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NOTE TECHNIQUE

IENA & ETHERNET FORMAT OVERVIEW

AIRCRAFT :	**-**	**AIRCRAFT N°:**	**VPRS :**
TEST PROGRAM :		**ATA :**	
PROJECT :		**OF :**	
AUTHORS :			
	S.MARTIN		

SUMMARY :

Since the A380 program, the FTI is based on a Ethernet network architecture, over which test data is transmitted. This data is encapsulated in a specific format called IENA format .

The goal of the present document is to give a clear view of:

1. The IENA format
2. The FTI network management. In particular, addressing and protocol requirements

KEY WORDS : INSTALLATION ESSAI V / IENA / ACQUISITION

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Issue history

Issue	Date	Modified pages	Justification for the modifications
1.0	20/02/2007	-	Creation of document
2.0	05/10/2007	p.5 p.10	Precision added about the encoding structure (Big endian) Precision added in the time structure of the IENA header
3.0	15/01/2008	§ 2.6 § 2.6.1 § 2.7	Correction added to the “Important remark” (number and order of parameter inside packets) Remark added concerning IENA Parameter ID for positional parameters Correction and precisions added concerning latency and maximum sizes
4.0	04/12/2009	§ 2.5 § 2.6.4 § 2.6.5 § 3.2	Correction: no padding needed at IENA packet level Correction: padding byte added at IENA parameter level Correction: padding byte added at IENA parameter level Added SNMP protocol for monitoring purposes
5.0	16/02/2011	§ 2, 2.4 and 3.2 § 2.5 and APP. 2	Added remark for transmission over Wifi: TCP protocol to be used Use of the ETR (Real Time Status) bit in the IENA N2 status field
6.0	11/09/2013	§ 2.3 § 2.5 and APP. 2	Correction of Flag field of IP layer, padding bytes info N2 status update (LS, IS and ETR bits)

