

Verification

25-09-02



Introduction

- **Verification during phase C/D mostly underestimated during proposal preparation / contract negotiations causing schedule delays and in worst-case technical problems**
- **Engineers like more creativity but not so much detailed formal proof that all requirements are fulfilled**
- **Depending on customer strength compromises can be "sold" but one should never rely on that**
- **Several examples where insufficient/wrong verification caused failures on-orbit or even complete mission loss.**



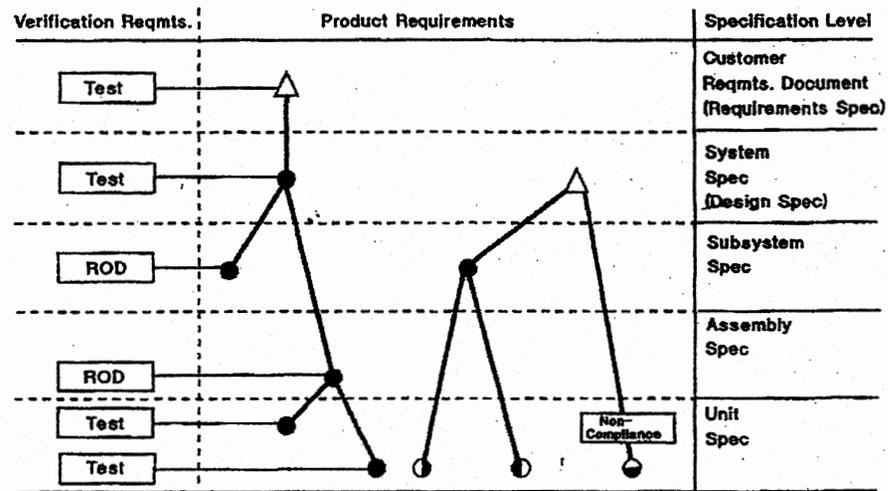
General

- **Definition: Verification is summary term for**
 - **Qualification activities**
 - **Acceptance activities**
- **Qualification**
 - **Proof that design fulfills all applicable requirements (incl. manufacturing tolerances, lifetime effects) in all combinations**
 - **Independent of serial number of Qualification Model; related to part number**
- **Acceptance**
 - **Proof that item (unit or system) is in accordance with qualified design and free of workmanship failures**
 - **Related to serial number**
- **Principle agreement with ECSS-E-10-02**



Qualification Reference: Specification

- System to be split in subsystems, assemblies and units with unambiguous and objectively verifiable interfaces
- Specifications



Legend:

△ Father Requirement

○ Partial Requirement

● Accepted Reqmts. Reduction

- Quality of Specifications
 - Tailored to products
 - Non-ambiguous / complete interrelations
 - Verification method(s)



ICD's

- **Interface requirements defined by customer (normally paragraph 5 of specification).**
- **ICD's are based on interface requirements and grow gradually in line with design progress, i.e. in addition to the wider requirements range the design capabilities as well as additional data are included as deemed necessary by the custodian to ensure interface compatibility.**
- **Interface Control Documents (ICD's)**
 - **Describe Actual status on design level (i.e. no repetition of interface requirements).**
 - **Common, formally agreements between interfacing design responsables under control of upper design level (= approval of design).**
 - **ICD's must be verified as early as possible to ensure successful integration on upper level.**
 - **Verification method design depending**
 - **ICD's are valid for EM and FM units**



Verification Methods

- **Qualification**
 - **Analysis** (final at CDR)
 - **Review of Design (ROD)** (final at CDR)
 - **Test**
 - **Inspection**
 - **ICD's have additional verification close-out options**
 - **Marking of ICD parameters on manufacturing drawings**
 - **Reference to acceptance test procedure**
 - **Acceptance**
 - **Test**
 - **Inspection**
- Note: Acceptance criteria to be tailored to design to find especially workmanship failures.**



Qualification Test: Principle Options

I. After-Test-Evaluation

- **Test success criteria/test procedure based on specification data**
- **As-run procedure extended by "Engineering evaluation" for:**
 - > **Variations due to temperatures, min./max. supply voltages**
 - > **Measurement tolerances**
 - > **Manufacturing tolerances**
 - > **Wear-out/degradation versus time etc.**

II. Pre-Test-Evaluation

- **Success criteria/test specification and/or procedure more stringent than specification or ICD, i.e. margins for tolerances, lifetime etc. are subtracted prior to test.**
- **No engineering evaluation necessary.**

Note:

Option II is more efficient but critical for marginal performances.



