	Mode S	ADS-B v2	ADS-B v2 Tx Rates	ADS-B v3	ADS-B v3 Tx Rates
IAS	Yes	No*	-	Yes	2.2 s
Mach Number	Yes	No	-	No	-

* IAS is defined in the ADS-B v2 protocol. However, due to the prioritisation of data items, it is not provided by the aircraft under nominal conditions.

The resolution of the values transmitted in the surveillance chain for the IAS and Mach number are indicated in the following table:

Table 2 IAS and MACH value resolution

Resolution							
Data Item	Mode S	ADS-B v2	ADS-B v3	ASTERIX CAT048	ASTERIX CAT020	ASTERIX CAT021	ASTERIX CAT062
IAS	1 Knot	-	1 Knot	1 Knot	1 Knot	2^{-14} NM/s ~0.22knots	1 Knot
Mach Number	0.004	-	-	0.004	0.004	0.001	0.008

Constraints

European ANSPs reported that due to resolution constraints in ASTERIX CAT062 (having a resolution of 0.008), the use of Mach Number is not ideal, but is still usable The following example illustrates the issue; a value of M0.754 set in the aircraft, this is downlinked as M0.756 (due to the downlink resolution) and encoded in CAT062 as M0.760 (due to the CAT062 resolution) and finally displayed as M0.76 (due to display configuration) while the expected shown value is M0.75.

2.1.4. Data item usage analysis

Performance requirements

The ADD-SPR document [RD 8] describes performance requirements related to the maximum delay between the interface D1 and G of the logical model defined in the ANNEX C. These performance requirements are applicable to the use of IAS /Mach Number with the ATCO consistency check, in high-traffic density and high-traffic complexity environment. The use of DAP in lower-traffic density or lower-traffic complexity environment might be less demanding in terms of performance and need to be assessed locally by ANSPs.

Table 3 IAS and MACH update delay requirements

UPDATE DELAY	
Environment	Value
En Route	14s @ 90%
TMA	6s @ 90%

2.1.5. Operational considerations

An ATCO using surveillance for the provision of ATC normally uses the ground speed of the aircraft under their control to predict closing range and the potential need for corrective actions. However, instructions issued to the pilot must be expressed in terms of IAS/Mach as aircraft operating limits are based on IAS/Mach and flight crews operate their aircraft within the limits given by their aircraft flight envelope. Issuing speed restrictions directly in terms of Mach Number or IAS would facilitate a pilot to determine whether the imposed speed restriction can be complied to.

Observing IAS/Mach DAP enables ATCO to assess speed difference between the aircraft. Operationally speed differences are compared at the same level (or similar levels, not more than 3000 feet of difference).

IAS/Mach may be used:

a. To facilitate coordination and transfer of inbound and outbound traffic.
b. To apply horizontal speed control within the sector.

A tolerance for displaying the discrepancy warning between assigned speed and IAS/Mach DAP to ATCO should be implemented in ATS system to allow enough time for the Flight crew to apply the changes of the speed. The delay to reach the assigned speed will vary depending on the aircraft performance, on the difference between current speed and assigned speed and on the altitude of the aircraft. Normally, the difference between current speed and assigned speed are more significant and take place more often in APP environment, because of the ATCO establishing and maintaining an approach sequence. Also, the Flight crew and the aircraft will perform better in reaching assigned speed at lower altitudes, unlike at higher altitudes in ACC environment where aircraft performance envelop is limited and there is a less need for ATCO to assign speed instruction with significant difference from current speed. When querying a discrepancy between the assigned speed and the IAS/Mach DAP value the air traffic controller must avoid using the value of the IAS/Mach DAP in the radiotelephony, as this may create confusion and lead to an undesired outcome.

IAS-MACH -REC-1. *The reliability of IAS and Mach DAP information displayed at CWP should be validated with the aim to enable ATCO to consider IAS/Mach DAP as equivalent to pilot´s report.*

IAS-MACH -REC-2. *The ATM system should provide for a meaningful display of IAS or Mach for an aircraft that complies with the operational use of IAS or Mach within the volume of the airspace concerned. E.g. display IAS below FL250 and Mach above FL250.*

IAS-MACH -REC-3. *In order to support use of downloaded IAS/Mach in monitoring compliance with ATC instruction and to maintain the identified benefits, the ATM system should provide for an automated system to detect discrepancies between assigned speed and IAS/Mach DAP and issue warnings to ATCO.*

IAS-MACH -REC-4. *When prescribed in local procedures, the downlinked IAS and Mach number displayed on air situation display at CWP should be considered by ATCO as equivalent to pilot´s report.*

IAS-MACH -REC-5. *Local procedures should prescribe the ATCO actions in case of detected discrepancy between assigned speed and displayed IAS/Mach value.*

IAS-MACH -REC-6. *When ATCO queries a discrepancy between the displayed IAS and the assigned speed, the ATCO will not state the value of the IAS observed on the situation display in the radiotelephony.*

IAS-MACH -REC-7 *When the speed value reported by the pilot differs from the displayed DAP value, the pilot report shall take precedence over displayed DAP value.*

IAS-MACH -REC-8. *Unless the discrepancy between displayed IAS/Mach and the aircraft speed reported by the pilot is caused by a pilot error, local procedures should establish a clear reporting mechanism for ATCO to ensure the information about the corrupted DAP value reaches a relevant technical department, as well as a decision process and criteria to stop using DAP for an individual aircraft concerned, an aircraft type or for all aircraft.*

IAS-MACH -REC-9. *When the loss of DAP IAS/Mach has been identified, i.e. no data displayed in the IAS/Mach field, ATCO should revert to a traditional application of horizontal speed control and use of pilot reports. Local procedures should establish a clear reporting mechanism for ATCO to ensure the information about missing DAP reaches a relevant technical department.*

2.1.6. Technical considerations

IAS-MACH-REC-10: *ATCO display should include option to display IAS/Mach number DAP in the track label.*

For ENR:

- *IAS should be displayed rounded off to the nearest 10 knots below FL250.*
- *Mach number should be displayed rounded off to two decimal places over FL250.*

For TMA:

- *IAS should be displayed rounded off to the nearest 1 knot below.*

IAS-MACH-REC-11: *In high density and high complexity environments the update delay (between D1 and G defined in Annex C) should be less than:*

- *14 seconds (with a 90% of probability) for ENR.*
- *6 seconds (with a 90% of probability) for TMA.*

Note: A maximum data age may be used for inhibiting display of out aged data at the CWP.