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Summary

NOTE TECHNIQUE

IENA & ETHERNET FORMAT OVERVIEW

1. INTRODUCTION

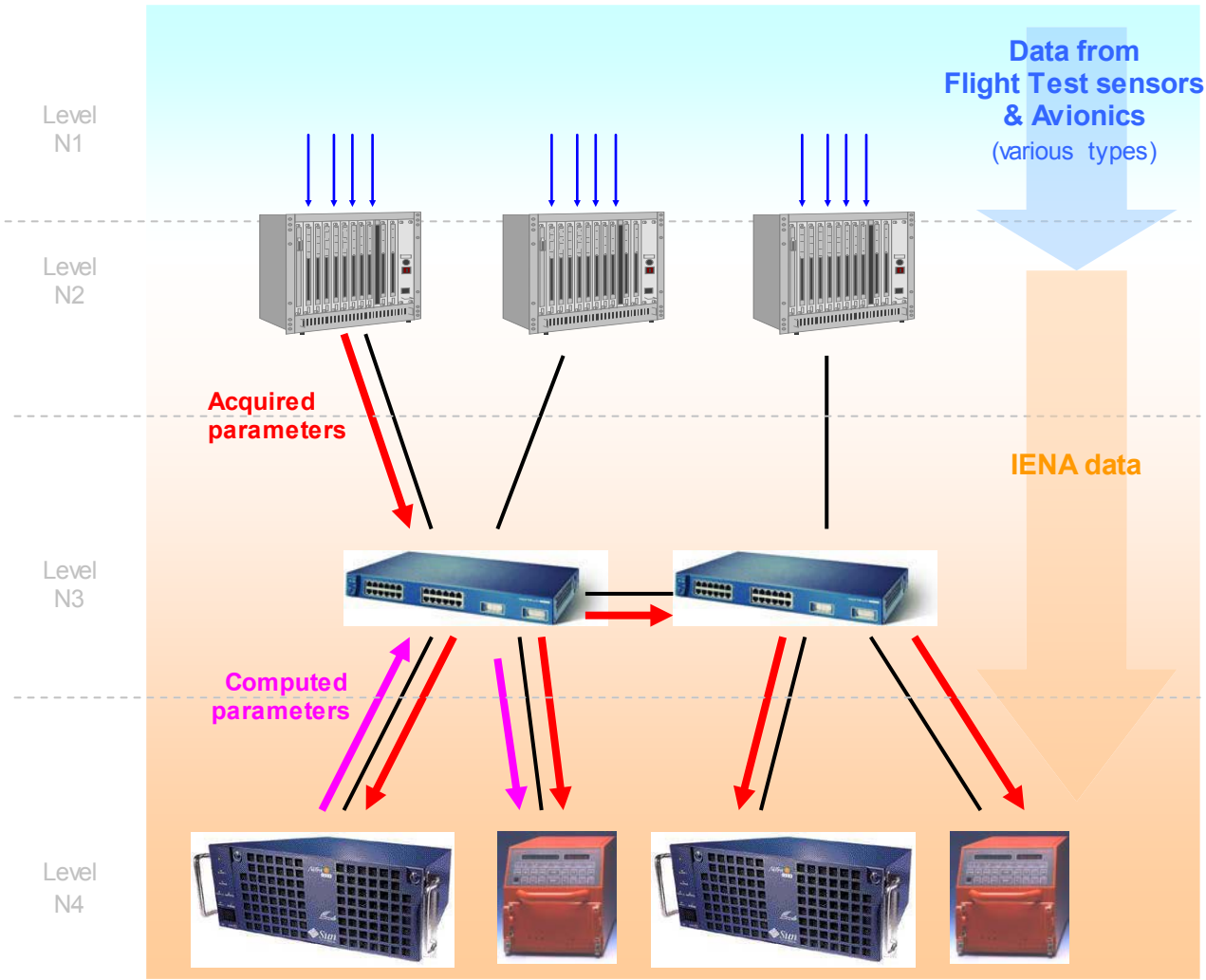
1.1. CONTEXT

To transmit test data from acquisition to processing units, the Flight Test Installation (FTI) uses a Ethernet type network and an Airbus specific data format called IENA format, which was first used for the A380 program. It allows to put various types of data (analog, ARINC, AFDX, CAN, etc) into one single format.

The data acquired by each acquisition system (N2 level) is put into the IENA format and sent over the FTI network (N3 level) towards recorders and processing systems (N4 level). Type of diffusion is then 1 transmitter / N receivers.

Moreover, some data received by on-board computers may be computed together and sent again over the network (computed parameters).

The following figure gives the principle of the FTI network architecture, with examples of data diffusion :



Remark : The FTI network is often called IENA network. In this document, only the first term will be used to avoid confusion between IENA Data and IENA network (on which there might be other types of data circulating, such as downloading frames for example)

1.2. GOAL OF THE PRESENT DOCUMENT

The aim of the present document is to give a clear view of:

1. The IENA format
2. The FTI network management. In particular, addressing and protocol requirements.

1.3. GLOSSARY

ARP Address Resolution Protocol

FTI Flight Test Installation

ICMP Internet Control Message Protocol

IENA Installation d'Essai Nouveaux Avions

IP Internet Protocol

LSB Less Significant Bit / Byte

MSB Most Significant Bit / Byte

N/A Not Applicable

TCP Transmission Control Protocol

TFTP Trivial File Transfer Protocol

UDP User Datagram Protocol

IMPORTANT NOTICE : the byte order used for the IENA encoding is the big endian (or Motorola) encoding, meaning that the Most Significant Byte is transmitted first.

2. ETHERNET & IENA STRUCTURE

This part focuses on the format used to transmit data over the FTI network. It is based on the classical Ethernet format and uses UDP/IP protocol. It can be presented using the following layer model:

5	APPLICATION	IENA
4	TRANSPORT	UDP *
3	NETWORK	IPv4
2	DATA LINK	MAC
1	PHYSICAL	100baseTx

* Remark: for transmission over Wifi media, TCP shall be used as the transport layer.

Each of the following paragraph details one of those layers.

2.1. PHYSICAL LAYER

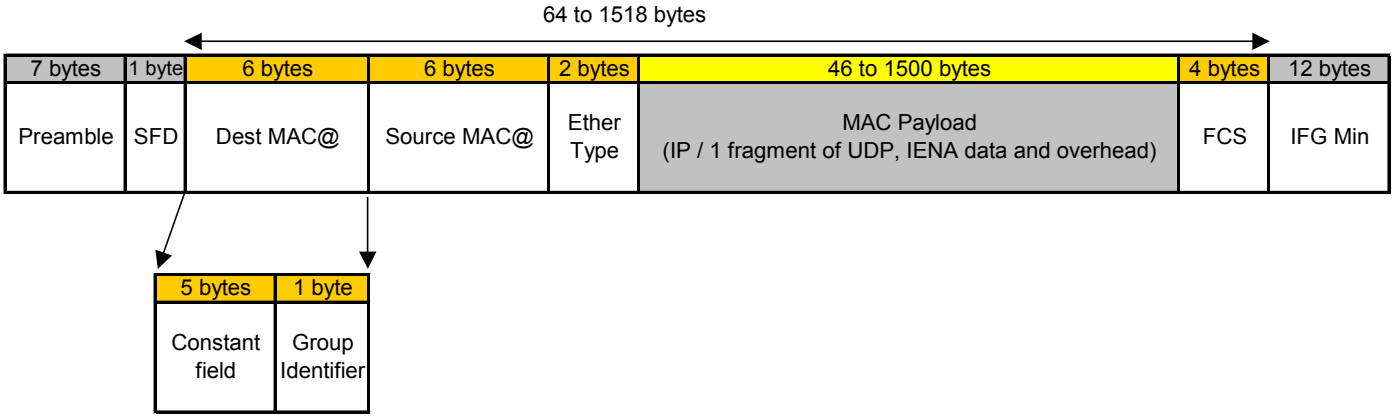
IENA Physical layer: **100baseTx**

Mode shall be forced to Full Duplex / 100Mbps (autonegociation shall be deactivated)

2.2. DATA LINK LAYER

MAC is the data link protocol used for IENA.