Qualification Model Philosophy

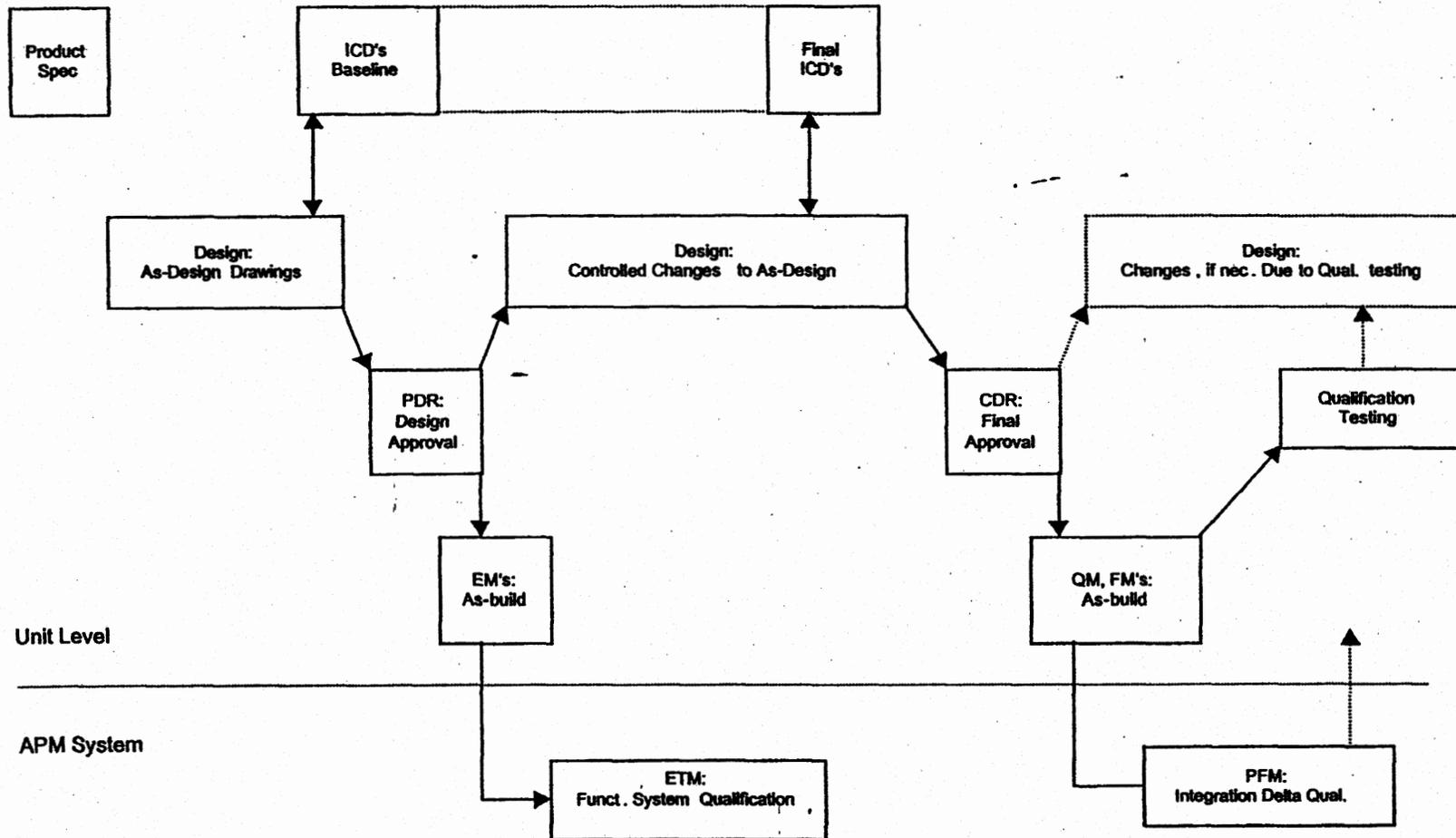
- **Qualification Model**
 - **Identical Flight Model design and manufacturing**
 - **High-reliability parts as for FM**
- **EQM**
 - **Identical Flight Model design and manufacturing**
 - **Commercial parts**
- **EM**
 - **Limited differences to Flight Model design and manufacturing**
 - **Commercial parts**
- **Protoflight Model**
 - **Flight Model tested with reduced levels/test durations**
 - **For units with low complexity and/or similar to items qualified in different programs**