IAS-MACH-REC-12: *The probability of update of the IAS and Mach number should be higher than 96% for an update interval of:*

- *8 seconds for ENR environments*
- *5 seconds for TMA environments*

Note: IAS-MACH-REC-12 ensures continuous availability of information at the CWP, regardless of whether the displayed DAP value has been updated during the last update interval. IAS-MACH-REC-12 is intended to be assessed independently of IAS-MACH-REC-11 which ensures maximum update delay of the information

IAS-MACH-REC-13: *Interrogation of IAS DAP through mode S should be avoided when this parameter is available through passive methods (ADS-B v3) or data sharing from other sensors*

IAS-MACH-REC-14: *The system should ensure enough time for the aircraft to adapt to the new cleared speed before issuing a discrepancy warning to the ATCO.*

2.2. MAGNETIC HEADING

2.2.1. Scenario description

The downlinked Magnetic Heading (MHDG) is received through the surveillance processing system and presented to the ATCO on a situation display at the CWP. The display of MHDG can be an option selected by the ATCO (may be global or track specific selection) or by default (always displayed and not selectable by the ATCO), as decided and prescribed by the ANSP. The display option depends on the intended use of MHDG DAP. However, for the purpose of these guidelines, it is assumed that the MHDG DAP is systematically used to ascertain an aircraft's current heading and to use the information directly (i.e., without asking the pilot) when there is a need for vectoring. Consequently, this parameter should be readily accessible to the ATCO.
The MHDG is used in vectoring an aircraft, i.e., providing navigational guidance to aircraft in the form of specific headings, based on the use of an ATS surveillance system. Usually, vectoring is achieved by issuing heading adjustment instructions to the aircraft, rounded up or down to the full 5 degrees. Vectoring is used when necessary to establish and/or maintain desired separation minima, or a specific spacing between two or more aircraft in arrival or departure phase of flight, etc.

The following sequence of actions is performed by ATCO and the Flight Crew:

a. The ATCO reads the current downlinked MHDG of an aircraft to determine an appropriate heading adjustment to be issued to an aircraft (turning into left or right direction) without asking the Flight Crew to report heading of the aircraft beforehand.
b. The ATCO issues the instruction to flight crew to fly the assigned MHDG. Simultaneously, the controller enters the assigned heading value in the system (ATCO HMI or paper strip).
c. The flight crew records their heading instruction on their log when applicable, reads back the vectoring instruction and adjusts the MHDG accordingly as assigned by ATCO.
d. The ATCO listens to the readback to determine whether the correct instruction has been received by the pilot.
e. The aircraft initiate the turn towards the assigned heading.
f. For an aircraft operating on an assigned MHDG, the MHDG DAP can be used for checking compliance with the ATC instruction. In order not to increase the ATCO workload with monitoring tasks, the implementation should pursue an automated functionality in the ground ATS system to detect discrepancies between the assigned heading and the MHDG DAP, and issue warnings to ATCO accordingly (see however technical consideration MHDG-REC-13 below). When such warning is issued, the ATCO contacts the Flight Crew to verify the heading flown and ensure compliance with the assigned heading.
g. When the discrepancy in point f) above is caused by a pilot non-compliance and the heading flown corresponds to MHDG DAP, the pilot will readjust to comply with the assigned heading.
h. When the discrepancy in point f) above is not the result of the pilot's error and the actual heading flown is compliant with the assigned heading (while MHDG DAP differs from it), and unless the discrepancy is caused by a nuisance warning, the ATCO will not rely on the DAP value and will initiate steps to report the corrupted DAP to the technical department.

2.2.2. Benefits

The expected benefits of the operational use of the downlinked MHDG are:

- Improvement of situational awareness.
- Improved accuracy in ascertaining an aircraft heading before issuing a vectoring instruction and estimating the wind effect on the course flown by the aircraft. This would reduce the need for further subsequent corrections of the assigned heading in order to achieve desired spacing or separation.
- Reduction of air-ground voice or data communication, when ATC does not request a flight crew to report heading, before issuing an ATC vectoring instruction.
- Automated detection of the discrepancies between the assigned and the flown heading.
- Support improved calculation of wind direction and speed by the ground systems.
- Improved accuracy of trajectories calculation.

2.2.3. Performance

The MHDG is available as follows:

Table 4 MHDG availability and transmission rates

Availability and Transmission rates					
Data Item	Mode S	ADS-B v2	ADS-B v2 Tx Rates	ADS-B v3	ADS-B v3 Tx Rates
Magnetic Heading	Yes	No*	-	Yes	2.2 s

* MHDG is defined in the ADS-B v2 protocol. However, due to the prioritisation of data items, it is not provided by the aircraft under nominal conditions.

The resolution of the values transmitted in the surveillance chain for the MHDG is indicated in the following table:

Table 5 MHDG value resolution

Resolution							
Data Item	Mode S	ADS-B v2	ADS-B v3	ASTERIX CAT048	ASTERIX CAT020	ASTERIX CAT021	ASTERIX CAT062
Magnetic Heading	90/512 º ~0.176º	-	0.088 º	90/512 º ~0.1757º	90/512 º ~0.1757º	$360º/2^{16}$ ~0.0055º	$360º/2^{16}$ ~0.0055º

2.2.4. Data item usage analysis

The ADD-SPR document [RD 8] describe performance requirements related to the maximum delay between the entry of the ground surveillance to the display of the updated value on the ATCO surveillance display (interface D1 and G of the logical model defined in the ANNEX C). These performance requirements are applicable to the use of MHDG with ATCO consistency check, in high-traffic density and high-traffic complexity environment. The use of MHDG in lower traffic density or lower traffic complexity environment might be less demanding in terms of performance and need to be assessed locally by ANSPs.

Table 6 MHDG update delay requirements

UPDATE DELAY	
Environment	Value
En Route	10s @ 90%
TMA	6s @ 90%

2.2.5. Operational considerations

An ATCO using surveillance for the provision of ATC normally uses the MHDG of the aircraft under their control to predict the potential need for corrective actions by means of vectoring in order to:

a) Establish or maintain a minimum horizontal separation between aircraft.

b) Achieve desired spacing and sequence between two or more aircraft in arrival or departure phase of flight.

c) Bring an aircraft in the position to intercept and establish on the final approach track.

The MHDG is used for vectoring in En-route and APP operational environment. It is used in aerodrome control too, when the TWR is authorised to use surveillance for establishing surveillance-based separation between succeeding departing aircraft.

The MHDG may also be used to:

a) facilitate coordination and transfer of inbound and outbound traffic.

b) apply vectoring within the sector.

A tolerance for displaying the discrepancy warning between assigned heading and MHDG DAP to ATCO should be implemented in ATS system to allow enough time for the Flight crew to apply the changes of the heading. The delay to reach the assigned heading will vary depending on the aircraft performance, on the difference between current and assigned heading and on the altitude of the aircraft. Normally, the difference between current and assigned heading are more significant and take place more often in APP environment, because of ATCO vectoring aircraft for approach. Also, the Flight crew and the aircraft will perform better in reaching assigned heading at lower altitudes, unlike at higher altitudes in ACC environment where aircraft performance envelop is limited. When querying a discrepancy between the assigned heading and the MHDG DAP value the air traffic controller must avoid using the value of the MHDG DAP in the radiotelephony, as this may create confusion and lead to an undesired outcome.

