EADS SPACE TRANSPORTATION

COLUMBUS

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DCR Daten/Dokument-Änderungsnachweis/Data/Document Change Record

Überarbeitung Revision	**Datum** Date	**Betroffener Abschnitt/Paragraph/Seite** Affected Section/Paragraph/Page	**Änderungsgrund/Kurze Änderungsbeschreibung** Reason for Change/Brief Description of Change
6/-	14.06.93	Complete document	In response to SSRR Board Disposition to RID 3.103-E3 1029
6/-*	16.06.93	Complete document	Verification entries added
7/-	30.06.94	Complete document	Reviewed APM B/L implemented (incl. SSRR-A-RIDs remaining valid) 3.103-E-0005 3.103-E-0006 3.103-E-0006 3.103-E-0007 3.103-E-0008 3.103-E-0009 3.103-E-0010 3.103-E-0011 3.103-E-0013 3.103-E-0014 3.103-E-0015 3.103-E-0017 3.103-E-0019 3.103-E-0022 3.103-E-0028 3.103-E-0029 3.103-E-0030 3.103-E-0041 3.103-E-0043 3.103-E-0046 3.103-E-0047 3.103-E-0049 3.103-E-0051 3.103-E-0053 3.103-E-0055 3.103-E-0056 3.103-E-0060 3.103-E-0063 3.103-E-0064 3.103-E-0065 3.103-E-0068 3.103-E-0069 3.103-E-0070 3.103-E-0071 3.103-E-0074 3.103-E-0078 3.103-E-0080 3.103-E-0081 3.103-E-0082 3.103-E-0083 3.103-E-0084 3.103-E-0085 3.103-E-0086 3.103-E-0087 3.103-E-0088 3.103-E-0093 3.103-E-0094 3.103-E-0095 3.103-E-0097

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7/- (cont.)	30.06.94	Complete document	Reviewed APM B/L implemented (incl. SSRR-A-RIDs remaining valid) 3.103-E-0098 3.103-E-0103 3.103-E-0105 3.103-E-0106 3.103-E-0109 3.103-E-0110 3.103-E-0111 3.103-E-0119 3.103-E-0120 3.103-E-0125 3.103-E-0126 3.103-E-0129 3.103-E-0130 3.103-E-0135 3.103-E-0137 3.103-E-0140 3.103-E-0141 3.103-E-0146 3.103-E-0148 3.103-E-0153 3.103-E-0154 3.103-E-0156 3.103-E-0157 3.103-E-0158 3.103-E-0160 3.103-E-0162 3.103-E-0163 3.103-E-0164 3.103-E-0166 3.103-E-0167 3.103-E-0168 3.103-E-0169 3.103-E-0170 3.103-E-0171 3.103-E-0173 3.103-E-0174 3.103-E-0178 3.103-E-0181 3.103-E-0182 3.103-E-0183 3.103-E-0185 3.103-E-0188 3.103-E-0193 3.103-E-0194 3.103-E-0199 3.103-E-0200 3.103-E-0202 3.103-E-0203 3.103-E-0204 3.103-E-0207 3.103-E-0208 3.103-E-0217

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7/- (cont.)	30.06.94	Complete document	Reviewed APM B/L implemented (incl. SSRR-A-RIDs remaining valid) 3.103-E-0218 3.103-E-0219 3.103-E-0226 3.103-E-0227 3.103-E-0228 3.103-E-0230 3.103-E-0233 3.103-E-0235 3.103-E-0236 3.103-E-0237 3.103-E-0238 3.103-E-0239 3.103-E-0240 3.103-E-0246 3.103-E-0256 3.103-E-0257 3.103-E-0258 3.103-E-0260 3.103-E-0264 3.103-E-0271 3.103-E-0272 3.103-E-0273 3.103-E-0274 3.103-E-0275 3.103-E-0277
8/-	31.03.95	Complete document	Implementation of Design-to-Cost Baseline
9/-	31.05.96	Each page	Change of doc. Number from SPE 121 1382 00 to COL-RIBRE-SPE-0028-00
		Several	Implementation of SRCR RIDs -E-SY-02-1 -E-SY-02-2 -E-SY-02-3 -E-SY-02-4 -E-SY-02-5 -E-SY-02-6 -E-SY-02-7 -E-SY-02-9 -E-SY-02-17 -E-SY-02-25 -E-SY-02-31 -E-SY-02-33 -E-SY-02-36 -E-SY-02-38 -E-SY-02-39 -E-SY-02-43 -E-SY-02-44 -E-SY-02-45 -E-SY-02-46 -E-SY-02-47 -E-SY-02-48

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9/- (cont).	31.05.96	Each page	Implementation of SRCR RIDS
		several	-E-SY-02-49 -E-SY-02-50 -E-SY-02-52 -E-SY-02-53 -E-SY-02-54 -E-SY-02-55 -E-SY-02-56 -E-SY-02-63 -E-SY-02-64 -E-SY-02-65 -E-SY-02-66 -E-SY-02-71 -E-SY-02-72 -E-SY-02-73 -E-SY-02-74
9/A	18.10.96	several	CSRD revision 3/C included: • Deletion of hooks and scars for - DRS-T - EVP - Automation & Robotics - P/L Utilities • Deletion of deliveries of PFEX and PBA (interfaces for accommodation maintained • Implementation of interface provisions for ISPRs with ARIS • Implementation of zones for local fire detection and suppression • Increase of primary shell end code wall thickness • Implementation of EWACS interfaces for Payload
		Several as follows	Implementation of agreements with ESA: • COL-RIBRE-MMO-0215-96 of 18.09.96 • COL-RIBRE-MMO-0226-96 of 24.09.96
		1.1	
		1.4	
		1.7	new
		2.1.1.15	
		2.1.4.1	new
		4.1.1	
		4.1.2	
		4.1.3	
		4.1.5	
		4.1.6	
		4.1.7	
		4.1.8	

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9/A (cont.)	18.10.96	4.1.9	
		4.2.1	
		5.2.1.6	
		5.2.2.1	
		5.2.3.3.6	
		5.2.5.3.2.3	
		5.2.5.4.2.2 thru 5.2.5.4.2.4	
		5.3.5.1 thru 5.3.5.3	
		Table 5.3.5-1	
		5.3.5.3.1	
		5.4.2.1.	
		Table 5.4-1	deleted
		5.5.1.2	
		Table 5.5.1-1	
		5.5.1.5	
		5.5.3.1	
		5.5.5.1.2	
		5.5.5.2.4.5.1	
		5.5.5.4.1 thru 5.5.5.4.3	
		5.7.4.4.1.1	
		5.7.8.2.1	
		5.7.8.3.2.1	
		5.7.8.4.8	
		5.7.9.3.3	
		Table 5.8.1-1	
		5.8.12.1	
		5.8.14.1	
		5.12.3	
		6.1.1.7	
		Table 6.1.1.-1	
		Fig. 6.1.2-1	
		Fig. 6.1.3-1	
		6.1.5.2	
		Fig. 6.1.5-2	new
		Fig. 6.1.6-1	
		6.1.6.2.2	
		6.1.7.1.2	
		6.1.7.2.11	
		6.1.7.3.1 and 6.1.7.3.2	
		6.1.7.4.2.1	
		6.1.7.4.2.5	
		6.1.7.4.2.9	

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9/A (cont)	18.10.96	Table 6.1.7-4 Table 6.2.1-3 Table 6.2.1-8 Table 6.2.1-15 6.2.1.2.1.2 Fig. 6.2.1.2-1 Table 6.2.1.2-1 Fig. 6.2.1.2-2 Table was: 6.2.1.2-6 is: 6.2.1.2-7 6.2.1.2.4.1.6 6.2.1.2.8.1.5 and 6.2.1.2.8.1.6 Fig. 6.2.1.2-13 and Fig. 6.2.1.2-14 Table 6.2.1.2-1 Table 6.2.2-2 Table 6.2.3.3-2 6.2.3.6 Table 6.2.3.6-1 6.2.3.8.1 Table 6.2.3.8-1 6.2.3.8.2 Table 6.2.3.8-2	new (Typo)
10/-	30.08.97	1.4	COL-RIBRE-CCN-1008, Europeanization of Video Equipment
		1.6	MPLM/ECLSS commonality actualized
		2.1.1 5.5.1.2 5.5.3.1 5.8.1, 5.8.12.1.1, 5.8.12.2.2.1, 5.12.1.4	COL-RIBRE-CCN-1026, CSRD Changes (Applicable Documents, PFE & PBA Accommodation, SVS Targets, ARIS)
		5.1.1 5.2.5.4.1.1, 5.2.5.4.1.2, 5.2.5.4.1.3, 5.2.5.4.1.4, 5.4.3.1.1, 5.4.3.2.2, 5.7.8.4.7.1.1, 5.7.8.4.7.2.1, 5.7.8.4.7.3.1 Fig. 6.1.10-1 Tables 6.2.1-13, -14, -16 6.2.1.2.4.1.5	COL-RIBRE-CCN-1017, Implementation of JEM Link

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10/- (cont)	30.08.97	6.2.1.2.6.1 6.2.1.2.6.2 Fig. 6.2.1.2-1 Fig. 6.2.1.2-6 Fig. 6.2.1.2-8 Table 6.2.2-1 Table 6.2.2-2 Table 6.2.2-3 Table 6.2.3.1-1 Table 6.2.3.2-1 Table 6.2.3.3-1 Table 6.2.3.3-2	
		Table 6.2.1.-14	COL-RIBRE-CCN-1007, FDS B/L Change
		Fig. 6.2.1.2-1 6.2.1.2.2.5 Fig. 6.2.1.2-4 6.2.1.2.4.2.2.3 6.2.1.2.8.1.2 6.2.1.2.8.1.3 (deleted) 6.2.1.2.8.1.4 6.2.1.2.8.1.5 6.2.1.2.8.1.6 6.2.1.2.8.1.13 Fig. 6.2.1.2-14 Fig. 6.2.1.2-15 6.2.1.2.8.2.1 6.2.1.2.8.2.2 6.2.1.2.8.2.3 Table 6.2.3.1-1 Table 6.2.3.2-1 Table 6.2.3.3-2 Table 6.2.3.6-1 Table 6.2.3.8-1 Table 6.2.3.8-2	
		5.2.5.2.3.3 5.5.1.3 5.5.5.2.4.6 5.7.1.2 5.7.8.4.4.2 5.7.8.5.1	Implementation of APM ICWG agreements (12/96; 06/97) (US LAN, GPS Time, PBA & PFEX, PDGF Data I/F, red. valve on SSMB side, US P/L Bus)

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10/- cont.	30.08.97	5.8. 5.8.12.1.2 Fig. 5.8.12-1 5.8.14.1 5.8.14.1.1 5.8.14.1.2 5.12.4.1.1 5.12.4.2 5.12.4.2.1 5.12.4.2.2 5.12.5 5.12.5.1 5.12.5.2 Fig. 6.2.1.2-1 6.2.1.2.7.8 Fig. 6.2.1.2-11 6.2.1.2.8.1.8 6.2.1.2.8.1.9 Table 6.2.2-2 Table 6.2.2-7	 deleted deleted deleted deleted
		2.2 6.1.9.2 Attachment 1	Reference to COL-TN-AI-0123, APM ORU List (deleted)
		5.9.1.1 5.9.1.2 5.9.2.2 5.9.3.1 5.9.3.2 5.9.3.3.1 Fig. 6.1.5-2	Confinement to C5 Air Transport removed
		5.4.2.1 6.1.6.2.1	Confinement to MPLM MGSE removed
		5.4.2.1 6.1.6.2.2	Launch Site testing capability only
		Fig. 5.7.8-1 Fig. 5.8.5-3 6.2.1.2.2.2.2	TBD/TBC removals
		Table 6.2.1.2-2	Warning parameter added
		Table 6.1.7-2	Colors actualized
		Table 6.1.7-4, Table 6.1.7-5	Tools actualized

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10/- cont.	30.08.97	5.	Precision of requirements
		5.2.3.3.1	
		5.2.5.1.1	
		5.2.5.3.2	
		5.2.5.4.2.4	
		5.3.5.3	
		5.4.3.3.1	
		5.5.2.1	
		5.5.5.1.2	
		5.5.5.1.4	
		5.5.5.1.5 (deleted); see 5.5.5.1.4	
		Table 5.7.1-1	
		5.7.4.1.1	
		5.7.4.1.2	
		5.7.8.2.1	
		5.7.8.3.2.3	
		5.7.8.4.1	
		5.7.8.4.7.3.1	Deleted, redundant to 5.2.5.4.1.2 and 5.2.5.4.1.3
		5.8.5.2.1.1	
		5.8.14.2.2.1	
		5.9.3.5 (delete); see GSE Spec.	
		5.10.1.1	deleted, covered by Mechanical and Thermal Design Specification
		6.1.5.1	
		6.1.5.2	
		6.1.7.3.1	
		6.1.7.4.2.26	
		6.1.8	
		Table 6.2.1-8	
		Table 6.2.1-11	
		6.2.1.1.4	
		6.2.1.2.2.1.2	
		6.2.1.2.4.1.14	
		Table 6.2.1.2-2	
		6.2.1.2.9.1.3	
		Table 6.2.3.2-1	Power allocation relevant on system level only
		Table 6.2.3.3-1	Values TBC
		Table 6.2.3.3-2	Values TBC
		6.2.3.4.2	deleted; topic of budget reports
		6.2.3.4.3	deleted; topic of budget reports

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10/-cont	30.08.97	Table 6.2.3.4-2	deleted; topic of budget reports
		Table 6.2.3.4-3	deleted; topic of budget reports
		7.1.7	
		7.1.8	Added, see req. 7.1.7 change
		Attachment 5	deleted, List of Figures after TOC
		Attachment 6	deleted List of Figures after TOC
		Fig. 5.8.5-1	Âctualization of Figures
		Fig. 5.8.5-2	
		Fig. 6.1.2-1	
		Fig. 6.1.3-1	
		Fig. 6.1.7-1	
		Fig. 6.1.7.2-2	
		Fig. 6.1.7.2-6	
		Fig. 6.1.7.2-7	
		Fig. 6.1.7.2-8	
		Fig. 6.1.7.2-9	
		Fig. 6.1.7.4-1 (deleted)	
		Fig. 6.1.7.4-2 (deleted)	
		Fig. 6.2.1.2-2	
		Fig. 6.2.1.2-5	
		Fig. 6.2.1.2-6 (deleted)	
		Fig. 6.2.1.2-8	
		Fig. 6.2.1.2-9	
		Fig. 6.2.1.2-10	
		4.1.1	Verification Requirements for Support Specifications completed/updated for system level
		4.1.2	
		4.1.7	
		4.1.9	
		Attachment 4	updated, verification on EQ level identified
		5.4.3.3.7	Chapter number missing
		6.1.6.3	deleted; SVF not subject of APM Specification
		6.1.6.3.1	
		6.1.6.3.2	
		6.1.6.3.3	
		6.1.6.3.4	
		6.1.6.3.5	
		6.1.6.3.6	
		6.1.6.3.7	

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10/A	04.07.97	2.1.6.3	page 8	APM ORU List changed from ref. doc. To applic. doc.
		2.2.7	page 9	
		6.1.9.2.2	page 179	
		6.1.9.3.1	page 179	APM ORU List applicable
		4.1.2	page 20	Applicability extent changed
		4.1.7	pages 29, 30	Applicability extent changed
		5.4.2.1	page 59	Launch site GSE MPLM compatible
		6.1.6.2.1	page 147	Launch site GSE MPLM compatible
		Table 6.2.3.2-1	page 280	S/S and EQ power specifications re-installed
		6.2.3.4.2	page 283	Re-installed from issue 9/A
		6.2.3.4.3	page 283	Re-installed from issue 9/A
		Table 6.2.3.4-2,	page 284	Re-installed from issue 9/A
		Table 6.2.3.4-3,	page 285	Re-installed from issue 9/A
		List of Tables,	page xix	
10/B	08.10.97	2.1		Applicable and Reference Documents updated
		2.2		
		4.1.1		Update acc. To
		4.1.8		1. COL-RIBRE-MIN-318-57
		4.1.9		2. MSM-MC/06609.97/HPL
		4.2.2		3. COL-RIBRE-DFX-2232-97
		5.2.5.4.2.4		4. COL-RIBRE-DFX-2254-97
		5.3.5.3.4		5. COL-RIBRE-DFX-2268-97
		5.4.2.1		and related negotiation 02./04.10.97
		Table 5.5.1-1		
		5.5.3.1		
		5.5.5.1.2		see COL-RIBRE-RFW-109
		5.7.8.4.1		
		Table 5.8-1		
		5.8.14.2.2.1		
		5.10.1.1		
		5.12.4.1		
		6.1.3		
		Fig. 6.1.7.2-3		
		6.2.1.2.2.2		See COL-RIBRE-RFW-109
		Fig. 6.2.1.2-7		
		6.2.1.2.8.1.6		
		Fig. 6.2.1.2-13		
		6.2.1.2.8.1.9		
		6.2.1.2.8.1.13		
		6.2.1.2.9.1.3		
		6.2.1.2.9.1.4		

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10/B cont	07.10.97	6.2.1.2.9.2.1.4 Table 6.2.1.2.9-1 6.2.1.2.9.6.5 6.2.1.2.9.6.6 Table 6.2.2.-2 Table 6.2.3.4-2 Table 6.2.3.4-3 6.2.3.6-1 Att. 4, Req. 5.2.5.4.1.6 Att. 4, Req. 5.8.14.2.1 Att. 4, Req. 5.10.1.1 Att. 4, 6.1.9.1.1 6.1.9.1.2 Att. 4, Req. 6.1.6.3.1 through 6.1.6.3.7 Att. 4, Req. 6.1.9.4.4	Requirement not existing (SVF deletion)
		5.2.5.4.1.1 5.2.5.4.1.2 Fig. 5.4.3-1 5.7.8.4.7.1.1 5.7.8.4.7.2.1 Fig. 6.1.10-1 Fig. 6.1.10-2 Table 6.2.1-13 through 6.2.1-18 Fig. 6.2.1.2-1 Fig. 6.2.1.2-6 Para. 6.2.1.2.4.1.15 (deleted) 6.2.1.2.6.1 6.2.1.2.6.2 Fig. 6.2.1.2-8 Table 6.2.2-1 Table 6.2.2-2 Table 6.2.3.2-1 Att. 4, Req. 6.2.1.2.4.1.15	Removal of JEM Uplink
		5.2.4.1.1 5.3.1.2 5.3.5.3.1 5.7.8.2.1 (deleted) 5.7.8.2.2 Fig. 5.7.8-1 (deleted) 5.8.14.1.1 5.12.1.4	PICA PDR results; harmonization with PICA Spec: payload mass, SVS targets, stowage items, WIFs, heat dissipation)

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10/B cont	08.10.97	5.12.2.3 (deleted) 6.1.7.3.1 6.1.7.4.2.26 Table 6.2.3.3-1 Table 6.2.3.3.-2 Att. 4 Req. 5.7.8.2.1 (deleted) Att. 4 Req. 5.12.2.3 (deleted) 4.2.1 6.1.6.4 Att. 4, Req. 6.1.6.4	Additional GSE Requirements
		Table 6.2.3.1-1 1.5.1	Mass allocation update according to second PBA DMS-R commonality completed
10/C	10.07.98	1.4 5.1.1 5.2.2.2 5.2.5.2.3.3 5.3.1.2 5.5.5.1.4 5.5.5.2.4.6 5.7.8.2.2 5.7.8.3.2.1 5.7.8.4.5.2 5.7.8.4.5.3 5.7.8.4.7.3.2 5.7.8.5.1 5.7.8.5.6 5.7.8.5.9 Table 5.8-1 5.8.15 5.8.15.1 5.8.15.1.1 5.8.15.2 5.8.15.2.1 5.8.15.2.2 5.8.15.2.3. 5.8.15.3 5.8.15.3.1 5.8.15.4 5.8.15.4.1 5.8.15.4.2	EPF Change

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10/C cont.	10.07.98	Table 6.2.2-1 Table 6.2.3-1 Table 6.2.3.2-1 6.2.3.2-1 6.2.3.3-1 6.2.3.3-2 6.2.3.6-1 6.2.3.7-1 6.2.3.8-1	
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		4.1.1, Req. 3.15.1.6, 3.19.4, 3.19.4.1 deleted 4.1.8, Req. 4.3.8 5.5.5.4.5 Table 5.7.4-2 5.7.4.4.4.1 6.1.9.4.9 6.2.1.2.8.1.12 6.2.1.2.9.1.7 Table 6.2.1.2-2 Fig. 6.2.1.2-10 Att. 4, Req. 5.3.5.3.3 5.3.5.3.4 6.1.9.1.4 6.1.9.4.9 6.2.1.2.4.2.8.1 6.2.1.2.4.2.6.9 6.2.1.2.9.1.7	ICD Harmonization, CSRD Harmonization, and Editorials
		2.1.1.1 2.1.1.6	ADL updates

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10/D	30.10.98		Configuration Review RIDs
		5.2.2.2	RID APM-CR-21-72-001
		5.3.1.2	RID APM-CR-21-72-005, FSS change
		5.5.5.1.4	RID APM-CR-25-72-003
		5.7.8.2.2	RID APM-CR-21-72-002
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		Table 5.8-1	RID APM-CR-25-72-006
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		5.11.1.2	RICA PM-CR-21-72-003
		Figure 5.11.1.3-1	RID APM-CR-21-72-007
		5.11.2	RID APM-CR-21-72-004
		5.14.2.4	RID APM-CR-25-72-007 & ICWG Clarification
		Table 6.2.2-1	RID APM-CR-25-72-008
		Table 6.2.3.1-1	RID APM-CR-21-72-005, FSS change
		Table 6.2.1.2-2 6.2.1.2.8.1.13	Caution Implementation
		4.1.3 5.2.2.1 Figure 6.1.7.2-6 Figure 6.2.1.2-8 Attachment 4	Editorials
		5.2.5.4.1.8 2.1.1.2 2.1.1.18 2.1.1.20	APM-ICD SSP 42001 constraints ECR-24 (COL-RIBRE-CCN-1072)
		1.6	Fire Suppression Design Change
		5.8.12.1.1 Fig. 5.8.12.1 Fig. 5.8.15.1 Fig. 6.1.7.2-3	APM/SSMB ICWG Nov. 1998
10/E	31.08.00	2.1.1.2 2.1.1.18 5.3.1.1 5.3.1.3 5.3.3.2 5.5.2.1 5.12.1.1 6.1.1.4 Table 6.1.1-1	ECR 024 residual items

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10/E cont.	31.08.00	6.1.4. 6.2.1.2.8.1.4	
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		2.1.1.3 2.1.1.5 2.1.1.24 5.5.7.3 5.5.7.4 5.5.7.5 5.8.14.1.1 5.11.1.4 5.11.1.5 5.11.1.6 5.11.1.7 Table 6.1.7-2 Table 6.2.3.1-1	ECR 038
		5.3.5.3.2 5.3.5.3.4 5.3.5.3.5 6.2.1.2.7.4 Table 6.2.3.2-1	Alignment with SSP 41150, APM/SSMB IRD
		Figure 6.2.1.2-6a)	PIRN 42001-ES-0276A
		Table 6.2.1.2-2	PIRN 42001-ES-0335A
		4.1.8	COL-RIBRE-SPE-0023, iss.11 not in line with contractual requirements baseline
		Figure 6.1.7.2-9 6.1.7.2.13 6.2.1.2.4.1.15.1 6.2.1.2.4.1.15.2 Figure 6.2.1.2-1 Figure 6.2.1.2-6b)	Network Patch Panel (NPP) deletion
		5.2.3.3.7 5.3.1.4 5.12.1.4	Residual changes from ECR 14, EPF change (Issue 10/C 10.07.98)

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		4.1.1 5.2.4.1.1 5.11.5.1.1 Figure 6.2.1.2-2b) Figure 6.2.1.2-6b)	ESA Comments per MC/APM/7758.99/hpl/A
		Table 5.5.1-1 5.7.8.2.2	RID-APM-CR-072-003
		5.7.8.4.5.3	RID-APM-CR-25-072-004
		5.7.8.5.1 5.7.8.5.2 5.7.8.5.2.1 5.7.8.5.2.2	RID-APM-CR-25-072-001
		4.1.8	RID SWV 1 IRR2-00-02-005
		6.2.1.2.3.2.1 Figure 6.2.1.2-1 Figure 6.2.1.2-5	Deletion of one lighting strip
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10/E cont.	31.08.00	Figure 5.11.1.3-1 5.11.2 5.11.3.1 5.11.5.1.6 5.11.7.1 Table 6.2.1.2-1 Figure 6.2.1.2-2a) Figure 6.2.1.2-2b) Figure 6.2.1.2-8 Table 6.2.3.6-1	
		Figure 6.2.1.2-10	ECLS diagram actualized
		6.2.1.2.9.2.1 6.2.1.2.9.2.1.1 6.2.1.2.9.2.1.2 6.2.1.2.9.2.1.3 6.2.1.2.9.2.1.4 6.2.1.2.9.2.1.5 6.2.1.2.9.2.1.6 6.2.1.2.9.2.1.7 6.2.1.2.9.2.1.8 6.2.1.2.9.3.2 Table 6.2.1.2.9-1 6.2.1.2.9.6.1 6.2.1.2.9.6.2	Deletion of Table-Driven Failure Management (TFM)
		6.2.1.2.9.2.4 6.2.1.2.9.2.4.1 6.2.1.2.9.2.4.2 6.2.1.2.9.2.4.3 6.2.1.2.9.2.4.4	Reconfiguration APs
		5.3.5.1.1 5.3.5.1.2 5.3.5.1.3 5.3.5.1.4 Table 5.3.5-1 5.3.5.3.1 Table 6.1.1-1 Figure 6.1.2-1 Table 6.2.1-11 Figure 6.2.1.2-1 Figure 6.2.1.2-11	APCU I/F

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10/E cont.	31.08.00	6.2.1.2.7.4	
		Table 6.2.3.4-2	DMS.MMT.RFW.5128
		Table 6.2.3.8-1 Table 6.2.3.8-2	Budget actualization
		6.2.3.9 Table 6.2.3.9-1	Leakage Budget added
		4.1.1	Alignment with PA & Safety Spec.
		5.7.8.5.3 5.7.9.4 6.2.1.2.4.1.5 6.2.1.2.4.2.3.1 6.2.1.2.4.2.3.2 6.2.1.2.4.2.3.3	S/W Baseline
		Figure 5.12.1-1	NSTS/APM ICD Introduction
		Figure 6.1.7.2-1	Reference to ISPR ICD
		6.1.5 6.1.7.2.9 6.1.7.4.2.1 6.1.7.4.2.6 6.2.1.2.2.1.2 Figure 6.2.1.2-2a)	Clarification
		Figure 6.2.1.2-9	ERC 30, WOOV Flow Rate selection
		6.2.1.2.8.1.4 6.2.1.2.8.2.2 6.2.3.4	Fire Suppression Design
		Attachment 3 Attachment 4	
		5.7.8.3.2.2 5.8.15.3.1 6.1.7.3.2 6.2.1.2.8.1.2	Editorial correction
Errata Sheets		pages 10, 126, 231, 261, 285, 292 Page 257	1) per MC/COL 00314.2000/hpl 2) Power Budget Data corrected
10/F	25.06.04	1.1 1.3 2.1.1.2 2.1.1.18 2.1.1.20	Implementation of ECR 65 and 66 and some editorial corrections

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10/F cont.		2.1.1.21 2.1.1.24 2.1.1.25 2.1.6.3 5.1.1 5.2.2.2 5.2.5.2.3.5 5.2.5.4.1.3 5.2.5.4.1.8 5.3.1.4 5.3.2.1 5.4.3.1.1 Figure 5.4.3-1 5.4.3.3.1 Table 5.5.1-1 5.5.1.3 5.5.2.1 5.5.5.2.4.4 5.5.5.5.3 5.5.5.4.7 5.5.5.5.4.1 5.5.7.3 5.5.7.4 5.5.7.5 5.7.1.2 Table 5.7.1-1 Figure 5.7.4-1 5.7.4.4.4.3 5.7.8.2.2 5.7.8.4.2 5.7.8.4.4.2 Table 5.8.-1 5.8.17 5.8.17.1 5.8.17.2 5.8.17.3 5.11.1.8 5.11.1.9 5.11.2.1 5.11.2.2 5.11.2.3 5.11.4.2 5.11.4.3 5.11.4.4	

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		Figure 6.2.1.2-6A	
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		Figure 6.2.1.2-6B	
		6.2.1.2.4.2.7.1	
		Figure 6.2.1.2-8	
		6.2.1.2.6.7	
		6.2.1.2.6.8	
		Table 6.2.1.2-2	
		Table 6.2.3.1-1	
		Attachment 4	

TOC-Inhaltsverzeichnis/Table of Contents

LOF-Liste der Abbildungen/List of Figures

LOT-Liste der Tabellen/List of Tables

1. SCOPE

1.1 Purpose

This specification in combination with the complete CSRD establishes the requirements for the design and development (D&D) verification and preparation for delivery of the COLUMBUS Attached Pressurized Module (APM) System, CI no. 1211382 including the provisions for later on-orbit implementation of the enhanced video system and Columbus Terminal during the operational phase.

1.2 Classification

This specification governs the APM Overall System as listed below:

- Attached Pressurized Module (APM) flight configuration
- Ground Support Equipment (GSE)
- Airborne and On-Orbit Support Equipment (ASE and OSE)
- Complements of:
  - APM and MGSE, FGSE, EGSE

1.3 Agency-Provided Equipment

The APM design shall be compatible with the following Agency-Provided Equipment:

- Radio Amateur Antennae

1.4 Space Station Common Equipment

The APM design shall be compatible with the following space station common equipment:

- Power Data Grapple Fixture (PDGF)
- Smoke Sensors
- Portable Fire Extinguisher (PFEX)
- Portable Breathing Apparatus (PBA)
- Audio Terminal Unit (with cold plate)
- Audio Antenna
- CBM (passive half)
- Hatch
- Laptops
- Master Alarm Panel
- Payload Ethernet HUB/Gateway (PEHG)
- FRAM (passive half)
- H-Fixture/Optical Target

NOTES:

- Though the CBM is procured by COLUMBUS industry the design responsibility is limited at the CBM/APM primary structure interface plane (external ICD interface plane) and other APM items interfacing with the CBM.

- The hatch is an SSMB common item procured by COLUMBUS industry and the overall design responsibility is limited at the Hatch/APM primary structure interface plane (external ICD interface plane) and other items interfacing with the hatch.

1.5 DMS-R Common Equipment

1.5.1

The APM design shall be compatible with the following DMS-R equipment:

- Control Post Computer (CPC) items
- Mass Memory (MMU) items.

1.5.2

The APM standard computer and Mass Memory Unit shall be realized by a CPC configured for this application.

1.6 MPLM ECLSS Common Equipment

The APM design shall be compatible with the following MPLM ECLSS equipment:

- Cabin Air Diffuser
- Cabin Depress Assy
- IMV S/O Valve
- Line S/O Valve
- Negative Pressure Relief Valve
- Positive Pressure Relief Assy

and the following MPLM ECLSS FGSE:

- Air Supply Cooling Unit
- Gas Leakage Test Stand.

1.7 MPLM Common Equipment

The APM design shall be compatible with the following MPLM equipment:

- Module Lighting Unit (MLU)
- Emergency Lighting Unit (ELU)
- Mechanical Support Equipment.

2. RELATED DOCUMENTS

The following documents form a part of this specification to the extent defined in the requirements paragraphs (identified below the document title).

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified herein. In case of conflict this specification shall be superseeding.

For applicable documents contained in the COLUMBUS specification hierarchy the order of precedence shall follow its order within the COLUMBUS specification document tree (DT 1213800 000/COL-RIBRE-TRE-0001).