Notes:

- **QM best from technical point of view but high costs and late results**
- **EQM/EM needs extensive evaluations to consider differences (e.g.: EM/FM Difference Lists)**



System Level Qualification Philosophy





EM/FM Differences



Dok.Nr./No: COL-RIBRE-TN-1440
 Ausgabe/Issue: 2 Datum/Date: 19.07.2002
 Überarbgt./rev: - Datum/Date: -
 Seite/Page: 17 von/of: 19

Equipment	Para.	Ref. To EM/FM Diff. Doc.	Impact on ETM Test Results (T40/T60)		Assessment/Remark EM to FM FFF difference	Reference to FM CIDL
			Yes	No		
ATU	4.2.1	N/A		X	FM type is integrated and flight suitable	N/A
CFA, IRFA, ISFA inclusive DPS	4.2.10	RD 2.2.3.5		X	EU: EM functionality in line with FM; Fan motor: No significant difference, for details see para 4.2.10	COL-SREM-LI-0055, Iss. 1/-
CTCU	4.2.11	RD 2.2.4.1		X	No significant difference, QM is used for testing	COL-KAY-LI-0046, Iss. 3/A
CTS	4.2.12	RD 2.2.3.5		X	EM identical to FM	*1; refer to para. 6.1
HCU	4.2.13	RD 2.2.4.1		X	No significant difference	COL-KAY-LI-0047, Iss. 3/A
CWSA	4.2.14	RD 2.2.3.5		X	EU: EM functionality in line with FM	COL-SREM-LI-0056, Iss. 1/-
FSU	4.2.15	Not existing		X	No significant difference	N/A
HS	4.2.16	RD 2.2.3.5,2.2.4.1		X	No significant difference	COL-DOR-HS-LI-0009, Iss. 4/7
IRSOV, ISSOV	4.2.17	RD 2.2.3.5		X	EM identical to FM	COL-CTH-LI-0026, Iss. 1/-
PPCS	4.2.18	RD 2.2.4.1		(X)	QM is timely not available; retest with representative model on PFM mandatory	N/A
PPOS	4.2.19	RD 2.2.4.1		(X)	QM is timely not available; retest with representative model on PFM mandatory	N/A
CDA	4.2.2	RD 2.2.3.5		X	No significant difference	*1; refer to para. 1.2
PPRA	4.2.20	RD 2.2.3.5		X	EM identical to FM	*1; refer to para. 1.3
TPS	4.2.21	RD 2.2.3.5,2.2.4.1		X	No significant difference	072530-154-553 (30.9.1999)
VVDD	4.2.22	RD 2.2.3.5		X	EM identical to FM	*1; refer to para. 8.1
RVPS, VVPS	4.2.23	RD 2.2.3.5		X	No significant difference	*1; refer to para. 9.1
TCV	4.2.24	RD 2.2.3.5		X	No significant difference	Parts List 2357123-1 Rev. D
MLU,ELS,RPCS	4.2.25	Not existing		X	EM and STE identical to FM	
OSS	4.2.26	Not existing		X	EM identical to FM	
PDU	4.2.27	RD 2.2.3.1		X	No significant difference	
PPSB	4.2.28	RD 2.2.3.2		X	No difference	COL-CIR-CDL-1003, Iss. 2/A

Table 5-1: EM to FM difference List - Equipment Level Synthesis for Functional Qualification Test



Verification Management and Control

- **Verification needs strict and formal control**
 - **Requirements/Spec coherence over all responsibility levels (product and verification requirements)**
 - **Verification activities definition and planning**
 - **Implementation of RFW's and DDR's**
 - **Close-out status accounting**
 - **Generation of VCD's and COQ's**

- **Competence/know-how to “control” technical results (separate organizational element)**



