2. MECHANICAL INTERFACE DESIGN.

SECTION 2 CONTENTS

2.1 EXPERIMENT MECHANICAL & STRUCTURAL DESIGN

2.1.1 Mechanical description

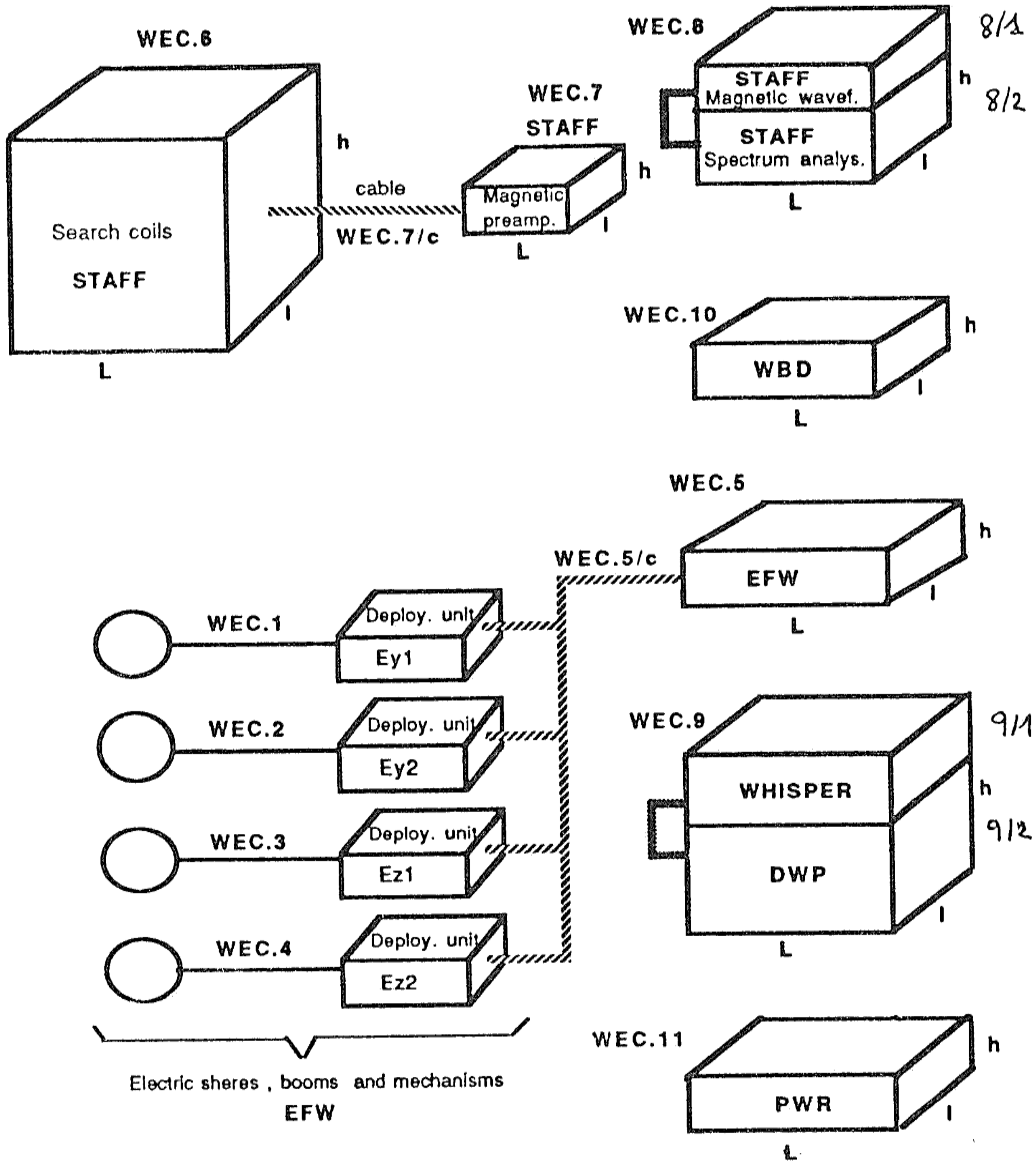
The Wave Experiment is composed of 11 mechanical elements schematically represented on Fig 2.1/2, summarised in tab 2.1/2 and listed below.

The different parts of the WEC are interconnected by a large number of wires. The internal harness is in charge of the WEC in term of resources but, apart from the connections inside the stacks, it cannot be realised by the experimenters. Obviously the Consortium has to define in detail the number, type, mapping of all the cables, but the contractor has to build the harness as a part of the satellite platform. The WEC/harness mass resource estimates are given in Sec. 2.4. Refer also to section 3.5 for more details.

WEC ref	experiment	description
WEC 1 2 3 4	EFW also used by WHISPER/TX	2 pairs of booms, 50 m each In orthogonal directions + electronic circuits
WEC 5/c	EFW	cables: deploy. units to main elect. box
WEC 5	EFW	main electronic box
WEC 6	STAFF	search coil antennas
WEC 7/c	STAFF	cable : magnetic sensor to preamplifier
WEC 7	STAFF	magnetic preamplifier
WEC 8/1	STAFF	magnetic waveform
WEC 8/2	STAFF	spectrum analyser
WEC 8/c	STAFF	common parts for the stack WEC.8
WEC 9/1	WHISPER	relaxation sounder
WEC 9/2	DWP	digital wave processor
WEC 9/c	WHISPER/DWP	common parts for the stack WEC.9
WEC 10	WBD	wide band data experiment
WEC 11	PWR	WEC power supply
harness	all	WEC interconnections

Tab 2.1/2 WEC nomenclature

Fig 2.1/2 WEC PACKAGING



a/ WEC 1/4

WEC 1 to 4 are the four Radial Wire Booms supplied by the EFW experiment. Each deployment mechanism deploys a @50 meters long wire boom which has a small spherical sensor with amplifier at the end. The shielding of two wires is used as a transmitting wire dipole for WHISPER. According to the current Payload accommodation and in order to minimize the effects of the WHISPER pulse on CIS, PEACE and RAPID, the transmitter will be connected with WEC 3 and WEC 4.

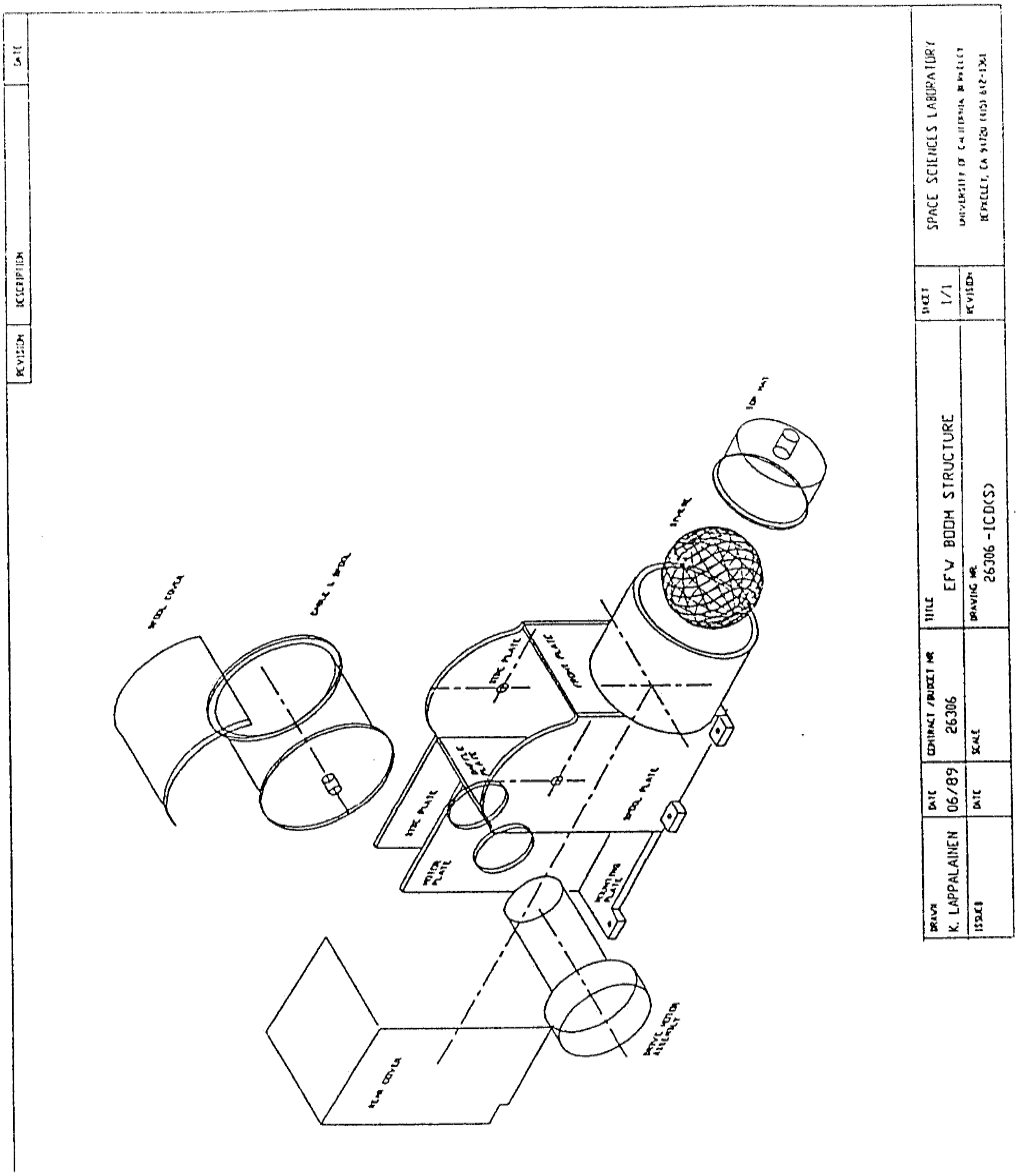
STRUCTURE AND MOUNTING

Each deployment unit is a compact, self-contained boxlike structure which should not require significant structural analysis. The lowest observed resonance in a previous mechanism was above 250 Hz. Operational wire boom forces on the mechanism are generally small compared to dynamic forces caused by launch vibration. The structure consists of machined aluminium plates, leaving stiffening ribs for strength and stiffness. Many of the ribs are external so as to avoid corners and edges inside which might catch or damage the boom cable. The arrangement of structural plates is shown in Figure 2.1/1.b. The plates are assembled with numerous screws into locking heli-coil inserts to minimize the possibility of rattling fasteners. The number of mounting holes is dictated by the spacecraft inserts selected by the project, rather than mechanism strength.

BOOM CABLE

The cable contains a 50 ohm coax, eight single conductors, and two braided jackets as shown in Figure 2.1/1.c. It is a special construction which is lightweight, strong, and flexible. The inner Kevlar braid provides the mechanical strength, and the outer silver plated copper braid provides mechanical protection. Aluminized Kapton tape is wrapped between the braids to provide a fully conductive cable outer surface.

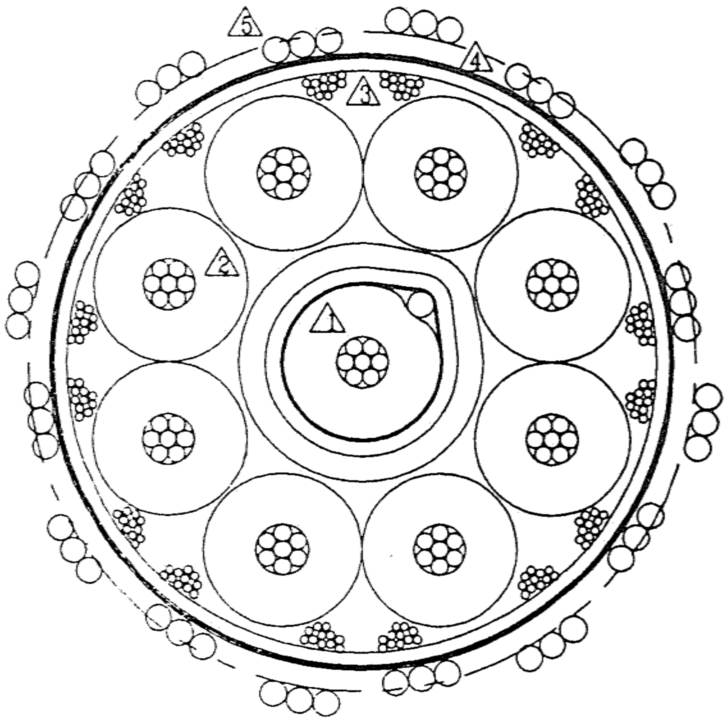
Fig 2.1/1.b EFW Deployment Unit - structural plates



REVISION	DESCRIPTION	DATE

Fig 2.1/1.c EFW Deployment Unit - Boom Cable

PREVIOUS WIRE BOOM CABLE CONSTRUCTION



1 **CENTER COAXIAL CABLE**

CENTER WIRE: AWG 36 (7/44) SILVER PLATED COPPER WIRE
DIELECTRIC: .006 THICK DOUBLE EXTRUDED PTFE TEFLON
DRAIN: SERVED AWG 38 SILVER PLATED COPPER WIRE
SHIELD: .0015 x .12 ALUMINIZED KAPTON TAPE (AL IN) - 50% OVERLAP
JACKET: .002 x .25 HEAT SEALED PTFE TAPE WRAP - 50% OVERLAP

2 **EIGHT SINGLE CONDUCTORS** (1 TWIST PER 1" TO 2" CABLE LAY)

CENTER WIRE: AWG 36 (7/44) SILVER PLATED COPPER WIRE
INSULATOR: .006 THICK DOUBLE EXTRUDED PTFE TEFLON

3 **LOAD CARRYING BRAID**

16 ENDS OF 200 DENIER DUPONT KEVLAR - 30° BRAID HELIX

4 **OUTER ELECTROSTATIC BARRIER**

.002 x .25 ALUMINIZED KAPTON TAPE (AL OUT) - 25% OVERLAP, NO SEAL

5 **OUTER BRAID** (70% COVERAGE)

48 ENDS (16x3) AWG 40 SILVER PLATED COPPER - 36 PICKS / INCH

0.085 in. (2.2 mm) NOMINAL CABLE OUTER DIAMETER

US STD THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES BILATERAL TOLERANCES ARE: FRACTIONS DECIMALS ANGLES	MATERIAL / FINISH	DRAWN: D PANKOW	DATE: 6/89	CONTRACT /BUDGET NR	TITLE: WIRE BOOM CABLE	SHEET	SPACE SCIENCES LABORATORIES
		ISSUED	DATE	SCALE - DO NOT SCALE - 50 : 1	DRAWING NR: PRELIMINARY	REVISION	UNIVERSITY OF CALIFORNIA, BERKELEY BERKELEY CA 94720 (415) 642-1361

b/ WEC 5

WEC 5 is the electronic Aluminium alloy box of EFW and **WEC 5/c** is the cables connecting the deployment units to the main box.

c/ WEC 6

WEC 6 is the search coil sensor provided by STAFF and mounted on one deployable rigid boom.
The sensor is composed of 3 cylindrical antenna assembled in a glass fiber epoxy box wrapped with thermal blanket.
The sensor must be placed, at least, at about 2.5 meters from the spacecraft body. This distance between the sensor and the body of the satellite is usually considered as acceptable from the point of view of EMI specifications.

d/ WEC 7

WEC 7 is the magnetic preamplifier, an Aluminium alloy box.
It is connected to the search coil sensor (WEC 6) with a special cable **WEC 7/c**.
The preamplifier is located inside the spacecraft, as close as possible from the root of the boom.
The 7 twisted shielded pair used to build the harness is supplied by the experimenter. Since the capacitance of the cable has an important effect on the band pass of the instrument, its length should not exceed about 6 meters.

e/ WEC 8

WEC 8 is a stack of 2 boxes from STAFF: - the electronic of Magnetic Wave Form (STAFF/mwf - WEC.8/1) and the spectrum analyser (STAFF/spa - WEC.8/2). The 2 boxes are made of Magnesium alloy.

f/ WEC 9

WEC 9 is a stack of 2 boxes including WHISPER (WEC.9/1) and DWP (WEC.9/2). The 2 boxes are made of Aluminium alloy.

g/ WEC 10

WEC 10 is the unit of WBD experiment. The box is made of Magnesium alloy.

h/ WEC 11

WEC 11 is the Power Supply (PWR). The box is made of Aluminium alloy.

2.1.2 Mechanisms description

The WEC 1/4 are the only mechanisms of the WEC.

The fig 2.1/1.a show the mechanism design.