Ethernet frame size: from 64 to 1518 bytes (excluding preamble, start of frame and Inter-frame gap)



	Value
Preamble	0xAA for 7 bytes
SFD (Start of Frame)	0xAB
Destination MAC address	Multicast diffusion shall be used: First 5 bytes: constant field 0x01005E0101 Last byte: diffusion group identifier
Source MAC address	Sender MAC address
Ether Type	0x0800 (IPv4)
FCS (Frame Check Sequence)	To be computed for each frame
IFG (Inter-Frame Gap)	-

Remark concerning Destination MAC address:

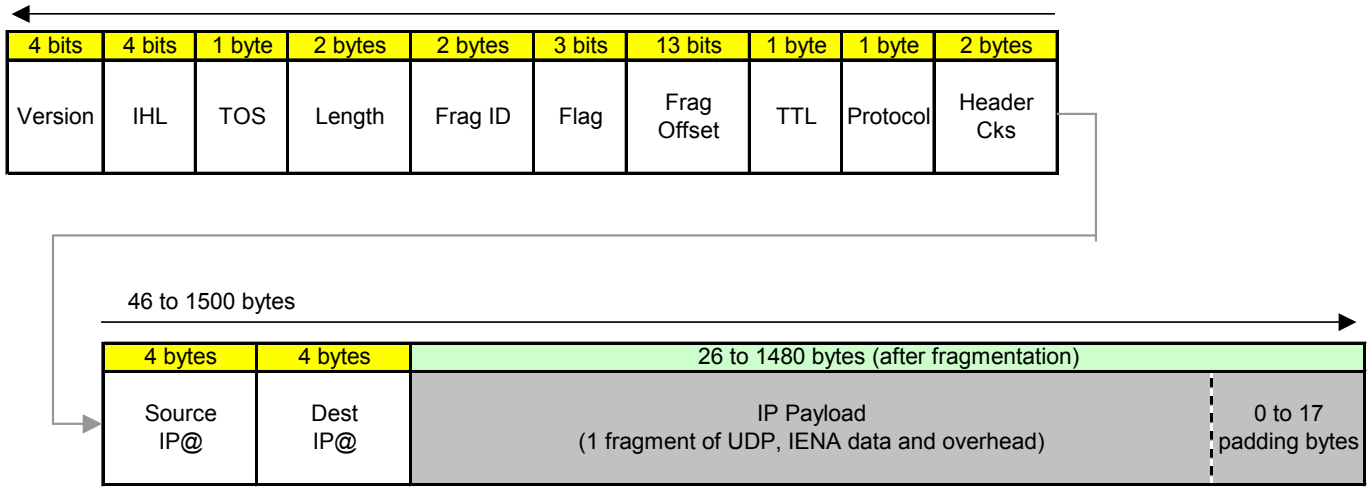
Multicast diffusion shall be used with the following pool of addresses: **01:00:5E:01:01:XX** where XX is the group identifier (e.g. 0A for group 10)

Group definition can vary from one installation to another.

2.3. NETWORK LAYER

IPv4 is the network protocol used for IENA.

IP packet size: from 46 to 1500 bytes. Fragmentation is realized at this level: UDP datagram delivered by the above layer is split up into 1480-bit length fragments, or less for last fragment (if last or only fragment is less than 26 bytes long, up to 17 padding bytes can be added – right justified – to reach 26 bytes). IP overhead is then added to each fragment (see also appendix 1).



	Value
Version	0100 (in binary)
IHL (Internet Header Length in 32-bit words)	0101 (in binary)
TOS (Type Of Service)	0x00
Length (of IP packet including overhead, in bytes)	From 46 to 1500 (decimal)
Fragment Identification	UDP Datagram Idenfier
Flags	010: no fragmentation 00X: fragmented: 001: fragmented with more fragments to come 000: Last fragment
Fragment Offset (in 8-byte blocks)	From 0 (1st fragment) to 8191
TTL (Time To Live)	01
Protocol	17 (decimal) for UDP
Header Checksum	To be computed for each packet
Source IP Address	172.28.A.B with (given by FTI Database*): A: A/C type and number B: equipment type and location
Destination IP Address	235.1.1.X with: X: group identifier (defined for each installation)
Padding bits	Shall be 0s

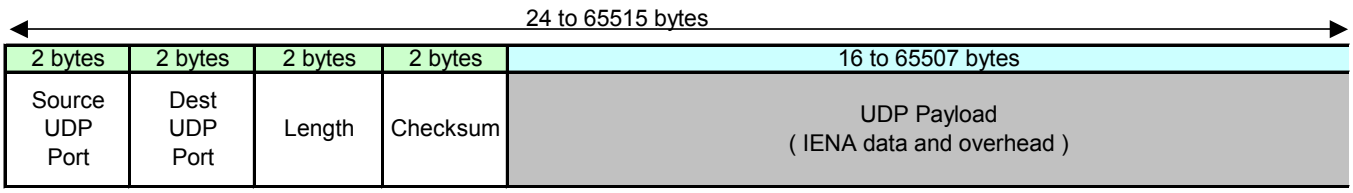
* FTI database is also called SABRE

2.4. TRANSPORT LAYER

UDP is the transport layer protocol used for IENA (exception for Wifi transmission: **TCP** protocol is to be used. Not detailed in this issue of the document).

UDP datagram size: from 25 to 65515 bytes * (including UDP header, and before IP fragmentation).

