EADS CASA	**NOTA TECNICA** **TECHNICAL REPORT**	Núm. No.	NT-FA-ADR-05001
		Pág. 1 de Page 1 of 24	Edic. Issue E
	Departamento Department: **Airframe Electromagnetic Protection**	Avión Aircraft	A330-MRTT

Título/Title

A330-200 MRTT AIRCRAFT IN-FLIGHT REFUELLING INSTALLATION ELECTRICAL BONDING REQUIREMENTS

Palabras clave/Key words	Clasificación acceso Access class
A330-200, MRTT, Electrical bonding Requirements	**P1**

Resumen/Summary

This technical note contains the bonding electrical continuity requirements to be met by the A330-200 MRRT A/C. The maximum resistance values required during the whole A/C life (electrical continuity measurements) are defined. General Lightning protection features concerning structure and systems are summarized in this document as well.

Distribución/Distribution	Realización/Execution	Fecha/Date Feb. 07
A. San José / A. Padín	Realizado Prepared	Firma Signature
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REGISTRO DE REVISIONES/REVISIONS RECORD

Revisión	Motivo de Modificación/Change reason	Realiz./Prep.	Aprobado/App.
Fecha/Date	Capítulos,Secciones,Hojas afectadas/Chapters,Sections,Sheets affected	Firma/Sign	Firma/Sign
A	Primera edición / First issue	J. I. López-Reina/V. Quero	F. Sequeiros
Feb. 06			
B	General	V. Quero	F. Sequeiros
May. 06			
C		V. Quero	F. Sequeiros
Sep. 06	Page 6.1		
D		V. Quero	F. Sequeiros
Feb. 07	Pages 3.2, 3.5, 5.4, 5.7, 6.1 and 6.2		
E		V. Quero	F. Sequeiros
Feb. 07	Pages 3.6, 6.1 and 6.2		

INDICE

1 Subject

This technical note contains the bonding electrical continuity requirements to be met by the A330-200 MRRT A/C. The maximum resistance values required during the whole A/C life (electrical continuity measurements) are defined. General Lightning protection features concerning structure and systems are summarized in this document as well.

A reference to this document must to be included in the design drawings

1.1 List of acronyms and abbreviations

AAR	Air to Air Refuel
ARBS	Advanced Refuelling Boom System
MRTT	Multitrole Tanker Transport
A/C	Aircraft
AC	Advisory Circular
ACJ	Advisory Circular Joint
FAR	Federal Aviation Regulations
JAR	Joint Airworthiness Requirements
ACT	Aircraft Central Tank
JAA	Joint Airworthiness Authorities
FAA	Federal Aviation Administration
UARRSI	Universal Aerial Refuelling Receptacle Slipway Installation

1.2 Definitions

Action Integral — The Integral of the square of the time varying current over its time duration ($\int_0^T I^2 dt$). It is usually expressed in units of ampere squared seconds (A^2s).

Arc — The ionised path between conductive elements isolated from each other, arising due to potential differences, which may be caused by large currents in the airframe or by changing magnetic fields.

Attachment — The contact of the lightning flash with the aircraft.

Bonding Jumper — Flexible metallic strip.

Directs Effects — Any physical effects to the aircraft and/or equipment due to the direct attachment of the lightning channel and/or conduction of lightning current. This includes dielectric puncture, blasting, bending, melting, burning and vaporisation of aircraft or equipment surfaces and structures. It also includes directly injected voltages and currents in associated wiring, plumbing, and other conductive components.

Electrical Bonding — Bonding refers to the establishment of a current path between electric conductive parts in order to assure electrical continuity. This may be between two points on a system ground plane as well as between ground reference and a part, circuit or structure element.

Electrical Continuity — means, that structural joints or joints of pipes or other conductive members of the airframe do not hinder the flow of electric current across the joint. The electrical properties of a joint are defined by its bonding resistance and its current carrying capability.

External Environment — Characterisation of the natural lightning environment for design and certification purposes.

First Return Stroke — The high current surge that occurs when the leader completes the connection between the two charge centres. The current surge has a high peak current, high rate of change of current with respect to time (di/dt) and high action integral.

Grounding — Grounding refers to the establishment of a current path to a reference potential (ground reference). The ground reference for aircraft is the metallic aircraft structure.

Indirect Effects — Electrical transients induced by lightning in aircraft conductive components such as electric circuits.

Leader — The low luminosity, low current precursor of a lightning return stroke, accompanied by an intense electric field.

Lightning Channel	The ionised path through the air along which the lightning current pulse passes.
Lightning Flash	The total lightning event. It may occur within a cloud (intra), between clouds (inter) or between a cloud and ground. It can consist of one or more return strokes, plus intermediate or continuing currents.
Lightning Strike	Any attachment of the lightning flash to the aircraft.
Swept Leader	A lightning leader that has moved its position relative to an aircraft, subsequent to initial leader attachment, and prior to the first stroke arrival, by virtue of aircraft movement during leader propagation.
Swept Stroke	A series of successive attachments due to sweeping of the flash across the surfaces of the aircraft by the motion of the aircraft.
Zoning	The process (or the end result of the process) of determining the location on an aircraft to which the components of the external environment are applied.

2 Airworthiness Requirements

2.1 FAR/JAR/CS Requirements

The documents/specifications and normative paragraphs or sections applicable to the provide a secure lightning protection to the aircraft are the following ones:

Applicable Airworthiness Regulations:

JAR/FAR/CS 25.581	"Lightning Protection"
JAR/CS 25.899	"Electrical Bonding and Protection against Lightning and static electricity"
JAR/FAR/CS 25.954	"Fuel systems lightning protection"
SFAR-88	

Acceptable means of compliance and Advisory Material / Policy

ACJ 25.581	"Lightning Protection"
ACJ 25x899	"Electrical Bonding and Protection against Lightning and static Electricity" (Tables 1 and 2 shall be replaced by those specified in JAA INT POL 25/3)
ACJ 25.954	"Fuel systems lightning protection"
AC20-53A	"Protection of Airplane Fuel Systems against Fuel Vapour Ignition due to Lightning"

Acceptable means of compliance and Additional Materials:

- Military Certification Review Item (MCRI):

  MCRI F-1 "Lightning Protection"

- EUROCAE / RTCA document:

  ED-14/DO-160D "Environmental Conditions and Test Procedures for Airborne Equipment"
  (Section 23) (Lightning Direct Effects)

- EUROCAE / RTCA document:

  ED-84/ARP5412 "Aircraft Lightning Environment and Related Test Waveforms Standard"

ED-91/ARP5414	"Aircraft Lightning zoning Standard"
ED-113/ARP5577	"Aircraft Lightning Direct Effects Certification"

Other documentation: Recommendations / Baseline Guidelines

TDD20S001F	"Electrical Bonding Lightning Strike and external radiation. Electrostatic Discharge A330 / A340"

2.2 References

Ref. 1 I+D-P-355: Bonding and Grounding installation

Ref. 2 NT-BM-ADR-04001: Advanced Refuelling Boom System (ARBS). Electrical Bonding Requirements

Ref. 3 NT-FA-SAM-06002: Bonding and Grounding Measurements requirements for the electric and electronic systems of the A330 MRTT conversion.