CABLE DRIVE ASSEMBLY

The Drive Assembly uses a DC Permanent Magnet Gearmotor. The motors are fitted with vacuum service composition brushes containing carbon, silver, and molybdenum disulfide. MoS dry lubricated bearings are used for the motor armature. A suitable vacuum service grease is used in the gearhead. Each motor is thoroughly inspected and tested for operation in both air and vacuum. Electromagnetic filters and a metallic barrier contain EMC Previous motors have passed MIL-STD-461A, Notice 3 EMC requirements while running. A three layer magnetic shield contains stray fields. With the magnetic shielding, the motor frame and shields must be disassembled to be successfully depermed. Given of large margins on motor power, overheating has not been a problem.

The cable is fed from the mechanism by an elastomer surface "meter wheel". Meter wheel friction forces are enhanced by three spring loaded "pinch rollers" providing a normal force at the cable and meter wheel surfaces. A tension and end of wire microswitch is provided in the input of the drive mechanism. This switch protects the cable, should it jamb in the mechanism, and also senses end of wire by the increased wire tension in the mechanism. A shear pin (shearing at a cable tension difference of about 250 N is also incorporated in the drive mechanism to protect both the cable and the drive mechanism from accidental damage, even in the event of total loss of command and control.

In a classical, frictionless analysis this motor is absorbing energy which is the result of centrifugal forces on the cable and sensor (by regulating the deployment velocity) rather than producing work. The drive motor has a high ratio five stage planetary gearhead which is self locking rather than overhauling, under all conditions. Thus, the work produced by the motor serves only to overcome friction, and motor power actually decreases slightly as cable tension is increased. However, it is instructive to consider the case where the mechanism would reel in cable to illustrate design margins.

The operational wire tension in the mechanism is about 60 N. The suggested deployment sequence in Section 10.1 produces a peak deployment tension of about 100 N. Rated continuous gearhead capacity (based on metal fatigue considerations) corresponds to 275 N wire tension. Maximum motor power is developed at a cable tension of 310 N, and the stall torque corresponds to 900 N wire tension. With these factors, we may conservatively rate and test the mechanism for 175 N repeatable wire tension. The mechanism will also push cable out of the front with a force of 10 to 15 N because the close fitting cable guides prevent buckling of the cable when pushed. These design constraints are illustrated in Figure 2.1/1.e.

CABLE GUIDES AND STORAGE SPOOL

A friction calliper on the cable spool prevents unwinding of the cable in vibration. The cable is manually level wound and the spool covers have only a small clearance, such that crossing of cable loops in vibration is unlikely. The rotating cable spool has redundant gold alloy slip rings on either side to transfer electrical signals from the cable to the output. The cable is pulled from the spool by the drive motor and back bent in the first wire guide to provide a straightening effect. This wire guide also serves as the tension monitor, which turns off the drive motor. The cable guides are all close fitting, so that the cable cannot double back, buckle, kink, knot, or otherwise jamb.

SENSOR AND TOP HAT CAGING MECHANISM

In vibration, the sensor is held by on either side by its rigid stubs. The inboard stub slides into the hinged wire guide of the caged damper, so that it is supported over the full length. The outboard stub is held by "collet like" pads on the clamshell clamps. The clamshell clamps also rigidly hold the top hat so as to avoid damaging the top hat release mechanism during vibration.

When released, each clamshell half is opened by a torsion spring which provides an opening torque over the full rotation. The springs also hold the clamshells fully open against elastomer bumpers. In addition, compression springs provide a short, higher kick force on the clamshells to overcome any initial friction. The clamshells are held closed in vibration by redundant stranded stainless steel cables.

The cables are cut by redundant electro-explosive devices (pyro's) (ref to section 3.2) to release the sensor and top hat. Firing both EED's releases two 100 mm restraint cables (0.7 mm braided ss cables.

These cables are significantly pretensioned to avoid possible "rattle" in vibration.

TOP HAT

The Top Hat contains the sensor outer segments during launch and initial deployment. Its purpose is to release the outer segments well away from the spacecraft, in order to avoid impact or tangling on the vehicle or the rigid booms. It will be released from the sensor by a centrifugal force of 4 to 8 g's, unfurling the outer segments. To minimize any uncertainties of friction in space, the top hat release is accomplished by a spring "latch" pulling against the centrifugal forces experienced by the top hat.

This force must act over a distance of 5 mm to avoid premature release by impulse forces such as the clamshell release. While this release is quite repeatable in tests, it is desirable to have a significant step in the centrifugal forces during operational boom deployment, to avoid repeating the manoeuvre. With the suggested deployment sequence described in Section 10.1 as an example, the centripetal acceleration is less than 4 g's for the first 20 m of deployment, and then increases to 20 g's after spin up. The top hat also has flexible fingers in its annulus to prevent premature unwinding of the outer segments.

COULOMB DAMPER CHARACTERISTICS

The boom cable passes through the coulomb damper slider plate as it exits the mechanism. On orbit, cable tension (T) and pendulum motions combine to produce lateral forces on this slider plate. A normal force is applied to the slider plate by spings, producing a desired friction force. This friction force (f) and the distance (b) between the slider and wire hinge point produce a moment that opposes wire motion of half angle amplitude α. The damper will have a dead band as α_o = arcsin(f/T). For a full cycle of wire motion of amplitude α, the slider will travel a total distance of 4*b*tan($\alpha-\alpha_o$). The energy absorbed in this process is the product of the constant sliding force and distance traveled. Wire motion of magnitude α_o+arctan(s/b) will cause limit cycling in the slider, where 2s is the physical limit of damper travel.

Energy absorbed per cycle is 4*f*b*tan($\alpha-\alpha_o$) when $\alpha < \alpha_{max}$
4*f*s when $\alpha > \alpha_{max}$

with $\alpha_{max} = \alpha_o$ + actan(s/b)

The present parameters of the coulomb danper are as follow :

half travel	s =	0.01	m	(TBC)
moment arm	b =	0.12	m	(TBC)
friction	f =	0.5	N	(TBC)

cable tension T = 55 N (TBC) => α_o = 0.009 rad (TBC)
α_{max} = 0.090 rad (TBC)

absorbed energy per cycle per boom :

0.020	J	(TBC)	$\alpha > \alpha_{max}$
0.24	J/rad	(TBC)	$\alpha < \alpha_{max}$

(ref to Fig 2.1/1.f)

Fig. 2.1/1.a EFW Deployment Unit - Mechanism drawing

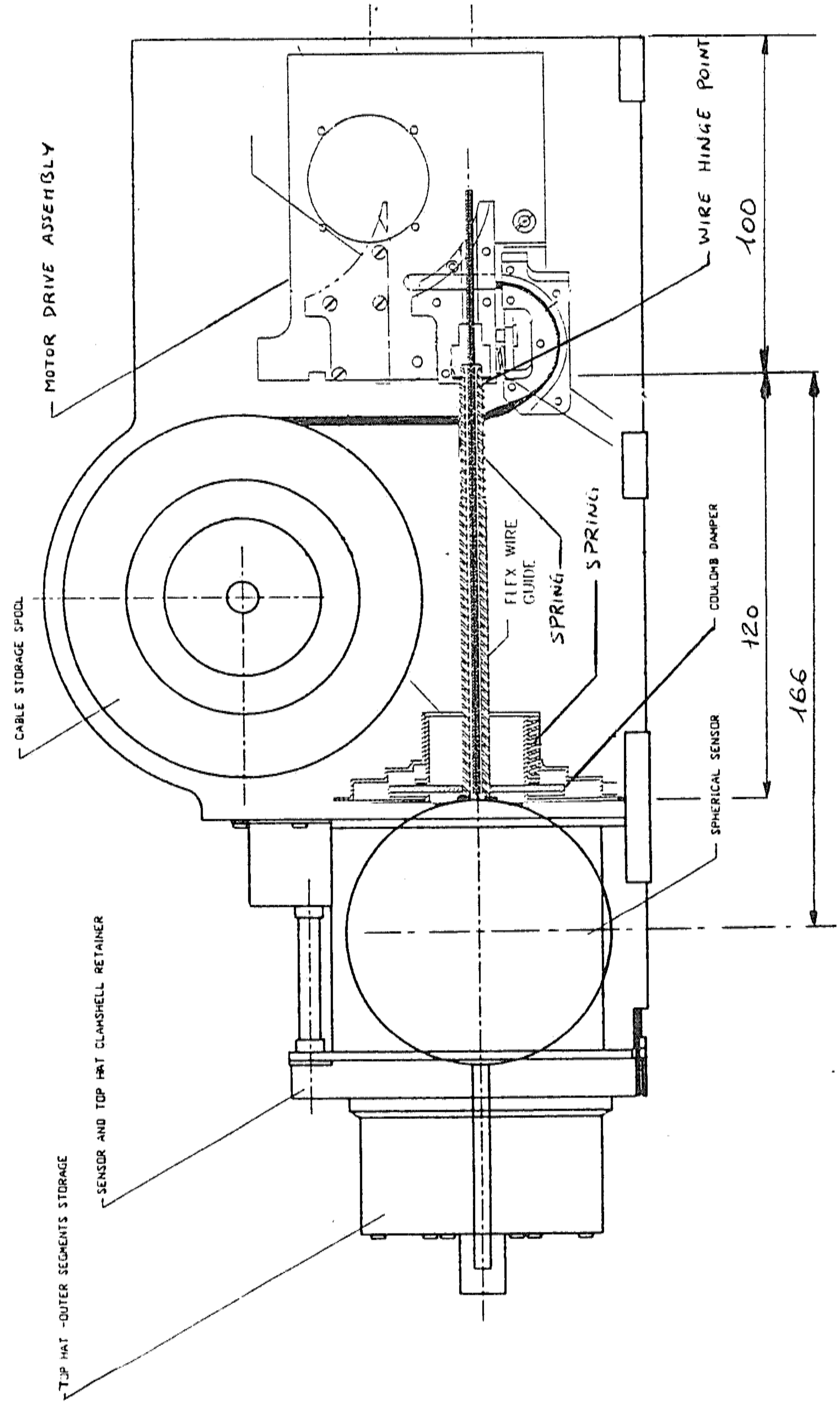


Fig. 2.1/1.e EFW Deployment Unit - Performance Characteristics

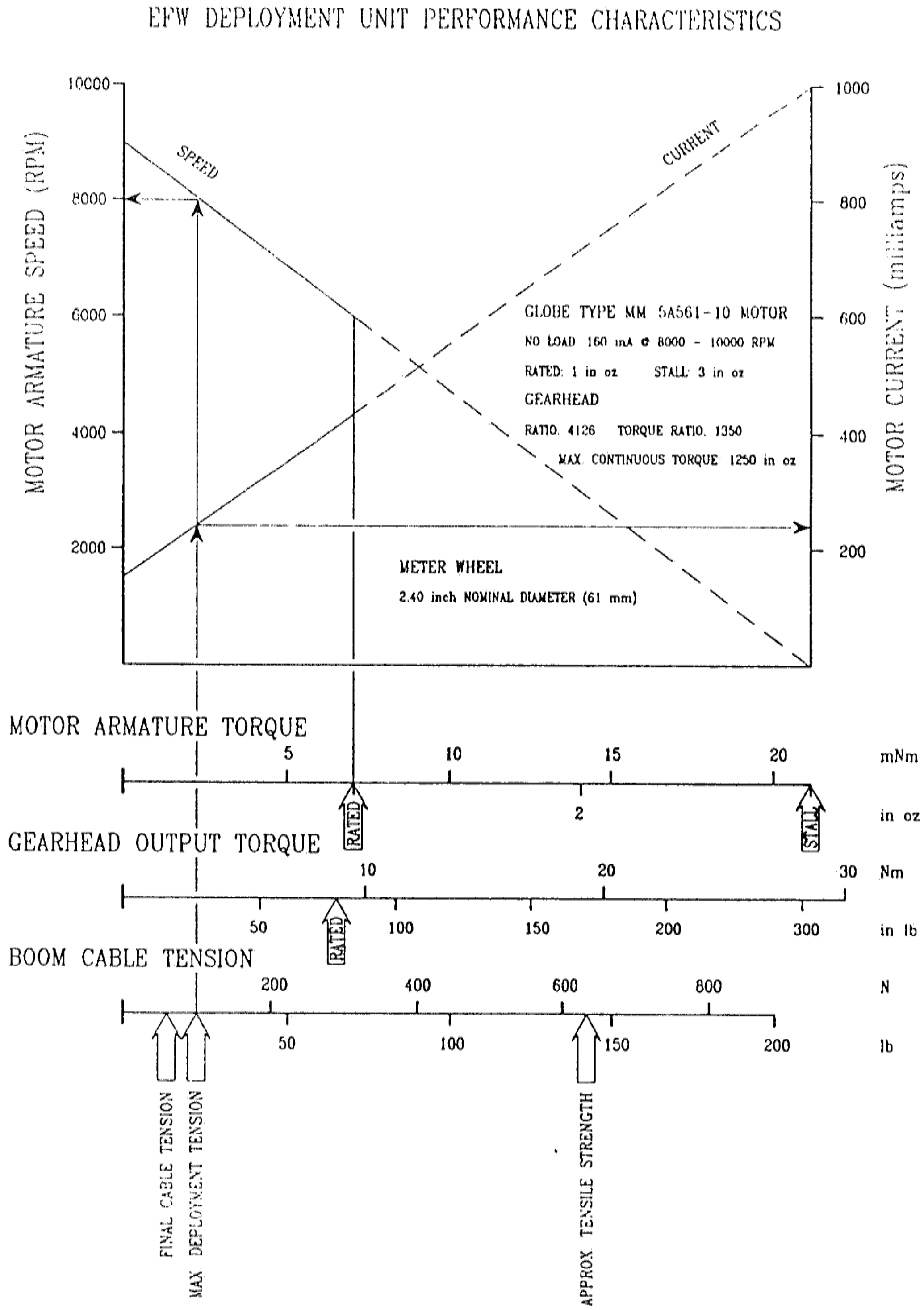


Fig. 2.1/1.f EFW Deployment Unit - damping absorbed energy (TBC)

TBD

2.2 MECHANICAL INTERFACE CONTROL DRAWINGS

2.2.1 Interface Drawings

The drawings of the long boom units, search coil sensor and electronic boxes provided by the different experimenters are given in Figs. 2.2/1.1 to 2.2/1.8.

EXP UNIT	FUNCTION	IDENTIFICATION CODE	DRAWING NUMBER
WEC 1	EFW deployment units	CLUSTER-EFW-WEC1	CL-DM-WEC-01
WEC 2	EFW deployment units	CLUSTER-EFW-WEC2	CL-DM-WEC-01
WEC 3	EFW deployment units	CLUSTER-EFW-WEC3	CL-DM-WEC-01
WEC 4	EFW deployment units	CLUSTER-EFW-WEC4	CL-DM-WEC-01
WEC 5	EFW electronic box	CLUSTER-EFW-WEC5	CL-DM-WEC-05
WEC 6	STAFF sensor	CLUSTER-STAFF-WEC6	CL-DM-WEC-06
WEC 7	STAFF preamplifier	CLUSTER-STAFF-WEC7	CL-DM-WEC-07
WEC 8	STAFF electronic	CLUSTER-STAFF-WEC8	CL-DM-WEC-08
WEC 9	WHISPER unit DWP wec processing unit	CLUSTER-WHISPER-WEC9.1 CLUSTER-DWP-WEC9.2	CL-DM-WEC-09 CL-DM-WEC-09
WEC 10	WBD unit	CLUSTER-WBD-WEC10	CL-DM-WEC-10
WEC 11	PWR wec power unit	CLUSTER-PWR-WEC11	CL-DM-WEC-11

Table 2.2/1 Unit Identification (flight items)

EXP UNIT	FUNCTION	IDENTIFICATION CODE	DRAWING NUMBER
WEC 1	test connector	tbd	CL-DM-WEC-01
WEC 2	test connector	tbd	CL-DM-WEC-01
WEC 3	test connector	tbd	CL-DM-WEC-01
WEC 4	test connector	tbd	CL-DM-WEC-01
WEC 9	Whisper small dummy load	tbd	Fig. 9.2/3.b

