EUROCONTROL Specification for Surveillance Data Exchange

ASTERIX Part 28 Category 015

Independent Non-Cooperative Surveillance System Target Reports

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Abstract

This document specifies the contents of ASTERIX Category 015 messages used for the transmission of Independent Non-Cooperative Surveillance (INCS) System Target Reports.

Keywords

Data Exchange	Messages	SAC	SIC
Data Category	Data Field	Data Block	Data Item
ASTERIX	UAP	INCS	

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DOCUMENT APPROVAL

This document has been approved by the ASTERIX Maintenance Group (AMG)

For management approval of the complete set of ASTERIX documentation, please refer to Part 1 [1].

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
0.1-0.20	Various	Draft versions of Category 015 for the transmission of Target Reports from Independent Non-Cooperative Surveillance Systems.	ALL
1.0	July 2019	Published Version	ALL

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EXECUTIVE SUMMARY

This document describes the general concepts and the message layout for the application of ASTERIX Category 015 for the transmission of target information derived by Independent Non-Cooperative Surveillance (INCS) systems.

This document provides a format for the transfer of INCS data in a form independent from the technology used to detect non-cooperative targets. Whilst the positional data can be presented in range and azimuth format (using data items I015/625 and I015/627) the preferred coordinate frame is the WGS-84 format.

The Category 015 format includes provision for a range of INCS system types (mono-static, bi-static, multi-static (Active and/or Passive techniques) and even electro-optic sensors). It includes provision for 2D and 3D systems and includes means for transferring a range of optional data such as target classification. It also includes a ‘hook’ to ASTERIX Category 016 that enables traceability to further information detailing the configuration of the sensor. Such information can include the location of the sensors receivers and the location and the nature of any opportunity transmitters that were used to support the detection e.g. FM, DAB and/or DVB-T[1].

ANNEX A contains a description of the basic principles applied for the processing of INCS Target Reports.

[1] FM = Frequency Modulation, DAB = Digital Audio Broadcast and DVB-T = Digital Video Broadcast – Terrestrial

1. INTRODUCTION AND SCOPE

1.1 Introduction

Many ASTERIX specifications are focussed upon addressing the requirements to support specific surveillance techniques – such as ADS-B or WAM. ASTERIX Category 015 is a more generic category supporting the needs of numerous types of Independent Non-Cooperative Surveillance Sensors (including mono-static, multi-static, rotating, electro-optic, …).
ANNEX A contains a description of the basic principles applied for the processing of INCS Target Reports.

1.2 Scope

This document describes the message structure for the transmission of Independent Non-Cooperative Surveillance target reports.

It details the general concepts and the message layout for the application of ASTERIX Category 015 for the transmission of information derived by Independent Non-Cooperative Surveillance (INCS) systems.

This document is not intended to replace the existing ASTERIX category for the transfer of mono-radar target data reports (such as Primary Surveillance Radar) - ASTERIX Categories 001 or 010 or 048. It provides a format for the transfer of INCS data in a form independent from the technology used to detect non-cooperative targets . Whilst the positional data can be presented in range and azimuth format (using Data Items I015/625 and I015/627) the preferred coordinate frame is the WGS-84 format.

The Category 015 format includes provision for a range of INCS system types such as, but not limited to, the following:

- Mono-Static – in which the transmitter and receiver share the same location,
- Bi-Static – in which the transmitter and the receiver of the system are spatially separated.
- Multi-Static Active – A distributed network of transmitter(s) and receiver(s) in which the transmitters are under the control of the end user.
- Multi-Static Passive - A distributed network of transmitter(s) and receiver(s) in which the transmitters are under the control of a third party. Such transmitters, which are referred to as ‘Transmitters of Opportunity’ in this context, are typically employed for other uses such as the transmission of DVB-T signals, DAB or FM radio.
- Electro-Optic Sensors – Video cameras or other techniques which can be used to provide an indication of the presence and potentially also an outline contour of a target.

In addition to providing the 2D WGS-84 position of the target the structure of the specification includes provision for 3D systems providing a measure of the height of the target.

The Category 015 format includes provision for a range of INCS system types (mono-static, bi-static, multi-static (Active and/or Passive techniques) and even electro-optic sensors). It includes provision for 2D and 3D systems and includes means for transferring a range of optional data such as target classification. It also includes a ‘hook’ to ASTERIX Category 016 that enables traceability to further information detailing the configuration of the sensor. Such information can include the location of the sensors receivers and the location and the nature of any opportunity transmitters that were used to support the detection e.g. FM, DAB and/or DVB-T[2]. An additional

[2] FM = Frequency Modulation, DAB = Digital Audio Broadcast and DVB-T = Digital Video Broadcast – Terrestrial

set of ASTERIX Category 015 optional data items detailing the covariance matrix of the target report may also be provided by the INCS sensor. Such information could be used to support the processing performed within subsequent tracking and data fusion components.

The principle applied when defining units for the various data items in this ASTERIX Category is based upon the use of SI units. The reasons behind adopting this approach are:

- The use of a mix of units, such as vertical information in ft/min and ft/min^2 and horizontal information for manoeuvring aircraft based upon m/s and m/s^2 is sub-optimal.
- This ASTERIX Category includes covariance data to allow subsequent processing stages to make 'more-intelligent' decisions. Matrices containing a mix of unit types introduce unnecessary degrees of complexity.
- 3D INCS sensors provide a geometric height (rather than a flight level as provided by Cooperative Surveillance Sensors). Subsequent tracking stages will need to treat these two types of information differently.

Retaining a mix of Imperial and SI units introduces unnecessary complexities and so this ASTERIX Category uses only SI Units.

The Sensor Reference Point is detailed in ASTERIX Category 016 – where there is also provision for including the reference points for the transmitter(s) and receiver(s) that are used within the sensor configuration. The Sensor Reference Point is also contained in ASTERIX Category 025.

In summary, ASTERIX Category 015 is a generic receptacle for all forms of data currently foreseen to be provided by INCS systems.

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2. REFERENCES

2.1 General

The following Documents and Standards contain provisions that, 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 Document(s) 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 and Related Documents

EUROCONTROL Documents:

1. EUROCONTROL Specification SPEC-0149, edition 2.4, 24 December 2016 “EUROCONTROL Specification for Surveillance Data Exchange – Part 1 All Purpose Structured EUROCONTROL Surveillance Information Exchange – ASTERIX”.
2. EUROCONTROL Standard Document for Radar Data Exchange Part 2a Transmission of Monoradar Data Target Reports (SUR.ET1.ST05.2000-STD-02A-01) Edition 1.2 Edition Date: August 2011 (ASTERIX CAT001))
3. EUROCONTROL Standard Document for Radar Data Exchange Part 7: Category 010 Transmission of Mono-sensor Surface Movement Data (SUR.ET1.ST05.2000-STD-07-01) Edition 1.1 Edition Date March 2007
4. EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 26 Category 025 CNS/ATM Ground System Status Reports (EUROCONTROL-SPEC-0149-26) Edition Number 1.2 Edition Date April 2018
5. EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 26 Category 016
6. EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 4 Category 48 Monoradar Target Reports (EUROCONTROL-SPEC-0149-4) Edition Number 1.23 Edition Date July 2017

ICAO Documents:

7. Aeronautical Surveillance Manual ICAO Doc 9924 First Edition 2011
8. ISO 5725-1: 1994 Accuracy (trueness and precision) of measurement methods and results – Part 1: General principles and definitions. Published December 1994

IEEE Documents:

9. IEEE Standard Radar Definitions IEE Std 686-2008

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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 ASTERIX Related Terms:

Please refer to ASTERIX Part 1 [1], chapter 3.1.

3.1.1.1 Measured Item

A piece of information (e.g. the position of a target) derived from the sensor information and transmitted without any smoothing.

3.1.2 INCS and Target Report Content Related Terms:

3.1.2.1 Independent Non-Cooperative Surveillance

ICAO Doc 9924 [7] defines the term Independent Non-Cooperative Surveillance as a system in which “The aircraft position is derived from measurement not using the cooperation of the remote aircraft. An example is a system using Primary Surveillance Radar (PSR), which provides aircraft position but not identity or any other aircraft data”.
Thus, an Independent Non-Cooperative Surveillance sensor is one in which the aircraft position, but not identity or other aircraft sourced data (such as Mode C height), is derived from measurement without relying upon the active cooperation of the aircraft. It is recognised that other objects reflect the RF signals used to illuminate the aircraft – and that the sensor may also output target reports for these objects in addition to those for the aircraft.
Note: in case of a combined primary / secondary radar, Category 015 is not foreseen for the output of combined target reports.

3.1.2.2 Precision

Precision is defined as the closeness of agreement between independent test results obtained under stipulated conditions (ISO 5725-1 [8]). Precision depends only on the distribution of random errors and does not relate to the true value or the specified value.

3.1.2.3 Sensor

In the framework of Category 015 an Independent Non-Cooperative Surveillance sensor is defined as a configuration of transmitter(s)/receiver(s) and a central processing system with associated data link, communication and synchronization means as well as monitoring.
The sensor may thus comprise multiple components. It may also be that these components are also capable of outputting surveillance data against their own component reference point.

3.1.2.4 Service

The provision of the necessary data and the definition of its characteristics (such as geographic volume served, update intervals, performance etc.) to support the ATC application or applications that are conducted using the data provided by this source.

3.1.2.5 Target

An object, reflecting and/or emitting electromagnetic energy, which is of interest to a non-cooperative sensor and results in the generation of a target report.

3.1.2.6 Target Report

A Target Report is an output from a non-cooperative sensor resulting from received electromagnetic energy being interpreted by the sensor as a target. In ASTERIX Category 015 a Target Report is a message containing data from an INCS sensor about a detection the sensor has made or has simulated to support diagnostic purposes.

3.2 Acronyms and Abbreviations

Numerous abbreviations, specific to this ASTERIX category are used within this document. When used, the abbreviation is detailed upon first usage.

For the purposes of this EUROCONTROL Document, the following shall apply for generic terminology:

°	Degree (angle)
AMG	ASTERIX Maintenance Group
ASTERIX	**A**ll Purpose **ST**ructured **E**UROCONTROL su**R**veillance **I**nformation E**x**change
dB	Decibel
dBm	Decibel milliwatt
CAT	Data Category
CWP	Controller Working Position
FRN	Field Reference Number
FSPEC	Field Specification
FX	Field Extension Indicator
ICAO	International Civil Aviation Organization
INCS	Independent Non-Cooperative Surveillance
LEN	Length Indicator
LSB	Least Significant Bit
MSPSR	Multi-Static Primary Surveillance Radar
NCS	Non-Cooperative Surveillance (See INCS)
PSR	Primary Surveillance Radar
REP	Field Repetition Indicator
s	second, unit of time
SAC	System Area Code
SIC	System Identification Code
SNR	Signal to Noise Ratio
UAP	User Application Profile (see Definitions)
UTC	Coordinated Universal Time
WGS-84	World Geodetic System 84

4. GENERAL PRINCIPLES

4.1 General

The naming convention adopted for the surveillance techniques to be addressed within this ASTERIX Category is 'Independent Non-Cooperative Surveillance' (INCS).

4.2 Time Management

4.2.1 Requirements for Time Stamping

Please refer to ASTERIX Part 1 [1], chapter 5.3.

In Category 015 reports the time stamp shall be consistent with the reported target position.

4.3 Projection Systems and Geographical Coordinates

4.3.1 Coordinates Expressed in WGS-84 Format (Geographical Coordinates)

The exported position can be expressed by item I015/600 SF#1 (Horizontal Position in WGS-84 Coordinates), potentially augmented with geometric height, given by item I015/601 SF#1 (Geometric Height (WGS-84)) Coordinates Expressed in a 2D Coordinate Reference System.

4.3.2 Altitude above WGS-84

Vertical distance between the target and the projection of its position on the earth's ellipsoid, as defined by WGS-84.

4.3.3 Target Velocity and Acceleration in Local Cartesian Coordinates

Velocity I015/602 SF #1 (Horizontal Velocity Vector) and acceleration I015/603 SF #1 acceleration vectors (Horizontal Acceleration Vector) however are consistently represented in a target centric Cartesian coordinate frame (e.g. Vx, Vy), which is tangent to the WGS-84 ellipsoid.

Its Y-axis is aligned to geographic North, and X-axis is perpendicular to the Y-axis and points to the East at the target location.