Ref. 4 NT-FA-SAM-05002: Antenna Installation Requirements for A330-200 MRTT RAAF

3 A330-200 MRTT General Lightning Protection Description Electrical Bonding Requirements.

A330-200 MRTT presents new and modified structural and system elements respect to the previous original A330-200 civil A/C which meets the requirements stated in TDD 20S001F (see paragraph 2.1). The general lightning protection features applied to the specific/modified elements of the MRTT A/C and the maximum resistance values to be met are defined hereafter.

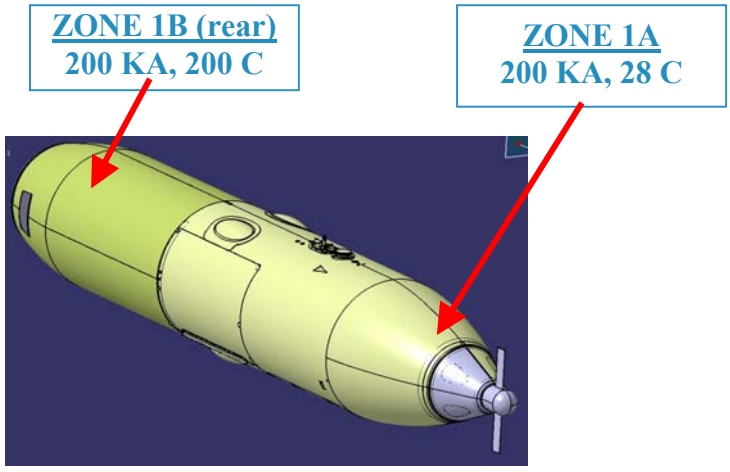
Therefore there is not need to repeat bonding measurements all over the aircraft; only the ones specified in this document have to be performed to ensure that the A330-200 MRTT aircraft also meets the requirements of the a.m. TDD.

3.1 Structure

Pod

The pod external skin is made of aluminium and fitted to the pylon through two fittings. A maximum resistance of **10 mOhm** (Measure No. 1- 1 a. See Summary Table 1) is requested between pod and pylon.

The front fitting is attached to the pod skin via 4 INCONEL bolts of 19 mm diameter. The rear fitting has 2 INCONEL bolts of 19 mm diameter.



Pylon

Pylon is manufactured in aluminium alloy except its leading edge skin and the rear trailing edge fairing (made of carbon fibre composite structure and protected by means of 80 gr/m^2 bronze mesh) with all pieces bolted and electrically bonded together.

Insulation breaks and non conductive PEEK sections have been installed in the fuel pipes to prevent lightning current to enter the wing fuel tank.

A maximum resistance of 10 mOhm (Measures No. 1- 2 a, No. 1- 2 b, No. 1- 2 c and No. 1- 2 d. See Summary Table 1) is requested between main metal parts. Between the static discharger base and the main metallic structure the resistance shall not exceed 150 mOhm (see measure No. 1- 2 e in summary Table 1).

Wing fittings, wing skin and access doors

Pylon attachment to the lower skin is based on three points of union, front fitting is the same principle as in A310 MRTT and the rear fitting is identical than the A340 engine pylon attachment system used. Central fitting is attached to the wing lower skin via six titanium bolts with a diameter of 9.5 mm (4 units) and 7.9 mm (2 units).

Four copper 22 mm^2 section-bonding braids are provided between pylon and wing structure.

The Front fitting is located at the leading edge area, is achieved via pylon front spar that attaches to the lower area of the wing front spar. This element is joined to the lower skin via 3 inconel bolts with a diameter of 22 mm.

A maximum resistance of 10mOhm (Measurement No. 1- 3 a. See Summary Table 1) is requested between wing and pylon.

3.2 System Installation

Fuel supply and Pressure Control for Aerial Refuelling

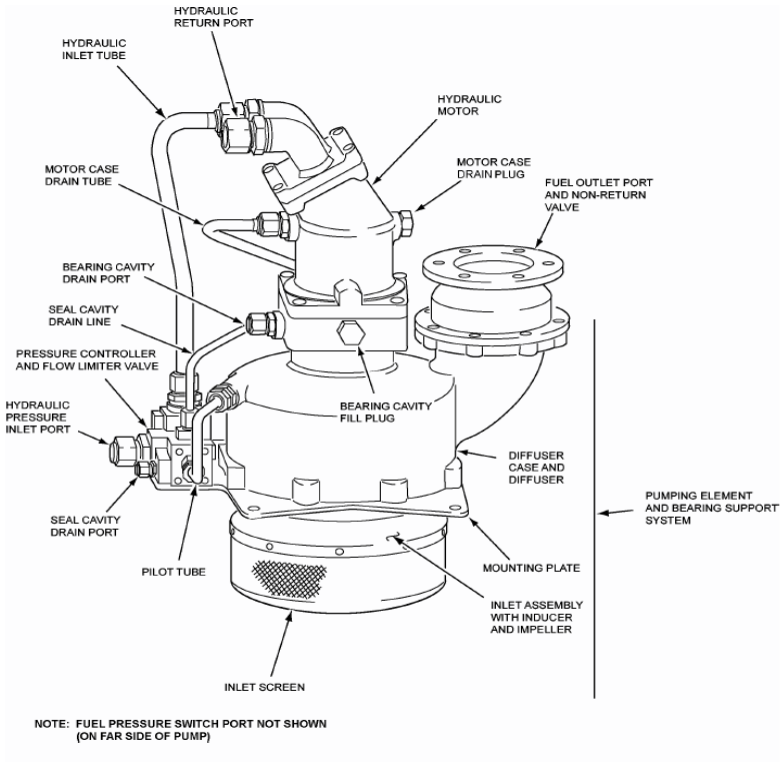
AR pump system

The AAR fuel pumps convert hydraulic power to transfer fuel from the inner and centre tanks to the aerial refuelling stations.

