

**GUIDANCE MATERIAL ON
GENERATION, PROCESSING & SHARING of ASTERIX
CATEGORY 21 ADS-B MESSAGES
(Including Attachments A, B, C & D)**

1. INTRODUCTION

1.1 The “All Purpose Structured Eurocontrol Surveillance Information Exchange” (ASTERIX) Category 21 is a data format standard globally accepted by the Air Traffic Management (ATM) system manufacturing industry for sharing of ADS-B data with ATM automation system. Asterix Category 21 data is used to convey ADS-B data from ADS-B ground stations to ATC processing and display system. This guidance material discusses various aspects of this process. Since the ASTERIX Category 21 version 0.23 was issued in November 2003, it has undergone continuous revisions with some 14 subsequent versions. The focus of this guidance material is to concentrate on 1090ES ADS-B data using:

- a) DO260;
- b) DO260A; and
- c) DO260B

1.2 The ASTERIX Category 21 version 1.0 issued in August 2008 has fully incorporated the DO260A standard while the latest version 2.1 issued in May 2011 has fully incorporated the latest DO260B standard.

2. ASTERIX CAT 21 IN ASIA AND PACIFIC REGIONS

2.1 To ensure interoperability of ADS-B ground stations in the Asia Pacific (ASIA/PAC) Regions, during the 16th APANPIRG Meeting held in August 2005, the ASTERIX Category 21 version 0.23 which had incorporated DO260 standard was adopted as the baselined ADS-B data format for deployment of ADS-B ground stations and sharing of ADS-B data in the ASIA/PAC Regions. At this time DO260A and DO260B standards were not defined.

3. CHOICE OF ASTERIX VERSION NUMBER

3.1 The Asterix standard has been developed over many years. Stability in the standard is desirable so that ADS-B ground station designers and ATM automation designers and manufacturers can build interoperable systems with confidence. Because ADS-B technology has been evolving over the years, and will continue to do so, it is not surprising that the Asterix standard has also developed along with the ADS-B link technology standards to grasp the best benefits of its intended design.

3.2 During 2005, Asia Pacific decided to use V0.23 as the version for sharing ADS-B data between states. This version provides adequate information so that useful ATC operational services can be provided including ATC 3 nautical mile and 5 nautical mile separation services. V0.23 can be used with DO260, DO260A and DO260B ADS-B avionics/ground stations to provide basic ATC operational services. However, V0.23 cannot fully support all the capabilities offered by DO260A and DO260B.

3.3 Nearly all V0.23 data items can be “re-constructed” from a received V2.1 data stream. However, most of the special DO260A/B data items cannot be “re-constructed” from a V0.23 data stream. In terms of domestic use and data sharing with other ANSPs concerning ADS-B data, several options exist for ANSPs as follows:

Option	Domestic use	Data sharing
1	V0.23	V0.23. This is the default and basic standard.
2	V2.1	V0.23. This will require some conversions to occur, probably through an ADS-B format conversion and filter system (see Paragraph 11), between a domestic system and a foreign system. Difficulties may exist if the domestic system requires special DO260A/B data items, since they cannot all be re-constructed from the external foreign V0.23 data stream.
3	V2.1	V2.1. Must negotiate bilaterally with data sharing partner regarding exact version to be used to achieve the intended functions.

Note: In this table, V2.1, the latest Asterix Cat 21 version, is chosen as a representation of an Asterix Cat 21 version after V0.23. There exists other Asterix CAT 21 versions (e.g. 0.26, 1.3. and etc.) after V0.23 that could be used by ANSPs for domestic and data sharing use.

4. SPECIFICATION OF ASTERIX MESSAGE PROCESSING

4.1 Care is needed to understand the difference in specifications :

4.2 **Asterix Cat 21:** Defines the characteristics of the data ON the interface including fields that are mandatory on the interface.

4.3 **ADS-B ground station specifications:** To define the Asterix standard, must also define which optional Asterix data items are required to be delivered on the Asterix interface, when the appropriate data is received from the aircraft. It is desirable that suppliers be required to :

- a) indicate how the ground station processes and outputs every received DO260, DO260A and DO260B data element into an Asterix data element/field; and
- b) indicate which and how each Asterix data element and field presented at the output are populated.