MHDG-REC-1.: *The reliability of MHDG DAP information displayed at CWP should be validated with the aim to enable ATCO to consider MHDG as equivalent to pilot´s report.*

MHDG-REC-2.: *In order to support use of downloaded MHDG in monitoring compliance with ATC instruction and maintain the identified benefits, the ATM system should provide for an automated system to detect discrepancies between assigned heading and MHDG DAP and issue warnings to ATCO.*

MHDG-REC-3 *When prescribed in local procedures, the downlinked MHDG displayed on air situation display at CWP should be considered by ATCO as equivalent to pilot´s report.*

MHDG-REC-4. *Local procedures should prescribe the ATCO actions in case of detected discrepancy between assigned heading and displayed MHDG downlinked value.*

MHDG-REC-5. *When ATCO queries a discrepancy between the displayed MHDG and the assigned heading, the ATCO will not state the value of the MHDG observed on the situation display in the radiotelephony.*

MHDG-REC-6 *When the heading value reported by the pilot differs from the displayed DAP value, the pilot report shall take precedence over displayed DAP value.*

MHDG-REC-7 *Unless the discrepancy between displayed MHDG and the aircraft heading reported by the pilot is caused by a pilot error, local procedures should establish a clear reporting mechanism for ATCO to ensure the information about the corrupted DAP reaches a relevant technical department, as well as a decision process and criteria to stop using DAP for an individual aircraft concerned, an aircraft type or for all aircraft.*

MHDG-REC-8 *When the loss of DAP MHDG has been identified, i.e. no data displayed in the MHDG field, ATCO should revert to a traditional application of vectoring and use of pilot reports. Local procedures should establish a clear reporting mechanism for ATCO to ensure the information about missing DAP reaches a relevant technical department.*

2.2.6. Technical considerations

MHDG-REC-9: *ATCO display should include option to display MHDG DAP in the track label.*

MHDG-REC-10: *In high density and high complexity environments the update delay (between D1 and G defined in Annex A) should be lower than:*

- *10 seconds (with a 90% of probability) for ENR.*
- *6 seconds (with a 90% of probability) for TMA.*

Note1: A maximum data age may be used for inhibiting display of out aged data at the CWP.

Note2: MHDG-REC-10 ensures continuous availability of information at the CWP, regardless of whether the displayed DAP value has been updated during the last update interval.

MHDG-REC-11: *The probability of update of the MHDG should be higher than 96% for an update interval of:*

- *8 seconds for ENR environments*
- *5 seconds for TMA environments*

Note: MHDG-REC-11 is intended to be assessed independently of MHDG-REC-10 which ensures maximum update delay of the information.

MHDG-REC-12: *Interrogation of MHDG DAP interrogation through mode S should be avoided when this parameter is available through passive methods (ADS-B v3)*

MHDG-REC-13: *The system should avoid the warning display to the ATCO after a new instruction is given to ensure enough time for the pilot to adapt for the new cleared MHDG.*

2.3. SELECTED ALTITUDE/SELECTED LEVEL

2.3.1. Scenario description

The downlinked Selected Altitude (SAL) is a parameter, entered by the flight crew into the Mode Control Panel (MCP) or Flight Control Unit (FCU), which is provided by the aircraft and received at ATC unit through the ATM surveillance system. Depending on the altimeter pressure setting, the SAL information downlinked by the aircraft could be a flight level when the reference is the standard pressure QNE (i.e., Selected Flight Level), or an altitude when the reference is QNH (selected altitude) or a height where reference is QFE. The description in this section of the guidelines covers all cases.

The use of SAL in operations provides for an acceptable means to reduce the potential for level bust occurrences. The SAL which is available on a situation display can be used to verify that flight crew's selections for vertical manoeuvres are consistent with the clearances issued by ATC (to compare the SAL with the cleared level (CFL) issued by ATC). It can also assist the ATCO to identify cases of read back errors.

However, an ATCO shall not use SAL on its own for the purpose of separation provision or as a substitute for the read-back and hear-back of level clearances.

The use of SAL comes with important limitations that need to be thoroughly understood and accommodated in the local procedures as well as in ATM system functionalities design. In a number of circumstances, the value of SAL could differ from confirmed (acknowledged and confirmed that it would be complied with by the pilot) cleared level i.e., it will not show pilot's definitive intention with regard to ATC instruction. These circumstances depend on and may vary according to aircraft type, aircraft operator, mode of operation, airspace, flight procedures design, etc.. The difference between SAL and confirmed cleared level does not represent non-compliance with ATC clearance in circumstances, such as:

a) when following SID/STARs with ATC level restrictions, pilots may select the final cleared level and utilise the aircraft flight management system to achieve the vertical constraints;

b) on final approach, where at a given moment pilots pre-select the missed approach procedure altitude;

c) when the aircraft is being flown manually;

d) where ATC level instructions contain an allowance for flight crew delay in compliance (i.e., "when ready climb/descend…" or cruise climb procedures).

Inasmuch as an ATCO should be aware of the limitations of SAL, the flight crew needs to be aware of a possibility that ATCO may contact the flight crew and query the intentions of the pilot, if there is any doubt over the discrepancy between cleared level and SAL.

Concerning the principles and the limitations in use of SAL stated above, as well as having due regard to the balance of workload and additional tasks for ATCO to monitor DAPs, the implementation of SAL should pursue an automated functionality in the ground ATS system. This automated functionality will detect discrepancies between assigned (cleared) level by ATCO and SAL DAP and present a discrepancy warning to ATCO on a situation display.

When a warning is presented, the ATCO instructs the Flight Crew to check SAL and ensure compliance with the cleared level.

In order to prevent nuisance warnings, the discrepancy warning should:

a) be inhibited within the circumstances where it is expected that the pilot could select a different level than the cleared one (e.g., aircraft flying SID/STAR procedure with published altitude constraint, or after cleared for approach);

b) include a tolerance for displaying the discrepancy warning to ATCO, between cleared level and SAL, to allow enough time for the Flight crew to apply the changes of level in MCP/FCU.

The following sequence of actions is performed by ATCO and the Flight Crew:

a) The ATCO issues the instruction to flight crew to climb, descent or maintain a level. Simultaneously, the controller enters cleared level value in the system (ATCO HMI or paper strip).

b) The flight crew reads back and applies a level instruction by setting SAL in the MCP/FCU accordingly as assigned by ATCO.

c) The ATCO listens to the readback to determine whether the correct instruction has been received by the pilot.

d) The aircraft initiate the vertical manoeuvre towards the assigned level.

e) When automated functionality in the ATS system detects a discrepancy between assigned (cleared) level by ATCO and SAL DAP, it issues a discrepancy warning to ATCO on a situation display.

f) When the ATCO detects such a warning, the ATCO instructs the Flight Crew to check SAL and ensure compliance with the cleared level.

g) When the discrepancy in point f) above is caused by a pilot error and the SAL does not correspond to cleared level, the pilot will readjust to comply with the cleared level.

h) When the discrepancy in point f) above is not the result of the pilot's error and the actual SAL flown is compliant with the cleared level (while SAL DAP differs from it), the ATCO will not rely on the DAP value and will initiate steps to report the discrepancy to the technical department. The ATCO should inhibit the warning for this particular flight if such functionality is available.