Two(2) pumps are installed inside of each inner wing tank. Two (2) more pumps are installed the centre tank. These pumps supply fuel to refuel gallery and from there to the underwing pods and ARBS.

The pump assembly is mounted in the vertical orientation, immersed in fuel, close to the bottom of the fuel tank. A total of six specific fuel pumps are installed. A maximum resistance of 10 mOhm (Measurement No. 1- 4 a See Summary Table 1) is requested between all these elements and the main metallic aircraft structure.

The requirement for valves is in Measurement No. 1- 4 b.



Air refuelling-Fuel dispense system in Pylon

A330-200 MRTT Pylon fuel lines (vent and refuel) are made of aluminium alloy. Vent line diameter is 0.5 inch and refuel line is 3 inch.

Refuel line lightning protection is based on a single bonding point philosophy for electrostatic discharge purposes and two non conductive sections of pipe (lightning insulators) are located at both line extremes to prevent lightning currents flowing through the pipe. The fuel line routed through the pylon leading edge is isolated from the structure, with a single redundant bonding point via two bolts at the upper leading edge rib support. Two insulator breaks are installed at the upper and lower locations of the fuel line to prevent lightning currents flowing through the pipe. See Figure 5.1.3.

Same principle is applied to the vent line running from the Pod upper area to the wing front spar.

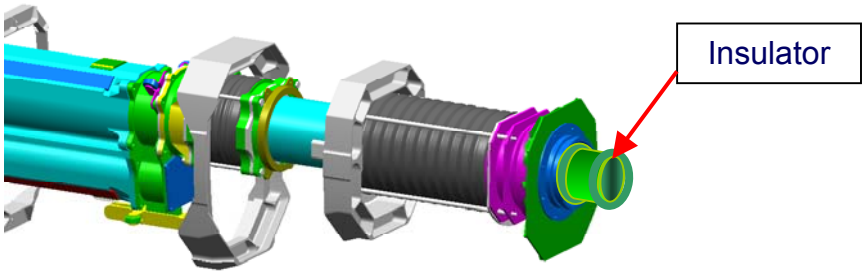
Electrical bonding measurements required for this equipment will be the following in Table 1. Measurements from No. 1- 5 a to No. 1- 5 f.

Advantage refuelling boom system (ARBS)

Tail Boom external structure is made of aluminium providing protection to the internal equipment and fuel pipes in retracted condition. Double bonding connection (13 mm^2 bonding braids) is provided between boom and aircraft structure.

An Insulation break has been implemented in the fuel pipe (Pipe section of non-conducting material).

Elevators are made of aluminium.



Electrical bonding measurements required for this equipment are enclosed in Ref. 1: NT-BM-ADR-04001.

The Electrical bonding requirements for the Boom installation are enclosed in Table 1, measurements from No. 1- 6 a to No. 1- 6 i.

Air to Air Refuelling (Receipt)

Universal aerial refuelling receptacle slipway (UARRSI)

UARRSI is a metallic component bolted and electrically bonded to a reinforced surrounding fuselage structure.

An insulator break made of PEEK (30% CFC reinforcement) is inserted in the main transfer/refuel line at non-pressurized area. This element prevents from high lightning currents flowing through the internal routing refuel pipe/devices at its pressurized area routing.

A movable metallic cover externally protects UARRSI Fuel devices when no refuelling is carried out. Therefore, Direct lightning strike to internal fuel system may not occur. See Figure 5.1.4.

The electrical bonding measurements that will be required for this equipment are enclosed in Summary Table 1 (measurements from No. 1- 7 a to No. 1- 7 d).

3.3 Other elements externally Mounted

Lights&Cameras

The Lights&cameras installed are enclosed in ATA 33 and ATA48 (AR Lights&cameras).

The Grounding requirements are enclosed in NT-FA-SAM-06002 (See Ref. 3) together with Summary Table 1. See measurement No. 1- 8 a.

Antennas

The Bonding requirements for Antennas and sensors are enclosed Table 1, Measurement No. 1- 9 a.

FTI Installation

The FTI cameras will be installed in aircraft MSN001. The Bonding requirements for FTI Cameras are enclosed Table 1, Measurement No. 1- 10 a.

4 Applicable Lightning Zoning

Lightning environment originally considered for A330-200 without pylon and refuelling pod is described in TDD20S001F, depending on the lightning strike probability three different zones are defined:

- **Zone 1**: Surfaces of the A/C for which there is a high probability of initial lightning flash attachment (entry or exit).

- **Zone 2**: Surfaces of the A/C across which there is a high probability of a lightning flash being swept from a zone 1 point of initial attachment.

- **Zone 3**: This includes all of the A/C surface areas not covered by zones 1 and 2. In these areas, there is a extremely remote of direct or swept strokes.

