EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

EUROCONTROL STANDARD DOCUMENT

FOR

SURVEILLANCE DATA EXCHANGE

Part 14 : Category 020

Multilateration Target Reports

SUR.ET1.ST05.2000-STD-14-02

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EUROPEAN AIR TRAFFIC MANAGEMENT

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Abstract

This document describes the application of ASTERIX messages to the transmission of multilateration target reports.

Keywords

Multilateration Data	ASTERIX	Target Reports
Data Item	Category 20	UAP

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The following table identifies all management authorities who have successively approved the present issue of this document.

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DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION	DATE	REASON FOR CHANGE	SECTIONS PAGES AFFECTED
0.10	March 2004	Creation of document	All
0.11	March 2004	Modifications after first reviewing	
0.12	April 2004	Corrections in header/footer and the ASTERIX Part Nr.	
0.13	Nov. 2004	Modification of section 4.3.1 Creation of I020/030 Modification of I020/170 New definition for I020/091 Modification of format of I020/400 Modification of I020/550	
0.14P	Dec. 2004	Modification of section 4.3.1 I020/060 becomes I020/070 Creation of I020/080 Creation of I020/100 I020/091 becomes I020/105 Explanation note added in I020/105	
0.15	Mar. 2005	Editorial Changes Executive Summary added Meaning of CDM in I020/170 corrected Value 11 for NOGO in I020/550 added I020/020 Updated Note added to I020/041 and I020/042 Item I020/090 Note 2 updated Item I020/245 description of bits 56/55 updated Item I020/500 updated Item I020/500 subfield #1: LSB changed to 0.25 Item I020/500 subfield #3 reference to WGS84 added	Almost all 1 25 38 5.2.3 5.2.5 / 5.2.6 5.2.9 5.2.19 5.2.25 5.2.25 5.2.25
0.16	April 2005	Document Identification Sheet updated Signature Page updated	ii iii
0.17	June 2005	Item I020/050 added Item I020/055 added Item I020/070 editorial change Item I020/080 removed Item I020/100 Name changed, Confidence	5.2.7 5.2.8 5.2.9 5.2.11

		Indicator removed, length changed to from 4 to 2 octets, LSB set to 1FL instead of 25ft or 100ft.	
		Item I020/260 editorial update	5.2.23
		Item I020/500 editorial update	5.2.27
		List of items, composition of messages and UAP adapted accordingly	
		Item I020/550 moved to new Category 019	
0.18	July 2005	Generation of new Cat. 019: Multilateration System Status Messages:	
		• Scope of document adapted	1.1.1
		• General part updated	4.1
		• Chapter 4.7 removed	-
		• Item I020/000 Message Type removed	
		• UAP and list of dataitems updated	
		Updates from RDE-FG #37:	
		• Item I020/110 re-introduced	5.2.11
		• Item I020/020 Editorial update	5.2.2
		• Table 1 (Standard Data Items) updated	5.1
		• Encoding rule: I020/041 mandatory	5.2.4
		• Encoding rule: I020/042 optional	5.2.5
		• Item I020/100 updated in line with cat. 048	5.2.10
		• Encoding rule: I020/140 mandatory	5.2.13
		• Standard UAP updated	5.3
1.0	November 2005	Definition in chapter 4.3.1 updated	4.3.1
		Reference in chapter 4.3.2 updated	4.3.2
		Encoding rule in item I020/041 modified	5.2.4
		Item I020/100 aligned with Category 048	5.2.10
		Encoding rule added to item I020/105	5.2.11
		Definition of item I020/110 updated	5.2.12
		Encoding rule added to item I020/110	5.2.12
		Item I020/500 updated	5.2.26
		UAP adapted accordingly	5.3
		Document status updated to Proposed Issue	
1.1	April 2006	Clarification of position information	4.3.1
		Structure of Item I020/055 corrected	5.2.7
		Definition of Item I020/110 enhanced	5.2.12
		Note added to Item I020/210	5.2.17
		Item I020/230: Value added for "Flight Status not yet extracted"	5.2.19
		Description of Item I020/245 corrected	5.2.20
		Item I020/500 subfield 1 corrected	5.2.26
	June 2006	Status changed to "Released Issue"	
1.2	April 2007	Document ID-Sheet Updated	ID-sheet
		Signature Page Updated	Signature pg.
		Reference to ASTERIX website added	5.2.1
		Editorial "clean-up"	