4.4 **ATM automation system specifications:** Defines which received Asterix data element and fields are processed and how they are processed. Also defines which Asterix optional data fields are required by the ATM automation systems (if any). ANSPs that specify ADS-B ground stations and ATM automation systems need to consider carefully and clearly about what they desire to achieve. Specifications which simply require compliance with a particular Asterix standard will be inadequate in most circumstances. In particular ANSPs, together with their suppliers should :

- a) Specify the Asterix standard version to be used. This defines the message formats that are placed on the link between ADS-B ground station and downstream systems like ATM automation, recording & analysis systems, bypass ATC systems and foreign ANSPs. The standard will define which messages elements are mandatory in each message (very few fields) and a large number of optional fields. The optional fields can only be filled if relevant data is received from the aircraft. The optional fields will only be filled if the ground station specification requires them to be filled.
- b) Specify the ADS-B ground station behaviour so that when data is received from the aircraft, the ground station is required to fill appropriate optional Asterix data fields.
- c) Specify the ATM automation system behaviour including appropriate semantic and syntax checks applied to the Asterix data, including any triggers for the system to discard data. The processing applied to each received Asterix data field.

5. MANDATORY FIELDS : ASTERIX AND 1090ES ADS-B

5.1 Asterix Cat 21 has been designed to support multiple datalinks. It has been defined to support data fields which are not available in the 1090ES standards. Therefore some data items and fields are not relevant when 1090ES is used.

5.2 The standard itself defines various items as optional or mandatory. This is defining what is ON the interface. It does NOT specify the behaviour of the transmitting ground station nor the behaviour of the receiving ATM automation system.

5.3 When a single link technology has been chosen it may be sensible to diverge from the formal V0.23 standard to reduce the required Asterix datalink bandwidth. E.g.: in an environment with only 1090ES, it is unnecessary to transmit “Link Technology Indicator”. Asterix Cat 21 Version 2.1 allows this selection.

Data Items	Description	Mandatory (M) or Optional (O) items as per ASTERIX Category 21	
		Version 0.23 Specification	Version 2.1 Specification
I021/010	Data Source Identification	M	M
I021/030	Time of Day	M	N/A
I021/071 or I021/073	Time of Applicability of Position or Time of Message reception for position	N/A	One of these is must be transmitted
I021/040	Target Report Descriptor	M	M
I021/080	Target Address	M	M
I021/210	Link Technology Indicator/ MOPS version	M	O

6. GENERATION OF ASTERIX AT AN ADS-B GROUND STATION

6.1 The following general principles should be adopted:

6.2 Commensurate with link bandwidth availability transmit all mandatory Asterix data items and also transmit those Asterix data items that are operationally desirable. That is, when the appropriate aircraft transmission is received by the ADS-B ground station, the data should be transmitted to the ATC system for operational use or for technical recording and analysis use. If no aircraft transmission data is received to fill an Asterix data item during any update cycle, the data item should not be included in the Asterix data stream to reduce bandwidth requirements.

6.3 **Group 1 (Mandatory Data Items):** An Asterix Cat21 message should not be transmitted unless the mandatory data items defined in Appendix A are all present.

6.4 **Group 2 (Desirable Data Items) :** The data items defined in Appendix B are operationally desirable which should always be transmitted in the Asterix Cat 21 messages whenever the data are received by the 1090ES ground station from aircraft (if allowed by the relevant Asterix standard chosen).

6.5 **Group 3 (Optional Data Items) :** The data items defined in Appendix C are considered optional and may or may not need to be transmitted depending on availability of such data from aircraft and/or other specific operational needs.

6.6. **Group 4 (Future Data Items):** The following data are defined in the DO260A and DO260B standards but are not yet defined in the Asterix standard. This group is provided for information only. It illustrates the need for system designers to provide for future adaptability when possible and when cost effective to do so. Not only will the Asterix standard continue to evolve, but changes to DO260 can also be anticipated within the decade.

- a) Target heading: Information from DO260A/B Target state and status messages (On condition messages). These could be used for detection of pilot errors in selection of heading/altitude; and
- b) GPS Offset: Could be used to more accurately display aircraft position on an airport surface, or better detect that an aircraft has passed an airport hold point.

6.7 When developing a specification for an ADS-B ground station, it is considered necessary that the specification requires the transmission of all data items that are operationally desirable (Group 2), when such data are received from the aircraft, in addition to the data items that are mandatory (Group 1) in Asterix messages. Whether Group 3 optional data items will need to be transmitted or not should be configurable on item-by-item basis within the ADS-B ground station depending on specific operational needs.