Verification Control Document (VCD): Manual

VFW-FOKKER ERNO Modular SPACELAB		SUBSYSTEM VERIFICATION CONTROL SHEET					DOC. NO.: LI-ER-0041		ISSUE: 5 DATE: Sept. 81	
SPEC. TITLE: MODULE STRUCTURE		SPEC. No.: SS-ER-0001		ISSUE: III		CHANGE: C		PAGE: 2 - 21		
IDENT. NO.	SS/EO SPEC. PARAGRAPH	VERIFICATION REQUIREMENTS	VERIFICATION METHOD			TRACE NO.	VERIFICATION REF. DOC.	FINAL VERIFIC. DOCUMENT (E.G. TEST, ANALYSIS, INSP. REPORT)	REMARKS	
			EQUIPMT LEVEL	SUBSYST. LEVEL	SYSTEM LEVEL					
1081 B	3.2.7 Handling	Verify that the end cones and cylinder assemblies permit individual handling installation and removal by NGSE	---	ROD	---	---	GS-ICD-003	Drwg 1-10001 1-20001 1-30001		
1082 A		Verify that the module is capable of being installed in the Orbiter in the horizontal position, can be removed from the Orbiter either in a launch (vertical) or landed (horizontal) position	---	ROD Anal	---	---	GS-ICD-001	Drwg 1-50001 RP-AI-0087		
1083 B		Verify that module/Orbiter installation and removal handling is accomplished by attachments to flight fittings	---	ROD	---	---	GS-ICD-001	Drwg 1-00003 1-50001		
1084 B		Verify that during removal and installation of the secondary structure using the NGSE mechanical rail, the lifting range is 10 ± 2 millimeters	---	ROD	---	---	GS-ICD-005	RP-AI-044/2 RP-AI-0045/2 0.09.80 VRS 3		
085		Verify that the module can be handled in the configurations with the corresponding masses listed in Table 3.10.6-1.	/	/	/	/	/	/	NIBT, covered under I.D. No. 201256 VRS 3 19.06.80	



VCD: Output from AIVDB

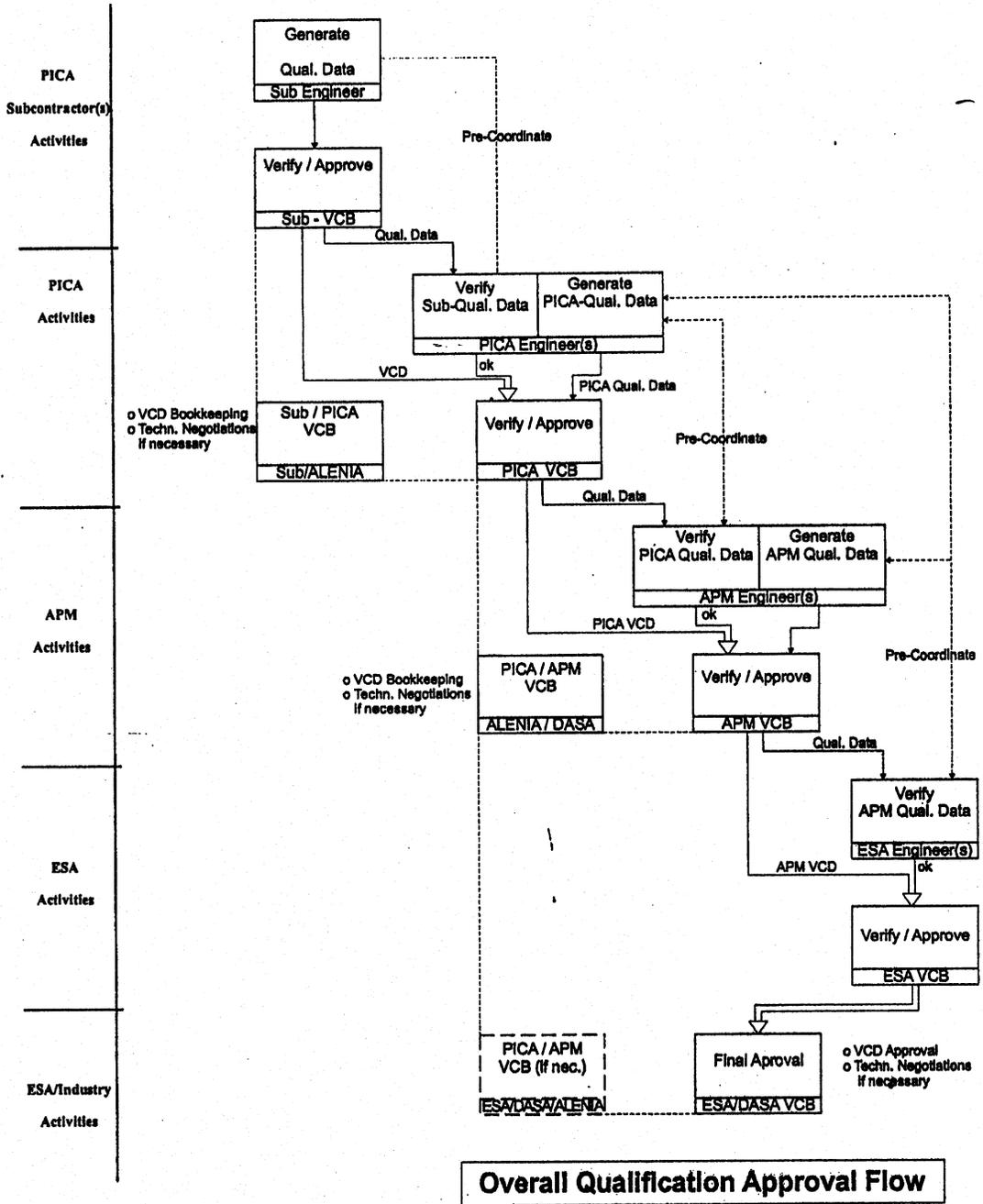
- Due to high amount of data and changes computerized AIVDB mandatory.
- Example from Columbus shows status "Agreed by Columbus VCB, sent to ESA VCB for approval"