Local Cartesian coordinates are used for the covariances in numerous items:

- I015/600 (Horizontal Position Information),
- I015/601 (Geometric Height Information),
- I015/602 (Horizontal Velocity Information),
- I015/603 (Horizontal Acceleration Information),
- I015/604 (Vertical Velocity Information),
- I015/605 (Vertical Acceleration Information),
- I015/625 (Range Information)
- I015/626 (Doppler Information)
- I015/627 (Azimuth Information)
- I015/628 (Elevation Information)

and are also used in I015/631 (Contour (Azimuth, Elevation Angle, Range Extent))

4.4 Covariance Matrices

4.4.1 Target-Centric Cartesian Covariance Matrix

The covariance matrixes, representing the precision of a state vector, are consistently represented in a target centric Cartesian coordinate frame.

4.4.2 Binary Representation of Covariance Matrices

The main diagonal elements of any covariance matrix are represented by the standard deviation values. The off-diagonal elements in the covariance matrix are represented by the correlation coefficient with a valid range of $-1+1/2^7$ to $+1-1/2^7$, both values included. The values -1 and +1 are non-physical and considered invalid.

This limitation is a format restriction rather than a system restriction.

4.5 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.

4.6 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.

4.6.1 System

In the framework of Category 015 a System is a Surveillance Sensor.

4.6.2 Addressing Concepts: Assigning SAC/SIC Codes

By convention a dedicated and unambiguous SAC/SIC code shall be assigned to every Independent Non-Cooperative Surveillance System.

4.7 Message Types

Five message types have been defined:

- Measurement Plot
- Measurement Track
- Sensor Centric Plot
- Sensor Centric Track
- Track End Message

ANNEX A provides a detailed introduction into the target processing in an INCS system and the use of ASTERIX Category 015 and 016 to convey the respective information.

The Track End Message indicates that a track has been terminated. This can be done automatically by the system or by User input. Only in the latter case data item I015/170 is to be included in the message with the TUR bit set to 1. All other bits in I015/170 have no meaning in the Track End Message.

4.8 User Application Profile

4.8.1 UAP

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

More information is available from ASTERIX Part 1 [1], chapter 4.2.4

4.8.2 ASTERIX Data Records

The General ASTERIX Message Structure is described in ASTERIX Part 1 [1], chapter 4.3.

Each ASTERIX Data Record shall have the following layout:

CAT = 015	**LEN**	**FSPEC**	Data Item	Data Item	…	Last Data Item of Record

where:

- Data Category (CAT) = 015, is a one-octet field indicating that the ASTERIX Data Record contains Independent Non-Cooperative Surveillance data
- Length Indicator (LEN) is a two-octet field indicating the total length in octets of the ASTERIX Data Record, including the CAT and LEN fields
- FSPEC is the Field Specification

NOTE: This ASTERIX Category 015 **does not follow** the blocking mechanism as used until edition 2.1 of Part 1 of ASTERIX. This means that it is **not permitted** to merge multiple ASTERIX records into an ASTERIX block.

More information is available from ASTERIX Part 1 [1], chapter 4.3.3

4.9 Composition of Messages

4.9.1 Sequence of Data Items

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

More information is available in ASTERIX Part 1 [1], chapter 4.3.7

4.9.2 Presence of Data Items

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

4.9.3 Message Construction

Whilst adhering to basic ASTERIX protocols, as defined in ASTERIX Part 1 [1], the configuration of ASTERIX Category 015 data items to form a target report is flexible.

In its basic form the target report can be structured to provide positional data only – using the mandatory data items. This could be in Range/Azimuth notation of the sort provided by conventional rotating Primary Surveillance Radars (PSRs) –

in which case Data Items I015/625 and I015/627 would be used. These may be supplemented by I015/626 if the sensor is capable of providing altitude information. Positional information in WGS-84 format can also be provided in Data Item I015/600.

Subject to the capability of the sensor and the nature of the techniques employed progressively enhanced configurations of ASTERIX Category 015 data items can be considered – in which a number of optional data items are populated.

These data items may be focussed to addressing the requirements of subsequent processing stages in the ATM architecture (such as providing covariance data to support tracking algorithms) or providing additional data, such as target classifications, to the air traffic controllers.

When being used as the target report category for a Multi-Static PSR (MSPSR) sensor, such as an active or passive MSPSR, Category 015 can be used in conjunction with Category 016 to provide additional details concerning which Transmitter / Receiver couplets were used when assembling the data contained in the target report. As described in Annex A, this information could be used to determine characteristics of the system and its performance.

5. LAYOUT OF TARGET REPORTS

5.1 Standard Data Items

The standardised data items, which shall be used for the transmission of Independent Non-Cooperative Surveillance data are defined in Table 5-1 and described in the following pages.

Table 5-1: Standard Data Items of Category 015

Data Item Ref. No.	Description	Resolution
I015/000	Message Type	N.A.
I015/010	Data Source Identifier	N.A.
I015/015	Service Identification	N.A.
I015/020	Target Report Descriptor	N.A.
I015/030	Warning/Error Conditions	N.A.
I015/050	Update Period	1/128 s
I015/145	Time of Applicability	1/128 s
I015/161	Track/Plot Number	N.A.
I015/170	Track/Plot Status	N.A.
I015/270	Target Size & Orientation	N.A.
I015/300	Object Classification	N.A.
I015/400	Measurement Identifier	N.A.
I015/480	Associations	N.A.
I015/600	Horizontal Position Information	N.A.
I015/601	Geometric Height Information	N.A.
I015/602	Horizontal Velocity Information	N.A.
I015/603	Horizontal Acceleration Information	N.A.
I015/604	Vertical Velocity Information	N.A.
I015/605	Vertical Acceleration Information	N.A.
I015/625	Range Information	N.A.
I015/626	Doppler Information	N.A.
I015/627	Azimuth Information	N.A.
I015/628	Elevation Information	N.A.
I015/630	Path Quality	N.A.
I015/631	Contour (Azimuth, Elevation Angle, Range Extent)	N.A.

5.2 Description of Standard Data Items

5.2.1 Data Item I015/000, Message Type

Definition: This data item conveys the report type and whether the output is periodically updated or asynchronous depending upon external events.

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
MT							RG

bits-8/2 (MT) Message Type (See notes 1 and 2 below)
= 1 Measurement Plot
= 2 Measurement Track
= 3 Sensor Centric Plot
= 4 Sensor Centric Track
= 5 Track End Message

bit-1 (RG) Report Generation
= 0 Periodic Report (See note 3 below)
= 1 Event Driven Report (See note 4 below)

The encoding rules for each data item per Message Type are defined in the following table.

M stands for mandatory, O for optional, X for never present.

Notes:

Note 1: See Section 4.7 and ANNEX A for definitions of the Message Types.

Note 2: Values 6 to 127 are reserved for future use

Note 3: Periodic Report: A periodic report is one transmitted periodically with an independently configurable period.

Note 4: Event Driven Report: An Event Driven Report is one generated in response to the occurrence of an external event such as an RF echo off a target.

Table 5-2: Items per Message Type

Item	Type	Measurement Plot	Measurement Track	Sensor Centric Plot	Sensor Centric Tracks	Track End Message
I015/000	Message Type	M	M	M	M	M
I015/010	Data Source Identifier	M	M	M	M	M
I015/015	Service Identification	O	O	O	O	O
I015/020	Target Report Descriptor	M	M	M	M	X
I015/030	Warning/Error Conditions	O	O	O	O	X
I015/050	Update Period	O	O	O	O	X
I015/145	Time of Applicability	M	M	M	M	M
I015/161	Track/Plot Number	O	M	O	M	M
I015/170	Track/Plot Status (See Note 4)	O	M	O	M	O
I015/270	Target Size & Orientation	O	O	O	O	X
I015/300	Object Classification	O	O	O	O	X
I015/400	Measurement Identifier	O	O	X	X	X
I015/480	Associations	X	X	O	O	X
I015/600	Horizontal Position Information (See Note 1)	O	O	M	M	X
I015/601	Geometric Height Information (See Note 1)	O	O	O	O	X
I015/602	Horizontal Velocity Information (See Note 1)	O	O	O	O	X
I015/603	Horizontal Acceleration Information (See Note 1)	O	O	O	O	X
I015/604	Vertical Velocity Information (See Note 1)	O	O	O	O	X
I015/605	Vertical Acceleration Information	O	O	O	O	X
I015/625	Range Information (See Note 2)	O	O	O	O	X
I015/626	Doppler Information	O	O	O	O	X
I015/627	Azimuth Information (See Note 2)	O	O	O	O	X
I015/628	Elevation Information (See Note 2)	O	O	O	O	X
I015/630	Path Quality	O	O	O	O	X
I015/631	Contour (Azimuth, Elevation Angle, Range Extent) (See Note 2)	O	O	O	O	X

Note 1: The implementation of ASTERIX Category 015 is to provide Sensor Centric positional data in WGS-84 coordinate system (as contained in I015/600, I015/601, I015/602, I015/603 and I015/604)

Note 2: If the sensor is outputting Measurement Plot or Measurement Track data items I015/625, I015/627 and possibly I015/628 and I015/631 could also be provided.

Note 3: The Sensor Centric Plot or Sensor Centric Track data are preferred as system's output for use by client systems. The Measurement Plot or Measurement Track messages should be used for intra-sensor communication.

Note 4: For Message Type = 5 "Track End Message", Data Item I015/170 "Track Status" **shall** only be sent in if the track has been terminated by User Request (TUR indication in Data Item I015/170 set to 1). In this case, all other bits in data item I015/170 have no meaning and **shall** be disregarded.

5.2.2 Data Item I015/010, Data Source Identifier

Definition: Identification of the sensor from which the data is 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: See Table 5-2: Items per Message Type

Notes:

Note 1: The up-to-date list of SACs is published on the EUROCONTROL Web Site (http://www.eurocontrol.int/asterix).

Note 2: The SICs are allocated by the national authority responsible for the surveillance infrastructure.

Note 3: The SIC and SAC values ***shall*** be formatted as binary unsigned integers.

5.2.3 Data Item I015/015, Service Identification

Definition: Identification of the service provided to one or more users.

Format: Two-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
SID							

bits-8/1 (SID) Service Identification

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: The Service Identification is allocated by the system.

Note 2: The SID value ***shall*** be formatted as binary unsigned integers.

5.2.4 Data Item I015/020, 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 Extensions as necessary.

Structure of First Part:

Octet no. 1

8	7	6	5	4	3	2	1
MoMu		TTAX		SCD		0	FX

bits-8/7 (MoMu) Mono-Static Target Report or Multi-Static Target Report (See Note 1 below)
= 00 Mono-Static Sensor
= 01 Multi-Static Sensor
= 10 Other
= 11 Unknown

bits-6/5 (TTAX) Target Taxonomy
= 00 Actual Target Report
= 01 Reference Target (See Note 2 below)
= 10 Synthetic Target (See Note 3 below)
= 11 Simulated / Replayed Target (See Note 4 below)

bits-4/3 (SCD) Scanning Direction (See Note 5 below)
= 00 unknown
= 01 forward
= 10 backward
= 11 static

bit-2 Spare bit, set to zero

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: The MoMu bit is used to indicate whether the target report was constructed from a multi-static (including bi-static) or mono-static sensor. Its setting dictates the interpretation of data items I015/625 and I015/626.
The meaning of the value “other” ***shall*** be described in the system ICD.

Note 2: In this context, a Reference Target Report stems from a non-aircraft target based on RF received externally to the system boundary. This may be generated, for example, by an external RF generator or a Permanent Echo or from a device, which is deployed in line of sight of the sensor.

Note 3: A synthetic target is an internally generated diagnostic signal prior to the generation of the ASTERIX Category 015 target report. For example used to support test processes.

Note 4: This value is used to represent externally generated targets or recorded data injected into the output data stream of the INCS system e.g. for test or training purposes.

Note 5: This indication is used to inform about the scanning direction of the system (e.g. left/right, up/down, clockwise/anti-clockwise). It's exact meaning is implementation dependent and ***shall*** be described in the system ICD.

5.2.5 Data Item I015/030, 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 Extensions 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
(See note below regarding the allocation of the values)

bit-1 (FX) = 0 End of data item
= 1 Extension following
(next W/E value)

Encoding Rule:
See Table 5-2: Items per Message Type.

Notes:

Note 1: It has to be stressed that a series of one or more W/E conditions can be reported per target report.

Note 2: The nature of the warning / error condition may differ between sensor types and the declaration and use of such alerts is driven by end user requirements.

Note 3: Potential applications could be to indicate that the target report correlates with road infrastructure (terrestrial vehicles) or a wind turbine or that it is a fixed or slow moving return or originating from an area of high clutter. Such data items could also be used to indicate the presence of interference – either deliberate or accidental.

Note 4: The Warning/Error Condition Values from 1-31 are reserved for designation by the ASTERIX Maintenance Group. System implementers are free to use values of 32 and above. The allocation of the remaining values of this data item ***shall*** be defined in a local Interface Control Document.

Note 5: The value of “0” must not be assigned.

5.2.6 Data Item I015/050, Update Period

Definition: Period until next expected output of a target report for this target.