2.3.2. Benefits

The expected benefits of the operational use of the SAL are:

- An effective mitigation to undetected misunderstandings over radiotelephony, incorrect read-backs and hear-backs.
- Improvement of situational awareness for ATCO.
- Improved accuracy of trajectory prediction function and related ATC tools, when SAL is used in FDP/SDP processing.
- Reduction of level busts linked to readback errors.

2.3.3. Performance

Extraction parameter

SAL is available through the following technologies:

Table 7 SAL availability and transmission rates

Availability and Transmission rates					
Data Item	Mode S	ADS-B v2	ADS-B v2 Tx Rates	ADS-B v3	ADS-B v3 Tx Rates
Selected Altitude	Yes	Yes	1.25 s	Yes	1.25 s

The resolution of the values transmitted in the surveillance chain for the SAL is indicated in the following table:

Table 8 SAL value resolution

Resolution							
Data Item	Mode S	ADS-B v2	ADS-B v3	ASTERIX CAT048	ASTERIX CAT020	ASTERIX CAT021	ASTERIX CAT062
Selected Altitude	16 feet	32 feet	32 feet	16 feet	25 feet	25 feet	25 feet

Constraints

European ANSPs reported that due to resolution constraints: 32 feet in ADS-B v2 and ADS-B v3 and 25 feet in ASTERIX CAT062, the use of SAL may indicate small differences between the SAL selected by flight crew and the SAL presented at the CWP. For example, the flight crew can set the SAL to 10000ft and while the controller sees 10025ft.

2.3.4. Data item usage analysis

Performance requirements

The ADD-SPR document [RD 8] describe performance requirements related to the maximum delay between the interface D1 and G of the logical model defined in the ANNEX C. These performance requirements are applicable to the use of SAL with the automatic consistency check, in high-traffic density and high-traffic complexity environment. These requirements are defined for a high-traffic density and high-traffic complexity environment. The use of SAL in lower-traffic density or lower-traffic complexity environment might be less demanding in terms of performance and need to be assessed locally by ANSPs.

Table 9 SAL update delay requirements

UPDATE DELAY	
Environment	Value
En Route	6s @ 90% (Note 1)
TMA	6s @ 90%

Note: The update delay requirement for the En Route service is under review and may be updated in future revisions of this document.

The ATC system should ensure a warning inhibition delay starting when the ATCO introduces a new CFL in the system. The Inhibition Delay of the display of the SAL/CFL discrepancy warning should be tailored locally to avoid nuisance warnings.

2.3.5. Operational considerations

Although SAL provides an effective mitigation to undetected misunderstandings over radiotelephony, incorrect read-backs and hear-backs, it must be re-emphasised that the availability of the SAL via DAPs does not replace the pilot and controller requirements for read-back and hear-back of the clearances.

When querying a discrepancy between the cleared level and the “selected level” the air traffic controller must avoid using the value of the SAL DAP in the radiotelephony, as this may create confusion and lead to an undesired outcome.

> **SAL-REC-1.**: *The reliability of SAL DAP information displayed at CWP should be validated with the aim to enable ATCO to consider SAL for detecting non-compliance with the cleared level.*

SAL-REC-2.: *In order to support use of downlinked* SAL *in detecting non-compliance with ATC instruction and maintaining the identified benefits, the ATM system should provide for an automated function to detect discrepancies between cleared level and SAL DAP and issue warnings to ATCO.*

SAL-REC-3. *Local procedures should prescribe the ATCO actions in case of detected discrepancy between cleared level and displayed SAL DAP value.*

SAL-REC-4. *When available, the SAL can be used, as prescribed by the appropriate ATS authority, to verify that flight crew's selections for vertical manoeuvres are consistent with the clearance issued by ATC.*

SAL-REC-5. *The SAL shall not be used on its own for the purpose of separation nor shall the availability of such information on a situation display be used as a substitute for the read-back and hear-back of level clearances.*

SAL-REC-6. *When ATCO queries a discrepancy between the displayed SAL and the cleared level, the ATCO will not state the value of the SAL observed on the situation display in the radiotelephony.*

SAL-REC-7. *Phraseologies to be used when checking discrepancy between the displayed* SAL *and the cleared level are***:**

CHECK SELECTED LEVEL. CLEARED LEVEL IS (level)

CHECK SELECTED LEVEL. CONFIRM CLIMBING (or DESCENDING) TO (or MAINTAINING) (level)

**CLIMBING (or DESCENDING) TO (or MAINTAINING) (level) (appropriate information on selected level)*

** Denotes pilot transmission*

SAL-REC-8. *When the discrepancy between SAL and cleared level is caused by a pilot non-compliance with ATC instruction, the pilot will readjust it to comply with the cleared level.*

SAL-REC-9. *When the discrepancy is not the result of the pilot's error and the actual SAL is compliant with the cleared level (while SAL DAP differs from it), the ATCO will not rely on the DAP value and will initiate steps to report the discrepancy caused by corrupted DAP value to the relevant technical department.*

SAL-REC-10 *When the discrepancy is not the result of the pilot's error and the actual SAL is compliant with the cleared level (while SAL DAP differs from it), the system should allow the ATCO to inhibit the warning for a particular flight.*

2.3.6. Technical considerations

SAL-REC-11: *ATCO display should include option to display SAL DAP in the track label.*

- *SAL should be displayed rounded off to the nearest flight level or 100 feet.*

SAL-REC-12: *In high density and high complexity environments the SAL update delay (between D1 and G defined in Annex C) should be less than:*

- *6 seconds (with a 90% of probability) for ENR.*
- *6 seconds (with a 90% of probability) for TMA.*

Note1: A maximum data age may be used for inhibiting display of out aged data at the CWP.

Note2: SAL-REC-12 ensures continuous availability of information at the CWP, regardless of whether the displayed DAP value has been updated during the last update interval.

SAL-REC-13: *The probability of update of the SAL should be higher than 96% for an update interval of:*

- *8 seconds for ENR environments*
- *5 seconds for TMA environments*

Note: SAL-REC-13 is intended to be assessed independently of SAL-REC-12 which ensures maximum update delay of the information.

SAL-REC-14: *Interrogation of SAL DAP through mode S should be avoided when this parameter is available through passive methods.*

2.4. BAROMETRIC PRESSURE SETTING

2.4.1. Scenario description

The downlinked Barometric Pressure Setting (BPS) is provided by the aircraft and received at ATC unit through the ATM surveillance system. BPS shows the actual altimeter pressure setting on board an aircraft as selected by the Flight Crew.