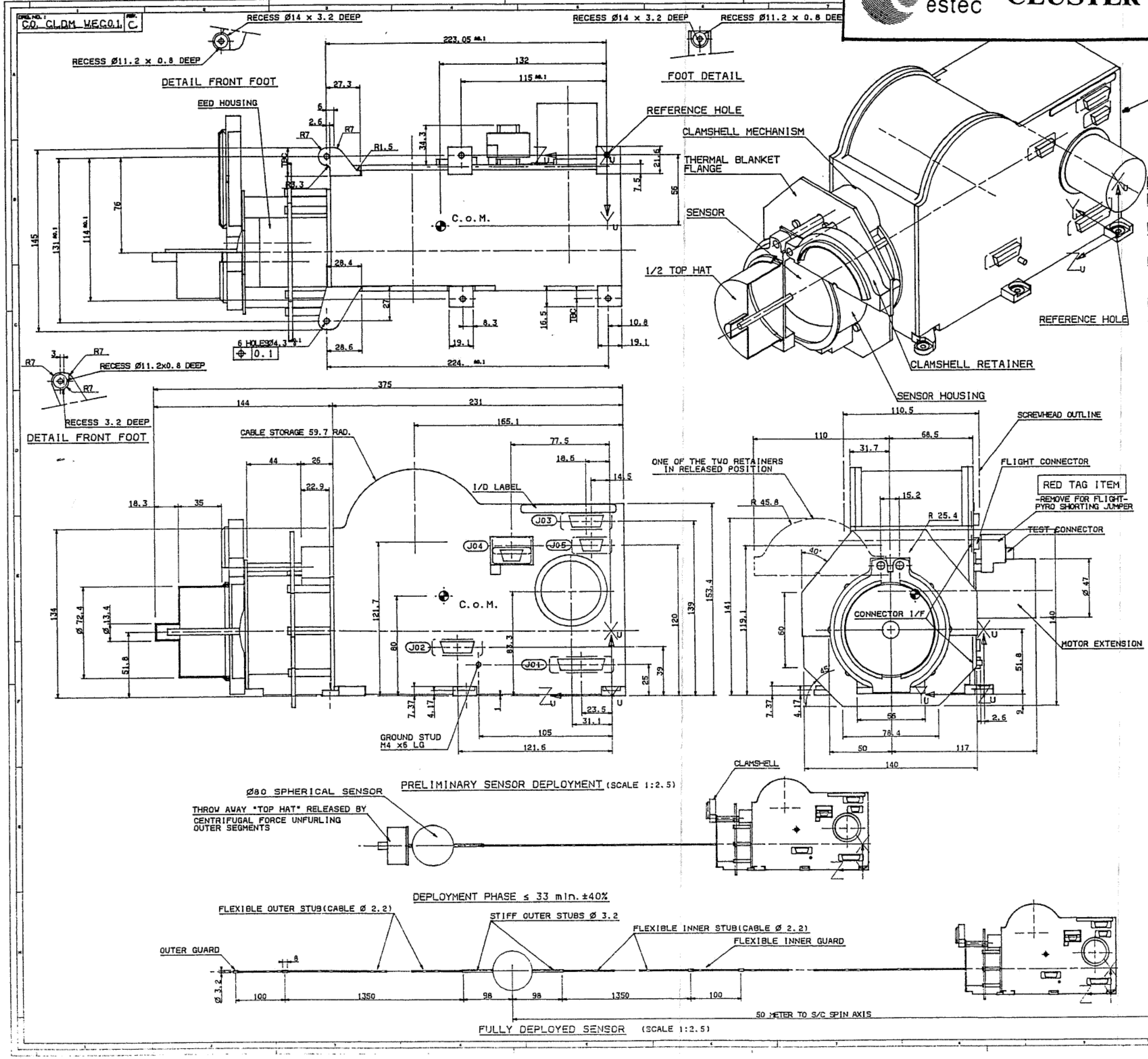
Tab 2.2/2 Non flight items (Red tag)

Fig. 2.2/1.1 WEC Mechanical ICD - WEC 1 - 4 (EFW)

DRAWING CHANGE RECORD SHEET

DRAWING NUMBER [D-26306-ICD (P)][CL-DM-WEC-01]	ORIGINATOR
TITLE EFW deployment unit Mechanical interface	WEC/EFW/ESA

ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-01	ESA	22/03/91
B	introduction of the P/L Belt Flange footpattern corrected : distance 224.1 become 224.0	ESA	15/07/91
C	Mass properties updated	ESA	



MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 1-4 ELECTRIC FIELDS DEPLOYMENT UNIT

EXPERIMENT DEVELOPER DRWG.NR.: D 26306-ICD(P); D 000

REV./REV.DATE: A/ 0789; B/040291

MASS: 3400 GRAMS +0-3%

C.o.M. (w.r.t. URF):

Xu= 80 mm ±5 mm
Yu= 56 mm ±5 mm
Zu= 132 mm ±5 mm

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.

Ix= 0.032 kgm2 ± 10 %
Iy= 0.033 kgm2 ± 10 %
Iz= 0.015 kgm2 ± 10 %

MATERIALS:

STRUCTURAL ITEMS: ALUMINIUM 6061 T6
SCREWS, ETC.: AUSTENITIC STAINLESS STEEL
OTHERS: ACETAL, BRASS, BRONZE, FIBERGLASS, POLYCARBONATE, STAINLESS STEEL

SURFACE TREATMENT:

MECHANISM: ALODINED
FEET: GOLD ALODINED
SENSOR HOUSING: GOLD ALODINED
TOP HAT: ANODIZED
CABLE: SILVER PLATED COPPER BRAID
SENSOR: CARBON BLACK COATING (DAG-213)

THERMAL INTERFACE HARDWARE:

PAYLOAD BELT FLANGE
0.5MM ALUM. ALLOY FOIL

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 26.3 cm2
FOOT THICKNESS: 7.37 mm(RECESSED 3.2 mm)
SURFACE ROUGHNESS: ≤ 1.6 µm
FOOT FLATNESS: ≤ 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11.2x 0.8 DEEP

EXPERIMENT CONNECTORS:

REF.	FUNCTION	MAKE	TYPE
J01	EFW INTERNAL HARNESS	CANNON	DBM-25 P
J02	STAFF WISPER WBD I/F	CANNON	DAM-15S
J03	BACKUP DEPLOYMENT	CANNON	DAM-15P
J04	SENSOR RELEASE PYROS	CANNON	DEM-9P
J05	MOTOR POWER PRI&SEC	CANNON	DEM-9P

INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

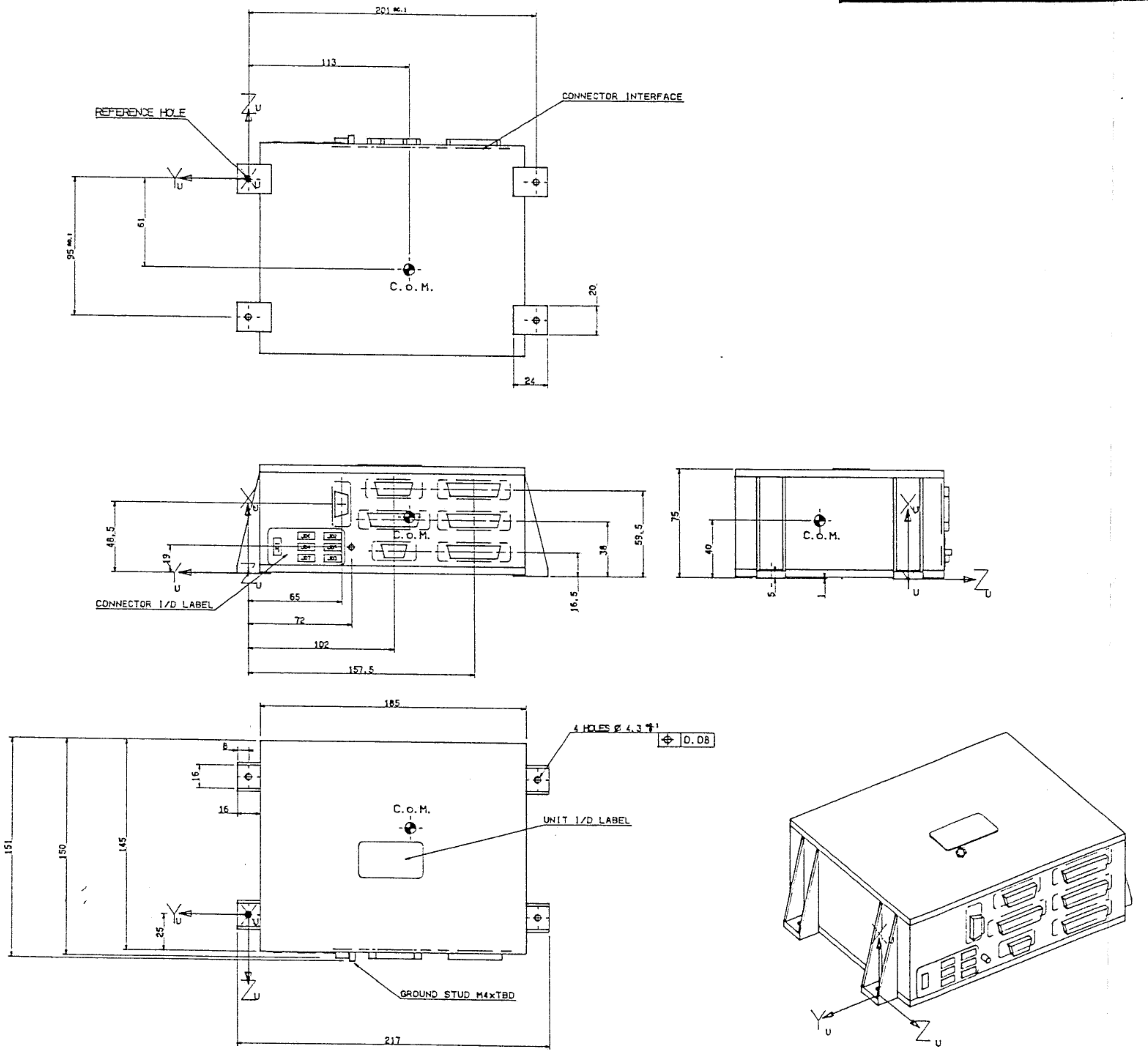
NO FLIGHT ITEMS: TEST CONNECTOR, RED TAG

PROJECT: CLUSTER
ESA-ESTEC
TITLE: EXP.: WEC 1-4 MECHANICAL I/F DRG
DRG.NO.: C0. CLDM. WEC0.1 C

Fig. 2.2/1.2 WEC - Mechanical ICD - WEC 5 (EFW Electr.)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [DM288-002][CL-DM-WEC-05]		ORIGINATOR WEC/EFW/ESA	
TITLE EFW electronic box Mechanical interface			
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-05	ESA	22/03/91

C.O. CLDM WEC05 A



MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 5 EFW ELECTRONIC BOX

EXPERIMENT DEVELOPER DRWG. NR.: DM288-002

REV./REV. DATE: 04/051290

MASS: 1800 GRAMS +0-1% (TBC)

C.o.M. (w.r.t. URF):

Xu= 40 mm ± 5 mm (TBC)
Yu= -113 mm ± 5 mm (TBC)
Zu= - 61 mm ± 5 mm (TBC)

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.

Ix= 8.90E-03 kgm2 ±25%
Iy= 4.30E-03 kgm2 ±25%
Iz= 6.20E-03 kgm2 ±25%

MATERIALS:

STRUCTURAL ITEMS: ALUMINIUM 6061-T651
SCREWS, ETC.: STAINLESS STEEL AISI 304
OTHERS: ACETATE RESIN, PTFE

SURFACE TREATMENT:

FEET: IRIDITE 14.2
BODY: BLACK ANODISED ACC. ESA-PSS-01-0703 ISS. 1

THERMAL INTERFACE HARDWARE: NO SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 17.6 cm2
FOOT THICKNESS: 5 mm
SURFACE ROUGHNESS: < 1.6 µm
FOOT FLATNESS: ≤ 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1
SPOTFACED AREA: TBD mm2
TORQUE MOUNTING SCREWS: 0.45 Nm

EXPERIMENT CONNECTORS

REF.	FUNCTION	MAKE	TYPE
J01	CONNECTOR POWER IN	CANNON	DEMA 9P
J02	INTERFACE TO BOOM 1	CANNON	DBMA 25S
J03	INTERFACE TO BOOM 2	CANNON	DBMA 25S
J04	INTERFACE TO BOOM 3	CANNON	DBMA 25S
J05	INTERFACE TO BOOM 4	CANNON	DBMA 25S
J06	DWP INTERFACE	CANNON	DAMA 15S
J07	STAFF INTERFACE	CANNON	DEMA 9S

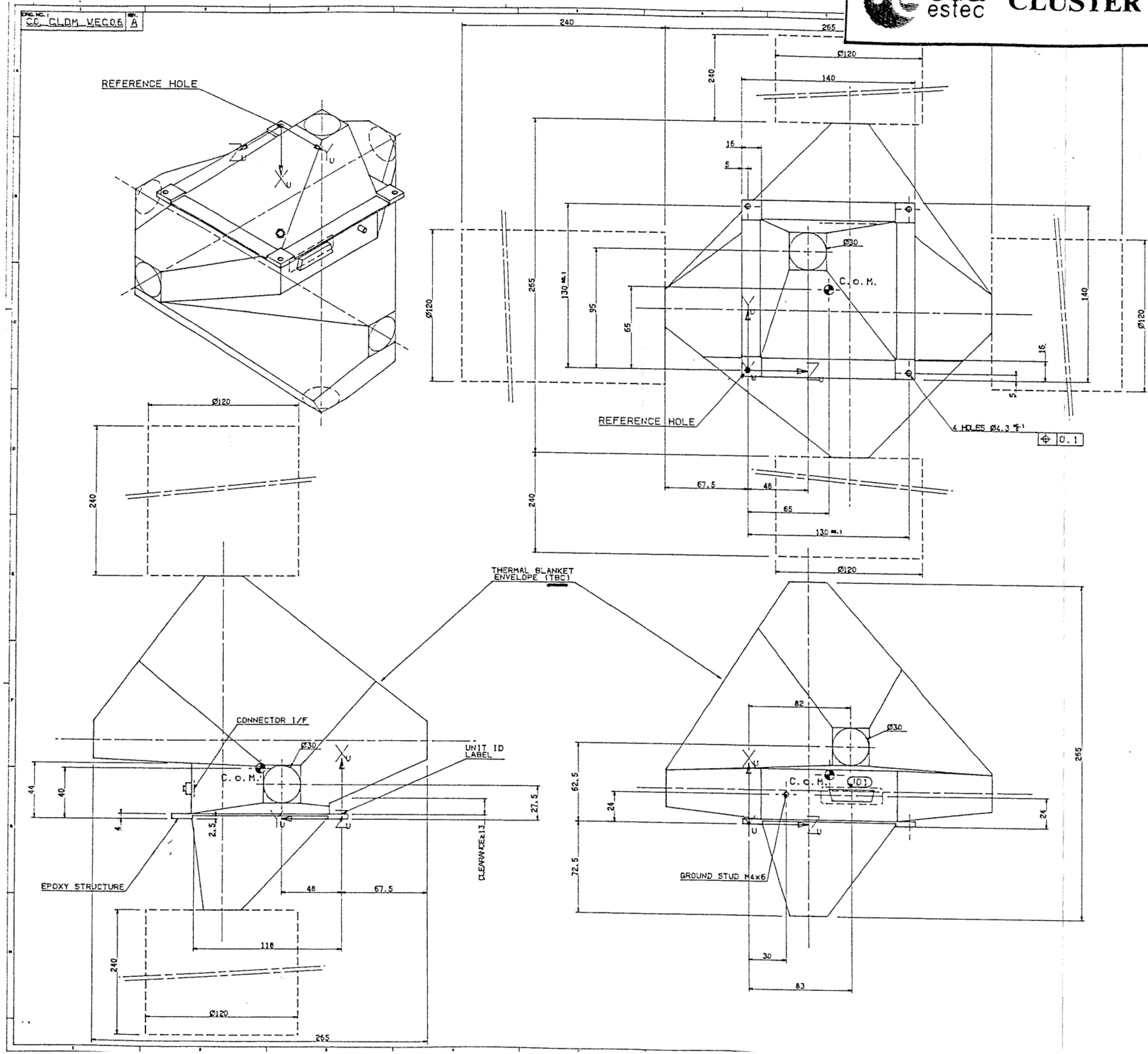
INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP: WEC 5 ELEC. BOX MECHANICAL I/F DRG
DRG. NO.: C.O. CLDM WEC05 A

Fig 2.2/1.3 WEC Mechanical ICD - WEC 6 (STAFF Sensor)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DM-WEC-06]		ORIGINATOR	
TITLE STAFF search coil Mechanical Interface		WEC/STAFF/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-06	ESA	22/03/91



MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: STAFF SENSOR WEC 6

EXPERIMENT DEVELOPER DRWG.NR.: A.M.

REV./REV.DATE: **/201190

MASS: 700 GRAMS +0-1% (TBC)

C.o.M.(w.r.t.URF):

Xu= 40.0 mm ±10 mm
Yu= 65.0 mm ±10 mm
Zu= 65.0 mm ±10 mm

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.

