NACC/WG/2 - IP/11
31/03/08

International Civil Aviation Organization
North American, Central American and Caribbean Office
Second North American, Central American and Caribbean Working Group Meeting (NACC/WG/2)
Ocho Rios, Jamaica, 12-16 May 2008

Agenda Item 3: CNS Developments
3.6 Surveillance Data Exchange Activities

ASTERIX TUTORIAL

(Paper presented by EUROCONTROL)

SUMMARY
The following Information Paper presents a briefing of the actual state of the ASTERIX Protocol used for Surveillance Data Sharing.

1. Introduction

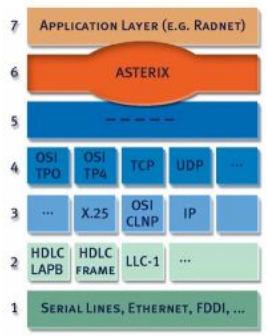
1.1 ASTERIX stands for **A**ll Purpose **ST**ructured **E**urocontrol Su**R**veillance **I**nformation E**X**change. The ASTERIX protocol, used by Eurocontrol, has been recommended by GREPECAS as the common regional protocol format for the surveillance data exchange.

1.2 It is an ATM Surveillance Data Binary Messaging Format which allows transmission of harmonised information between any surveillance and automation system. ASTERIX defines the structure of the data to be exchanged over a communication medium, from the encoding of every bit of information up to the organisation of the data within a block of data - without any loss of information during the whole process.

1.3 ASTERIX is a EUROCONTROL Standard which refers to the Presentation and Application layers (layers six and seven) as defined by the Open Systems Interconnection (OSI) Reference Model (International Standards Organization (ISO) Standard 7498).

1.4 Transmission of ASTERIX coded surveillance information can make use of any available communication medium, for instance Wide Area Network (WAN), Local Area Network (LAN), Internet Protocols (IP), etc as those belong to lower layers.

1.5 Considering that there is information common to all systems (for instance position, Mode-A Code and Mode-C Code information), ASTERIX specifies minimum requirements at the Application level, so as to ease data exchange between heterogeneous applications. The communication between two different systems (even located in different countries) is thus made possible, based on a core of commonly used surveillance related data, transferred in the same way by the ASTERIX Presentation layer.



1.6 For the transmission of information related to a specific application, data items are grouped in ASTERIX Categories. Up to 256 categories can be defined. The definition of these categories and their composition is managed by the RDE-TF.

2. Scope of ASTERIX

2.1 ASTERIX has been developed to ease the exchange of surveillance information between and within countries. Thus, the main users of ASTERIX are the Air Traffic Control (ATC) Centres. Today almost all ECAC States are using this data format in their ATC Centres.

2.2 But ASTERIX is also used by Industries to help stabilisation/maturation of new technologies, and is then integrated in surveillance sensors and in automation systems such as **ARTAS** (ATM surveillance Tracker And Server), **RMCDE** (Radar Message Conversion and Distribution Equipment) and **RADNET** (RADar NETwork implemented in the so-called four states area - Benelux and Germany), **RAPS II** (Radar Analysis, Playback & Simulation System for Surveillance Data).

2.3 As the volume of Air Traffic is continuously increasing and as high level of Safety must be maintained, the surveillance systems are under constant evolution. New-generation surveillance technologies are being developed which need to cohabit with current systems. The information they generate must be transmitted in a harmonised and efficient way.

3. *Philosophy of ASTERIX*

3.1 The philosophy of ASTERIX can be described in two short phrases: "Distribute everything as required" and "Do not transmit more than necessary". ASTERIX has been designed as a flexible way of encoding surveillance related information to be exchanged between users. It is characterised by the grouping of information in data categories and the flexible generation of messages in order to save bandwidth in the transmission.

3.2 For the various applications within the surveillance domain, individual data categories are defined. This allows the designer of a system to implement exactly what is needed, not more and not less. The software to be implemented can be tailored exactly to the function of the respective system.

3.3 Should at a later stage additional functionality be required, the necessary interface can easily be added by integrating the ASTERIX category defined for the specific application.

3.4 The same flexibility applies to the generation of the ASTERIX messages itself. Subdividing the whole information into individual data-items, a message can be composed according to the information available. Items carrying no information are simply left out when creating the message. The FSPEC, a sort of "Table of Contents" for each ASTERIX message precedes the data items, indicating unambiguously to the receiving system, which data items are present and which is not. This allows the processing to be adapted to the real message contents. There is no need anymore to transmit useless bits and bytes or to skip unwanted information in a message.