	Attached Pressurised Module VERIFICATION CONTROL DOCUMENT	Dok.Nr./No: Ausgabe/Issue: Datum/Date: 12.04.2002 Überarbtg./rev: Datum/Date: Seite/Page: 2 von/of: 7
Spec No.: COL-ESA-RQ-001 Title: CSRD Issue: 3 Rev: H Date: 04.07.1999 5.3.3	Induced motions or moments resulting from fluid transfer dynamics and venting shall be controlled.	CI No.: 1213800-00

Spec requirement					Closeout Docs	RFWs	VCB Reference	Close-out status	Doc Location	Remarks
Para	Verification Method									
	FC	SS	AS	EQ						
5.3.3	A				COL-RP-AI-0111 Iss 5/-	COL-DOR-RFW-0035	COL-RIBRE-MIN-0040-02	P	APM CDR DP V4, B14	ESA pending



Verification Control Boards (VCB's)





Certificate of Qualification (COQ)

CERTIFICATE OF QUALIFICATION

CI. No. : 1081625	CI. Spec. no : COL.RIBRE.SPE.0010 Issue/Rev : 6	CI. Nomenclature: Data Management Sub-System
Part No. :	Model/Serial No: EM V2.1/V4.0	

The following is certified :

1. All exceptions listed against lower level certifications have been resolved and closed out.

2. The item has successfully been qualified against all requirements of specification(s) :

 DMS sub/system specification : COL.RIBRE.SPE.0010 Issue 6

 and in accordance with the associated methods/processes as documented in the related
 Verification Control Document DMS.MMT.VCD.0002 issue 5
 & Verification Status Report :

3. ~~The item has successfully passed all safety-related tests.~~ *Not Applicable at S/S level*

4. All hazards identified in the Safety Analyses are eliminated or controlled and all Hazard Reports are closed.

5. A configuration inspection has been performed with the result that the item complies with the contractual baseline as per CIDL DMS.MMT.COL.0004 , Issue 5, Rev.-.

6. Each deviation from the specification/drawing has been approved by the Material Review Board or by a contractual waiver.