2.1.1 Specifications

2.1.1.1	SPE 1242 877 / COL-RIBRE-SPE-0101 PA/Safety System Support Specification - 4.1.1	Iss. 1/E
2.1.1.2	COL-ESA-RQ-013 plus errata sheets dated 04.11.03, 15.01.04 and 23.03.04 COLUMBUS Human Factors Engineering Requirements - 4.1.2	Iss. 3/H 12.10.2001
2.1.1.3	SPE 1211 361 / COL-RIBRE-SPE-0020 EMC and Power Quality System Support Specification - 4.1.3 - 5.7.8.3.2.3	Iss. 5/E
2.1.1.4	(Intentionally left blank.	
2.1.1.5	SPE 1211 363/COL-RIBRE-SPE-0021 Environment and Test System Support Specification - 4.1.5 - 5.5.4.1 - 5.7.4.3 - 5.8.13.1.2	Iss. 09/D
2.1.1.6	COL-RIBRE-SPE-0025 Electrical Design System Support Specification - 4.1.6	Iss. 4/D
2.1.1.7	SPE 1211 371 / COL-SP-AI-0007 Mechanical/Thermal Design System Support Specification - 4.1.7	Iss. 7/-

2.1.1.8	COL-RIBRE-SPE-0023 Software System Support Specification - 4.1.8	Iss. 11/-
2.1.1.9	SPE 1211 385 / COL-SP-AI-0006 Contamination Control System Support Specification - 4.1.9	Iss. 8/-
2.1.1.10	SPE 1211 364 / COL-RIBRE-SPE-0022 Ground Support Equipment System Support Specification - 4.2.1 - 5.9.3.1 - 5.9.3.5 - 7.2.1	Iss. 8/E
2.1.1.11	(Intentionally left blank.)	
2.1.1.12	COL-RIBRE-STD-0005-00 APM Flight HCI Standard - 6.2.1.2.4.2.7.2	Iss. 2/A
2.1.1.13	(Intentionally left blank.)	
2.1.1.14	(Intentionally left blank.)	
2.1.1.15	(Intentionally left blank.)	
2.1.1.16	(Intentionally left blank.)	
2.1.1.17	(Intentionally left blank.)	
2.1.1.18	SSP 41150 SSMB to COLUMBUS APM-IRD - 5.2 - 5.2.2.1 - 5.2.3.3.1	Rev. H
2.1.1.19	(Intentionally left blank)	
2.1.1.20	SSP 41152 ISPR-IRD - 5.5	Iss. D 31.07.2001

2.1.1.21	(Internationally left blank)	
2.1.1.22	SSP 30575 Space Station Interior & Exterior Operational Location Coding System - 6.1.7.4.2.22	Rev. C 13.02.1998
2.1.1.23	Initially left blank	
2.1.1.24	SSP 50008 International Space Station Interior Color Scheme - 6.1.7.4.2.23	Rev. C 02.01.2001
2.1.1.25	SSP 41015 Hatch ICD (part 1) - 5.12.1.4	Rev. F 31.05.2002

2.1.2 Standards

2.1.2.1	MIL-STD P116 - 7.1.4	Iss. TBD
2.1.2.2	FED-STD 209E - 7.1.7	11.09.92
2.1.2.3	FED-STD 595B. Codification - 6.1.7.4.2.23	15.12.89
2.1.2.4	(Intentionally left blank)	
2.1.2.5	(Intentionally left blank)	
2.1.2.6	POSIX Standards (1003.1b, 1003.5) - 6.2.1.2.4.2.4.1	
2.1.2.7	EIA-RS-170-A EIA Industrial Electronics Tent. Standard No. 1: Colour Television Studio - 5.5.5.4.2	Nov. 1977

2.1.3 Ground Operation Handbook

N/A

2.1.4 Interface Control Documents

2.1.4.1	COL-RIBRE-ICD-0026 ICD Identification List	Latest Issue

2.1.5 Internationally left blank

2.1.6 Other Documents

2.1.6.1	COL-TN-AI-0092 APM Coding and Coordinate System - 6.1.7.1.3 - 6.1.7.1.5	Iss. 01 31.03.95
2.1.6.2	1F01789F (BOEING) Caution and Warning Panel Specification - 5.8.1.1.5	Issue C 05.02.93
2.1.6.3	COL-TN-AI-0123 APM ORU List - 6.1.9.2.2 - 6.1.9.3.1	Latest Issue

2.2 Reference Documents

The following documents as referenced herein shall be considered as non-contractual in nature.

Their reference is to support the clarification, explanation and/or definition to a specific set of require-ments for better understanding.

2.2.1	(Intentionally left blank)	
2.2.2	(Intentionally left blank)	
2.2.3	(Intentionally left blank)	
2.2.4	(Intentionally left blank)	
2.2.5	(Intentionally left blank)	
2.2.6	PL 1213800 007/COL-RIBRE-PL-0022 EMC Control Plan - 5.7.8.3.2.3	Iss. 4/C 15.12.95
2.2.7	(deleted)	

3. FUNCTIONAL/PERFORMANCE REQUIREMENTS

3.1 General

All functional/performance requirements on APM system level are contained within the CSRD.

APM Flight Configuration derived functional/performance requirements allocations to subsystems and assemblies are contained in para. 6, if applicable.

3.2 (Intentionally left blank)

4. SUPPORT REQUIREMENTS

In the following, applicability matrices of the various support specifications the following abbreviations are used defining the qualification methods on APM system level.

DEF	-	Definition
A	-	Analysis
T	-	Test
I	-	Inspection
R, ROD	-	Review of Design
N	-	not applicable

4.1 On Board System

4.1.1 Product Assurance and Safety

The following requirements of applicable document 2.1.1.1, Product Assurance/Safety Specification, are applicable to APM system level.

3	PA/SAFETY REQUIREMENTS - FLIGHT SYSTEMS	
3.1	Reliability Criticality Cat	
3.1.1		DEF
3.2	Hazard Severity Cat	
3.2.1	Catastrophic Hazard	DEF
3.2.2	Critical Hazard	DEF
3.2.3	Marginal Hazard	DEF
3.3	Design Control Res. Hazard	A,R
3.4	Design to Tolerate Failure	A,T
3.4.1	Failure w.r.t. Hazard Cat. I	A
3.4.1.1		A,T
3.4.1.2		A
3.4.2	Failure w.r.t. Hazard Cat. II	A
3.4.2.1		A,T
3.4.3	Additional Failure Tolerance	DEF
3.4.3.2		A
3.4.3.3		A
3.4.3.4		R
3.4.3.5		A
3.4.4	Failure Propagation	
3.4.4.1		A
3.4.4.4		A,T
3.4.4.5		A
3.4.4.6		A,R
3.4.4.7		A

3.5	Redundancy	
3.5.1	General	
3.5.1.1		A,T
3.5.1.2		T
3.5.2	Redundancy Management	
3.5.2.1		T
3.5.2.2		A,T
3.5.2.4		T
3.5.2.5		A,R
3.5.3	Sep. of Red. Paths	A
3.7	General Design Criteria	
3.7.2		R,I
3.7.3		R,I
3.7.5		A,R
3.7.6.1		A
3.7.7		A
3.7.10		R
3.7.11		A,R
3.7.12		R
3.7.13		R
3.7.15		R,I
3.7.18		A,R
3.7.19		R
3.7.20		R
3.8	Operational Safety	
3.8.2		A,T
3.8.4		A,T
3.8.6		A,R
3.9	Monitoring and Command	
3.9.1	Monitoring and Command of Safety Critical Functions	
3.9.1.1		A,T
3.9.1.2		R
3.9.1.3		T
3.9.1.4		A,T
3.9.3	Monitoring and Command of Inhibits	
3.9.3.1		A,T
3.9.3.2		R,T
3.9.4	Emergency, Warning, Caution & Safing	
3.9.4.1	General	
3.9.4.1.1		A,R
3.9.4.1.2		A,R
3.9.4.1.4		R,T
3.9.4.1.5		R,T
3.9.4.1.6		R,T
3.9.4.2	Detection and Annunciation	
3.9.4.2.2		T
3.9.4.2.4		R,T
3.9.4.2.6		A,T

3.9.4.2.7		T,A
3.10	Resistance to Micrometeoroids/Debris	
3.10.1		DEF
3.10.2		A
3.10.6		A,R
3.11	Habitability	
3.11.3		A
3.11.5		A,T
3.12	Evaluation	
3.12.1		A,R
3.12.3		A
3.12.5		A,R
3.13	Combustion/Fire Detection, Isolation and Suppression	
3.13.1	General	
3.13.1.2		A,R
3.13.1.3		A
3.13.2	Fire Detection	
3.13.2.2		R,T
3.13.4	Fire Suppression	
3.13.4.1	General	
3.13.4.1.1		A,R
3.15	Pressure/Vacuum Systems	
3.15.1	General	
3.15.1.2		A,R
3.15.1.3		A
3.15.1.5		DEF
3.15.2	Enclosed Volumes	
3.15.2.1		A
3.15.2.2		A
3.15.3	Lines, Hoses	
3.15.3.1		A
3.15.3.2		I
3.15.3.3		R
3.15.3.4		A,R
3.15.3.7		R
3.15.4	Filters	
3.15.4.1		R
3.15.4.2		A,R
3.15.5	Valves - General	
3.15.5.1		A,R
3.15.5.2		R
3.15.6	Pressure Relief	
3.15.6.1		R
3.15.6.2		R,I
3.15.6.3		A
3.15.6.4		R

3.15.6.5		R
3.15.6.6		R
3.15.6.7		R
3.15.6.8		A,R
3.15.6.9		A,R
3.15.6.10		R
3.15.7	Pressure Regulators	A
3.15.8	Shut-Off Valves	R
3.15.9	Pressure Monitoring	A,R
3.15.10	Manual Press. Mod./Vol.	A
3.15.11	Module Depressurization	
3.15.11.1		R
3.15.11.3		A
3.15.11.4		A
3.15.11.5		A
3.16	Structural Design	
3.16.3		T
3.16.4		A,R
3.17	Mechanical Design	
3.17.1		R
3.17.2		R
3.18	Electrical and Electronic	
3.18.1	Genera	A
3.18.1.1		A,R
3.18.1.2		A,R
3.18.1.2.1		A,R
3.18.1.3		R
3.18.1.5		R
3.18.1.5.1		R,T
3.18.1.7		R,T
3.18.1.8		A,T
3.18.1.10		A
3.18.1.11		T
3.18.2	Batteries	R
3.18.4	EEE Parts	
3.18.4.1	Selection/Procurement/Manufacturing/Qualification	
3.18.4.1.2		R
3.18.4.1.5		A
3.18.4.2	Materials Requirements	R
3.18.4.3	Radiation Requirements	
3.18.4.3.1	Total Dose	
3.18.4.3.1.1		A
3.18.4.3.1.2		A
3.18.4.4	Single Event Upset (SEU)	
3.18.4.4.1		A
3.18.4.4.2		A
3.18.4.5	Latch-Up (LU)	
3.18.4.5.1		A
3.18.4.5.2		A

3.18.4.6	Burn-Out (BO)	
3.18.4.6.1		A
3.18.4.7	Radiation Test	A
3.19	Material	
3.19.1	Special Requirements	
3.19.1.1		A
3.19.1.2		A
3.19.1.3		A
3.19.1.4		A
3.19.1.5		A
3.19.1.6		A
3.19.1.7		R
3.19.1.8		R
3.19.2	Flammability	
3.19.2.1		A
3.19.2.2		A
3.19.2.3		A
3.19.2.4		A
3.19.2.5		A
3.19.2.6		A
3.19.2.7		A
3.19.2.8		A
3.19.3	Offgassing and Toxicity	
3.19.3.1		T
3.19.5	Thermal Vacuum Stability	
3.19.5.1		A
3.19.5.2		A
3.19.6	UV and Radiation Res.	A
3.19.7	Stress Corrosion	
3.19.7.1		A
3.19.7.2		A
3.19.7.3		A
3.19.8	Atomic Oxygen	A
3.19.9	Galvanic Corrosion	
3.19.9.1		A
3.19.9.2		A
3.19.9.3		A
3.19.10	Corrosion Protection	
3.19.10.1		R
3.19.10.2		R
3.19.10.3		R
3.19.10.4		R
3.19.10.5		R
3.19.10.6		R
3.19.11	Fluid Compatibility	
3.19.11.1		R
3.19.11.2		R
3.19.11.3		A
3.19.11.5		R

3.19.11.6		A
3.19.12	Resistance to Microbial Growth	
3.19.12.1		A
3.19.12.2		A
3.19.12.3		A
3.19.12.4		A
3.19.12.5		A
3.19.12.6		A
3.19.13	Lubricants	
3.19.13.1		A
3.19.13.2		A
3.19.13.3		A
3.19.14	Material Restrictions	R
3.19.14.2		R
3.19.14.3		A
3.19.14.5		A
3.19.14.6		A
3.19.14.8		A
3.19.14.9		A
3.19.14.10		A
3.19.14.12	Magnetic Material	
3.19.14.12.1		A
3.19.14.12.2		A
3.19.14.12.3		A
3.19.14.13	Restriction for Ti/Ti Alloys	A
3.19.14.14		R
3.19.14.15		A
3.19.14.16		A
3.19.14.17		A
3.19.14.18	Shatterable Materials	A
3.19.14.19	Ionizing Radiation Materials	
3.19.14.19.1		A
3.19.14.19.2		R
3.19.14.19.3		A
3.19.14.19.4		A
3.19.15	Prohibited Materials	
3.19.15.1		R
3.19.15.2		A
3.19.15.3		A
3.19.16		A
3.19.17	Moisture Resistance	
3.19.17.1		R
3.20	Mechanical Parts	
3.20.1	Material Requirements	A
3.20.2	Life	A
3.20.3	Titanium Bolts	A
3.21	Processes	A
3.21.1		A

3.21.2		A
3.21.3		A
3.21.4		A
3.21.5		A
3.21.6		A
3.22	Maintainability Requirements	
3.22.1		A
3.22.2		A,T
3.22.3		R
3.22.5		A, I
3.22.6	Numerical Maintainability	
3.22.6.1		A,T
3.22.6.3		A,T
3.23	Numerical Reliability	
3.23.2.1		A
3.23.2.2		A

4.1.2 Human Factors Engineering

The requirements of applicable document 2.1.1.2, Human Factors Engineering, defined for APM system level qualification therein are applicable.

4.1.3 EMC and Power Quality

The following requirements of applicable document 2.1.1.3, EMC and Power Quality, are applicable to APM system level:

3	APM POWER INTERFACE CHARACTERISTICS	Headline
3.1	Characteristics of 120 VDC Power Bus	DEF
3.2	Characteristics of 28 VDC Power Bus	DEF
4.1.2	Flight Configuration Requirements	Headline
4.1.2.1	Safety Margin	Headline
4.1.2.1.1	Verification by Test	T,A
4.1.2.1.2	Verification by Analysis	A
4.1.2.2	Grounding and Isolation	T
4.1.2.2.1	Ground of Equipment not Permanently Attached to APM	R
4.1.2.3	Bonding	Headline
4.1.2.3.1	Bonding Connection Installations	R
4.1.2.3.2	Joinings of Dissimilar Metals	R
4.1.2.3.3	Structure	Headline
4.1.2.3.3.1	Metallic Members of Structure	R
4.1.2.3.3.2	Contact Resistance	T
4.1.2.3.3.3	Bonding Strap	R
4.1.2.3.3.5	CFRP members of Structure	T
4.1.2.3.3.6	Bonding Paths	R
4.1.2.3.4	Electrical Equipment	Headline
4.1.2.3.4.1	Bonding Resistance	T
4.1.2.3.5	Electrostatic Protection	Headline
4.1.2.3.5.1	Mechanical Equipment	T
4.1.2.3.5.2	Multi-Layer Insulation (MLI)	R
4.1.2.3.5.3	Bonding Resistance of MLI	T
4.1.2.3.5.4	Metallized Foil	R
4.1.2.3.5.5	Bonding Resistance of Metallized Foil	T
4.1.2.4	Shielding	Headline
4.1.2.4.1		T
4.1.2.5	Lightning Protection	A
4.1.2.5.1		A
4.1.2.6	Voltage Emission on DC Power Lines	
4.1.2.6.1	Narrowband Emission	T
4.1.2.6.2	Broadband Emission	T
4.1.2.6.3	Transient Emission	T
4.1.2.7	Radiated Emission	Headline
4.1.2.7.1	Narrowband Emission	Headline
4.1.2.7.1.1	Outside	T
4.1.2.7.1.2	Inside	T
4.1.2.7.2	Broadband Emission	Headline
4.1.2.7.2.1		T
4.1.2.7.3	H-Field Emission	T
4.1.2.8	Conducted Susceptibility	T
4.1.2.9	Electric Field Susceptibility	Headline
4.1.2.9.1		T

4.1.2.9.2		T
4.1.2.10	Arc Discharge Susceptibility	T
4.2	Verification Requirements	Headline
4.2.1	Safety Margin	DEF
4.2.2	Grounding and Isolation	Headline
4.2.2.1	Measurement Definition	DEF
4.2.2.2	Measurement Voltage	DEF
4.2.2.3	Flight Configuration Measurement	DEF
4.2.3	Bonding	Headline
4.2.3.1	Measurement Principle	DEF
4.2.3.2	Measurement Current	DEF
4.2.3.3	Polarity	DEF
4.2.4	Conducted Emission	Headline
4.2.4.1	Narrow-Band Voltage Emission	Headline
4.2.4.1.1	Test Method	DEF
4.2.4.1.2	Bandwidth	DEF
4.2.4.1.3	Bandwidth	DEF
4.2.4.1.6	LISN	DEF
4.2.4.1.7	Flight Configuration Measurement	DEF
4.2.4.2	Broad-Band Voltage Emission	Headline
4.2.4.2.1	Test Method	DEF
4.2.4.2.2	Bandwidth	DEF
4.2.4.2.3	Test Result Documentation	DEF
4.2.4.2.4	LISN	DEF
4.2.4.2.5	Flight Configuration Measurement	Headline
4.2.4.3	Narrow-Band Current Emission	Headline
4.2.4.3.1	Test Method	DEF
4.2.4.3.2	DC Voltage Level	DEF
4.2.4.3.3	Bandwidth	DEF
4.2.4.4	Transient Emission	Headline
4.2.4.4.1	Test Method	DEF
4.2.4.4.2	Transient Definition	DEF
4.2.4.4.3	Test Result Documentation	DEF
4.2.4.4.4	Test Mode	DEF
4.2.4.4.5	Set-up	DEF
4.2.4.4.6	LISN	DEF
4.2.4.5	Inrush Current	Headline
4.2.4.5.1	Test Method	DEF
4.2.4.5.2	Test Result Documentation	DEF
4.2.4.5.4	LISN	DEF
4.2.4.5.5	Flight Configuration Measurement	DEF
4.2.5	Radiated Emission	Headline
4.2.5.1	Bandwidth	DEF
4.2.5.2	Bandwidth	DEF
4.2.5.3	Bandwidth	DEF
4.2.5.4	E-Field Emission	Headline
4.2.5.4.1	Frequency Range	DEF
4.2.5.4.2	Frequency Range	DEF
4.2.5.4.3	Bandwidth	DEF

4.2.5.4.4	Test Method	DEF
4.2.5.5	AC Magnetic Field Emission	DEF
4.2.6	Conducted Susceptibility	Headline
4.2.6.1	Sine Wave Injection	Headline
4.2.6.1.1	Current Limit	DEF
4.2.6.1.2	DC Voltage Legel	DEF
4.2.6.1.3	Test Method	DEF
4.2.6.1.4	Flight Configuration Management	DEF
4.2.6.2	Transient Injection	Headline
4.2.6.2.1	Transient Definition	DEF
4.2.6.2.2	Current Limit	DEF
4.2.6.2.3	DC Voltage Level	DEF
4.2.6.2.4	Test Method	DEF
4.2.6.2.5	Test Result Documentation	DEF
4.2.7	Radiated Susceptibility	Headline
4.2.7.1	E-Field Susceptibility	Headline
4.2.7.1.1	Frequency Range	DEF
4.2.7.1.2	Modulation	DEF
4.2.7.1.4	Test Method	DEF
4.2.7.2	Magnetic Field Susceptibility	DEF
4.2.8	ESD Susceptibility	Headline
4.2.8.1	Test Method	DEF
4.2.8.2	Flight Configuration Measurement	DEF
4.2.8.3	Portable Equipment	DEF
4.2.9	Shielding Effectiveness	Headline
4.2.9.1	Test Method	DEF
4.2.10	Corona Effects	DEF
5	TEST CONFIGURATION REQUIREMENTS	Headline
5.2	System Test Configuration	Headline
5.2.1		DEF
5.2.2		DEF
5.3	Test Criteria	Headline
5.3.1	Monitoring Points and Pass/Fail Limits	Headline
5.3.1.1	Test Points	DEF
5.3.1.2	Pass/Fail Limit	DEF
5.3.1.3	Test Success	DEF
5.3.1.4	On-line Evaluation	DEF

4.1.4 (Intentionally left blank

4.1.5 Environment and Test

Applicable document 2.1.1.5: Environment and Test System Support Specification, is to be considered on APM system level mainly in terms of Definition, i.e. the environments have been derived from system level for lower levels, against which the qualification evidence is generated.

In addition, the Environment and Test System Support Specification defines also the approaches/ means to be considered for APM system level qualification. The requirements, against which qualification activities have to be executed, are contained in the CSRD and the other specific paragraphs of this document.

For only a limited number of cases the Environment and Test System Support Specification provides the specific requirements, which have to be qualified as shown in the following matrix.

3	GENERAL REQUIREMENTS	DEF
4	MECH. ENVIRONMENT AND TESTS	
4.1	Ground Environment	DEF
4.2	Flight Environment	DEF
4.3	Qualification Tests	T
5	THERMAL ENVIRONMENT AND TESTS	
5.1	Ground Environment	DEF
5.2	Flight Environment	DEF
6	ATMOSPHERIC/CHEMICAL ENVIRONMENT AND TEST	
6.1	Ground Environment	DEF
6.2	Flight Environment	DEF
7	RADIATION ENVIRONMENT AND TESTS	
7.1	Ground Environment	DEF
7.2	Flight Environment	DEF
7.3	Qualification Tests	A
8	MECHANISMS TESTS	DEF
9	AUDIBLE NOISE/HUMAN VIBRATION	DEF
10	LEAKAGE TESTS	DEF
11	OFFGASSING TEST	DEF
11.3		T
12	MICRO-G ENVIRONMENT AND TESTS	DEF
13	DEFINITION OF EMC ENVIRONMENT	DEF
14	FATIGUE SPECTRUM	DEF
15	SYSTEM FUNCTIONAL PERFORMANCE TEST DEFINITION	DEF

16	DEFINITION OF CONTAMINATION LEVEL	DEF
17	HUMAN FACTORS ENGINEERING TESTS	DEF
18	DEFINITION OF LIFE/LIFE CYCLE	DEF
19	ALIGNMENTS	DEF
20	PHYSICAL PROPERTIES	DEF

4.1.6 Electrical Design

The following requirements of applicable document 2.1.1.6, Electrical Design System Support Specification, are applicable to APM system level:

3.15	Harness Requirements	DEF
3.15.1	Harness Voltage Drop	Headline
3.15.1.1		A
3.15.1.2		R
3.15.2	Load Current Capability	Headline
3.15.2.1		R
3.15.2.2		R
3.15.2.3		A
3.15.2.4		R
3.15.3	Harness Overload Capability	Headline
3.15.3.1		
3.15.3.2		DEF
3.15.3.3		A
3.15.3.4		A
3.15.4	Power Protection	Headline
3.15.4.1		A
3.15.4.2	Power Harness Overload Protection	Headline
3.15.4.2.1		A
3.15.4.2.2		R
3.15.4.3	Selective Protection Concept	Headline
3.15.4.3.1		R
3.15.4.3.2		A

4.1.7 Mechanical and Thermal Design

The following requirements of applicable document 2.1.1.7, Mechanical/Thermal Design Specification, are applicable to APM System level:

3.1.2.1.2.1.1.1	A
3.1.2.2.2.3	A
3.1.2.2.3.3	A
3.1.2.2.4.2	A
3.1.2.2.5.4.1	A
3.1.2.2.5.4.2	A
3.1.2.2.5.5.3	A,T
3.1.2.2.5.5.6.1	A,ROD
3.1.2.2.5.5.6.2	A/I
3.2.5.1	T = demo
3.2.5.3	I
4.1.1	R
4.1.2	R
4.1.3	R
4.1.4	R
4.2.1.3	R
4.2.1.4	A
4.2.1.5	A
4.2.1.6	A
4.2.1.7	A
4.2.1.8	A/T
4.2.1.9	A
4.2.1.10	R
4.2.2.3	R
4.2.3.1	A
4.2.3.3	R
4.2.5.1.1.1	R
4.2.5.1.2.5	A
4.2.5.3.1	A
4.2.5.3.2.1	A
4.2.5.3.2.2	A
4.2.5.3.3	A

4.1.8 Flight Software Design

The following requirements of applicable document 2.1.1.8, Software Support Specification, are applicable to APM system level:

4.3.8	Testability Requirements	R
5.1.4.4	Failure Processing Priority (not relevant for APM design)	T
5.1.5.1	Failure Recovery & Redundancy Management	T
5.1.6.2.9	Report Destinations	T (sel. cases)
5.1.6.2.10	Report Destinations	T
5.1.7.1	Error Prevention	T
5.1.7.2	Error Prevention	T
5.3.2.1	COLUMBUS Specific Commonality	R
5.4.1	Consistency Requirements	R
5.4.2	Consistency Requirements	R
5.8.1.6	General Modularity Requirements	R
5.14.1.2.1	SW Systems and Subsystems	A
5.14.1.2.2	SW Systems and Subsystems	A
5.14.1.2.6	SW Systems and Subsystems	T
5.14.1.2.7	SW Systems and Subsystems	R
5.14.1.2.8	SW Systems and Subsystems	T
5.14.2.1	Distributivity	R
5.16.2.2.1-3	Cat. A SW	A
5.16.2.2.6-8	Cat. A SW	A
5.16.2.3.1	Cat. B SW	A
5.16.2.3.3-6	Cat. B SW	A
6.1.2.3	Resource Management	T
6.2.2.1	Enable/Disable	T
6.2.3.1/2	Command Source Acceptance	T
6.2.4.1	Command Failure	T
6.3.1-4	Data Storage and Access	R
6.3.5	Data Storage and Access	A
6.8.3.1	General Requirements for Design of SWRUs	Title
6.8.3.1.2		T
6.8.3.1.3		T
6.8.3.1.4		A
6.8.3.1.6		T
6.8.4.1.7	General Requirements for SWRU Onboard Support	T
6.8.4.1.9	General Requirements for SWRU Onboard Support	I

4.1.9 Contamination

The following requirements of applicable document 2.1.1.9, Contamination Control System Support Specification, are applicable to APM system level:

3.1	Environmental Factors	Headline
3.1.1		DEF
4.1	Design Requirements for Cleanliness	Headline
4.1.1		R,I
4.1.2		R,I
4.1.3		R,I
4.1.4		R,I
4.1.5		R,I
4.1.6		R,I
4.1.7		R,I
4.1.8		R,I
4.1.9		R,I
4.1.10		R,I
4.2	Design Requirements for External Contamination Control	Headline
4.3	Design Requirements for Internal Contamination Control	Headline
4.3.2		A
4.3.3		A
4.3.4		R
4.4	Acceptance Cleanliness/Contamination Levels	Headline
4.4.1	On-Ground Acceptable Levels	Headline
4.4.1.1		I
4.4.1.2		DEF
4.4.1.3		I
4.4.1.4		R
4.4.1.8		I
5.1	Cleanliness Levels of Facilities	Headline
5.1.1		I
5.1.2		I
5.2	Test Environment	I
5.3	Storage	I
5.4	Shipping/Transport	I
5.5	Launch Site	R
5.6	Cleaning Methods and Processes	Headline
5.6.1		R
5.6.2		R
5.7	On-Ground Contamination: National Laws	I

4.2 Ground Support System

4.2.1 GSE Design

The following requirements of applicable document 2.1.1.10, Ground Support Equipment System Support Specification, are applicable to APM system level:

3.3.2	Compatibility	Headline
3.3.2.2		ROD
3.5.2	Materials and Mechanical Parts	Headline
3.5.2.8.12		ROD
3.8.2	Mechanical Interface	Headline
3.8.2.2		ROD
3.12.1	Basic Requirements	Headline
3.12.1.3		ROD
3.12.1.4		ROD
3.12.1.5		ROD
3.13.1	Grounding	Headline
3.13.1.1		T
3.13.1.4		ROD
3.13.2	Bonding	Headline
3.13.2.2		T
3.13.2.9		T
4.	MGSE Specific Design Requirements	Headline
4.1		DEF
4.3.1	Compatibility	Headline
4.3.1.1		A

4.2.2 Ground SW Design

The following requirements of applicable document 2.1.1.8, Software System Support Specification, are applicable to APM system level:

5.1.6.2.9	Report Destinations	T
5.4.1	Consistency Requirements	R
5.4.2	Consistency Requirements	R
5.8.1.6	General Modularity Requirements	R
6.2.1.3	Command Verification	T
6.2.4.1	Command Failure	T
6.4.1	Checkout	T

5. INTERFACE REQUIREMENTS

The APM system shall fulfill the following interface requirements, which are complementary to the respective Interface Requirements Documents (IRD and part I ICDs), where existing. The detailed interface design data are contained in the respective Interface Control Documents (ICDs).

5.1 Interface Identification and Definition

5.1.1

The APM interfaces considered under this section comprise all external interfaces of the APM overall system to external systems:

- APM to Core Station including up-/downlinks para. 5.2
- APM to Shuttle/Orbiter para. 5.3
- APM System (incl. GSE) to Ground Segment para. 5.4
- APM to Payload Rack Interfaces para. 5.5
- APM System to Payload (overall and for individual P/L items) para. 5.7
- APM Interfaces to Station Common Equipment (incl. CHECS) para. 5.8
- APM System/GSE to Transport Facilities para. 5.9
- APM equipment to Logistics Carrier para. 5.10
- APM to External P/L Interfaces para. 5.11
- APM to Station Remote Manipulator System Interfaces para. 5.12
- APM to Amateur Antennae Interfaces para. 5.14

NOTE: The APM interface requirements to the crew are covered by the HFE requirements as made applicable in para. 4.1.2.

5.2 APM to Core Station

The following interface requirements are complementary to the interface requirements document SSP 41150: Space Station Manned Base (SSMB) to COLUMBUS Attached Pressurized Module (APM).

NOTES:
- The APM to SSRMS interface requirements are contained in para. 5.12 of this document.
- The APM to CHECS interface requirements are contained in para. 5.8.13.5 of this document.

5.2.1 General

5.2.1.1 (Intentionally left blank)

5.2.1.2 (Intentionally left blank)

5.2.1.3 (Intentionally left blank)

5.2.1.4 (Intentionally left blank)

5.2.1.5 (Intentionally left blank)

5.2.1.6

The APM shall allow berthing and de-berthing to/from the SSMB by the SS Remote Manipulator System interfacing at the APM Power/Data Grapple Fixture (PDGF).

NOTE:
Though the operational interface is between the SSRM and the PDGF the external ICD plane is between APM primary shell and PDGF as this is a Station Common Item.

5.2.2 Structure Interfaces

5.2.2.1

The APM shall be capable of withstanding the limit forces and moments at the PCBM/APM interface as required in the respective IRD (SSP 41150, latest agreed version).

5.2.2.2

The lowest fundamental frequency (effective mass ≥ 25 %) of the APM in its on-orbit configuration with maximum internal payload mass (9000 kg) and maximum external payload mass (1160 kg) shall be ≥ 1.0 Hz.

NOTES:

- The racks shall be fixed at the on-orbit interfaces as specified in section 5.5.3.
- Total APM on-orbit mass is 20.435 kg (including P/L and Columbus Terminal as defined above).

5.2.3 Mechanical Interfaces

5.2.3.1 Utility/Bulkhead Interfaces

5.2.3.1.1.1

The APM shall accommodate the Core Station utility connectors at the APM Port cone bulkhead.

5.2.3.1.2

All electrical and fluid connectors at the APM bulkhead facing to the node are part of APM.

NOTES:

- All jumper cables and lines between Node 2 bulkhead and APM bulkhead will be manually mated on orbit after opening of the hatch of Node 2.
- All jumper cables are SSMB provided as follows:
  - Flight items are delivered by ESA to APM integration site for interface mating check
  - Flight items are delivered with APM Flight Configuration as loose items for launch outside the APM.

5.2.3.1.3

All bulkhead connectors shall be designed as feedthrough connectors with seals to withstand all the pressure cases between APM and the SSMB node for the complete lifetime of the APM.

5.2.3.2 (Intentionally left blank)

5.2.3.3 APM External Configuration

5.2.3.3.1

The APM shall not exceed the dimensions shown in the SSMB to APM IRD.

5.2.3.3.2 (Intentionally left blank)

5.2.3.3.3 (Intentionally left blank)

5.2.3.3.4 (Intentionally left blank)

5.2.3.3.5

The APM shall accommodate the passive part of the CBM at the port cone.

NOTE:

The interface plane is between the CBM and the APM primary structure as defined in the respective ICD.

5.2.3.3.6

The MDPS shall be designed to allow

- external inspection and repair of the pressure shell
- replacement of external equipment, e.g. HCU.

5.2.3.3.7

The MDPS shall be designed to allow grappling of the APM by the SSRMS for unloading of the APM from the NSTS cargo bay for berthing to the SSMB.

NOTES (for para. 5.2.3.3.6 and 5.2.3.3.7):

The APM design data will be provided to ESA/NASA for the integrated maintenance analysis performed by NASA. Design changes, if required, will be negotiated via the ICD process.

5.2.4 Environmental Interfaces

5.2.4.1 Induced Environment

5.2.4.1.1 Audible Noise/Human Vibrations

The APM design shall fulfill the performance requirements specified in the CSRD without consideration of noise and vibrations transmitted from the Core Station to the APM and vice versa as specified in A.D 2.1.1.18, SSMB to APM IRD.

5.2.5 System Interfaces

NOTE:
The APM interfaces to the SSRMS are specified in para. 5.12.

5.2.5.1 Electrical Power System

5.2.5.1.1

The APM design shall fulfill the functional/performance requirements during the berthed phase by receiving exclusively power from the Core Station via two main feeders, which shall not be connected together inside the APM.

5.2.5.1.2 (Intentionally left blank)

5.2.5.2 Data Management System

5.2.5.2.1 General

5.2.5.2.1.1

The APM Data Management System shall interface with SSMB via the two MIL Std. 1553 B system busses for:

- activation/monitoring from SSMB,
- up-/downlink data transfer,
- time data transfer from SSMB.