7. PROCESSING OF ASTERIX ADS-B DATA AT ATC SYSTEM

7.1 An Asterix Cat21 message should not be accepted by the ATC system for processing unless it includes at least all the Group 1 data items.

7.2 The ATC system should process all received Asterix Cat21 message data items that bring operational benefits (i.e. Group 2 data items). An ATM automation specification should require that the system appropriately process those Group 2 data items depending on specific operational need. Whether the ATC system will process Group 3 optional data items will depend on specific operational needs.

8. DATA SHARING OF ASTERIX ADS-B DATA

8.1 In principle, all data receiving from the shared ADS-B ground station should be delivered to the receiving party as far as practicable without filtering unless owing to technical reasons such as the need to convert the data from one ASTERIX format to another or it is requested by the receiving party of the data.

8.2 It is considered necessary that all data items that are mandatory in Asterix messages (i.e. Group 1 data items) and operationally desirable (i.e. Group 2 data items) when such data are received from aircraft, should be included in data sharing. In the event that the data have to be filtered, the list of optional data items (i.e. Group 3 data items) needs to be shared will be subject to mutual agreement between the two data sharing parties concerned.

9. ISSUE RELATED TO DO260A

9.1 Support of DO260A using Asterix Cat 21 V0.23

- a) DO260A was developed after V0.23 of Asterix was defined. Therefore, V0.23 does not directly support DO260A. However, ground station software can generate useful V0.23 Asterix data from DO260A reports through use of the following techniques;
- b) A useful I021/090 Figure of Merit can be generated from DO260A messages. Some implementations have a table, which defines the FOM/PA to be generated for each combination of SIL, NIC and NAC. The contents of the table can be offline defined to generate the appropriate FOM/PA values. The downstream ATC system can then process DO260A reports as if they were DO260 reports; and
- c) If there is a particular need for the ATC system to have access to the NIC/NAC or SIL or other data item that exist in DO260A (but not in DO260), then users may need to consider a more recent version of Cat 21.

9.2 Support of DO260A using Asterix Cat 21 V2.1

- a) If DO260A is used, then the ANSP could decide to use Asterix Cat 21 V1.0 (or later versions) or V2.1; and
- b) Readers are invited to carefully examine the DO260A fields (see Appendix D) to determine if the benefits of additional DO260A fields are large enough to warrant adoption of Asterix Cat 21 V1.0 (or later versions) or V2.1.

10. ISSUE RELATED TO DO260B

10.1 Support of DO260B using Asterix Cat 21 V0.23

- a) DO260B was developed some years after DO260A. Therefore, Asterix Cat 21, V0.23 does not directly support DO260B;

- b) The same techniques used for processing DO260A can be used for processing DO260B, however, the table used must account for NIC supplement B & NIC supplement C; and
- c) If there is a particular need for the ATC system to have access to the new data items offered by DO260B, then users may need to consider a more recent version of Cat 21 (e.g. V2.1).

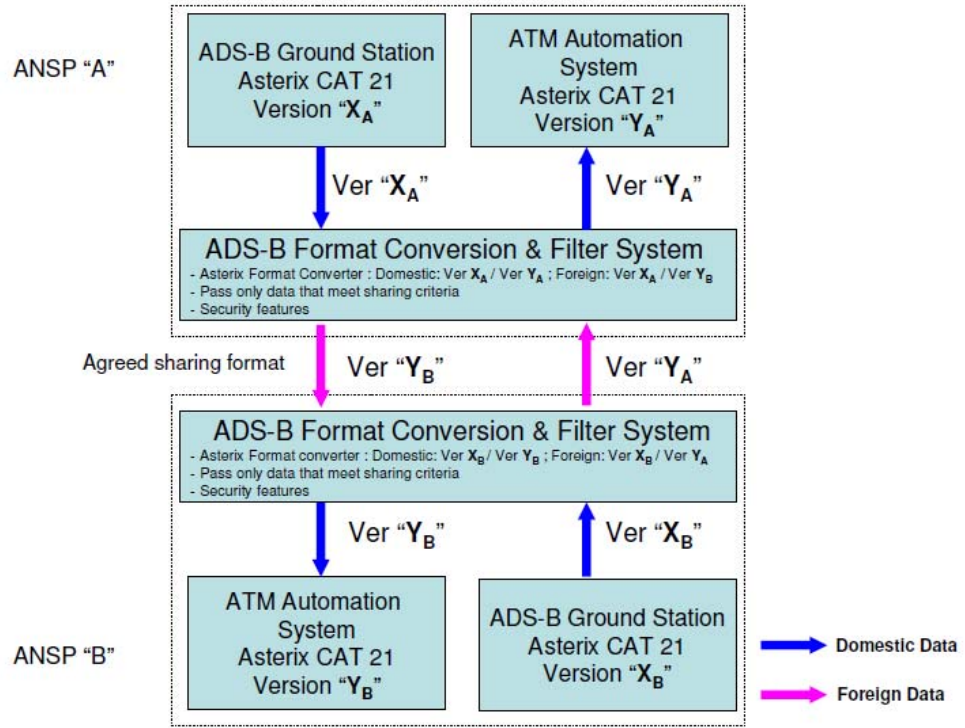
10.2 Support of DO260B using Asterix Cat 21 V2.1