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
0	0							UPD							LSB

bits-16/15 Spare bit set to zero

bits-14/1 (UPD) Update period
max. value = 128 s
bit-1 (LSB) = 1/128 s

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: It is not necessary that all targets detected by the INCS sensor have target reports generated at the same update period.

Note 2: This data item indicates the period until the next expected output of a target report for this target relative to the Time of Applicability contained in data item I015/145

5.2.7 Data Item I015/145, Time of Applicability

Definition: Absolute time stamping for applicability of the measured information expressed as UTC.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
Time							

Octet no. 2 / Octet no. 3

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

bits-24/1		Time of Applicability
bit-1	(LSB)	= 1/128 s

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: The Time of Applicability refers to the information contained in data item I015/600, I015/601, I015/625, I015/626, I015/627, I015/628 whichever is available. In case of a Track End Message (Message Type = 5) it refers to the time at which the track is terminated and the track number (data item I015/161) is released for re-use.

Note 2: A distributed sensor, such as an MSPSR, may have multiple elements that are each individually time stamped which are consolidated in to a target report. Rather than provide details of each time stamped message, this data item conveys the time of applicability of position of the target report.

Note 3: The Time of Applicability value is reset to zero each day at midnight.

Note 4: The Time of Applicability value ***shall*** be formatted as a binary unsigned integer.

5.2.8 Data Item I015/161, Track/Plot Number

Definition: An integer value representing a unique reference to a track/plot record.

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
Track Number															

bits-16/1 Track number
max. value = 65,535

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: Track numbers are required for Sensor and Measurement Tracks. However, for Sensor and Measurement Plots the inclusion of a track number is optional – depending upon whether the INCS sensor has used tracking processing to reduce the false alarm rates.

Note 2: The track number is allocated by the system.

Note 3: The track number value ***shall*** be formatted as binary unsigned integers.

5.2.9 Data Item I015/170, Track/Plot Status

Definition: Status of Track/Plot.

Format: Variable length data item comprising a first part of one-octet, followed by one-octet Extensions as necessary.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
BIZ	BAZ	TUR	0	CSTP	CSTH	CNF	FX

bit-8 (BIZ) = 0 Target not in Blind Zone
= 1 Target in Blind Zone

bit-7 (BAZ) = 0 Target not in Blanked Zone
= 1 Target in Blanked Zone

bit-6 (TUR) = 0 Track Alive (See note below)
= 1 Track Terminated by User Request

bit-5 Spare bit, set to “0”

bit-4 (CSTP) Coasted - Position (See notes below)
= 0 Not extrapolated
= 1 Extrapolated

bit-3 (CSTH) Coasted – Height (See notes below)
= 0 Not extrapolated
= 1 Extrapolated

bit-2 (CNF) Confirmed vs. Tentative Track
= 0 Confirmed Track
= 1 Tentative Track

bits-1 (FX) = 0 End of Data Item
= 1 Extension into next octet

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: The indication for CSTP and/or CSTH applies only to data items I015/600 and I015/605 respectively. In case one of these data items is not present, CSTP and/or CSTH has no meaning.

Note 2: A coasted track is one for which the sensor detections have been interrupted and whose position/height is being predicted based on the previously received responses.

Note 3: The blind zone or blanked zone are predictable zones where no detection is predicted.

If bit 5 is set and TTS = 1 then the track is coasted because it is in a blind zone or sector blank zone.

Note 4: The indication TUR=1 **shall** be sent only with Message Type = 5 “Track End Message”.

5.2.10 Data Item I015/270, Target Size & Orientation

Definition: Data item containing the size and orientation information of the target.

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
LEN	WDT	HGT	ORT	0	0	0	FX

bit-7 (LEN) Subfield #1: Target Length
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (WDT) Subfield #2: Target Width
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (HGT) Subfield #3: Target Height
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (ORT) Subfield #4: Target Orientation
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bits-4/2 Spare bits set to zero

bit-1 (FX) = 0 End of Primary Subfield
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Note: If length and width cannot be clearly determined, the greater value of the two ***shall*** be transmitted as length.

Structure of I015/270 Subfield #1: Target Length

Definition: The target length is the longest dimension in the targets direction of motion

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
LGT															LSB

bits-16/1 (LGT) Target Length
max. value = 655.35 m
bit-1 (LSB) = 0.01 m

Structure of I015/270 Subfield #2: Target Width

Definition: The target width is the longest dimension orthogonal to the targets direction of motion

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
WDT															LSB

bits-16/1 (WDT) Target Width
max. value = 655.35 m
bit-1 (LSB) = 0.01 m

Structure of I015/270 Subfield #3: Target Height

Definition: The target height is the longest dimension in the vertical direction.

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
HGT															LSB

bits-16/1 (HGT) Target Height
max. value = 655.35 m
bit-1 (LSB) = 0.01 m

Structure of I015/270 Subfield #4: Target Orientation

Definition: The orientation gives the direction, which the target nose is pointing, relative to the Geographical North.

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
ORT															LSB

bits-16/1 (ORT) Target Orientation
max. value = 360 degrees
bit-1 (LSB) = $360/2^{16}$ degree

Note:

The orientation shall increment in a clockwise manner relative to Geographic North.

5.2.11 Data Item I015/300, Object Classification

Definition: Classification result of the object detection.

Format: Repetitive data item starting with a one-octet field repetition indicator (REP) followed by at least one classification result and corresponding probability comprising two-octets.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
REP							

Octet no. 2 / Octet no. 3

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

bits-24/17	(REP)	Repetition factor
bits-16/8	(CLS)	Classification
bits-7/1	(PRB)	Probability
bit-1	(LSB)	= 1 per cent

Notes:

Note 1: INCS processing may be able to provide an indication of the nature of the target e.g. road vehicle or aircraft with the potential for further discrimination in the type of the aircraft e.g. two engine, fixed wing/helicopter etc.

Before including requirements for target classification it is necessary to consider the operational manner in which such information would be used and how/if such data would be made available to the controllers.

Note 2: Target classification is attributing, with an acceptable degree of confidence, a target report as having originated from a specific object or target type e.g. fixed wing aircraft, flock of birds etc. (It should be noted that the probabilities assigned to a target do not necessarily need to add up to 100%)

The ability of an INCS sensor to classify the targets it detects is dependent upon the systems capabilities and is driven by end user requirements. The use of this optional data item is to be agreed between parties such as the system manufacturer, the system operator agency and the end user. The allocation of the CLS octet is to be defined in a local Interface Control Document that ***shall*** be agreed by both parties.

Note 3: If this functionality is implemented in the sensor, the classification result (CLS), PRB and REP value ***shall*** be formatted as a binary unsigned integer.

5.2.12 Data Item I015/400, Measurement Identifier

Definition: An identifier pointing to a measurement that was created from a specific contributing Tx/Rx Pair where the Pair Identifier refers to the index which details both the transmitter characteristics (DVB-T, DAB, FM, dedicated etc.) and the receiver characteristics. These are defined in ASTERIX Category 016 – Data Item I016/300).

Format: Five-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
PID															

Octet no. 3							
24	23	22	21	20	19	18	17
Observation Number							

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

bits-40/25 (PID) Pair Identifier

bits-24/1 Observation Number
max. value: 16,777,215

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: INCS sensors may achieve their operational requirements based upon different techniques and technologies. Some may utilise multiple transmitter stations or multiple receiver stations.

This data items provides the means for subsequent processing stages to be able to analyse the target report data based upon the system components that contributed to the formation of the target report.

See ANNEX A for further details.

Note 2: The Pair Identifier shall be defined in ASTERIX Category 016 (Data Item I016/300).

Note 3: The Observation Number is identifying an element of ‘raw data’ information. The sensor plots and sensor tracks are usually composed of several raw data information. Therefore, the Observation number is defined in the Measurement Plots and Measurement Tracks.

5.2.13 Data Item I015/480, Associations

Definition: Information on which Measurement Identifiers contributed to the Sensor Centric Plot / Sensor Centric Track.

Format: Repetitive data item starting with a one-octet field repetition indicator (REP) followed by at least one five-octet Measurement Identifier.

Structure

Octet no. 1

48	47	46	45	44	43	42	41
REP							

Octet no. 2 / Octet no. 3

40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
Measurement Identifier															

Octet no. 4

24	23	22	21	20	19	18	17
Measurement Identifier							

Octet no. 5 / Octet no. 6

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

bits-48/41 (REP) Repetition factor

bits-40/1 (Measurement Identifier) – As defined in I015/400

Encoding Rule: See Table 5-2: Items per Message Type

5.2.14 Data Item I015/600, Horizontal Position Information

Definition: Data item containing the horizontal position information of the target.

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
P84	HPR	HPP	0	0	0	0	FX

bit-8 (P84) Subfield #1: Horizontal Position in WGS-84 Coordinates
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (HPR) Subfield #2: Horizontal Position Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (HPP) Subfield #3: Horizontal Position Precision
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bits-5/2 Spare bits, set to 0

bit-1 (FX) = 0 End of Primary Subfield
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/600 Subfield #1: Horizontal 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.
bit-33	(LSB)	= $180/2^{31}$ degree

bits-32/1	(Longitude)	In WGS-84, in Two's complement. Range -180 <= longitude < 180 deg.
bit-1	(LSB)	= $180/2^{31}$ degree

Note:

The LSB provides a resolution of 1cm.

Positive longitude indicates East. Positive latitude indicates North.

Structure of I015/600 Subfield #2: Horizontal Position Resolution

Definition: A horizontal 2D dimensional area (ellipse) within which the sensor is unable to resolve two separate targets.

Format: Five-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
Rs_HP_X															LSB

Octet no. 3								Octet no. 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Rs_HP_Y															LSB

Octet no. 5							
8	7	6	5	4	3	2	1
$CoRs\_HP_{XY}$							LSB

bits-40/25 (Rs_HP_X) Horizontal position resolution of the target in target centric Cartesian coordinates (X-component)
max. value = 32,767 m
bit-25 (LSB) = 0,5 m

bits-24/9 (Rs_HP_Y) Horizontal position resolution of the target in target centric Cartesian coordinates (Y-component)
max. value = 32,767 m
bit-9 (LSB) = 0,5 m

bits-8/1 ($CoRs\_HP_{XY}$) Correlation of horizontal position resolution of X and Y components, in Two's complement.
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/600 Subfield #3: Horizontal Position Precision

Definition: The distribution of horizontal position random errors.

Format: Five-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
SD_HP_X															LSB

Octet no. 3								Octet no. 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
SD_HP_Y															LSB

Octet no. 5							
8	7	6	5	4	3	2	1
$CoSD\_HP_{XY}$							LSB

bits-40/25 (SD_HP_X) Standard Deviation of horizontal position of the target in target centric Cartesian coordinates (X-component)
max. value 16,383.75 m
bit-25 (LSB) = 0.25 m

bits-24/9 (SD_HP_Y) Standard Deviation of horizontal position of the target in target centric Cartesian coordinates (Y-component)
max. value 16,383.75 m
bit-9 (LSB) = 0.25 m

bits-8/1 ($CoSD\_HP_{XY}$) Correlation of standard deviation of horizontal position of X and Y components, in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

5.2.15 Data Item I015/601, Geometric Height Information

Definition: Data item containing the geometric height information of the target in WGS 84 height above ellipsoid.

Format: Compound data item, comprising a primary subfield of up to two-octet, followed by one or more defined subfields.

Structure of Primary Subfield:

Octet no. 1

16	15	14	13	12	11	10	9
GH	Rs_GH	SD_GH	CI6	CI9	Co_GHHP	Co_GHHV	FX

Octet no. 2

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

bit-16 (GH) Subfield #1: Geometric Height (WGS-84)
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-15 (Rs_GH) Subfield #2: Geometric Height Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-14 (SD_GH) Subfield #3: Geometric Height Precision
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-13 (CI6) Subfield #4: Confidence Interval for Geometric Height (67%)
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-12 (CI9) Subfield #5: Confidence Interval for Geometric Height (95%)
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bit-11 (Co_GHHP) Subfield #6: Correlation of Geometric Height and Horizontal Position
= 0 Absence of Subfield #6
= 1 Presence of Subfield #6

bit-10	(Co_GHHV)	Subfield #7: Correlation of Geometric Height and Horizontal Velocity = 0 Absence of Subfield #7 = 1 Presence of Subfield #7
bit-9	(FX)	= 0 End of data item = 1 Extension into first Extension
bit-8	(Co_GHHA)	Subfield #8: Correlation of Geometric Height and Horizontal Acceleration = 0 Absence of Subfield #8 = 1 Presence of Subfield #8
bits-7/2	Spare bits, set to zero	
bit-1	(FX)	= 0 End of data item = 1 Extension into second Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/601 Subfield #1: Geometric Height (WGS-84)

Definition: Vertical distance between the target and the projection of its position on the earth's ellipsoid, as defined by WGS-84, in Two's complement form.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
GH							

Octet no. 2 / Octet no. 3

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
GH (cont.)															LSB

bits-24/1	(GH)	Geometric Height (WGS-84), in Two's complement max. range ~ ± 83,286 m
bit-1	(LSB)	= 0.01 m

Structure of I015/601 Subfield #2: Geometric Height Resolution

Definition: Vertical distance within which the sensor is unable to resolve two separate targets.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
Rs_GH							

Octet no. 2 / Octet no. 3

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Rs_GH (cont.)															LSB

bits-24/1 (Rs_GH) Geometric Height resolution
max. value = 167,772.15 m

bit-1 (LSB) = 0.01 m

Structure of I015/601 Subfield #3: Geometric Height Precision

Definition: The distribution of random Geometric Height errors (see also the definition of Precision in the appendix).