5.2.5.2.1.2

Each of these system busses shall be one-failure tolerant, i.e. be realized by a nominal bus and a cold-redundant second one.

5.2.5.2.1.3

Each system bus shall be able to handle the data traffic related to

- Essential Command and Data
- System and Payload Command and Data

as further specified in the following.

5.2.5.2.1.4

Each of the two system buses shall provide stub interfaces on Standard Utility Panels within the APM to connect SSMB Laptops.

NOTES:

- System functionality with the SSMB Laptops is not under APM responsibility.
- SSMB Laptops are used for APM Safety Critical operations (e.g. sending of safing commands)

5.2.5.2.2 Essential Command and Data Interfaces

5.2.5.2.2.1

After successful berthing the APM shall interface with the Core Station for monitoring and control of the essential APM functions as defined in para. 6.2.1.2.

5.2.5.2.2.2 (Intentionally left blank)

5.2.5.2.2.3

The APM system shall be able to accept any combination of the nominal and redundant data buses and signal interfaces for APM primary activation and related monitoring.

5.2.5.2.3 System and Payload Data Interfaces

5.2.5.2.3.1

Depending on its redundancy configuration, the APM shall use one of the two system busses for:

- receipt of individual non-essential uplink commands via Core Station to APM system and Payload
- transmission of packetized telemetry data from APM System and Payload to Core Station for downlink
- receipt of ancillary data from Core Station by APM

in addition to:

- essential commands from Core Station to APM system
- transmission of EWACS data to SSMB

on both buses.

5.2.5.2.3.2

The APM shall route the US P/L 1553 Bus (nominal and redundant) from the bulkhead to each active ISPR and to two Standard Utility Panels.

5.2.5.2.3.3

The APM shall route the US LAN link from the bulkhead to the PEHG.

5.2.5.2.3.4

The APM shall route the PCS LAN link from the bulkhead to one Standard Utility Panel.

5.2.5.2.3.5

The APM shall provide an APM LAN interface on a dedicated panel to allow connection to the PCS LAN specified in 5.2.5.2.3.4.

NOTES:

- Harness jumper not provided
- Functional I/F between the two LAN networks not defined in the present SSMB, APM ICD.

5.2.5.3 Thermal Control System

5.2.5.3.1 Active Thermal Interfaces

5.2.5.3.1.1

The APM Thermal Control System shall interface with the core station low and moderate temperature water loops.

5.2.5.3.2 Passive Thermal Interface

5.2.5.3.2.1

The APM shall be designed for conductive thermal interfacing with the SSMB via the APM/PCBM interface.

5.2.5.3.2.2

The APM shall be designed for radiative thermal interfaces with the SSMB with the thermal character-istics of the SSMB and APM constituents identified in the SSMB/APM ICD.

5.2.5.3.2.3

The APM-MLI shall be designed to allow berthing and de-berthing of the APM at the SSMB node and grappling of the APM by the station SSRMS.

5.2.5.4 Communications

5.2.5.4.1 Up-/Downlinks

5.2.5.4.1.1

The APM shall provide the following composite data interfaces to SSMB for system and payload data:

- high rate data to SSMB/TDRS downlink terminal via SSMB APS
- high rate data to JEM/ICS downlink terminal via SSMB APS

NOTE:

The high rate data streams to the two downlinks are identical, alternatively active, and supplied by two separate HRM outputs.

5.2.5.4.1.2

The data stream for the composite data interfaces shall be:

- ≤ 43 Mbps for downlink

5.2.5.4.1.3

The APM shall provide the capability to change the downlink data stream in increments of 0.5 Mbps from 0.512 Mbps up to 43 Mbps.

5.2.5.4.1.4

The coding of the data shall be according to CCSDS-701.0-B-2.

5.2.5.4.1.5

Each composite data shall be provided cold redundant on fiber optic medium.

5.2.5.4.1.6

The APM shall exchange also data with the core station via the system MIL-STD-1553B interfaces as specified in para. 5.2.5.2.3.1 for up- and downlinks by the SSMB communication equipment.

5.2.5.4.1.7

During nominal operations the APM design shall be compatible with the following characteristics made available by the Core Station for APM communication via MIL-STD-1553 B interfaces:

- <u>Core Station down-link</u>
  - average (per orbit) ≥ 20 kbps
  - black-out (per orbit) ≤ 10 %

- <u>Core Station up-link</u>
  - average (per orbit) ≥ 3 kbps
  - black-out (per orbit) ≤ 10 %

5.2.5.4.1.8

During abnormal operations (e.g. trouble shooting) the APM design shall be compatible with the following increased rates:

- Downlink:
  - average (per orbit) ≥ 80 kbps

- Uplink:
  - average (per orbit) ≤ 20 kbps

NOTE: The APM design is compatible with the requirements 5.2.5.4.1.7 and 5.2.5.4.1.8, i.e. the provided interface and processing capabilities can handle the specified data rates. However, the up /downlink rates have to be made available by the Core Station. NASA introduced a synchronized up- and downlink concept via the ICD SSP 42001, which leaves little degree of freedom for direct utilization by partner provided systems. The result is that APM data rates depend on the overall Space Station mission scenario and cannot be predicted by EADS-ST. Therefore, EADS-ST cannot commit "operability" (responsibility of ESA/APM CC).

5.2.5.4.2 Audio Interfaces

5.2.5.4.2.1

The APM shall include two station common Audio Terminal Units.

5.2.5.4.2.2

The APM shall provide eight (4 + 4) fibre-optic connections between the SSMB/APM utility interface and the two Audio Terminal Units with a maximum length of 10 meters each.

NOTE:

The signals on these lines nor the communication performance are under APM responsibility except cabling performances as agreed in the ICD.

5.2.5.4.2.3

The APM shall include one station common Audio Antenna for communication with SSMB EVA-UHF equipment.

5.2.5.4.2.4

The APM shall provide one coax line (50 ± 10 Ohm) between the SSMB/APM utility interface and the EVA UHF Audio Antenna located in the APM with a maximum length of 19 meters.

NOTES:

- The signals on these audio interface lines nor the communication performance between audio antenna and wireless headsets are not under APM responsibility.
- It is assumed that SSMB provided wireless headsets systems to be connected to the ATUs are used on-orbit, i.e no flight qualified headsets are delivered as part of the APM system.
- The signals on these lines nor the communication performance are under APM responsibility except cabling performances as agreed in the ICD.

5.2.5.4.3 Video/Payload High Rate Data

5.2.5.4.3.1

The APM shall provide six fibre optic interfaces for distribution of two video channels to/from the core station video system and one sync signal from the core station video system:

- 1 + 1 sync to APM (cold redundant)
- 2 x SSMB video to APM (can work in parallel)
- 2 x APM video to SSMB (can work in parallel).

5.2.5.4.3.2

The APM video system shall be synchronized by the sync signals received from the SSMB when available. When no sync signal is available, the APM shall generate an own sync signal, so that the APM video functions are available without any degradation.

5.2.5.4.3.3 (Intentionally left blank)

5.2.5.4.3.4

The APM shall route two fibre optic lines per active P/L rack to the SSMB/APM interface plane with a maximum length of 10 meters and no more than two intermediate connectors (High Rate Data Link/HRDL).

5.2.5.5 Environmental Control/Life Support System

5.2.5.5.1

The APM Environmental Control and Life Support System shall functionally interface with the SSMB.

5.2.6 Flight Software Interfaces

5.2.6.1 General

5.2.6.1.1

The APM software shall interface with the Core Station Software to support the essential command and data interfaces specified in para. 5.2.5.2.2.

5.2.6.1.2

The APM software shall interface with the Core Station software to support the system and P/L data interfaces specified in para. 5.2.5.2.3.

5.3 APM to Shuttle/Orbiter

The following interface requirements are complementary specifically to the CSRD, para. 11.1.

5.3.1 General

5.3.1.1

The APM as shown in Figure 5.12.1-1 shall be capable of being launched and transported to the Core Station by the Shuttle/Orbiter.

5.3.1.2

The APM launch mass (including initial payload) shall be 12775 kg.

NOTE:

The initial P/L mass distribution is assumed as follows:

- Mass as specified in Table 6.2.3.1-1 distributed equally over five racks (incl. ARIS)
- Rack braces kit for five racks included in payload mass
- Location: in overhead racks (4) and deck stowage rack (1)
- No external P/L attached.

5.3.1.3 (Intentionally left blank)

5.3.1.4

The APM design shall fullfil the functional performance requirements for the Unberthed Phase by receiving only redundant electrical power via the APCU after cargo bay opening and up to grapping from the SSRMS.

NOTE:
Though the operational interface is between the Shuttle/Orbiter APCU and the APM, the physical interface is at the standard interface plan (SIP).

5.3.2 Structural Interfaces

5.3.2.1

The APM shall withstand the launch and emergency landing limit forces for Non-Returnable Cargo Elements at the Shuttle/ Orbiter interfaces.

5.3.2.2

The APM design shall withstand a potential difference of max. 3 volts prior to grappling by the SSRMS.

NOTE:

The discharge will be handled by the SSRMS when contacting the Power/Data Grapple Fixture of the APM.

5.3.3 Mechanical Interfaces

5.3.3.1

The APM shall be integrated to the Shuttle/Orbiter launcher system for launch, as shown in Figure 6.1.3-1.

5.3.3.2 (Intentionally left blank)

5.3.4 Environmental Interfaces

The APM shall withstand the environments as specified for Shuttle/Orbiter payloads.

5.3.5 System Interfaces

NOTE:

In the following each interface is related to all mission phases up to berthing with the SSMB.

5.3.5.1 Electrical Power System

5.3.5.1.1

The APM Power I/F Design shall be in accordance with PDGF Power Quality also for the APCU I/F.

5.3.5.1.2

Temperature control shall be performed by the HCU in the fully automatic mode.

5.3.5.1.3

The APCU interface bracket location shall be at the external side of the port cone, full accessible by EVA astronauts, APM being installed in the Shuttle/Orbiter cargo bay.

5.3.5.1.4

The APM design shall allow for onboard removal of the Shuttle/Orbiter cables by crew from APCU bracket (EVA).

5.3.5.2 Data Management

5.3.5.2.1

The APM shall not rely on control and monitoring by the Shuttle/Orbiter.

5.3.5.3 Thermal Control System

The Thermal Load Case Definitions in the following subparagraphs correlate to the APM Mission Phase/Modes Definitions as shown in Table 5.3.5-1.

APM Thermal Load Cases Definition		APM Mission Phases Definition		Remarks
Load Case	**Mission Mode**	**Mission Phase**	**Mission Mode**	
para. 5.3.5.3.1 APM in Shuttle/Orbiter C/B (duration: 72 h/APM Spec.)	APM Passive	Launch/Ascent (duration: 72 h/CSRD)	APM Passive	Heating from Orbiter APCU
para. 5.3.5.3.2 APM Grappled by SSRMS (duration: max. 70 min/APM Spec.)	APM Unberthed Survival	Initialization (duration: min. 70 min/OPS)	APM Unberthed Survival	Duration for Thermal Load Case assumed by industry
para. 5.3.5.3.3 APM Docked to Core Station (duration: 24 h/APM Spec.)	APM Passive	-	-	
para. 5.3.5.3.4 Contingency Phase (duration: 72 h/APM Spec.)	APM Unberthed Survival	Initialization (duration: unlimited/CSRD)	APM Unberthed Survival	Duration for Thermal Load Case assumed by industry
para. 5.3.5.3.5 APM Berthed to Core Station (duration: Unlimited/APM Spec.)	APM Berthed Survival	Initialization (duration: unlimited/CSRD)	APM Berthed Survival	none

Table 5.3.5-1 APM Thermal Load Cases vs. Mission Phases Comparison Matrix

5.3.5.3.1 APM in Shuttle/Orbiter Cargo Bay (APM Passive/unberthed survival)

The APM shall be designed to survive without any degradation within the Shuttle/Orbiter Cargo Bay with resources and limits as follows:

- APM max. stay time from launch time: 72 hours
- Heater power supply capability to APM : ≤ 1800 W (continuously and peak)
- Shuttle/Orbiter attitudes during launch/ascent with open cargo bay as follows:
  - **Cold case**
    a) Orbiter cargo bay in earth pointing attitude for 8 hours and in deep space point attitude for 35 minutes, repeated alternatively for 7 times.
    b) Orbiter cargo bay in earth pointing attitude for 8 hours and in deep space point attitude for 90 minutes.
    c) Orbiter cargo bay in earth pointing attitude for 145 minutes.
  - **Hot case**
    a) Orbiter cargo bay in earth pointing attitude for 8 hours and in deep space point attitude for 35 minutes, repeated alternatively for 7 times.
    b) Orbiter cargo bay in earth pointing attitude for 8 hours and in sun pointing attitude for 30 minutes.
    c) Orbiter cargo bay in earth pointing attitude for 205 minutes.

NOTE:

It is assumed that the Shuttle/Orbiter ground infrastructure ensures a stabilized outside APM temperature of 22 ± 2 °C prior to lift-off.

5.3.5.3.2 APM Grappled by SSRMS (APM Unberthed Survival)

The APM shall be designed to survive without any degradation during this phase with the following limits:

- max. duration: 70 min
- attitude: APM in any direction
- heater power supply capability to APM: ≤ 1800 W

5.3.5.3.3 APM Docked to Core Station (APM Passive)

The APM shall be designed to survive without any degradation during this phase with the following limits, i.e. to maintain all internal equipment in the temperature limits "switch-on" temperature up to max. operation temperature.

- max. duration: 24 hours
- attitude: Earth pointing (APM -Z-axis to Earth)
- heater power: no power available

DEFINITION:

Nominally the initial activation of the APM starts from this phase.

5.3.5.3.4 Contingency Phase (APM Unberthed Survival)

The APM shall be designed to survive without any degradation during this phase with the following limits (i.e., to maintain all internal equipment in the temperature limits as specified in para. 5.3.5.3.3 above):

- APM mechanically berthed to the Core Station
  - max. duration: 72 hours
  - attitude: Earth pointing (APM minus z-axis to earth)
  - APM system power: ≤ 1800 W from SSRMS (continuously)

DEFINITION:

After this phase the APM starts operations with receiving electrical power from the core station via the normal power interfaces without time limitation.

NOTE:

Is is assumed that the current to the APM is monitored by the SSMB/SSRMS so that APM heater operation can be monitored.

5.3.5.3.5 APM Berthed to Core Station (APM Berthed Survival)

The APM shall be designed to survive without any degradation during this phase with the following limits (i.e., to maintain all internal equipment in the temperature limits as specified in para. 5.3.5.3.3 above):

- APM berthed to the Core Station
  - duration: unlimited
  - attitude: Earth pointing (final attitude)
  - APM System Power: ≤ 1800 W from SSMB/DDCU

5.3.5.4 Communications

N/A

5.3.5.5 Environmental Control and Life Support System

N/A

5.3.5.6 Flight SW Interfaces

N/A

5.4 APM System (including GSE) to Ground Facilities

5.4.1 AIT Site

5.4.1.1

The APM system design shall be compatible with the AIT facility at the integration site in the integrated launch configuration (including installed initial payload) in horizontal orientation for ground operator access and system testing.

5.4.1.2

The APM GSE shall be compatible with the AIT facility environment and utility interfaces.

5.4.2 Launch Site

The following requirements are complementary to the CSRD, para.7.1.4 and 11.4.

5.4.2.1

The APM and its GSE in the configuration needed for check-out and launch preparation shall be compatible with all environments and used interfaces at the KSC NSTS Launch Center.

NOTES:

- It is assumed that NASA's Launch Site MPLM compatible MGSE is available for APM launch site processing.
- The APM EGSE does not include the complete functionality to check-out the initial P/L but provides the interface capabilities as specified in para. 5.7.9.3.
- Nominally the EGSE will not be needed for pre-launch activities (ship and shoot concept); only if repair is necessary after transport to the launch site, check-out will be performed.

5.4.3 Operations Control Center

5.4.3.1 General

5.4.3.1.1

The APM system shall be compatible with the

- Space Station Control Center (SSCC, US)
- JEM Control Center (SSIPC, Japan)
- COL Control Center (COL CC, Europe)

the communication being established via the Interconnection Ground Subnet (IGS) as shown in Figure 5.4.3-1.

5.4.3.1.2 (Intentionally left blank)

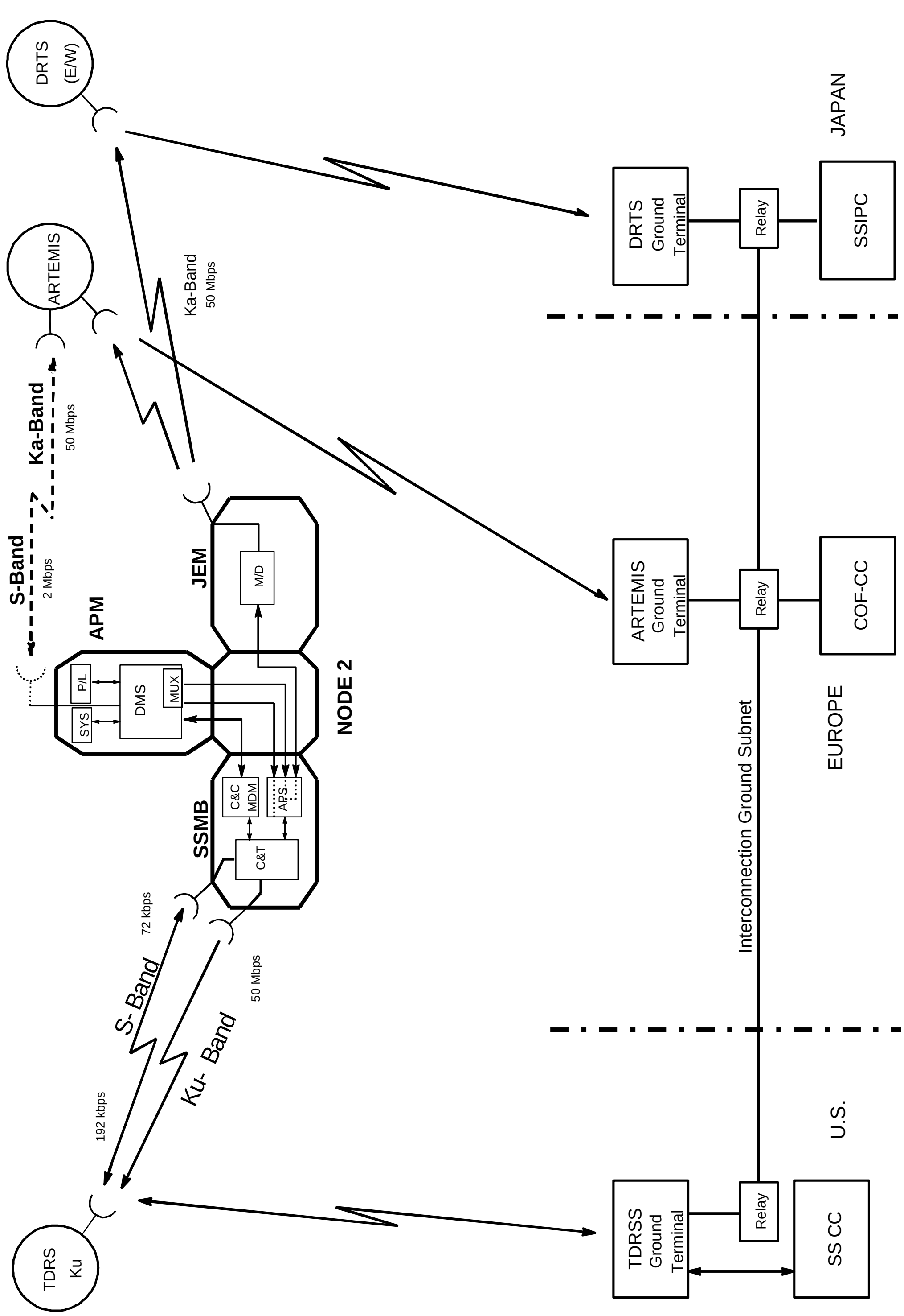


Figure 5.4.3-1 APM Communications Interfaces

NOTE: APM baseline containes provision for later on-orbit accommodation of a Terminal communicating with ARTEMIS.

5.4.3.2 Flight Configuration Interfaces

5.4.3.2.1 (Intentionally left blank)

5.4.3.2.2 Control Center Links

NOTES:

- The direct telemetry and telecommand interfaces to/from the APM are implemented by the communications interfaces described in para. 5.2.5-.4.
- The data interface between SSMB and APM, which is used indirectly also for telemetry and telecommand, is specified in paragraphs:
  - 5.2.5.2: Data Management System
  - 5.2.6: Flight SW Interfaces
- The protocols/standards specified in para. 5.2.5.4 and para. 5.2.6 are understood to ensure also compatibility with the ISS, APM and JEM Operations Control Centers.

5.4.3.3 APM EGSE Interfaces

5.4.3.3.1

The APM EGSE shall provide an interface to allow interface testing with the COL Control Center for compatibility testing.

NOTE:

The data link between the APM EGSE located at the APM AIT site and the COL Control Center is assumed to be provided by ESA.

5.4.3.3.2

The APM EGSE shall convert the digital data stream of the SSMB/APM interface 1553B busses such that they can be interfaced with the APM Operations Control Center via standard communication lines.

5.4.3.3.3

The APM EGSE shall accept a digital data stream from the APM Operations Control Center and transmit it to the APM as if received onboard via the SSMB/APM interface.

5.4.3.3.4

The APM EGSE shall forward data on the SSMB/APM 1553 B busses interface to and from the SSMB ground facilities for compatibility testing.

NOTES:

- The interfaces are identical to those identified in 5.4.3.3.2 and 5.4.3.3.3 above.
- The data links between the APM EGSE and the SSMB ground facilities are assumed to be provided by ESA/NASA.

5.5 APM to ISPR (Payload Rack) Interfaces

The following interface requirements are complementary to the IRD SSP 41152.

5.5.1 General

5.5.1.1

The APM design shall provide the following ISPR interface categories for usage by the payload using the resources available at the different locations

ISPR Rack Category	Remarks
Active ISPR	Fulfills all ISPR I/F requirements*
Stowage Rack	Fulfills mechanical/passive thermal ISPR I/F requirements

*) as detailed in Table 5.5.1-1.

5.5.1.2

The APM design shall allow to accommodate racks in accordance with mechanical/thermal ISPR interface requirements and ARIS provisions at all APM lateral rack locations, and without ARIS provisions at two overhead locations.

NOTES:

- Stowage rack locations (three locations, see Figure 6.1.7.2-2) allow accommodation of P/L racks with ARIS for launch; at rack locations with ARIS provisions no rack can be accommodated for launch.
- No rack mechanisms interfaces are installed in lateral rack locations.
- Rack mechanisms are the locking mechanisms at the rack lower rear interface attachments and the braces interfacing at the upper rack attachment.

5.5.1.3

The APM design shall provide functional interfaces for active ISPRs with different interface resources depending on the location within the APM as shown in Table 5.5.1-1.

Interfaces	**Active ISPR Rack Positions**	
	Lateral	**Overhead**
Cooling water	X	X
Venting	X	X
Vacuum	X	-
Nitrogen Supply	X	X
High Power (average/peak) 1) 2)	5 x 6 / 6 kW	-
Medium Power (average/peak)1)	3 x 3 / 3.6 kW	2 x 3 / 3.6 kW
Essential/Auxiliary Power (average/peak)	8 x 1.2 / 1.2 kW	2 x 1.2 / 1.2 kW
P/L Local Bus	X	X
US P/L Bus	X	X
APM LAN	X	X
US LAN	X	X
Video / High Rate Data	X	X
Special Video I/F 1) FO & Dig. Electrical3	X	-
P/L EWACS	X	X

1) detailed location see Figure 6.1.7.2-2.

2) ISPRS A3 and F3 share power with external payload

3) APM baseline contains harness provisions for later on-orbit implementation of a digital video system (Electrical interfaces)

Table 5.5.1-1 APM ISPR Interface Resources for P/L Usage

5.5.1.4

The APM design shall provide all interfaces to and from each active P/L rack, to accommodate the fire detection equipment located in each active payload rack as integral part of the APM EWACS:

- Fire Sensor
- Circulation Fan Assembly
- FDS Panel.

NOTE:

The hardware up to the module to payload rack interface plane is provided within APM deliveries whereas the rack structure and the items within the payload rack are no APM deliverable items.

5.5.1.5

The APM design shall provide for each active P/L rack:

- 2 discrete inputs to APM EWACS/VTC
- 2 discrete outputs from APM EWACS (15 V pulse commands).

NOTES:

- It is assumed that for failure tolerance purposes the P/L delivers the same data via the P/L local bus to the PLCU and the P/L Appl. SW sends the respective command to the P/L.
- The SW in PLCU stays at cat. C.

5.5.1.6

The VTC Software shall automatically issue the related output command when the input goes HIGH. It shall be possible to inhibit this function by an external command.

NOTE:

It will be P/L Design Integration Responsible task to assure that safing within the P/L will be initiated upon reception of the command.

5.5.1.7

The APM shall provide the specified micro-g environment at the module to ISPR interface without consideration of micro-g accelerations generated by the payload, the crew and the SSMB.

5.5.1.8

One discrete input per rack shall be processed as EMERGENCY, the other one as WARNING and transmitted accordingly to the SSMB.

NOTE:

It is assumed that the SSMB processing of the P/L Emergency and Warning signal results in a station-wide annunciation and that the US Laptop will indicate by a pop-up menue the source of the alarm (= which P/L rack in the APM) based on the data transmitted by the VTC.

5.5.2 Structure Interfaces

5.5.2.1

The APM structure interface shall consist of attachment points being able to attach any ISPR on-orbit, and at ISPR locations without ARIS provisions, with a maximum total mass of 500 kg on ground, being able to transfer the forces occurring during ground transport of the APM and during launch and berthing at ISS and emergency landing for Non-Returnable Cargo Elements.

5.5.2.2

The APM structure interface shall consist of attachment points being capable to attach any ISPR with a maximum total mass of 800 kg during on-orbit operations.

5.5.3 Mechanical Interfaces

5.5.3.1

The APM shall provide at each ISPR rack location

without ARIS Provison	with ARIS Provision
Upper attachment points	Upper attachment points for ARIS
Lower attachment points	Pivot points
Pivot points	As defined in SSP 41017 (Rack to MPLM ICD)

NOTE:

During launch racks with and without ARIS are attached with standard ISPR mechanisms (see para. 5.5.1.2).

5.5.3.2

The pivot points shall be part of the stand-off structure and shall allow on-orbit rack installation and removal at each ISPR location.

5.5.3.3

At each active ISPR location a Utility Interface Panel shall be provided as agreed in the ICD.

5.5.3.4 (Intentionally left blank)

5.5.3.5

For on-orbit rack attachment simplified upper rack provisions shall be provided and safely installed/- stowed at launch for the lateral ISPR locations. The mass of these strut sets shall be accounted to the APM structure mass.

5.5.4 Environmental Interfaces

5.5.4.1

The APM system design shall ensure the environment suitable to accommodate ISPRs as defined in applica-ble document 2.1.1.5: Environment and Test Specification.

5.5.5 System Interfaces

Each active ISPR shall receive its resources interfacing with the following functional APM systems, which are specified in detail in para. 6 of this specification:

- Electrical Power System 6.2.1.2.2
- Data Management System 6.2.1.2.4
- Communications 6.2.1.2.6
- Thermal Control/Environ-mental Life Support System 6.2.1.2.7
- Emergency, Warning and Caution and Safing Support 6.2.1.2.8

5.5.5.1 Electrical Power System

5.5.5.1.1

The Electrical Power System shall provide Main Power interfaces rated for

- up to 6.0 kW at high power locations at one feeder at each High Power P/L rack position
- up to 3 kW at medium power locations at one feeder at each Medium Power P/L rack position

with a trip time of ≥ 1.5 msec.

5.5.5.1.2

The Electrical Power System shall provide up to 1.2 kW essential/auxiliary power on a dedicated feeder per P/L rack location.

NOTE:

Overhead ISPR I/Fs provide reduced inrush current capability, see para. 6.2.1.2.2.2.

DEFINITION:

Auxiliary power is derived from the other SSMB main power feeder than that supplying main power to the rack.

5.5.5.1.3

Each feeder shall be individually protected and switchable.

5.5.5.1.4

- voltage
- ON/OFF status
- current.

NOTE:

The voltage is measured centrally in the PDU for the payload complement. For one dedicated ISPR feeder (see Figure 6.1.7.2-2) supplying a Payload Rack together with External Payload current is measured for the ensemble. Thus an overall power measurement accuracy of ± 5 % full scale is ensured.

5.5.5.1.5 (Deleted)

5.5.5.1.6

All harness connections to the P/L racks shall be manually mateable/demateable on orbit after mechanical rack attachment in the tilted and non-tilted positions.

5.5.5.1.7

The Electrical Power System shall switch off the main and safing power to that P/L rack, which delivers a switch-off command.

NOTE:

This command is normally delivered from FDS panel in the rack containing the manually to be operated "Power Maintenance Switch".

5.5.5.2 Data Management System (DMS)

5.5.5.2.1 Vital DMS Interfaces

Two discrete inputs/outputs for Emergency and Warning monitoring and safing of P/L items per active ISPR location shall be foreseen (see para. 5.5.1.5 to 5.5.1.7 for functional requirements).

5.5.5.2.2 Fire Detection System Interfaces

The APM System shall interface with the standard equipment inside each active P/L for Fire Detection purpose by:

- Outputs from rack
  - Fire/Smoke Sensor Signals
  - Status of Air Circulation Fan Assembly

- Inputs to rack
  - Fire/Smoke Sensor Check-out Command
  - Fire Indicator Display Command to FDS Panel

5.5.5.2.3 (Intentionally left blank)

5.5.5.2.4 Nominal DMS Interfaces (APM System)

5.5.5.2.4.1

The Payload local bus MIL-STD-1553B (nominal and cold redundant) shall interface with each active P/L rack at the interface panel by a stub realized by two twisted/shielded pairs ending in two con-nectors on the Utility Interface Panel.

5.5.5.2.4.2

The Payload local bus shall allow for an extension within the rack by up to 3 m with a 75 ± 5 Ohm twisted-shielded cable.

5.5.5.2.4.3

The Payload local bus shall provide the following functions for each active P/L rack:

- Data transfer to/from Payload Control Unit (for processing therein or up-/down-link transfer)
- Data transfer to/from APM system management layer
- Time
- Back-up for P/L EWACS (see para. 5.5.1.5).

5.5.5.2.4.4

The APM LAN shall provide for each active P/L rack location and center aisle Payload (at Standard Utility Panels) a dedicated (cold redundant) interface from the central ETHERNET controller (HUB/LAN Switch).

5.5.5.2.4.5 US P/L Bus Interfaces

5.5.5.2.4.5.1

The US P/L MIL-STD-1553B bus for US ISPRs hosted in APM (nominal and cold redundant) shall be routed from the APM feedthroughs to each active P/L rack interface panel by a stub realized by two twisted/shielded pairs ending in two connectors on the Utility Interface Panel.

NOTE:
Usage and protocol on the US P/L bus is not under APM responsibility.

5.5.5.2.4.5.2

The length of the stub from the MIL-STD-1553B bus interconnection station up to the active P/L rack interface panel shall be < 1.5 m.

5.5.5.2.4.6 US P/L LAN Interfaces

The US LAN shall be routed from the PEHG to each active P/L rack interface panel.

NOTE:
Usage and performance of the US LAN is not under APM responsibility.

5.5.5.3 Thermal Control System

5.5.5.3.1

The water loop shall interface with each active ISPR at the interface panel using a self-sealing quick disconnect for water inlet and for water return.

5.5.5.3.2 (Intentionally left blank)

5.5.5.4 Communications System

5.5.5.4.1

The APM shall provide fibre optic video/high rate data interfaces to/from each active P/L rack to the communication system consisting of:

- 1 Video Sync control to P/L rack
- 2 Video or high rate data to/from P/L rack

for downlinking (video and high rate data) and onboard display and recording (video only).

5.5.5.4.2

The video signals shall be in accordance with Video Standard EIA-RS-170A (NTSC) as defined in applicable document 2.1.2.7 with PFM modulation on an optical carrier.

5.5.5.4.3

The internally generated sync signal shall be in accordance with the SSMB sync signal (EIA-RS-170A Black Burst).

5.5.5.4.4

When using the rack output for high rate data transfer instead of video the interface shall enable data transfer in accordance with the Transparent Asynchronous Transmitter/Receiver Interface (TAXI) protocol.

5.5.5.4.5

In addition to the interfaces specified in para. 5.5.5.4.1 for the one dedicated P/L video processing rack the following interfaces shall be provided:

- 5 video interfaces to rack as specified in 5.5.5.4.2
- 1 processed (e.g. compressed with special algorithm) video signal interface from rack with the same characteristics as the digital data from any payload rack (as specified in para. 5.5.5.4.4 above)
- 1 sync signal interface from video processing rack.

5.5.5.4.6

From any active P/L rack two fibre opric lines shall be routed to the SSMB/APM interface plan as specified in para. 5.2.5.4.3.4

NOTE:

The APM design commits only the transfer media characteristics.