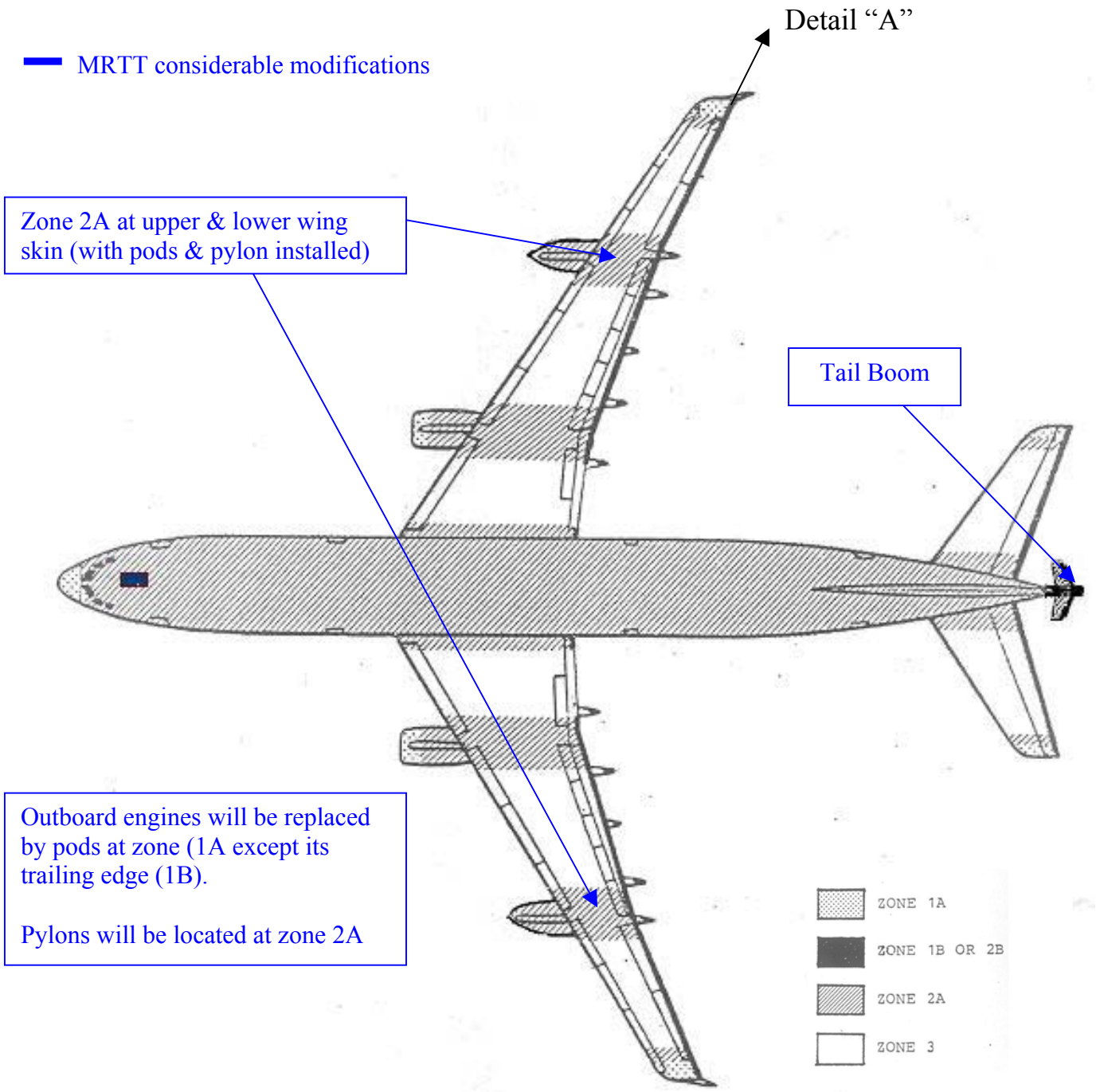
Note: Zones 1 and 2 are subdivided into A and B regions depending on the probability that the lightning flash will hang on for a certain period of time.

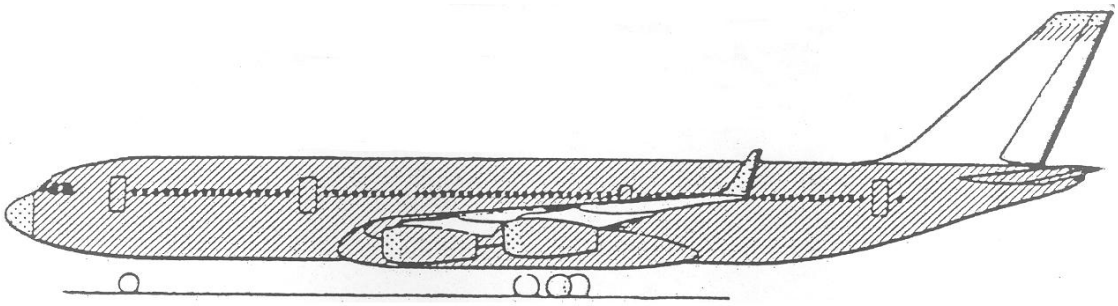
Previous lightning zoning probability is showed in Figure 5.1.1.

When considering in-flight refuelling pod, lightning environment is no longer modified due to mentioned elements will be installed replacing outboard engines of A340 (each side) at Rib 25 position. Therefore Zone 2 A (upper and lower skin) will be maintained in the same extension areas at outboard engine wing skin (see Figure 5.1.1). In addition, the pod will be considered as protruding part of the A/C in zone 1A, with its trailing edge in zone 1B and the pylon assumed as swept stroke zone (2A).

5 Figures

Figure 5.1.1 A330-200 Lightning Zoning





Detail "A"
Wing Tip Lightning Strike Zones (Slats Out)