Having a correct pressure setting in the altimeter of an aircraft is essential to prevent collision with obstacles and terrain – in particular when operating in accordance with instrument flight rules as well as ensuring a common reference datum for the application of vertical separation. Correct altimeter setting is equally important to an ATCO, beside the provision of vertical separation between aircraft, to monitor compliance with issued level instructions.

Barometric altimeters measure the air pressure and are calibrated according to the variation of the pressure with height, as specified for the international standard atmosphere (ISA). Depending the reference datum set on the barometric altimeter, the information on the scale would indicate a flight level, altitude or height, as follows:

a) Standard Pressure (1013.2hPa/mbar): it is set when flying by reference to flight levels (FL), at or above the transition level.
b) QNH: it is set when flying by reference to an altitude above mean sea level, at or below the transition altitude.
c) QFE: it is set when flying by reference to height above airfield or runway, when approaching to land at airfield where this procedure is in use. (Rarely used by civil air traffic at controlled aerodromes, hence it is less relevant for BPS usage).

The local QNH is determined on the ground and transmitted to flight crew by air traffic services (ATS) by ATCOs or FISOs or, when implemented, automatically by means of ATIS. It is reported in whole hectopascals (hPa) or millibars (mbar) using four digits. The downlinked BPS can be used to detect a discrepancy between the actual altimeter setting selected by the flight crew and the local QNH or the Standard pressure available to ATCOs or FISOs.

In order not to increase the workload of ATCOs or FISOs deriving from monitoring tasks, the implementation should pursue an automated functionality in the ground ATS systems to detect discrepancies between BPS and QNH for the flights at or below the transition altitude, as well as between BPS and the standard pressure for the flights above transition level. When a discrepancy is detected, a warning should be provided to the ATCO on the CWP situation display accordingly. When implementing the logic for generating automated warnings, the designers need to consider several operational aspects, such as:

a) An aircraft instructed to climb to a level above the transition level (i.e. flight level) may select standard pressure setting before initiating, or during the climb;
b) An aircraft instructed to descend to a level below the transition altitude (i.e. altitude) may select QNH as pressure setting before initiating or during the descent;
c) When a change in the QNH occurs, the passing of this information to aircraft below the transition altitude will be performed differentially, taking into account the criticality of vertical positioning with regards conducting instrument flight procedures and clearance over terrain and obstacles (e.g. MSA, MVA, Baro-VNAV IAP), as well as compliance with vertical separation minima;
d) Inasmuch as prevention of collision with terrain and obstacles are within pilots' responsibility, ATCOs and FISOs need to provide accurate pressure reference datum information at well-defined stages during arrival and departure phases of flight;
e) The time needed for the Flight Crew to change/input the altimeter setting;
f) evolution of the aircraft through the transition layer (i.e., between transition altitude and transition level).

When a BPS discrepancy warning has been triggered, the value of the downlinked BPS should be available for display. The ATCO should ask the flight crew to check altimeter setting and restate currently applicable altimeter setting, without mentioning displayed BPS value in air ground communication with the flight crew.

Subsequently, an ATCO, after receiving confirmation from a pilot that the altimeter has been set to the correct pressure, should have a possibility to dismiss the display of the warning for this particular aircraft.

A tolerance (number of hPa) for displaying the discrepancy warning between BPS and QNH (or BPS and the Standard pressure) to ATCO may be needed in an ATS system to prevent nuisance warnings (e.g. to avoid rounding/resolution errors see section B.3).

A time margin is required between the QNH change and the display of the discrepancy warning.

2.4.2. Benefits

The expected benefits of the operational use of the BPS are:

- Early detection of any discrepancies between currently applicable altimeter setting (QNH or the Standard) at the ATC unit and the actual altimeter setting on board an aircraft, during all phases of flight.
- Additional safety barrier which contributes to the reduction of a risk of an incident related to CFIT, airspace infringement or loss of vertical separation between the aircraft.
- Reduces the risk of flying too low or too high on an instrument approach for landing, in particular RNP Baro-VNAV approaches to LNAV/VNAV minima.

2.4.3. Performance

Extraction parameter

The BPS is available through the following technologies:

Table 10 BPS availability and transmission rates

Availability and Transmission rates					
Data Item	Mode S	ADS-B v2	ADS-B v2 Tx Rates	ADS-B v3	ADS-B v3 Tx Rates
BPS	Yes	Yes	1.25 s	Yes	1.25 s

The resolution of the values transmitted in the surveillance chain for the BPS is indicated in the following table:

Table 11 BPS value resolution

Resolution							
Data Item	Mode S	ADS-B v2	ADS-B v3	ASTERIX CAT048	ASTERIX CAT020	ASTERIX CAT021	ASTERIX CAT062
BPS	0.1 mbar	0.8 mbar	0.8 mbar	0.1 mbar	0.1 mbar	0.1 mbar	0.1 mbar

Constraints

An issue related to the rounding of BPS downlinked parameter has been reported. When mixing BPS from Mode S (0.1 mbar resolution) and ADS-B (0.8 mbar resolution), the displayed BPS (1 mbar resolution) may constantly change depending on the reception of a Mode S or an ADS-B message.

2.4.4. Data item usage analysis

Performance requirements

The ADD-SPR document [RD 8]describe performance requirements related to the maximum delay between the interface D1 and G of the logical model defined in the ANNEX C. These performance requirements are applicable to the use of BPS with automatic consistency check, in high-traffic density and high-traffic complexity environment. The use of DAP in lower-traffic density or lower-traffic complexity environment might be less demanding in terms of performance and need to be assessed locally by ANSPs.

Table 12 BPS update delay requirement

UPDATE DELAY	
Environment	Value
TMA	8s @ 90%

The ATC system should ensure a warning inhibition delay starting when the new QNH is changed. The Inhibition Delay of the display of the BPS discrepancy warnings should be tailored locally to avoid nuisance warnings.

2.4.5. Operational considerations

Operating on a correct pressure setting in each phase of flight, is very important to the flight crew to ensure compliance with ATC instructions and the minimum safe altitudes, navigating on certain instrument flight procedures, in particular RNP Baro-VNAV and preventing collision with terrain/obstacle.

For ATCO, the correct altimeter setting of all aircraft flying within the area is important to ensure provision of vertical separation between the aircraft, compliance with minimum safe altitudes and boundaries of controlled airspace when vectoring or issuing direct routings.

An undetected erroneous pressure setting by the pilot could result in a loss of vertical separation with another aircraft, airspace infringement or CFIT.

If an erroneous altimeter setting on board an aircraft is lower than currently applicable pressure setting (QNH) an aircraft would actually be levelled above the assigned level (or too high on the approach).

If an erroneous altimeter setting on board an aircraft is higher than currently applicable pressure setting (QNH) an aircraft would actually be levelled below the assigned level (or too low on the approach).

In ATC surveillance service ATCO uses pressure-altitude-derived level information, together with the additional parameters linked to the tolerance of the pressure-altitude-derived level information to assess that the aircraft maintains, has reached, has left or passed a level.