3.5 It is the task of the “Surveillance Data Exchange Task Force (RDE-TF)” to manage and co-ordinate the maintenance and evolution of existing or the development of new ASTERIX categories, should the need come up. In most cases this will be triggered by the launch of a new application (such as ADS-B or Multi-Lateration) or by the need to adapt an existing category to changing needs. In any case, the fact that this process is controlled by a body composed of members of most ANSPs makes sure that the results and a new ASTERIX category are commonly accepted and form the specification against which at a later stage the implementation will be validated.

3.6 The **Appendix** to this paper includes a Tutorial of ASTERIX. More information about ASTERIX is available on the following website:
http://www.eurocontrol.int/asterix/public/standard_page/overview.html

4. Suggested Action:

4.1 The Meeting is invited to take note of the information container in this paper.

– – – – – – – – – – – – – – – –

Introduction to ASTERIX

Objectives

- Introduction to the ASTERIX standard
- ASTERIX data structures
- Working Arrangements

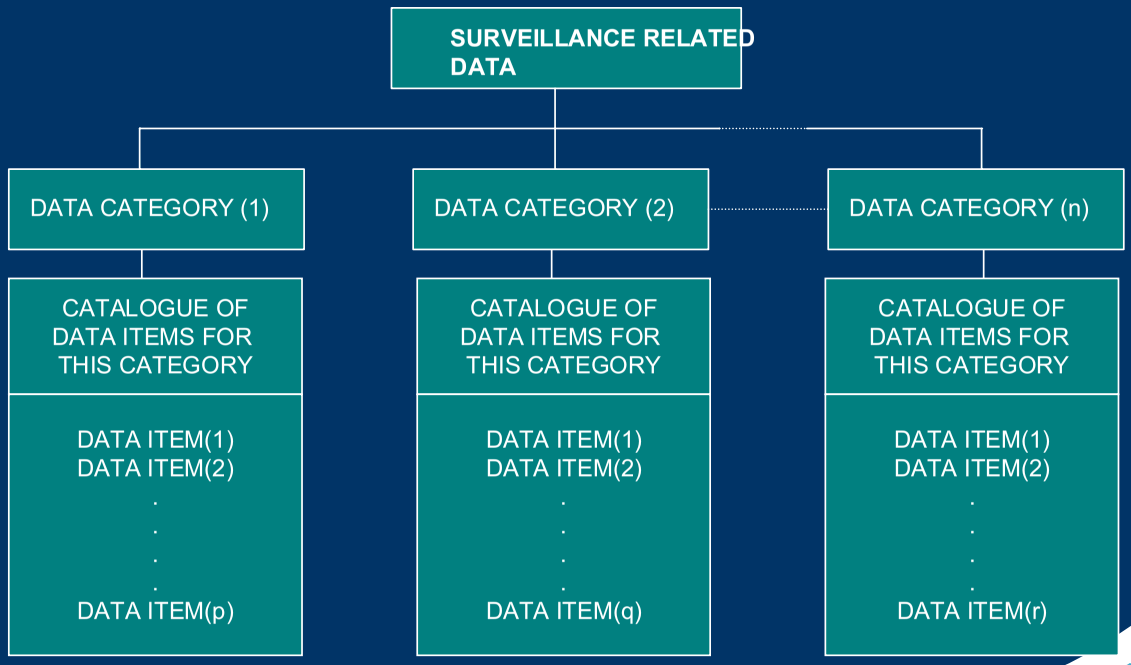
ASTERIX Acronymn

- **A**ll purpose
- **ST**ructured
- **E**urocontrol
- su**R**veillance
- **I**nformation
- e**X**change

ASTERIX documentation

- EUROCONTROL Standard document for surveillance data exchange, subdivided in parts
  - Part 1: ASTERIX General Description
  - Parts 2 ff: Describing the individual categories
    - Examples:
      - Part 4: Transmission of Monoradar Target Reports (cat 048)
      - Part 12: ADS-B Messages (cat 021)
      - Part 14: MLT Messages (cat 020)
      - Part 17: Safety Nets Messages (cat 004)