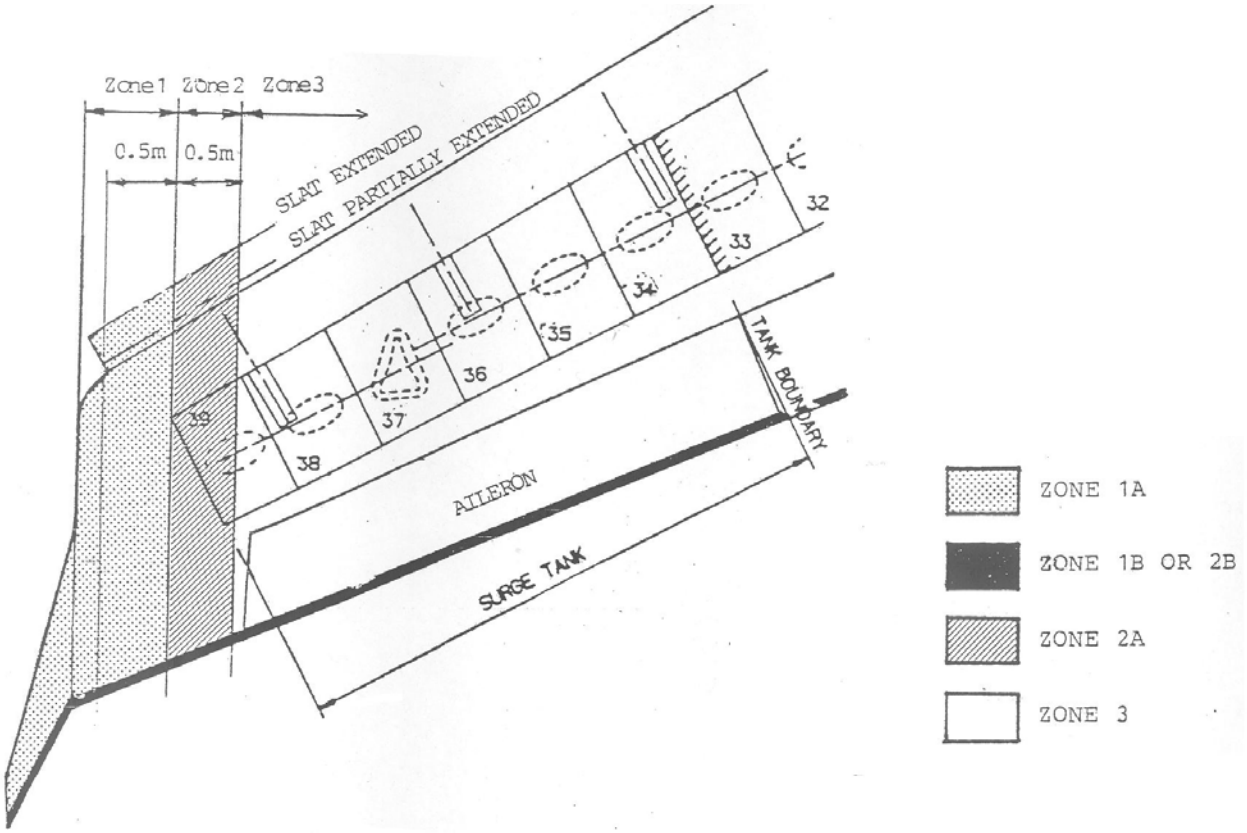
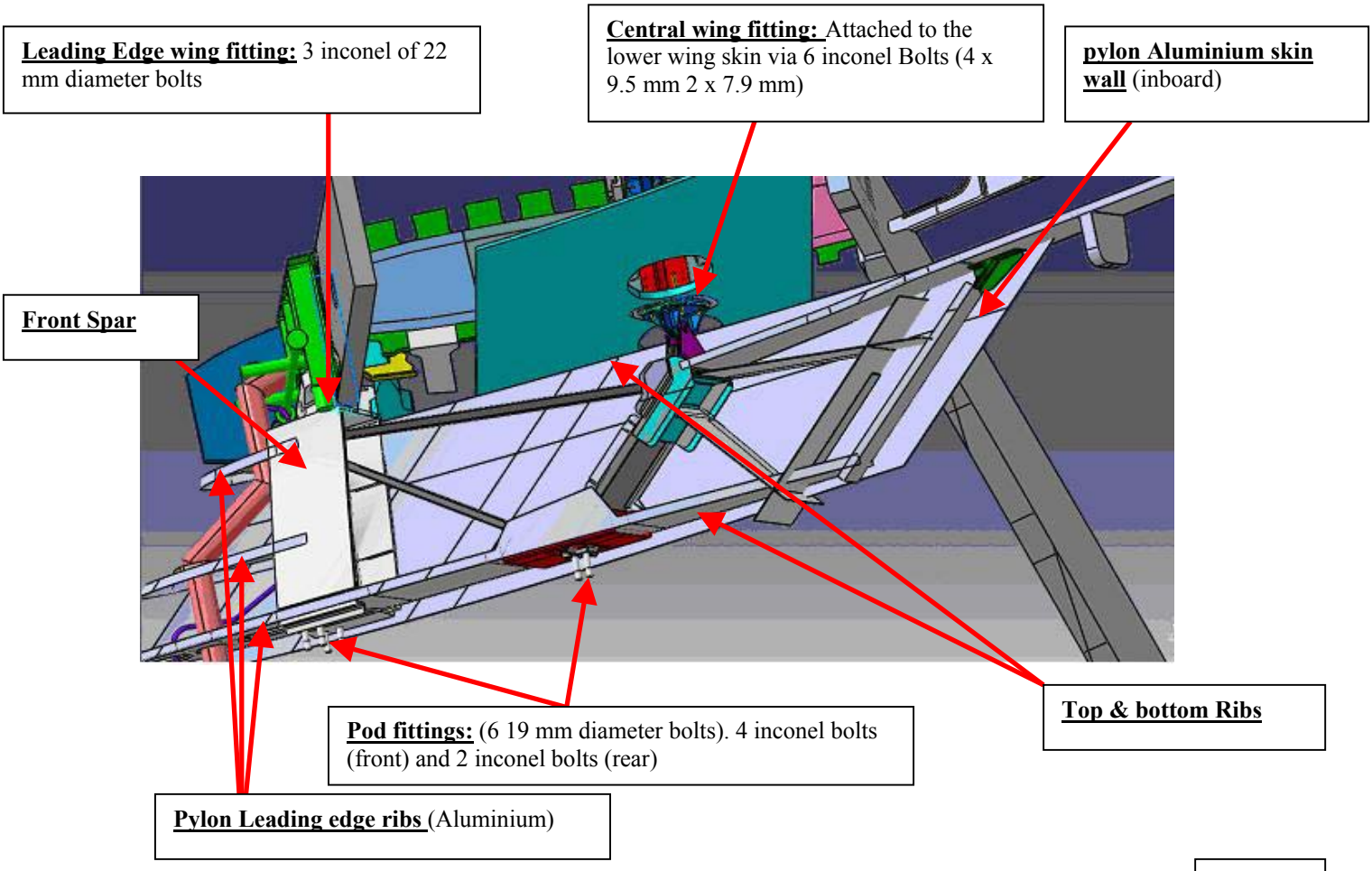