Format: Three-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
SD_GH							

Octet no. 2 / Octet no. 3

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
SD_GH (cont.)															LSB

bits-24/1 (SD_GH) Standard Deviation of Geometric Height
max. value = 167,772.15 m

bit-1 (LSB) = 0.01 m

Structure of I015/601 Subfield #4: Confidence Interval for Geometric Height (67%)

Definition: A measure of the uncertainty within which 67% of geometric height measurements will be contained.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
					UCI6						LSB				

Octet no. 3							
8	7	6	5	4	3	2	1
			LCI6				LSB

bits-24/13	(UCI6)	Upper confidence interval for Geometric Height (67%) max. value = 65,520 m
bit-13	(LSB)	= 16 m
bits-12/1	(LCI6)	Lower confidence interval for Geometric Height (67%) max. value = 65,520 m
bit-1	(LSB)	= 16 m

Structure of I015/601 Subfield #5: Confidence Interval for Geometric Height (95%)

Definition: A measure of the certainty within which 95% of geometric height measurements will be contained.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1 / Octet no. 2

24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
					UCI9						LSB				

Octet no. 3

8	7	6	5	4	3	2	1
			LCI9				LSB

bits-24/13	(UCI9)	Upper confidence interval for Geometric Height (95%) max. value = 65,520 m
bit-13	(LSB)	= 16 m
bits-12/1	(LCI9)	Lower confidence interval for Geometric Height (95%) max. value = 65,520 m
bit-1	(LSB)	= 16 m

Structure of I015/601 Subfield #6: Correlation of Geometric Height and Horizontal Position

Definition: Correlation of Geometric Height converted into metres and Horizontal Position of X/Y-components.

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
Co_GHHP_X							LSB	Co_GHHP_Y							LSB

bits-16/9	(Co_GHHP_X)	Correlation of Geometric Height converted into metres and Horizontal Position of (X-component), in Two's complement max. range = ±1
bit-9	(LSB)	$= 1/2^7$
bits-8/1	(Co_GHHP_Y)	Correlation of Geometric Height converted into metres and Horizontal Position of (Y-component), in Two's complement max. range = ±1
bit-1	(LSB)	$= 1/2^7$

Structure of I015/601 Subfield #7: Correlation of Geometric Height and Horizontal Velocity

Definition: Correlation of Geometric Height converted into metres and Horizontal Velocity.

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
Co_GHHV_X							LSB	Co_GHHV_Y							LSB

bits-16/9 (Co_GHHV_X) Correlation of Geometric Height converted into metres and Horizontal Velocity of (X-component), in Two's complement
max. range = ±1
bit-9 (LSB) = $1/2^7$

bits-8/1 (Co_GHHV_Y) Correlation of Geometric Height converted into metres and Horizontal Velocity of (Y-component), in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/601 Subfield #8: Correlation of Geometric Height and Horizontal Acceleration

Definition: Correlation of Geometric Height converted into metres and Horizontal Acceleration of X/Y-components.

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
Co_GHHA_X							LSB	Co_GHHA_Y							LSB

bits-16/9	(Co_GHHA_X)	Correlation of Geometric Height converted into metres and Horizontal Acceleration of (X-component), in Two's complement max. range = ±1
bit-9	(LSB)	$= 1/2^7$
bits-8/1	(Co_GHHA_Y)	Correlation of Geometric Height converted into metres and Horizontal Acceleration of (Y-component), in Two's complement max. range = ±1
bit-1	(LSB)	$= 1/2^7$

5.2.16 Data Item I015/602, Horizontal Velocity Information

Definition: Magnitude of the Horizontal Velocity Vector.

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
HV	Rs_ HV	SD_ HV	Co_ HVHP	0	0	0	FX

bit-8 (HV) Subfield #1: Horizontal Velocity Vector
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (Rs_HV) Subfield #2: Horizontal Velocity Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (SD_HV) Subfield #3: Horizontal Velocity Precision
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (Co_HVHP) Subfield #4: Correlation of Horizontal Velocity and Horizontal Position
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bits-4/2 Spare bits, set to zero

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/602 Subfield #1: Horizontal Velocity Vector

Definition: Horizontal velocity vector expressed in target centric Cartesian coordinates.

Format: Four-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
HV_X															

Octet no. 3								Octet no. 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
HVx			LSB	HVy											

Octet no. 5							
8	7	6	5	4	3	2	1
HVy							LSB

bits-40/21	(HV_X)	Horizontal Velocity (X-component), in Two's complement max. range ±5,242.87 m/s
bit-21	(LSB)	= 0.01 m/s
bits-20/1	(HV_Y)	Horizontal Velocity in (Y-component), in Two's complement max. range ±5,242.87 m/s
bit-1	(LSB)	= 0.01 m/s

Note: The characteristics of the Cartesian Coordinate System are described in 4.3.3 above

Structure of I015/602 Subfield #2: Horizontal Velocity Resolution

Definition: Minimum difference in Horizontal Velocity at which a sensor system is able to distinguish two targets with otherwise identical parameters in range and angular domain (under ideal measurement).

Format: Five-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
RsHVx															LSB

Octet no. 3								Octet no. 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Rs_HVy															LSB

Octet no. 5							
8	7	6	5	4	3	2	1
$CoRs\_HV_{XY}$							LSB

bits-40/25	(Rs_HV_X)	Horizontal velocity resolution of the target in target centric Cartesian coordinates (X-component) max. value = 655.35 m/s
bit-25	(LSB)	= 0.01 m/s
bits-24/9	(Rs_HV_Y)	Horizontal velocity resolution of the target in target centric Cartesian coordinates (Y-component) max. value = 655.35 m/s
bit-9	(LSB)	= 0.01 m/s
bits-8/1	($CoRs\_HV_{XY}$)	Correlation of horizontal position resolution of X and Y components, in Two's complement. max. value = ±1
bit-1	(LSB)	= $1/2^7$

Note: The velocity resolution describes the capability of a sensor to be able to separate two closely located targets in the velocity domain.
The velocity resolution for an INCS system depends on the signal integration time as well as the transmit frequency. A longer integration time or a higher transmit frequency leads to a better velocity resolution.
Depending on the specific INCS application, a better velocity resolution may be more important than a high sensor refresh rate. The velocity resolution might also alleviate the limitations on the range resolution, in order to make small bandwidth applications possible.

Structure of I015/602 Subfield #3: Horizontal Velocity Precision

Definition: Root-mean-square (rms) error of the Horizontal Velocity estimate provided by a sensor system.

Format: Five-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
SD_HVx															LSB

Octet no. 3								Octet no. 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
SD_HVy															LSB

Octet no. 5							
8	7	6	5	4	3	2	1
Co_HV_{XY}							LSB

bits-40/25	(SD_HV_X)	Standard Deviation of horizontal velocity (X-component) max. value 655,35 m/s
bit-25	(LSB)	= 0.01 m/s
bits-24/9	(SD_HV_Y)	Standard Deviation of horizontal velocity (Y-component) max. value 655,35 m/s
bit-9	(LSB)	= 0.01 m/s
bits-8/1	(Co_HV_{XY})	Correlation of standard deviation of horizontal velocity of X and Y components, in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$

Structure of I015/602 Subfield #4: Correlation of Horizontal Velocity and Horizontal Position

Definition: Correlation of the errors associated with the estimates of Horizontal Velocity and Horizontal Position provided by a sensor system.

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
$Co\_HV_XHP_X$							LSB	$Co\_HV_XHP_Y$							LSB

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

bits-32/25	($Co\_HV_XHP_X$)	Correlation of Horizontal Velocity (X-component) and Horizontal Position (X-component), in Two's complement max. range = ±1
bit-25	(LSB)	$= 1/2^7$
bits-24/17	($Co\_HV_XHP_Y$)	Correlation of Horizontal Velocity (X-component) and Horizontal Position (Y-component), in Two's complement max. range = ±1
bit-17	(LSB)	$= 1/2^7$
bits-16/9	($Co\_HV_YHP_X$)	Correlation of Horizontal Velocity (Y-component) and Horizontal Position (X-component), in Two's complement max. range = ±1
bit-9	(LSB)	$= 1/2^7$
bits-8/1	($Co\_HV_YHP_Y$)	Correlation of Horizontal Velocity (Y-component) and Horizontal Position (Y-component), in Two's complement max .range = ±1
bit-1	(LSB)	$= 1/2^7$

5.2.17 Data Item I015/603, Horizontal Acceleration Information

Definition: Magnitude of the Horizontal Acceleration Vector.

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
HA	SD_ HA	Co_ HAHP	Co_ HAHV	0	0	0	FX

bit-8 (HA) Subfield #1: Horizontal Acceleration Vector
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (SD_HA) Subfield #2: Horizontal Acceleration Precision
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (Co_HAHP) Subfield #3: Correlation of Horizontal Acceleration and Horizontal Position
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (Co_HAHV) Subfield #4: Correlation of Horizontal Acceleration and Horizontal Velocity
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bits-4/2 Spare bits, set to zero

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/603 Subfield #1: Horizontal Acceleration Vector

Definition: Horizontal acceleration vector expressed in target centric local Cartesian coordinates, in Two’s complement representation.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
HAx							

Octet no. 2 / Octet no. 3

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

bits-24/13 (HA_X) Horizontal Acceleration (X-component),
in Two’s complement
max. range ±128 m/s^2

bit-13 (LSB) = 1/16 m/s^2

bits-12/1 (HA_Y) Horizontal Acceleration (Y-component),
in Two’s complement
max. range ±128 m/s^2

bit-1 (LSB) = 1/16 m/s^2

Note:

The characteristics of the Cartesian Coordinate System are described in chapter 4.3.3 above.

Structure of I015/603 Subfield #2: Horizontal Acceleration Precision

Definition: Root-mean-square (rms) error of the Horizontal Acceleration estimate provided by a sensor system.

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
SD_HA_X											LSB	SD_HA_y			

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

bits-32/21 (SD_HA_X) Standard Deviation of Horizontal Acceleration (X-component)
max. value 255.9375 m/s^2
bit-21 (LSB) = 1/16 m/s^2

bits-20/9 (SD_HA_Y) Standard Deviation of Horizontal Acceleration (Y-component)
max. value 255.9375 m/s^2
bit-9 (LSB) = 1/16 m/s^2

bits-8/1 (Co_HA_{XY}) Correlation of standard deviation of Horizontal Acceleration of X and Y components, in Two's complement
max. range ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/603 Subfield #3: Correlation of Horizontal Acceleration and Horizontal Position

Definition: Correlation of the errors associated with the estimates of Horizontal Acceleration and Horizontal Position provided by a sensor system.

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
$Co\_HA_XHP_X$							LSB	$Co\_HA_XHP_Y$							LSB

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

bits-32/25	($Co\_HA_XHP_X$)	Correlation of Horizontal Acceleration (X-component) and Horizontal Position (X-component), in Two's complement max. range = ±1
bit-25	(LSB)	= $1/2^7$
bits-24/17	($Co\_HA_XHP_Y$)	Correlation of Horizontal Acceleration (X-component) and Horizontal Position (Y-component), in Two's complement max. range = ±1
bit-17	(LSB)	= $1/2^7$
bits-16/9	($Co\_HA_YHP_X$)	Correlation of Horizontal Acceleration (Y-component) and Horizontal Position (X-component), in Two's complement max. range = ±1
bit-9	(LSB)	= $1/2^7$
bits-8/1	($Co\_HA_YHP_Y$)	Correlation of Horizontal Acceleration (Y-component) and Horizontal Position (Y-component), in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$

Structure of I015/603 Subfield #4: Correlation of Horizontal Acceleration and Horizontal Velocity

Definition: Correlation of the errors associated with the estimates of Horizontal Acceleration and Horizontal Velocity provided by a sensor system.