1.3	July 2007	Item I020/020: bit 2 redefined	5.2.2
		Item I020/041: encoding rule updated	5.2.4
		Item I020/090: encoding rule precised	5.2.9
		Item I020/105: renamed ("altitude">"height")	5.2.11
		Item I020/500: subfield 1 renamed	5.2.26
		LSB changed to1e-05	
1.4	November 2007	Item I020/500: Re-structured in line with the definitions contained in Cat. 062, I062/500 NOTE: These changes cause incompatibility with previous editions!	5.2.26
1.5	April 2008	NOTE: Due to incompatibility introduced with editions 1.3 & 1.4, this edition is based on 1.2 including the following changes,	
		Item I020/020: bit 2 redefined	5.2.2
		Item I020/041: encoding rule updated	5.2.4
		Item I020/090: encoding rule precised	5.2.9
		Item I020/105: renamed ("altitude">"height")	5.2.11
		Item I020/500: subfield 3 renamed	5.2.26
		Note added	
		UAP, FRN22 corrected ("1+">"2")	5.3.1
1.6	July 2010	Document ID Sheet updated	
		Signature page updated	
		Note added to item I020/400	5.2.25
		Editorial correction I020/500 Subfield 1	5.2.26
1.7	September 2010	Note added to item I020/250	5.2.21
1.8	December 2010	Encoding rule in item I020/140 updated	5.2.13

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EXECUTIVE SUMMARY

This document describes the general concepts and the message layout for the application of ASTERIX category 20 for the transmission of target reports derived by multilateration systems.

1.   INTRODUCTION

1.1   Scope

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

1.1.2   A complex of MLT (transmitter)/receivers and a central processing system is seen as a mono sensor.

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 000-1-92. Directives for the Uniform Drafting and Presentation of Eurocontrol Standard Documents. 1992.

2.   Eurocontrol Standard SUR.ET1.ST05.2000-STD-01-01. All Purpose Structured Eurocontrol Surveillance Information Exchange - ASTERIX. Edition 1.30, Released Issue, November 2007.

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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	**A**ll Purpose **ST**ructured **E**urocontrol su**R**veillance **I**nformation E**X**change
CAT	Data Category
DOP	Dilution Of Precision
EATM	European Air Traffic Management
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
NM	Nautical Mile, unit of distance (1852 metres)
PSR	Primary Surveillance Radar
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)
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 MLT 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.

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 exported 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. The height of the MLT System Reference Point is defined in item I019/610. 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 complex of MLT (transmitter)/receivers and 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

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

4.8.2 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

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

4.9.2 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 defined in Table 1 and described on the following pages.

Table 1 - Standard Data Items of Category 020

Data Item Ref. No.	Description	Resolution
I020/010	Data Source Identifier	N.A.
I020/020	Target Report Descriptor	N.A.
I020/030	Warning/Error Conditions	N.A.
I020/041	Position in WGS-84 Coordinates	$180/2^{25}°$
I020/042	Position in Cartesian Coordinates	0.5 m
I020/050	Mode-2 Code in Octal Representation	N.A.
I020/055	Mode-1 Code in Octal Representation	N.A.
I020/070	Mode-3/A Code in Octal Representation	N.A.
I020/090	Flight Level in Binary Representation	¼ FL
I020/100	Mode-C Code	1 FL
I020/105	Geometric Height (WGS-84)	6.25 ft
I020/110	Measured Height (Local Coordinates)	6.25 ft
I020/140	Time of Day	1/128 s
I020/161	Track Number	N.A.
I020/170	Track Status	N.A.
I020/202	Calculated Track Velocity in Cartesian Coord.	0.25 m/s
I020/210	Calculated Acceleration	0.25 m/s^2
I020/220	Target Address	N.A.
I020/230	Comms/ACAS Capability and Flight Status	N.A.
I020/245	Target Identification	N.A.
I020/250	Mode S MB Data	N.A.
I020/260	ACAS Resolution Advisory Report	N.A.
I020/300	Vehicle Fleet Identification	N.A.
I020/310	Pre-programmed Message	N.A.
I020/400	Contributing Receivers	N.A.
I020/500	Position Accuracy	0.25 / 0.5 m