* Theoretical limit of UDP datagram is 65535 bytes, but practical limit is 65515 bytes when it is used with IP protocole (as maximum IP packet size is also 65535 bytes according to the standard)



	Value
Source UDP Port	50 000 + system reference (given by FTI database)
Destination UDP Port	51 000 (identifying IENA application)
Length (including overhead, in bytes)	From 24 to 65515 (decimal)
Checksum	To be computed for each datagram

2.5. IENA LAYER (HEADER & FOOTER)

IENA is the specific format used for FTI, above the transport layer.

IENA packet size: from 16 to 65506 bytes * (including IENA header & footer). The number of bytes is always an even number (as the length of each parameter in the IENA payload is an even number of bytes)

* Max size could theoretically be 65507 bytes but IENA packets must be 16-bit aligned. Min size 16 is for an empty packet (otherwise min size is 18).

16 to 65506 bytes

2 bytes	2 bytes	6 bytes	1 byte	1 byte	2 bytes	0 to 65490 bytes	2 bytes
IENA KEY	Size	Time	KEY Status	N2 Status	SEQ NUM	PARAMETERS 1 or more parameters (of the same type)	END Field

	Value		
IENA Key	Identify IENA packet type Set by configuration (allocated by FTI Database)		
Size (including IENA overhead, in 16-bit words)	From 8 to 32753 (decimal)		
Time (packet opening time)	Time of current year in µs (number of µs since January 1st) e.g. 13h12m04s 0us of January 3rd = 0x00334C557100		
Key Status	Static for a given key (given by configuration)		
	Bit 7 (MSB)	0 / 1	Not positional / positional parameters key
	Bit 6	0 / 1	To be proceeded / discarded by the CUB
	Bit 5	0 / 1	Not message / message parameters key
	Bit 4	0 / 1	Delay field not used / used in parameters
	Bit 3	0 / 1	N4 equipment may / may not Tx this key
	Bit 2 to 0 (LSB)	XXX	Std / Pos parameter size (in 16-bit words) Not used if message parameter
N2 Status **Bit 1, 2 and 5 to 7 NOT USED (set to 0)**	Set for each key instance		
	Bit 7 to 5 (MSB)	XXX	Not used
	Bit 4	0 / 1	LS: local synchro ok / lost 0 if system synchronized to external source 1 if system is on freewheel
	Bit 3	0 / 1	IS: Inconsistent synchro 0 if system is or has been synchronized 1 if system has never been synchronized (since last reset)
	Bit 2	0 / 1	TD: emitted by N2 / N4 Telemetry eqpmt
	Bit 1	0 / 1	OVF: Overflow Error when set to 1
	Bit 0	0 / 1	ETR: Real Time Status. Latency ok/nok 0 if send date – packet date < 100 ms 1 if send date – packet date > 100 ms
SEQ NUM (circular counter incremented at each Key instance)	From 0 to 65535 (decimal)		

END Field	Unique value for all keys. Set by configuration (given by FTI Database). Default (and common) value: 0xDEAD

2.6. IENA PAYLOAD (PARAMETERS)

There are 5 different types of parameters. Each type is described hereafter.
The type of parameter to be used depends on the characteristics of the acquired data and on how it is going to be processed. There shall be only one type of parameter of a given IENA key.

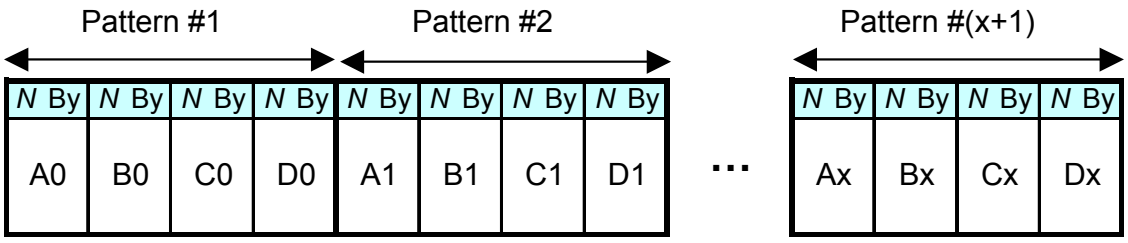
2.6.1. P TYPE : POSITIONAL Parameters

Those parameters have no overhead. Only data appears in this structure.
In each given IENA key, positional parameters necessarily appears in a predefined pattern, defined in the FTI database by the following inputs:

- Length of the parameters: ***N*** bytes in the example above
  Is necessarily an even number of bytes, with 2 ≤ N ≤ 14.
  For each IENA key, all parameters must have the same length.
  This length is given in the FTI database (***N***) and in the IENA key status field (***N/2***) (cf. § 2.5)
- Number of parameter in the pattern
- Number of patterns in a packet.
- Each parameter is then identified by its position in the pattern.

NB: The FTI database assigns a IENA Parameter ID to each positional parameter, and uses the position in the given key to match the parameter to its ID. The ID does not appear in the structure.

Example: (By = Bytes)



In this case, the IENA key would have the following parameters:

- Length of the parameters: N bytes
- Number of parameter in the pattern: 4
- Number of patterns in a packet: x+1

Parameter A (resp. C) would be identified by its position 0 (resp. 2) in the pattern.

