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This document specifies the contents of ASTERIX Category 020 messages used for the transmission of Multilateration Target Reports reports.			
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This document has been approved by the ASTERIX Maintenance Group (AMG).

For management approval of the complete set of ASTERIX documentation refer to Part 1.

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1. INTRODUCTION

1.1 **Scope**

This document describes the message structure for the transmission of multilateration target reports.

A system of multilateration receivers and, if applicable transmitters, connected to a central processing system is seen as a single sensor.

This version has been extended to allow integration of ADS-B data, while indicating the source in I020/020.

2. REFERENCES

2.1 General

The following Documents and Standards contain provisions which, through references in this text, constitute provisions of this EUROCONTROL Document.

At the time of publication of this EUROCONTROL Document, the editions indicated for the referenced documents and standards were valid.

Any revision of the referenced ICAO Documents shall be immediately taken into account to revise this EUROCONTROL Document.

Revisions of the other referenced documents shall not form part of the provisions of this EUROCONTROL Document until they are formally reviewed and incorporated into this EUROCONTROL Document.

In case of a conflict between the requirements of this EUROCONTROL Document and the contents of the other referenced documents, this EUROCONTROL Document shall take precedence.

2.2 Reference Documents

1. EUROCONTROL Standard SUR.ET1.ST05.2000-STD-01-01. "All Purpose Structured EUROCONTROL Surveillance Information Exchange – ASTERIX". Edition 3.1, Released Issue, November 2021.
2. EUROCAE ED-73F/DO181F "MOPS for Secondary Surveillance Radar Mode S Transponders".
3. EUROCAE ED-102()/RTCA DO-260(): "Minimum Operational Performance Standard (MOPS) for 1090 MHz Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Services-Broadcast (TIS-B)".
4. EUROCAE ED-275/RTCA DO-386 "MOPS for Airborne Collision Avoidance System X_u (ACAS X_u)".
5. RTCA DO-282(): Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance Broadcast (ADS-B)
6. RTCA DO-185(): Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (TCAS II).

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3. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

3.1 Definitions

For the purposes of this EUROCONTROL Document, the following definitions shall apply:

- | | | |
|-------|----------------------------------|--|
| 3.1.1 | Catalogue of Data Items: | List of all possible Data Items of each Data Category describing the Data Items by their reference, structure, size and units (where applicable). |
| 3.1.2 | Data Block: | Unit of information seen by the application as a discrete entity by its contents. A Data Block contains one or more Record(s) containing data of the same category. |
| 3.1.3 | Data Category: | Classification of the data in order to allow for, inter alia, an easy identification. |
| 3.1.4 | Data Field: | Physical implementation for the purpose of communication of a Data Item. It is associated with a unique Field Reference Number and is the smallest unit of transmitted information. |
| 3.1.5 | Data Item: | The smallest unit of information in each Data Category. |
| 3.1.6 | Measured Item: | A piece of information (e.g. the position of a target) derived from the sensor information and transmitted without any smoothing. |
| 3.1.7 | Record: | A collection of transmitted Data Fields of the same category preceded by a Field Specification field, signalling the presence/absence of the various Data Fields |
| 3.1.8 | User Application Profile: | The mechanism for assigning Data Items to Data Fields, and containing all necessary information which needs to be standardised for the successful encoding and decoding of the messages. |

3.2 Acronyms and Abbreviations

For the purposes of this EUROCONTROL Document the following shall apply:

°	Degree (angle)
ASTERIX	All Purpose ST structured EUROCONTROL su R veillance Information EX change
CAS	Collision Avoidance System
CAT	Data Category
CF	Control Field as defined in Ref. [2] Table 2-7
DOP	Dilution Of Precision
EATM	European Air Traffic Management
EHS	(Mode S) Enhanced Surveillance
FL	Flight Level, unit of altitude (expressed in 100's of feet)
FRN	Field Reference Number
FSPEC	Field Specification
FX	Field Extension Indicator
ICAO	International Civil Aviation Organization
kt	knot = NM/hour, unit of speed
LEN	Length Indicator
LSB	Least Significant Bit
MLT	Multilateration
MOPS	Minimum Operational Performance Standard
NM	Nautical Mile, unit of distance (1852 metres)
PSR	Primary Surveillance Radar
RA	Resolution Advisory (CAS Capability)
RDE-FG	Radar Data Exchange Focus Group
RE	Reserved Expansion Indicator
REP	Field Repetition Indicator
s	second, unit of time
SAC	System Area Code
SIC	System Identification Code
SMR	Surface Movement Radar
SMS	Surface Movement System
SP	Special Purpose Indicator
SPI	Special Position Identification
SSR	Secondary Surveillance Radar

SURT	Surveillance Team (EATM)
TA	Traffic Advisory (CAS Capability)
UAP	User Application Profile (see Definitions)
UTC	Coordinated Universal Time
WAM	Wide Area Multilateration
WGS-84	World Geodetic System 84

4. GENERAL PRINCIPLES

4.1 General

For the transmission of multilateration data of the following two types of messages have been defined:

- target reports,
- service messages.

This document describes the target report messages. Service messages are defined as category 019 or category 025.

4.2 Time Management

4.2.1 Definition

The time stamp shall be consistent with the reported target position.

4.2.2 Requirements for Time Stamping

The timestamping shall comply with ICAO Annex 5.

4.3 Projection Systems and Geographical Coordinates

Two different types of Coordinate reference systems are supported.

4.3.1 Coordinates Expressed in the Local 2D Coordinate Reference System (Cartesian Representation):

The position can be expressed in a 2D Cartesian Coordinate system, which is a plane tangential to the WGS-84 Ellipsoid at the location of the MLT System Reference Point as defined in item I019/600 and in item I025/600. The height of the MLT System Reference Point is defined in item I019/610 and in item I025/610. The origin of the Cartesian Coordinate system coincides with the published system origin. The Y-axis points to the geographical north at that position. The X-axis is perpendicular to the Y-axis and points to the east. The X, Y Coordinates are calculated using either the measured height or an assumed target height and apply a suitable projection technique for the final 3D to 2D conversion (e.g. a stereographical projection).

All tracker derived information elements, shall be a consistent set of values, expressed in the same Coordinate reference system (state vector components and the corresponding elements of the track quality vector).

4.3.2 Coordinates Expressed in WGS-84 Format (Geographical Coordinates):

The exported position can be expressed in a 2D or 3D WGS-84 format. In case of 3D representation the item 020/105 (Geometric Height) has to be used in combination with item 020/041 (Position in WGS-84 Coordinates).