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:

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

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)	bit 8=	1	Non-Mode S 1090MHz multilateration
		=	0	no Non-Mode S 1090MHz multilat.
		bit 7=	1	Mode-S 1090 MHz multilateration
		=	0	no Mode-S 1090 MHz multilateration
		bit 6=	1	HF multilateration
		=	0	no HF multilateration
		bit 5=	1	VDL Mode 4 multilateration
		=	0	no VDL Mode 4 multilateration
		bit 4=	1	UAT multilateration
		=	0	no UAT multilateration
		bit 3=	1	DME/TACAN multilateration
		=	0	no DME/TACAN multilateration
		bit 2=	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 Extent:**

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 extent

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:

Octet no. 1

8	7	6	5	4	3	2	1
			W/E Value				FX

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:

Octet no. 1								Octet no. 2							
64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
Latitude in WGS - 84															

Octet no. 3								Octet no. 4							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
															LSB

Octet no. 5								Octet no. 6							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Longitude in WGS - 84															

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

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 two's complement representation.

Format: Six-octet fixed length Data Item.

Structure:

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

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

Octet no. 5								Octet no. 6							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Y															LSB
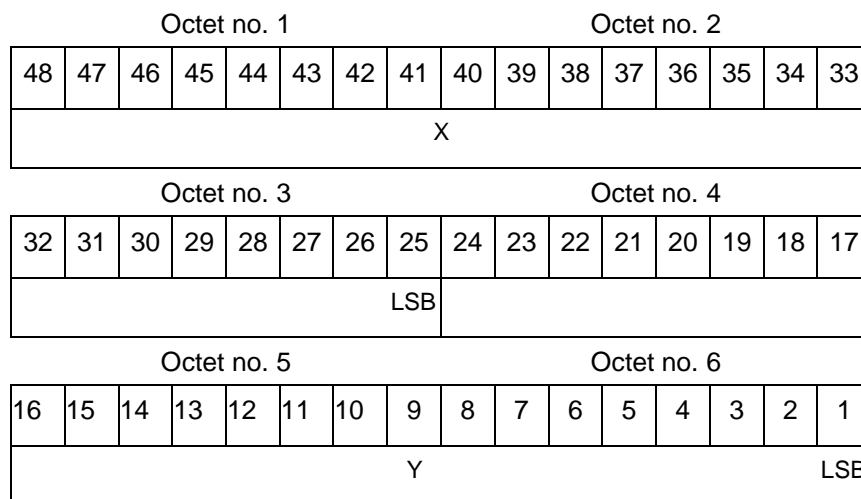
bits 48/25   = X

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-2 code as
                                          provided by a local tracker n

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:

<table>
<tr><td colspan="7">Octet no. 1</td><td colspan="9">Octet no. 2</td></tr>
<tr><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>V</td><td>G</td><td colspan="13">Flight Level</td><td>LSB</td></tr>
</table>

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 onehigh.

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:

<div align="center">

Octet no. 1

24	23	22	21	20	19	18	17
Time								

</div>

<div align="center">

Octet no. 2   Octet no. 3

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

</div>
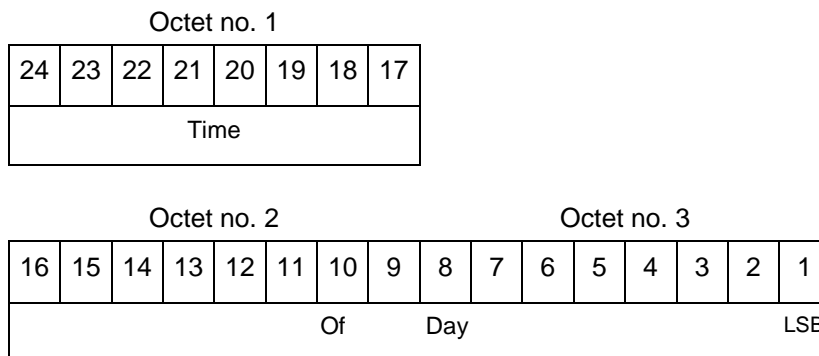
bit-1   (LSB)   1/128 s

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:

<div align="center">

Octet no. 1   Octet no. 2

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	0	0	0	TRACK NUMBER(0…4095)												

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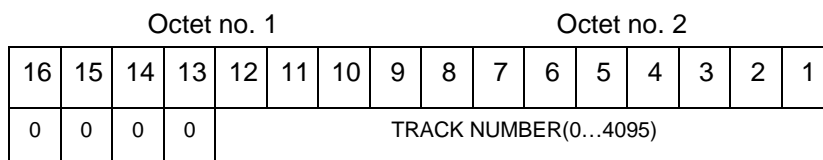
bits-16/13   Spare bits set to zero.
bits-12/1   Track number.

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 extrapolated
                 = 1   Extrapolated

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
							Vx								LSB

Octet no. 3   Octet no. 4

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

Octet no. 1

16	15	14	13	12	11	10	9
			Ax				LSB

Octet no. 2

8	7	6	5	4	3	2	1
			Ay				LSB

bits 9 & 1   (LSB)   = $0.25 \ \text{m/s}^2$

Max. range $\pm 31 \ \text{m/s}^2$
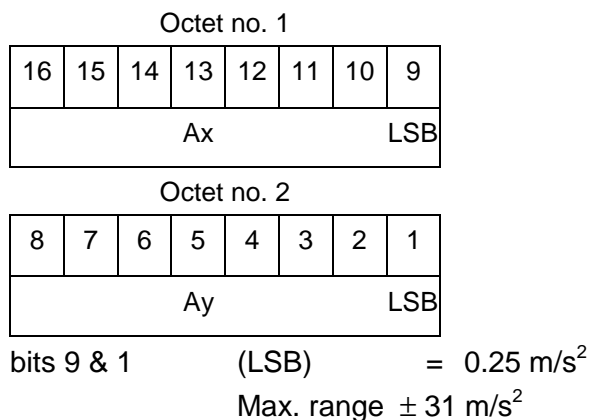
Encoding Rule: This item is optional

NOTE: Maximum value means "maximum value or above"

5.2.18   Data Item I020/220, Target Address

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

Format: Three-octet fixed length Data Item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
			Target				

Octet no. 2   Octet no. 3

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

bits-24/1   24-bits Target Address, A23 to A0
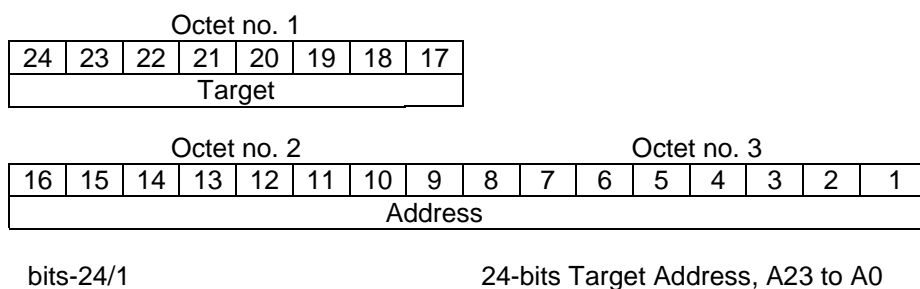
Encoding Rule: This item is optional

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			0	0	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	(spare)	spare bits set to zero
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
bits 4/1	(B1B)	BDS 1,0 bits 37/40

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.

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

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.

NOTE: See ICAO document Annex 10, Volume IV, section 3.1.2.9
           for the coding rules.

5.2.21   Data Item I020/250, Mode S MB Data

Definition: Mode S Comm B 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 report comprising
one seven octet BDS register and one octet BDS code.