2.6.2. D TYPE : STANDARD Parameters with Delay field

2 bytes	2 bytes	2 bytes	2 bytes		2 bytes	2 bytes
Param ID	Delay	Data Word N Nmax = 7	Data Word N-1	. . .	Data Word 2	Data Word 1

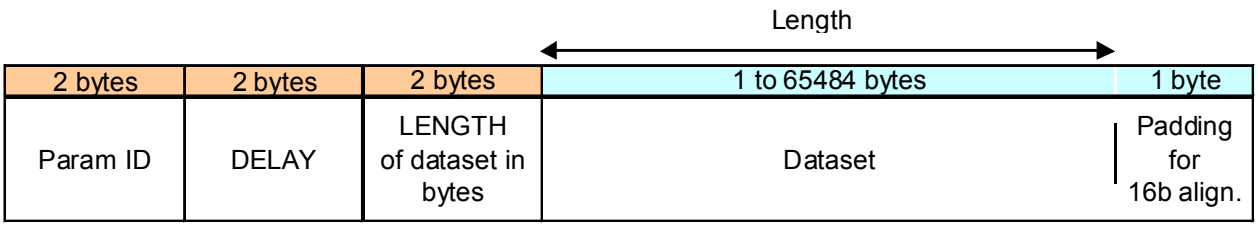
	Value
Param ID	Given by FTI Database
Delay	Time difference between key opening date and parameter acquisition date (in µs)
Data words	From 0 to 7 data words (as described in key status in § 2.5)

2.6.3. N TYPE : STANDARD Parameters without Delay field

2 bytes	2 bytes	2 bytes		2 bytes	2 bytes
Param ID	Data Word N Nmax = 7	Data Word N-1	. . .	Data Word 2	Data Word 1

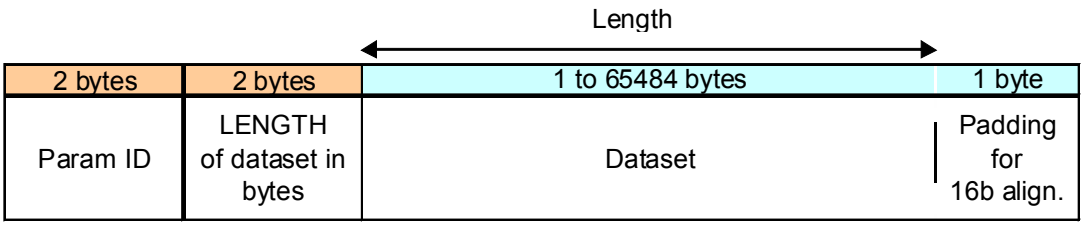
	Value
Param ID	Given by FTI Database
Data words	From 0 to 7 data words (as described in key status in § 2.5)

2.6.4. M TYPE : MESSAGE Parameters with Delay field



	Value
Param ID	Given by FTI Database
Delay	Time difference between key opening date and parameter acquisition date (in µs)
Length (of dataset in bytes)	From 1 to 65484 (decimal). Does not include padding byte.
Dataset	Can contain one or several data (strictly defined or opaque). Information stored in FTI database.
Padding	1-byte padding if necessary (for 16-bit alignment) No requirement on value (0x00 is a possible value)

2.6.5. Q TYPE : MESSAGE Parameters without Delay field



	Value
Param ID	Given by FTI Database
Length (of dataset in bytes)	From 1 to 65484 (decimal). Does not include padding byte.
Dataset	Can contain one or several data (strictly defined or opaque). Information stored in FTI database.
Padding	1-byte padding if necessary (for 16-bit alignment) No requirement on value (0x00 is a possible value)

2.7. IENA PACKET CONSTRUCTION RULES

This paragraph gives the main rules that shall be taken into account to construct and transmit IENA packets over the FTI network:

- One system may transmit more than one key
- All the packets of a given IENA key shall contain only one type of parameters. The number of parameters and the order in which they appear may change from one packet to another, except for P type parameters as explained in § 2.6.
- 1 parameter shall be allocated to only one IENA key (although on-board processing systems may copy each parameter in one of the five specific keys used for telemetry transmission)
- IENA packets are put into UDP datagrams to be sent over the FTI Ethernet network. IENA packets cannot be divided into different UDP datagrams.
  Each IENA packet shall be assigned a UDP Destination port and an IP Destination address (different keys may have the same UDP and IP destination fields).
- The maximum size of each IENA packet, as well as the maximum size of UDP datagrams (or a threshold value from which datagrams may be sent) shall be specified and may be configurable in the configuration files.

  NB: maximum sizes of IENA packets (65506 bytes) and Message parameters (65484 bytes) indicated in § 2.6 are theoretical limits. Smaller values are generally used to optimize data processing (avoiding burst problems) and to satisfy latency requirements.
- The latency, i.e. the time for the data to go through the entire system (from acquisition to IENA packet sending) shall not exceed the value specified by the FTI system specialist. It includes time to constitute IENA packets and UDP datagrams. For information, a typical value is 50 ms.
  For that matter, latency will generally supersede the packet or UDP size limits.