Format: For-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
$Co\_HA_{X}HV_{X}$							LSB	$Co\_HA_{X}HV_{Y}$							LSB

Octet no. 3								Octet no. 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
$Co\_HA_{Y}HV_{X}$							LSB	$Co\_HA_{Y}HV_{Y}$							LSB

bits-32/25	($Co\_HA_{X}HV_{X}$)	Correlation of Horizontal Acceleration (X-component) and Horizontal Velocity (X-component), in Two's complement max. range = ±1
bit-25	(LSB)	= $1/2^{7}$
bits-24/17	($Co\_HA_{X}HV_{Y}$)	Correlation of Horizontal Acceleration (X-component) and Horizontal Velocity (Y-component), in Two's complement max. range = ±1
bit-17	(LSB)	= $1/2^{7}$
bits-16/9	($Co\_HA_{Y}HV_{X}$)	Correlation of Horizontal Acceleration (Y-component) and Horizontal Velocity (X-component), in Two's complement max. range = ±1
bit-9	(LSB)	= $1/2^{7}$
bits-8/1	($Co\_HA_{Y}HV_{Y}$)	Correlation of Horizontal Acceleration (Y-component) and Horizontal Velocity (Y-component), in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^{7}$

5.2.18 Data Item I015/604, Vertical Velocity Information

Definition: Vertical velocity as given by the rate of change of the Geometric Height.

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
VV	Rs_VV	SD_VV	Co_VVHP	Co_VVHV	Co_VVHA	0	FX

bit-8 (VV) Subfield #1: Vertical Velocity
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (Rs_VV) Subfield #2: Vertical Velocity Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (SD_VV) Subfield #3: Vertical Velocity Precision
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (Co_VVHP) Subfield #4: Correlation of Vertical Velocity and Horizontal Position
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-4 (Co_VVHV) Subfield #5: Correlation of Vertical Velocity and Horizontal Velocity
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bit-3 (Co_VVHA) Subfield #6: Correlation of Vertical Velocity and Horizontal Acceleration
= 0 Absence of Subfield #6
= 1 Presence of Subfield #6

bit-2 Spare bit, set to zero

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/604 Subfield #1: Vertical Velocity

Definition: Vertical velocity as given by the rate of change of the Geometric Height expressed in Two's Complement.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
VV							

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

bits-16/1 (VV) Vertical velocity,
in Two's complement
max. range ± 83,886.07 m/s
bit-1 (LSB) = 0.01 m/s

Note: Positive values indicates climbing target and negative values indicates descending target.

Structure of I015/604 Subfield #2: Vertical Velocity Resolution

Definition: Minimum difference in Vertical Velocity at which a sensor system is able to distinguish two targets with otherwise identical parameters in range and angular domain (under ideal measurement).

Format: Two-octet fixed length data item.

Structure:

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

bits-8/1 (Rs_VV) Vertical Velocity resolution
max. value = 655.35 m/s
bit-1 (LSB) = 0.01 m/s

Structure of I015/604 Subfield #3: Vertical Velocity Precision

Definition: Root-mean-square (rms) error of the Vertical Velocity estimate provided by a sensor system.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
SD_VV															LSB

Octet no. 3							
8	7	6	5	4	3	2	1
Co_VVGH							LSB

bits-24/9	(SD_VV)	Standard Deviation of Vertical Velocity max. value = 655.35 m/s
bit-9	(LSB)	= 0.01 m/s
bits-8/1	(Co_VVGH)	Correlation of Vertical Velocity and Geometric Height, in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$

Structure of I015/604 Subfield #4: Correlation of Vertical Velocity and Horizontal Position

Definition: Correlation of the errors associated with the estimates of Vertical Velocity converted in to metres/sec and Horizontal Position provided by a sensor system.

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
Co_VVHP_X							LSB	Co_VVHP_Y							LSB

bits-16/9 (Co_VVHP_X) Correlation of Vertical Velocity and Horizontal Position (X-component), in Two's complement
max. range = ±1
bit-9 (LSB) = $1/2^7$

bits-8/1 (Co_VVHP_Y) Correlation of Vertical Velocity and Horizontal Position (Y-component), in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/604 Subfield #5: Correlation of Vertical Velocity and Horizontal Velocity

Definition: Correlation of the errors associated with the estimates of Vertical Velocity converted in to metres/sec and Horizontal Velocity provided by a sensor system.

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
Co_VVHV_X							LSB	Co_VVHV_Y							LSB

bits-16/9	(Co_VVHV_X)	Correlation of Vertical Velocity and Horizontal Velocity (X-component)), in Two's complement max. range = ±1
bit-9	(LSB)	$= 1/2^7$
bits-8/1	(Co_VVHV_Y)	Correlation of Vertical Velocity and Horizontal Velocity (Y-component)), in Two's complement max. range = ±1
bit-1	(LSB)	$= 1/2^7$

Structure of I015/604 Subfield #6: Correlation of Vertical Velocity and Horizontal Acceleration

Definition: Correlation of the errors associated with the estimates of Vertical Velocity converted in to metres/sec and Horizontal Acceleration provided by a sensor system.

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
Co_VVHA_X							LSB	Co_VVHA_Y							LSB

bits-16/9	(Co_VVHA_X)	Correlation of Vertical and Horizontal Acceleration (X-component)), in Two's complement max. range = ±1
bit-9	(LSB)	= $1/2^7$
bits-8/1	(Co_VVHA_Y)	Correlation of Vertical Velocity and Horizontal Acceleration (Y-component)), in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$

5.2.19 Data Item I015/605, Vertical Acceleration Information

Definition: Rate of change of vertical speed.

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
VA	Rs_VA	Co_VAHP	Co_VAHV	Co_VAHA	0	0	FX

bit-8 (VA) Subfield #1: Vertical Acceleration
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (Rs_VA) Subfield #2: Vertical Acceleration Precision
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (Co_VAHP) Subfield #3: Correlation of Vertical Acceleration and Horizontal Position
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (Co_VAHV) Subfield #4: Correlation of Vertical Acceleration and Horizontal Velocity
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-4 (Co_VAHA) Subfield #5: Correlation of Vertical Acceleration and Horizontal Acceleration
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bits-3/2 Spare bits, set to zero

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/605 Subfield #1: Vertical Acceleration

Definition: Vertical acceleration information expressed in Two's complement.

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
							VA								LSB

bits-16/13 Spare bits set to zero

bits-12/1 (VA) Vertical Acceleration,
in Two's complement
max. range ±327.67 m/s^2
bit-1 (LSB) = 0.01 m/s^2

Note: Positive values indicates accelerating during climb or descent and negative values indicates deceleration during climb or descent.

Structure of I015/605 Subfield #2: Vertical Acceleration Precision

Definition: Root-mean-square (rms) error of the Vertical Acceleration estimate provided by a sensor system.

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
SD_VA															LSB

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

bits-32/17	(SD_VA)	Standard Deviation of Vertical Acceleration max. range = 167.772, 15 m/s^2
	(LSB)	= 0.01 m/s^2
bits-16/9	(Co_VAGH)	Correlation of Vertical Acceleration and Geometric Height, in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$
bits-8/1	(Co_VAVV)	Correlation of Vertical Acceleration and Vertical Velocity, in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$

Structure of I015/605 Subfield #3: Correlation of Vertical Acceleration and Horizontal Position

Definition: Correlation of the errors associated with the estimates of Vertical Acceleration and Horizontal Position provided by a sensor system.

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
Co_VAHP_X							LSB	Co_VAHP_Y							LSB

bits-16/9 (Co_VAHP_X) Correlation of Vertical Acceleration and Horizontal Position (X-component), in Two's complement
max. range = ±1
bit-9 (LSB) = $1/2^7$

bits-8/1 (Co_VAHP_Y) Correlation of Vertical Acceleration and Horizontal Position (Y-component), in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/605 Subfield #4: Correlation of Vertical Acceleration and Horizontal Velocity

Definition: Correlation of the errors associated with the estimates of Vertical Acceleration and Horizontal Velocity provided by a sensor system.

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
Co_VAHV_X							LSB	Co_VAHV_Y							LSB

bits-16/9	(Co_VAHV_X)	Correlation of Vertical Acceleration and Horizontal Velocity (X-component), in Two's complement max. range = ±1
bit-9	(LSB)	= $1/2^7$
bits-8/1	(Co_VAHV_Y)	Correlation of Vertical Acceleration and Horizontal Velocity (Y-component), in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^7$

Structure of I015/605 Subfield #5: Correlation of Vertical Acceleration and Horizontal Acceleration

Definition: Correlation of the errors associated with the estimates of Vertical Acceleration and Horizontal Acceleration provided by a sensor system.

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
Co_VAHA_X							LSB	Co_VAHA_Y							LSB

bits-16/9 (Co_VAHA_X) Correlation of Vertical Acceleration and Horizontal Acceleration (X-component), in Two's complement
max. range = ±1
bit-9 (LSB) = $1/2^7$

bits-8/1 (Co_VAHA_Y) Correlation of Vertical Acceleration and Horizontal Acceleration (Y-component), in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

5.2.20 Data Item I015/625, Range Information

Definition: The targets range information is given relative to the sensor reference point(s).

Format: Compound data item, comprising a primary subfield of one-octet extensible, followed by the indicated subfields.

Structure of Primary Subfield:

Octet no. 1

16	15	14	13	12	11	10	9
R	Rs_R	SD_R	RR	Rs_RR	SD_RR	RA	FX

Octet no. 2

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

bit-16 (R) Subfield #1:Range
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-15 (Rs_R) Subfield #2: Range Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-14 (SD_R) Subfield #3: Range Precision
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-13 (RR) Subfield #4:Range Rate
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-12 (Rs_RR) Subfield #5: Range Rate Resolution
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bit-11 (SD_RR) Subfield #6: Range Rate Precision
= 0 Absence of Subfield #6
= 1 Presence of Subfield #6

bit-10 (RA) Subfield #7: Range Acceleration
= 0 Absence of Subfield #7
= 1 Presence of Subfield #7

bit-9 (FX) = 0 End of data item
= 1 Extension into first Extension

bit-8	(SD_RA)	Subfield #8: Range Acceleration Precision	
		= 0	Absence of Subfield #8
		= 1	Presence of Subfield #8
bits-7/2	Spare bits		
bit-1	(FX)	= 0	End of data item
		= 1	Extension into second Extension

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Note 1: Depending upon its design the manner in which the positional data is declared by an INCS sensor may be expressed in WGS-84 (I015/ 600) or sensor centric coordinate system based upon the 'system reference point' of the sensor (I015/625).

Note 2: The optional 'precision' fields (in Data Items I015/600 – I015/625) provide a measure of the accuracy the INCS system has assigned to positional data contained in the target report.

Such information can be used to improve the quality with which the INCS target report data is integrated in to the subsequent processing stages of the ATM infrastructure.

However a consideration of the sensor characteristics and capabilities, the manner in which INCS data is used operationally, the weighting assigned to INCS data within a multi-sensor tracker and the credibility assigned to the covariance data items should be made to support the decision of whether these optional covariance data items are required or whether the basic data items provide sufficient performance.

Whilst not an operational consideration the additional costs that may be associated with the provision and use of such data items should also be weighed against the potential performance benefits that would be achieved through the inclusion of these Data Items in performance specifications.

Note 3: If I015/020 MoMu indicates that the target report is Bi-Static (MoMu =1) then the range information is the difference between the path from the transmitter to target to the receiver less the distance between the transmitter and receiver. In this case, the reference points referred to above are the positions of the transmitter and receiver.

If I015/020 MoMu indicates that the target report is Mono-Static (MoMu =0) then the range information is the distance between the sensor and the target. In this case, the reference point referred to above is the position of the mono-static sensor.

Note 4: The meaning of range in Category 015 is significantly broader than the traditional hence the different INCS working principles. This is especially true for bi-static and multi-static radars. For readability the field is still called range and not mono-/bi-/multi-static range or pseudo-range.

For radar the measured range is calculated from time differences of signals assumed to be transmitted/received at the sensor reference point(s). As noted above for bi-static radars the reference points are the positions of the transmitter and receiver. Moreover multi-static radars may receive identical signals from other transmitters than the assumed reference transmitter (e.g. passive INCS which are using single frequency networks as illuminators) and therefore may calculate negative values for bi-static range measurement data.

Structure of I015/625 Subfield #1: Range

Definition: Measured range between a target object and a pre-defined point associated with the sensor system (e.g., for a mono-static radar system the phase centre of the antenna aperture) or measured bistatic range between a pre-defined point associated with the transmitter station, the target object position and a pre-defined point associated with the sensor system (e.g., for a bistatic radar system the phase centres of the transmitter and receiver antenna aperture).