Organisation of the Data



Data Categories

- Allow easy identification of the data
- Facilitate easy dispatching of data to tasks
- Establish certain hierarchy among data
- 256 data categories are possible
  - 000 to 127 : standard civil and mil. applications
  - 128 to 240 : special mil. applications
  - 241 to 255 : non standard applications

Used Data Categories
Examples

- Cat 001, 002 and 008
  Used for mono radar data
- Cat 004
  Safety Net Data
- Cat 019 and 020
  Used for Multilateration data
- Cat 021 and 023
  Used for ADS-B data
- Cat 034, 048 and 017
  Used for Mode-S radar data

Data Items

- Smallest unit of information defined and standardised
- For each category, a Catalogue of Data Items shall be standardised
- Each data item has an unique reference:

  Innn/AAp

Data Items

- Innn/AAp
- I indicates the data item
- nnn is a 3 digit decimal number indicating the category to which the item belongs
- AA is a 2 digit decimal number indicating the type of data
- p is a one digit decimal number which may indicate up to 10 different representations

Example: Data Items of Cat 048

- I048/010: Data Source Identifier
- I048/020: Target Report Descriptor
- I048/030: Warning/Error Conditions
- I048/040: Measured Position in Polar Coordinates
- I048/042: Calculated Position in Cartesian Coordinates
- I048/050: Mode-2 Code in Octal Representation
- I048/055: Mode-1 Code in Octal Representation
- I048/060: Mode-2 Confidence Indicator
- I048/065: Mode-1 Confidence Indicator
- I048/070: Mode-3/A Code in Octal Representation
- I048/080: Mode-3/A Confidence Indicator

Example: Data Items of Cat 048
(continued)

- I048/090: Flight Level in Binary Representation
- I048/100: Mode C Code and Confidence Indicator
- I048/110: Height measured by 3D-radar
- I048/120: Radial Doppler Speed
- I048/130: Radar Plot Characteristics
- I048/140: Time of Day
- I048/161: Track Number
- I048/170: Track Status
- I048/200: Calculated Track Velocity, Cartesian Coordinates
- I048/210: Track Quality
- I048/220: Aircraft Address

Example: Data Items of Cat 048
(continued)

- I048/230: Communications/ACAS Capability, Flight Status
- I048/240: Aircraft Identification
- I048/250: Mode S MB Data
- I048/260: ACAS Resolution Advisory Report

Data Fields

- For communication purposes, Data Items are assigned to Data Fields
- Each Data Field has a number, certain length and Field Reference Number (FRN)

Standard Data Field Formats

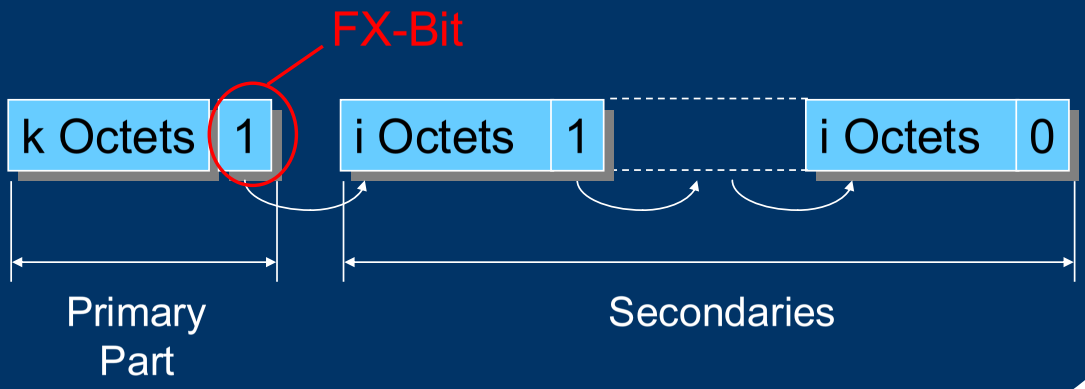
- Fixed length
- Extended or variable length by using a Field Extension Indicator (FX)
- Repetitive Data Fields by using a one octet Field Repetition Indicator (REP)
- Compound Data Fields using a primary subfield, followed by data subfields