The use of BPS automated discrepancy warning provides one additional means to detect erroneous altimeter setting not only during the read back and verification of the pressure-altitude-derived level information by realising that the information observed on the surveillance display is outside a specified accuracy from the report of the pilot. The use of BPS automated discrepancy warning allows for detection of erroneous altimeter setting much earlier than the verification of altitude, and even during a climb or descent. It also enables earlier detection of errors compared to tools such as MSAW and APM.

Therefore, both discrepancy warning between BPS and QNH below transition altitude, as well as between BPS and the Standard pressure above transition level, brings benefits to both ATCO and flight crew.

The assumption is that applicable (up to date) QNH is available in the ATM system (either automatically or entered by the operator). Also, the value of a Standard Pressure (1013 mbar) should be available in ATM system for the volume of airspace above a transition level. The BPS received is compared against these pressure values available in the ATM system.

As QNH changes over time, the new value of QNH in the ATM system will trigger a BPS/QNH discrepancy warning for all aircraft set on previous QNH. As ATS should anyway transmit changed/new QNH to the Flight Crew (by means of ATIS or ATCO), the discrepancy warnings appearing for all aircraft, could be used as a reminder to ATCO to provide the new QNH value to the aircraft concerned.

As the transition altitude varies from airport to airport and the operational procedures may differ locally, the system should ensure to avoid the display of nuisance warnings to the ATCO in the proximity of the transition layer e.g., avoid warning display when descending in the transition layer with QNH set. The margin to be considered close to the transition layer should be assessed locally based on the local procedures and environment.

BPS-REC-1. *Local procedures should prescribe the ATCO actions in case of detected discrepancy between BPS and current QNH or the Standard pressure.*

BPS-REC-2. *When BPS discrepancy warning has been detected on the situation display, ATCO should request the flight crew to check altimeter setting and transmit the currently applicable altimeter setting, as early as practicable.*

BPS-REC-3. *Although the BPS value may be shown to the ATCO (BPS can be seen as a part of radar label or elsewhere on a situation display), the ATCO shall not state displayed BPS value in communication with the flight crew.*

BPS-REC-4. *When the altimeter setting value reported (confirmed) by the Flight Crew complies with currently applicable pressure setting and the displayed BPS continues to differ from it, the pilot report shall take precedence over the displayed BPS value. Such BPS value displayed in ATM system should be considered as a corrupted and ATCO can remove discrepancy warning from a situation display for the particular flight concerned.*

BPS-REC-5. *Local procedures should establish a clear reporting mechanism for ATCO to ensure that the information about a corrupted or missing BPS reaches relevant technical department.*

2.4.6. Technical considerations

BPS-REC-6.: *ATCO display should include option to display BPS DAP in the track label.*

- *BPS should be displayed rounded off to the nearest mbar.*

BPS-REC-7.: *In high-traffic density and high-traffic complexity environments the BPS update delay (between D1 and G defined in Annex C) should be less than:*

- *8 seconds (with a 90% of probability) for TMA.*

Note: A maximum data age may be used for inhibiting display of out aged data at the CWP.

BPS-REC-8.: *Interrogation of BPS DAP through mode S should be avoided when this parameter is available through passive methods.*

BPS-REC-9. *When setting up the discrepancy warning tolerances (number of mbars) and time margins, the ANSP should consider the local environment and local procedures, including transition layer, phase of flight (e.g. vectored near to MRVA, established on Baro-VNAV approach) and the times required for the ATCO to transmit the new/changed QNH and the flight crew to configure the new value.*

Note: Transition altitude may not necessarily be used only in TMA. This is a local configuration.

ANNEX A INCONSISTENT DAP VALUES

This annex includes guidance for the occurrences of consistent errors in the downlinked aircraft parameters identified in ATM system of an ATC unit. This guidance is common to all downlinked aircraft parameters described in this document.

B.1 Corrupted DAP values

The following cases that have an impact on operations are identified:

False negative: The actual flying parameter of the aircraft is equal to/complies with the clearance assigned by the ATCO. However, due to the corruption the DAP value displayed to ATCO does not match the assigned clearance, i.e., differs from actual flying parameter. The ATCO would detect the discrepancy or there would be an automated warning and contact the Flight Crew to verify compliance with the clearance. The Flight Crew would confirm they are flying the assigned speed.

False positive: In the opposite case, the actual flying parameter of the aircraft differs from/does not comply with the assigned ATCO clearance. However, due to the corruption, the DAP value displayed to the ATCO appears to match the assigned clearance. The automated warning would not be triggered, and the case would most probably go undetected. This case seems less feasible.

DAP value different from the actual flying parameter: This case is applicable when ATCO hasn't issued a clearance to the aircraft yet. When assessing the current situation of the air traffic within the airspace (e.g., the spacing evolution and the need for speed adjustments), the ATCO observes (corrupted) DAP value and uses it (instead of a pilot report) as a reference for new ATC instruction (e.g. instruct an aircraft to "increase or reduce speed"). The pilot may be unable to comply with such ATCO instruction (already flying at a higher speed than ATC instruct to increase to) and would report it so to ATCO.

As a consequence of a corrupted DAP value detection, the ATCO will not rely on displayed DAP and will stop using DAP as a reference. This may affect the ATCO´s trust for other aircraft DAPs too.

B.2 Loss of DAP in DAP-equipped aircraft

Assuming ATCO actively uses DAP values, if there was no data displayed in a specific DAP field, for a DAP-equipped aircraft, ATCO would report the issue. Depending on the reason for the failure, the flight crew may not know why DAPs are missing in ATC. The ATCO would need to check the DAPs of other aircraft in the sector to determine if other losses were also present.

ATCO should be informed of the aircraft equipage. The ATCO interface shall provide clear warnings to distinguish DAP-equipped aircraft and non-DAP-equipped aircraft. In case the DAP values information is not available to ATCO, for a DAP-equipped aircraft, the ATCO will apply the procedures defined for non-DAP-equipped aircraft.

B.3 Technical report of consistent DAP errors

There are a limited number of aircraft whose DAPs configuration is sending bad information, not reflecting the correct values displayed to or set by the pilot. In order to further investigate and correct the aircraft sending the bad information, it is strongly encouraged to report the detected cases of consistent errors to the EUROCONTROL avionic issue database.

Few aircraft may be exempt from providing one or more DAP parameters. When few parameters are missing, they may still be filing EHS/DAP capability in the flight plan. If an aircraft is consistently not providing one or more DAP and it is not expected to be exempt to provide them, it may be considered an error and it is strongly encouraged to be reported to the EUROCONTROL avionic issue database.

The issue registration to the EUROCONTROL avionic issue database is submitted using the surveillance issue ticketing system SAFPA MANTIS. ANSPs can request access or report consistent errors directly through email (sur.avionics@eurocontrol.int).