5.5.5.4.7

The APM shall provide harness interfaces to allow for (after later on-orbit implementation of the digital video system-Mark II) video/high rate data interfaces to/from each active P/L rack with the following options:

A) Standard

- 1 Video sync control to P/L on FO as before (with Payload Adapter Kit/PAK located on UIP)
- 2 Video or high rate data to/from P/L on FO as before (with PAK)

B) New

- 1 Video Sync control to P/L (electrical/TSP)
- 2 Video or high rate data to/from P/L (electrical/TSP)

NOTES:

- The PAK will be configured depending on the required interface to P/L
- The present FO interfaces will be de-activated with implementation of the mark II video system.

5.5.5.5 Environmental and Life Support System

5.5.5.5.1 Payload Rack Heat Leak

The APM shall be able to accept up to 5 % of the active P/L rack internal heat dissipation rejected via the front panel to the cabin air under consideration of a maximum allowable total heat injection into the APM cabin as defined in para. 5.7.8.4.8.

NOTE:

The P/L Design Integration Responsible must ensure that the rack surface mean radiant temperature does not exceed 35 °C.

5.5.5.5.2 Nitrogen

5.5.5.5.2.1

The N_2 supply line shall interface with each active P/L rack at the interface panel using a self-sealing quick disconnect.

5.5.5.5.2.2

The N_2 supply line shall provide the active P/L rack with a gas pressure as defined in the SSMB to APM IRD.

5.5.5.5.3 Intentionally left blank

5.5.5.5.4 Venting

5.5.5.5.4.1

The venting system shall interface with each active P/L rack at the interface panel, for the disposal of waste gases, using a self-sealing quick-disconnect.

NOTE:

It is mission integrator a to ensure that toxic and re-active gases are taken into account for the Integrated Safety Analysis to be approved by the Safety Panel per mission increment.

5.5.5.5.4.2

The APM system shall provide one remotely controlled valve per active P/L rack.

5.5.5.5.5 Vacuum

5.5.5.5.5.1

The vacuum system shall interface with each lateral active P/L rack at the interface panel using a self-sealing quick disconnect.

5.5.5.5.5.2 (Intentionally left blank)

5.5.6 Flight SW Interfaces

5.5.6.1

The flight S/W interfaces on rack level are covered by the requirements on system level, which are specified in para. 5.7.8.5.

5.5.7 ISPR Bonding

5.5.7.1

The APM shall provide a bonding interface point for each ISPR location.

5.5.7.2

APM shall provide in addition to 5.5.7.1 a dedicated bonding interface point at all lateral ISPR locations with ARIS provisions.

5.5.7.3

APM shall provide bonding straps for installation at each ISPR rack location for NASA and NASDA ISPR racks (incl. Stowage Racks, assuming that these racks have the same mechanical and bonding I/Fs as the standard ISPRs) using the BOEING provided modified CAMLOCK bolt at the interface to the racks.

NOTES:

- In total ten (10) bonding strap sets shall be provided by APM.
- Qualification of Bonding resistance between the APM provided bonding straps comected to the ISPR racks with the modified CAMLOCK devices is with NASA taking into account the necessary number of cycles into account

5.6 Payload Rack to Pressurized Logistics Module Interfaces

N/A

NOTE:
No payload rack structure designed/provided as part of APM system.

5.7 APM to Payload Interfaces (Individual P/L Items and overall P/L Complement)

5.7.1 General

5.7.1.1

The APM flight configuration shall provide the following interfaces to individual payload items accommodated at the different internal APM locations as identified in Table 5.7.1-1.

5.7.1.2

The APM flight configuration shall provide the above interfaces to the overall payload complement within the overall system resources and environment limits as identified in Table 5.7.1-2.

NOTE:

The overall APM Flight Configuration to the overall P/L complement interface are specified in para. 5.7.8. (internal and external)

5.7.1.3

The APM System GSE shall provide the following interfaces to payload racks/items as identified in Table 5.7.1-3.

INTERFACE TYPE	INTERFACE PLANE LOCATION FOR P/L ITEMS		REMARKS
	At Center Aisle[1)]	At Utility Provisions (SUP)	
• Structure Interfaces	X	-	Seat track
• Mechanical Interfaces	X	-	Seat track
• Environment			extension
- Microgravity	(X)	(X)	
- EMC	(X)	(X)	
- Thermal	(X)	(X)	
- Atmosphere	(X)	(X)	
- Radiation	(X)	(X)	
• System Interfaces			
- Electrical Power	-	X	
- Time	-	X[2)]	P/L local bus
- System Data	-	X[2)]	P/L local bus
- Payload Data	-	X[2)]	P/L local bus
- Communication			
-- up-/downlinks	-	X	P/L local bus[2)]/ LAN
-- video/high rate data	-	X[3)]	
- Fire/Smoke	-	X	
• US P/L Bus	-	X[2)]	SSMB P/L bus extension

Legend: X designed/verified under APM responsibility

(X) general APM environment

1) connection to APM system interfaces by mission-dependent harness to Standard Utility Panel (= Utility Provisions)

2) on some Standard Utility Panels (see Table 5.7.4-2)

3) on XUP after implementation of Video Mark II

Table 5.7.1-1 APM Flight Configuration Interfaces to internal P/L Items for other than Rack Location

Resources and Environm./Interface Type	Overall Payload Interface/Para.
• Structure Interfaces	N/A (covered on rack level)
• Mechanical Interfaces	N/A (covered on rack level)
• Environment - Microgravity - Audible Noise/Human Vibration - EMC - Thermal - Atmosphere - Radiation	 N/A (specified at active P/L rack interface plane) x / 5.7.8.3.2.1 x / 5.7.8.3.2.3 N/A (covered on rack/item level) N/A N/A (covered on rack/item level)
• System Interfaces - Electrical Power - Time and Frequency (P/L Local Bus) - System Data (P/L Local Bus) - System LAN - Payload Data (P/L Local Bus) - Thermal Control - Communications -- up-/down-links -- video/high rate data - Environmental/Life Support -- P/L heat leak to cabin -- N_2 provision -- Venting -- Vacuum provision	 x / 5.7.8.4.1 x / 5.7.8.4.4 N/A (covered on item level) x / 5.7.8.4.5 x / 5.7.8.4.5 x / 5.7.8.4.6 x / 5.7.8.4.7.2 x / 5.7.8.4.7.3 x / 5.7.8.4.8 N/A (covered on rack level) N/A (covered on rack level) N/A (covered on rack level)
• Flight SW	x / 5.7.8.5

NOTE: The system limits related to the US P/L Bus and the US LAN are not under APM responsibility.

Table 5.7.1-2 APM Flight Configuration Resources and Environments Limits versus Overall internal Payload Complement

APM System GSE	Payload Provisions
MGSE	• Lifting of P/L racks (including P/L items configured for flight) • Installation of integrated P/L racks into APM
EGSE	• Provisions to connect P/L EGSE to APM EGSE LAN • Provision to connect P/L EGSE to Ground High Rate Demultiplexer outputs
SDDF	• Environment for P/L application SW development and integration for P/L dedicated onboard computer S/W

NOTE: The detailed requirements to the above overall interface definitions are contained in para. 5.7.9.

Table 5.7.1-3 APM System GSE/Payload Interfaces

5.7.2 (Intentionally left blank)

5.7.3 Stowage Rack

5.7.3.1 General

The APM design shall ensure the mechanical interfaces for accommodation of stowage rack identical as to ISPRs without ARIS provisions (see para. 5.5.2).

5.7.4 Center Aisle Interfaces

5.7.4.1 General

5.7.4.1.1

The APM design shall allow accommodation of P/L items in the center aisle area by provision of a standard attachment scheme as identified in Figure 6.1.7.2-4 and four standard utility panels with locations as identified in Figure 6.1.7.2-3.

5.7.4.1.2

The Standard Utility Panels shall provide interfaces as identified in Figure 5.7.4-1 and Table 5.7.4-2 for

- Electrical Power
- P/L Local Bus
- Video/High Rate Data
- APM LAN (ETHERNET)
- Fire/Smoke Sensor
- US P/L Bus.

5.7.4.2 Structural/Mechanical Interfaces

5.7.4.2.1

The APM system shall provide standard modular mounting interfaces by seat tracks at the center aisle as shown in Figure 6.1.7.2-4.

5.7.4.2.2

Each attachment point of the seat tracks shall withstand the local loads and moments acting simultan-eously as specified in Table 5.7.4-1.

Axial Force	≤ 225 pounds (1000 N)
Shear Force	≤ 450 pounds (2000 N)
Bending Moment	≤ 6195 lb-in (700 Nm)
Torsion	≤ 6195 lb-in (700 Nm)

Table 5.7.4-1 Limit Forces and Moments at the Center Aisle Interface

5.7.4.3 Environmental Interfaces

The APM system design shall ensure the environment suitable to accommodate center aisle payload as defined in applicable document 2.1.1.5: Environment and Test Specification.

5.7.4.4 System Interfaces

5.7.4.4.1 Electrical Power

5.7.4.4.1.1

Each Standard Utility Panel (SUP) shall provide three utility power outlets with positive status indication as listed in Table 5.7.4-2 rated for 1.2 kW with a current capability of up to 24 A with a duration of up to 10 msec.

5.7.4.4.1.2

Each power outlet shall provide an individual Grounding Failure Interrupt or (GFI) cutting off the power automatically when the return current differs by more than 20 mA (reaction time ≤ 25 msec).

5.7.4.4.1.3

Each GFI shall have a manual test button simulating a grounding failure such that the switch function is tested.

NOTES:

- This test function may be used as switch-off for the loads supplied form the outlet.
- Switch-on is only possible by remote command.

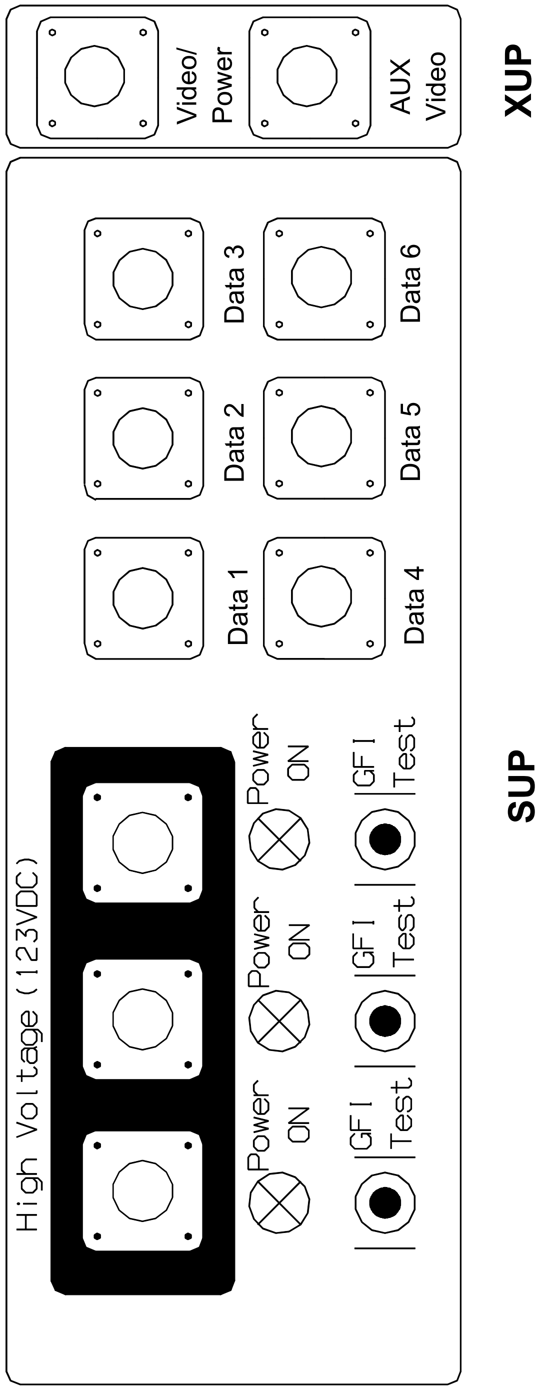


Figure 5.7.4-1 Standard Utility Panel (SUP) and Extented Utility Panel (XUP)

NOTES:

- Digital Video Interface on XUP becomes active after on-orbit video Mark II implementation.
- XUP1 is located close to SUP1, XUP4 close to SUP4

Connector	SUP 1	SUP 2	SUP 3	SUP 4
Data 1	APM LAN	APM LAN	APM LAN	APM LAN
Data 2	APM P/L Bus	Spare	Spare	APM P/L Bus
Data 3	Video (FO)	Spare	Spare	Video (FO)
Data 4	P/L Fire/Smoke	Spare	Spare	P/L Fire/Smoke
Data 5	Video (electrical)[1)]	Spare	Spare	Video (electrical)[1)]
Data 6	APM LAN	APM LAN	APM LAN	APM LAN
Power 1/Bus	120 VDC/ CHECS BUS	120 VDC/ C&C Bus 1	120 VDC/ C&C Bus 2	120 VDC/ CHECS BUS
Power 2/Bus	120 VDC	120 VDC/US P/L	120 VDC/US P/L	120 VDC
Power 3	120 VDC	120 VDC OPS LAN	120 VDC	120 VDC

[1)] Note: APM System use only.

Table 5.7.4-2 Standard Utility Panel Allocations and Functions

5.7.4.4.2 Data Management

5.7.4.4.2.1

The Standard Utility Panels shall provide two stub interfaces to the P/L local bus to connect center aisle P/L items as shown in Table 5.7.4-2.

5.7.4.4.2.2

The Standard Utility Panels shall provide four LAN interfaces to connect center aisle P/L items as shown in Table 5.7.4-2.

NOTE:

As these interfaces are also used for the APM laptops, the P/L Design Integrator has to agree usage with the Mission Integrator.

5.7.4.4.2.3

Each data interface (P/L local bus and LAN) shall allow for an extension by at least 3.0 m with a twisted shielded cable with 75 ± 5 Ohm impedance.

5.7.4.4.3 Thermal Control System

N/A

5.7.4.4.4 Communications

5.7.4.4.4.1

The Standard Utility Panels shall provide

- fibre optic video/high rate data interfaces (video bi-directional, data from P/L to ground)

as shown in Table 5.7.4-2.

5.7.4.4.4.2

Each interface shall provide for an extension by at least 2.5 meters by mission dependent harness.

5.7.4.4.4.3

The two Extented Utility Panels located aside SUP1 and SUP2 shall provide:

- 2 Digital, electrical video / high rate data interfaces (video bi-directional, data from P/L to ground)
- Elecrical power to Payload Adapter Kit (PAK).

NOTES:

- Digital, electrical interface becomes active after on orbit video Mark II implementation
- PAK allows P/L's with FO inputs/outputs to interface later with the digital electrical interfaces on the XUP's

5.7.4.4.5 Environmental Control and Life Support System

5.7.4.4.5.1

The APM shall collect up to 0.5 kW heat dissipated by payload items located at the center aisle.

NOTE:
For overall dissipation limits see para. 5.7.8.4.8.

5.7.4.4.5.2

The APM shall provide the following thermal environment:

- radiation environment: 16 ÷ 37 °C
- surrounding air: 10 ÷ 30 °C

NOTE:
No air circulation is ensured.

5.7.4.5 Flight SW Interfaces

See para. 5.7.8.5

5.7.4.6

The APM shall provide in the vicinity of each SUP a bonding provision for the Center Aisle P/L.

5.7.5 (Intentionally left blank)

5.7.6 (Intentionally left blank)

5.7.7 Portable Payload Equipment

5.7.7.1

The APM interface provisions defined in para. 5.7.4 (Center Aisle Interfaces) shall also allow connec-tion of P/L Portable Equipment, i.e. shall be accessible to the crew for connection of portable equip-ment (outlet).

NOTE:
No additional requirements than those contained already in paragraphs 5.7.4 are assumed for this type of P/L equipment accommodation.

5.7.8 Overall Flight Configuration System to Overall Payload Complement Interfaces

5.7.8.1 General

In addition to the specific interface requirements specified in above paragraphs for each APM to P/L item interface the overall system resources and interfaces shall be provided for the overall Payload complement as follows.

5.7.8.2 Structural/Mechanical Interface

5.7.8.2.1 deleted

5.7.8.2.2

The APM shall allow for a total mass of the on-orbit Payload of 10,160 kg (until the COL-Terminal is attached).

NOTE:

- It is assumed that the total P/L mass is equally distributed over the active and stowage racks.
- Max. 370 kg of P/L is attached externally to each EPF P/L Location.
- Max. 100 kg is attached externally at the trunnion attachment mechanism at the External P/L Parking Position

5.7.8.3 Environment

5.7.8.3.1 Natural Environment

N/A

5.7.8.3.2 Induced Environments

5.7.8.3.2.1 Microgravity

The APM shall provide on system level for the active P/L rack interface and external P/L interface a micro-g environment as specified in the CSRD.

5.7.8.3.2.2 Audible Noise/Human Vibration

The APM shall provide the specified audible noise/human vibration environment without consideration of noise and vibration generated by the payload complement, the crew and/or transferred from the SSMB.

5.7.8.3.2.3 EMC

The APM shall provide the overall EMC environment that is specified in applicable document 2.1.1.13: EMC and Power Quality System Support Specification, paragraphs 4 and 5.

NOTE:

The system support specification splits from integrated APM system (incl. P/L) EMC requirements given in COL-ESA-RQ-14 an APM portion (see ref. document 2.2.6: EMC Control Plan), which is the qualification criterion for the APM design under industry responsibility as specified in applicable document 2.1.1.13.

5.7.8.4 System Interfaces

5.7.8.4.1 Electrical Power

During the nominal operation phase the APM design shall be able to deliver as a minimum in total

- continuous power: 13.5 kW
- peak power: 13.5 kW

via the various Main and Essential/Auxiliary Power Interfaces to the Payload.

NOTE:

The actual power available to the P/L depends on the power received from SSMB minus system power consumption related to the APM mode as specified in para. 6.2.3.2.

5.7.8.4.2 Intentionally left blank

5.7.8.4.3 (Intentionally left blank)

5.7.8.4.4 Time Interfaces

5.7.8.4.4.1

Time shall be provided by periodic transmission of time data via the payload local bus.

5.7.8.4.4.2

The time code format shall be the CCSDS calendar segmented time code format with a resolution of 1 msec and an accuracy of ± 20 msec based on GPS time received from the SSMB.

NOTE:
The accuracy is referenced to the time received at the SSMB/APM interface.

5.7.8.4.5 Payload Data

5.7.8.4.5.1

The APM shall allow on the P/L Bus a data traffic of ≥ 380 kbps (average data rate) in total via all P/L Local Bus interfaces.

5.7.8.4.5.2

The P/L local bus shall support not less than 29 unique remote terminal addresses to be used to interface with P/L items interfacing at the active P/L racks and the standard utility panels and the External Payload Locations.

5.7.8.4.5.3

The APM LAN shall provide 18 redundant interfaces, which can be used by the P/L interfacing at the active P/L racks, the standard utility panels, and the four External Payload Locations.

NOTE:

LAN interfaces of utility panels are also used by APM laptops. Therefore, usage by P/L to be agreed between P/L Design Responsible and Mission Integrator.

5.7.8.4.5.4

The APM shall allow on the APM LAN a data traffic ≥ 1.25 Mbps in total via all P/L LAN interfaces.

5.7.8.4.6 Thermal System

5.7.8.4.6.1

The APM design shall provide for heat removal:

- ≥ 14.5 kW via the water loop

via the active P/L rack interfaces in total during routine operation phases.

NOTES:

- No heat removal for internal P/L is available during all other phases.
- Heat removal by cabin loop is specified in para. 5.7.8.4.8.
- No heat removal for external P/L is provided during all phases

5.7.8.4.7 Communications

5.7.8.4.7.1 General

5.7.8.4.7.1.1

For the APM overall communications (including Payload) the SSMB/TDRSS up-/downlink and JEM downlink systems shall be used.

5.7.8.4.7.2 Telemetry/Telecommand

5.7.8.4.7.2.1

During the nominal operation phase the APM shall provide for the following data rates via the P/L local bus:

Link	APM Design Limit	Link Limits for APM
• Downlink SSMB	≥ 380 kbps	≥ 16 kbps
• Uplink SSMB	≥ 30 kbps	≥ 3 kbps

NOTES:

- Data rates are APM design provisions per link; the actual rates have to be agreed between ISS operations and JEM, respectively, and P/L Design Integration responsible.
- The overall rate on the P/L bus shall not exceed 380 kbps in total for both functions.

5.7.8.4.7.3 Video/High Rate Data

5.7.8.4.7.3.1 Intentionally left blank

5.7.8.4.7.3.2

The APM shall be able to multiplex video/high rate data from any active payload rack and standard utility panel connector interface and high rate data from external Payload in any combination for downlinking in discrete bandwidth increments.

5.7.8.4.8 Environmental/Life Support

The APM shall be able to accept maximum P/L heat rejection in the cabin including:

- Leak from active P/L rack surfaces
- Payload items at Center Aisle provisions incl. Portable Payload equipment

dependent on the metabolic heat load of the crew as defined in Table 6.2.3.3-1.

5.7.8.5 Flight Software

5.7.8.5.1

The Payload Control Unit and its basic software shall provide the following Standard Services to the Payload and XCMU as available also to the APM system when interfacing via the P/L local bus and obeying the valid protocols/-standards for:

- data acquisition
- command execution
- automated procedures
- monitoring/limit sensing
- provision for file management for the P/L Control Unit
- packetize service for down-link
- depacketize service for up-link
- transfer of APM system and ISS ancillary data
- transfer of APM P/L data to SSMB.

5.7.8.5.2 P/L Software Interfaces

5.7.8.5.2.1

The Payload Control Unit basic software shall support execution of P/L provided Application Software coded in ADA, which has a logic interface to the P/L Control Unit basic S/W.

5.7.8.5.2.2

The PLCU basic software for XCMU operation shall support the execution of logically interfacing P/L provided Application Software coded in ADA.

5.7.8.5.3

The APM on-board SW shall be able to deliver system data to each P/L data interface via the APM LAN.

5.7.8.5.4

The APM onboard SW shall acquire those data from the P/L data stream necessary for overall APM system operation.

NOTES:

- P/L data packets to be addressed to on-board S/W destination.
- P/L Design Integration Responsible to ensure selection of packets.

5.7.8.5.5

The P/L Application SW resident in the Payload Control Unit shall be able to interchange data with the APM Laptop which is connected via the LAN to the APM data management system for P/L commanding and display services.

NOTE:

The P/L Appl. SW is not provided by the APM program but the P/L Design Integration Responsible.

5.7.8.5.6

The Payload Control Unit shall provide as a minimum the following data processing resources for the P/L application software and XCMU managing software:

- ≥ 1.0 MIPS
- ≥ 3.0 Mbytes local memory.

5.7.8.5.7

The APM system shall provide mass data storage within the Mass Memory Unit for P/L application SW or P/L intermediate storage data:

- Capacity: see Table 6.2.3.4-3
- Average access time by P/L Control Unit: ≤ 300 msec. (for 4 kbytes).

5.7.8.5.8

The APM system shall provide LAN interfaces to the P/L for down-linking of P/L data at higher rates than via the P/L Local Bus.

5.7.8.5.9

The APM Laptop shall provide processing capability for applications to allow display for P/L software applications (including XCMU data managing SW) executed either in the PLCU or in payload processors.

NOTE:

The actual display software in the Laptop is to be provided by the P/L Design Integration responsible.

5.7.9 APM System GSE/Pyload Interfaces

5.7.9.1 General

The APM System GSE, which is designed for APM Assembly, Integration and Test activities, shall provide the following resources interfacing either directly with Payload provided GSE and/or on-board Payload items (see Table 5.7.1-3).

5.7.9.2 MGSE

The MGSE shall provide for ground handling of payload racks and movement of the integrated P/L rack to its final destinations for launch and testing (at the APM integration site):

- for rack tilting and final destination (for functional testing)
- for launch configuration.

NOTE:

Integration of P/L items into P/L racks is not under APM responsibility and no related requirements are imposed on the MGSE.

5.7.9.3 EGSE

5.7.9.3.1

The EGSE LAN shall accommodate at least 5 (five) interfaces for P/L provided computers or Front End Equipment (FEE).

5.7.9.3.2

The EGSE shall ensure that the drag-on cables from the P/L FEEs to the onboard P/L items shall be routed in the same way as subsystem drag-on cables.

5.7.9.3.3

The APM EGSE shall be designed to accommodate compatible payload EGSE, which is able to manage and execute Payload provided software which conforms to the CGS definitions for user software (i.e. Special Application Software, Automated Procedures written in UCL and display definitions).

5.7.9.3.4

As a portion of the aggregate EGSE data processing, display and storage capability, the EGSE shall provide the following resources to handle payload low rate/housekeeping data during payload related ground operations with the integrated APM:

- Processing performance equivalent to one CGS test node platform (HP 9000-745i/100 MHz)
- 128 MB memory
- 1 GB hard disk
- Display capacity equivalent to one 20" high-resolution colour monitor
- Laser printing at 10 pages/min
- System time synchronization with an accuracy of ± 5 ms

- Communication with payload provided test equipment via FDDI LAN
- 1 GB of storage in the EGSE Data Base before off-loading to final archive.

NOTE:

Processing of payload high rate data is assumed to be totally handled by payload provided EGSE.

5.7.9.4 SDDF

The SDDF shall provide all tools and interfaces to allow for development and integration of:

- P/L Application Software executing on the Payload Control Unit

5.8 Station Common Equipment Accommodation/Interfaces

The APM design shall be compatible with or accommodate the following Station Common Equipment with a varying level of accommodation responsibility as defined Table 5.8-1 and detailed for those areas which are not fully under APM system design responsibility.

5.8.1 (Intentionally left blank)

Item	Installation		Accommodation Responsibility	Related Para.
	at Launch	on Orbit		
• Power / Data Grapple Fixture	X		Full	
• Common Berthing Mechanism (passive)	X		Interface Verification only	5.8.11
• Audio Antenna	X		Excl. communication performance	5.8.5.2
• Hatch	X		Full	
• Portable Fire Extinguisher		X	On-orbit accommodation only*)	5.8.12
• Portable Breathing Apparatus		x	Accommodation only	5.8.14
• Laptops1) 2)	X		Full	
• Smoke Sensor	X		Full	
• MAL Panel	X		Full	
• Module Lighting Assy	X		Full	
• Emergency Lighting Assy	X		Full	
• Servicing Equipment including CHECS		X	Accommodation only	5.8.13
• Audio Terminal Unit (including cold plate)	X		excl. communication performance	5.8.5.1
• Berthing Target	X		Accommodation only**)	5.12.1.4
• Payload Ethernet Hub / Gateway	X		excl. data processing performance	5.8.15
• Passive FRAM/H-Fixture	X		I/F Verification only	5.8.16
• Passive Trunnion Attachm. Mechanism.	X	Full		5.18.17

*) Flight models delivered by NASA to be launched prior to or together with APM as separate items in Shuttle/Orbiter.

**) Flight models delivered by NASA for installation during pre-launch activities.

1) Laptops for APM system operation (not SSMB Laptops used for APM operation)

2) Launched outside APM

3) Qualification only by ROD, A as hardware needed for testing is not yet funded

Table 5.8-1 Station Common Equipment Accommodation Responsibility

5.8.2 (Intentionally left blank)

5.8.3 (Intentionally left blank)

5.8.4 (Intentionally left blank)

5.8.5 Audio Equipment

5.8.5.1 Audio Terminal Unit

5.8.5.1.1 General

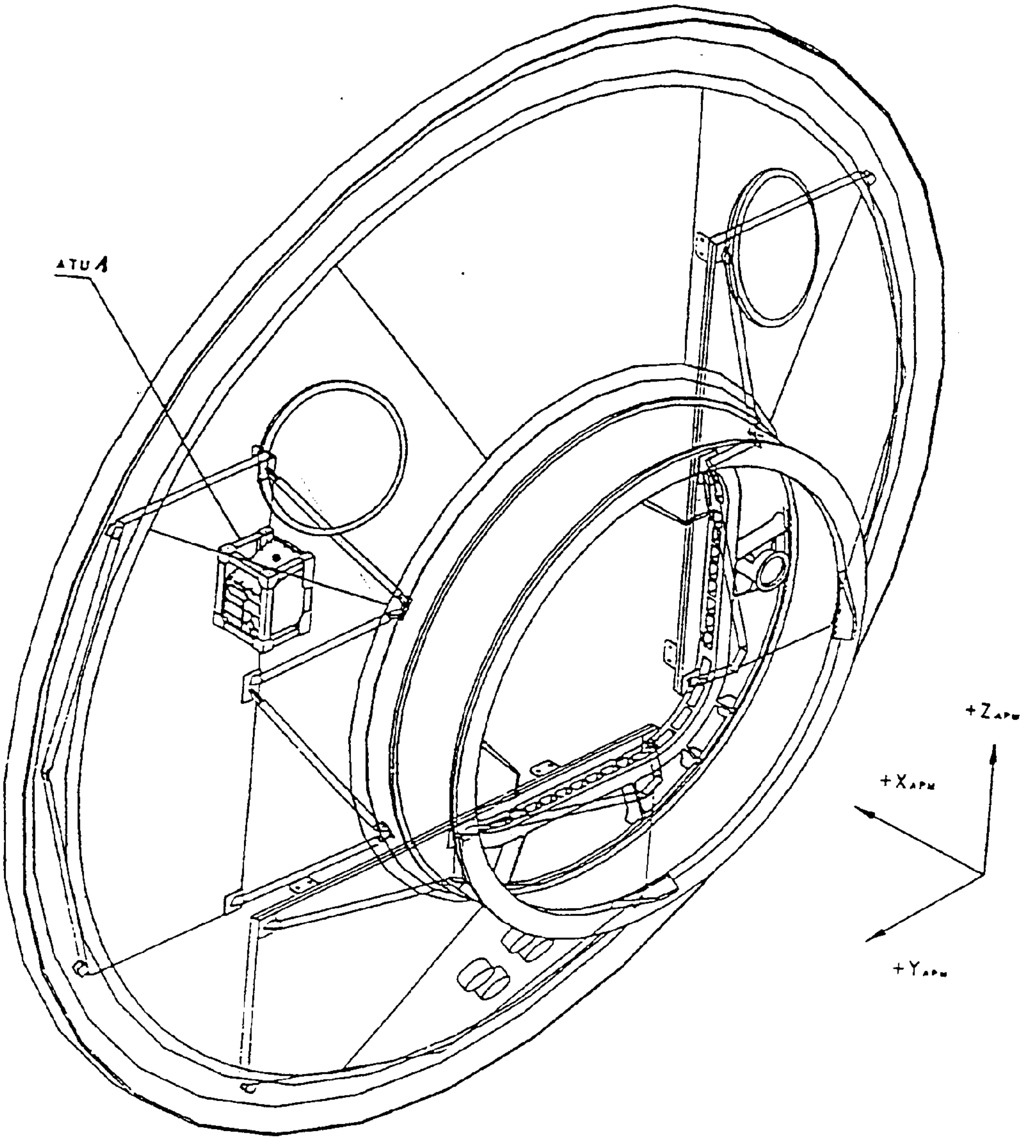
The APM shall accommodate two station common Audio Terminal Units (ATU) including dedicated cold plates.

NOTE:

The audio signal performance qualification is not under APM responsibility. Only a checkout will be performed on APM system level.

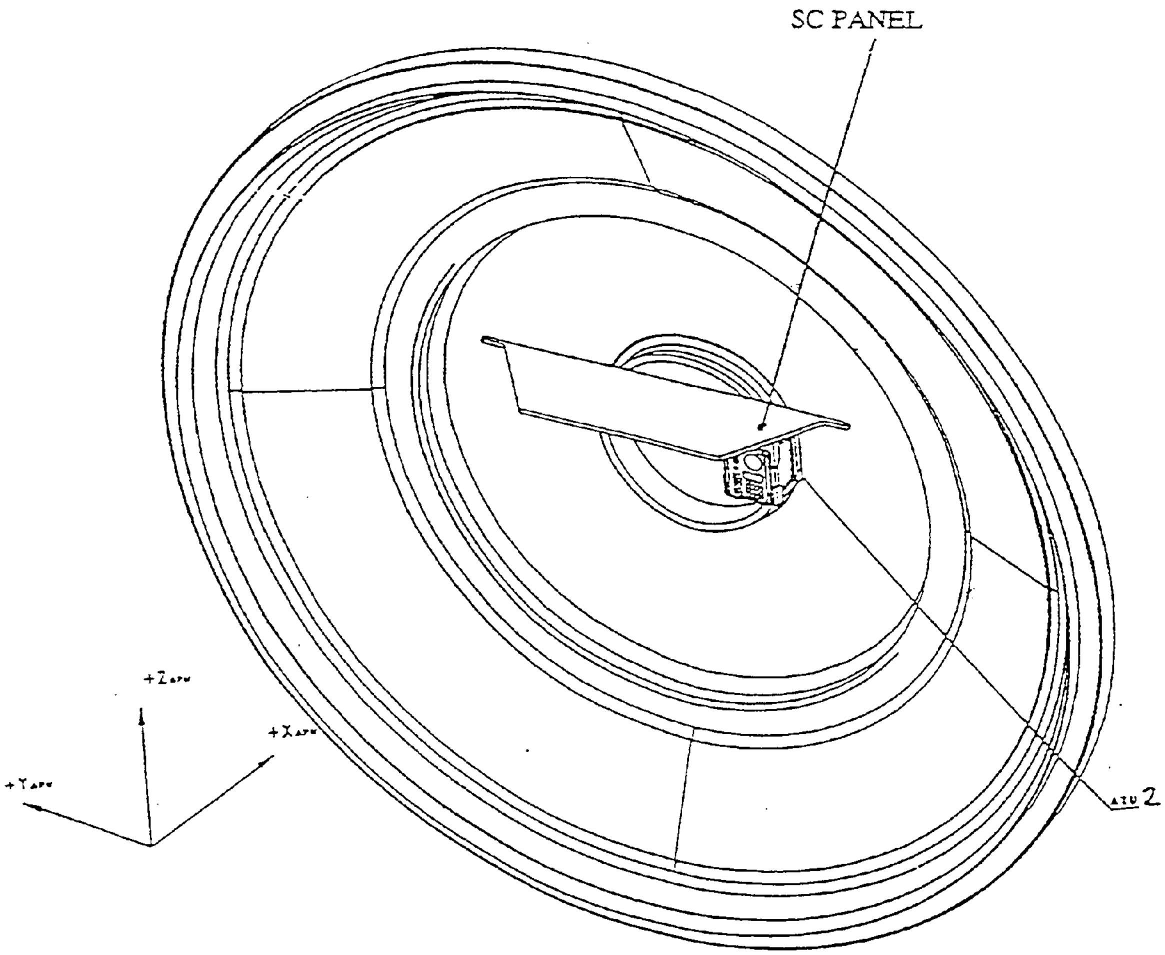
5.8.5.1.1.1

The APM shall allow Audio Terminal Unit installation inside the APM as shown in Figure 5.8.5-1 (Port Cone) and Figure 5.8.5-2 (Starboard Cone).