4.4 Unused Bits in Data Items.

Decoders of ASTERIX data shall never assume and rely on specific settings of spare or unused bits. However in order to improve the readability of binary dumps of ASTERIX records, it is recommended to set all spare bits to zero.

4.5 Definitions and Addressing Concepts

In order to address sources in an unambiguous way, a simple abstract model for concepts like sensors or systems has been designed.

4.5.1 Sensor

In the framework of Category 020 a multilateration sensor is:

- a system of multilateration receivers and, if applicable transmitter, in combination with a central processing system

4.5.2 System

In the framework of category 020 a System is a Sensor.

4.5.3 Addressing Concepts: Assigning SAC/SIC Codes

By convention a dedicated and unambiguous SAC/SIC code shall be assigned to every System.

4.6 Target Reports

Target reports include reports from a multilateration system.

4.7 User Application Profile and Data Blocks

4.7.1 A single User Application Profile (UAP) is defined and shall be used for both target reports and service messages.

4.7.2 Data Blocks shall have the following layout.

CAT = 020	LEN		FSPEC	Items of the first record	FSPEC	Items of the last record
------------------	------------	--	--------------	---------------------------	--------------	--------------------------

where:

- Data Category (CAT) = 020, is a one-octet field indicating that the Data Block contains Multilateration data;
- Length Indicator (LEN) is a two-octet field indicating the total length in octets of the Data Block, including the CAT and LEN fields;
- FSPEC is the Field Specification.

4.8 Composition of Messages

4.8.1 Messages shall be composed of Data Items assembled in the order defined by the Field Reference Number (FRN) in the associated UAP.

4.8.2 When sent, items shall always be transmitted in a record with the corresponding FSPEC bits set to one.

5. LAYOUT OF MESSAGES

5.1 Standard Data Items

The standardised Data Items, which shall be used for the transmission of Multilateration data are described on the following pages.

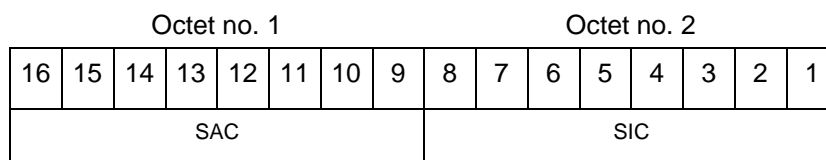
5.2 Description of Standard Data Items

5.2.1 Data Item I020/010, Data Source Identifier

Definition: Identification of the system from which the data are received.

Format: Two-octet fixed length Data Item.

Structure:



bits-16/9 (SAC) System Area Code

bits-8/1 (SIC) System Identification Code

Encoding Rule: This data item shall be present in each ASTERIX record

NOTE: The up-to-date list of SACs is published on the EUROCONTROL Web Site (<http://www.eurocontrol.int/asterix>).

5.2.2 Data Item I020/020, Target Report Descriptor

Definition: Type and characteristics of the data as transmitted by a system.

Format: Variable length Data Item comprising a first part of one-octet, followed by one-octet extents as necessary.

Structure of First Part:

Octet no. 1

8	7	6	5	4	3	2	1
TYP							FX
SSR	MS	HF	VDL4	UAT	DME	OT	

- bits-8/2 (TYP) SSR = 1 Non-Mode S 1090MHz multilateration
= 0 No Non-Mode S 1090MHz multilat.

- MS = 1 Mode-S 1090 MHz multilateration
= 0 No Mode-S 1090 MHz multilateration

- HF = 1 HF multilateration
= 0 No HF multilateration

- VDL4 = 1 VDL Mode 4 multilateration
= 0 No VDL Mode 4 multilateration

- UAT = 1 UAT multilateration
= 0 No UAT multilateration

- DME = 1 DME/TACAN multilateration
= 0 No DME/TACAN multilateration

- OT = 1 Other Technology multilateration
= 0 No Other Technology multilateration

- bit-1 (FX) = 0 End of Data Item
= 1 Extension into first extent

Encoding Rule: This data item shall be present in each ASTERIX record

Structure of First Extension:

Octet no. 1

8	7	6	5	4	3	2	1
RAB	SPI	CHN	GBS	CRT	SIM	TST	FX

bit-8	(RAB)	= 0	Report from target transponder
		= 1	Report from field monitor (fixed transponder)
bit-7	(SPI)	= 0	Absence of SPI
		= 1	Special Position Identification
bit-6	(CHN)	= 0	Chain 1
		= 1	Chain 2
bit-5	(GBS)	= 0	Transponder Ground bit not set
		= 1	Transponder Ground bit set
bit-4	(CRT)	= 0	No Corrupted reply in multilateration
		= 1	Corrupted replies in multilateration
bit-3	(SIM)	= 0	Actual target report
		= 1	Simulated target report
bit-2	(TST)	= 0	Default
		= 1	Test Target
bit-1	(FX)	= 0	End of Data Item
		= 1	Extension into next extension

**Structure
of Second Extension:**

Octet no. 1

8	7	6	5	4	3	2	1
CF	0	0	0	0	0	0	FX

bits-8/7 (CF) = 0 Target with 24-bit ICAO address
 = 1 Target with a non-ICAO 24-bit address
 = 2 Non-ADS-B Message
 = 3 Information not available
See Notes below

bits-6/2 (Spare) Spare bits, set to 0

bit-1 (FX) = 0 End of Data Item
 = 1 Extension into next extension

NOTE - The CF-indication (Bits 8/7) is related to the CF value received in the DF-18 format of the ADS-B 1090 MHz Extended Squitter as described in the EUROCAE ED-102B/RTCA DO-260C (Table 2-7) document. This field provides information on the type of address provided (ICAO versus non-ICAO).

CF=0 denotes an ADS-B Message with the target carrying a 24-bit ICAO address (DF-18 with CF = 0).

CF=1 denotes an ADS-B Message with the target carrying another kind of address for the transmitting ADS-B participant: a self-assigned "anonymous" address, a ground vehicle address, or a surface obstruction address (DF-18 with CF = 1).

CF=2 denotes a Non-ADS-B Message received from the ADS-B system. Further details are available in EUROCAE ED-102B/RTCA DO-260C (Table 2-7) (DF-18 with CF > 1).

CF=3 indicates that information is not available, set for targets not providing DF-18 messages.