Figure 5.1.2 Pylon



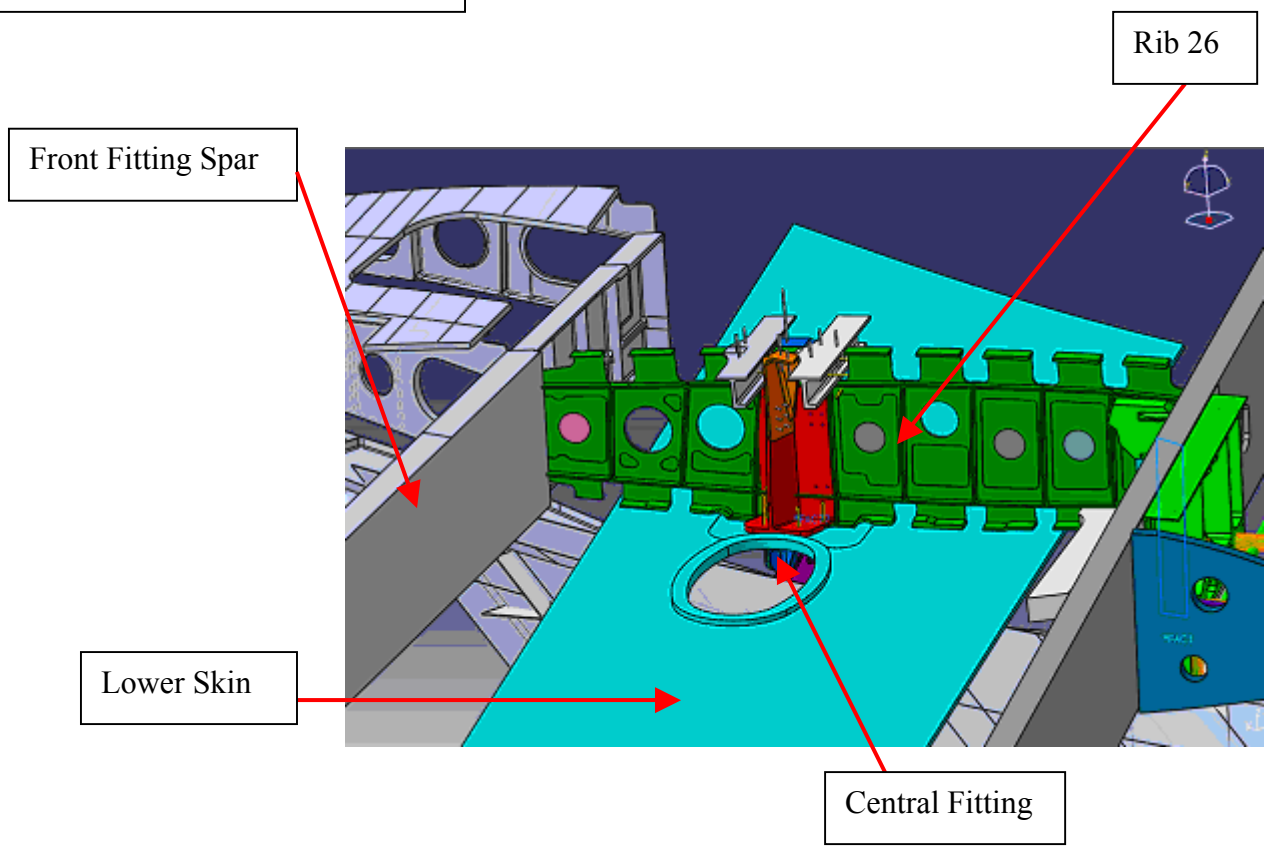


Figure 5.1.3 Pylon Air refuelling-Fuel dispense system

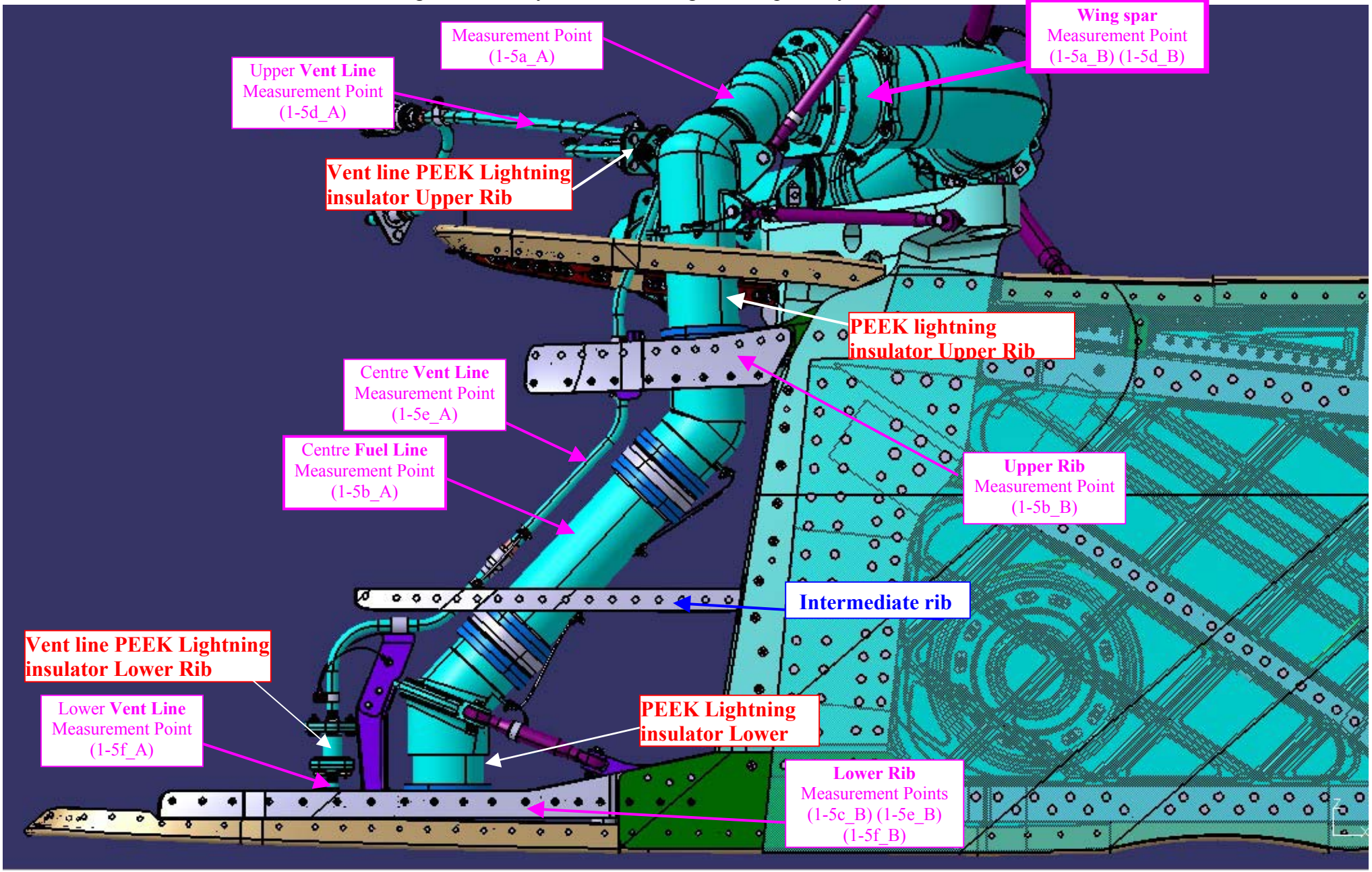


Figure 5.1.4 Boom Installation

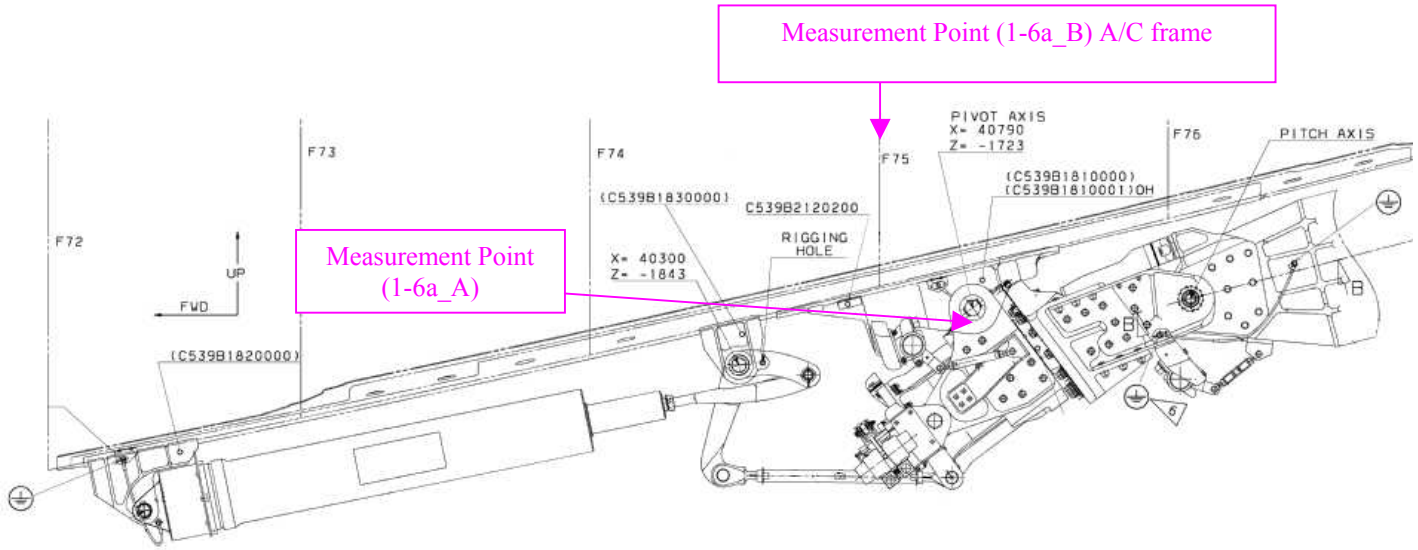


Figure 5.1.5 Section 18 installation

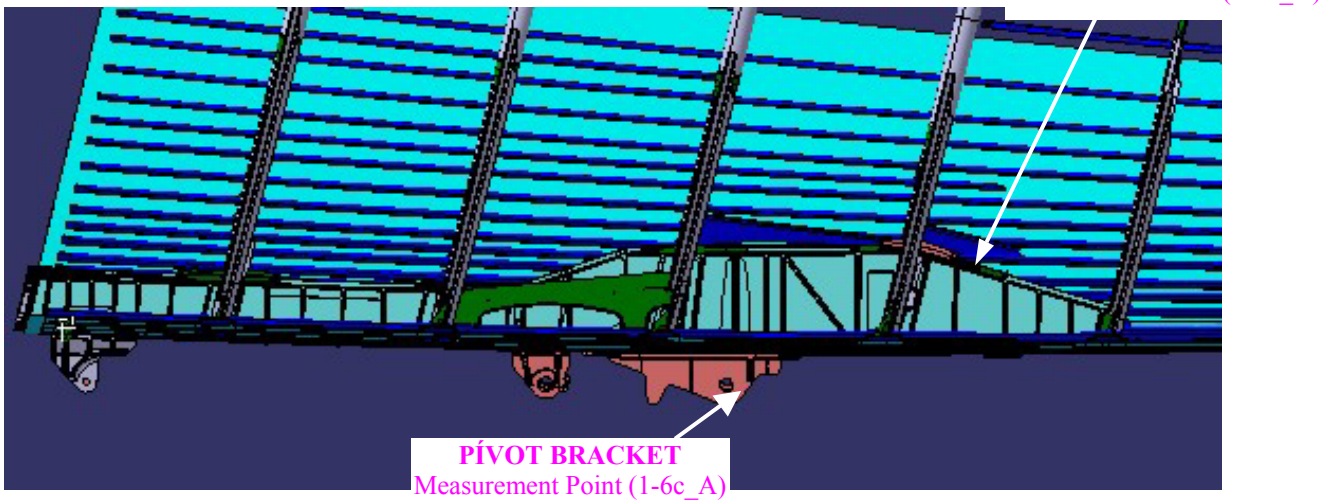


Figure 5.1.6 Section 19 installation

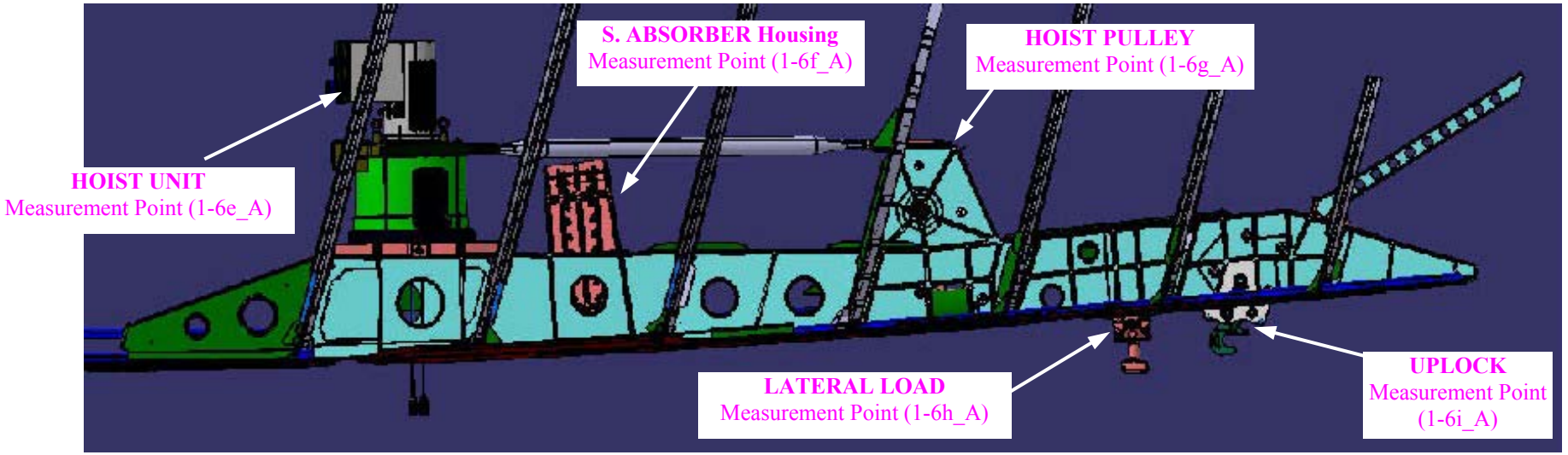
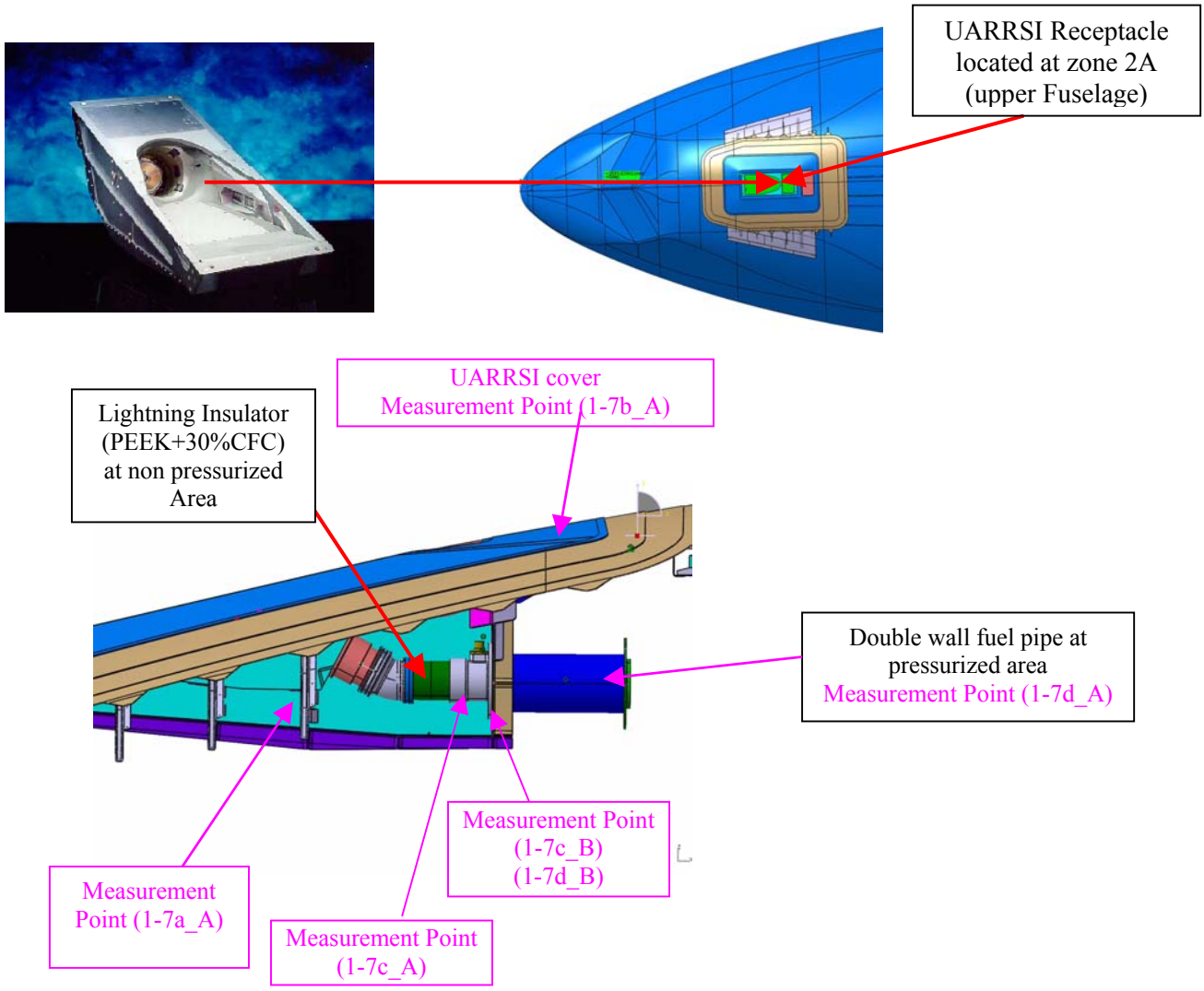


Figure 5.1.7 UARRSI



6 Annex

6.1 Annex 1

The Electrical resistance measurement shall be carried out between each point in column A bellow and the corresponding point (s) in column B.

Table 1: Bonding requirements

Measurement Nº		Element A	Element B	Max Resistance Value (mΩ)
No. 1- 1 a		Pod	Pylon	10
Figure 5.1.2	**No. 1- 2 a**	Al Skin	Central Wing Fitting	10