Ix= TBD kgm2
Iy= TBD kgm2
Iz= TBD kgm2

MATERIALS:

STRUCTURAL ITEMS: GLASS FIBER EPOXY
SCREWS, ETC.: TBD
THERMAL BLANKETS: SHELDAHL G143700 or SHELDAHL G113600 (TBC)

SURFACE TREATMENT: N/A

THERMAL INTERFACE HARDWARE: MLI

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 10.24 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: < TBD µm
FOOT FLATNESS: < 0.05 mm
ATTACHMENT PLANE FLATNESS ≤ 0.1 mm
SPOTFACED AREA: N/A

EXPERIMENT CONNECTORS

REF.	FUNCTION	MAKE	TYPE
J01	WEC 7 LINK	(TBC)	DBMA-25S-NMB

INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

FIELD OF VIEW: 6 CYLINDERS Ø120 x 240 LENGTH AT THE TOP OF EACH ANTENNA

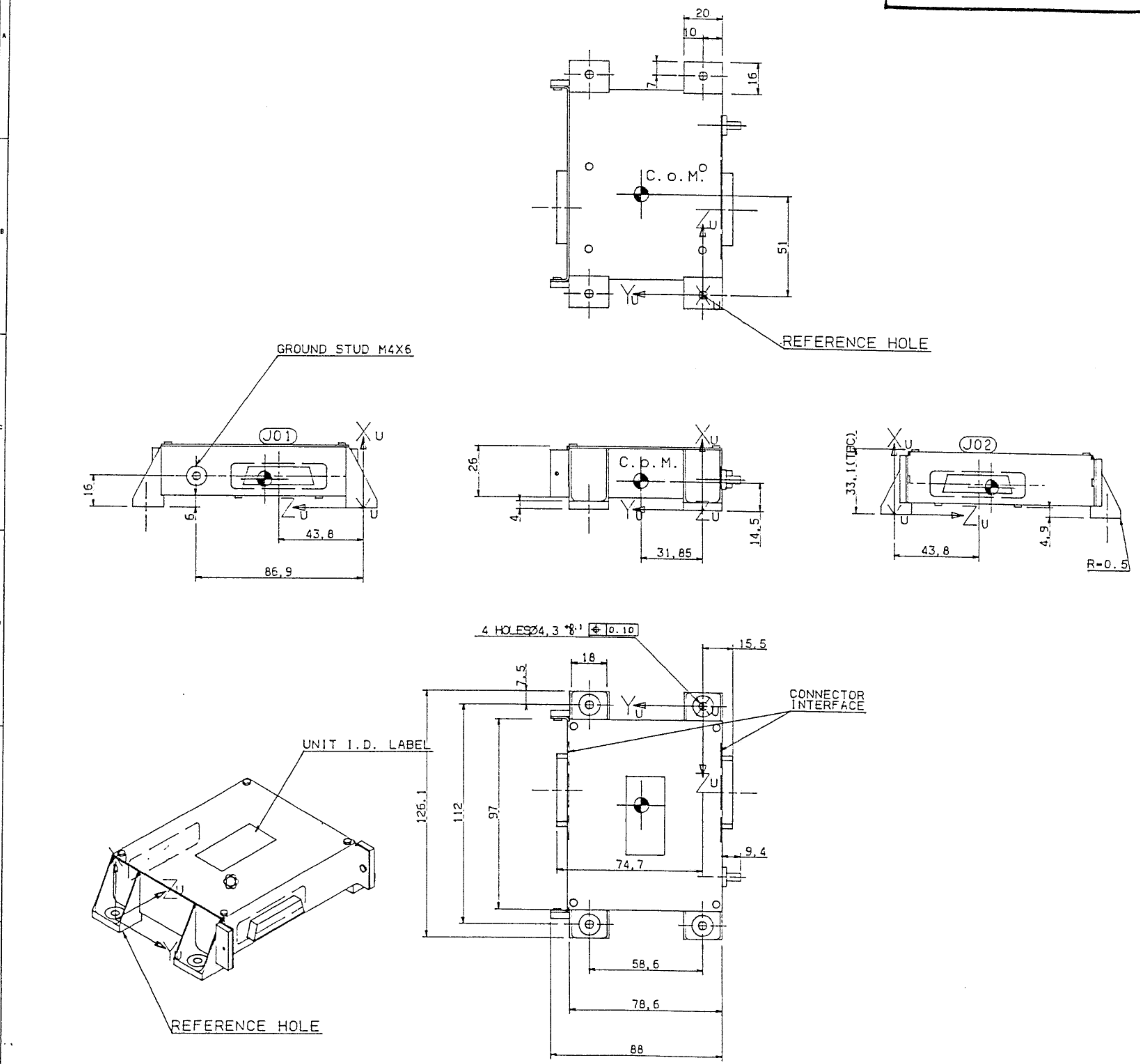
	NAME	DATE	VISA
	FARMER	011190	
	A. STOLK	170191	
	[illegible]	210191	

MATERIAL: SEE ANEX SPECIFICATION
FINISH: SEE ANEX
SCALE: 1/1
ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP.: WEC 6 MECHANICAL I/F DRG
DRG. NO.: C.O. CLDM. WEC0.5 A

Fig. 2.2/1.4 WEC - Mechanical ICD WEC 7 (STAFF preamplifier)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [39718568][CL-DM-WEC-07]		ORIGINATOR	
TITLE STAFF preamplifier Mechanical Interface		WEC/STAFF/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-07	ESA	22/03/91

DRG. NO.: C1_CLDM_WEC07 REV. A



MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: MODULE WEC 7
STAFF EXPERIMENT

EXPERIMENT DEVELOPER DRWG.NR.: 397118568 900

REV./REV.DATE: 0/11.89

MASS: 300 GRAMS +0 - 1% (TBC)

C.o.M. (w.r.t. URF):
Xu= 14.5 mm ± 5 mm
Yu= 31.85 mm ± 5 mm
Zu= 51.00 mm ± 5 mm

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.
Ix= 0.00042 kgm2 ± 25%
Iy= 0.00028 kgm2 ± 25%
Iz= 0.00019 kgm2 ± 25%

MATERIALS:
STRUCTURAL ITEMS: A2618A
SCREWS, ETC.: 26CN1809
OTHERS: (TBD)

SURFACE TREATMENT: BOX - CUVERTINE 306
FEET - SILVER PLATED

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:
CONTACT AREA MOUNTING FEET: 12.8 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
SURFACE FLATNESS: ≤ 0.05 mm
SPOTFACED AREA: Ø 11 mm DEEP 0.1 mm
ATTACHMENT PLANE FLATNESS: ≤0.1 mm

EXPERIMENT CONNECTORS:

REF.	FUNCTION	MAKE	TYPE
J01	INPUT SENSOR	CANNON	TBD 25S NMB
J02	POWER AND OUTPUT	CANNON	TBD 25P NMB

INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

	NAME	DATE	VISA
	VH SUNTER	100191	
	R. STOLK	150191	
	SCHWETTERLE	170191	

MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
300 gr/TBC gr

SURFACE ROUGHNESS 3,2 (µm)
TOLERANCES
DIMENSIONS ± TBD
ANGLES ± TBD
unless otherwise specified
DIMENSIONS: mm
SCALE: 1:1
NO. OFF:

PROJECT: CLUSTER

ESA-ESTEC
ENGINEERING SECTION
NOORDWIJK - HOLLAND

TITLE: EXP.: MODULE WEC 7 MECHANICAL I/F DRG

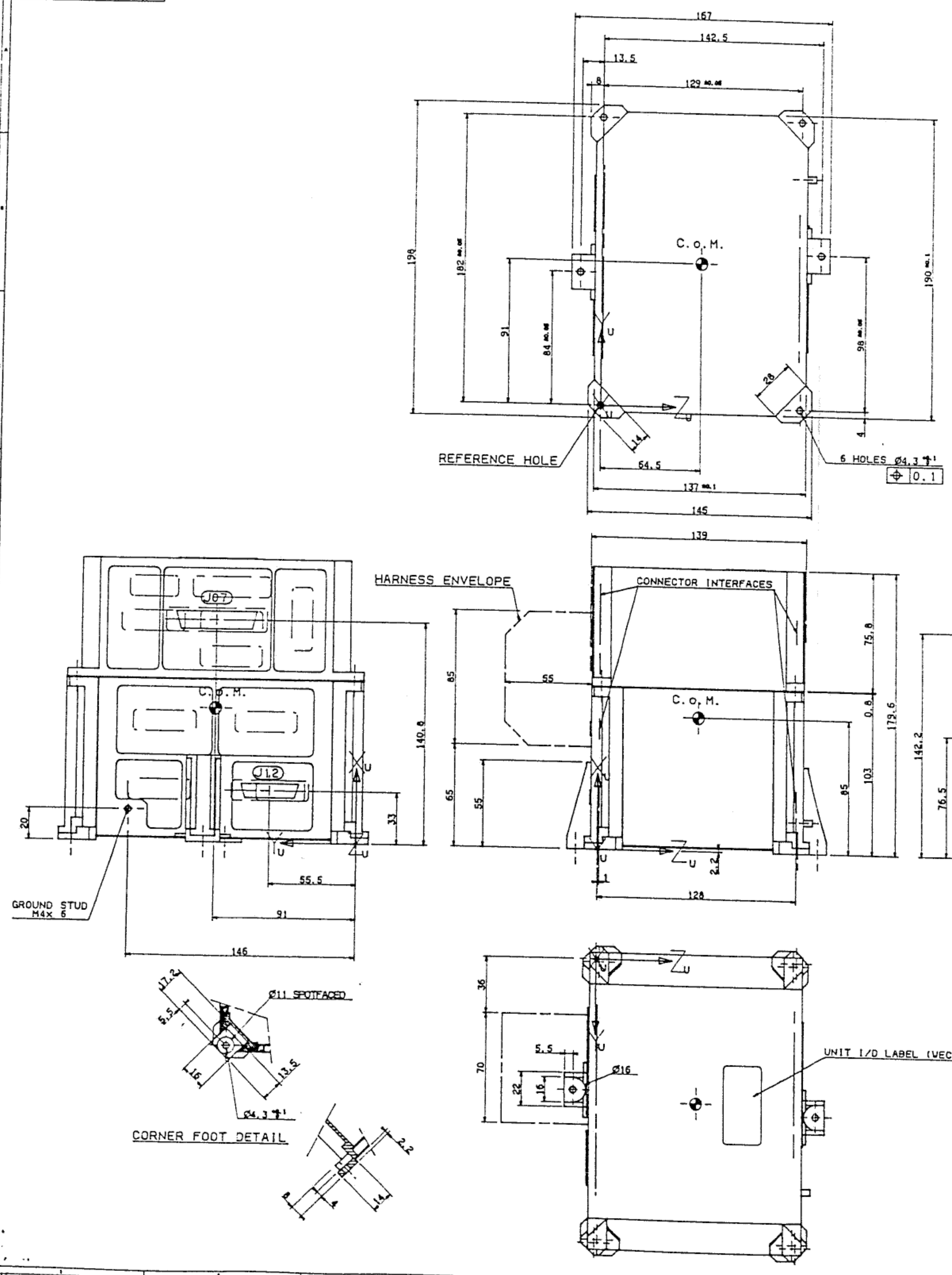
NEXT ASSY:

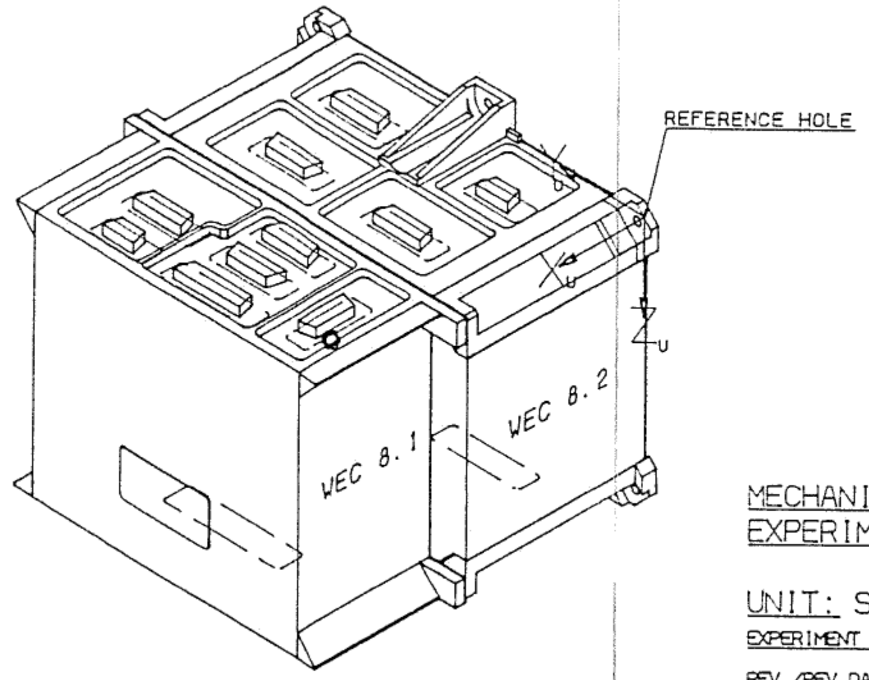
DRG. NO.: C1_CLDM_WEC07 REV. A

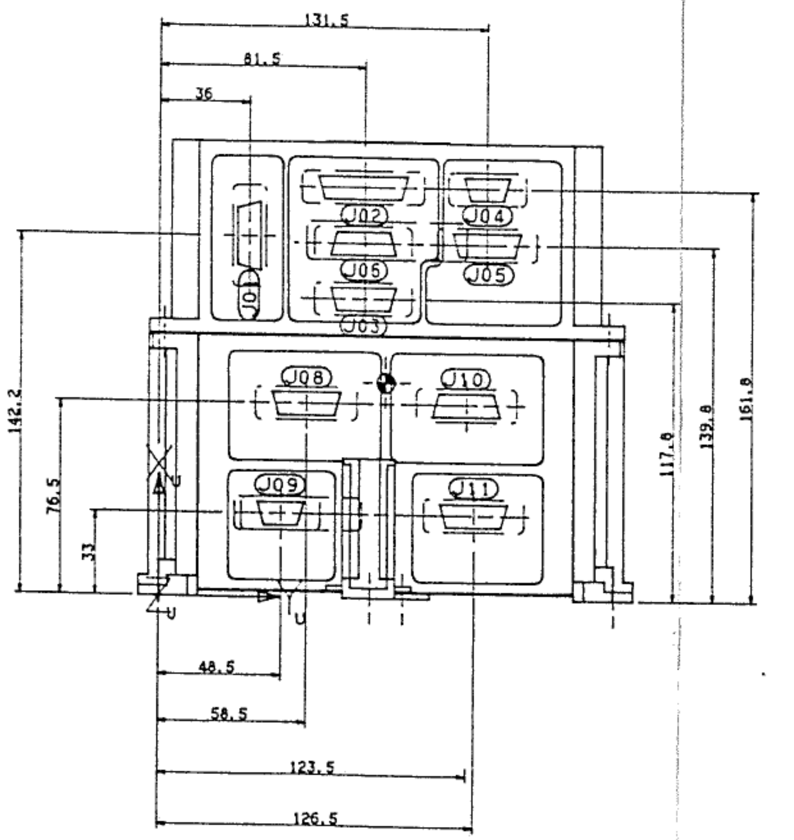
Fig. 2.2/1.5 WEC - Mechanical ICD WEC 8 (STAFF Electr. Box)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [0130001][CL-DM-WEC-08]		ORIGINATOR	WEC/STAFF/ESA
TITLE STAFF MAIN BOX Mechanical Interface			
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
x	size of the unit	A. Meyer	29/05/89
A	first release of CL-DM-WEC-08	ESA	22/03/91

C.O. CLOM. VEC0.8 | A







MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: STAFF-WEC 8

EXPERIMENT DEVELOPER DRWG.NR.: 013.00.01

REV./REV.DATE: */181090

MASS: 2990 GRAMS +0-1% (TBC)
+60 GRAMS HARNESS AND SCREWS

C.o.M. (w.r.t.URF):

Xu= 85.0 mm ±5 mm
Yu= 91.0 mm ±5 mm
Zu= 64.5 mm ±5 mm

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.