- a) If DO260B is used, then the ANSP could decide to use Asterix Cat 21 V2.1; and
- b) Readers are invited to carefully examine the DO260B data items (see Appendix D) to determine if the benefits of additional DO260B data items are large enough to warrant adoption of Asterix Cat 21 Version 2.1.

11. ADS-B FORMAT CONVERSION AND FILTER SYSTEM

11.1 It is clear that the evolution of 1090ES ADS-B transmission will continue. Avionics software will be upgraded to provide additional or changed functionality. As a result Asterix standards will also continue to evolve, and ATC systems will need to be adaptable to be able to cope with new functionality requirements and new message standards.

11.2 The use of an ADS-B format conversion & filter (ADS-B FC&F) system between domestic ADS-B systems and data shared with other states is a cost-effective way to provide the necessary protection and flexibility in this evolution. Such a system provides ADS-B format conversion between domestic and foreign ADS-B systems. While decoupling one ADS-B Asterix environment from another, the system allows information that meets specific sharing criteria to be passed through for data sharing. By doing so, loading on the ATM automation systems to process ADS-B data and bandwidth requires to transmit the ADS-B data could then be reduced. The system also allows independent domestic format changes without disruption to the foreign environment. A typical structure could be as shown below:



Attachment A - Group 1 (Mandatory Data Items)

Data Items	Description	V	V	Remarks
		0.23	2.1	
I021/010	Data Source Identification	X	X	Identifies source of data. Important if validity checks are performed as an anti spoofing capability. Validation that the data is received from an approved ADS-B ground station. Data received from a ground station should not be processed if the position of the reported aircraft is an unreasonable distance away from the known location of the ADS-B ground station
I021/030	Time of Day	X		Necessary to extrapolate the ADS-B data to time of display. Data received with a Time of Day too far in the past should be discarded. This data is too old.
I021/071 or I021/073	Time of Applicability of Position or Time of Message reception for position		X	Necessary to extrapolate the ADS-B data to time of display. Data received with a Time of Day too far in the past should be discarded. This data is too old.
I021/040	Target Report Descriptor	X	X	Indicates if report is a duplicate, on the ground, is a simulated target, is a test target. This needs to be checked by ATC system prior to processing. If the data indicates that the report is a test target or a simulated target, it is normally processed differently to "real" targets.
I021/080	Target Address	X	X	Included in all 1090ES downlink messages, so always available. Used for report/report linkage in ATC tracking.
I021/090	Figure of Merit/Quality Indicators	X	X	Position cannot be used without quality indicator. If the quality of the positional data does not meet the requirements the data should be discarded.
I021/130	Position in WGS-84 co-ordinates	X	X	Report cannot be used without position

Attachment B - Group 2 (Desirable Data Items)

Data Items	Description	v 0.23	v 2.1	Remarks
I021/008	Aircraft operational status		X	TCAS capability, Target state reporting capability, CDTI capability, Single/dual aircraft antenna. It is desirable to have immediate knowledge of RA event.
I021/020	Emitter Category	X	X	Aircraft or vehicle type
I021/140	Geometric Altitude/Height	X	X	Useful for RVSM monitoring. Not normally used for ATC application. Could perhaps be used as an indicator of correct QNH setting in aircraft.
I021/145	Flight Level	X	X	Flight level is an important information to ATC
I021/155	Barometric Vertical Rate	X	X	Used for predictive tools and safety nets. Either Barometric vertical rate or Geometric vertical rate is provided by the aircraft – not both. However, the ATC system can calculate vertical rate from multiple flight level reports if these data items are not available.
I021/157	Geometric Vertical Rate	X	X	
I021/160	Ground Vector	X	X	Provides excellent vector to support extrapolation of positional data to time of display. However, the ATC system can calculate the velocity vector (ground vector) from multiple position reports. I021/160 however, is normally far superior that ATC system calculation.