Structure:

Octet no. 1

72	71	70	69	68	67	66	65
REP

Octet no. 2   Octet no. 3

64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
MSB								MB							

Octet no. 4   Octet no. 5

48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
DATA															

Octet no. 6   Octet no. 7

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

Octet no. 8   Octet no. 9

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
							LSB	BDS1				BDS2			

bits-72/65   (REP)   Repetition factor

bits-64/9   (MB Data)   56-bit message conveying Mode S
Comm B message data

bits-8/5   (BDS1)   Comm B Data Buffer Store 1 Address

bits-4/1   (BDS2)   Comm B Data Buffer Store 2 Address

NOTES

1. For the transmission of BDS20, item 245 is used.
2. For the transmission of BDS30, item 260 is used.

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
					MB DATA								

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   (MB Data)   56-bit message conveying Mode S
                                  Comm B message data of 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.

5.2.23　　　　**Data Item I020/300, Vehicle Fleet Identification**

Definition:　　　Vehicle fleet identification number.

Format:　　　One octet fixed length Data Item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
VFI							
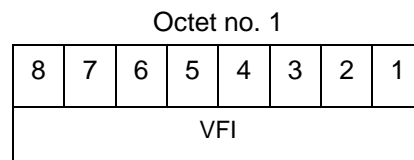
Bits 8-1　　　(VFI)　　　= 0　Unknown
　　　　　　　　　　　　　= 1　ATC equipment maintenance
　　　　　　　　　　　　　= 2　Airport maintenance
　　　　　　　　　　　　　= 3　Fire
　　　　　　　　　　　　　= 4　Bird scarer
　　　　　　　　　　　　　= 5　Snow plough
　　　　　　　　　　　　　= 6　Runway sweeper
　　　　　　　　　　　　　= 7　Emergency
　　　　　　　　　　　　　= 8　Police
　　　　　　　　　　　　　= 9　Bus
　　　　　　　　　　　　　= 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 Receivers**

Definition: Overview of Receiver Units, which have contributed to the
Target Detection

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

Bits 16/9   (REP)   Repetition Factor

Bit x (1≤ x ≤ 8)   RUx Contribution
= 0 RUx has NOT contributed to the target detection
= 1 RUx has contributed to the target detection

Encoding Rule: This item is optional

NOTE: In case of more than 8 receivers 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 receivers with receivers 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

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

σx   LSB

Octet no. 3   Octet no. 4

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

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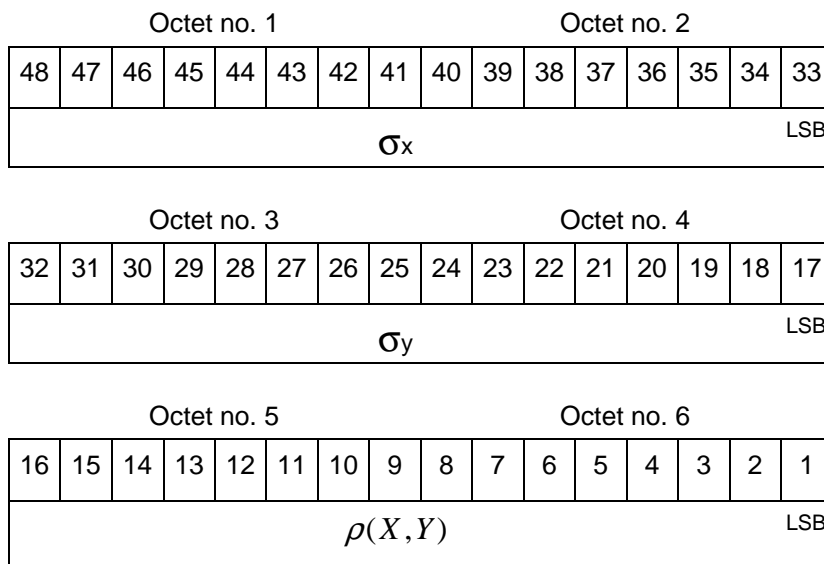
bits-48/33   (σx)   Standard Deviation of X component
                               LSB= 0.25 m
bits-32/17   (σy)   Standard Deviation of Y component
                               LSB= 0.25 m
bits-16/1   ($\rho(X,Y)$)   Correlation coefficient in two's complement
                               LSB=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

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

Structure of Subfield # 3:

Standard Deviation of Geometric Height (WGS 84)

				Octet no. 1								Octet no. 2			
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
σ_{GH}															LSB

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 Receivers	1+1+
21	I020/250	Mode S MB 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.