Ix= 1.30E-0.2 kgm2 ± 25%
Iy= 1.30E-0.2 kgm2 ± 25%
Iz= 1.65E-0.2 kgm2 ± 25%

MATERIALS:

STRUCTURAL ITEMS: MAGNESIUM AZ31BF
STACK SCREWS.: M4x18 Ns22s
WASHERS: Mu Ns22s
NUTS: Mu Ns22s
OTHERS: TBD

SURFACE TREATMENT: 2µm GOLDPLATING

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 12 cm2
FOOT THICKNESS: 8 mm RECESSED 4 mm
SURFACE ROUGHNESS: ≤ 1.0 µm
FOOT FLATNESS: ≤ 0.01 mm
ATTACHEMENT PLANE FLATNESS: ≤ 0.01 mm
SPOTFACED AREA: Ø11 mm

EXPERIMENT CONNECTORS:

REF.	FUNCTION	MAKE	TYPE
J01	MWF (POWER)	CANNON	DAMA-15P-NMB
J02	MFV (MAGN.PREAMPS	CANNON	DBMA-25S-NMB
J03	MWF SA (J08)	CANNON	DAMA-15P-NMB
J04	MWF (WBD)	CANNON	DEMA-9S-NMB
J05	MWF (EWF)	CANNON	DAMA-15S-NMB
J06	MWF (EDI)	CANNON	DAMA-15P-NMB
J07	MWF (DWP)	CANNON	DDMA-50S-NMB
J08	SA (MWF-J03)	CANNON	DAMA-15S-NMB
J09	SA (POWER)	CANNON	DEMA-9P-NMB
J10	SA (TEST)	CANNON	DAMA-15S-NMB
J11	SA (EFV)	CANNON	DAMA-15P-NMB
J12	SA (DWP)	CANNON	DBMA-25S-NMB

INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

ESA-ESTEC

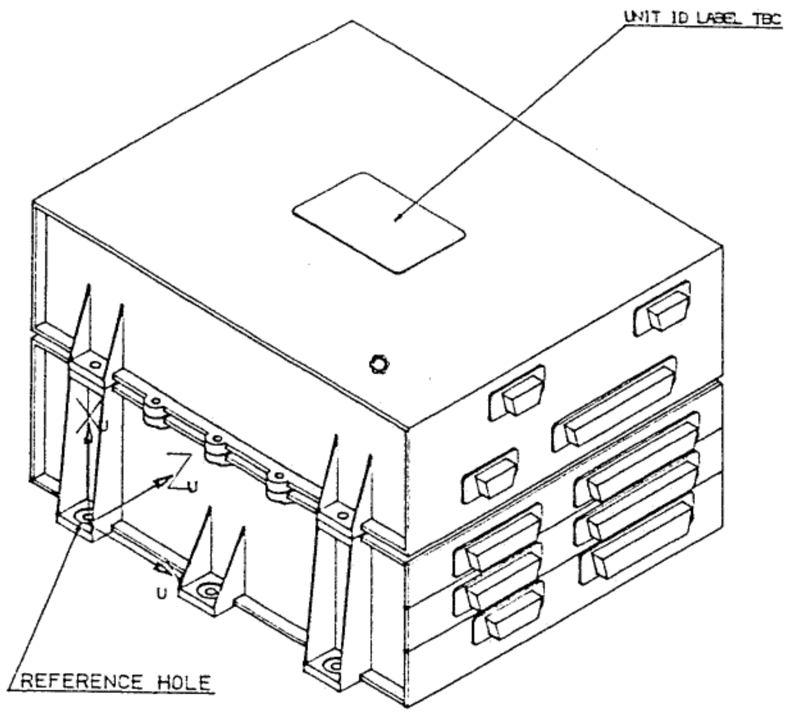
PROJECT: CLUSTER

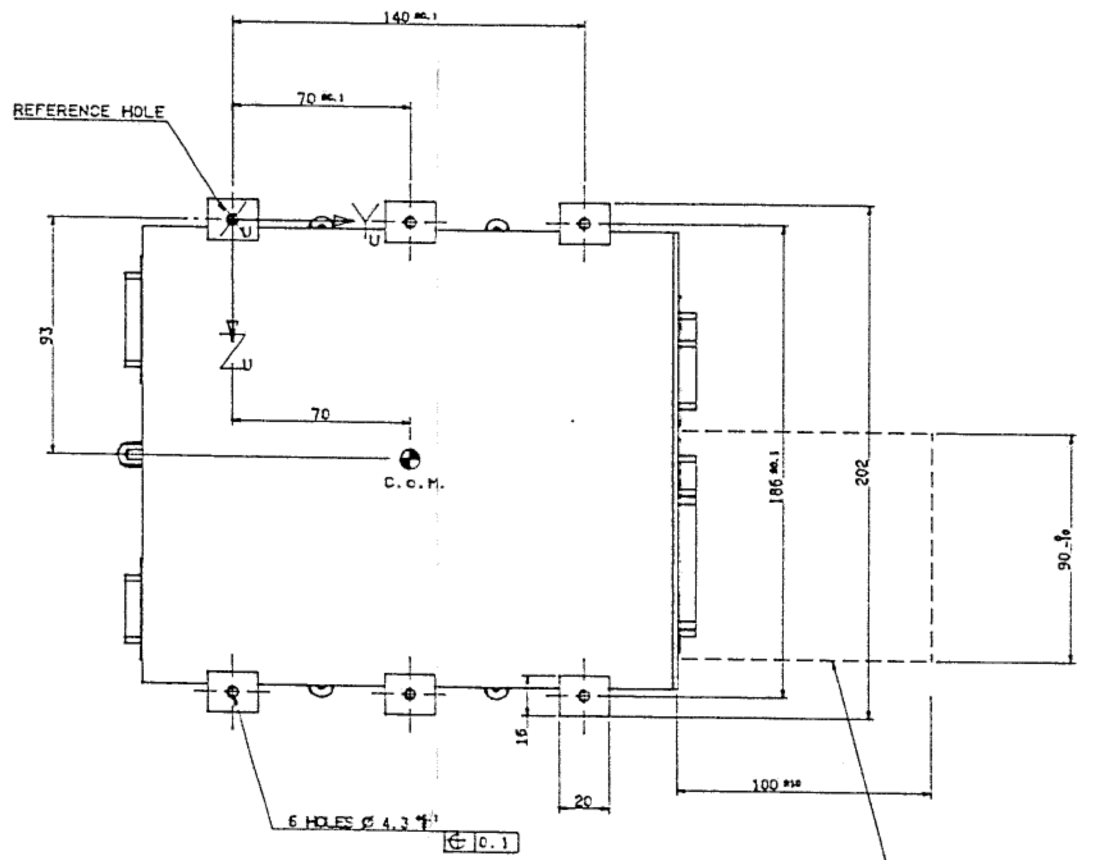
TITLE: EXP.: STAFF WEC 8 MECHANICAL I/F DRG

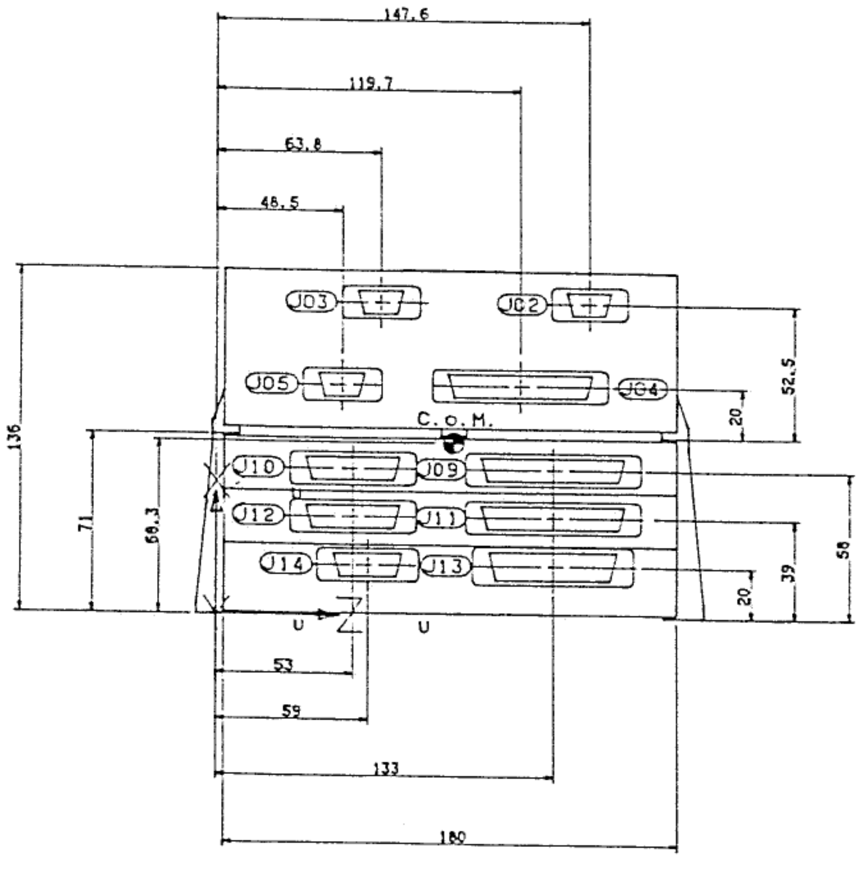
DRG. NO.: C.O. CLOM. VEC0.8 A

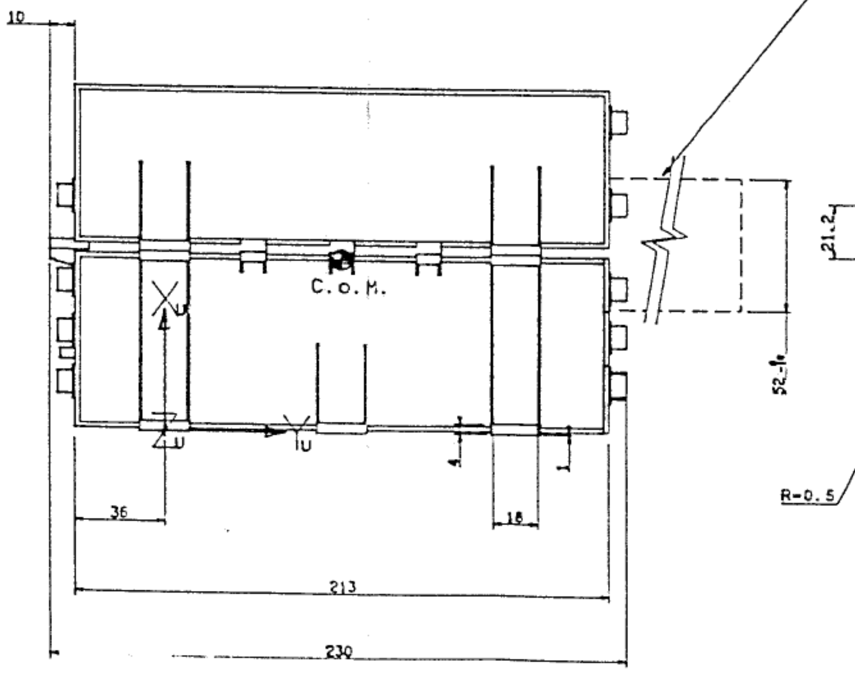
Fig. 2.2/1.6 WEC - Mechanical ICD WEC 9 (WHISPER/DWP)

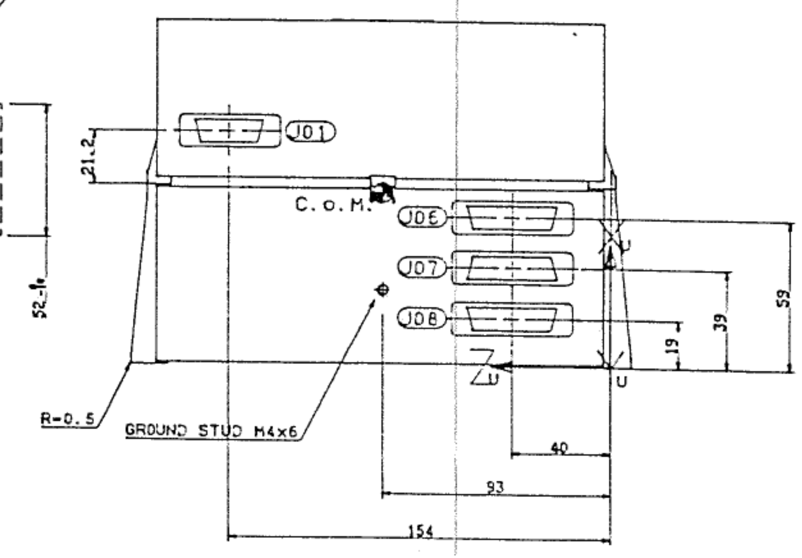
DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [WHI0010][CL-DM-WEC-09]		ORIGINATOR WEC/WHISPER /DWP/ESA	
TITLE WHISPER/DWP unit Mechanical Interface			
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-09	ESA	22/03/91











MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 9 WHISPER/DWP

EXPERIMENT DEVELOPER DRWG. NR.: N:WHI0010

REV./REV. DATE: 04/031290

MASS: 4000 GRAMS +0 -1% (TBC)
+ 130 GRAMS HARNASS AND SCREWS

C.o.M. (w.r.t. URF):
Xu= 71 mm ± 5%
Yu= 70 mm ± 5%
Yu= 70 mm ± 5%

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.
Ix= 2.6810-2 kgm2 ± 25%
Iy= 1.7510-2 kgm2 ± 25%
Iz= 2.2010-2 kgm2 ± 25%

MATERIALS:

STRUCTURAL ITEMS: HOUSING: WEC 9.1 AL. ALLOY 2618A
WEC 9.2 AL. ALLOY AA6082T6
SCREWS, ETC.: WEC 9.1 STAINLESS STEEL Z2CN1810
WEC 9.2 STAINLESS STEEL TBD
LABELS: SCOTCHCALL 8015, SCOTCHWELD 3900
OTHERS: TBD

SURFACE TREATMENT: ALODYNE 1200

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:
CONTACT AREA MOUNTING FEET: 19.2 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
SURFACE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm

EXPERIMENT CONNECTORS:

EXP.	REF.	FUNCTION	MAKE	TYPE
WEC 9.1	J01	PWR I/F	SOURIAU	DAM -15P-NMB
	J02	WEC 3 & 4 DATA LINK	SOURIAU	DEMA- 9S-NMB
	J03	WEC 1 & 2 DATA LINK	SOURIAU	DEMA- 9P-NMB
	J04	DWP DATA LINK	SOURIAU	DCMA-37P-NMB
	J05	TEST AND HV CONTROL	SOURIAU	DEMA- 9S-NMB
WEC 9.2	J06	OBDH I/F	SOURIAU	DBMA-25S-NMB
	J07	OBDH I/F	SOURIAU	DBMA-25S-NMB
	J08	PWR I/F	SOURIAU	DBMA-25P-NMB
	J09	WHISPER DATA LINK	SOURIAU	DCMA-37P-NMB
	J10	WBD DATA LINK	SOURIAU	DBMA-25S-NMB
	J11	IEL I/F	SOURIAU	DCMA-37S-NMB
	J12	STAFF DATA LINK	SOURIAU	DBMA-25P-NMB
	J13	STAFF DATA LINK	SOURIAU	DCMA-50P-NMB
	J14	EFW DATA LINK	SOURIAU	DAMA-15P-NMB

INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: n/a

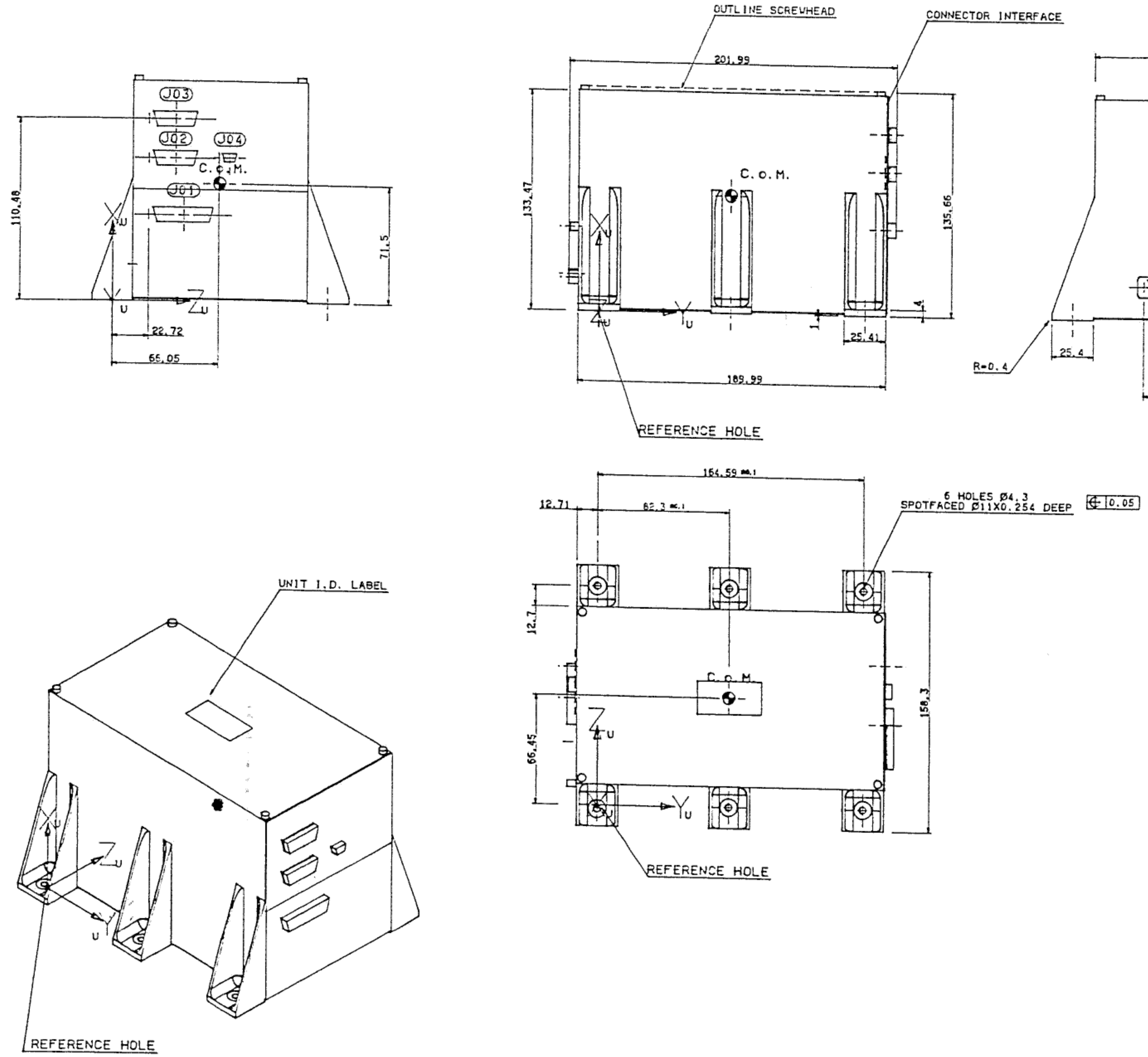
VENTING: 4 HOLES Ø5 IN WEC 9.1 AND WEC 9.2

ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP.: WEC 9 MECHANICAL I/F DRG
DWG. NO.: C.O. CLDM WEC09 A

Fig. 2.2/1.7 WEC - Mechanical ICD WEC 10 (WBD)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [50008][CL-DM-WEC-10]		ORIGINATOR	
TITLE WBD unit Mechanical Interface		WEC/WBD/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-10	ESA	22/03/91

C.O. CLDM WEC10 A



MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 10 WIDEBAND RECEIVER

EXPERIMENT DEVELOPER DRWG.NR.: REV./REV DATE

DRWG. NR.	REV./REV DATE
02542/93/D/50008	D /030190
02542/93/D/50008	D /030190
02542/92/D/50008	D /030190
02542/92/D/50008	A /030190

MASS: 1550 GRAMS +0 -1% TBC

C.o.M. (w.r.t.URF):

Xu= 71.5 mm ± 1 mm TBC
Yu= 82.296 mm ± 1 mm TBC
Zu= 66.454 mm ± 1 mm TBC

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.

Ix= 6.17X10 -3 kgm2 ± 25%
Iy= 4.15X10 -3 kgm2 ± 25%
Iz= 7.30X10 -3 kgm2 ± 25%

MATERIALS:

STRUCTURAL ITEMS: MAGNESIUM ALLOY AZ310-H24
SCREWS, ETC.: 300 SERIES CRES

SURFACE TREATMENT:

COPPER UNDERPLATE :
PER MIL-C-14550B-CLASS II
SILVER UNDERPLATE :
PER QQ-S-365D TYPE II GRADE B
GOLD PLATE :
PER MIL-G-45204C TYPE 1 GRADE C CLASS II

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 38.7 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
SURFACE FLATNESS: ≤ 0.05 mm
SPOTFACED AREA: Ø 11 mm
ATTACHMENT PLANE FLATNESS : ≤ 0.1 mm

EXPERIMENT CONNECTORS:

REF.	FUNCTION	MAKE	TYPE
J01	SPACECRAFT I/O OBDH	CANNON	DBM25P -NMB
J02	ELEC. SIGNALS FROM EY ANTENNA EFW(Y)	CANNON	DAM7W2P-NMB
J03	ELEC. SIGNALS FROM EZ ANTENNA EFW(Z)	CANNON	DAM7W2S-NMB
J04	MAGN. SIGNLS FRM SEARCH COILS STAFF	CANNON	DEM9S -NMB
J05	INSTR. CONTROL/DATA HANDLING DWP	CANNON	DAM25S -NMB
J06	SWITCHED, UNREGULATED POWER WEC POWER	CANNON	DEM9P -NMB

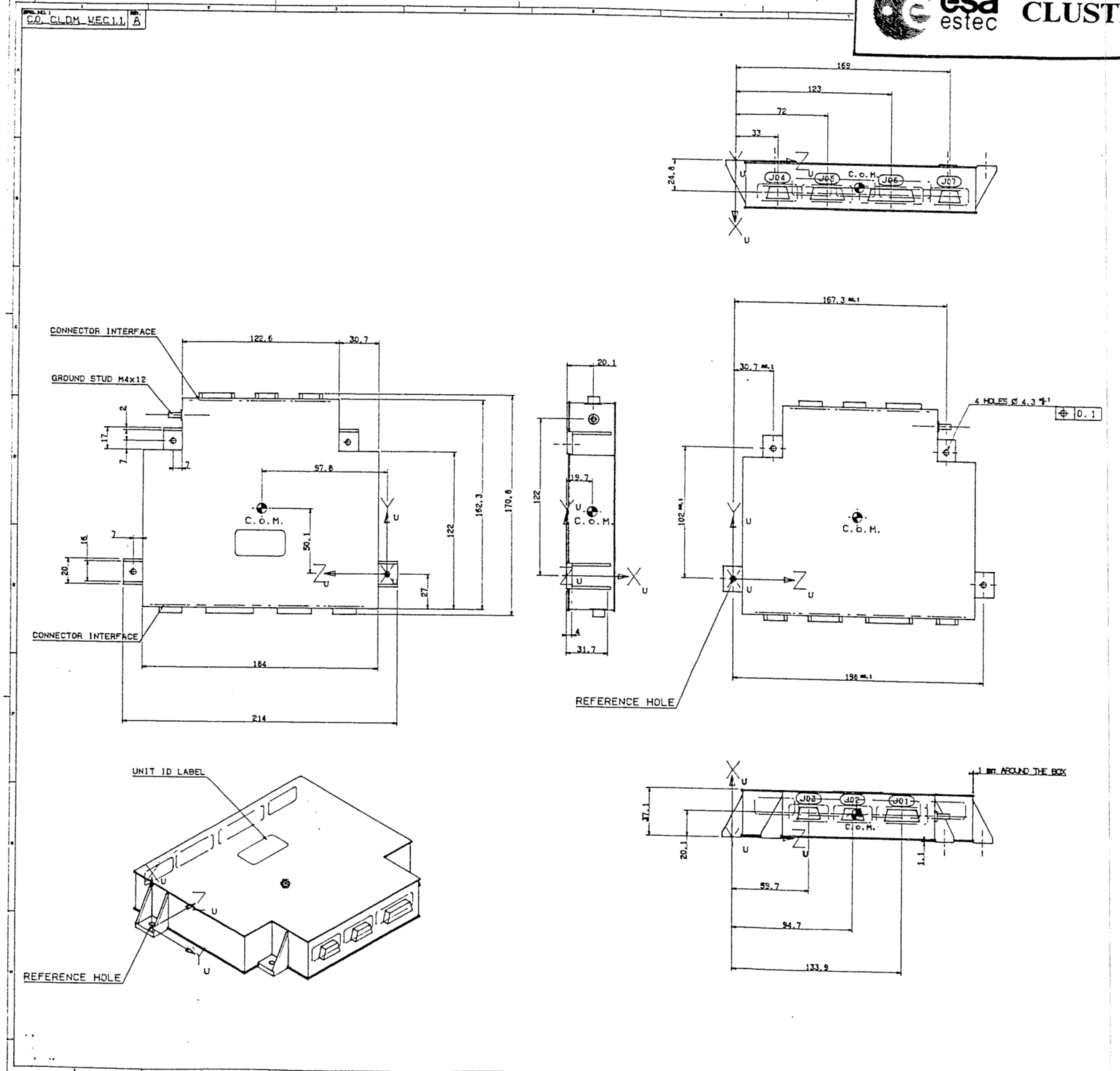
INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

PROJECT: CLUSTER
ESA-ESTEC
TITLE: EXP. : WEC 10
MECHANICAL I/F DOC C.O. CLDM WEC10

Fig. 2.2/1.8 WEC - Mechanical ICD WEC 11 (Power Supply)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DM-WEC-11]		ORIGINATOR	
TITLE WEC power unit Mechanical Interface		WEC/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DM-WEC-11	ESA	22/03/91



MECHANICAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC11 POWER SUPPLY

EXPERIMENT DEVELOPER DRWG.NRS.: 11 0085231

REV./REV.DATE: 4/910211

MASS: 900 GRAMS +0 -0.1%(TBC)

C.o.M. (w.r.t.URF):

Xu= 19.7 mm ±1 mm
Yu= 50.1 mm ±1 mm
Zu= 97.8 mm ±1 mm

TENSOR of INERTIA: w.r.t. U.R.F. centered at C.o.M.

Ix= 0.00399 kgm2 ±15%
Iy= 0.00223 kgm2 ±15%
Iz= 0.00195 kgm2 ±15%

MATERIALS:

STRUCTURAL ITEMS: HOUSING ALUMINIUM ALLOY 2618A
SCREWS: STAINLESS STEEL Z2CN1810
LABELS: SCOTCHCALL 8005
OTHERS: TBD

SURFACE TREATMENT: BLACK ANODIZED

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 9.1 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
FOOT FLATNESS: ≤ 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11 mm

EXPERIMENT CONNECTORS:

REF.	FUNCTION	MAKE	TYPE
J01	WEC.11 TO S/C POWER	SOURIAU	DAM-15P-NMB
J02	WEC.11 TO WEC.5	SOURIAU	DEM- 9S-NMB
J03	WEC.11 TO WEC.10	SOURIAU	DEM- 9S-NMB
J04	WEC.11 TO WEC.8/1	SOURIAU	DEM- 9S-NMB
J05	WEC.11 TO WEC.9/1	SOURIAU	DAM-15S-NMB
J06	WEC.11 TO WEC.9/2	SOURIAU	DBM-25S-NMB
J07	WEC.11 TO WEC.8/2	SOURIAU	DEM- 9S-NMB

INSTRUMENT GROUNDING: VIA GROUND STUD

PURGE VALVES: N/A

ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP.: WEC11 MECHANICAL I/F DRG
C.O. CLDM WEC.1.1 A

2.2.2 Configuration Requirements

The most parts of the units (WEC 5 and WEC 7 to 11) do not make any special request as far as boresight and FOV are concerned.

2.2.2.1 Field of View

a) WEC 6 :

The Search Coils WEC.6 are subject to some constraints regarding the vicinity of metallic surfaces. No metallic surface has to be located in cylinders envelopes of 120 mm diameter and 240 mm long centred on each 3 antennas axis and at each 2 tips of each antenna.

The conductive surfaces located outside and around the cylinders cannot completely encircle the sensors. These surfaces must be electrically opened not to create conductive closed loops around the sensors. This requirement is applicable in particular to the spacecraft mounting support of WEC.6.

The thickness of conductive surfaces, external to the cylinders, located in the axis of the sensors is given by the following formula which corresponds to a field loss of 2%:

$$e = 10^5 \times n \times (d^2 + 36 \times 10^{-4})^{3/2} / (2.8 + \log(r))$$

where
- e = thickness
- n = resistivity of the material in Ohm.m
- d = distance between the sensor and the material
- r = radius of the circle inscribed in the surface of the conductive material perpendicular to the sensor axis

all distances in meter, neperian log

example:					
	d =	0.5	1.0	2.0	m
	e max =	0.16	1.2	9.6	mm

b) WEC 1/4

Obviously, the front of the long booms must be free of any obstacle in order to permit the deployment.

2.2.2.2 Boresight

There is no real boresight requirement, but a certain orientation is required between units.

a) WEC 1/4 :

The boresight directions correspond to the deployment axis.

The long boom mechanisms are orthogonally mounted as shown on figure 2.2/2. The two pairs of long booms are orthogonally mounted in the rotation plane. They are at 90 degrees w.r.t. spin axis.

b) WEC 6 :

The 3 magnetic sensors are orthogonally mounted inside the WEC.6 structure. Independently of the URF axis of this structure, the sensors must be aligned with the Electrical Axis defined in section 2.6.1.

c) WHISPER :

The WHISPER transmitter will be connected to WEC3 and WEC4.

UNIT	BORESIGHT POSITION		SCIENTIFIC FIELD OF VIEW					UNOBSTRUCTED FIELD OF VIEW(*)				
	Azimuth	Elevation	SOA	SOE	vertex position			SOA	SOE	vertex position		
					$\bar{X}$	$\bar{Y}$	$\bar{Z}$			$\bar{X}$	$\bar{Y}$	$\bar{Z}$
whole WEC see 2.2.2.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 2.2/3 Boresight and Field Of View definition w.r.t. the URF

2.2.2.3 Mounting

a) WEC1/4 :

each unit deployment unit (WEC1/4) will have its front feet fixed on the reinforced ring (dia 2840).
The footpattern (see sect 2.5) is not symetric allowing the deployment axis to be radial.

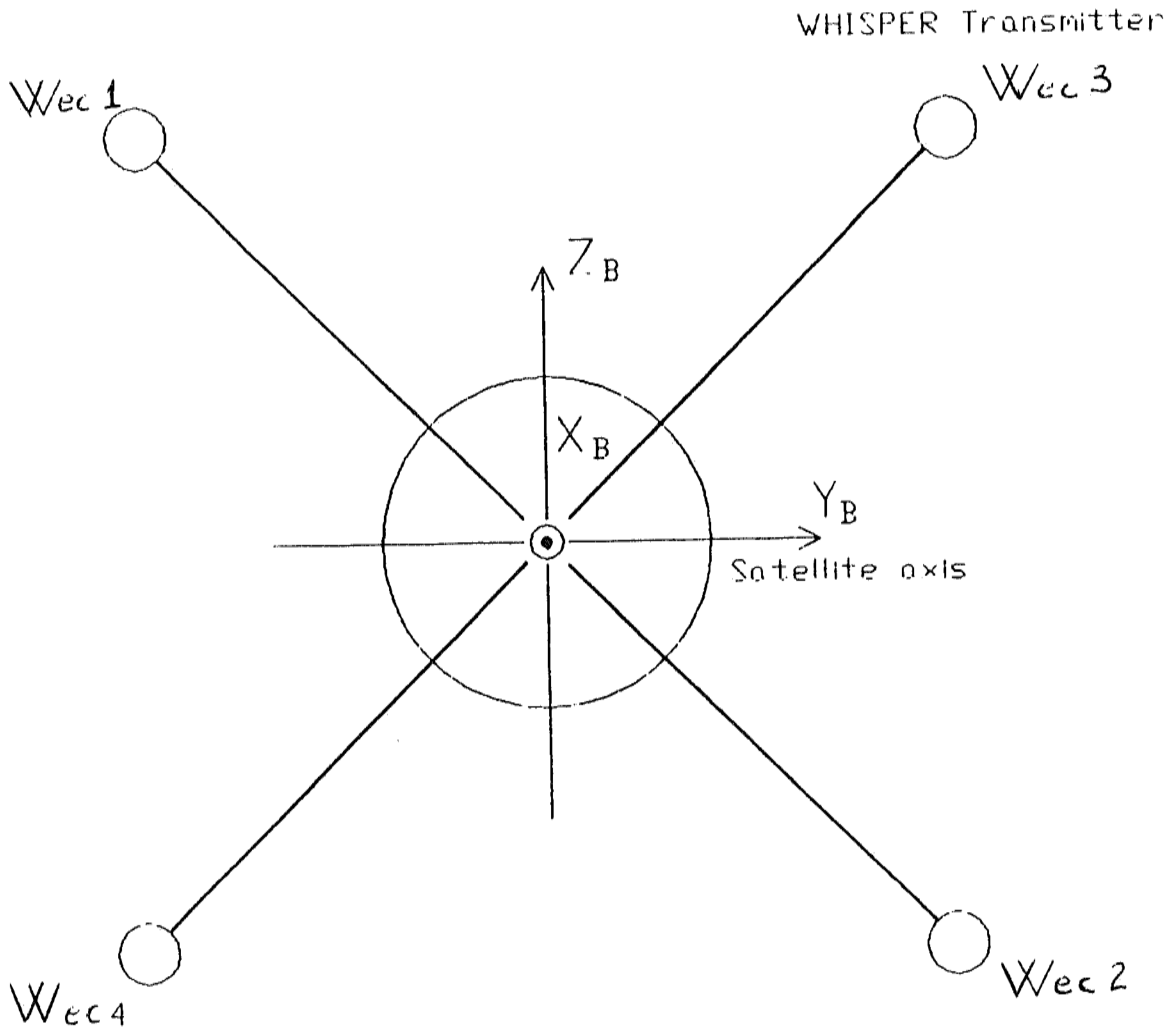
b) WEC 6 :

Search coil antennas (WEC 6) to be mounted on the rigid radial boom at a minimum of 2,5 m from the spacecraft body.

c) WEC 7c :

Any wire of this cable shall be bended with a radius larger than 50 mm.