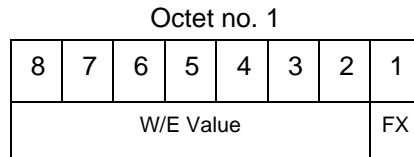
Population of this element requires the Multilateration system to be capable of decoding ADS-B 1090 MHz Extended Squitter messages received from the aircraft. Multilateration systems not capable of decoding ADS-B 1090 MHz Extended Squitter messages shall encode CF=3.

5.2.3 Data Item I020/030, Warning/Error Conditions

Definition: Warning/error conditions detected by a system for the target report involved.

Format: Variable length Data Item comprising a first part of one-octet, followed by one-octet extents as necessary.

Structure:



bits-8/2 (W/E Value) Warning/error condition value

bit-1 (FX) = 0 End of Data Item
 = 1 Extension into first extent (next W/E condition value)

Warning/Error Code	Description
0	Not defined; never used.
1	Multipath Reply (Reflection)
3	Split plot
10	Phantom SSR plot
11	Non-Matching Mode-3/A Code
12	Mode C code / Mode S altitude code abnormal value compared to the track
15	Transponder anomaly detected
16	Duplicated or Illegal Mode S Aircraft Address
17	Mode S error correction applied
18	Undecodable Mode C code / Mode S altitude code

Encoding Rule:

This Data item is optional. When used, it shall be transmitted only if different from zero.

NOTES

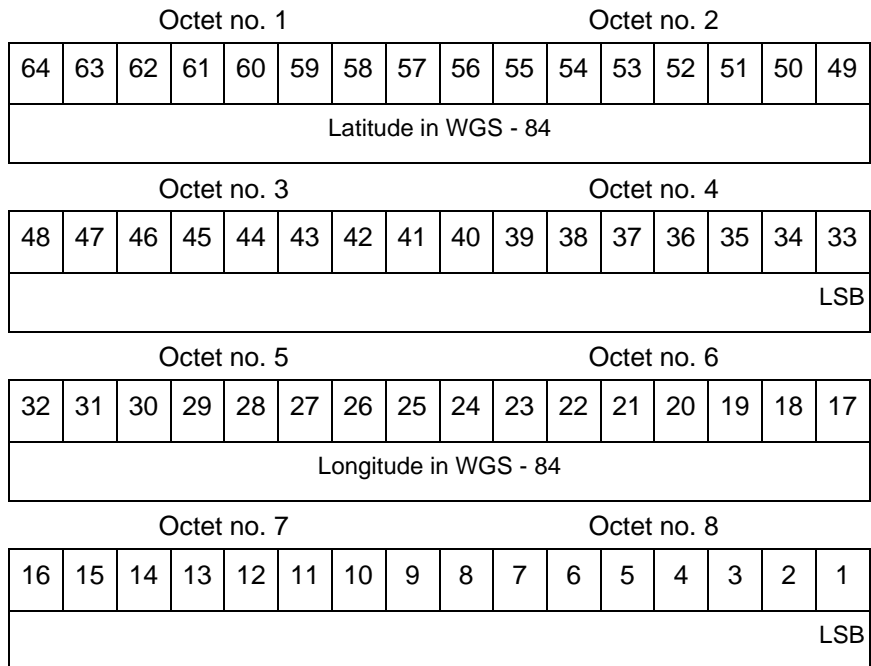
1. It has to be stressed that a series of one or more W/E conditions can be reported per target report.
2. Data conveyed in this item are of secondary importance, and can generally also be derived from the processing of mandatory items.
3. Definitions can be found in SUR.ET1.ST03.1000-STD-01-01 Radar Sensor Performance Analysis.
4. The coding of Warning/Errors is kept consistent with category 048.

5.2.4 Data Item I020/041, Position in WGS-84 Coordinates

Definition : Position of a target in WGS-84 Coordinates.

Format : Eight-octet fixed length Data Item

Structure:



bits-64/33	(Latitude)	In WGS-84 in two's complement. Range -90 <= latitude <= 90 deg.
	(LSB)	= 180/2 ²⁵ degrees
bits-32/1	(Longitude)	In WGS-84 in two's complement. Range -180 <= longitude < 180 deg.
	(LSB)	= 180/2 ²⁵ degrees

The LSB provides a resolution better than 0.6m.

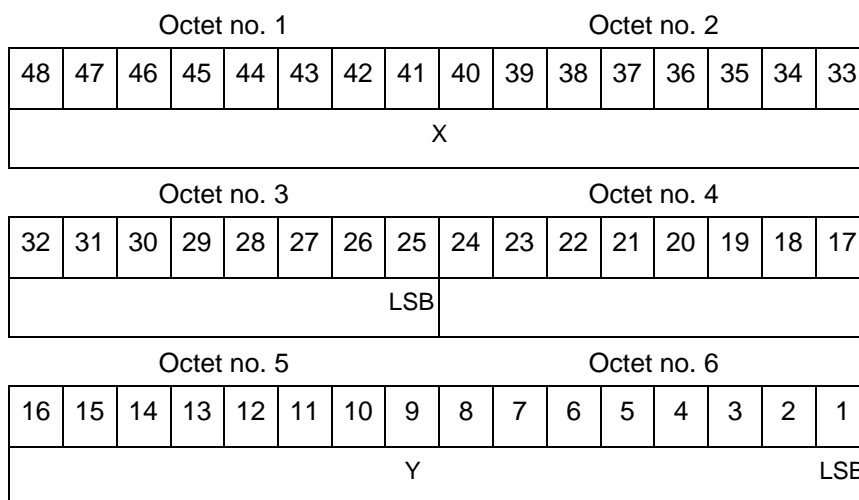
Encoding Rule : This data item shall be present in each ASTERIX record used in the scope of Wide Area Multilateration (WAM) if available. For airport applications this item is optional. In this case either item I020/041 or item I020/042 shall be sent.

5.2.5 Data Item I020/042, Position in Cartesian Coordinates

Definition: Calculated position in Cartesian Coordinates in reference to the MLT System Reference Point as defined in item I019/600 and I019/610 or I025/600 and I025/610, provided in two's complement representation.

Format: Six-octet fixed length Data Item.

Structure:



- bits 48/25 = X
- bit 25 (LSB) = 0.5 m, max range=+/-4194.3km (~2265 NM)
- bits 24/1 = Y
- bit 1 (LSB) = 0.5 m, max range=+/-4194.3km (~2265 NM)

Encoding Rule : This item is optional

5.2.6 Data Item I020/050, Mode-2 Code in Octal Representation

Definition: Mode-2 code converted into octal representation.