Standard Data Field Formats

Fixed length Data Fields

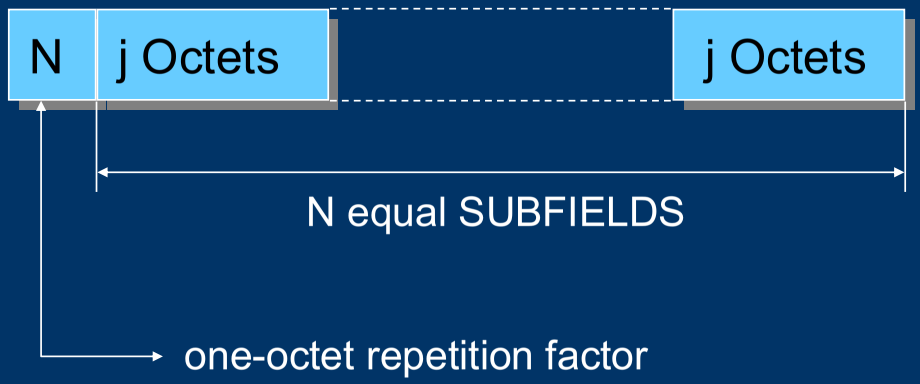
Standard Data Field Formats

Extended length Data Fields



Standard Data Field Formats

Repetitive Data Fields



Standard Data Field Formats

Repetitive Data Field - Example

5.2.33 Data Item I007/440, Directed Interrogation BDS Register Request

Definition Directed Interrogation BDS Register Request

Format Repetitive Data Item starting with a one-octet Field Repetition Indicator (REP) followed by at least one one-octet Field describing the BDS register to be interrogated.

Structure

Octet no. 1

8	7	6	5	4	3	2	1
REP							

Octet no. 2

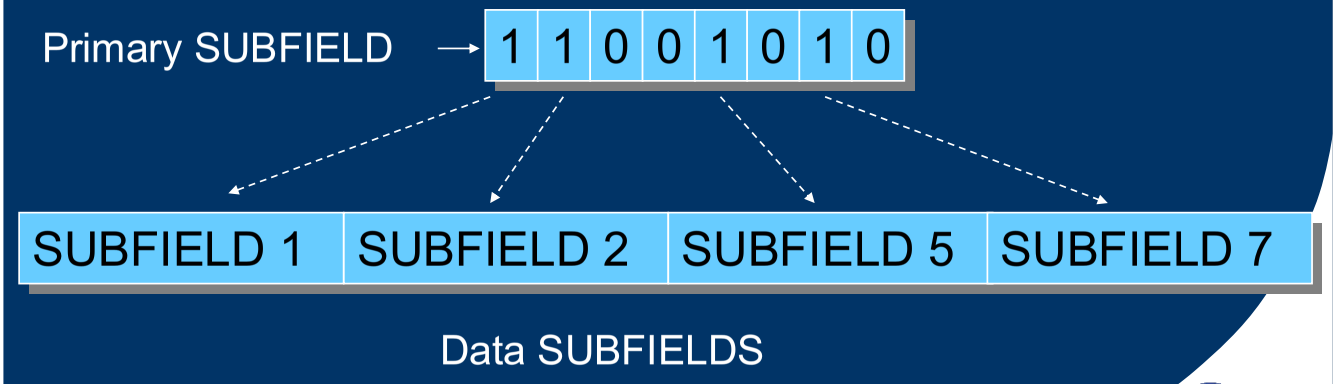
16	15	14	13	12	11	10	9
BDS1				BDS2			

bits 8/1 (REP) Repetition Factor

bit-16/13 (BDS1) Comm B Data Buffer Store 1 Address
bit-12/9 (BDS2) Comm B Data Buffer Store 2 Address

Standard Data Field Formats

Compound Data Fields



Standard Data Field Formats

Compound Data Field - Example

5.2.15 Data Item I048/120, Radial Doppler Speed

Definition: Information on the Doppler Speed of the target report.

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

Structure of Primary Subfield:

Octet no.1

8	7	6	5	4	3	2	1
CAL	RDS	0	0	0	0	0	0

bit-8 (CAL) Subfield #1: Calculated Doppler Speed
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (RDS) Subfield #2: Raw Doppler Speed
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bits-6/1 (Spare) Subfields #3/7: Spare
= 0 Absence of Subfield
= 1 Presence of Subfield

Standard Data Field Formats

Compound Data Field - Example

Structure of Subfield # 1:
Calculated Doppler Speed

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

bit-16	(D)	= 0	Doppler speed is valid
		= 1	Doppler speed is doubtful
bits-15/11	(Spare)		Fixed to zero
bits-10/1	(CAL)		Calculated Doppler Speed, coded in two's complement LSB= 1 m/sec