Note: Principle shown only

Figure 5.8.5-1 ATU 1 Location (Port Cone)



Note: Principle shown only

Figure 5.8.5-2 ATU 2 Location (Starboard Cone)

5.8.5.2 Audio Antenna

5.8.5.2.1 General

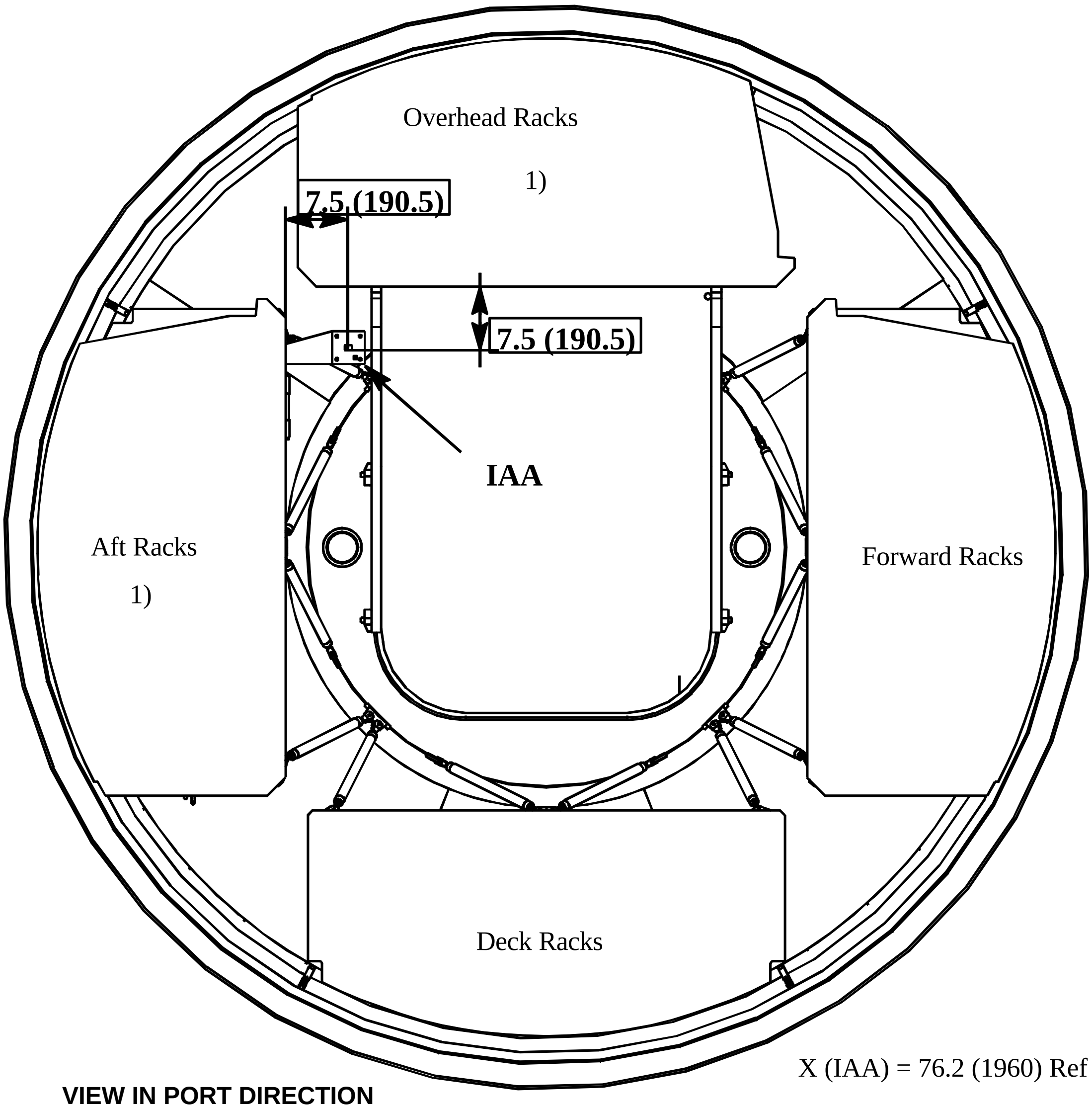
The APM shall accommodate one AUDIO antenna according to the interface requirements of this chapter.

5.8.5.2.1.1

The APM shall allow one AUDIO antenna (IAA) installation inside APM as shown in Figure 5.8.5-3.

NOTES:

- The APM will provide the harness between SSMB/APM interface plane and the APM / Audio Antenna Interface Plane as agreed in the APM/SSMB ICD.
- The APM will install the Audio Antenna at the location agreed in the APM/SSMB ICD (no performance commitment).
- Operation of Audio Antenna with ground versions of wireless headsets will be demonstrated (no performance qualification).



VIEW IN PORT DIRECTION

Note 1) ISPR Static Envelope
- Principle shown only,
  detailed dimensions agreed in SSMB/APM ICD

Figure 5.8.5-3 Audío Antenna (IAA) Location

5.8.6 (Intentionally left blank)

5.8.7 (Intentionally left blank)

5.8.8 Smoke Detector

The APM shall use station common fire smoke detectors for fire detection and localization as defined in para. 6.2.1.2.8.

5.8.9 (Intentionally left blank)

5.8.10 (Intentionally left blank)

5.8.11 Common Berthing Mechanism (CBM)

5.8.11.1

The APM launch configuration shall include the passive half of the station common berthing mechanism.

5.8.11.2

The APM primary structure shall provide at the flange to which the CBM is bolted the interface characteristics as agreed in the external ICD.

NOTE:

The CBM installation will be executed in accordance with the installation procedures as qualified by the ISS program.

5.8.12 Portable Fire Extinguisher (PFEX)

5.8.12.1 General

The APM shall accommodate two station-common portable fire extinguishers (PFEX).

NOTE:

The two PFEX flight models are not provided by the APM program.

5.8.12.1.1

The APM shall allow on-orbit the installation of two station-common portable fire extinguishers as shown in Figure 5.8.12-1.

5.8.12.1.2

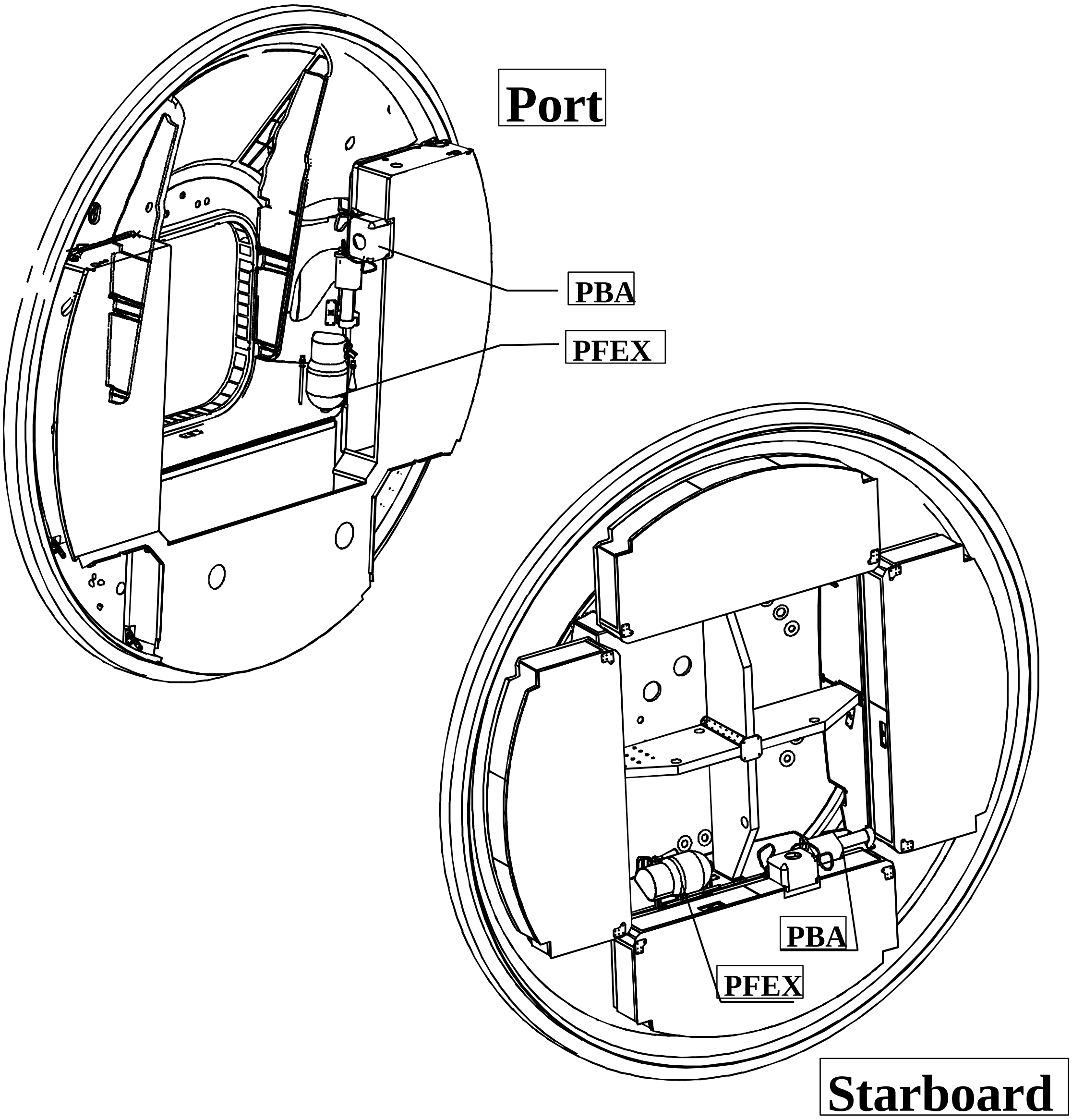
The APM shall be compatible with the portable fire extinguisher's static envelope as per Fig. 5.8.12-2.

5.8.12.1.3 (Intentionally left blank)

5.8.12.1.4 (Intentionally left blank)

5.8.12.1.5

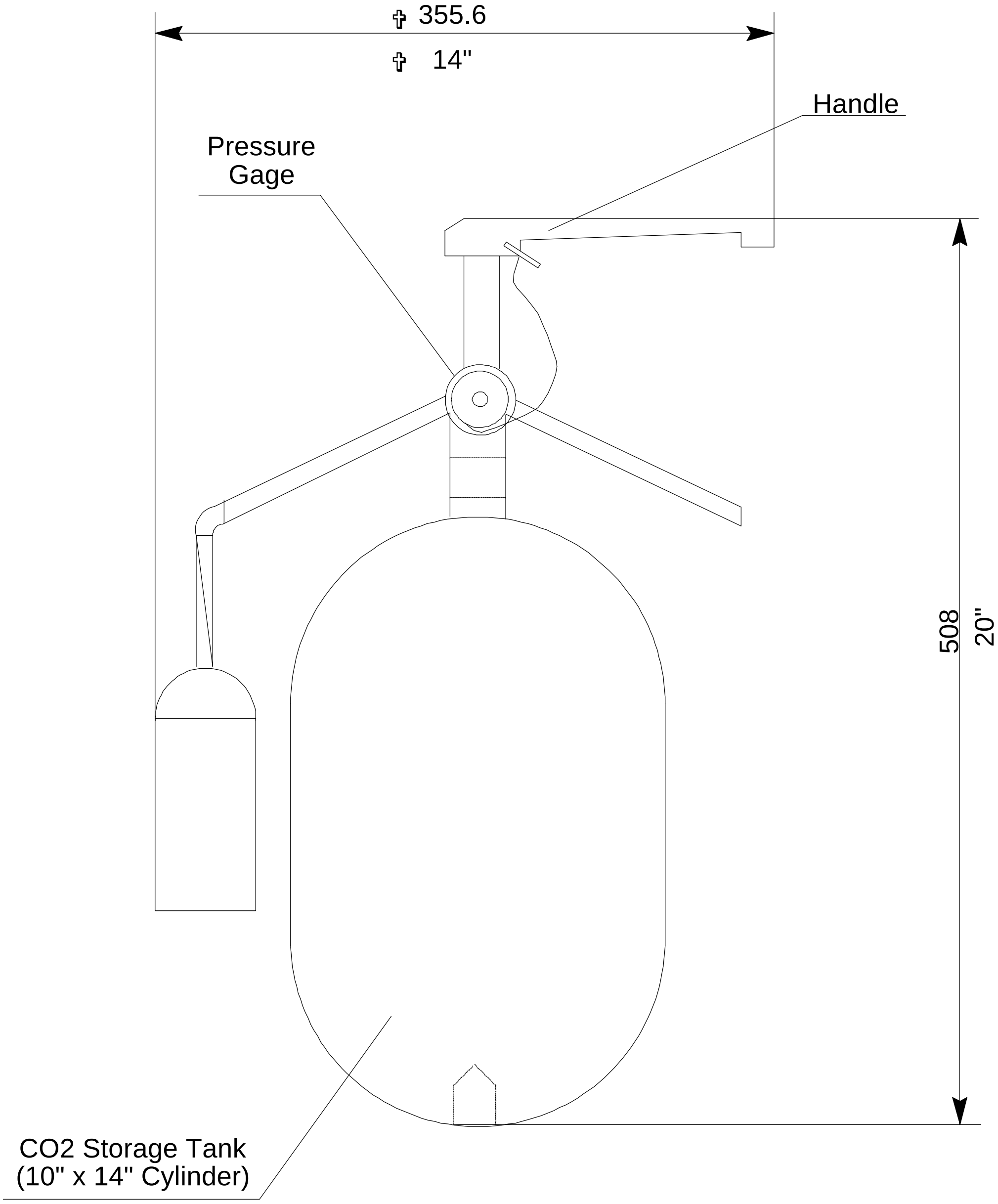
The APM shall accommodate the portable fire extinguisher mass of ≤ 8 kg (incl. CO_2).



NOTE:

1) PRINCIPLE SHOWN ONLY, FOR DETAILS SEE SSP 42001, APM/SSMB ICD
2) THE LOCATION OF PBA/PFE ARE INDICATIVE

Figure 5.8.12-1 Portable Fire Extinguisher Location



Note: Accommodation / Interface details agreed in SSMB/APM ICD

Figure 5.8.12-2 Portable Fire Extinguisher Envelope

5.8.12.2 Structure Mechanical Interface

5.8.12.2.1 Mounting Provisions

5.8.12.2.1.1

The APM shall be compatible with the attachment requirements compliant with the common PFEX design.

5.8.12.2.2 Environments

5.8.12.2.2.1 Mechanical Environment

The APM shall provide at the APM/PFEX interface the on-orbit mechanical environment as specified in applicable document 2.1.1.5, "Environment and Test Specification", para. 4.2.

5.8.12.2.2.2

The APM shall provide to the portable fire extinguisher the environment defined in applicable document 2.1.1.5, "Environment and Test Specification", chapter 5.

5.8.13 Station Equipment for Servicing

5.8.13.1 General

5.8.13.1.1 Servicing Equipment Overview

The APM design shall accommodate in-orbit temporarily the following station servicing equipment:

- Portable Fan
- Portable Vacuum Cleaner
- Portable Light
- CHECS equipment
- Housekeeping/Trash Management Basket
- IVA special tools.

5.8.13.1.2

The APM shall provide to the above equipment the environment defined in applicable document 2.1.1.5, "Environment and Test Specification", chapter 5.

5.8.13.2 Portable Fan

5.8.13.2.1

5.8.13.3 Portable Vacuum Cleaner

5.8.13.3.1

The portable vacuum cleaner has no mechanical interface in the APM.

5.8.13.4 Portable Light

5.8.13.4.1

The portable light has no mechanical interface in the APM.

5.8.13.5 CHECS Equipment

5.8.13.5.1 Power and Data

The CHECS equipment is using the power and data interfaces at the standard utility panel as defined in para. 5.7.4.4.

5.8.13.5.2 Mechanical Attachment

The CHECS equipment shall be mechanically attached to the seat track of subsystem racks.

NOTE:

Seat tracks on P/L racks, which are not APM provided, may be used also.

5.8.13.5.3 APM to CHECS Interfaces

The following interface requirements are complementary to the interface requirements document SSP 41150: Space Station Manned Bases (SSMB) to COLUMBUS Attached Pressurized Module (APM).

5.8.13.5.3.1

The APM shall be designed to accommodate on-orbit CHECS equipment comprising one Compound Specific Analyser - Combustion Products (CSA-CP), one Intra-Vehicular Charged Particle Directional Spectrometer (IV-CPDS) and one Tissue Equivalent Proportional Counter (TEPC).

5.8.13.5.3.2

The CSA-CP shall be located in an area which provides access to cabin airflow representative of the APM.

The TEPC and IV-CPDS shall be located in areas of high crew occupancy or low module shielding.

5.8.13.6 Housekeeping/Trash Management

5.8.13.6.1

The housekeeping/trash management basket shall be mechanically attached to the seat track of system racks and has no power/data interfaces.

NOTE:

Accommodation of trash management baskets on P/L racks is under P/L design integrator responsibility.

5.8.13.7 SSMB IVA-Special Tools

5.8.13.7.1

The SSMB IVA special tools are battery-powered or use the power outlet at the Standard Utility Panels, if applicable, and have no mechanical interfaces to the APM.

5.8.14 Portable Breathing Apparatus (PBA)

5.8.14.1 General

NOTES:

- The PBA flight models are not provided by the APM program.
- It is assumed that the PBAs withstand the specified Kick-Loads.

5.8.14.1.1

The APM shall allow for on-orbit installation of two station common Portable Breathing Apparatus as shown in Figure 5.8.12-1.

5.8.14.1.2

The APM shall accommodate the Portable Breathing Apparatus static envelope as per Figure 5.8.14-1.

5.8.14.1.3

Each PBA shall be located within ≤ 1 m distance to one of the two Portable Fire Extinguishers.

5.8.14.1.4

The APM shall accommodate the Portable Breathing Apparatus mass (filled) of ≤ 8 kg.

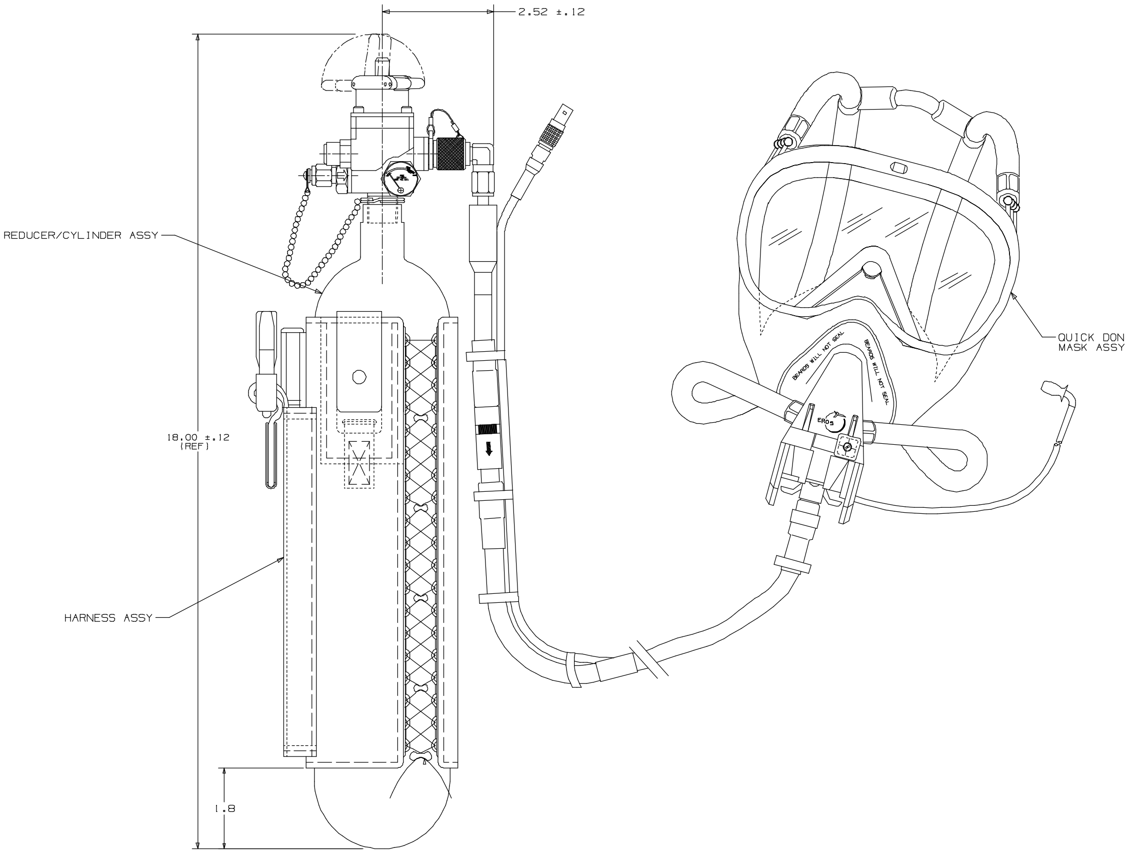


Figure 5.8.14-1 Portable Breathing Apparatus Envelope

5.8.14.2 Structure-Mechanical Interface

5.8.14.2.1 Mounting Provisions

The APM shall be compatible with the attachment requirements compliant with the common PBA design.

5.8.14.2.2 Environments

5.8.14.2.2.1 Mechanical Environment

The APM shall provide at the APM to PBA Interface the launch and on-orbit mechanical environment as specified in applicable document 2.1.1.5, "Environment and Test Specification", para. 4.2.

5.8.14.2.2.2 Thermal Environment

The APM shall provide to the PBA the environment defined in applicable document 2.1.1.5, "Environment and Test Specification", chapter 5.

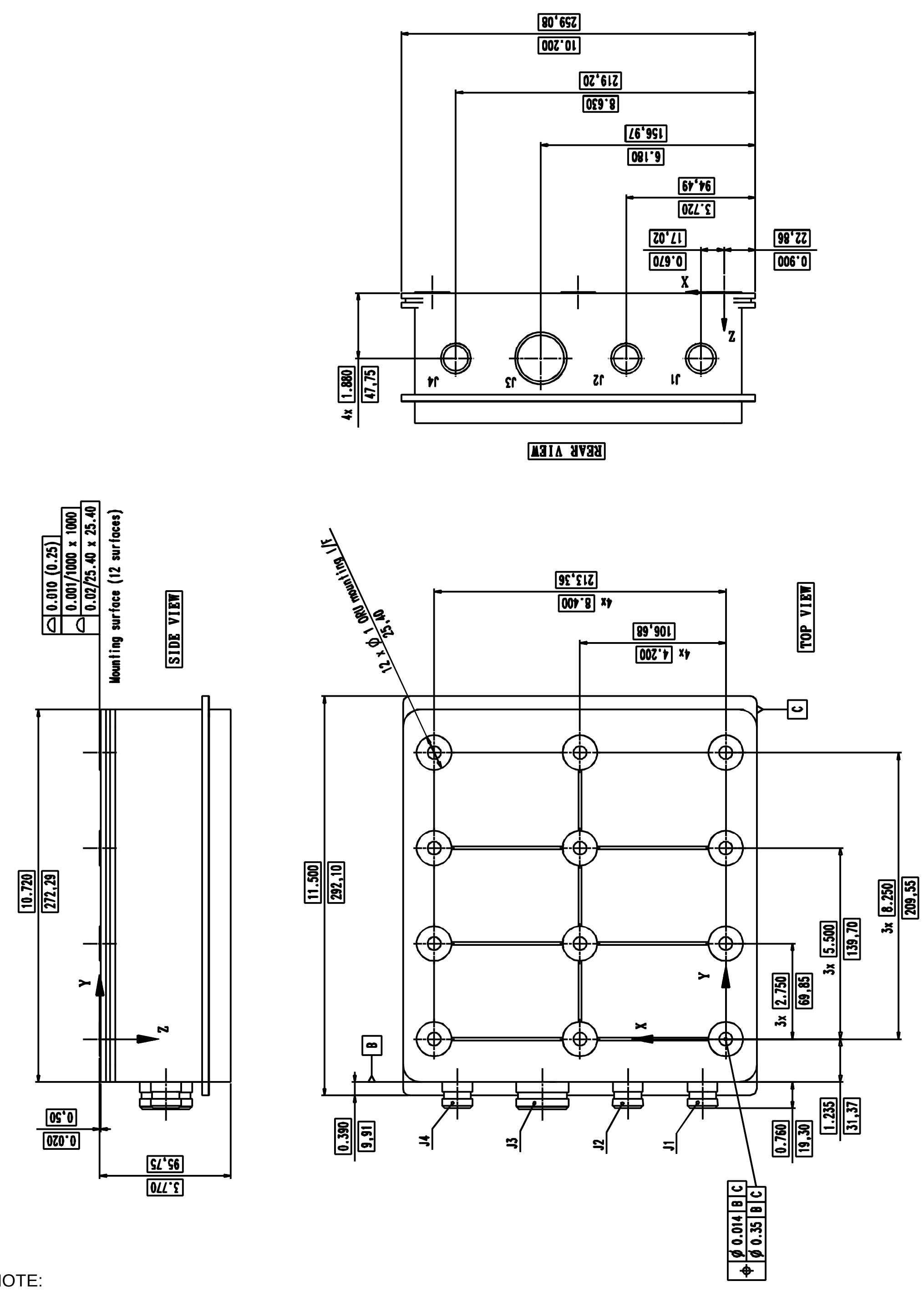
5.8.15 Payload Ethernet Hub/Gateway (PEHG)

5.8.15.1 General

The APM shall accommodate one PEHG (Station Common).

5.8.15.1.1

The PEHG shall be accommodated with the static dimensions as shown in Figure 5.8.15-1.



NOTE:

1) PRINCIPLE SHOWN ONLY, FOR DETAILS SEE SSP 42001, APM/SSMB ICD

Figure 5.8.15-1 PEHG Envelope

5.8.15.2 Environments

5.8.15.2.1 Mechanical Environment

The APM shall ensure a mechanical environment to the PEHG as specified in applicable document 2.1.1.5, "Environment and Test Specification, para. 4.2.

5.8.15.2.2 Microgravity/Audible Noise/Human Vibration

The APM shall accommodate the micro-g noise and vibration contribution of the PEHG not exceeding the values as defined in para. 6.2.3.7 and 6.2.3.8.

5.8.15.2.3 Thermal Environment

The APM shall provide to the PEHG the environment defined in applicable document 2.1.1.5, "Environment and Test Specification", chapter 5.

5.8.15.3 Thermal/Environmental Interfaces

5.8.15.3.1 Unit Thermal Control

The APM shall accommodate the PEHG designed for radiation cooling method as defined in applicable document 2.1.1.7, "Mechanical/Thermal Design Specification", section 4.2.5 and subparagraphs.

NOTE:

The specified method is applicable to APM Nominal Mode.

5.8.15.4 Electrical Interfaces

5.8.15.4.1

The APM shall provide to the PEHG 120 VDC power as specified in applicable document 2.1.1.3.

5.8.15.4.2

The APM shall accommodate the PEHG with a maximum power supply of 29 W.

5.8.16 Flight Releasable Attachment Mechanism (FRAM)

5.8.16.1 General

The APM shall accommodate at each of the four External Payload Locations of the EPF a passive FRAM.

NOTES:

- The FRAM is a fully passive item for mechanical accommodation of external Payloads comprising a station common active FRAM (brackets and connectors).
- It is assumed that the overall integrity of the FRAM complement is ensured, i.e. not under APM design responsibility.

5.8.16.1.1

The FRAM shall be accommodated with the static dimensions as shown in Figure 5.8.16-1.

5.8.16.2 Environments

5.8.16.2.1 Mechanical Environment

The APM shall ensure a mechanical environment to the FRAM as specified in applicable document 2.1.1.5, "Environment and Test Specification, para. 4.2.

5.8.16.2.2 Microgravity/Audible Noise/Human Vibration

The APM shall assume that the FRAM does not provide any micro-g and vibration disturbances.

5.8.16.2.3 Thermal Environment

The APM shall provide to the FRAM the environment defined in applicable document 2.1.1.5, "Environment and Test Specification", chapter 5.

5.8.16.3 Thermal/Environmental Interfaces

5.8.16.3.1

When the payload is attached to the EPF, the thermal interface design shall consider a zero net heat flux in both directions between APM/EPF and payload in order not to rely on uncontrolled parasitic heat fluxes.

5.8.16.3.2

The APM design shall ensure that the common FRAM items accommodated on the EPF support structures will be maintained within the range of -120 °C/+120 °C in an unberthed condition (without external payload).

5.8.16.4 Harness Interfaces

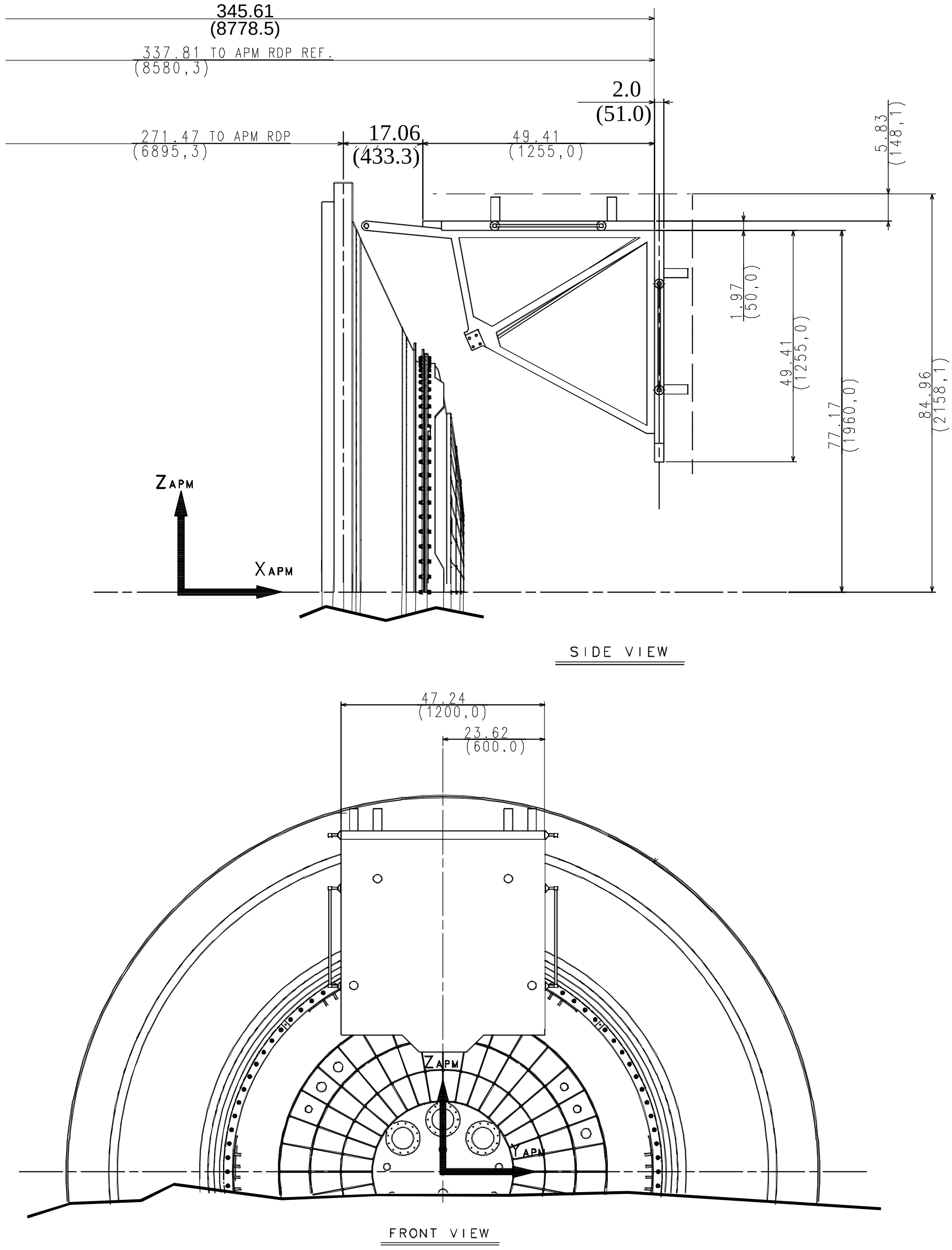
5.8.16.4.1

The APM shall provide to the FRAM two 120 VDC power feeders (AWG8) on separate connectors.