Format: Two-octet fixed length Data Item.

Structure:

Octet no. 1								Octet no. 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
V	G	L	0	A4	A2	A1	B4	B2	B1	C4	C2	C1	D4	D2	D1

bit-16	(V)	=	0	Code validated
		=	1	Code not validated
bit-15	(G)	=	0	Default
		=	1	Garbled code
bit-14	(L)	=	0	Mode-2 code derived from the reply of the transponder
		=	1	Smoothed Mode-2 code as provided by a local tracker n
bit-13				Spare bit set to 0
bits-12/1				Mode-2 reply in octal representation

Encoding Rule:

This data item is optional. It shall be sent when Mode-2 is present. Then, it represents the Mode-2 code of the plot, even if associated with a track.

5.2.7 Data Item I020/055, Mode-1 Code in Octal Representation**Definition:** Mode-1 code converted into octal representation.**Format:** One-octet fixed length Data Item.**Structure:**

Octet no. 1							
8	7	6	5	4	3	2	1
V	G	L	A4	A2	A1	B2	B1

bit-8	(V)	=	0	Code validated
		=	1	Code not validated
bit-7	(G)	=	0	Default
		=	1	Garbled code
bit-6	(L)	=	0	Mode-1 code derived from the reply of the transponder
		=	1	Smoothed Mode-1 code as provided by a local tracker
bits-5/1				Mode-1 Code in octal representation

Encoding Rule:

This data item is optional. It shall be sent when Mode-1 is present. Then, it represents the Mode-1 code of the plot, even if associated with a track.

5.2.8 Data Item I020/070, Mode-3/A Code in Octal Representation

Definition: Mode-3/A code converted into octal representation.

Format: Two-octet fixed length Data Item.

Structure:

Octet no. 1								Octet no. 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
V	G	L	0	A4	A2	A1	B4	B2	B1	C4	C2	C1	D4	D2	D1

bit-16	(V)	= 0	Code validated
		= 1	Code not validated
bit-15	(G)	= 0	Default
		= 1	Garbled code
bit-14	(L)	= 0	Mode-3/A code derived from the reply of the transponder
		= 1	Mode-3/A code not extracted during the last update period
bit-13			Spare bit set to 0
bits-12/1			Mode-3/A reply in octal representation

Encoding Rule:

- For Mode S, once a Mode-3/A code is seen, that code shall be sent every update period, provided the MLT system is receiving replies for that aircraft.
- Bit 14 (L) will be set when the Mode 3/A Code was taken from the Track file

NOTES

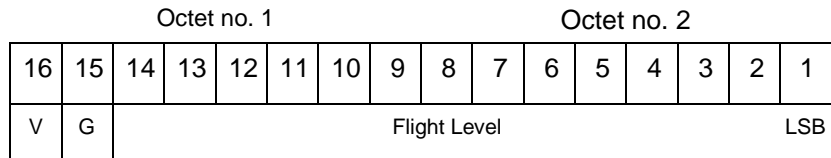
1. Bit 15 (G) is set to one when an error correction has been attempted.
2. Bit 16 (V) is normally set to zero, but can exceptionally be set to one to indicate a non-validated Mode-3/A code (e.g. alert condition detected, but new Mode-3/A code not successfully extracted).

5.2.9 Data Item I020/090, Flight Level in Binary Representation

Definition: Flight Level (Mode S Altitude) converted into binary two's complement representation.

Format: Two-octet fixed length Data Item.

Structure:



bit-16 (V) = 0 Code validated
 = 1 Code not validated

bit-15 (G) = 0 Default
 = 1 Garbled code

bits-14/1 (Flight Level)
 LSB= 1/4 FL

Encoding Rule:

This data item shall be sent when Mode S / Mode C altitude code is present and decodable. It represents the flight level of the plot, even if associated with a track.

NOTES

1. When Mode C code / Mode S altitude code is present but not decodable, the "Undecodable Mode C code / Mode S altitude code" Warning/Error should be sent in I020/030.
2. When local tracking is applied and the received Mode S altitude code corresponds to an abnormal value (i.e: the difference in altitude between the current and the previous plot exceeds a predefined system threshold), the "Mode C code / Mode S altitude code abnormal value compared to the track" Warning/Error should be sent in I020/030.
3. The value shall be within the range described by ICAO Annex 10
4. For Mode S, bit 15 (G) is set to one when an error correction has been attempted.

5.2.10 Data Item I020/100, Mode-C Code

Definition: Mode-C height in Gray notation as received from the transponder together with the confidence level for each reply bit as provided by a MSSR/Mode-S station.

Format: Four-octet fixed length Data Item.

Structure:

Octet no. 1								Octet no. 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
V	G	0	0	C1	A1	C2	A2	C4	A4	B1	D1	B2	D2	B4	D4

Octet no. 3								Octet no. 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	0	0	0	QC1	QA1	QC2	QA2	QC4	QA4	QB1	QD1	QB2	QD2	QB4	QD4

- bit-32 (V) = 0 Code validated
= 1 Code not validated
- bit-31 (G) = 0 Default
= 1 Garbled code
- bits-30/29 Spare bits set to 0
- bits-28/17 Mode-C reply in Gray notation
- bits-16/13 Spare bits set to 0
- bits-12/1 (QXi) = 0 High quality pulse Xi
= 1 Low quality pulse Xi

Encoding Rule:

This data item is optional. When used, it shall only be sent when a not validated or undecodable Mode C has been received.

For Mode-C, it represents the confidence level for each reply bit of the Mode C code of the plot.

For Mode-S, if this data-item is sent because of an undecodable Mode-C Code received in a Mode-S Altitude reply, then all pulse quality bits will be set to one (high).

Notes:

1. For Mode S, bit 31 (G) is set to one when an error correction has been attempted.
2. For Mode S, D1 is also designated as Q, and is used to denote either 25ft or 100ft reporting.

5.2.11 Data Item I020/105, Geometric Height (WGS-84)

Definition: Vertical distance between the target and the projection of its position on the earth's ellipsoid, as defined by WGS84, in two's complement form.

Format: Two-octet fixed length Data Item.

Structure:

Octet no. 1								Octet no. 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Geometric Height (WGS-84)														LSB	

bits-16/1 Geometric Height (WGS-84)
 LSB= 6.25 ft
 Range= +/- 204 800 ft

Encoding Rule: This item is optional.