Introduction to ASTERIX

Standard Data Field Formats

Compound Data Field - Example

Structure of Subfield # 2:
Raw Doppler Speed

Octet no.1							
56	55	54	53	52	51	50	49
REP							

Octet no.2								Octet no.3							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
DOP															LSB

Octet no.4								Octet no. 5							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
AMB															LSB

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

bits-56/49	(REP)	Repetition Factor
bit-48/33	(DOP)	Doppler Speed LSB= 1 m/sec
bits-32/17	(AMB)	Ambiguity Range LSB= 1 m/sec
bits-16/1	(FRQ)	Transmitter Frequency LSB= 1 Mhz

Non-Standard Data Field

- Special Purpose Field
- First octet contains length including length indicator
- The Data Field may contain information such as test data, text for operator comm.
- Contents is agreed among users, others may skip it

Reserved Expansion Data Field

- First octet contains length including length indicator
- The Data Field is intended to introduce intermediate changes.
- Contents is agreed by the RDE-TF
- Description in a separate document

User Application Profile

- Defines which of the catalogued data items will be used.
- Defines the Frame Reference Number of the catalogued data items: the sequence of the items inside the ASTERIX message.

User Application Profile

- The UAP can be considered as a control table attached to the message assembly/disassembly program resident in the relevant processing system

User Application Profile

Example: Category 048

Table 2 - Standard UAP

FRN	Data Item	Data Item Description	Length in Octets
1	I048/010	Data Source Identifier	2
2	I048/140	Time-of-Day	3
3	I048/020	Target Report Descriptor	1+
4	I048/040	Measured Position in Slant Polar Coordinates	4
5	I048/070	Mode-3/A Code in Octal Representation	2
6	I048/090	Flight Level in Binary Representation	2
7	I048/130	Radar Plot Characteristics	1+1+
FX	n.a.	Field Extension Indicator	n.a.
8	I048/220	Aircraft Address	3
9	I048/240	Aircraft Identification	6
10	I048/250	Mode S MB Data	1+8*n
11	I048/161	Track Number	2
12	I048/042	Calculated Position in Cartesian Coordinates	4
13	I048/200	Calculated Track Velocity in Polar Representation	4
14	I048/170	Track Status	1+
FX	n.a.	Field Extension Indicator	n.a.

User Application Profile

Example: Category 048 (continued)

15	I048/210	Track Quality	4
16	I048/030	Warning/Error Conditions	1+
17	I048/080	Mode-3/A Code Confidence Indicator	2
18	I048/100	Mode-C Code and Confidence Indicator	4
19	I048/110	Height Measured by 3D Radar	2
20	I048/120	Radial Doppler Speed	1+
21	I048/230	Communications / ACAS Capability and Flight Status	2
FX	n.a.	Field Extension Indicator	n.a.
22	I048/260	ACAS Resolution Advisory Report	7
23	I048/55	Mode-1 Code in Octal Representation	1
24	I048/50	Mode-2 Code in Octal Representation	2
25	I048/65	Mode-1 Code Confidence Indicator	1
26	I048/60	Mode-2 Code Confidence Indicator	2
27	SP-Data Item	Special Purpose Field	1+1+
28	RE-Data Item	Reserved Expansion Field	1+1+
FX	n.a.	Field Extension Indicator	n.a.

Field Organisation

- Ordered Field Organisation
- The relationship between FSPEC, Data Fields and Data Items is defined in the UAP
- Minimum length of FSPEC is one octet