7. The item has successfully performed its specified function in the integrated flight configuration, as reported in :

	DMSS contractor		Prime		ESA	
	NAME	DATE	NAME	DATE	NAME	DATE
ENGINEERING	<i>[Signature]</i>	10.2.02			/	
PRODUCT ASSURANCE	<i>[Signature]</i>	13.2.02			/	



Acceptance Documentation

- **Certificate of Acceptance (COA) for each serial number:**
 - **Configuration identical to "Qualified Design"**
 - **COQ approved by customer**
 - **Acceptance activities in accordance with approved test procedure successful**

- **COA to be countersigned by customer**

- **Certificate of Conformance**
 - **Formal/legal declaration**

- **Detailed contents of documents differ depending on company standards; quite different approach for American items**

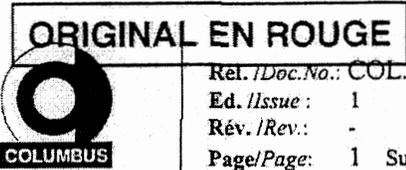


Réf./Doc.No.: COL.SXT.COA.0011
 Ed./Issue : 1 Date/Date : 15/09/2001
 Rév./Rev.: - Date/Date :
 Page/Page: 1 Sur / Of: 2



COA

CERTIFICATE OF ACCEPTANCE							
(2) The endorsements herein certify that the item offered for acceptance has been manufactured, assembled and tested in accordance with released engineering data and complies in all respects with contractual requirements, except as recorded in the List of Exceptions of this certificate.							
(3) CI. NO. 1235086	(4) CI. SPEC. NO. COL.RIBRE.SPE.0085 Issue 2 Rev. D			(5) CI. NAME PDU			
(6) PART NO. C22380CA01	INDEX	(7) SERIAL NO. FM1	(8) ACCEPTANCE LEVEL FALS - Plan 15.3				
			1	2	3	X	4
THE FOLLOWING IS CERTIFIED:					(10) EXCEPTIONS		
(9) 1. All exceptions listed against lower level certifications have been resolved and closed out. Except open work list/open test list					N/A		
2. Qualification of the item is satisfactorily completed and recorded in COL.SXT.VCD.003 Issue 4 rev. -					LOE		
3. A Configuration Inspection has been performed and the item complies with the contractual baseline.					OK		
4. Each departure from specification and drawing has been approved by the Material Review Board or by contractual waiver.					Part I Sect 10.3 RLOE		
5. Hazards identified in Safety Analyses are closed or accepted as controlled residual hazards.					OK		
6. Acceptance testing in accordance with a approved test procedure has been successfully completed and all discrepancies have been resolved.					LOE		
7. The Acceptance Data Package ADP No. COL.SXT.ADP.0011 Issue 1 Rev. - complete and is available for shipment with the configuration item.					OK		
8. Open work/test and unresolved non-conformances defined in the ADP are acceptable for transfer to the user site.					OK		
9. Packaging and shipping arrangements are defined and agreed as per					Delivery Insp Rep COL.SXT.RP.0453		
The undersigned certify that all exceptions listed can be satisfactorily resolved at the place and time stipulated in the Log of Exceptions without degradation of the required CI performance.							
(11) LOWER TIER SUBCONTRACTOR	DATE	ALCATEL	DATE	ASTRIUM	DATE	ESA	DATE
PRODUCT/QUALITY ASSURANCE	12/01/02	S. ZANINOTTI	12.01.02	H. Hoffmann			
PROJECT MANAGEMENT	19/09/01	C. BOYER					



Rel./Doc.No.: COL.SXT.COC.0011
 Ed./Issue : 1 Date/Date : 15.09.2001
 Rév./Rev.: - Date/Date :
 Page/Page: 1 Sur / Of : 1



CERTIFICATE OF CONFORMANCE

Nomenclature	Specification Number	
PDU	COL.RIBRE.SPE.0085 Issue 2 rev. D	
Drawing/Identification Number	Serial Number	Model
C22380CA01	FM1	FM
CI Number	Contract Number	
1235086	C.CD.SEXI.22 Issue 2	

CERTIFICATION:

We certify that the product defined above is found in accordance with the engineering documents, the quality requirements and the order for development / production and has been inspected and accepted.
 The product Status is documented in the pertinent.
 Acceptance Data Package: COL.SXT.ADP.0011 Issue 1 Rev. -

Prepared by: S. BERNA

Dept: BO/EI/OC

Date: 14/09/01

Approved by: S. ZANINOTTI

Dept: Q/EVA

Date: 14/10/01

(Handwritten signature and initials)

COC