5.8.16.4.2

The APM shall provide to FRAM signal lines with nominal and redundant channels on separate connectors.

NOTE. It is assumed that the FRAM provides the above connectors.



Note: Principle shown only

Figure 5.8.16-1 FRAM Envelope

5.8.17 Passive Trunnion Attachment Mechanism.

5.8.17.1

The APM shall accommodate 3 Passive Trunnion Attachment provisions at the following locations:

- AFT Board and STB
- Forward STB

5.8.17.2

The AFT locations shall allow for on-orbit accommodation by EVA of external Payloads equipped with the complementary Active Trunnion Attachment Mechanism.

5.8.17.3

The FWD location shall allow for on-orbit accommodation by EVA of the Columbus Terminal equipped with the complementary Active Trunnion Attachment Mechanism.

5.9 APM System/GSE to Transport Facility Interfaces

5.9.1 General

5.9.1.1

The APM flight configuration (excluding the initial P/L) in its transport container and the empty transport container shall be compatible with the following transport facilities:

- road transporter (European)
- air transport.

5.9.1.2

The APM flight configuration including the integrated initial payload with the APM transport container shall be compatible with the following transport facilities:

- road transporter (European and US American)
- air transport.

5.9.2 Road Transporter Interfaces

5.9.2.1

The APM flight configuration together with the MGSE shall be designed to be compatible with road transporters for:

- European roads
- US American roads.

5.9.2.2

The overall dimensions of the container/road transporter, which shall be optimized for air transport, shall be such that they do not exceed the restrictions for European roads.

5.9.2.3

The interfaces between transport container and road transporter shall be designed such that the dynamic accelerations on the APM flight configuration structures and all items inside the APM are less than the launch/flight values.

5.9.2.4

The transport container shall ensure the APM flight configuration and all items inside stay within their storage temperature limits for a road transport of

- max. 20 hours
- environment air temperatures -10 to +40 °C.

5.9.3 Aircraft Interfaces

5.9.3.1 Deleted

5.9.3.2

The Transport Container shall mechanically interface with the selected aircraft supplied support structure without receiving any other resources.

5.9.3.3 Container Complement

5.9.3.3.1

The APM flight configuration/transport container complement[1] shall be compatible with the selected aircraft environmental conditions.

5.9.3.3.2

The APM flight configuration/transport container complement[1] shall ensure that all environments to the flight configuration structure and all items inside the APM are less stringent than the ground/orbital flight environment requirements.

5.9.3.4

The APM flight configuration/transport container complement[1] design shall allow for up to 12 hours flight environment.

5.9.3.5 Deleted

1 Note: Complement is a set of equipment/accessories used with the transport container during transport.

5.10 APM Equipment to Logistics Carriers

The following requirements are complementary to the CSRD, para. 11.3.

5.10.1 APM Equipment to Pressurized Logistics Carrier

5.10.1.1

The APM ORUs and materials to be resupplied/returned shall be compatible with the Pressurized Logistics Carrier (PLC) environment without receiving any resources.

5.10.1.2 (Intentionally left blank)

5.10.1.3

The APM ORUs shall be either directly or with interfacing APM ASE compatible with the Logistics Carrier attachment system.

NOTE:

It is assumed that the Logistics Carrier racks/attachment system does not need mechanisms on the APM ASE for accommodation of APM ORUs.

5.10.2 APM Equipment to Unpressurized Logistics Carrier

NOTE:

It is not foreseen to transport APM equipment with Unpressurized Logistics Carriers

5.11 APM to External Payload Interfaces

5.11.1 General

5.11.1.1

The APM design shall provide the following payload interfaces for usage by the payload equipped with active FRAM at four payload locations as shown in Table 5.11.1.1-1.

Interfaces	Locations
Power	Overhead X, Overhead Z, Deck X, Deck-Z
Data	ditto
Mechanical	ditto

NOTE: No thermal resources are provided.

Table 5.11.1.1-1 Ex. Interface Resources to P/L Usage

5.11.1.2 Deleted

5.11.1.3

The APM design shall consider a payload envelope as shown in Figure 5.11.1.3-1 for each external payload location.

5.11.1.4

The APM shall provide all interfaces (H-fixture/Optical target) to support handling of payloads by means of the SSRMS/SPDM for all EPF payload locations.

5.11.1.5

The APM shall provide all interfaces to support EVA activities for handling of payloads and contigency operations for all EPF payload locations.

5.11.1.6

Each external payload shall receive ist resources via the FRAM connector interfaces.

5.11.1.7

Two external P/Ls shall be oriented to APM x-direction, one external P/L shall be viwed to APM + z - and one to APM -z-direction, as shown in Figure 6.3.1.1-7.

5.11.1.8

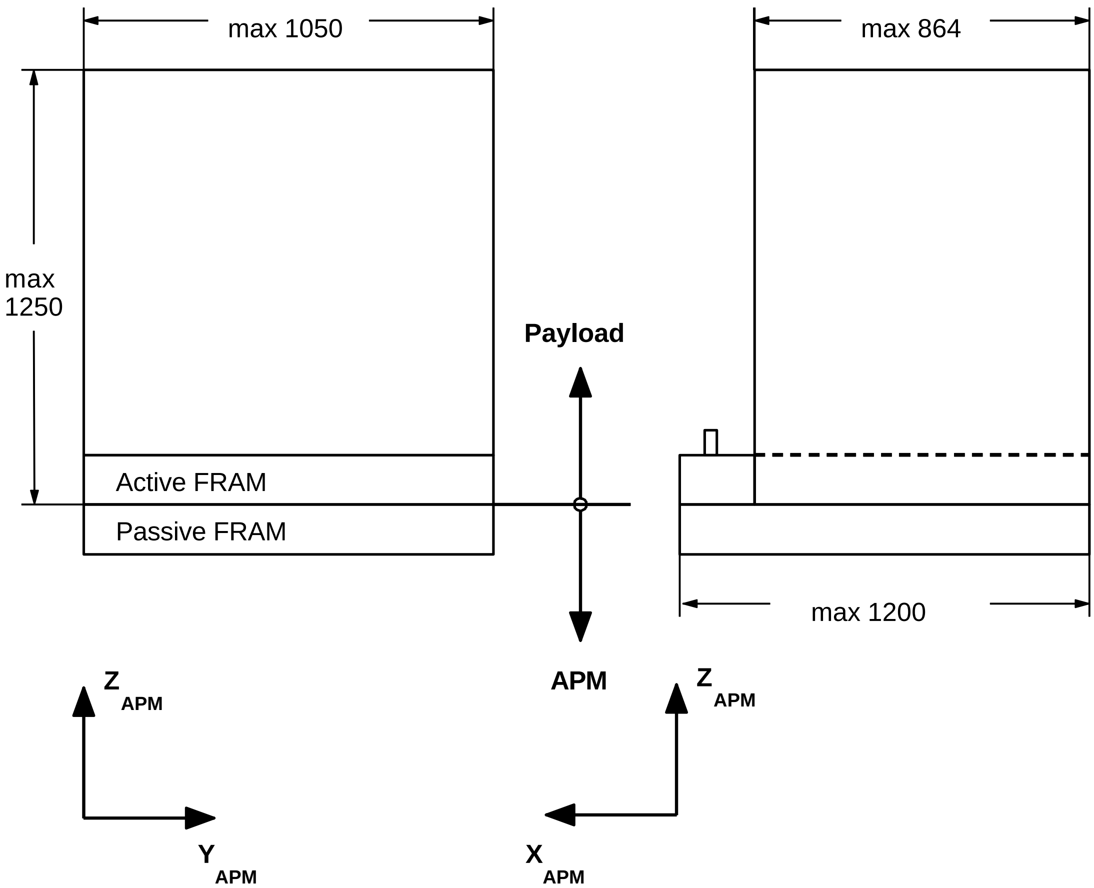
The APM shall provide two parking positions for on-orbit accommodation of P/L's at the forward and aft trunnions (in-y-direction) by EVA.

NOTES: Connectors with tethered caps and dummy connetors on the bracket are not foreseen.

5.11.1.9

The APM shall provide a bracket on the Stb cone (aft side) to connect interface cabling from there to the P/L's on the parking position by EVA.

NOTES: Connectors with tethered caps and dummy connectors on the bracket are not foreseen.



Note: The given dimensions are to be taken as limit envelopes. They are further detailed and controlled by SSP 42001.

The shown coordinate system is given for position OZ, see Figure 6.1.7.2

Figure 5.11.1.3-1 External Payload Envelope

5.11.2 Structural Interfaces

5.11.2.1

The APM structural interface shall consist of the ISS common passive FRAM bracketry being able to accommodate at each location on-orbit a maximum external P/L ORU mass 370 kg (incl. CEPA).

5.11.2.2 (Intentionally left blank)

5.11.2.3

The APM structural interface at the parking positions shall be implemented by a passive EUTAS mechanism or equivalent on the two related trunnions as shown in Fig. 6.1.2-1

5.11.3 Mechanical Interfaces

5.11.3.1

Each External Payload shall receive its resources via the FRAM connector interfaces.

5.11.4 Environmental Interfaces

5.11.4.1

The APM system design shall ensure the environment suitable to accommodate External Payloads as defined in para. 4.1.5 of this specification.

5.11.4.2

The PM design shall ensure that the common FRAM items accommodated at the EPF support structures will be maintained within the range of -120° / +120°C in an unberthed condition (without external payload)

5.11.4.3

When the payload is attached to the EPF, the thermal system design shall consider a zero net heat flux in both directions between APM/EPF and payload in order not to rely on uncontrolled parasitic heat fluxes.

5.11.4.4

The APM design shall ensure that the EUTAS items accommodated on the trunnions wil be maintained within the range of -120° / + 120°C in an unberthed conditions (without external payload)

5.11.4.5

When the payload is attached to the parking position (s) the thermal interface design shall consider a zero net heat flux in both directions between APM and payload in order not to rely on uncontrolled parasitic heat fluxes.

5.11.5 System Interfaces

Each external Payload location shall receive its resources interfacing with the following functional APM systems, which are specified in detail in para. 6 of this specification:

- Electrical Power System 6.2.1.2.2
- Data Management System 6.2.1.2.4
- Communications 6.2.1.2.6

5.11.5.1 Electrical Power System

5.11.5.1.1

The Electrical Power System shall provide Main Power interfaces delivering 1.25 kW maximum each, with a trip time of ≥ 1.5 msec.

5.11.5.1.2 (Intentionally left blank)

5.11.5.1.3

The feeder to each external payload location shall be individually protected and configurable, as described in section 6.2.1.2.2.3.9.

5.11.5.1.4

The power interface to the external Payload complement shall be monitored for

- voltage
- ON/OFF status
- current.

NOTE:

The voltage and current are measured centrally in the PDU supplying a dedicated ISPR together with the External Payload, thus ensuring an overall power measurement accuracy of ± 5 % full scale.

5.11.5.1.5 (Intentionally left blank)

5.11.5.1.6

All harness connections to the External Payload shall be mateable/de-mateable on orbit by the P/L to EPF berthing process.

5.11.5.1.7

The Electrial Power System shall provide two Main Power interfaces delivering 1.25 kw maximum each at the External Parking Position bracket.

NOTES:

These feeders are branched-off from standard EPF power interfaces specified in para 5.11.5.1.1 above i.e. the sum of two feeders must stay within the 1.25 kw limit.

5.11.5.2 Data Management System (DMS)

5.11.5.2.1 Vital DMS Interfaces

N/A

5.11.5.2.2 Fire Detection System Interfaces

N/A

5.11.5.2.3 (Intentionally left blank)

5.11.5.2.4 Payload Bus Interfaces

5.11.5.2.4.1

The APM shall route either the APM P/L Bus or the US P/L bus (stubs) to the four External Payload locations, manually configurable as described in para. 6.2.1.2.4.1.15.

5.11.5.2.4.2

The Payload local bus shall allow for an extension within each of the four External Payloads by up to 1 m with a 75 ± 5 Ohm twisted-shielded cable.

5.11.5.2.4.3

The APM Payload bus shall provide the following functions for each of the four External payloads:

- Data transfer to/from Payload Control Unit (for processing therein or up-/down-link transfer)
- Data transfer to/from APM system management layer
- Time

5.11.5.2.5 LAN Interfaces

The APM shall route either the APM LAN or the US LAN (output from APM Hub or PEHG) to the four external Payload locations, manually configurable as described in para. 6.2.1.2.4.1.15.

5.11.5.3 Thermal Control System

N/A

5.11.5.4 Communications System

5.11.5.4.1

The APM shall provide electrical high-rate data interfaces from each External P/L location to the communication system for down-linking.

5.11.5.4.2 (Intentionally left blank)

5.11.5.4.3 (Intentionally left blank)

5.11.5.4.4

The high-rate data transfer shall be in accordance with the Transparent Asynchronous Transmitter/ Receiver Interface (TAXI) protocol.

5.11.5.5 Environmental and Life Support System

N/A

5.11.5.5.1 Payload Heat Leak

N/A

5.11.5.5.2 Nitrogen

N/A

5.11.5.5.3 (Intentionally left blank)

5.11.5.5.4 Venting

N/A

5.11.5.5.5 Vacuum

NA/

5.11.6 Flight SW Interfaces

5.11.6.1

The flight S/W interfaces on external Payload level are covered by the requirements on system level, which are specified in para. 5.7.8.5.

5.11.7 External Payload Bonding

5.11.7.1

The APM shall provide a bonding interface at each EPF P/L location. The bonding path is provided at each location via the FRAM mechanical interface.

5.12 APM to Space Station RMS (SSRMS) Interfaces

The APM design shall be compatible with the SSRMS by accommodation of a Power Data Grapple Fixture.

5.12.1 General

5.12.1.1

The APM shall provide one Power Data Grapple Fixture (PDGF) for interfacing with the station RMS for:

- berthing of the APM to the core station
- supply of power to APM heater system

5.12.1.2

The location of the APM Power Data Grapple Fixture shall be in accordance with Figure 5.12.1-1.

5.12.1.3

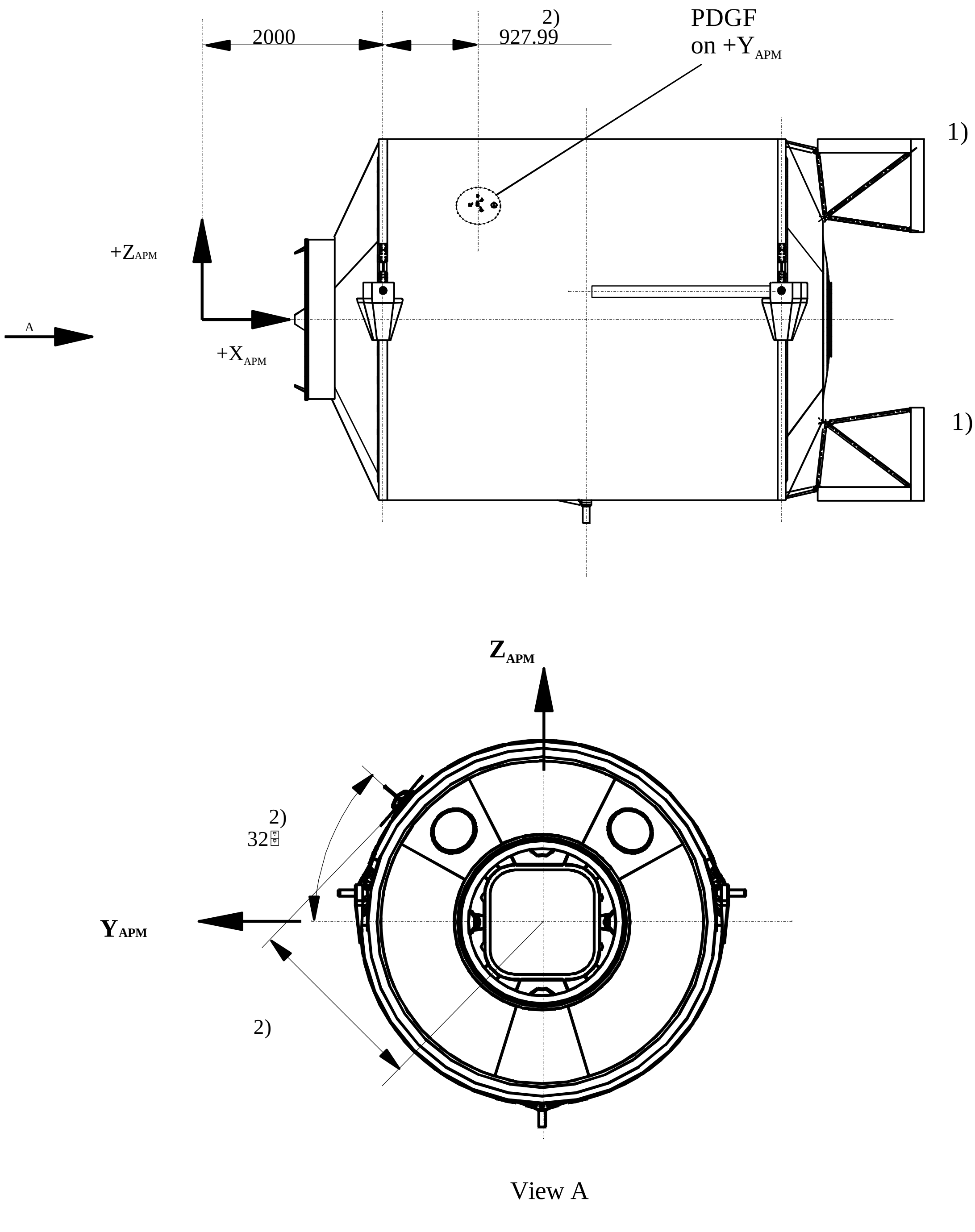
The APM design shall fulfill the functional/performance requirements related to the Unberthed Phase by receiving only electrical power from the Station SSRMS via the PDGF.

5.12.1.4

The APM shall provide stay-out zones for the berthing target located on the ISS common hatch according to applicable document 2.1.1.25.

NOTES:

- The installation of the targets to the APM is under NASA responsibility (incl. qualification of mechanical integrity during launch and during the on-orbit lifetime).



NOTE:
1) Shown without payload at all possible four locations as valid for launch, berthing
2) The actual location is controlled by the NSTS/APM ICD

FIGURE 5.12.1-1: APM GRAPPLE FIXTURE / SSRMS INTERFACES

Figure 5.12.1-1 APM Grapple Fixture / SSRMS Interfaces

5.12.2 Structural/Mechanical Interfaces

5.12.2.1

The PDGF and the APM shall withstand the limit loads acting at this interface.

5.12.2.2

The APM shall provide the stiffness at the PDGF-to-module interface that maintains a minimum fundamental structural frequency while constrained only at the APM-to-PDGF interface.

NOTES:

- The racks shall be fixed at the launch interfaces, i.e. upper part with braces and lower rear part to the shell.
- The APM mass for berthing and de-berthing as defined in para. 5.3.1.2 is to be ensured by Design Integration Responsible.

5.12.2.3 (Deleted)

5.12.3 Environmental Interfaces

No specific environmental interface requirements to be fulfilled during berthing/de-berthing phase in addition to the CSRD.

5.12.4 System Interfaces

5.12.4.1 Electrical Power System

5.12.4.1.1

The APM shall receive power from the SSMB for heaters by two independent feeders.

NOTE:

It is assumed that the feeder currents are measured by the SSMB to allow for heater operation monitoring.

5.12.4.1.2

The APM design shall be compatible with the power quality/voltage as delivered by the SSRMS.

NOTE: The interface planes for the specified voltages are:
- at PDGF/SSRMS interface.

5.12.4.2 Data Management System

No interface existing.

5.12.4.3 Thermal Control System

5.12.4.3.1

The Thermal Control System needed for APM thermal conditioning shall rely solely on electrical power supplied directly from the SSRMS/PDGF power interface in the unberthed survival mode.

5.12.4.3.2

Temperature control shall be performed by the APM Heater Control Unit in a fully automatic mode.

5.12.4.4 Communications

No interface existing.

5.12.4.5 Environmental Control and Life Support System

No interface existing.

5.12.5 Flight Software Interfaces

No interface existing.

5.13 (Intentionally Left blank)

5.14 APM Harness Interfaces

5.14.1

The APM shall provide an interface bracket inside in the STB cone to connect P/L Laptops for interfacing with the P/L's on the EPF Locations.

5.14.2

The harness shall allow RS422 communication by providing a twisted-shielded pair to each of the four EPF locations.

5.15 Radio Amateur Antennae Accommodation

5.15.1 General

The APM shall accommodate 2 L/S-Band antennae and 2 VHF antennae according to the interface requirements of this chapter.

5.15.1.1

The APM shall accommodate the 2 x 2 antennae as defined in Table 5.15.1-1

ACRONYM	FULL NAME	LOCATION	FIGURE
L/SBA	L/S Band Antenna	Outside	5.15-1
VHFA	VHF Antenna	Outside	5.15-1

Table 5.15.1-1 Radio Amateur Antennae Location

5.15.1.2

The APM shall be compatible with the Radio Amateur Antennae static envelope as identified in the Figure of Table 5.15.1-2

EQUIPMENT	FIGURE
L/S-Band Antenna	5.15-2
VHF Antenna	5.15-2

Table 5.15.1-2 Radio Amateur Antennae Envelopes

NOTES

1) The figures is showing design principles of the antennae which shall be used for the configurational accommodation

2) The shown attachment hole pattern is only for reference.

3) Each one antennae of each type is to be accommodate on a different MDPS panel as it is cut-off in case of MDPS panel removal

4) The harness is part of the antennae (pigtail) up to the feedthrough connector on port cone.

5.15.1.3

The APM shall accommodate in the system configuration the Radio Amateur Antennae using the local coordinate system as shown in Figure 6.1.2-1

5.15.1.4

The APM harness shall interface with the Radio Amateur Antennae pigtail connectors at the one feedthrough connector, which shall be inside accessible so that later-on harness to/from Amateur transceivers can be connected on-orbit.

NOTES

- Connectors are standard connectors i.e. no EVA-type connectors
- In case the related MDPS panel has to be removed the harness to the antennae will be cut i.e. no antenna replacement on-orbit is required

Figure 5.15-1 Intentionally left blank

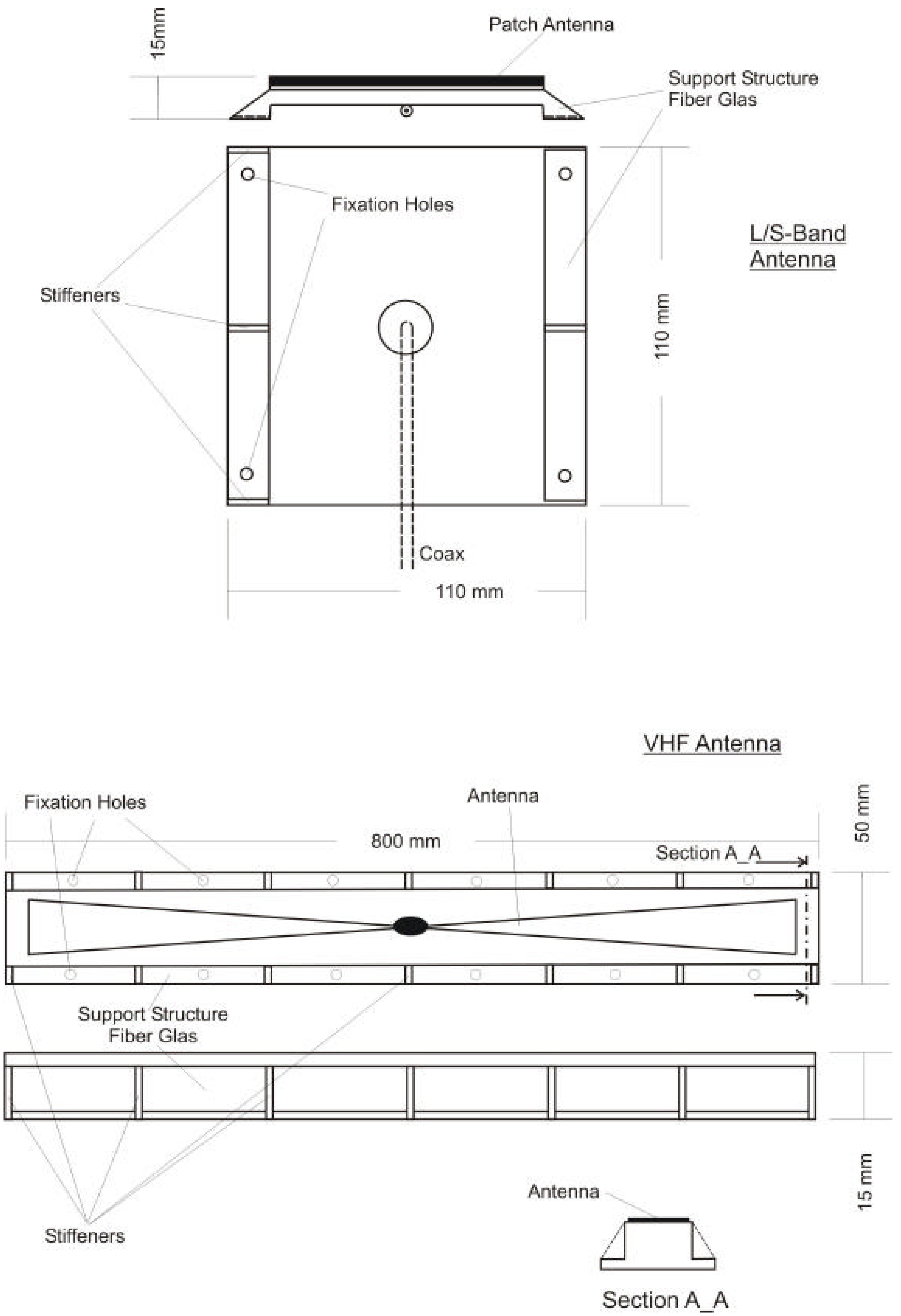


Figure 5.15-2 Radio Amateur Antennae Envelopes

5.15.1.5 Radio Amateur Antennae Mass

The APM shall accommodate the antennae masses as per Table 5.15.1-3

EQUIPMENT	MAX. MASS1)	QUANTITY
US-Band Antenna	0,8[2)]	2
VHF Antenna	0,5[2)]	2

Note [1)]The attachment hardware is to be provided by APM
[2)]incl. harness pigtail

Tabele 5.15.1-3 Radio Amateur Antennae Mass

5.15.2 Structure Mechanical Interface

5.15.2.1 Mounting Provisions

5.15.2.1.1

The APM shall be compatible with the Equipment Attachment requirements defined in applicable document 2.1.1.7, "Mechanical/Thermal Design Specification", para. 3.2.3.1, para. 3.2.3.5 and para 3.2.4.5.

5.15.2.2 Environments

5.15.2.2.1

The APM shall ensure a mechanical environment to the Radio Amateur Antennae as specified in applicable document 2.1.1.5, "Environment and Test Specification", para 4.2

Note: Qualification of antennae versus these requirements is under Agency responsibility.

5.15.2.2.2 Microgravity/Audible Noise / Human Vibration

N/A

6. IMPLEMENTATION REQUIREMENTS

The implementation requirements to the APM system are defined in the following sequence:

- APM System Configurations para. 6.1
- APM Flight Configuration Functions/Allocations para. 6.2

6.1 APM System Configurations

6.1.1 General

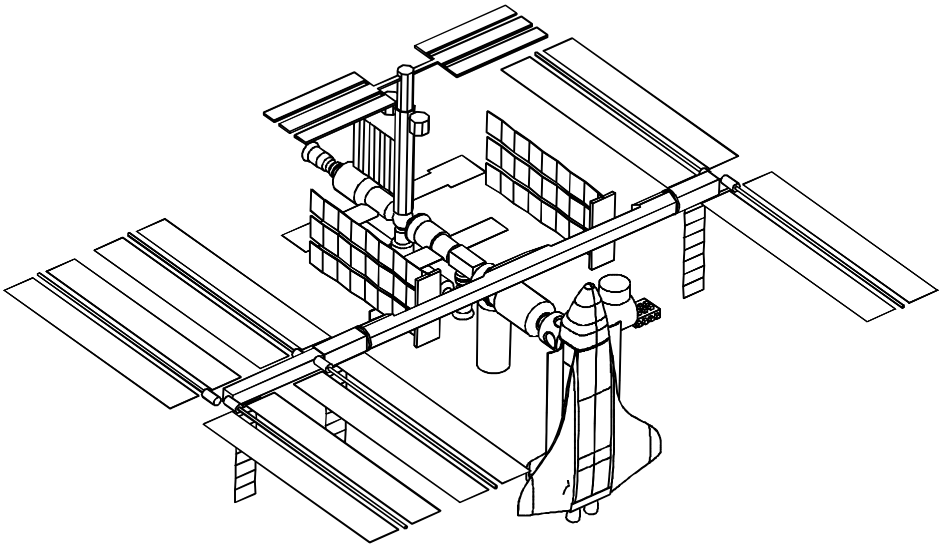
6.1.1.1

The APM System Configurations shall be compatible with the requirements and constraints of the on-orbit scenario and all mission phases and all proceeding ground phases starting with acceptance at the APM integration site.

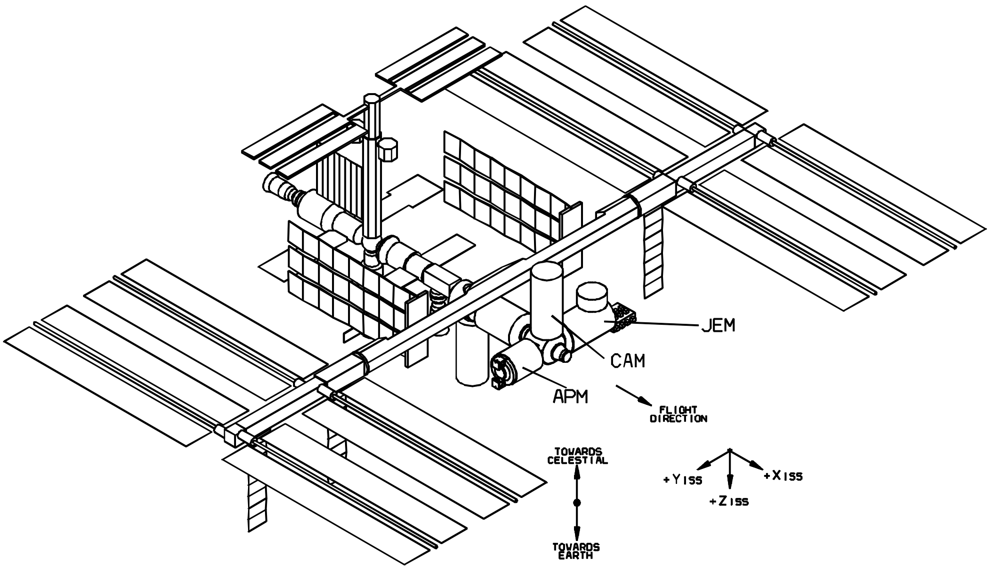
6.1.1.2 (Intentionally left blank)

6.1.1.3

The APM flight configuration (including initial Payload) shall allow for berthing to node 2 of the core station as visualized in Figure 6.1.1-1.



a) After Shuttle/Orbiter berthing to Core Station



b) APM Final Position at Core Station

Figure 6.1.1-1 On-Orbit Scenario

6.1.1.4 (Intentionally left blank)

6.1.1.5

The servicing configuration shall be the same as the overall APM operational configuration with all ORUs and consumables transported to/from ground via the SSMB logistics system which is based on NSTS.

6.1.1.6 (Intentionally left blank)

6.1.1.7

The APM system design shall allow APM internal and external on-orbit system and payload reconfiguration and operation by:

- replacement of complete P/L racks as an ORU (ISPR)
- installation/removal of center aisle P/L items
- installation/removal of complete External P/L at each EPF location and parking position
- installation/removal of Columbus Terminal

NOTES:

- The above requirements are only qualified in a generic way and not in relation to the initial P/L, as all related ISPR/Payload hardware is not under APM responsibility.
- There are no APM items hindering full accessibility to ISPR front faces.

6.1.1.8 (Intentionally left blank)

6.1.1.9 Mission Phases

DEFINITIONS:

Mission phases correspond to periods of time for which a defined set of APM flight configuration system functions is required.

Global mission phases such as "Initialization" have to be subdivided into specific mission/subphases characterized by different system functions required or in order to react due to unplanned events/ situations (e.g. power loss).

The definition of these mission phases (global and subphases) is given in Table 6.1.1-1.

Changes between mission phases are indicated by changes of the set of required system functions.