Field Organisation

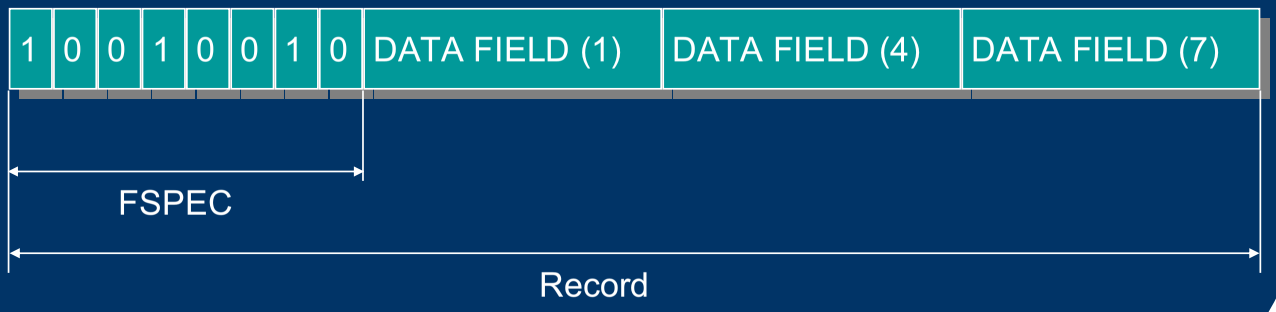
Structure of the FSPEC

F1 to F14 : Field Present Indicator
= 0 Data Field not present
= 1 Data Field present

FX : Field Extension Indicator
= 0 No FSPEC extension
= 1 Following octet contains an FSPEC

Field Organisation

Example of a one-octet FSPEC



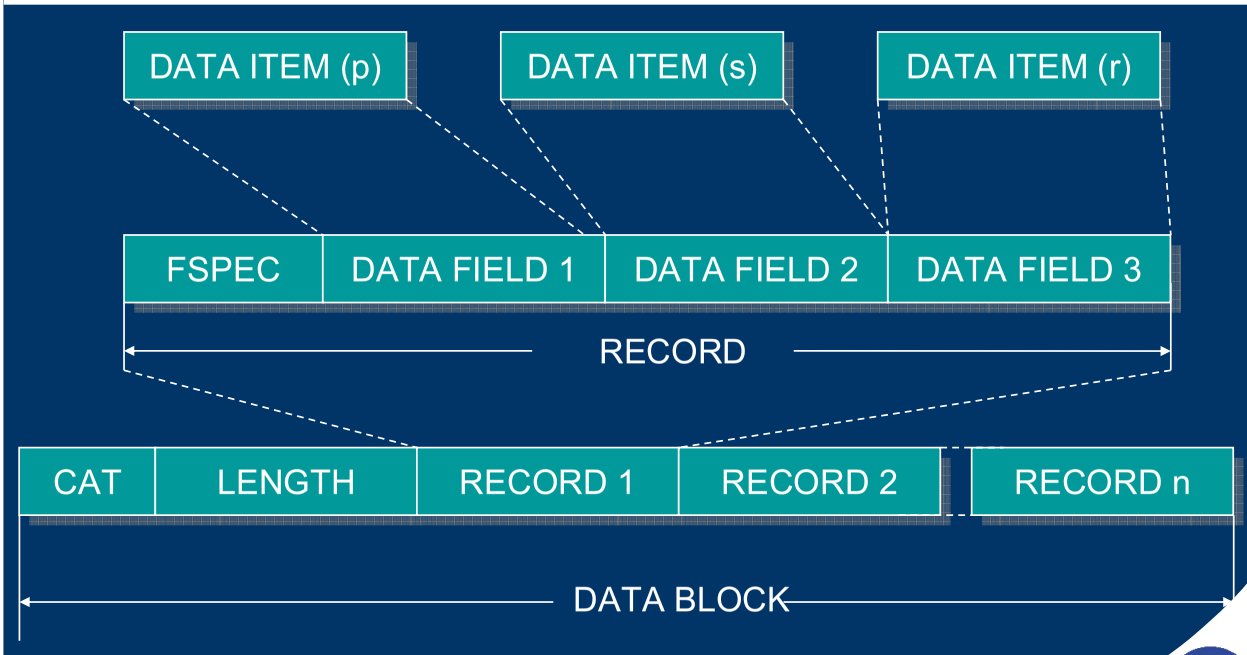
General Message Structure: Data Block

- Message consists of Data Blocks.
- Data Block:
  - One octet field Data Category (CAT)
  - Two octet field Length Indicator (LEN)
  - One or more Records

General Message Structure: Record

- Contains information of the same data category
- Has a field specification (FSPEC) of variable length, indicating order and presence of data fields
- Has a variable number of data fields with implicit or explicit length. Each data field is associated with one and only one data item, as defined in the UAP
- Is always a multiple of an octet long

General Message Structure



ASTERIX Adressing Scheme

- Based on SAC/SIC codes
- Always Ixxx/010, First item in UAP
- SAC:
  - System Area Code
  - 8 bit number assigned to area or country
  - Central EUROCONTROL Allocation
- SIC:
  - System Identification Code
  - 8 bit number assigned to every system within an area or country defined by the SAC
  - De-central, local Allocation