ANNEX B ROUNDING/RESOLUTION ERRORS

This annex includes information for handling of resolution limitations for some DAP items combined with mitigations for the reduction of the operational impact on the use of these DAPs. Due to different data resolutions in the surveillance chain, the value displayed to the controller may be different to the actual value onboard the aircraft.

B.1 Mach number

The resolution of Mach number downlinked through Mode S is 0.004 and the resolution of the CAT062 is 0.008. In some cases, this resolution error may cause some inconsistencies between the value sent by the aircraft and the value displayed at the CWP when this value is rounded to the second decimal.

The following example illustrates the issue; a value of M0.754 set in the aircraft, this is downlinked as M0.756 (due to the downlink resolution) and encoded in CAT062 as M0.760 (due to the CAT062 resolution) and finally displayed as M0.76 (due to display configuration) while the expected shown value is M0.75.

The effect of this error is observed when the controller display only shows two decimals. In this case it is recommended as mitigation to round the value of the Mach Number to the second decimal before the codification into ASTERIX CAT062. This mitigation does not solve the issue completely, but it reduces the number of occurrences.

ROUNDING-REC-1.: *If the ATS display is configured to show the Mach Number with 2 decimals, the Mach number should be rounded to the nearest multiple of 0.01 before codifying it into ASTERIX CAT062.*

B.2 Selected altitude

The resolution of the SAL downlinked through Mode S is 16 feet and 32feet when downlinked through ADS-B v2 and v3 and the resolution of the CAT062 is 25 feet. In some cases, this resolution error may cause inconsistencies between the value sent by the aircraft and the value displayed at the CWP. A value of 10000 feet set in the aircraft is displayed as 10025 while the expected value is 10000 feet.

B.3 Barometric pressure setting

The resolution of the BPS when downlinked through ADS-B v2 and v3 is 0.8mbar. In some cases, this resolution error may cause some inconsistencies between the value configured in the aircraft and the value displayed at the CWP. For example, a value of 1001.2 mbar configured in the aircraft is displayed as 1002 mbar at CWP while the expected value is 1001.

The issue described above is affecting the value displayed to the controller. However, in ASTERIX CAT062 the value has higher resolution. Therefore, for the discrepancy warning, it is recommended to use the BPS value available in ASTERIX CAT062 to perform the comparison with the applicable reference pressure (e.g., QNH or Standard Pressure).

ROUNDING-REC-2.: *The discrepancy warning should be using the BPS with the resolution as received in ASTERIX CAT062 and avoid warnings when the difference between the reference pressure issued by the ATCO and the BPS, as received in ASTERIX CAT062, is less than 1 mbar.*

Note: An assessment is needed to determine the appropriate discrepancy warning threshold in the local environment.

Unless mitigated, the different resolutions of BPS when downlinked through ADS-B and mode S may cause a constant change of the BPS value displayed in the CWP. Following the example described above, the downlinked BPS through ADS-B would be displayed as 1002 while the downlinked BPS through Mode S would be displayed as 1001. Depending on the time of arrival of the messages the displayed value may be flickering between both values in each display update.

ANNEX C LOGICAL MODEL

This section introduces the logical model used in this document, covering the related Aircraft, Spatial and Ground domains for which assumptions and requirements are defined.

The logical model describes the main functions and their interfaces and interactions necessary to perform the ATC services with support of ADD/DAP in a given environment.

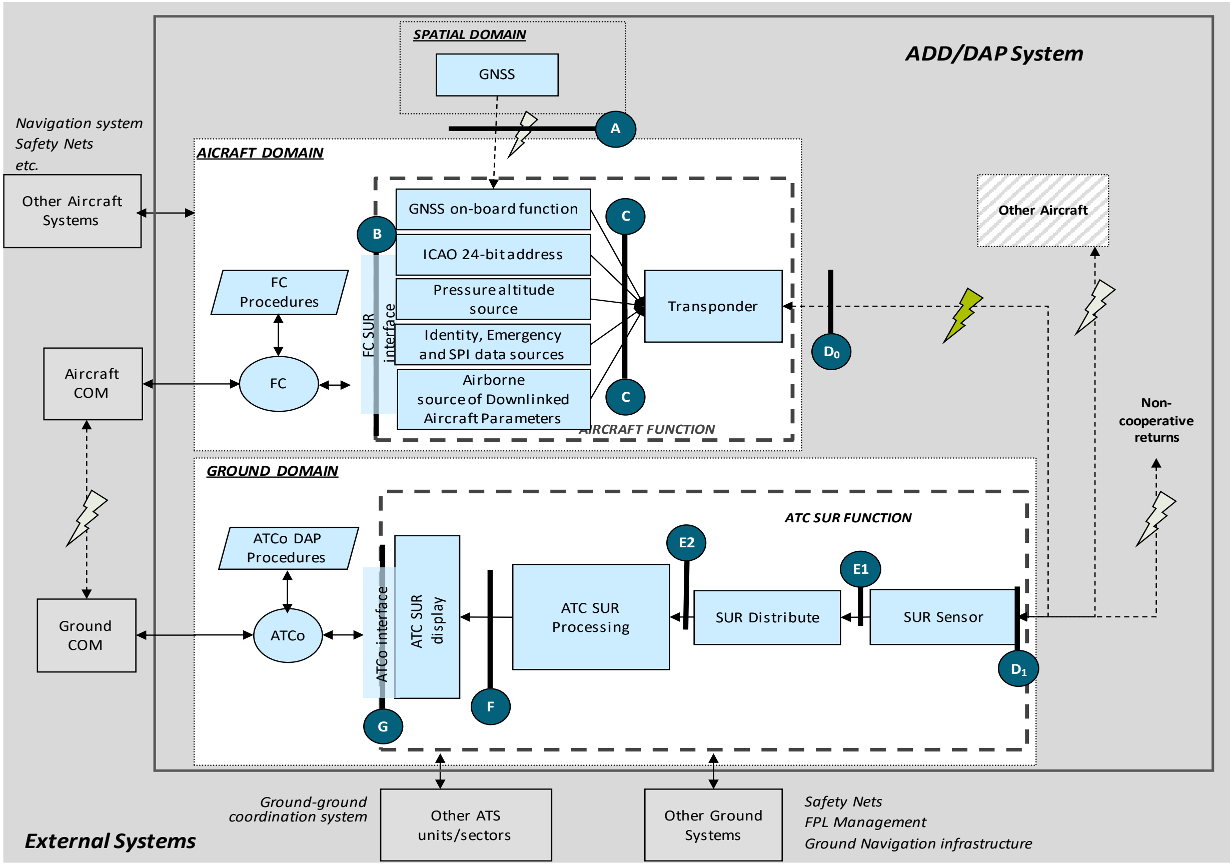

Figure 1 System Logical Architecture

ANNEX D DAP/ADD OVERVIEW

DAP overview

Both Mode S and ADS-B provide DAP/ADD. Many data items are overlapping between the protocols but there is also information which is only available through one or the other protocol. There are also differences in the resolution for few data items and the update rate may also vary between the protocols. Table D-1 provides an overview of the registers in which the data items are availability in Mode S and ADS-B version 2 and 3 protocols. For ADS-B it also provides the transmit rate (messages/second) for the respective data item.