3. NETWORK MANAGEMENT

3.1. ADRESSES

IENA packets transmission

Protocol	Item		Value	Example	Provider of information
UDP	Port number	Source	UDP Source = 50 000 + Syst. reference	**RR602 :** UDP Source = 50 602 **RR380 :** UDP Source = 50 380 **RR373 :** UDP Source = 50 373 **EW540 :** UDP Source = 50 540 …	System data sheet
		Destination	UDP Dest = 51 000 Identify IENA application	Always 51 000	This document
IP	IP@	Source	IP Source = 172.28.A.B **A** identifies A/C **TYPE** and **NUMBER** **B** identifies SYST. **TYPE** and **POSITION** *A and B = [1..254]* *Values 0 and 255 are forbidden*	A380 n°1 : A = 1 A380 n°2 : A = 2 … ------ RR602 20ZXA: B = 2 …	Fields A and B are given by SABRE database
		Destination	IP Dest = 235.1.1.GR multicast address GR = destination group number	GR = 10: N4 systems of BASIC chain 20 : WIDE BAND chain 30 : ACCIDENT chain 12 : BASIC + WIDE BAND 13 : BASIC + ACCIDENT 23 : WIDE BAND + ACCIDENT 123 : All chains …	Group numbers are stored in SABRE database
MAC	MAC@	Source	MAC Source = free unique for each interface	Free. Compliant to IEEE	N/A
		Destination	MAC Dest (hexa) = 01:00:5E:01:01:GR underlined fields = mapping of multicast Dest IP@	Compliant to IEEE	N/A

Downloading

Protocol	Item		Value	Example	Provider of information
UDP	Port number	Source	UDP Source dynamically allocated by the operating system		N/A
		Destination	UDP Dest depends on downloading protocol TFTP 69/udp #TFTP FTP 20/tcp #FTP, data 21/tcp #FTP. Control other (based on TCP) -> to be set		N/A
IP	IP@	Source	IP Source = 172.28.**254**.B A = 254 (tools) **B** = identifies tool PN/SN *Network address: 172.28.0.0* *Broadcast address: 172.28.255.255*	Downloading PC (SHERPA) n° 1: **IP Source = 172.28.254.1**	IP@ are stored in SABRE database
		Destination	IP Source = 172.28.A.B **A** identifies A/C **TYPE** and **NUMBER** **B** identifies SYST. **TYPE** and **POSITION**	A380 n°1: A = 1 RR602 20ZXA: B = 2 => **IP Dest = 172.28.1.2**	IP@ are stored in SABRE database
MAC	MAC@	Source	MAC Source = free unique for each interface	Free. Compliant to IEEE	N/A
		Destination	MAC destination = MAC@ of equipment to be downloaded obtained by ARP	Free. Compliant to IEEE	N/A

3.2. PROTOCOL RECOMMENDATIONS

Shall be used :

UDP	Standard	*Tx / Rx*	RFC 768 : USER DATAGRAM PROTOCOL
IP v4	Unicast	*Tx / Rx*	RFC 791 : INTERNET PROTOCOL
(all services)	Fragmentation	*Tx / Rx*	
	Multicast	*Tx / Rx*	RFC 1112 : Multicast IPv4 to Ethernet physical address correspondence
	IP@ compliant to class B and D formats	*Tx / Rx*	RFC 1200 : ASSIGNED NUMBERS
ICMP	ICMP_Echo	*N2 : Rx only*	RFC 792 : INTERNET CONTROL MESSAGE PROTOCOL
(services restreints)	ICMP_Echo_Response	*N2 : Tx only*	
	ICMP_Destination Unreachable	*N2 : Tx only*	
ARP	ARP Request	*N2 : Rx only*	RFC 826 : Ethernet Address Resolution Protocol
	ARP Response	*N2 : Tx only*	

May be used :

TCP	Downloading Or IENA transmission over Wifi	RFC 793 : TRANSMISSION CONTROL PROTOCOL
ICMP	Other response code to ICMP_Echo	RFC 792 : INTERNET CONTROL MESSAGE PROTOCOL
FTP	Downloading only	RFC 959 : File Transfer Protocol
TFTP	Downloading only	RFC 1350 : Trivial File Transfer Protocol
SNMP V2c (or V1)	System monitoring	V2c preferred. V1 accepted. **V3 forbidden**. Cf. Airbus document SP0908904 Ed 1.0

Shall not be used:

IGMP
SNMP v3
IPv6
All routing protocol : RIP, OSPF…
Systems shall not emit any trafic other than : * Acquisition data (UDP / IP Multicast) * Downloading data (TFTP, FTP, TCP…) * ARP * ICMP