5.2.12 Data Item I020/110, Measured Height (Local Cartesian Coordinates)

Definition: Height above local 2D co-ordinate system in reference to the MLT System Reference Point as defined in item I019/610, in two's complement form, based on a direct measurement not related to barometric pressure.

Format: Two-octet fixed length Data Item.

Structure:

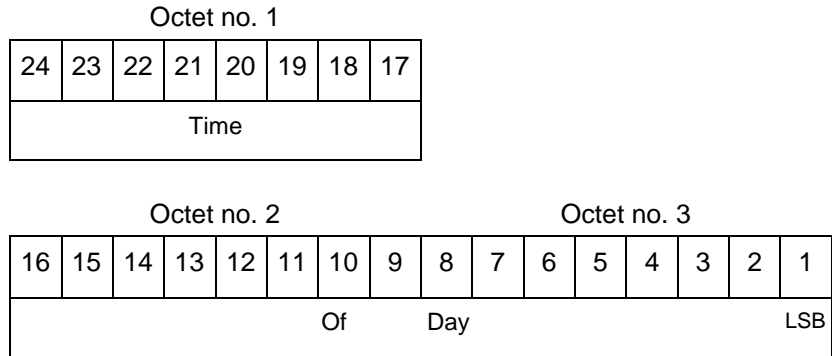
Octet no. 1								Octet no. 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Measured Height														LSB	

bits-16/1 Measured Height
 LSB= 6.25 ft
 Range= +/- 204 800 ft

Encoding Rule: This item is optional.

5.2.13 Data Item I020/140, Time of Day

Definition: Absolute time stamping expressed as UTC.
Format: Three-octet fixed length Data Item.
Structure:



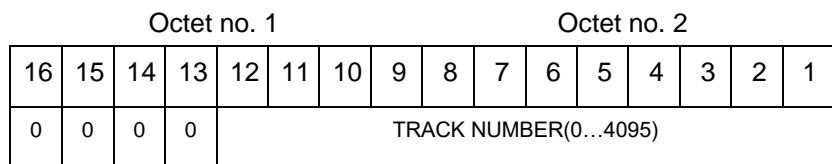
bit-1 (LSB) 1/128 s

NOTE - The time of day value is reset to zero each day at midnight.

Encoding Rule : This data item shall be present in every ASTERIX record, except in case of failure of all sources of time-stamping.

5.2.14 Data Item I020/161, Track Number

Definition: An integer value representing a unique reference to a track record within a particular track file.
Format: Two-octet fixed length Data Item.
Structure:



bits-16/13 Spare bits set to zero.
 bits-12/1 Track number.

Encoding Rule: This item is optional

5.2.15 Data Item I020/170, Track Status**Definition:** Status of track.**Format:** Variable length Data Item comprising a first part of one-octet, followed by one-octet extents as necessary.**Structure of First Part:**

Octet no. 1

8	7	6	5	4	3	2	1
CNF	TRE	CST	CDM	MAH	STH	FX	

bit-8	(CNF)	= 0	Confirmed track
		= 1	Track in initiation phase
bit-7	(TRE)	= 0	Default
		= 1	Last report for a track
bits-6	(CST)	= 0	Not Coasted
		= 1	Coasted
bit-5/4	(CDM)	= 00	Maintaining
		= 01	Climbing
		= 10	Descending
		= 11	Invalid
bit-3	(MAH)	= 0	Default
		= 1	Horizontal manoeuvre
bit-2	(STH)	= 0	Measured position
		= 1	Smoothed position
bit-1	(FX)	= 0	End of Data Item
		= 1	Extension into first extent

Encoding Rule: This item is optional

Structure of First Extent:

Octet no. 1							
8	7	6	5	4	3	2	1
GHO	0	0	0	0	0	0	FX

bit-8 (GHO) = 0 Default
 = 1 Ghost track

Bit 7/2 Spare bits set to 0

bit-1 (FX) = 0 End of Data Item
 = 1 Extension into second extent

NOTES

1. Bit-8 (GHO) is used to signal that the track is suspected to have been generated by a fake target.

5.2.16 Data Item I020/202, Calculated Track Velocity in Cartesian Coordinates

Definition: Calculated track velocity expressed in Cartesian Coordinates, in two's complement representation.

Format: Four-octet fixed length Data Item.

Structure:

Octet no. 1								Octet no. 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
V _x LSB															
Octet no. 3								Octet no. 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
V _y LSB															

bit-17 & 1 (LSB) = 0.25 m/s,
 Max.range = ±8192m/s

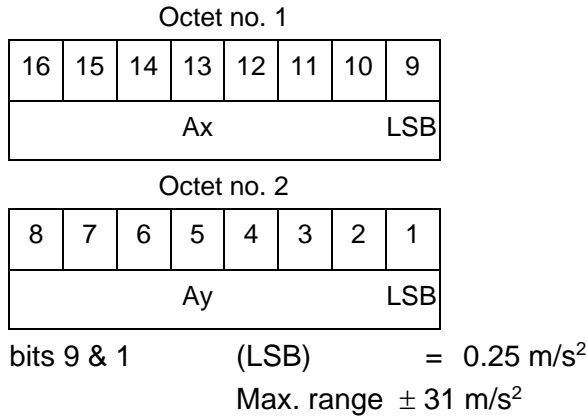
Encoding Rule: This item is optional

5.2.17 Data Item I020/210, Calculated Acceleration

Definition : Calculated Acceleration of the target, in two's complement form.

Format : Two-Octet fixed length data item.

Structure:



Encoding Rule: This item is optional

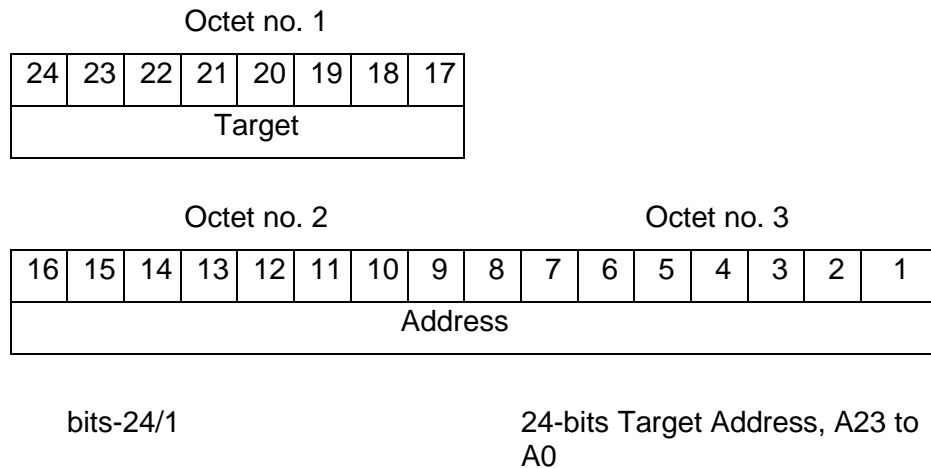
NOTE: Maximum value means “maximum value or above”

5.2.18 Data Item I020/220, Target Address

Definition: Target address (24-bit address) assigned to each Target.