Fig. 2.2/2 WEC1/4 accomodation



2.2.3 Installation drawings

See fig 2.2/3.1 to 2.2/3.12.

EXP UNIT	FUNCTION	DRAWING NUMBER
WEC 1	EFW deployment units	CL-DI-WEC-01
WEC 2	EFW deployment units	CL-DI-WEC-02
WEC 3	EFW deployment units	CL-DI-WEC-03
WEC 4	EFW deployment units	CL-DI-WEC-04
WEC 5	EFW electronic box	CL-DI-WEC-05
WEC 6	STAFF sensor	CL-DI-WEC-06
WEC 7	STAFF preamplifier	CL-DI-WEC-07
WEC 8	STAFF electronic	CL-DI-WEC-08
WEC 9	WHISPER unit DWP wec processing unit	CL-DI-WEC-09 CL-DI-WEC-09
WEC 10	WBD unit	CL-DI-WEC-10
WEC 11	PWR wec power unit	CL-DI-WEC-11
WEC	unit accomodation harness routine	CL-DI-WEC-12

Tab 2.2/4 Experiment installation drawing

EXP UNIT	Yb [mm]	Zb [mm]	Yu direction wrt Yb counterclockwise [degrees]
WEC 1	- 898.74	791.26	45
WEC 2	898.74	- 791.26	135
WEC 3	791.26	898.74	- 45
WEC 4	- 791.26	- 898.74	- 135
WEC 5	- 497.00	1143.00	- 160
WEC 6	tbd	tbd	45 * - 45
WEC 7	1214.00	- 168.00	180
WEC 8	1176.00	361.00	- 86
WEC 9	690.00	85.00	- 90
WEC 10	- 478.00	910.00	- 146
WEC 11	1140.00	- 80.00	180

(TBC end of phase B)

* Xu direction wrt Yb

Tab 2.2/5 URF location and orientation

HARNESS from	to	length [mm]
WEC 1	WEC 5	1000
WEC 1	WEC 8/2	3200
WEC 1	WEC 9/1	3600
WEC 1	WEC 10	1000
WEC 2	WEC 5	3800
WEC 2	WEC 8/2	1600
WEC 2	WEC 9/1	1300
WEC 2	WEC 10	4200
WEC 3	WEC 5	1800
WEC 3	WEC 8/2	1200
WEC 3	WEC 9/1	1700
WEC 3	WEC 10	2100
WEC 4	WEC 5	3200
WEC 4	WEC 8/2	5600
WEC 4	WEC 9/1	5800
WEC 4	WEC 10	2700
WEC 5	WEC 8/1	2600
WEC 5	WEC 9/2	3100
WEC 5	WEC 11	2700
WEC 6	WEC 7	5600
WEC 7	WEC 8/1	1200
WEC 8/1	WEC 9/2	700
WEC 8/2	WEC 9/2	1000
WEC 8/1	WEC 10	2700
WEC 8/1	WEC 11	700
WEC 8/2	WEC 11	1000
WEC 9/2	WEC 10	3400
WEC 9/1	WEC 11	400
WEC 9/2	WEC 11	200
WEC 10	WEC 11	3200
PDU	WEC 11	tbd

(TBC end of phase B)

Tab 2.2/6 Harness length

Fig. 2.2/3.1 WEC 1/4 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-01]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.1

TBI

Fig. 2.2/3.2 WEC 1/4 installation drawing

DRAWING CHANGE RECORD SHEET

DRAWING NUMBER [][CL-DI-WEC-02]			ORIGINATOR DOR/ESA	
TITLE				
ISSUE NO.	DESCRIPTION OF CHANGE		AUTHORITY	DATE

Fig 2.2/3.2

TBI

Fig. 2.2/3.3 WEC 1/4 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-03]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.3

TBI

Fig. 2.2/3.4 WEC 1/4 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-04]			ORIGINATOR
TITLE			DOR/ESA
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.4

TBI

Fig. 2.2/3.5 WEC 5 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-05]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.5

TBI

Fig 2.2/3.6 WEC 6 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-06]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.6

TBI

Fig. 2.2/3.7 WEC 7 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-07]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.7

TBI

Fig. 2.2/3.8 WEC 8 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-08]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.8

TBI

Fig. 2.2/3.9 WEC 9 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-09]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.9

TBI

Fig. 2.2/3.10 WEC 10 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DI-WEC-10]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.10

TBI

Fig. 2.2/3.11 WEC 11 installation drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][C1-DI-WEC-11]		ORIGINATOR	
TITLE		DOR/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.11

TBI

Fig. 2.2/3.12 WEC unit accomodation and harnes routine drawing

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][C1-DI-WEC-12]			ORIGINATOR
TITLE			DOR/ESA
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE

Fig 2.2/3.12

TBI

2.3 STRUCTURE AND MECHANISMS ANALYSIS

2.3.1 Dynamic Analysis

a/ WEC 1/4

LAUNCH VIBRATION

The primary concern in this regard is resonances below 100 Hz, which might alter the dynamic behaviour of the spacecraft. The frequently used assumption is that small boxes with resonances above 100 Hz may be considered as rigid point masses. As was the case with dynamic stresses, the best analysis is actual test results. The Fig 2.3/1 show results taken from the Swedish VIKING Wire Boom Tests. The test shown is a ten G sine sweep in the Yu direction. The first observed resonance (250 Hz) physically was the Cable Spool and stored cable as the mass element, and the housing as the spring element. The second observed resonance (250 HZ) physically was the motor and cable drive assembly as the mass element, and the housing as the spring element. These resonances will be slightly lower in the Cluster mechanisms because they are 25 mm taller than the Viking Units. Other, not so well defined resonances were noted at even higher frequencies.

FLIGHT DYNAMICS

The deployed wire boom mass properties, deployment rates, damping characteristics, and on orbit behaviour have been presented, and discussed in detail at an ESA splinter meeting devoted to wire boom dynamics. It is our understanding that ESA has assumed the modelling tasks to incorporate the Spacecraft, the two rigid booms, and the AOCS.

b/ WEC 6

A dynamic evaluation will be requested prior to the manufacturing and provided to ESTEC when available.

c/ other units

The dynamic response will be verified by vibration tests, in sinus low level, and provided 6 months before delivery of EM to ESTEC.

EXP UNIT	RESONANCE FREQUENCY	PART CONCERN	METHOD USED	CONFIGURATION
WEC1/4	250 Hz	cable spool & cable motor & cable drive	VIKING units test	
WEC 5	tbd Hz			
WEC 6	388 Hz	structure	FEM	0.26 Kg
WEC 7	tbd Hz			
WEC 8	tbd Hz			
WEC 9	tbd Hz			
WEC10	tbd Hz			
WEC11	tbd Hz			

Table 2.3/1 Dynamic Characteristics

2.3.2 Stress Analysis

a/ WEC 1/4

BOOM CABLE

Tests of previous cable constructions give a "virgin" tensile strength of more than 600 newtons. The "spring constant" of the kevlar and braid is much higher than that of the conductors, such that (due to strain compatibility) mechanical forces are carried by the kevlar braid rather than the tiny conductors. The elongation at failure of kevlar fibers is about four percent as compared to thirty percent for copper conductors. In fact, in tensile strength tests, the braids rupture first exposing about five cm. of the ductile wires before they finally rupture.

UNIT

In general, this mechanism design is dictated by dynamic stiffness concerns rather than strength. This is often the case in small boxes or mechanisms. The overriding concerns in this design environment usually, or frequently, are as follows:

Reasonable, and repeatable fabrication tolerances

Adequate number of fasteners to avoid dynamic unloading of joints, or to provide adequate "pull in" forces for very thin plates possibly warped by raw material, or fabrication residual stresses.

Adequate material around, and thread engagement for fasteners plus additional thickness needed to accommodate fastener locking devices.

Redundant load paths generally enhance the desired overall device stiffness, but make a unique stress determination dependent upon detailed factors such as fit, temperature, precise tolerancing interactions, and even to minute details such as the fastener tightening sequences.

Thin section material property degradation due to rolling direction granularity, as well as preferential chemical attack in the desired plating and finishing operations.

Magnetic cleanliness concerns often dictate relatively low strength materials (e.g. aluminium or austenitic stainless steels) which are quite forgiving in that the ductility will accommodate very significant overloads without catastrophic failure.

In this context, calculated stresses tend to be very low, and the safety margins large, such that a detailed stress analysis is not generally informative, or appropriate. In larger well defined geometric structures such as the spacecraft, or when comparatively brittle materials such as composites, honeycomb, SCC, or fracture sensitive materials this detailed analysis is indeed appropriate.

As an example, consider the Mechanism Side Plate. The present design has 18 4-40 UNC screws tightened with 0.5 Nm torque and 10 2-56 UNC screws tightened to 0.3 Nm torque. Simple addition of the tension in fasteners (Fi = 5 T/d) gives an unseating force of 26000 N. Yet, all of these fasteners are needed for the dynamic stiffness integrity of this box.

Static and Dynamic mounting foot limit load stress analysis will be generated, when bolt locations are finalised. The box stresses, adjacent to the feet attenuate rapidly due to the dramatic jump in sectional stiffness of the box as compared to the foot.

DYNAMIC STRESSES

The strength safety margin in calculated dynamic stresses is directly dependent upon the assumed "Q", or material damping properties. This behaviour is reasonably well known for metallic, polymeric, honeycomb, or even perhaps composite structures. When polymeric / metallic interfaces exist, the actual dampimg factor may be geometry and tolerance dependent, thus somewhat more difficult to estimate. In this case, testing better establishes the adequacy of the design.

As for test results, the Swedish FREJA wire booms (of the same design, and flight heritage) have recently been successfully subjected to the Qualification Level random vibration of 20.6 G's RMS, and an Acceptance Level of 13.7 G's RMS. These levels are well above those currently stated in the EID-A, and should adequately demonstrate the dynamic strength margins.

The Cable Spool with stored cable represents the largest mass supported by this mechanism. The cable spool is supported by Delrin AF bushings on both ends. The Yu axis (also the spool axis) is the critical direction for stiffness. The spool bushing flanges are individually sized in each mechanism to intentionally bow the side and spool plates by about 0.2 mm. This prevents "rattling" of the spool, avoids resonant jump phenomenon, and doubles the effective stiffness of the box. This interference is based on the the measured stiffness of the plates, which is about 0.50 MN/m, and generates about 90 N preload on each end of the spool shaft. The limiting stress for this preload is shearing of the Delrin bushing flange (0.625" x .065" thick) which requires a force of 1300 N . A SS washer is used on each end of the spool shaft to distribute the load, keeping the Delrin PV wear rate at negligible levels.

The Sensor is also preloaded in its housing by an interference fit of 0.2 to 0.3 mm generating a preload of about 15 N across the spherical sensor. The measured housing stiffness is 120 KN/m, and the limiting strength is 40 lb test restraint cables. Wavy washers are used inside the spherical sensor, for the same purpose.

b/ WEC 6

For the search coil WEC.6, a mechanical structure will be designed by an industrial contractor.

EXP UNIT	MAX STRESS MPa	LOCATION	MATERIAL	DESIGN MARGIN YIELD/ULTIMATE	METHOD USED
WEC1/4	tbd	tbd			FREJA units test
WEC 5	tbd	tbd			
WEC 6	tbd	tbd			
WEC 7	20.4	feet	AL2618 AT851	tbd TBD	FEM 21g RMSx
WEC 8	tbd	tbd			
WEC 9	tbd	tbd			
WEC10	tbd	tbd			
WEC11	tbd	tbd			

Table 2.3/2 Stress Design Margin

2.3.3 Mechanism analysis

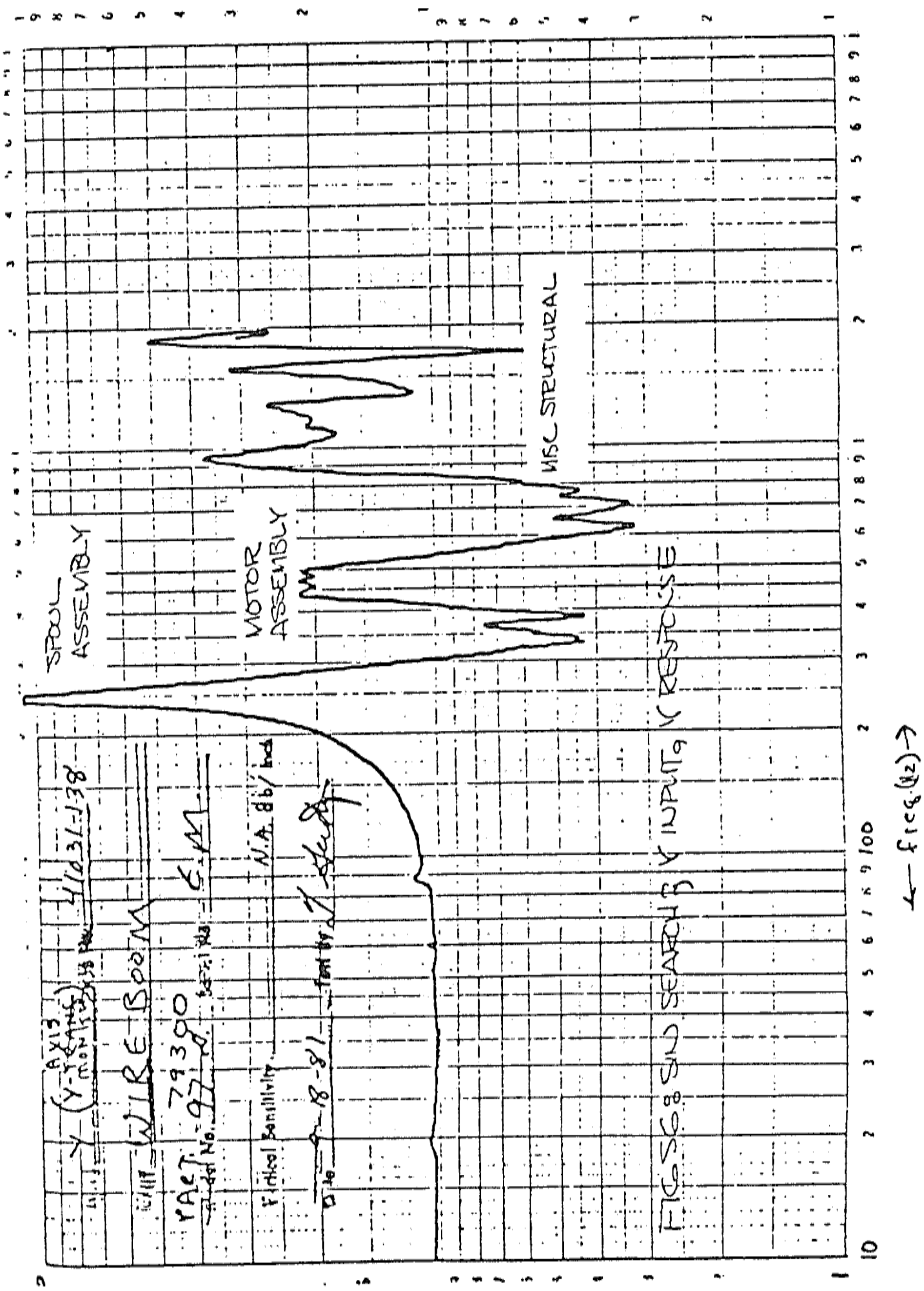
The only determinate external static load applied to this mechanisms due the centripetal acceleration induced wire tension. The maximum cable tension during deployment is about 90 N. The forces or stresses induced in the box by this tension are a small fraction of the dynamic loads. The construction, and properties of the cable is provided in the beginning of this section, and the specification is provided with the parts listing. The actual test strength of the cable is about 600 N. The rated tension for the full mechanism and cable is 200 N. Each mechanism will actually be

tested to this load. The functioning, loads, and margins in the cable drive assembly are described in Figure 2.1/4 above, and in the FMECA.

The Cable Storage Spool shaft bushing size (0.250" diameter) was selected on the basis of PV wear rate data for the Delrin AF bushings. The Spool Fiction Brake pad size (0.375" diameter) were also selected on this basis. Previous test programs has verified wear to be virtually unmeasurable in perhaps 10 full deployments of each mechanism. Previous tests have established that about 0.4 Nm of brake friction torque is needed to prevent significant cable unwinding in the random vibration tests.