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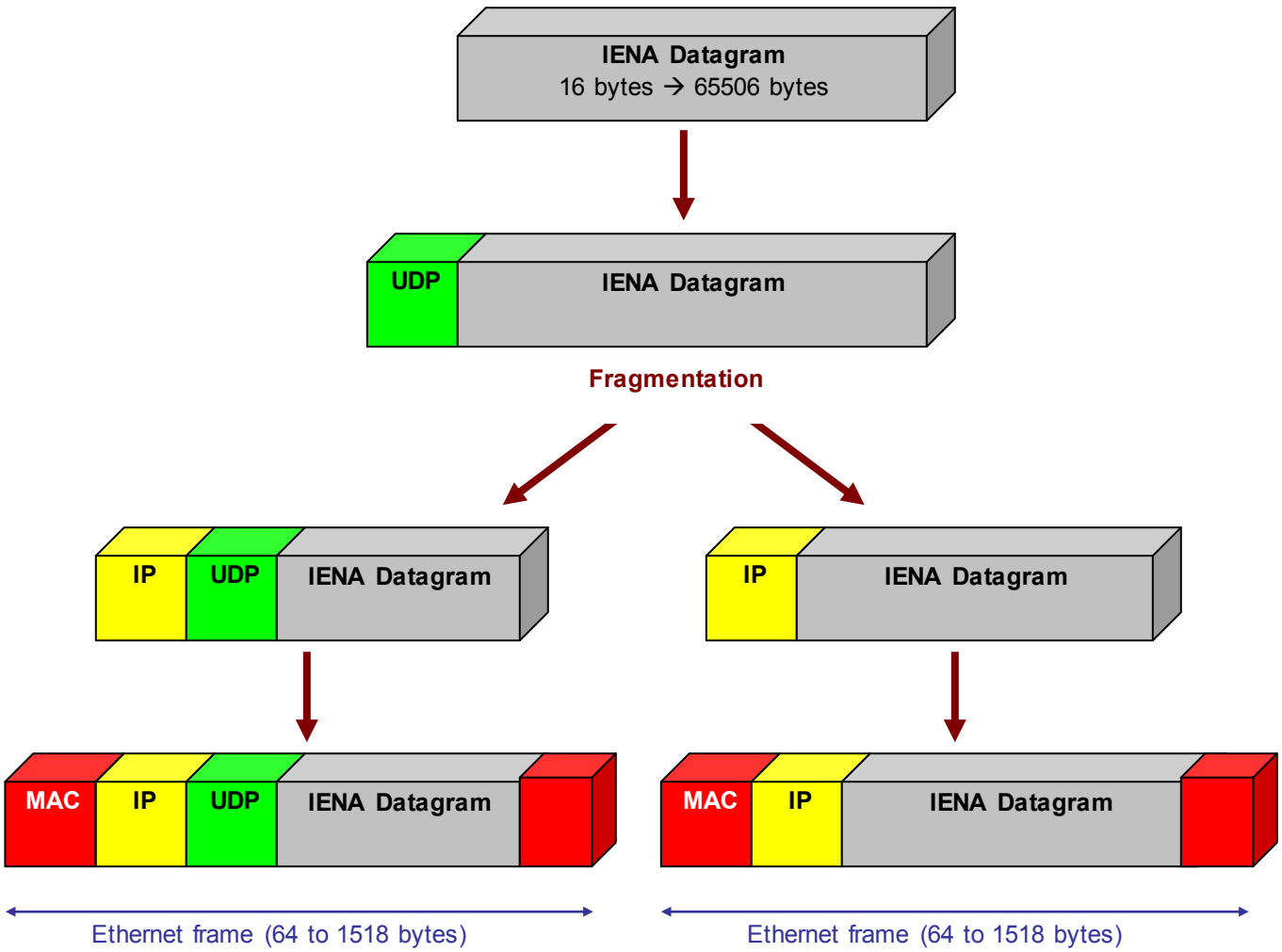
APPENDIX 1: ETHERNET STRUCTURE PRESENTATION

Fragmentation



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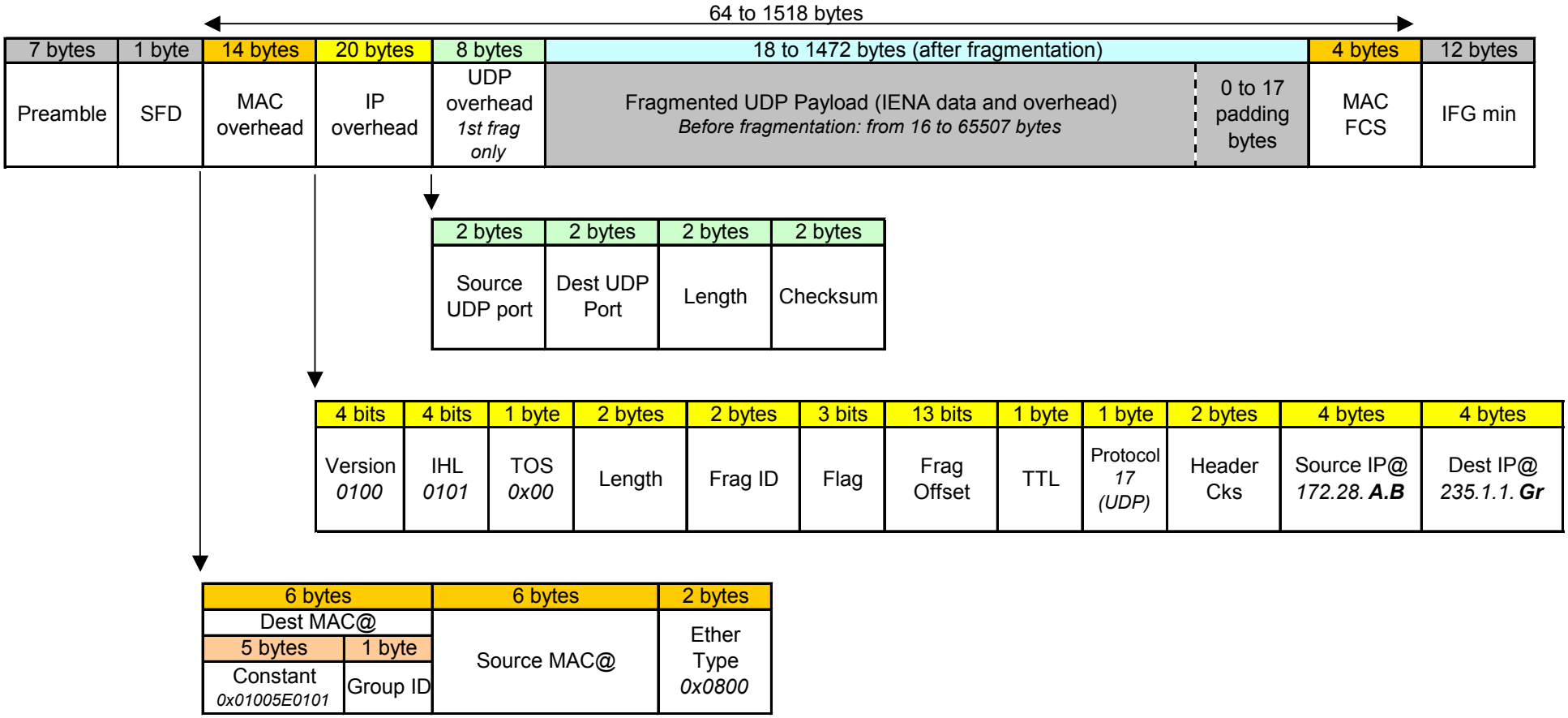
Ethernet structure