Format: Three-octet fixed length Data Item.

Structure:



NOTE: The type of address (ICAO or non-ICAO address, type of message) is defined by the CF-indication in Data Item I020/020, second extension, bits 8/7.

Encoding Rule: This item is optional

5.2.19 Data Item I020/230, Communications/ACAS Capability and Flight Status

Definition: Communications capability of the transponder, capability of the on-board ACAS equipment and flight status.

Format: Two-octet fixed length Data Item.

Structure:

Octet no. 1								Octet no. 2								
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
COM				STAT				CASEVN	MSSC	ARC	AIC	B1A	B1B			

bits-16/14	(COM)	Communications capability of the transponder
		= 0 No communications capability (surveillance only)
		= 1 Comm. A and Comm. B capability
		= 2 Comm. A, Comm. B and Uplink ELM
		= 3 Comm. A, Comm. B, Uplink ELM and Downlink ELM
		= 4 Level 5 Transponder capability
		5 to 7 Not assigned
bits-13/11	(STAT)	Flight Status
		= 0 No alert, no SPI, aircraft airborne
		= 1 No alert, no SPI, aircraft on ground
		= 2 Alert, no SPI, aircraft airborne
		= 3 Alert, no SPI, aircraft on ground
		= 4 Alert, SPI, aircraft airborne or on ground
		= 5 No alert, SPI, aircraft airborne or on ground
		= 6 Not assigned
		= 7 Information not yet extracted
bits-10/9	(CASEVN)	CAS Extended Version Number (see Note)
		= 0 Non-extended version
		= 1 ACAS Xa Version 1
		= 2 ACAS Xu Version 1
		= 3 Reserved for future use
bit-8	(MSSC)	Mode-S Specific Service Capability

		= 0	No
		= 1	Yes
bit-7	(ARC)	Altitude reporting capability	
		= 0	100 ft resolution
		= 1	25 ft resolution
bit-6	(AIC)	Aircraft identification capability	
		= 0	No
		= 1	Yes
bit-5	(B1A)	BDS 1,0 bit 16 (see Note)	
bits 4/1	(B1B)	BDS 1,0 bits 37/40 (see Note)	

Encoding Rule:

This item shall be present in every ASTERIX record conveying data related to a Mode S target. If the datalink capability has not been extracted yet, bits 16/14 shall be set to zero.

NOTE: (applicable to bits-10/9 (CASEVN)): if bits-2/1 (of the B1B field) are set to '11', bits-10/9 contain information about the Extended Version Number of the CAS. If bits-2/1 (of the B1B field) contain a value different from '11', bits-10/9 are set to zero.

NOTE: (applicable to bit-5 (B1A)): this is a copy of bit 16 of BDS register 1,0. If set to '1', bit-5 indicates that the interface between the CAS and the Transponder is operational. If set to '0', bit-5 indicates that the CAS has failed or is in standby.

NOTE: (applicable to bits 4/1 (B1B)): this is a copy of bits 37 to 40 of BDS register 1,0.

bit-4 (bit 37 of BDS Register 1,0): If set to '1' indicates Hybrid Surveillance Capability. If set to '0' indicates no Hybrid Surveillance Capability

bit-3: (bit 38 of BDS Register 1,0): If set to '1' indicates the capability of the CAS to generate TAs and RAs. If set to '0' indicates the capability of the CAS to generate TAs only.

bits-2/1: (bits 40 and 39 of BDS Register 1,0) indicate the CAS Version Number:

00 = RTCA DO-185

01 = RTCA DO-185A

10 = EUROCAE ED-143/RTCA DO-185B

11 = CAS Extended Version Number (see bits-10/9)

5.2.20 Data Item I020/245, Target Identification**Definition:** Target (aircraft or vehicle) identification in 8 characters.**Format:** Seven-octet fixed length Data Item.**Structure:**

Octet no. 1

56	55	54	53	52	51	50	49
STI	0	0	0	0	0	0	0

Octet no. 2

Octet no. 3

48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
MSB		Character 1			Character 2				Character 3						

Octet no. 4

Octet no. 5

32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
				Character 4				Character 5							

Octet no. 6

Octet no. 7

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Character 6				Character 7				Character 8				LSB			

bits-56/55 (STI) = 00 Callsign or registration not downlinked from transponder

 = 01 Registration downlinked from transponder

 = 10 Callsign downlinked from transponder

 = 11 Not defined

bits-54/49 Spare bits set to zero

bits-48/1 Characters 1-8 (coded on 6 bits each) defining target identification.