Compression Springs are used throughout the mechanism, except for the torsion springs on the clamshell doors. Each spring pitch was selected, such that closed coil compression (i.e. all coils touch) occurs before material yielding. Thus, these springs cannot be overloaded, accidentally or otherwise. The installed clamshell torsion springs have rotation limit stops, which safely limit both the rotation angles and spring material stresses. Austenitic stainless steel is used for the smaller springs. Larger springs are fabricated with half hard Beryllium Copper wire, for magnetic cleanliness.

Fig 2.3/1 WIKING test results



2.4 EXPERIMENT PHYSICAL PROPERTIES

2.4.1 Total mass

The total mass for the WEC units and h/n experiment provided is 26.77 kg.
This value don't include the efw and commnon h/n (estimated 3.1 Kg).

2.4.2 Physical properties of the units

The physical characteristics of the WEC are specified in table 2.4/1. for the mechanical elements and a summarised description of the internal harness is given in Sec. 3.5.

In table 2.4/1 the weights are given without any margin and are therefore considered by the experimenters as minimum values. Taking into account the current payload accommodation and the corresponding length of the cables, the total mass of the WEC harness is now evaluated to about 2.2 kg (see Sec. 3.5). The final value can be slightly different depending on the final routing designed by the contractor. The position of the centre of gravity and the moment of inertia are only calculated values and cannot be given with the accuracy requested in EID_A before measurements of the EMs.

2.4.3 Perturbations generated by mechanisms movements

During the deployment of the long booms, the variation of the centre of gravity on the spacecraft is nul since the booms deploy symmetrically. The variation in the moment of inertia is estimated 3400 kgm2 for 100 m sphere to sphere. The part A allocation of 2600 kgm2 might be met by reducing the sphere to sphere distance to 90 m if this is a firm requirement. The installed cable lengths will be updated as the actual cable and sensor properties are evaluated. For balance purposes, deployed wire lengths are microprocessor controlled to a tolerance of 5 cm and spheres balanced to 1 gram. The total linear forces and torques on the spacecraft are balanced by symmetry under equilibrium conditions. Transient forces and torques are dictated by the AOCS and spacecraft dynamics. For analyses, the boom cable may be treated as a distributed mass having virtually no residual stiffness.

EXPERIMENT UNIT		MASS (kg)		DIMENSIONS (mm)			CENTRE OF MASS (mm) w.r.t. URF			MOMENT OF INERTIA ($Kg\ m^2$) w.r.t. URF centered at C.O.M.		
				L	W	H	X	Y	Z	Ix	Iy	Iz
WEC	1	3.400		375	227	181	80.0	56.0	132.0	]	]	]
	2	3.400		"	"	"	""	""	""	]	]	]
	3	3.400		"	"	"	""	""	""	]	]	]
	4	3.400		"	"	"	""	""	""	] 9.0E-3	] 9.0E-3	] 4.0E-3
WEC	5/c		0.730	8300								
WEC	5	1.800		217	155	75	40.0	-113.0	-61.0	8.90E-3	4.30E-3	6.20E-3
WEC	6	0.760		265	265	265	40.0	65.0	65.0	TBD	TBD	TBD
WEC	7/c	0.677		6300								
WEC	7	0.300		126	94	32	14.5	31.8	51.0	4.18E-4	2.82E-4	1.85E-4
WEC	8	3.050		198	167	180	85.0	91.0	64.5	1.30E-2	1.30E-2	1.65E-2
WEC	9	4.130		230	202	136	71.0	70.0	93.0	2.68E-2	1.75E-2	2.20E-2
WEC	10	1.550		192	159	146	71.5	82.3	66.5	4.10E-5	3.10E-4	3.10E-4
WEC	11	0.900		214	174	37	19.7	50.1	97.8	4.07E-3	2.24E-3	2.03E-3
Harness			2.368	see section 3.4 for details								
TOTAL		26.77	3.10									

Table 2.4/1.1 **WEC physical properties**

EXPERIMENT UNIT	MASS (kg)	DIMENSIONS (mm)			CENTRE OF MASS (mm) w.r.t. URF(1)			MOMENT OF INERTIA ($kg\ m^2$) w.r.t. URF(2)		
		L	W	H	X	Y	Z	Ix	Iy	Iz
WEC 8/1	1.200	190	137	76						
WEC 8/2	1.790	198	167	104						
WEC 8/c	0.060									
WEC 9/1	1.950	230	190	65						
WEC 9/2	2.050	230	202	71						
WEC 9/c	0.130									

Table 2.4/1.2 WEC physical properties

L = Length, W = Width, H = Height
global dimensions including all protuberances

2.5 EXPERIMENT MOUNTING ATTACHMENTS

2.5.1 Mounting Attachment Concept

Attachment concept is hard mounted for all units.
The footpattern are defined in the interface drawing (Fig 2.2/1.1 TO 2.2/1.8).
The units are attached by standard fasteners (M4).
The EFW deployment units (WEC 1/4) will have their front feet attached on the reinforced ring.

2.5.2 Inserts Loads

The calculated bolt loads are shown in tables 2.5/1.1 to 2.5/1.8.

2.5.3 Reference hole

The mounting reference holes are shown on the mechanical drawings (section 2.2).

2.5.4 Critical features

For the electronic boxes WEC.5 and WEC.7 to WEC.11, there is no critical feature in the mounting design. It is proposed that the mounting be achieved by four (or six) mounting brackets or "feet" near the corner of the units (and in the middle in case of 6 brackets). The attachment surfaces will have sufficient area for good thermal and electrical contacts. The concept will comply with the specifications of EID part A section 2.6.

The search coil package (WEC 6) will be attached to the boom on a dedicated platform defined by the contractor. The structure shall not create any closed loop around the sensor perpendicular to the boom. The package must be easily dismounted from the boom for the check out requiring the antennas inside the mu-metal box.

The cable WEC 7/c, will be mounted along the rigid deployable boom by a method defined by the contractor.

The attachment of the electric booms (WEC.1..4) will be made by using the reinforced ring as shown on Fig. 2.2/1 and according to EID_A Fig. 2.6.3 and 2.6.4.

MASS (KG)				3.400		
Coordinates of Centre of Mass with respect to URF (mm)				X 80.0	Y 56.0	Z 132.0
Applied Forces (N)				1055	1055	1055
Bolt No.	Coordinates (mm)			Maximum Loads (N)		
	X	Y	Z	Normal	Shear	Total
1	0.0	0.0	0.0	544	240	594
2	0.0	0.0	115.0	416	264	487
3	0.0	0.0	223.0	622	290	674
4	0.0	131.0	223.0	643	278	694
5	0.0	114.0	115.0	374	258	449
6	0.0	114.0	0.0	502	241	557

Table 2.5/1.1 Calculated mounting bolt loads for WEC 1/4

MASS (KG)				1.800		
Coordinates of Centre of Mass with respect to URF (mm)				X 37.5	Y -100.5	Z - 47.5
Applied Forces (N)				709	709	709
Bolt No.	Coordinates (mm)			Maximum Loads (N)		
	X	Y	Z	Normal	Shear	Total
1	0.0	0.0	0.0	383	250	458
2	0.0	0.0	- 95.0	383	250	458
3	0.0	-201.0	- 95.0	383	250	458
4	0.0	-201.0	0.0	383	250	458

Table 2.5/1.2 Calculated mounting bolt loads for WEC 5

MASS (KG)					0.700		
Coordinates of Centre of Mass with respect to URF (mm)					X 40.0	Y 65.0	Z 65.0
Applied Forces (N)					343	343	343
Bolt No.	Coordinates (mm)				Maximum Loads (N)		
	X	Y	Z		Normal	Shear	Total
1	0.0	0.0	0.0		192	121	227
2	0.0	0.0	130.0		192	121	227
3	0.0	130.0	130.0		192	191	227
4	0.0	130.0	0.0		192	121	227

Table 2.5/1.3 Calculated mounting bolt loads for WEC 6

MASS (KG)					0.300		
Coordinates of Centre of Mass with respect to URF (mm)					X 14.5	Y 31.8	Z 51.0
Applied Forces (N)					147	147	147
Bolt No.	Coordinates (mm)				Maximum Loads (N)		
	X	Y	Z		Normal	Shear	Total
1	0.0	0.0	0.0		100	84	130
2	0.0	0.0	112.0		90	81	121
3	0.0	58.6	112.0		100	80	127
4	0.0	58.6	0.0		110	88	137

Table 2.5/1.4 Calculated mounting bolt loads for WEC 7

MASS (KG)				3.050		
Coordinates of Centre of Mass with respect to URF (mm)				X 85.0	Y 91.0	Z 64.5
Applied Forces (N)				986	986	986
Bolt No.	Coordinates (mm)			Maximum Loads (N)		
	X	Y	Z	Normal	Shear	Total
1	0.0	0.0	0.0	594	236	638
2	0.0	0.0	129.0	594	236	638
3	0.0	98.0	142.5	403	234	466
4	0.0	182.0	129.0	570	232	615
5	0.0	182.0	0.0	570	232	615
6	0.0	84.0	-13.5	403	234	466

Table 2.5/1.5 Calculated mounting bolt loads for WEC 8

MASS (KG)				4.130		
Coordinates of Centre of Mass with respect to URF (mm)				X 71.0	Y 70.0	Z 93.0
Applied Forces (N)				1192	1192	1192
Bolt No.	Coordinates (mm)			Maximum Loads (N)		
	X	Y	Z	Normal	Shear	Total
1	0.0	0.0	0.0	650	281	709
2	0.0	0.0	186.0	646	281	705
3	0.0	70.0	186.0	348	281	447
4	0.0	140.0	186.0	655	281	712
5	0.0	140.0	0.0	659	285	716
6	0.0	70.0	0.0	352	283	452

Table 2.5/1.6 Calculated mounting bolt loads for WEC 9

MASS (KG)				1.550		
Coordinates of Centre of Mass with respect to URF (mm)				X 71.5	Y 82.3	Z 66.5
Applied Forces (N)				645	645	645
Bolt No.	Coordinates (mm)			Maximum Loads (N)		
	X	Y	Z	Normal	Shear	Total
1	0.0	0.0	0.0	363	152	394
2	0.0	0.0	132.9	363	152	394
3	0.0	82.3	132.9	223	152	270
4	0.0	164.6	132.9	363	152	394
5	0.0	164.6	0.0	363	152	394
6	0.0	82.3	0.0	223	152	270

Table 2.5/1.7 Calculated mounting bolt loads for WEC 10

MASS (KG)				0.900		
Coordinates of Centre of Mass with respect to URF (mm)				X 19.7	Y 50.1	Z 97.8
Applied Forces (N)				442	442	442
Bolt No.	Coordinates (mm)			Maximum Loads (N)		
	X	Y	Z	Normal	Shear	Total
1	0.0	0.0	0.0	183	154	239
2	0.0	0.0	198.0	214	166	267
3	0.0	102.0	136.6	178	161	236
4	0.0	102.0	30.7	170	156	231

Table 2.5/1.8 Calculated mounting bolt loads for WEC 11

2.6 EXPERIMENT ALIGNMENT

2.6.1 Boresight Direction

Ref to section 2.2.2.2.

The long booms and the spin axis of the S/C define a reference axis for the wave measurements for WEC. It will be called "Electrical Axis" and is specified as follows (see Fig 2.6/1) :

X_E parallel to the spin axis
Y_E in the direction of V3 (WEC.3)
Z_E in the direction of V1 (WEC.1)

2.6.2 Boresight Accuracy

Exp Unit	Boresight Position	Alignment Tolerances Azimuth			Elevation		
		Accuracy	Knowledge	Stability	Accuracy	Knowledge	Stability
WEC 1	See Table 2.2/3 and Drawing Fig.2.2/ 1.1and1.3	30'	N/A	N/A	30'	N/A	N/A
WEC 6		45'	N/A	18'	45'	N/A	18'

Table 2.6/1 Alignment requirement between S/C reference axis and interface mounting plate axis.

WEC6:

In order to reduce the number of errors an accuracy of 0,1 degree is requested in the mechanical positioning of the unit on its bracket.

There is no request for the rest of the experiment.

2.6.3 Experiment Optical Reference

N/A

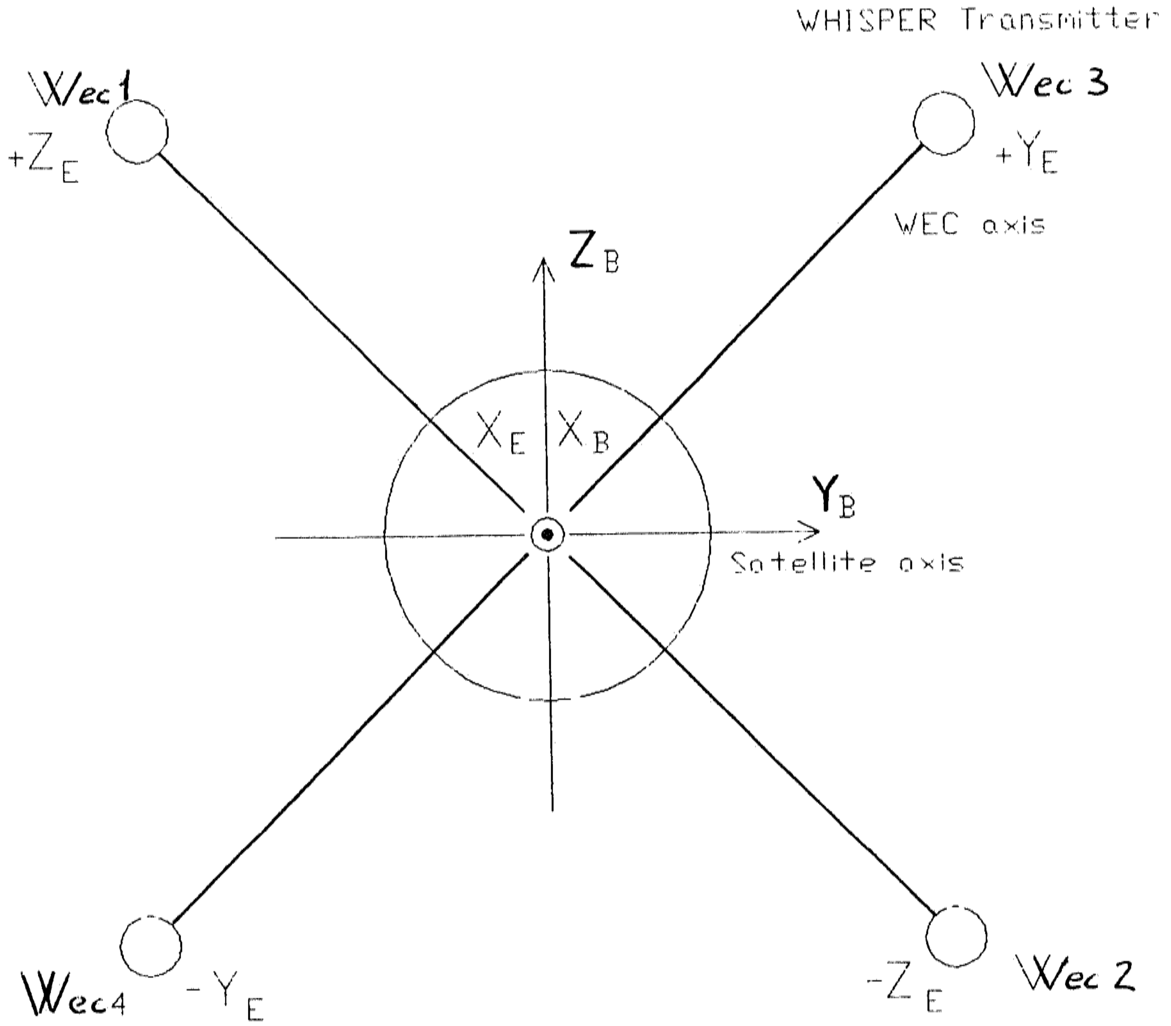
2.6.4 Method of Alignment

N/A

2.6.5 Coalignment

No requirement.

Fig. 2.6/1 WEC reference axis



2.7 EXPERIMENT APERTURE COVERS

2.7.1 Type of Aperture Cover

The EFW deployment units (WEC1/4) have flight covers:
The boom mechanisms have gull-wing type doors which are opened prior to deployment.

No covers for any other units.

2.7.2 Cover Deployment and Retention Systems

The spring loaded doors are held in place by a wire which is fed through a pair of pyrotechnic
cable cutters in the base of the unit. If either cable cutter works, the doors will be released.
The cable cutters have been approved in the CRRES project for use on the STS.

2.7.3 Purging Interface

N/A