Table D-1 DAP Overview

ADD Item	Mode S	ADS-B v2	ADS-B v2 Tx Rates	ADS-B v3	ADS-B v3 Tx Rates
Mode A code	ID	6,1	0.8s / 5s	6,1	0.8s / 5s
Special Position Indicator (SPI, IDENT)	FS	0,5	0.5s	0,5	0.5s
Barometric Pressure Altitude (Mode C)	AC	0,5	0.5s	0,5	0.5s
Aircraft Identification (ACID)	2,0	0,8	5s	0,8	5s
ACAS Active RA*[1]	3,0	6,1	0.8s / 5s	6,1	0.8s / 5s
MCP/FCU Selected altitude	4,0	6,2	1.25s	6,2	1.25s
FMS Selected altitude	4,0	-	-		
Barometric pressure setting	4,0	6,2	1.25s	6,2	1.25s
MCP/FCU Mode bits	4,0	6,2	1.25s	6,2	1.25s
Meteorological routine air report	4,4	-	-	-	-
Meteorological hazard report	4,5	-	-	-	-
Roll angle	5,0	-	-	(6,A)	(2.2s)
True track angle	5,0	0,9*[2]	0.5s	0,9*[2]	0.5s
Ground speed	5,0		0.5s		0.5s
Track angle rate	5,0	-	-	-	-
True airspeed	5,0*[5]	-	-	(-)	(-)
Horizontal Position	5,1/5,2	0,5/0,6	0,5s (5s*[5])	0,5/0,6	0.5s (5s*[5])
Air-referenced state vector	5,3	-	-	-	-
Magnetic heading	6,0	-	-	(6,A)	(2.2s)
Indicated airspeed	6,0	-	-	6,9/6,A	2.2s

Mach No	6,0	-	-	-	-
Barometric altitude rate	6,0*4	0,9*3	0.5s	0,9*3	0.5s
Inertial vertical velocity	6,0*4		0.5s		0.5s
Airborne horizontal position QIs: NIC, NACp, SDA & SIL	-	0,5/0,6/ 6,2/6,5	various	0,5/0,6/ 6,2/6,5	various
ADS-B Emitter category	-	0,8	5s	0,8	5s
Geometric Altitude (HAE)	5,2	0,9	0.5s	0,9	0.5s
Geometric Altitude Accuracy (GVA)	-	0,9	0.5s	0,9	0.5s
Aircraft length and width [Ground]	-	6,5[Gnd]	2.5s / 5s	6,5[Gnd]	2.5s / 5s
GNSS antenna offset [Ground]	-	6,5[Gnd]	2.5s / 5s	6,5[Gnd]	5s / 10s
Transponder antenna offset [Ground]	-	-	-	6,5[Gnd]	5s / 10s
Transponder side	1,0	-	-	6,5[Air]	2.5s / 5s
RCE – Reduced capability equipment	-	(6,5[Air])	(2.5s / 1.25s)	6,5[Air]	2.5s / 1.25s
Collision Avoidance info (Type, Sense)*1	3,3-3,7	-	-	6,5[Air]	2.5s / 1.25s
Single antenna	-	6,5	2.5s / 5s	6,5	2.5s / 5s
ADS-B WX AIREP	-	-	-	6,9/6,A	If impl. (2.2s)
ADS-B WX PIREP	-	-	-	6,B/6,C/6,D	Active (3.3s)
IRM - Interrogation Rate Monitor	6,6	-	-	6,6	If impl. (14.3s)
IRM - Reply Monitor	6,7	-	-	6,7	If impl. (1s)
HVA – High Vel. and Geo.Alt. msg.	-	-	-	6,E/6,F	Replace (0.5s)

*"-" Not provided, () conditionally provided, *1 When equipped with ACAS II / ACAS X, *2 E/W N/S Velocity airborne, *3 Only one Vertical Rate, priority for blended. *4 Minimum to provide at least one of the two. The ADS-B transmit (Tx) rates are provided as the average rate for airborne traffic and, when applicable, given for both high and low rates (High / Low). *5 If Track angle rate is not available. *6 Reduced rate when on ground and not moving*

ADS-B v2 and ADS-B v3 Tx rates columns indicate the requirements on the transmission of the parameters from the aircraft, including both high and low rates (High / Low). As such, these columns are not indicating the update rate on the display. The colour indicates the regulatory requirement, per EASA CS-ACNS, to provide the data item, where blue refers to required by Mode S ELS, green refers to required by Mode S EHS, purple refers to required for ADS-B version 2 and orange refers to conditionally required for ADS-B version 3.

ANNEX E ANSP FEEDBACK

In February 2022 the OEP workstream 13.6 and 01.07 sent a questionnaire containing a series of questions about the use of DAP/ADDs across Europe. This questionnaire was circulated to increase awareness of the current DAP/ADD usage and technical implementations. This annex contains the performance requirements of the data items described in the present document identified by the European ANSP.

E.1 Indicated Airspeed and Mach Number

European ANSPs have reported performance requirements related to the IAS and Mach number.

Table 13 IAS and MACH ANSP performance requirements

ANSPs IAS/Mach number performance Requirements		
ANSP 1	Maximum update delay	5s
ANSP 1	Extraction rate	5s
ANSP 2	Extraction rate	Radar scan time
ANSP 3	Probability of update	97% (SSR Pd from blue book)

Only one ANSP has reported performance requirements for maximum update delay IAS for display at CWP. This is a more demanding requirement than that for an En Route environment, but similar to that for a TMA environment. In the questionnaire, the environment where this requirement is applicable is not specified.

E.2 Magnetic Heading

European ANSPs have reported performance requirements related to the MHDG.

Table 14 MHDG ANSP performance requirements

ANSPs MHDG performance Requirements		
ANSP 1	Extraction rate	Scan time
ANSP 2	Probability of update	97% (SSR Pd from blue book)

Only one ANSP has reported performance requirements linked maximum update delay MHDG for display at CWP and this requirement is stricter than the assumed in the ADD-SPR in ENR but similar to the TMA requirement In the questionnaire, the environment where this requirement is applicable is not specified.

E.3 Selected altitude/Selected Level

European ANSPs have reported performance requirements related to the SAL.

Table 15 SAL ANSP performance requirements

ANSPs SAL performance Requirements		
ANSP 1	Maximum update delay	5s
ANSP 1	Extraction rate	5s
ANSP 2	Extraction rate	Radar scan time
ANSP 3	Extraction rate	Extraction on every track update
ANSP 4	Probability of update	97% (SSR Pd from blue book)

Only one ANSP has reported performance requirements for maximum update delay on SAL for display at CWP. This requirement is similar to the requirement of TMA environments.

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