Format: Three-octet fixed length data item in Two's complement.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
RNG							

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

bits-24/1	(RNG)	Range, in Two's complement max. range = ±838,860.7 m
bit-1	(LSB)	= 0.1 m

Structure of I015/625 Subfield #2: Range Resolution

Definition: Minimum difference in Range at which a sensor system is able to distinguish two targets with otherwise identical parameters in velocity and angular domain (under ideal measurement).

Format: Two-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
RS_R							

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

bits-24/1	(Rs_R)	Range resolution max. value = 1,677,721.5 m
bit-1	(LSB)	= 0.1 m

Note: This may differ from the cell size applied within the Sensor.

Structure of I015/625 Subfield #3: Range Precision

Definition: Root-mean-square (rms) error of the Range estimate provided by a sensor system.

Format: Two-octet fixed length data item.

Structure:

Octet no. 1

24	23	22	21	20	19	18	17
SD_R							

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

bits-24/1	(SD_R)	Standard Deviation of Range max. value = 1,677,721.5 m
bit-1	(LSB)	=0.1 m

Structure of I015/625 Subfield #4: Range Rate

Definition: The range rate is derived from different range measurements.

Format: Two-octet fixed length data item.

Structure:

Octet no. 1							
24	23	22	21	20	19	18	17
RR							

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

bits-24/1	(RR)	Range Rate, in Two's complement max. range ±838,860.7 m/s
bit-1	(LSB)	= 0.1 m/s

Note: The range rate is the first derivative computed from the range. In contrast, the Doppler velocity in I015/626 is actually measured through Doppler.

Structure of I015/625 Subfield #5: Range Rate Resolution

Definition: Minimum difference in Range Rate at which a sensor system is able to distinguish two targets with otherwise identical parameters in position and angular domain (under ideal measurement).

Format: Two-octet fixed length data item.

Structure:

Octet no. 1							
24	23	22	21	20	19	18	17
Rs_RR							

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

bits-24/1	(Rs_RR)	Range Rate Resolution max. value = 1,677,721.5 m/s
bit-1	(LSB)	= 0.1 m/s

Structure of I015/625 Subfield #6: Range Rate Precision

Definition: Root-mean-square (rms) error of the Range Rate estimate provided by a sensor system.

Format: Two-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	18	18	17
							SD_RR								LSB

Octet no. 3

16	15	14	13	12	11	10	9
			SD_RR (cont.)				LSB

Octet no. 4

8	7	6	5	4	3	2	1
			Co_RRR				LSB

bits-32/9 (SD_RR) Standard Deviation of Range Rate
max. value = 1,677,721.5 m/s
bit-9 (LSB) =0.1 m/s

bits-8/1 (Co_RRR) Correlation of Range Rate and Range, in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/626 Subfield #7: Range Acceleration

Definition: The range acceleration is derived from different range rates.

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
							RA								LSB

bits-16/1 (RA) Range Acceleration, in Two's complement
max. range = ±512 m/s^2
bit-1 (LSB) = $1/2^6$ m/s^2

Structure of I015/625 Subfield #8: Range Acceleration Precision

Definition: Root-mean-square (rms) error of the Range Acceleration determined by the sensor system.

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
SD_RA															LSB

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

bits-32/17	(SD_RA)	Standard Deviation of Range Acceleration max. value = 512 m/s^2
bit-17	(LSB)	$=1/2^7$ m/s^2
bits-16/9	(Co_RAR)	Correlation of Range Acceleration and Range, in Two's complement max. range = ±1
bit-9	(LSB)	$= 1/2^7$
bits-8/1	(Co_RARR)	Correlation of Range Acceleration and Range Rate, in Two's complement max. range = ±1
bit-1	(LSB)	$= 1/2^7$

5.2.21 Data Item I015/626, Doppler Information

Definition: Doppler measurement of the Target.

Format: Compound data item, comprising a primary subfield of up to two-octets, followed by the indicated subfields.

Structure of Primary Subfield:

Octet no. 1

16	15	14	13	12	11	10	9
DV	SD_DV	DA	SD_DA	Co_DVR	Co_DVRR	Co_DVRA	FX

Octet no. 2

8	7	6	5	4	3	2	1
Co_DAR	Co_DARR	Co_DARA	0	0	0	0	FX

bit-16 (DV) Subfield #1: Doppler Velocity
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-15 (SD_DV) Subfield #2: Doppler Velocity Precision
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-14 (DA) Subfield #3: Doppler Acceleration
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-13 (SD_DA) Subfield #4: Doppler Acceleration Precision
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-12 (Co_DVR) Subfield #5: Correlation Doppler Velocity and Range
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bit-11 (Co_DVRR) Subfield #6: Correlation Doppler Velocity and Range Rate
= 0 Absence of Subfield #6
= 1 Presence of Subfield #6

bit-10 (Co_DVRA) Subfield #7: Correlation Doppler Velocity and Range Acceleration
= 0 Absence of Subfield #7
= 1 Presence of Subfield #7

bit-9 (FX)
= 0 End of data item
= 1 Extension into first Extension

bit-8	(Co_DVR)	Subfield #8: Correlation Doppler Acceleration and Range = 0 Absence of Subfield #8 = 1 Presence of Subfield #8
bit-7	(Co_DVRR)	Subfield #9: Correlation Doppler Acceleration and Range Rate = 0 Absence of Subfield #9 = 1 Presence of Subfield #9
bit-6	(Co_DVRA)	Subfield #10: Correlation Doppler Acceleration and Range Acceleration = 0 Absence of Subfield #10 = 1 Presence of Subfield #10
bits-5/2	Spare bits, set to zero	
bit-1	(FX)	= 0 End of data item = 1 Extension into second Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/626 Subfield #1: Doppler Velocity

Definition: Radial velocity or bistatic velocity of a target object measured by a sensor system via a corresponding Doppler frequency shift.

Format: Two-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
DV															

Octet no. 3							
8	7	6	5	4	3	2	1
DV (cont.)							LSB

bits-16/1 (DV) Doppler Velocity, in Two’s complement
max. range = ±83,886.07 m/s
bit-1 (LSB) = 0.01 m/s

Note: The radial velocity is the magnitude of the 3-dimensional velocity vector (i.e., the time derivative of the 3-dimensional position vector) projected onto the line between target object and sensor. The bistatic velocity is the magnitude of the 3-dimensional velocity vector projected onto the line between transmitter station and target object plus the magnitude of the 3-dimensional velocity vector projected onto the line between target object and sensor.

Structure of I015/626 Subfield #2: Precision of Doppler Velocity

Definition: Root-mean-square (rms) error of the Doppler Velocity measured by the sensor system.

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
SD_DV															LSB

bits-16/1 (SD_DV) Standard Deviation of Doppler Velocity
max. value = 1,024 m/s
bit-1 (LSB) $=1/2^6$ m/s

Structure of I015/626 Subfield #3: Doppler Acceleration

Definition: Radial acceleration or bistatic acceleration of a target object measured by a sensor system via a corresponding Doppler frequency shift and a subsequent difference operation.

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
DA															LSB

bits-16/1	(DA)	Doppler Acceleration, in Two's complement max. range = ±512 m/s^2
bit-1	(LSB)	= $1/2^6$ m/s^2

Note: The radial acceleration is the magnitude of the 3-dimensional acceleration vector (i.e., the time derivative of the 3-dimensional velocity vector) projected onto the line between target object and sensor. The bistatic acceleration is the magnitude of the 3-dimensional acceleration vector projected onto the line between transmitter station and target object plus the magnitude of the 3-dimensional acceleration vector projected onto the line between target object and sensor.

Structure of I015/626 Subfield #4: Precision of Doppler Acceleration

Definition: Root-mean-square (rms) error of the Doppler Velocity measured by the sensor system.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
SD_DA															LSB

Octet no. 3							
8	7	6	5	4	3	2	1
Co_DADV							LSB

bits-24/9 (SD_DA) Standard Deviation of Doppler Acceleration
max. value = 1,024 m/s^2
bit-9 (LSB) $=1/2^6$ m/s^2

bits-8/1 (Co_DADV) Correlation of Doppler Acceleration and Doppler Velocity, in Two's complement
max. range = ±1
bit-1 (LSB) $= 1/2^7$

Structure of I015/626 Subfield #5: Correlation of Doppler Velocity and Range

Definition: Correlation of Doppler Velocity and Range (e.g. bistatic range).

Format: One-octet fixed length data item.

Structure:

Octet no. 1							
8	7	6	5	4	3	2	1
Co_DVR							LSB

bits-8/1 (Co_DVR) Correlation of Doppler Velocity and Range, in Two's complement
max. range = ±1
bit-1 (LSB) $= 1/2^7$

Structure of I015/626 Subfield #6: Correlation of Doppler Velocity and Range Rate

Definition: Correlation of Doppler Velocity and Range Rate.

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
Co_DVRR							LSB

bits-8/1 (Co_DVRR) Correlation of Doppler Velocity and Range Rate , in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/626 Subfield #7: Correlation of Doppler Velocity and Range Acceleration

Definition: Correlation of Doppler Velocity and Range (e.g. bistatic range).

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
Co_DVRA							LSB

bits-8/1 (Co_DVRA) Correlation of Doppler Velocity and Range Acceleration , in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/626 Subfield #8: Correlation of Doppler Acceleration and Range

Definition: Correlation of Doppler Acceleration and Range (e.g. bistatic range).

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
Co_DAR							LSB

bits-8/1 (Co_DAR) Correlation of Doppler Acceleration and Range, in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/626 Subfield #9: Correlation of Doppler Acceleration and Range Rate

Definition: Correlation of Doppler Acceleration and Range Rate.

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
Co_DARR							LSB

bits-8/1 (Co_DARR) Correlation of Doppler Acceleration and Range Rate, in Two's complement
max. range = ±1
bit-1 (LSB) = $1/2^7$

Structure of I015/626 Subfield #10: Correlation of Doppler Acceleration and Range Acceleration

Definition: Correlation of Doppler Acceleration and Range Acceleration.

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
Co_DARA							LSB

bits-8/1	(Co_DARA)	Correlation of Doppler Acceleration and Range Acceleration, in Two's complement max. range = ±1
bit-1	(LSB)	$= 1/2^7$

5.2.22 Data Item I015/627, Azimuth Information

Definition: Azimuth information that is provided relative to the sensor or component reference point.

Format: Compound data item, comprising a primary subfield of up to two-octets, followed by the indicated subfields.

Structure of Primary Subfield:

Octet no. 1

8	7	6	5	4	3	2	1
Az	RS_ Az	SD_ Az	AzR	SD_ AzR	AzEx	0	FX

bit-8 (Az) Subfield #1: Azimuth
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (RS_Az) Subfield #2: Azimuth Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (SD_Az) Subfield #3: Azimuth Precision
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (AzR) Subfield #4: Azimuth Rate
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-4 (SD_AzR) Subfield #5: Azimuth Rate Precision
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bit-3 (AzEx) Subfield #6: Azimuth Extent
= 0 Absence of Subfield #6
= 1 Presence of Subfield #6

bit-2 Spare bit, set to ‘0’

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Note: The Sensor Reference Point is detailed in ASTERIX Category 016 – where there is also provision for including the reference points for the transmitter(s) and receiver(s) that are used within the sensor configuration. The Sensor Reference Point is also contained in ASTERIX Category 025.

Structure of I015/627 Subfield #1: Azimuth

Definition: Target angle relative to geographic North in the local reference system centred on the sensor.

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
Azimuth															LSB

bits-16/1 (Az) Azimuth
max. value = 360 degrees
bit-1 (LSB) = $360/2^{16}$ degree

Note:

The azimuth shall increment in a clockwise manner relative to geographic North.

Structure of I015/627 Subfield #2: Azimuth Resolution

Definition: Minimum angle in order to separate targets by the sensor in the azimuth dimension.

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
RS_Az															LSB

bits-16/1 (RS_Az) Azimuth Resolution
max. value = 45 degrees
bit-1 (LSB) = $45/2^{16}$ degree

Structure of I015/627 Subfield #3: Standard Deviation of Azimuth

Definition: Estimated standard deviation of the azimuth angle.

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
SD_Az															LSB

bits-16/1 (SD_Az) Standard Deviation of Azimuth
max. value = 45 degree
bit-1 (LSB) = $45/2^{16}$ degree

Structure of I015/627 Subfield #4: Azimuth Rate

Definition: Rate of change of the azimuth angle.