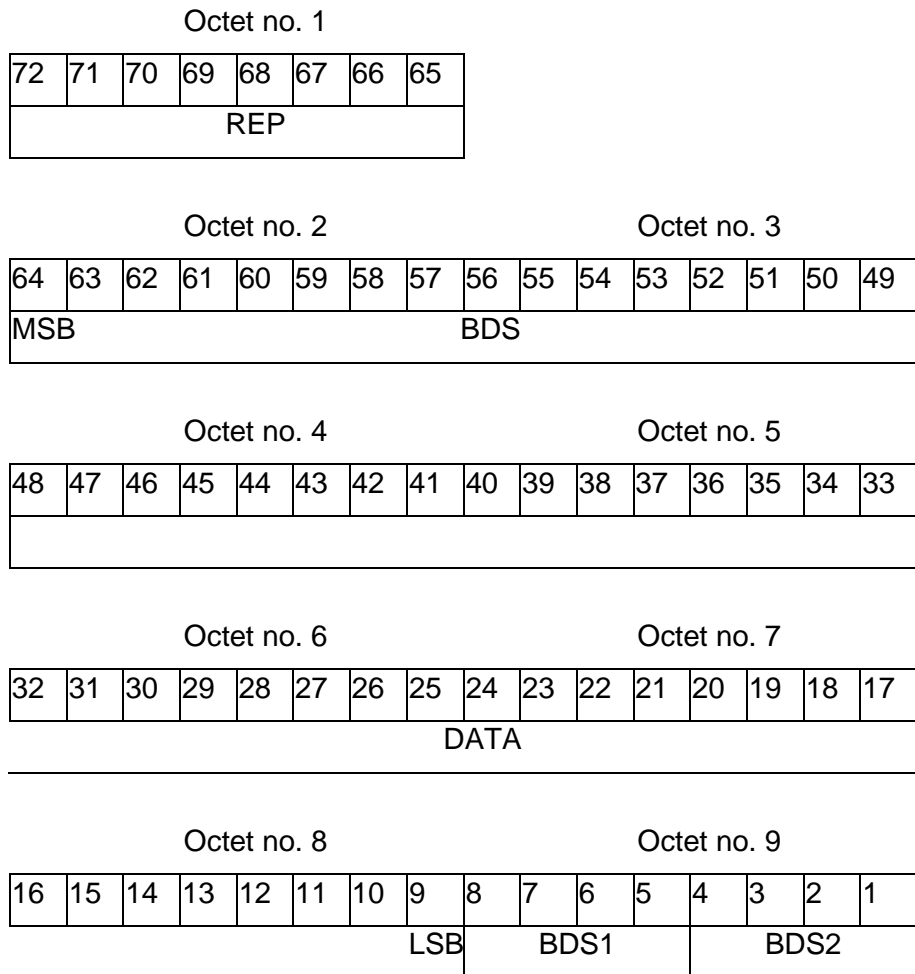
Encoding Rule: This item is optional**NOTE:** See ICAO document Annex 10, Volume IV, section 3.1.2.9 for the coding rules.

5.2.21 Data Item I020/250, BDS Register Data

Definition: BDS Register Data as extracted from the aircraft transponder.

Format: Repetitive Data Item starting with a one-octet Field Repetition Indicator (REP) followed by at least one BDS Register comprising one seven octet BDS Register Data and one octet BDS Register code.

Structure:



- bits-72/65 (REP) Repetition factor
- bits-64/9 (BDSDATA) 56-bit message conveying
BDS Register Data
- bits-8/5 (BDS1) BDS Register Address 1
- bits-4/1 (BDS2) BDS Register Address 2

Encoding Rule: This item is optional

NOTES

1. For the transmission of BDS Register 2,0, Data Item I020/245 is used.
2. For the transmission of BDS Register 3,0, Data Item I020/260 is used. In case of ACAS X_u (as defined in [4]), the Resolution Advisory consists of two parts (BDS Register 3,0 and BDS Register 3,1). BDS Register 3,1 will be transmitted using Data Item I020/250. For the detailed definition of BDS Register 3,0 and 3,1 please refer to [2] Tables B-3-48a and B-3-49.

5.2.22 Data Item I020/260, ACAS Resolution Advisory Report

Definition: Currently active Resolution Advisory (RA), if any, generated by the ACAS associated with the transponder transmitting the report and threat identity data.

Format: Seven-octet fixed length Data Item.

Structure:

Octet no. 1							Octet no. 2								
56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41

Octet no. 3							Octet no. 4								
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
ACASRA															

Octet no. 5							Octet no. 6								
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9

Octet 7							
8	7	6	5	4	3	2	1

bits-56/1 (ACASRA)

56-bit message conveying the ACAS Resolution Advisory Report as contained in BDS Register 3,0.

Encoding Rule:

This item shall be present when a Resolution Advisory has been generated in the last update period.

NOTES

1. Refer to ICAO Draft SARPs for ACAS for detailed explanations.

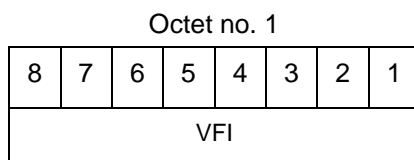
2. In case of ACAS X_u, the Resolution Advisory consists of two parts (BDS Register 3,0 and BDS Register 3,1). The contents of BDS Register 3,1 will be transmitted using item 250.

5.2.23 Data Item I020/300, Vehicle Fleet Identification

Definition: Vehicle fleet identification number.

Format: One octet fixed length Data Item.

Structure:



- | | | | |
|----------|-------|------|---------------------------|
| Bits 8-1 | (VFI) | = 0 | Unknown |
| | | = 1 | ATC equipment maintenance |
| | | = 2 | Airport maintenance |
| | | = 3 | Fire |
| | | = 4 | Bird scarer |
| | | = 5 | Snow plough |
| | | = 6 | Runway sweeper |
| | | = 7 | Emergency |
| | | = 8 | Police |
| | | = 9 | Bus |
| | | = 10 | Tug (push/tow) |
| | | = 11 | Grass cutter |
| | | = 12 | Fuel |
| | | = 13 | Baggage |
| | | = 14 | Catering |
| | | = 15 | Aircraft maintenance |
| | | = 16 | Flyco (follow me) |

Encoding Rule: This item is optional

5.2.24 Data Item I020/310, Pre-programmed Message

Definition: Number related to a pre-programmed message that can be transmitted by a vehicle.

Format: One octet fixed length Data Item.

Structure:

Octet no. 1							
8	7	6	5	4	3	2	1
TRB	MSG						

Bit-8 (TRB) = 0 Default
 = 1 In Trouble

Bits 7-1 (MSG) = 1 Towing aircraft
 = 2 "Follow me" operation
 = 3 Runway check
 = 4 Emergency operation (fire, medical...)
 = 5 Work in progress (maintenance, birds scarer, sweepers...)

Encoding Rule: This item is optional

5.2.25 Data Item I020/400, Contributing Devices

Definition: Overview of the devices, which have contributed to the Target Detection. In case of active Multilateration systems this may include transmitters.

Format: Repetitive Data Item starting with a one-octet Field Repetition Indicator (REP) followed by at least one Contributing Units list comprising one octet

Structure:

Octet no. 1							
16	15	14	13	12	11	10	9
REP							

Octet no. 2							
8	7	6	5	4	3	2	1
x	x	x	x	x	x	x	x

Bits 16/9 (REP) Repetition Factor

Bit x ($1 \leq x \leq 8$) TU x /RU x Contribution
 = 0 TU x /RU x has NOT contributed to the target detection
 = 1 TU x /RU x has contributed to the target detection

Encoding Rule: This item is optional

Note: The actual meaning of the individual bits is implementation dependent.