Data Items	Description	v 0.23	v 2.1	Remarks
I021/170	Target Identification	X	X	<p>This is the callsign/Flight ID is extremely useful for ATC and matching to the flight plan (if any).</p> <p>Target identification is only sent once per 5 seconds. Some ground stations designs attach the target identification (if known from previous recent downlinks) even if not received in the last 5 seconds.</p> <p>The field can be missing at the edge of ADS-B coverage – for flights inbound to coverage.</p>
I021/200	Target Status	X	X	This is the emergency type and is highly desirable.

Attachment C - Group 3 (Optional Data Items)

Data Items	Description	V 0.23	V 2.1	Remarks
I021/077	Time of report transmission		X	Time of applicability is relevant for ATC system processing. Time of transmission is less relevant.
I021/032	Time of Day Accuracy	X		Maximum error in Time of day. Normally the maximum value is known by the ANSP because of station design.
I021/095	Velocity Accuracy	X		If using GPS, velocity accuracy will be adequate if the Position quality is accurate.
I021/072	Time of applicability of velocity		X	Can be managed by a velocity data time out in Ground station.
I021/075	Time of message reception of velocity		X	Normally velocity is in the same Asterix message as position. Velocity data time out in Ground station.
I021/161	Track number		X	Tracking can be performed by ATC system. Also the 24 bit code (aircraft address) could be used as a pseudo track number.
I021/110	Trajectory Intent	X	X	Defined in DO260 but not transmitted by any known product. Not defined in DO260A or DO260B
I021/146	(Intermediate) Selected Altitude	X	X	Target altitude : Information from DO260A/B Target state and status messages (On condition messages). These could be used for detection of pilot errors in selection of heading/altitude.
I021/148	Final State Selected Altitude	X	X	
I021/015	Service identification		X	Type of Service (VDL4, Ext Squitter, UAT, TIS-B VDL4, TIS-B Ext Squitter, TIS-B UAT, FIS-B VDL4, GRAS VDL4, MLT). Not useful to most ATC systems.
I021/016	Service management		X	Update rate or whether data driven output from GS. Normally known by receiver.

Data Items	Description	v 0.23	v 2.1	Remarks
I021/074	Time of message reception of position – high resolution		X	High resolution is designed to support MLAT system processing by receiver. Not required for pure ADS-B.
I021/076	Time of message reception of velocity – high resolution		X	High resolution is designed to support MLAT system processing by receiver. Not required for pure ADS-B.
I021/210	MOPS version/ Link Technology Indicator	X	X	Maybe useful for statistics about equipage. Not operationally relevant
I021/070	Mode 3/A code		X	Could be used for legacy ATC system that do not use Flight ID
I021/165	Rate of Turn/Track Angle rate	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/271	Surface capabilities and characteristics		X	
I021/132	Message amplitude		X	Useful for technical analysis. Not operationally relevant
I021/250	Mode S MB data		X	
I021/260	ACAS resolution advisory report		X	
I021/400	Receiver ID		X	
I021/295	Data ages		X	
I021/150	Air Speed	X	X	Defined in standards but only sent in absence Ground vector information. Can't be used for extrapolation unless wind speed known.
I021/151	True Air Speed	X	X	
I021/152	Magnetic Heading	X	X	Defined in standards but only sent in absence Ground vector information.
I021/220	Met Report	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/230	Roll Angle	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/131	Position in WGS-84 coordinates, high resolution		X	