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
Azimuth Rate															LSB

bits-16/1 (AzR) Azimuth Rate, in Two’s complement
max. range = ±90 degree/s
bit-1 (LSB) = $180/2^{16}$ degree/s

Structure of I015/627 Subfield #5: Standard Deviation of Azimuth Rate

Definition: Estimated standard deviation of the azimuth angle rate.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
SD_AzR															LSB

Octet no. 3							
8	7	6	5	4	3	2	1
Co_AzRAz							LSB

bits-24/9	(SD_AzR)	Standard Deviation of Azimuth Rate max. value = 45 degree/s
bit-1	(LSB)	= $45/2^{16}$ degree/s
bits-8/1	(Co_AzRAz)	Correlation of Azimuth Rate and Azimuth, in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^{7}$

Structure of I015/627 Subfield #6: Azimuth Extent

Definition: Target size in the azimuth angle dimension. The target extends between start angle and end angle traversed clockwise.

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
Azimuth Extent Start															LSB

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

bits-32/17	(AzExS)	Azimuth Extent Start, max. value = 360 degree
bit-1	(LSB)	= $360/2^{16}$ degree
bits-16/1	(AzExE)	Azimuth Extent End, max. value = 360 degree
bit-1	(LSB)	= $360/2^{16}$ degree

5.2.23 Data Item I015/628, Elevation Information

Definition: Information related to the elevation angle provided by the sensor. (Predominantly used by electro-optic sensors).

Format: Compound data item, comprising a primary subfield of up to two-octets, followed by the indicated subfields.

Structure of Primary Subfield:

Octet no. 1

8	7	6	5	4	3	2	1
El	RS_El	SD_El	ER	SD_ER	ElEx	0	FX

bit-8 (El) Subfield #1: Elevation
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (RS_El) Subfield #2: Elevation Resolution
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (SD_El) Subfield #3: Elevation Precision
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bit-5 (ER) Subfield #4: Elevation Rate
= 0 Absence of Subfield #5
= 1 Presence of Subfield #5

bit-4 (SD_ER) Subfield #5: Elevation Rate Precision
= 0 Absence of Subfield #6
= 1 Presence of Subfield #6

bit-3 (ElEx) Subfield #6: Elevation Extent
= 0 Absence of Subfield #7
= 1 Presence of Subfield #7

bit-2 Spare bit

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Structure of I015/628 Subfield #1: Elevation

Definition: The elevation shall be given with respect to the horizontal plane of the sensor expressed in Two's Complement.

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
Elevation															LSB

bits-16/1 (El) Elevation, in Two's complement
max. range = ±90 degree
bit-1 (LSB) = $180/2^{16}$ degree

Note:
The elevation shall be given with respect to the local WGS-84 tangential plane of the receiver dedicated by I015/400.

Note:
For targets above the horizontal plane the elevation angle is positive and for targets below negative.

Structure of I015/628 Subfield #2: Elevation Resolution

Definition: Minimum angle in order to separate targets by the sensor in the elevation dimension.

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
RS_El															LSB

bits-16/1 (RS_El) Elevation Resolution
max. value = 45 degrees
bit-1 (LSB) = $45/2^{16}$ degree

Structure of I015/628 Subfield #3: Standard Deviation of Elevation

Definition: Estimated standard deviation of the elevation angle.

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
SD_El															LSB

bits-16/1 (SD_El) Standard Deviation of Elevation
max. value = 45 degree
bit-1 (LSB) = $45/2^{16}$ degree

Structure of I015/628 Subfield #4: Elevation Rate

Definition: Rate of change of the elevation angle.

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
Elevation Rate															LSB

bits-16/1 (ElR) Elevation Rate, in Two's complement
max. range = ±90 degree/s
bit-1 (LSB) = $180/2^{16}$ degree/s

Structure of I015/628 Subfield #5: Standard Deviation of Elevation Rate

Definition: Estimated standard deviation of the elevation angle rate.

Format: Three-octet fixed length data item.

Structure:

Octet no. 1								Octet no. 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
							SD_ElR								LSB

Octet no. 3							
8	7	6	5	4	3	2	1
			Co_ElREL				LSB

bits-24/9	(SD_ElR)	Standard Deviation of Elevation Rate max. value = 45 degree/s
bit-1	(LSB)	= $45/2^{16}$ degree/s
bits-8/1	(Co_ElREL)	Correlation of Elevation Rate and Elevation, in Two's complement max. range = ±1
bit-1	(LSB)	= $1/2^{7}$

Structure of I015/628 Subfield #6: Elevation Extent

Definition: Target size in the elevation angle dimension. The target extends between start angle and end angle.

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
Elevation Extent Start															LSB

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

bits-32/17 (ElExS) Elevation Extent Start, in Two's complement
max. range = ±90 degree
bit-17 (LSB) = $180/2^{16}$ degree

bits-16/1 (ElExE) Elevation Extent End, in Two's complement
max. range = ±90 degree
bit-1 (LSB) = $180/2^{16}$ degree

5.2.24 Data Item I015/630, Path Quality

Definition: Measure characterising the signal quality associated with a specific target echo signal.

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
DPP	DPS	RPP	RPS	0	0	0	FX

bit-8 (DPP) Subfield #1: Direct Path - Power
= 0 Absence of Subfield #1
= 1 Presence of Subfield #1

bit-7 (DPS) Subfield #2: Direct Path - SNR
= 0 Absence of Subfield #2
= 1 Presence of Subfield #2

bit-6 (RPP) Subfield #3: Reflected Path - Power
= 0 Absence of Subfield #3
= 1 Presence of Subfield #3

bit-5 (RPS) Subfield #4: Reflected Path - SNR
= 0 Absence of Subfield #4
= 1 Presence of Subfield #4

bits-4/2 Spare bits, set to zero

bit-1 (FX) = 0 End of data item
= 1 Extension into first Extension

Encoding Rule: See Table 5-2: Items per Message Type

Notes:

Some INCS sensors may be capable of outputting an indication of the signal quality based upon the received echo signal strength for that target.

Before including the provision of such data items in the technical specification, it is advised that the cost and operational benefits of the availability of such data is assessed.

Structure of I015/630 Subfield #1: Direct Path - Power

Definition: Signal power measured for the direct signal received from a specific transmitter station.

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
			DPP				LSB

bits-8/1 (DPP) Power of direct path,
in Two's complement
-128 dBm ≤ value ≤ 127 dBm
bit-1 (LSB) = 1 dB

Structure of I015/630 Subfield #2: Direct Path - Signal to Noise Ratio (SNR)

Definition: Signal to noise ratio measured for the direct signal received from a specific transmitter station.

Format: One-octet fixed length data item.

Structure:

Octet no. 1

8	7	6	5	4	3	2	1
			DPS				LSB

bits-8/1 (DPS) SNR of direct path,
in Two's complement
-128 dB ≤ value ≤ 127 dB
bit-1 (LSB) = 1 dB

Structure of I015/630 Subfield #3: Reflected Path - Power

Definition: Signal power measured for a specific target echo signal found within range-Doppler matrix (associated with a specific transmitter station).

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
0	0	0	0	0	0	0	RPP								LSB

bits-16/10 Spare bits, set to zero

bits-9/1 (RPP) Power of reflected path,
in Two's complement
-256 dBm ≤ value ≤ 255 dBm
bit-1 (LSB) = 1 dB

Structure of I015/630 Subfield #4: Reflected Path - Signal to Noise Ratio (SNR)

Definition: Signal to noise ratio measured for a specific target echo signal found within range-Doppler matrix (associated with a specific transmitter station).

Format: One-octet fixed length data item.

Structure:

Octet no. 1							
8	7	6	5	4	3	2	1
RPS							LSB

bits-8/1 (RPS) SNR of reflected path,
in Two's complement
-128 dB ≤ value ≤ 127 dB
bit-1 (LSB) = 1 dB

5.2.25 Data Item I015/631, Contour (Azimuth, Elevation Angle, Range Extent)

Definition: Azimuth, elevation angles and range extent of all elementary presences constituting a plot.

Format: Repetitive data item starting with a one-octet field repetition indicator (REP) indicating the number of presences associated to the plot, followed by at least one eight-octets contour information.

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
Az Con															LSB

Octet no. 4 / Octet no. 5

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

Octet no. 6 / Octet no. 7

32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Rg Con (Stop)															LSB

Octet no. 8 / Octet no. 9

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Rg Con (Start)															LSB

bits-72/65	(REP)	Repetition factor
bits-62/49	(Az Con)	Azimuth Contour (See Note 1 below) max. value = 360 degree
bit-49	(LSB)	= $360/2^{16}$ degree
bits-48/33	(El Con)	Elevation Contour, in Two’s complement (See Note 2 below)

		max. range = ±90 degree
bit-33	(LSB)	= $180/2^{16}$ degree
bits-32/17	(Rg Con Stop)	Range Contour Stop (See Note 3 below)
bit-17	(LSB)	= $10,000/2^{16}$ metres (approx 0.15m)
bits-16/1	(Rg Con Start)	Range Contour Start (See Note 3 below)
bit-1	(LSB)	= $10,000/2^{16}$ metres (approx 0.15 metres)

Notes:

Note 1: The azimuth shall increment in a clockwise manner relative to geographic North centred at the System Reference Point.

Note 2: The elevation shall be given with respect to the local WGS-84 tangential plane of the receiver dedicated by I015/400.

Note 3: If populated, the range contour requires a start and stop point. The stop point is to be greater or equal than the start point.

5.3 Standard User Application Profile

The following UAP shown in Table 5-3 shall be used for the transmission of target reports and service messages:

Table 5-3: Standard UAP

FRN	Data Item	Information	Length in Octets
1	I015/010	Data Source Identifier	2
2	I015/000	Message Type	1
3	I015/015	Service Identification	2
4	I015/020	Target Report Descriptor	1+
5	I015/030	Warning/Error Conditions	1+
6	I015/145	Time of Applicability	3
7	I015/161	Track/Plot Number	2
FX	-	Field Extension Indicator	-
8	I015/170	Track/Plot Status	1
9	I015/050	Update Period	2
10	I015/270	Target Size & Orientation	1+
11	I015/300	Object Classification	1+2n
12	I015/400	Measurement Identifier	5
13	I015/600	Horizontal Position Information	1+
14	I015/601	Geometric Height Information	1+
FX	-	Field Extension Indicator	-
15	I015/602	Horizontal Velocity Information	1+
16	I015/603	Horizontal Acceleration Information	1+
17	I015/604	Vertical Velocity Information	1+
18	I015/605	Vertical Acceleration Information	1+
19	I015/480	Associations	1+5n
20	I015/625	Range Information	1+
21	I015/626	Doppler Information	1+
FX	-	Field Extension Indicator	-
22	I015/627	Azimuth Information	1+
23	I015/628	Elevation Information	1+
24	I015/630	Path Quality	1+
25	I015/631	Contour (Azimuth, Elevation Angle, Range Extent)	1+8n
26	SP	Special Purpose Field	1+
27	-	not used	-
28	-	not used	-
FX	-	Field Extension Indicator	-

whereas:

- 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 Extensions as necessary

ANNEX A PLOT/TRACK CONSTRUCTION AND THE USE OF ASTERIX CATEGORIES 015 AND 016 TO CONVEY THE INFORMATION

Introduction

MSPSR sensors are distributed surveillance systems with multiple receiver (Rx) and/or transmitter (Tx) stations. MSPSR is based on the principle of bistatic radar in which signals from multiple pairs of Rxs and Txs are combined to produce a single target report.

Various stages of processing are performed to elevate the data from a bi-static report (originating from a pair of a single Tx and a single Rx), through a Measurement Plot / Measurement Track stage before finally forming a Sensor Centric Plot / Sensor Centric Track.

One of the uses of INCS ASTERIX Category 015 is to convey the different types of target report outputs from Multi-Static Primary Surveillance Radar (MSPSR) sensors.

Plot Data:

Plot data is target data that is provided without any history information. Each plot is a standalone piece of data, no correlation or association with other plots can be assumed.

Track Data:

Track data is target data that is provided based on a history or chain of plots. Whilst a track number is optional for plot data it is mandatory for track data. (The track number connects the current target report with preceding or following reports for the same target and a velocity and direction vector component).

The Sensor Centric Plot / Sensor Centric Track output from the sensor may be considered by some to be the most important because it is used operationally in the ATM system. However, for the following reasons, the value of the Measurement Plot / Measurement Track should not be under-estimated.

Measurement data is described in the frame of reference of the sensor or sensor component. This may be either plot data (Measurement Plots) or track data (Measurement Tracks). Examples of this kind of data include data from a mono-static sensor provided only in range and azimuth, partial bi-static data provided as a bi-static range and azimuth from a bi-static pair and data from a camera system provided in azimuth and elevation.

Whilst not yet a ‘fully-formed’ target report the Measurement Plot / Track is of value:

- Within the sensor the ASTERIX Category 015 Measurement Plot / Measurement Track can be used to support tuning and performance monitoring. When analysed in conjunction with ASTERIX Category 016 data it provides visibility and traceability through all the processing stages that were used to establish the presence of the target, the measurement plots and the sensor centric target report output.