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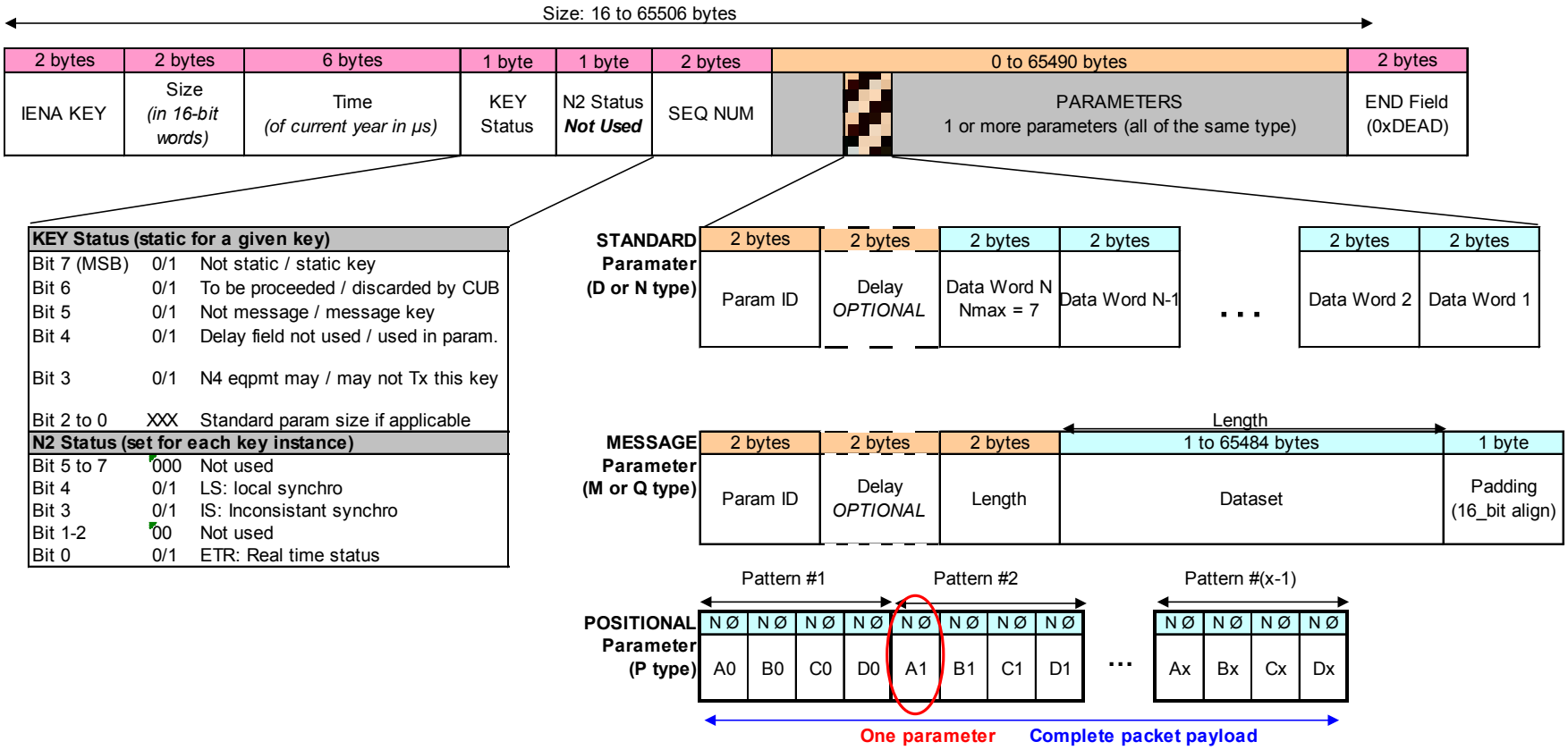
APPENDIX 2: IENA STRUCTURE PRESENTATION



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Validation Report

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