Recommendation: For active Multilateration systems both, transmitters and receivers may be included. It is recommended that in such a configuration the higher bit numbers (i.e. starting at Octet no. 1) should be allocated to transmitters since it is expected that there will be a smaller number of transmitters than receivers. Such an implementation would save bandwidth in case of target reports derived from active multilateration.

NOTE: In case of more than 8 devices connected to the system, the numbering of the field “RUx Contribution” follows the standard ASTERIX rule: bits are numbered from right to left. The example below shows the case of a maximum of 16 devices with devices 1, 7 and 14 contributing to the target:

Octet no. 1

24	23	22	21	20	19	18	17
0	0	0	0	0	0	1	0

Octet no. 2							Octet no. 3								
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1

In this particular example, for an active Multilateration system transmitters should be allocated to bits 16 and lower.

5.2.26 Data Item I020/500, Position Accuracy

Definition: Standard Deviation of Position

Format: Compound Data Item, comprising a primary subfield of one octet, followed by one or more defined subfields.

Structure of Primary Subfield:

Octet no. 1							
8	7	6	5	4	3	2	1
DOP	SDP	SDH	0	0	0	0	0

Bit-8	(DOP)	Subfield #1: DOP of Position = 0 Absence of Subfield #1 = 1 Presence of Subfield #1
Bit-7	(SDP)	Subfield #2: Standard Deviation of Position = 0 Absence of Subfield #2 = 1 Presence of Subfield #2
Bit-6	(SDH)	Subfield #3 Standard Deviation of Geometric Height =0 Absence of Subfield #3 =1 Presence of Subfield #3
bits-5/1	(Spare)	Subfields #4/7: Spare = 0 Absence of Subfield = 1 Presence of Subfield

Encoding Rule: This item is optional

**Structure of Subfield # 1:
DOP of Position**

Octet no. 1										Octet no. 2					
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
DOP-x														LSB	

Octet no. 3								Octet no. 4							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
DOP-y															LSB

Octet no. 5								Octet no. 6								
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
DOP-xy																LSB

- bits-48/33 (DOP-x) DOP along x axis
LSB= 0.25
- bits-32/17 (DOP-y) DOP along y axis
LSB= 0.25
- bits-16/1 (DOP-xy) = $\rho(X, Y)$
LSB= 0.25
Note: if $DOP_x=0$ or $DOP_y=0$
then $DOP_{xy}=0$

**Structure of Subfield # 2:
Standard Deviation of Position**

Octet no. 1								Octet no. 2							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
σ_x															LSB

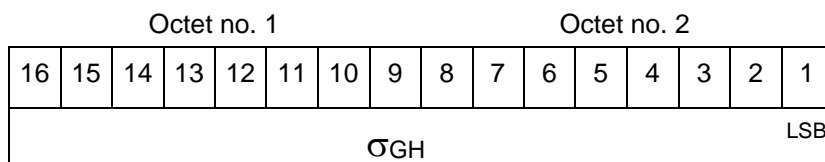
Octet no. 3								Octet no. 4							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
σ_y															LSB

Octet no. 5								Octet no. 6							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
$\rho(X,Y)$															LSB

- bits-48/33 (σ_x) Standard Deviation of X component
LSB= 0.25 m
- bits-32/17 (σ_y) Standard Deviation of Y component
LSB= 0.25 m
- bits-16/1 ($\rho(X,Y)$) Correlation coefficient in two's complement
LSB= 0.25

Encoding Rule : If $\sigma_x = 0$ or if $\sigma_y = 0$ then $\rho(X,Y) = 0$

**Structure of Subfield # 3:
Standard Deviation of Geometric Height (WGS 84)**



bits-16/1 (σ_{GH}) Standard Deviation of Geometric Height
LSB= 0.5 m

NOTE - There is now a new Item for the Position Accuracy defined in the Reserved Expansion Field (REF), more complete (includes a Standard Deviation of Position in WGS-84) and is based on a different calculation method (covariance instead of correlation). It is recommended to use the new definition. Nevertheless, Item I020/500 is kept in order to prevent a full incompatibility with previous releases of ASTERIX Cat. 020 already implemented.

5.3 Standard User Application Profile

5.3.1 The following UAP shown in Table 3 shall be used for the transmission of target reports and service messages :

Table 3 - Standard UAP

FRN	Data Item	Information	Length in Octets
1	I020/010	Data Source Identifier	2
2	I020/020	Target Report Descriptor	1+
3	I020/140	Time of Day	3
4	I020/041	Position in WGS-84 Coordinates	8
5	I020/042	Position in Cartesian Coordinates	6
6	I020/161	Track Number	2
7	I020/170	Track Status	1+
FX	-	Field Extension Indicator	-
8	I020/070	Mode-3/A Code in Octal Representation	2
9	I020/202	Calculated Track Velocity in Cartesian Coord.	4
10	I020/090	Flight Level in Binary Representation	2
11	I020/100	Mode-C Code	4
12	I020/220	Target Address	3
13	I020/245	Target Identification	7
14	I020/110	Measured Height (Cartesian Coordinates)	2
FX	-	Field Extension Indicator	-
15	I020/105	Geometric Height (WGS-84)	2
16	I020/210	Calculated Acceleration	2
17	I020/300	Vehicle Fleet Identification	1
18	I020/310	Pre-programmed Message	1
19	I020/500	Position Accuracy	1+n
20	I020/400	Contributing Devices	1+1+
21	I020/250	BDS Register Data	1+8n
FX	-	Field Extension Indicator	-
22	I020/230	Comms/ACAS Capability and Flight Status	2
23	I020/260	ACAS Resolution Advisory Report	7
24	I020/030	Warning/Error Conditions	1+
25	I020/055	Mode-1 Code in Octal Representation	1
26	I020/050	Mode-2 Code in Octal Representation	2
27	RE	Reserved Expansion Field	-
28	SP	Special Purpose Field	-
FX	-	Field Extension Indicator	-

where:

- the first column indicates the FRN associated to each Data Item used in the UAP;
- the fourth column gives the format and the length of each item. A stand-alone figure indicates the octet count of a fixed-length Data Item, 1+ indicates a variable-length Data Item comprising a first part of one-octet followed by n-octet extents as necessary.



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