ASTERIX Adressing Scheme

(Example: CAR/SAM-Regions)

State/Territory Estado/Territorio	SAC Code Format Formato Código SAC								Hexadecimal SAC Code Código SAC Hexadecimal
	B7	B6	B5	B4	B3	B2	B1	B0	
Anguilla (United Kingdom)	1	1	1	0	0	0	0	0	E0
Antigua & Barbuda	1	1	1	0	0	0	0	1	E1
Argentina	1	1	1	0	0	0	1	0	E2
Aruba (Netherlands)	1	1	1	0	0	0	1	1	E3
Bahamas	1	1	1	0	0	1	0	0	E4
Barbados	1	1	1	0	0	1	0	1	E5
Belize	1	1	1	0	0	1	1	0	E6
Bolivia	1	1	1	0	0	1	1	1	E7
Brasil	1	1	1	0	1	0	0	0	E8
Cayman Islands (United Kingdom)	1	1	1	0	1	0	0	1	E9
Chile	1	1	1	0	1	0	1	0	EA
Colombia	1	1	1	0	1	0	1	1	EB
Costa rica	1	1	1	0	1	1	0	0	EC
Cuba	1	1	1	0	1	1	0	1	ED
Dominica	1	1	1	0	1	1	0	1	EE
Dominican Republic	1	1	1	0	1	1	1	1	EF
Ecuador	1	1	1	1	0	0	0	0	F0
El Salvador	1	1	1	1	0	0	0	1	F1

ASTERIX Adressing Scheme
(Example: CAR/SAM-Regions)

Guadeloupe, French Antilles (France)	0	0	0	0	1	0	0	0	08
Martinique, French Antilles (France)	0	0	0	0	1	0	0	0	08
French Guiana (France)	0	0	0	0	1	0	0	0	08
Grenada	1	1	1	1	0	1	0	1	F5
Guatemala	1	1	1	1	0	1	1	0	F6
Guyana	1	1	1	1	0	1	1	1	F7
Haiti	1	1	1	1	1	0	0	0	F8
Honduras	1	1	1	1	1	0	0	1	F9
Jamaica	1	1	1	1	1	0	1	0	FA
Mexico	1	1	1	1	1	0	1	1	FB
Montserrat (United Kingdom)	1	1	1	1	1	1	0	0	FC
Netherland Antilles (Netherlands)	1	1	1	1	1	1	0	1	FD
Nicaragua	1	1	1	1	1	1	1	0	FE
Panama	1	1	1	1	1	1	1	1	FF
Paraguay	1	1	0	1	0	0	0	0	D0
Peru	1	1	0	1	0	0	0	1	D1

Introduction to ASTERIX

ASTERIX Adressing Scheme
(Example: CAR/SAM-Regions)

Puerto Rico (United States)	1	1	0	1	0	0	0	1	D2
Saint Kitts and Nevis	1	1	0	1	0	0	1	1	D3
Saint Lucia	1	1	0	1	0	1	0	0	D4
Saint Vincent and Grenadines	1	1	0	1	0	1	0	1	D5
Saint Maarten	1	1	0	1	0	1	1	0	D6
Suriname	1	1	0	1	0	1	1	1	D7
Tortola	1	1	0	1	1	0	0	0	D8
Trinidad and Tobago	1	1	0	1	1	0	0	1	D9
Turks and Caicos Is. (United Kingdom)	1	1	0	1	1	0	1	0	DA
United States (For sharing with CAR Region)	1	1	0	1	1	0	1	1	DB
Uruguay	1	1	0	1	1	1	0	0	DC
Venezuela	1	1	0	1	1	1	0	1	DD
Virgin Island (United Kingdom)	1	1	0	1	1	1	1	0	DE
Virgin Island (United States)	1	1	0	1	1	1	1	1	DF

ASTERIX Working Arrangements

- **suRveillance Data Exchange Task Force – RDE-TF**
  - EUROCONTROL Task Force
  - Management of ASTERIX Development
  - Allocation of SACs
- **EUROCONTROL ASTERIX Manager**
  - Central ASTERIX Contact Point
  - EUROCONTROL DAP/SUR
  - Surveillance Domain

ASTERIX documentation

- Latest editions available on ASTERIX website:

  www.eurocontrol.int/asterix/
- Contact information:

  asterix@eurocontrol.int