Ground Proc.		Acceptance at the AIT site	Initial P/L integration. Transport of the APM to launch site and processing until lift-off
Launch/ Ascent	Passive	NSTS Shuttle lift-off	Transport of APM by NSTS Shuttle to the ISS Heating from Orbiter APCU
Initialization	Unberthed Survival (APM grappled by SSMRS)	Grapple by SSRMS and switch-on of SSRMS power to APM	Minimum survival mode of APM by provision of power via SSMRS to APM for thermal conditioning only
	Berthed Survival[3)]	Connect utilities, availability of power for essential Command & Control functions	Survival mode of APM based on external resources from ISS
	Support	Preparation for nominal APM operations	Initial activation from survival to full system performance including crew support but excluding P/L operations
Ops under reduced Performance	Support (manned)	(Re-)preparation for nominal APM ops excluding P/L	Re-activation to full system performance excluding P/L operations
	Support (unmanned)	(Re-)preparation for nominal APM ops excluding crew and P/L	Re-activation to full system performance excluding crew and P/L operations
	Housekeeping	Setting of APM to a reduced but active mode including min. crew support, excluding P/L ops	Survival conditions for crew (max. two persons not working)
	Stand-by (unmanned) (1)	Setting of APM to a reduced but active mode excluding crew support and P/L ops	Survival conditions equipment (incl. P/L); allows quick re-activation
	Berthed Survival (2)	Switch to: - exclusively power to heater and essential Command & Control function	Degraded survival of APM and P/L based on external resources.
Routine Ops	Nominal (manned)	Start of P/L and crew ops	In orbit nominal operations with crew including maintenance and servicing
	Nominal (unmanned)	Start of P/L ops	In orbit nominal autonomous operations

Legend: * = End event identical with start event of those phase that follows.
1) Objective: Contingency repair
2) Objective: Power saving
3) Prior to the Berthed Survival Mode the APM is berthed and in Passive Mode (no heating)

Table 6.1.1-1 APM Mission Phases Definition

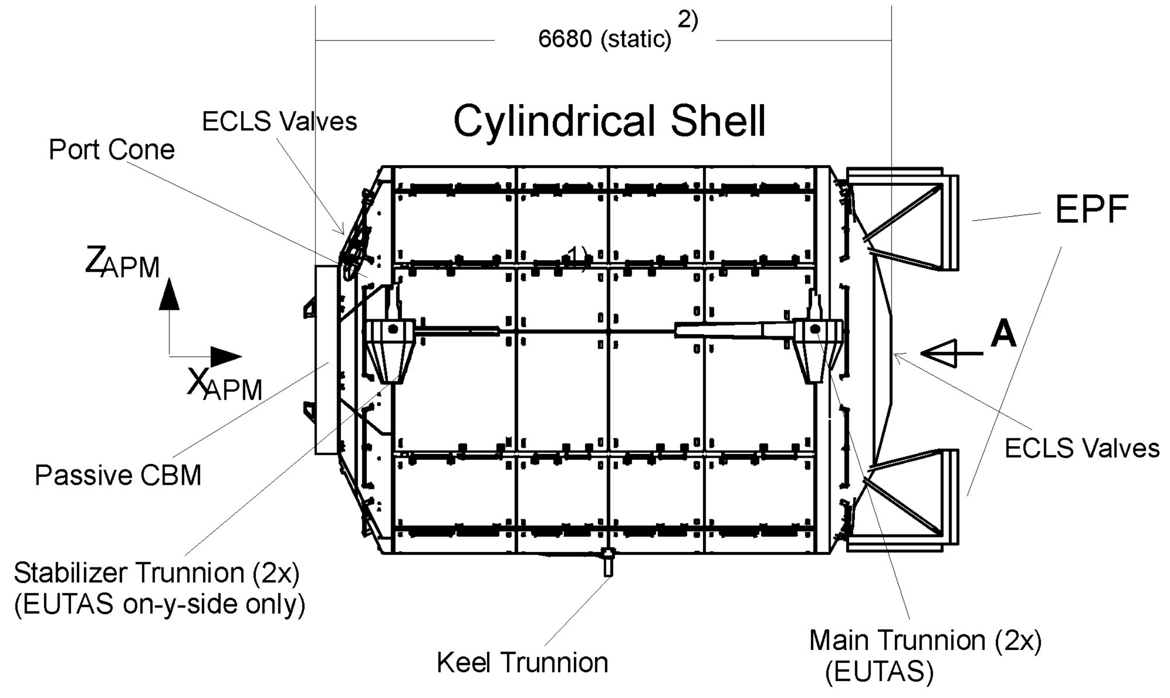
6.1.2 On-Orbit APM Configuration

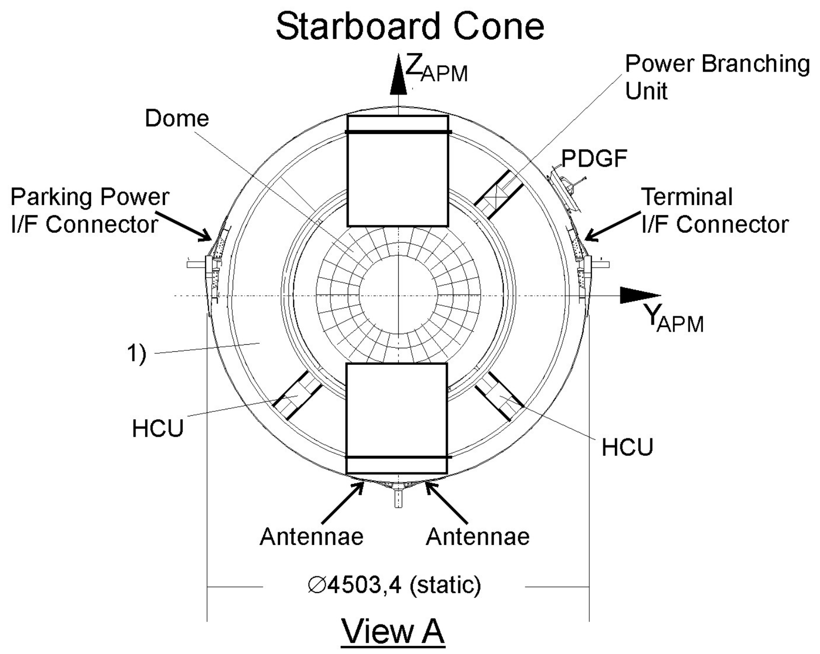
6.1.2.1 Initial

The on-orbit APM external configuration shall be in accordance with the layout and dimensions shown in Figure 6.1.2-1.

6.1.2.2 Final Configuration

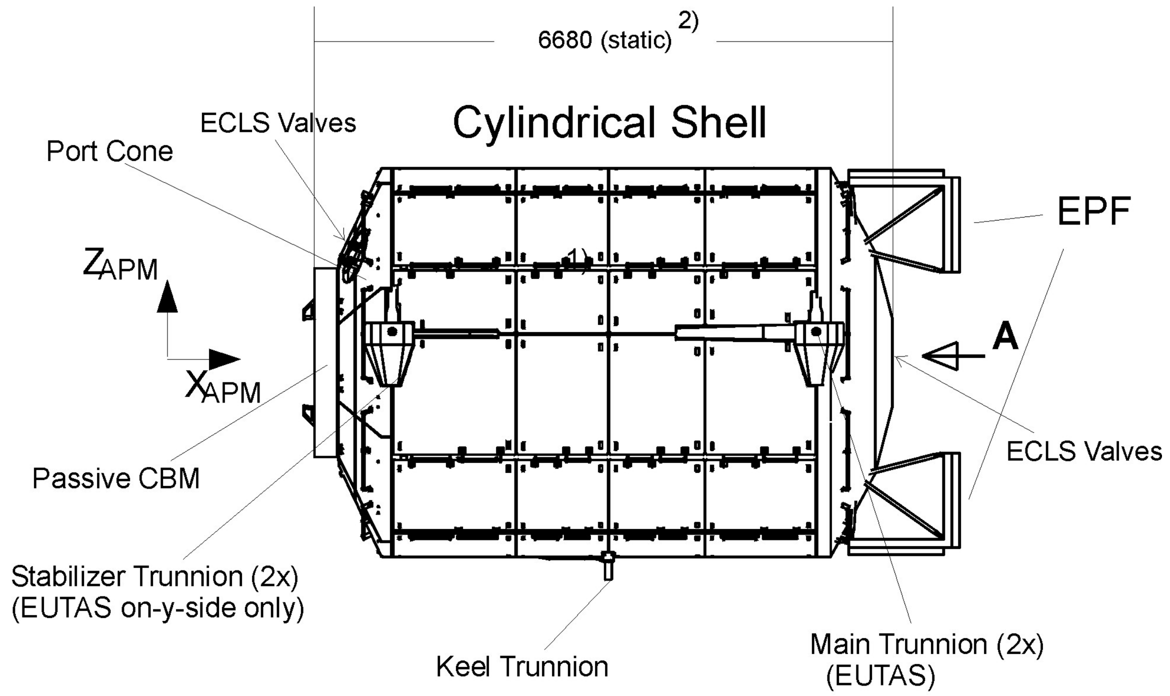
The on-orbit APM external configuration after Columbus Terminal implementation shall be in accordance with the lay-out and dimensions shown in Figure 6.1.2-2.

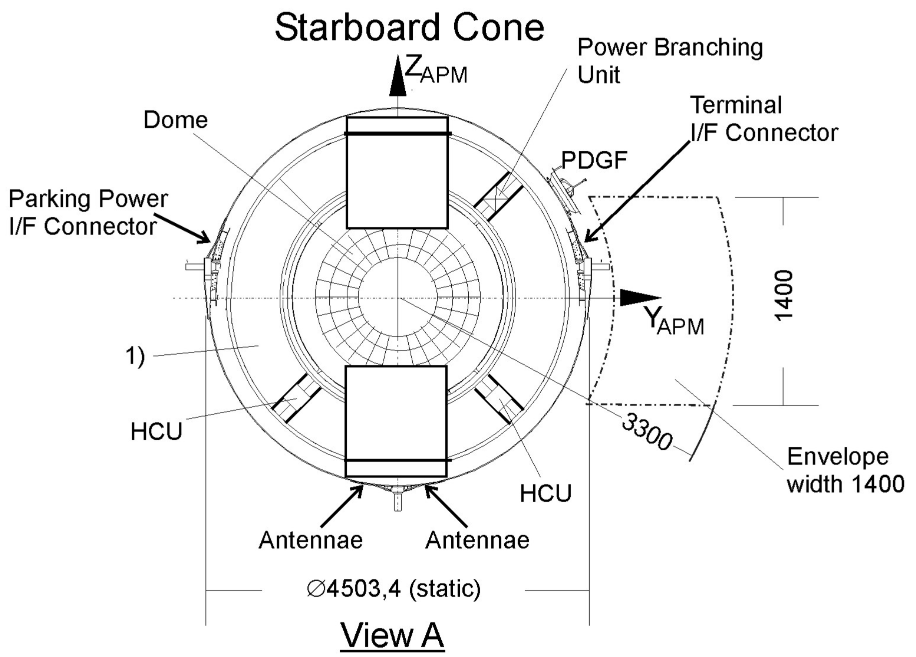




Note:
1) MDPS/MLI not shown
2) Including MDPS
Detailed dimensions agreed in SSMB/APM ICD

Figure 6.1.2-1 APM On-Orbit Configuration (Initial)





Note:
1) MDPS/MLI not shown
2) Including MDPS
Detailed dimensions agreed in SSMB/APM ICD

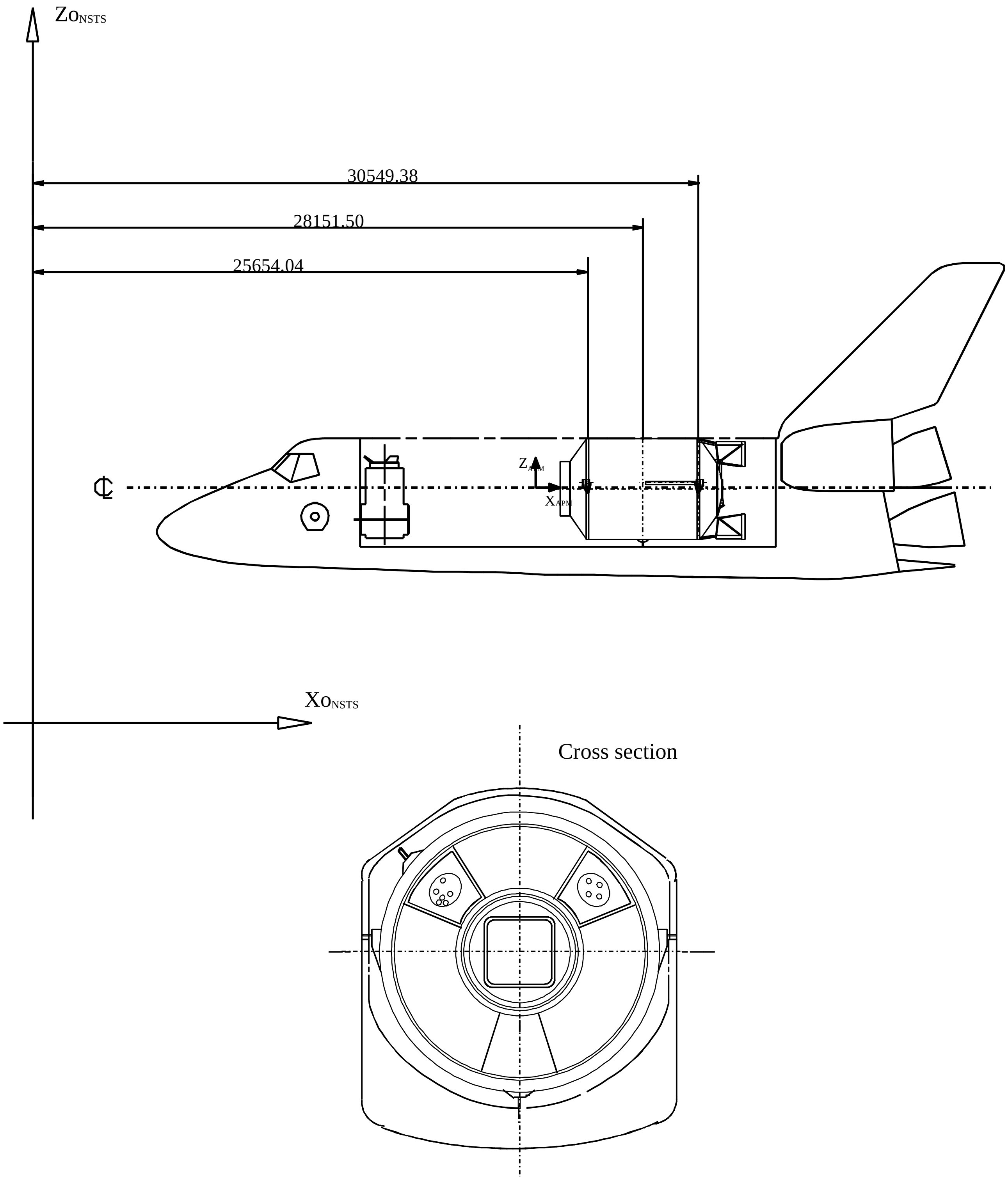
Figure 6.1.2-2 APM On-Orbit Configuration (Final)

6.1.3 APM Launch Configuration

The APM Launch Configuration shall be in accordance with the layout and dimensions shown in Figure 6.1.3-1.

NOTE:

The Launch Configuration includes the initial P/L inside the APM as well as station common equipment to be launched inside the APM as identified in Table 5.8-1.



NOTES:

- For Shuttle Coordinate Systems see NSTS-210000-IDD/ISS as made applicable in the CSRD

Figure 6.1.3-1 APM Launch Configuration

6.1.4 (Intentionally left blank)

6.1.5 APM Transport Configurations

NOTE:

The APM transport configuration from the APM integration site to the launch site includes the same P/L and system items as specified for the Launch Configuration (para. 6.1.3).

6.1.5.1

The overall APM Road Transport Configuration with the APM Transport Container shall be in accordance with the valid road traffic restrictions.

6.1.5.2

The overall APM Air Transport Configuration with the APM Transport Container shall be identical to the APM Road Transport Configuration with respect to the external layout and dimensions.

6.1.6 APM System Ground Configurations

6.1.6.1 APM Acceptance Configuration

6.1.6.1.1

The APM acceptance configuration to be built-up at the APM Integration Facility for acceptance by the customer shall be in accordance with Figure 6.1.6-1 and shall include all station common items installed at launch inside the APM.

NOTES:

- The station common items not delivered by the APM program are excluded.
- The acceptance configuration excludes any payload racks.

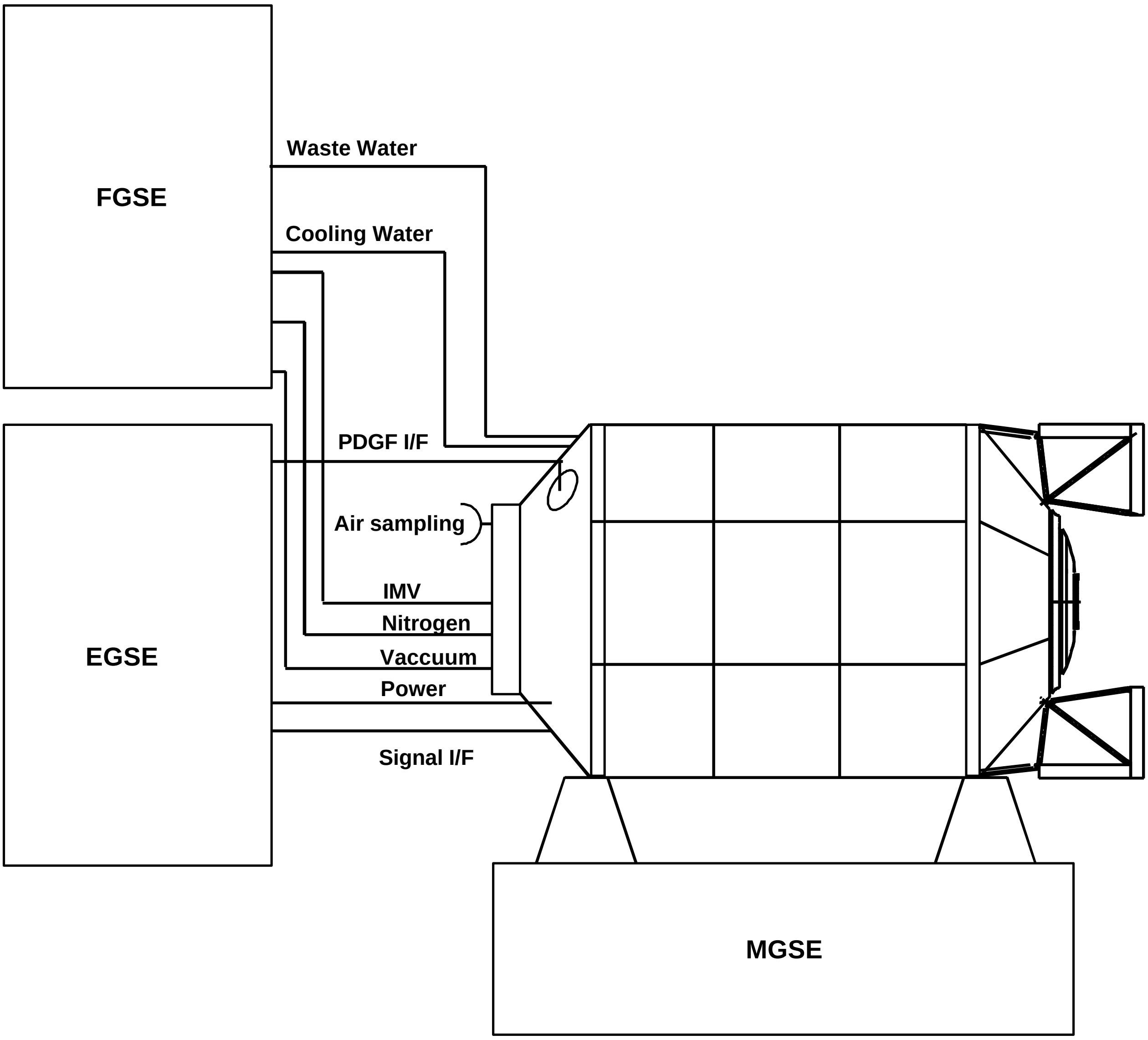


Figure 6.1.6-1 APM System Acceptance Configuration

6.1.6.1.2

The APM system acceptance configuration shall terminate all functional external interfaces by GSE to allow execution of all specified functions as necessary to demonstrate that the APM flight configuration is free of workmanship failures.

6.1.6.1.3

The APM on-board P/L and ISPR interfaces shall be terminated by P/L Simulators as necessary to demonstrate that the APM flight configuration is free of workmanship failures.

6.1.6.1.4 (Intentionally left blank)

6.1.6.1.5

The APM system acceptance configuration shall allow for initial internal Payload integration and checkout after removal of APM internal GSE.

6.1.6.2 Launch Site Configuration

6.1.6.2.1

The APM shall be compatible with the launch site MPLM compatible GSE for structural support, hoisting and access.

6.1.6.2.2

The APM system together with the GSE shall be configurable at the launch site in accordance with Figure 6.1.6-1, if necessary.

NOTES:

- The launch site configuration includes the initial payload, which was tested under Agency responsibility at the APM integration site.
- It is not foreseen to activate the APM prior to launch (ship and shoot).
- If maintenance is necessary because of damage detected at "After Transport Inspection" the checkout configuration will be established.

6.1.6.3 (Deleted)

6.1.6.4

The GSE needed for checkout and launch preparation shall be capable to operate the APM utilizing APM bulkhead external FU interfaces with the use of appropriate connector savers and equivalent tools to save the interfaces.

6.1.7 APM Flight Configuration

6.1.7.1 Reference Coordinate Systems

6.1.7.1.1 APM/ISS Reference Coordinate System

The APM/ISS Reference Coordinate System identified in Fig. 6.1.7-1 shall be used.

6.1.7.1.2

The APM/ISS coordinates shall be transformable by the equations

- $X_{APM} = Y_{ISS} + K_y$
- $Y_{APM} = X_{ISS} + K_x$
- $Z_{APM} = Z_{ISS} + k_z$

NOTES:

- The constants K_x, K_y, K_z are defined in the SSMB/APM ICD.
- All drawings used on system level for system design reviews show the APM coordinate systems.
- One drawing/matrix will show the principle/values to transform the APM coordinate system to the ISS coordinate system.
- All drawings provided for on-orbit operations will show the ISS coordinate system.

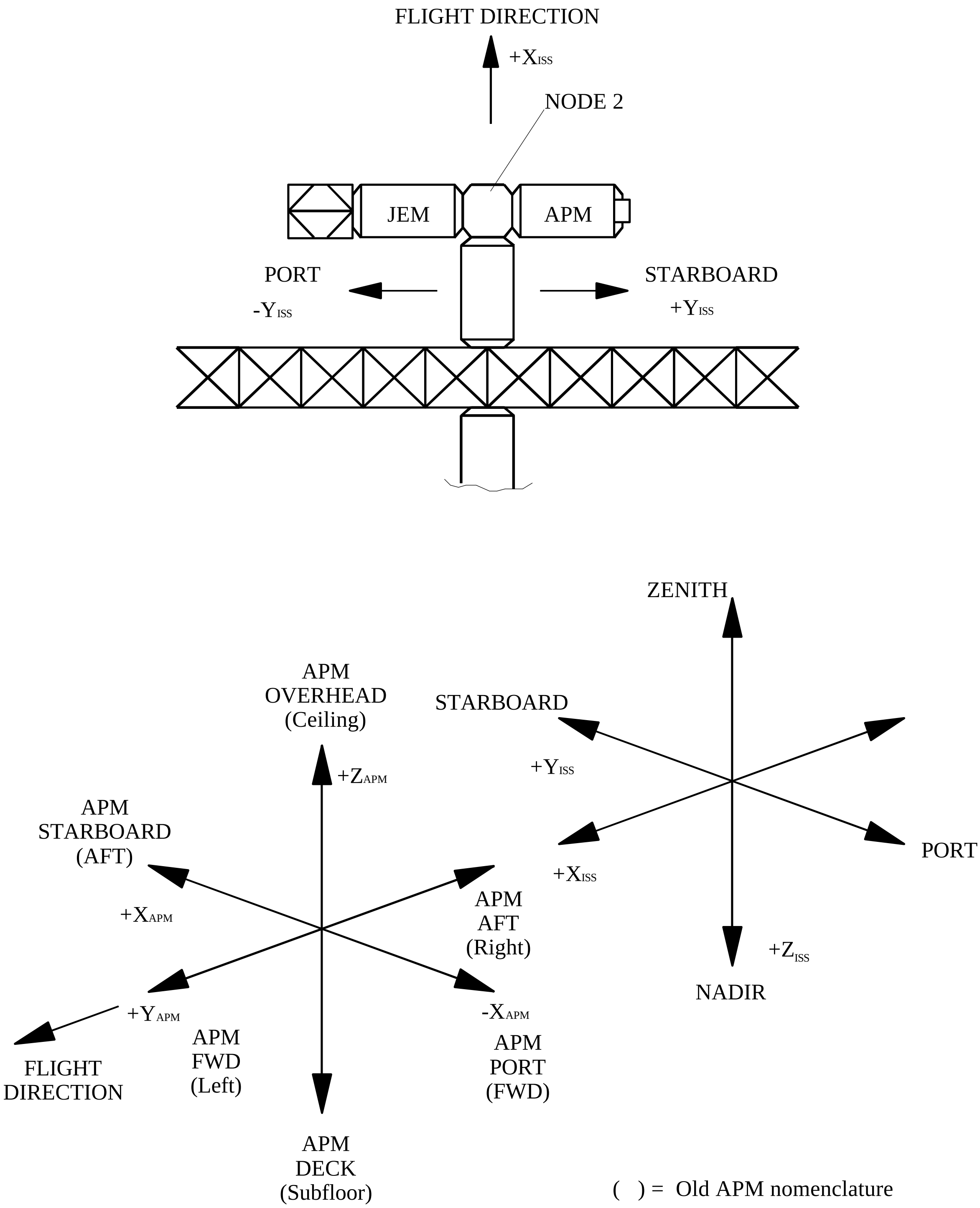


Figure 6.1.7-1 APM/ISS Reference Coordinate System

6.1.7.1.3 Coordinate References

The APM coordinates shall be referenced to axes and reference sources as identified in applicable document 2.1.6.1: APM Coordinate and Coding System.

6.1.7.1.4 (Intentionally left blank)

6.1.7.1.5 APM Location Coding

The abbreviations and nomenclatures identified in Table 6.1.7-1 shall be used addressing locations of the APM in accordance with applicable document 2.1.6.1: APM Coordinate and Coding System.

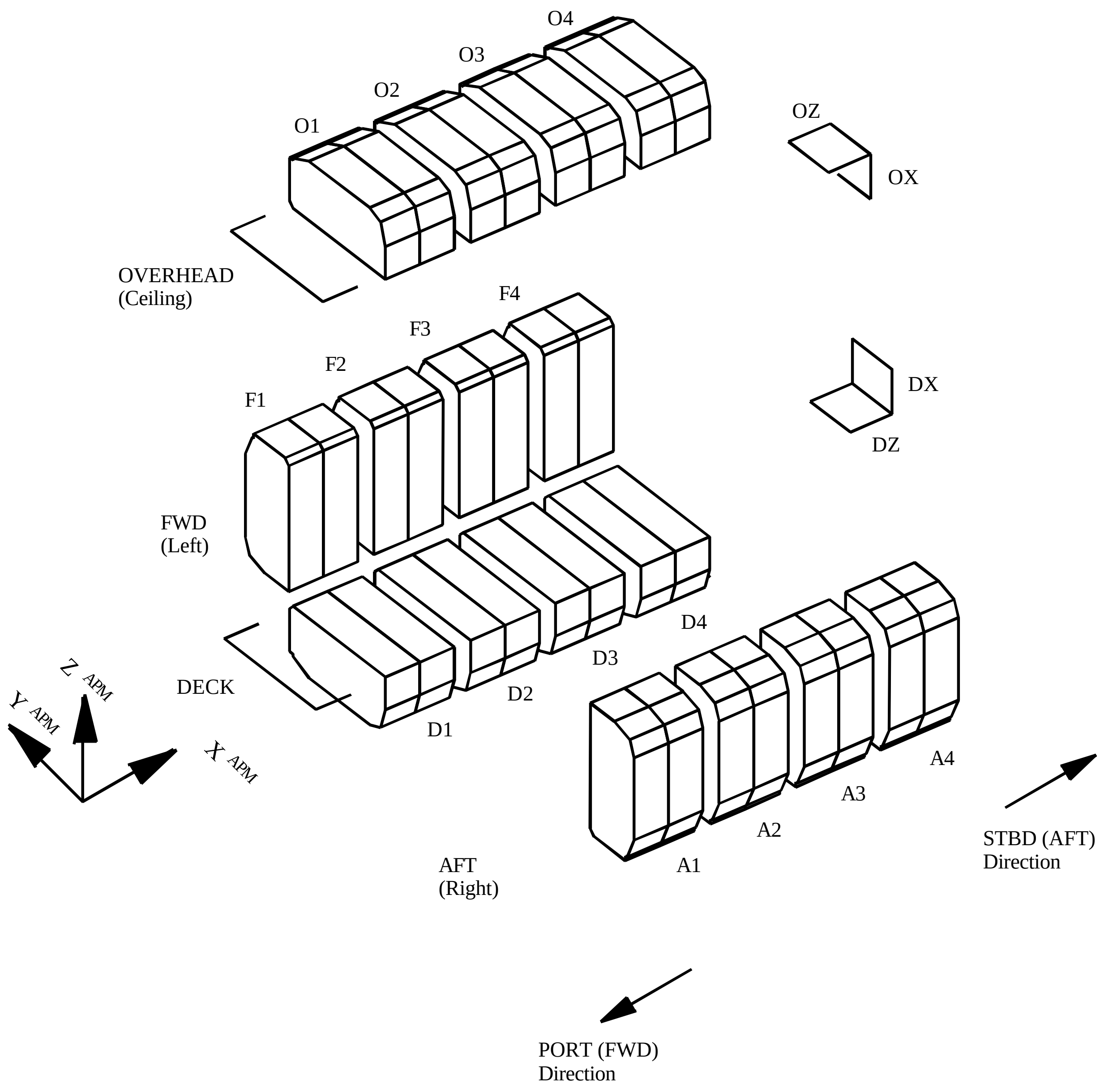
NOTE: ( )
See detailed paragraphs and figures in applicable document 2.1.6.1.

Abbreviations	Nomenclature
A( )	Aft Lateral Rack
F( )	Fwd Lateral Rack
O( )	Overhead Rack
D( )	Deck Rack
PF( )	Port Cone Feedthrough
SFC( )	Starboard Cone Feedthrough
OF( )	Overhead Fwd Stand-off
OA( )	Overhead Aft Stand-off
FD( )	Fwd Deck Stand-off
AD( )	Aft Deck Stand-off
PCC( )	Port Cone Center Quadrant
POF( )	Port Overhead Fwd Cone Quadrant
PFD( )	Port Fwd Deck Cone Quadrant
PAD( )	Port Aft Deck Cone Quadrant
POA( )	Port Overhead Aft Cone Quadrant
SCC( )	Starboard Cone Center Quadrant
SOF( )	Starboard Overhead Fwd Cone Quadrant
SFD( )	Starboard Fwd Deck Cone Quadrant
SAD( )	Starboard Aft Deck Cone Quadrant
SOA( )	Starboard Overhead Aft Cone Quadrant
PF( )	Port Cone Fwd Panel
PA( )	Port Cone Aft Panel
PD( )	Port Cone Deck Panel
SA( )	Starboard Cone Aft Panel
SO( )	Starboard Cone Overhead Panel
SD( )	Starboard Cone Deck Panel
SF( )	Starboard Cone Fwd Panel
SC( )	Starboard Cone Center Panel
PPA	Port Cone Protective Cover Aft
PPF	Port Cone Protective Cover Fwd
PPD	Port Cone Protective Cover Deck
SPO	Starboard Cone Protective Cover Overhead
SPA	Starboard Cone Protective Cover Aft
SPF	Starboard Cone Protective Cover Fwd
SPD	Starboard Cone Protective Cover Deck
L (-,I,-)	APM Internal (Shell or Cone)
L (-,E,-)	APM External (Shell or Cone)
SOZ	Ext. P/L at Zenith Location
SOX	Ext. P/L at APM AFT TOP Location
SDX	Ext. P/L at APM AFT DECK Location
SDN	Ext. P/L at APM NADIR Location
AMT	Ext. P/L at Aft Main Trunnion Position
AST	Est. P/L at Aft Stabilizer Trunnion Position
FMT	COL Terminal Position / Forward Main Trunnion

Table 6.1.7-1 APM Location Coding

6.1.7.1.6 Rack/Bay Location Coding

For the APM rack/bay identification the coding shall be used as defined in Figure 6.1.7-2.



Note: 1) PORT Cone Bay Location Coding = 0 (Zero)
2) STBD Cone Bay Location Coding = 5
3) P1 means first Port Double Rack
4) O1 means first Overhead Rack

Figure 6.1.7-2 Rack/Bay Postion Coding

6.1.7.2 Layout

6.1.7.2.1

The APM internal layout shall provide the internal cross-section as shown in Figure 6.1.7.2-1.