- It is envisaged that ASTERIX Category 015 Measurement Plot / Measurement Track and ASTERIX Category 016 (Sensor Configuration data) could be used in advanced trackers, particularly of a military design, to fuse overlapping coverage data from multiple sensors potentially even from different manufacturers. In this way, targets which wouldn't be detected by individual sensors, due to an insufficient number of measurements, could be elevated in to a 3D plot/track.
- INCS data, both Measurement Plot / Measurement Tracks and/or Sensor Centric Plot / Sensor Centric Tracks, can be used to validate certain data items obtained by cooperative surveillance sensors.

In addition to an Operational Output (Sensor Centric Plot / Sensor Centric Track), the MSPSR sensor may therefore also provide a Technical Output (Measurement Plot / Measurement Track) and a System Configuration output.

This section provides an explanation of how the above mentioned traceability between the various processing stages can be assured.

Measurement Plot and Track

The initial stage in any MSPSR process is the establishment of a bi-static coupling between a transmitter (Tx) and a receiver (Rx).

When compiling the ASTERIX messages, the Tx and Rx used to establish the bi-static coupling are assigned a Pair Identifier (PID) reference number.

The common PID assignment used in both ASTERIX Category 015 and ASTERIX Category 016 establishes the link between the two categories.

In ASTERIX Category 016 the Pair Identifier (PID), the Transmitter Identifier (TID) and the Receiver Identifier (RID) are assembled together into the System Configuration data item. (The details conveyed in Category 016 are those which are variable or which are considered to be of potential benefit to a generic tracker later in the ATM infrastructure. It is to be noted that other fixed attributes of the transmitters and receivers may be configured at system deployment and recorded in a system file elsewhere).

In ASTERIX Category 015 the PID and a unique Observation Number (which can be interpreted as a cyclic counter – see I015/400) are assembled together into the Measurement Identifier (MID) (Data Item I015/400). This establishes a link between the PID and the Measurement Plot / Measurement Track Reports that are subsequently derived from the bi-static coupling.

Data Item I015/400 Measurement Identifier serves as a unique discriminator to a specific Measurement plot or track. Uniqueness is guaranteed through a combination of both the Observation Number (unique number in time) and the Pair Identifier (PID) (identifying the Tx-Rx pair used when establishing the measurement).

Sensor Centric Plot/Track

Sensor centric data is described in the WGS-84 frame of reference. This may be either plot data (Sensor Centric Plots) or track data (Sensor Centric Tracks). Examples of this kind of data include horizontal positional and altitude provided by a mono-static sensor and horizontal position and altitude provided by a multi-static sensor after processing multiple bi-static measurements.

Sensor Centric data is intended to be used by client systems.

In the case of an MSPSR sensor a Sensor Centric Plot or Sensor Centric Track is produced by consolidating multiple timed measurements each belonging to different contributing pairs (Tx-Rx pairs).

Sensor Centric Plot or Sensor Centric Track Reports (which are designated as such in data item I015/000 (Message Type)) carry not only target position and other relevant information but may also include details of the numerous measurements from which target information was derived. The inclusion of associations and the identity of the contributing measurements in the form of the Measurement ID, provide the final link in the chain which enables a trace back through the processing to the raw data (Measurement Plots / Measurement Tracks) that was used when compiling the report.

As can be seen in Figure 1 below, Data Item I015/480 (Associations) contains references to the Measurement Identifiers which contributed to Sensor Centric Plot or Sensor Centric Tracks.

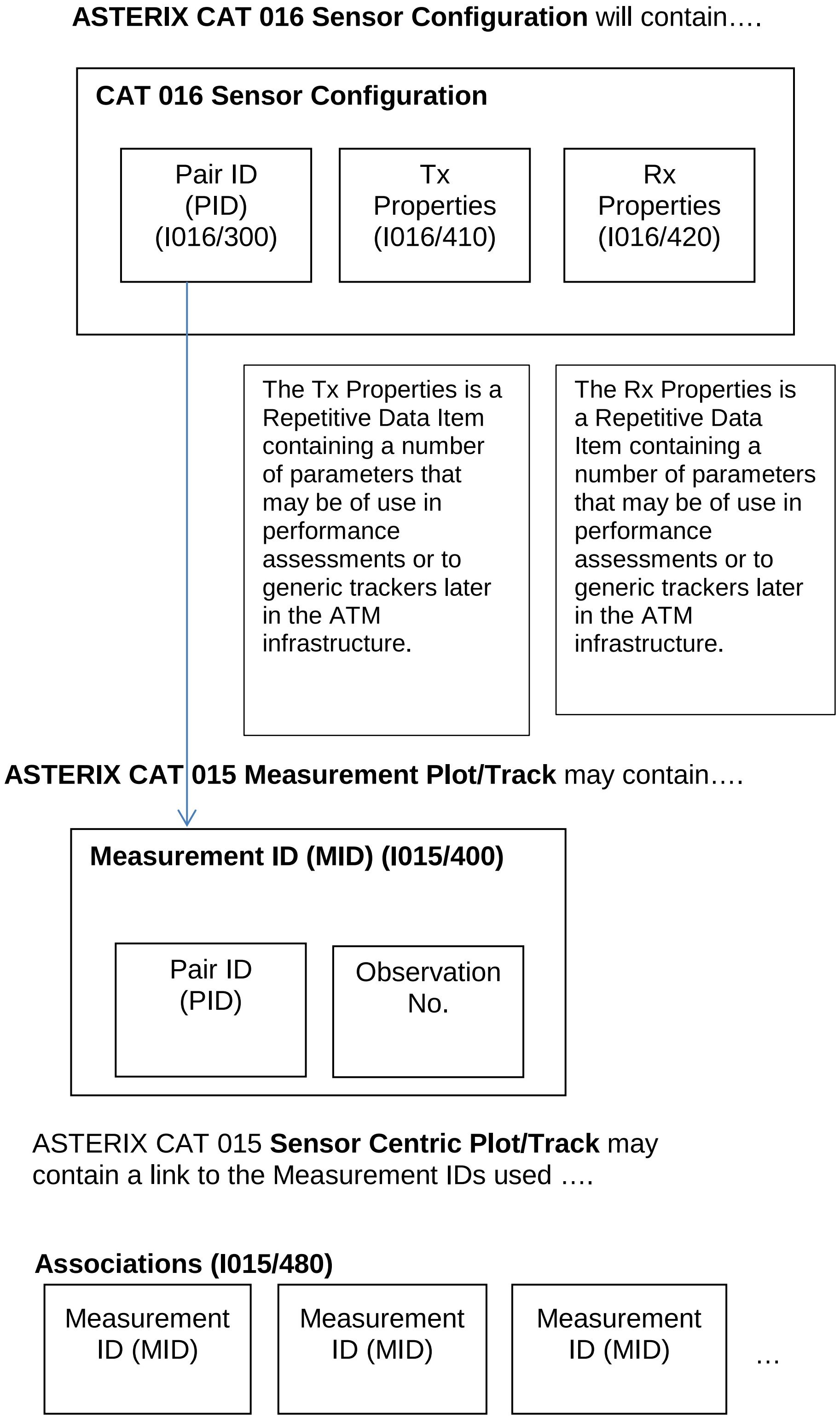
Assessing the various data items within ASTERIX Category 015 (Measurement and Sensor Centric Outputs) and Category 016 permits full traceability between the bi-static pair that initiated the process all the way through the processing chain to the Sensor Centric Plot / Sensor Centric Track output.

NOTE: The output data in Sensor / Measurement Plot types is neither smoothed, extrapolated nor coasted.

MSPSR Processing Chain

Through its distributed architecture the application and use of an MSPSR sensor can be very flexible. For example, part of the sensor can provide coverage over a wide area for En-route purposes whilst, at the same time, a small portion could also deliver data over a smaller area for TMA purposes.

The following example, described in Figure 2, illustrates a sensor configuration supporting two Services. It is of interest to note that a component of the system may provide data supporting both Services offered. The figure also illustrates the contributing Pair (PID) philosophy.



ASTERIX CAT 016 (Sensor Configuration) will contain a reference to a Pair ID, a Transmitter ID and a Receiver ID.

A common Pair ID (PID) assignment in both CAT 015 and CAT 016 permits a trace from the Plot/Track stages to the Tx and Rx that were used when establishing the Target Report.

The data contained in the Tx Properties and Rx Properties data items will be supplemented by a configuration file of fixed Tx/Rx attributes that would be established during system deployment.

The optional Measurement ID Data Item (I015/400) is a data item within a Measurement Plot/Track that contains details of which Pair ID and Observation No. were used when establishing the Measurement Based Target Report.

The optional Associations Data Item (I015/480) is a recurring data item within a Sensor Centric Plot/Track that contains details of which Measurement IDs were used when establishing the Target Report.

Figure 1: Illustration of traceability between Transmitter(s) and Receiver(s) that Contributed to a Measurement and Sensor Centric Plot / Sensor Centric Track.

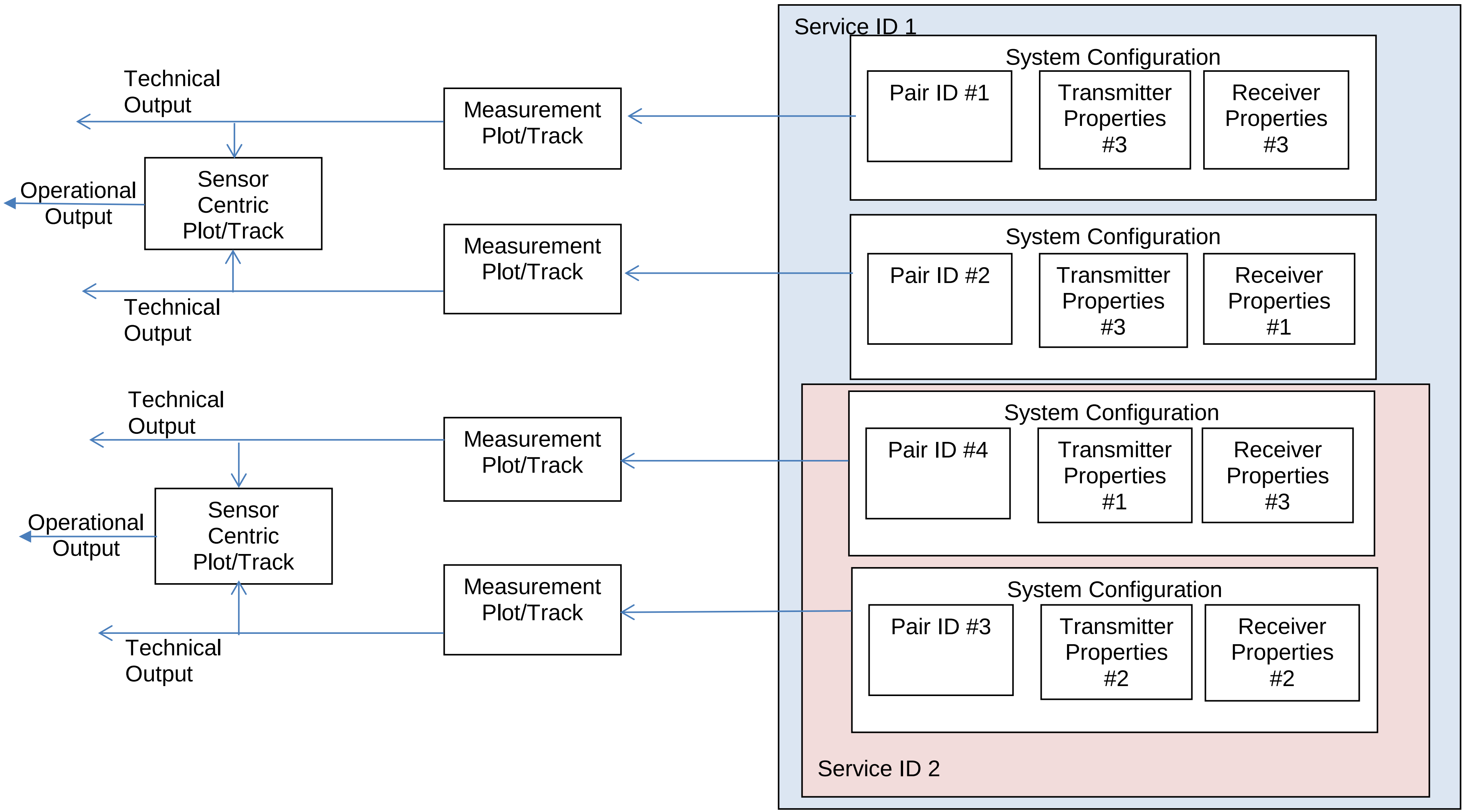


Figure 2: Contributing Pair Philosophy and the Relationship between ASTERIX CAT 015 Output Type