	No. 1- 2 b	Front Spar	"	10
	No. 1- 2 c	Rib 26	"	10
	No. 1- 2 d	Pod Fitting	"	10
No. 1- 2 e		Aft CFRP Pylon Fairing Static discharger	"	150 (*)
No. 1- 3 a		Pylon	Wing	10
No. 1- 4 a		Fuel pump	Main metallic structure	10
No. 1- 4 b		Valves	"	10
Figure 5.1.3	**No. 1- 5 a**	Upper Fuel pipe (steel) section	Metallic Wing Spar	100
	No. 1- 5 b	Center Fuel pipe (steel) section	Upper Pylon LE Rib	100
	No. 1- 5 c	Lower Fuel pipe (steel) section	Lower Pylon LE Rib	100
	No. 1- 5 d	Upper vent pipe section	Metallic Wing Spar	10
	No. 1- 5 e	Center vent pipe section	Lower Pylon LE Rib	10
	No. 1- 5 f	Lower vent pipe section	"	10

Measurement Nº		Element A	Element B	Max Resistance Value (mΩ)
No. 1- 6 a (Figure 5.1.4)		Roll/Pitch joint	Aircraft structure	1
Figure 5.1.5	**No. 1- 6 b**	Torque box	"	10
	No. 1- 6 c	Pivot Bracket	"	10
	No. 1- 6 d	Refueling mast fuel pipe connection	"	10
Figure 5.1.6	**No. 1- 6 e**	Hoist main unit	"	10
	No. 1- 6 f	Shock absorber Housing	"	10
	No. 1- 6 g	Hoist Pulley Housing	"	10
	No. 1- 6 h	Lateral Load	"	10
	No. 1- 6 i	Up-lock	"	10
Figure 5.1.7	**No. 1- 7 a**	UARRSI	"	10
	No. 1- 7 b	UARRSI movable metallic cover	"	10
	No. 1- 7 c	UARRSI fuel line (steel)	UARRSI receptacle	100
	No. 1- 7 d	Double wall pipe Steel Al	Main metallic structure	100 10
No. 1- 8 a		Lights/Cameras metallic assembly	Adjacent metallic structure	10
No. 1- 9 a		Antennas metallic base and sensors	"	2.5
No. 1- 10 a		The FTI cameras metallic casing	"	10

Note (*): This requirement is also met by measuring static discharger base against one of the dimpled bonding washer before Aft Fairing installation.