Attachment D - Differences among DO260, DO260A, DO260B

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Introduction of Navigation Integrity Category (NIC) to replace Navigation Uncertainty Category (NUC _P)	NUC _P is used.	NIC is used to replace NUC _P .	More level of NIC available. Vertical component removed.	NIC is shown in v1.0 and above. More level of NIC (shown as PIC) is available in v2.1.	The additional quantum levels of NIC would allow the ANSP more flexibility in deciding whether the NIC is considered as 'good' (if required) However, for 3 NM & 5 NM separation with HPL 1Nm and 2 Nm respectively, this additional quantum is not useful.
Quality Indicator for Velocity (NUC _R and NAC _V)	NUC _R is used.	Replaced with NAC _V . Definition remains the same.	Vertical component removed.	Available in v0.23 and above.	Vertical component is not available for DO260B.
Surveillance Integrity Level and Source Integrity Level (SIL)	Not available.	Surveillance Integrity Level is used.	Renamed as Source Integrity Level. Definition is changed to exclude avionics fault.	Available in v1.0 and above.	The SIL will allow the user to further assess the integrity of the reported position (if required). NB: An implied SIL exists for DO260 aircraft if they always use GPS. However DO260 aircraft do not provide SIL.
System Design Assurance (SDA)	Not available.	Not available.	To address probability of avionics fault.	Available in v2.1.	The SDA will indicate the robustness of the system. ANSPs may decide on a minimum SDA for ADS-B services. If this action is taken then DO260 aircraft will be unable to meet the criteria.

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	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Navigation Accuracy Category (NAC _P)	Not available.	Derived from HFOM and VFOM.	Relies only on HFOM.	Available in v1.0 and above.	A reported accuracy is not provided by DO260. However, an estimated accuracy can be derived from NUC – assuming that NUC is HPL based.
Geometric Vertical Accuracy (GVA)	Not available.	Not available.	Derived from VFOM.	Available in v2.1.	Geometric altitude accuracy is not normally required for operational purposes.
Barometric Altitude Integrity Code (NIC _{BARO})	Not available.	To indicate integrity of barometric altitude.	Same as DO-260A	Available in v1.0 and above.	The NIC _{BARO} indicates the integrity of the barometric height. ANSPs could indicate to the controller that Barometric data has not been verified, however, aircraft without dual barometric systems/air data computers may be unable to provide a non zero NIC _{BARO} as data could be unnecessarily discarded.
Length / Width of Aircraft	Not available.	Provide an indication of aircraft size.	Same as DO-260A	Available in v1.0 and above.	The width / length indicate the size of the aircraft. This information may be used as an input for generating alerts on airport surface movement control.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Indication of capabilities	Only show status of TCAS and CDTI.	More information available including capability to send Air Reference Velocity, Target State and Trajectory Change reports. Status of Identity Switch.	Additional information on type of ADS-B in (i.e. 1090ES in or UAT in).	Available in v1.0 and above, except availability of 1090ES/UAT in and information on GPS antenna offset.	Indication on the availability of 1090ES in / UAT in may allow the controller to anticipate a potential request for in-trail procedure clearance. NB: ITP requires decision support aids which are more complex than ADS-B IN alone.
Status of Resolution Advisory	Not available.	Information on whether Resolution Advisory is active.	Same as DO-260A	Available in v1.0 and above,	Indication of the resolution advisory status allows the controller to know whether the pilots were alerted about the potential conflict.
GPS offset	Not available.	Indication on whether GPS offset is applied.	Information on GPS antenna offset is provided.	GPS offset status is available in v1.0 and above. Information on GPS offset is not available in ASTERIX	Indication on GPS offset may be one of the inputs for generating alerts on airport surface movement control.
Intention	Not available.	Able to indicate intended altitude and heading.	Same as DO-260A	Intended altitude is available in v0.23. Intended heading is not available in ASTERIX.	The intended heading and flight level can be used as an input to the trajectory prediction algorithm in the Short-Term Conflict Alert.

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	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Target Status	Not available.	Not available.	Indication of Autopilot mode, Vertical Navigation mode, Altitude Hold mode, Approach Mode and LNAV Mode.	Vertical Navigation mode, Altitude Hold mode and Approach Mode are available in v 0.23 and above LNAV Mode is available in v2.1	The target status allows the controller to know the mode that the aircraft is in. i.e.: It could be presented to ATC.
Resolution Advisory	Not available.	Not available.	Availability of Active Resolution Advisories; Resolution Advisory complement record, Resolution Terminated; Multiple Threat encounter; Threat Type indicator; and Threat Identity data.	Available in v1.0 and above.	The Resolution Advisory will help the controller know the advisories that are provided to the pilots by the ACAS. This helps prevent the controller from giving instructions that are in conflict with the ACAS.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Mode A	DO260A change 1, allows this using test message in USA only. This was not implemented in actual products.	Broadcasted using test message in USA only.	Broadcasted worldwide as a regular message.	Available in v0.26 and above.	The Mode A allows flight plans to be coupled with the ADS-B tracks (supports legacy ATM automation system).