6.1.7.2.2

The APM internal layout shall hinder fire propagation by making the subsystem racks D2 and D3 and two Starboard cone halves separate enclosed zones.

6.1.7.2.3

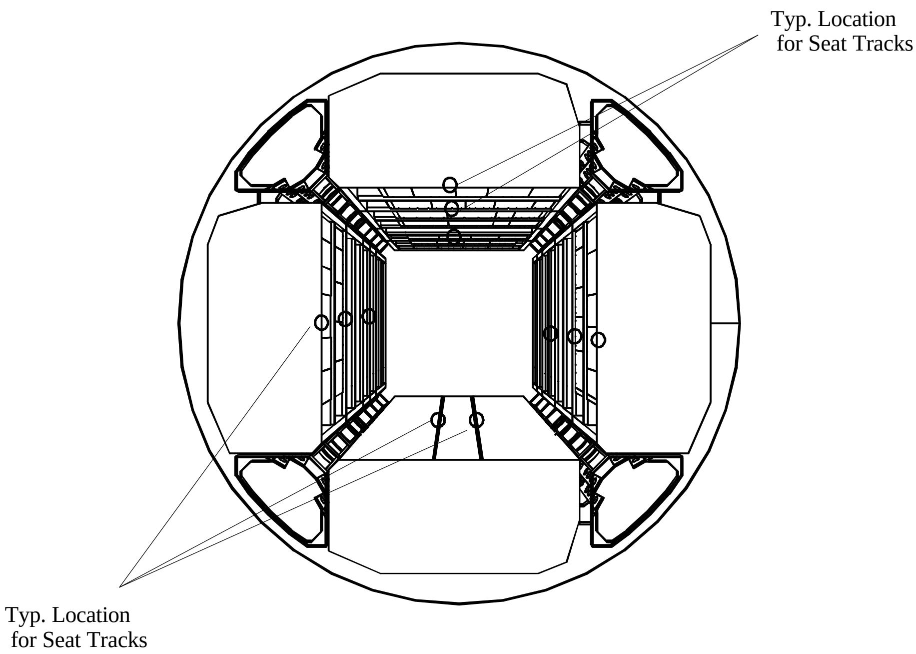
Equipment in the deck accommodation shall be in subsystem racks, which shall be tiltable in two directions (D1/D2 hinged at APM AFT side, while D3/D4 hinged at APM FWD side) to allow for redundant harness routing in the two lower stand-offs.

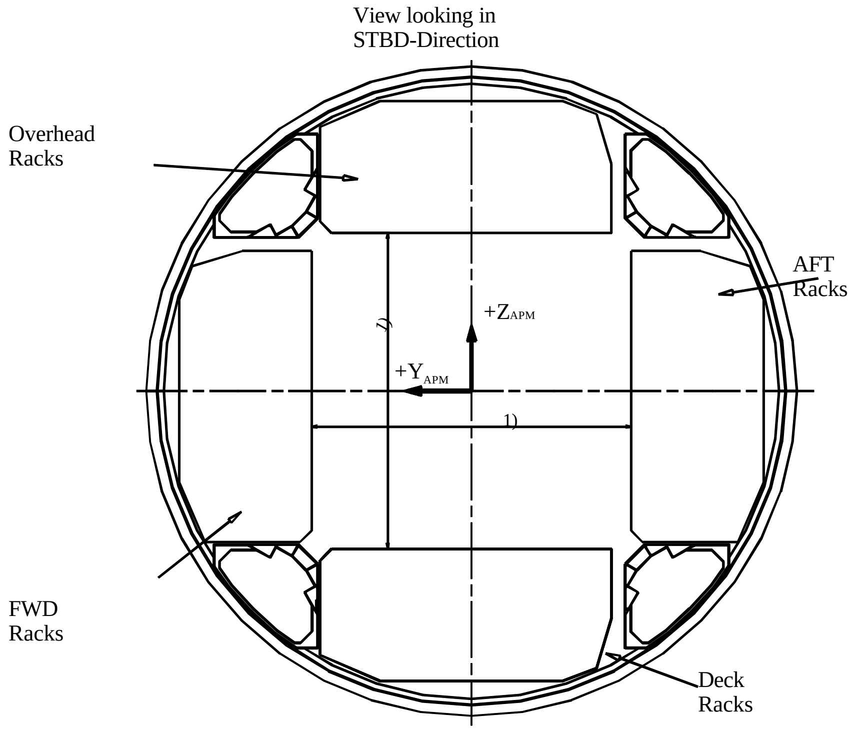
6.1.7.2.4

The APM shall provide interface locations for the different types of racks as shown in Fig. 6.1.7.2-2.

6.1.7.2.5

The APM shall provide three rack locations as on-orbit stowage provision for other than APM system items at the location shown in Figure 6.1.7.2-2.





Note: 1) Minimum 2117 mm on-orbit, in respect to ICD ISPR envelope, when rack is not locked

Figure 6.1.7.2-1 APM Cross Section

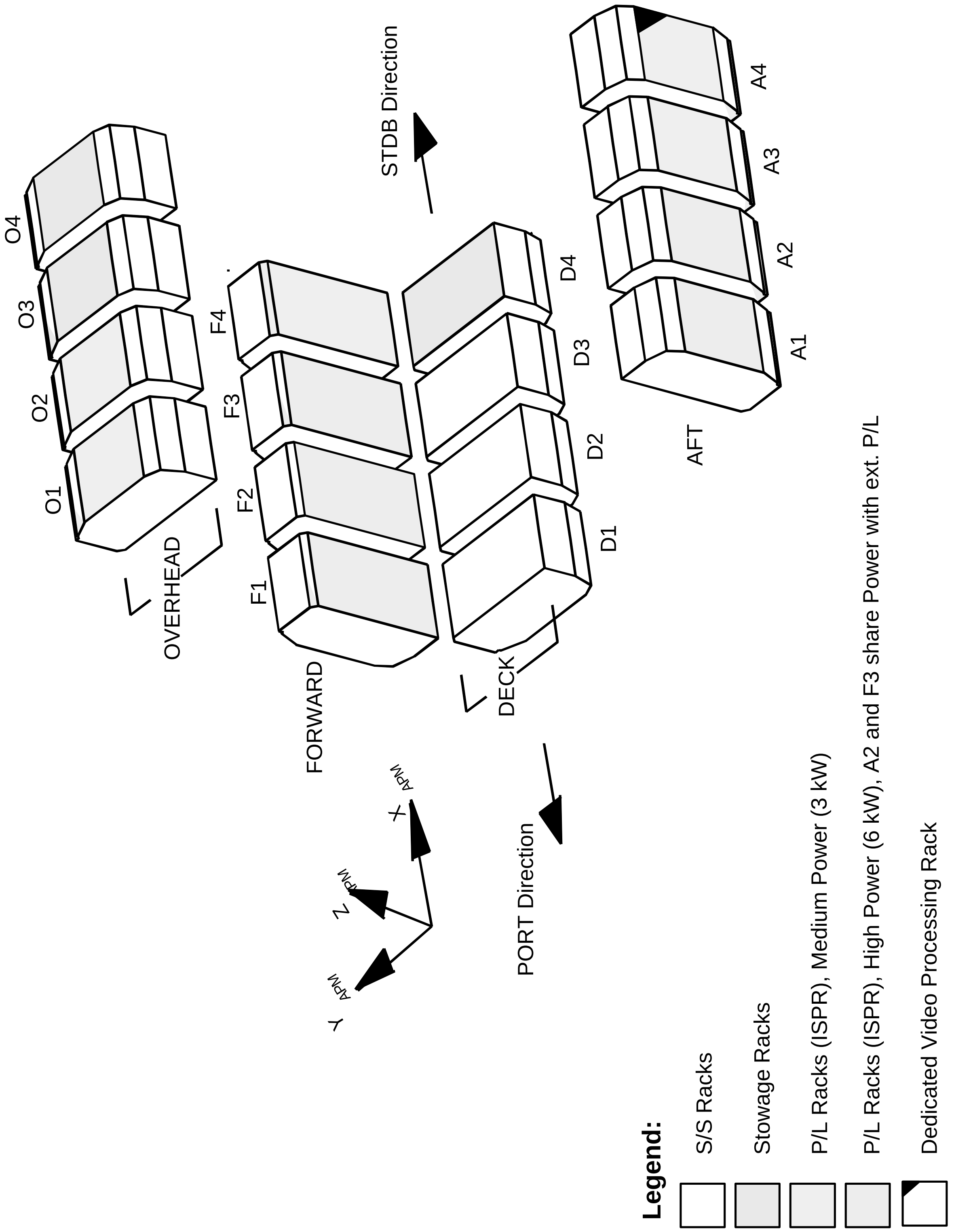


Figure 6.1.7.2-2 Payload Rack Location Provisions

6.1.7.2.6

The APM shall provide four locations with Standard Utility Panels for electrical connection of portable system equipment:

- US laptops
- APM laptops
- video cameras
- station common equipment

as well as P/L interface provisions for

- portable P/L items
- center aisle P/L items

as shown in Figure 6.1.7.2-3.

6.1.7.2.7

The APM shall provide two locations with Extended Utility Panels (XUP's) for electrical Digital Video for Center Aisle P/L as shown in Fig. 6.1.7.2-3

6.1.7.2.8

The APM shall provide one Interstation LAN (ISL) Panel for connection of the APM system LAN with SSMB Ops LAN as shown in Fig. 6.1.7.2-3.

Notes: Provisions only; Jumper not provided

6.1.7.2.9

The APM shall provide attachments provisions for payload provided items in the Center Aisle area as shown in Figure 6.1.7.2-4.

6.1.7.2.10

The APM shall provide four internal luminaries at each side at the overhead stand-offs at the locations shown in Figure 6.1.7.2-5.

6.1.7.2.11

The APM shall provide two video camera attachment provisions in the Port and Starboard cone as shown in Figure 6.1.7.2-6 and 6.1.7.2-7 for on-orbit use age.

NOTE:

The cameras have to be manually installed and configured before and during operation.

6.1.7.2.12

The APM layout shall be such that the two Master Alarm Light (MAL) Panels can be seen from any working location by accommodation of the MAL Panels as shown in Figures 6.1.7.2-8 and 6.1.7.2-9.

6.1.7.2.13

The APM shall provide one internal interface bracket (PLNB, Payload Notebook Bracket) in the starboard cone for connections of P/L Laptops for interfacing with the external Payload as shown in Fig. 5.8.1-1.

6.1.7.2.14

The APM design shall allow for access to the external harness between Starboard cone feed through plate up to the four ExPM I/F plate connectors.

6.1.7.2.15

The APM shall provide two external brackets (TEF-A and -B, Terminal Forward External) with EVA-connection outside on the starboard cone (close to Forward Main Trunnion) for on-orbit installation of the Columbus Terminal.

6.1.7.2.16

The APM shall provide one external bracket with EVA-connectors outside on the starboard cone (close to Aft Main Trunnion) for on-orbit connection of interface cables to Payloads on the Parking Positions accommodated on the aft trunnions equipped with EUTAS.

6.1.7.2.17

The APM shall provide one external interface bracket (SCT, Starboard Cone Terminal) in the starboard cone for connection of Power and signals as shown in Fig. 6.1.2-1.

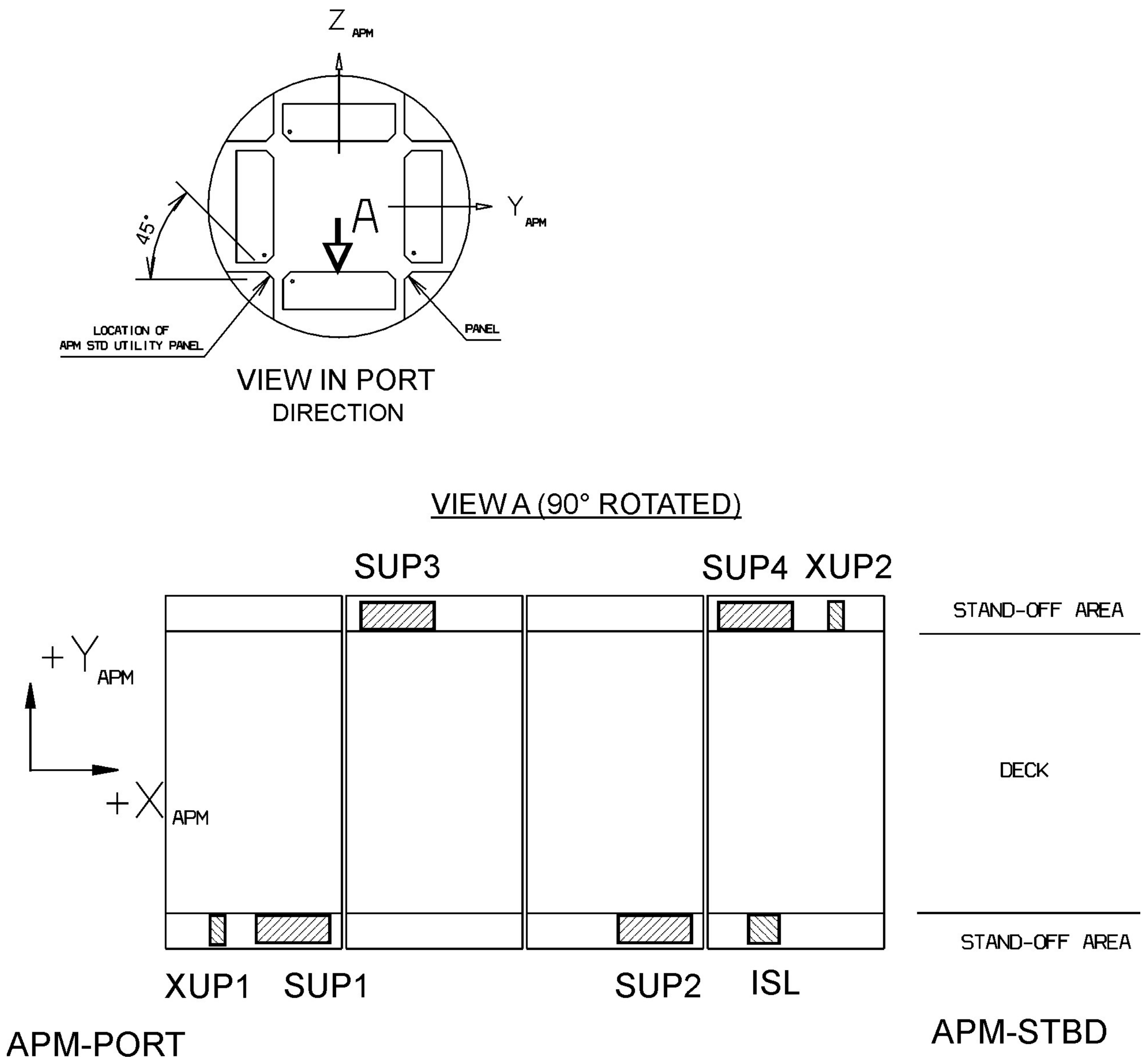


Figure 6.1.7.2-3 Locations for Utility Panels:

- Standard Utility Panel SUP
- Extented Utility Panel XUP
- Interstation LAN ISL

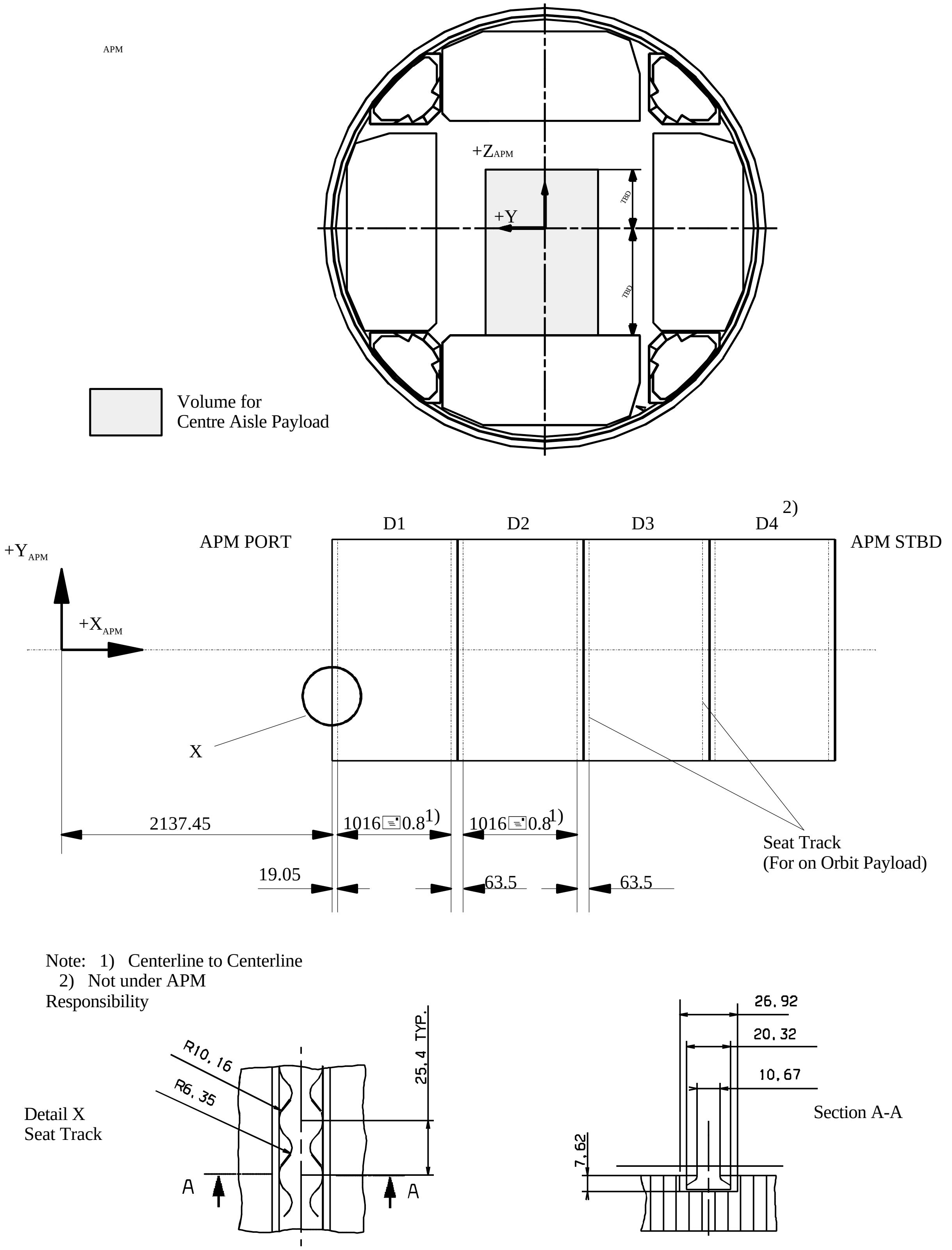


Figure 6.1.7.2-4 Center Aisle Volume Provision for Payload

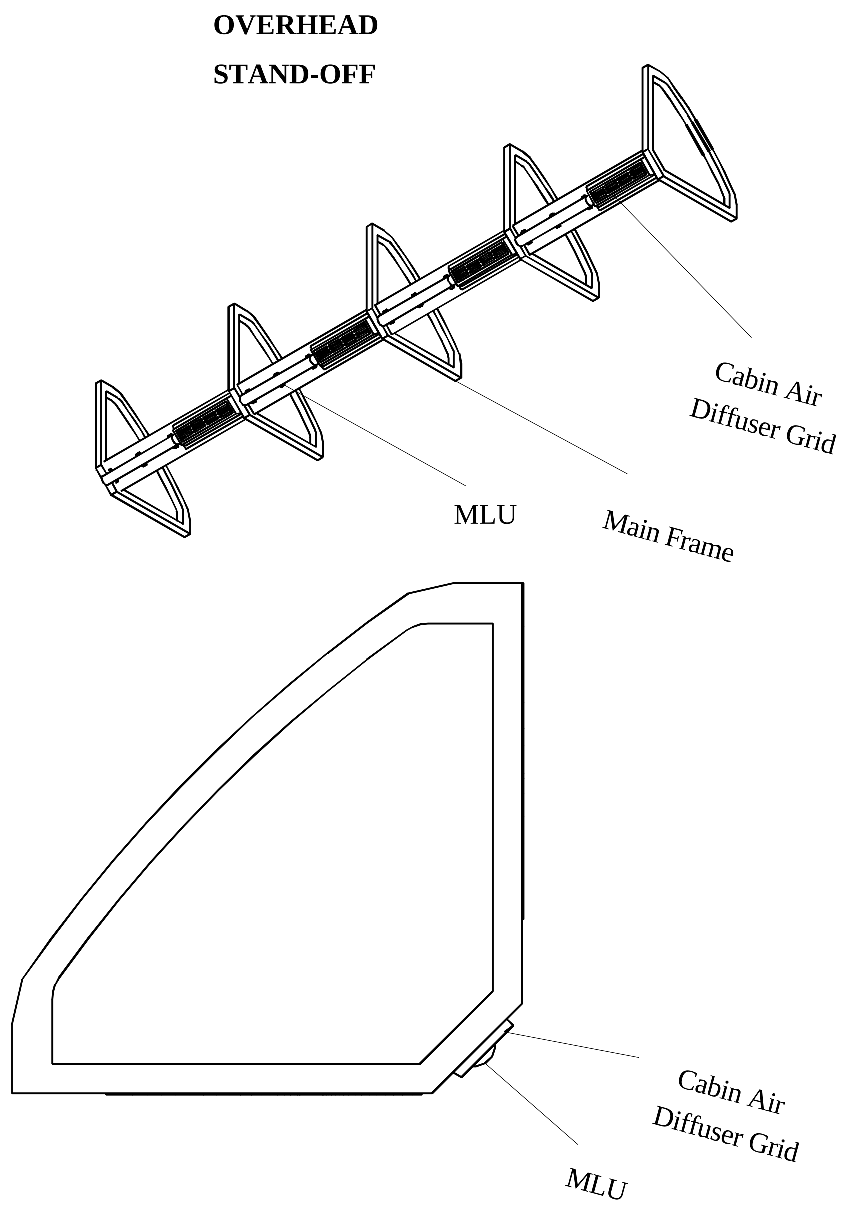
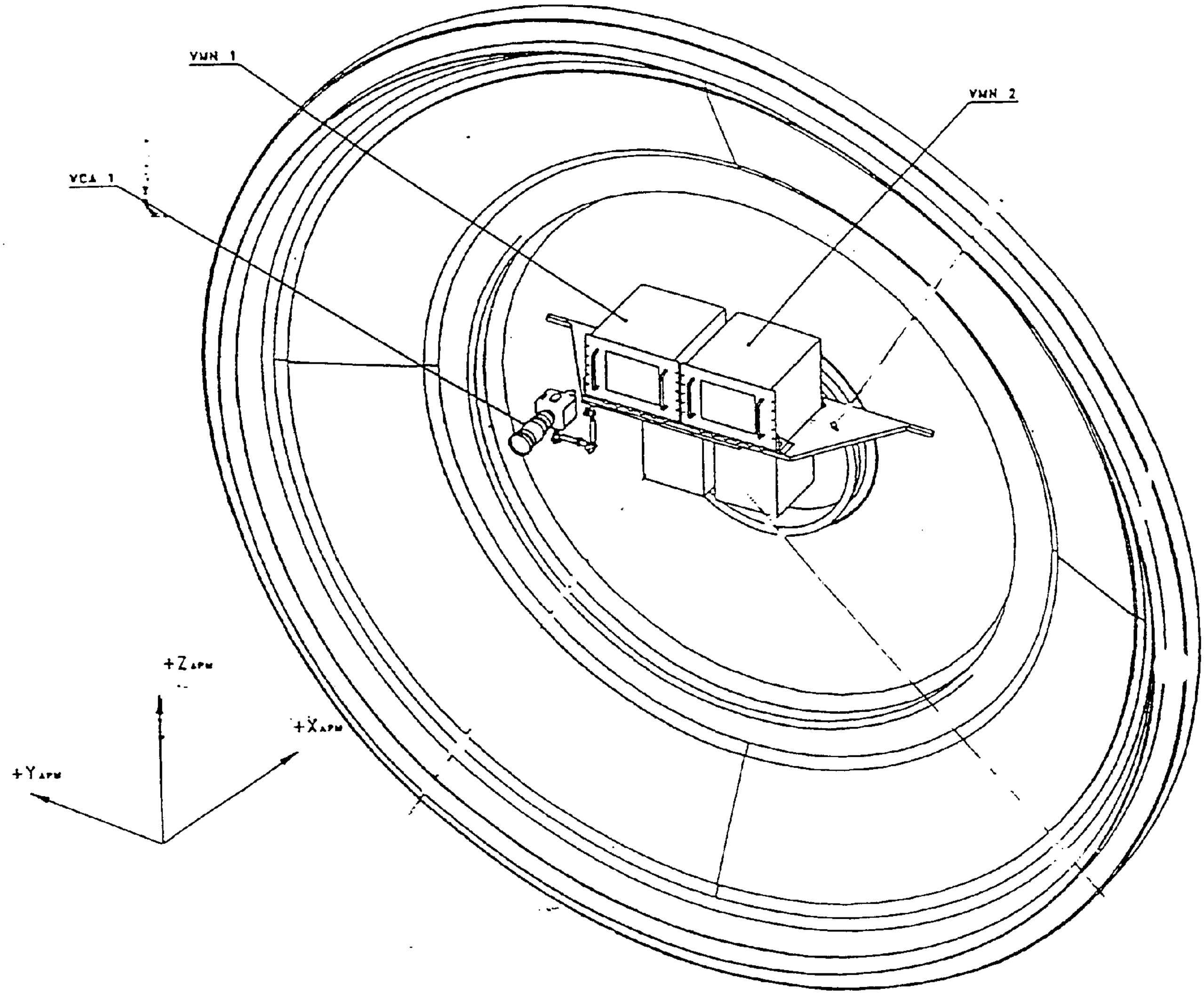
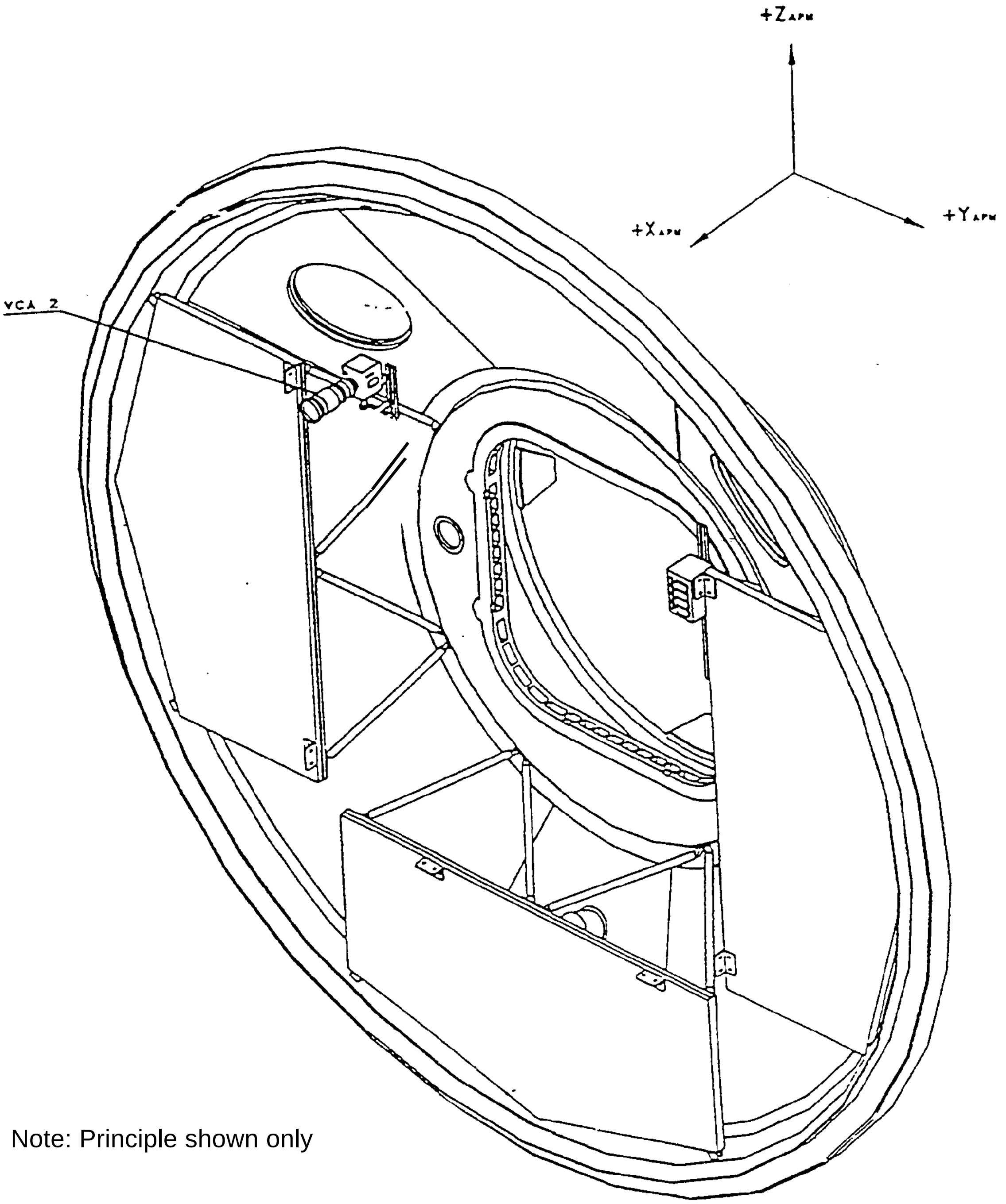


Figure 6.1.7.2-5 MLU Location (Overhead Stand off)



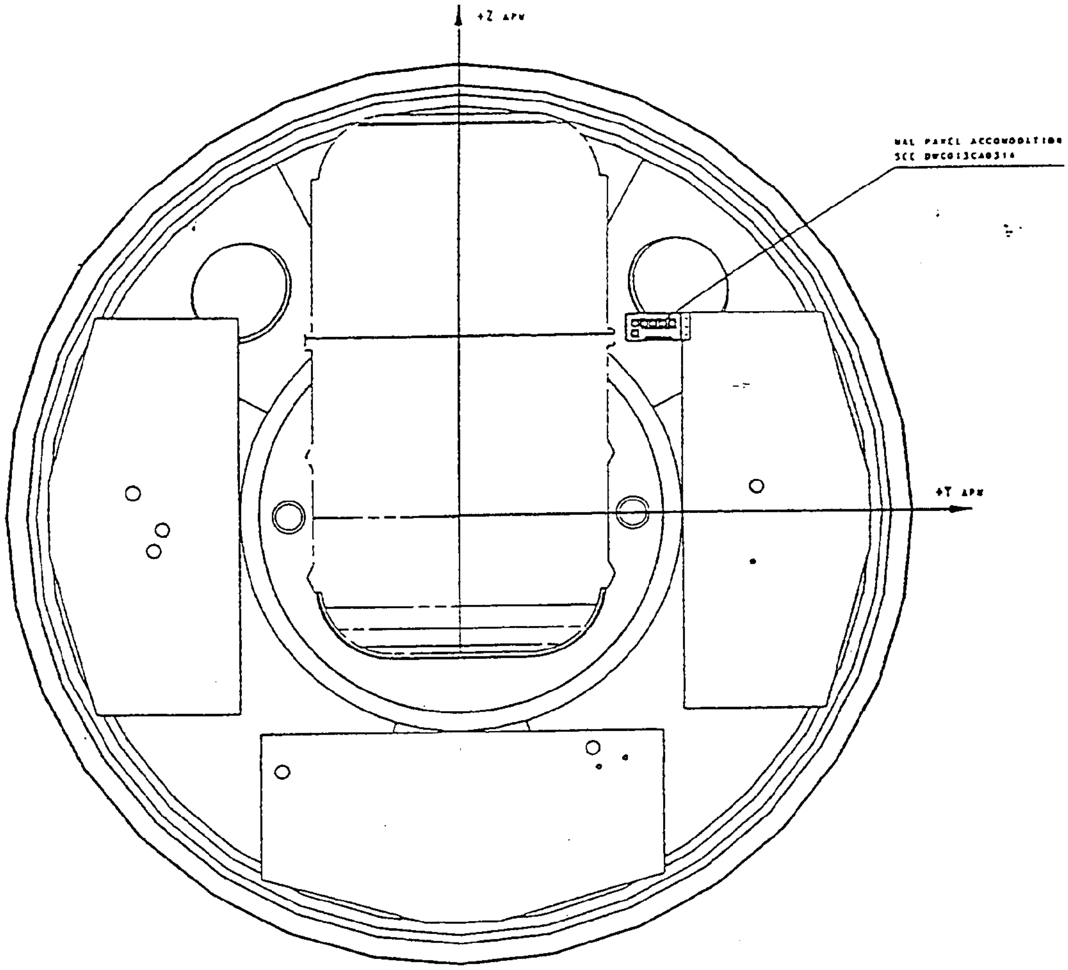
Note: Principle shown only

Figure 6.1.7.2-6 Video Camera 1 Location (Starboard Cone)



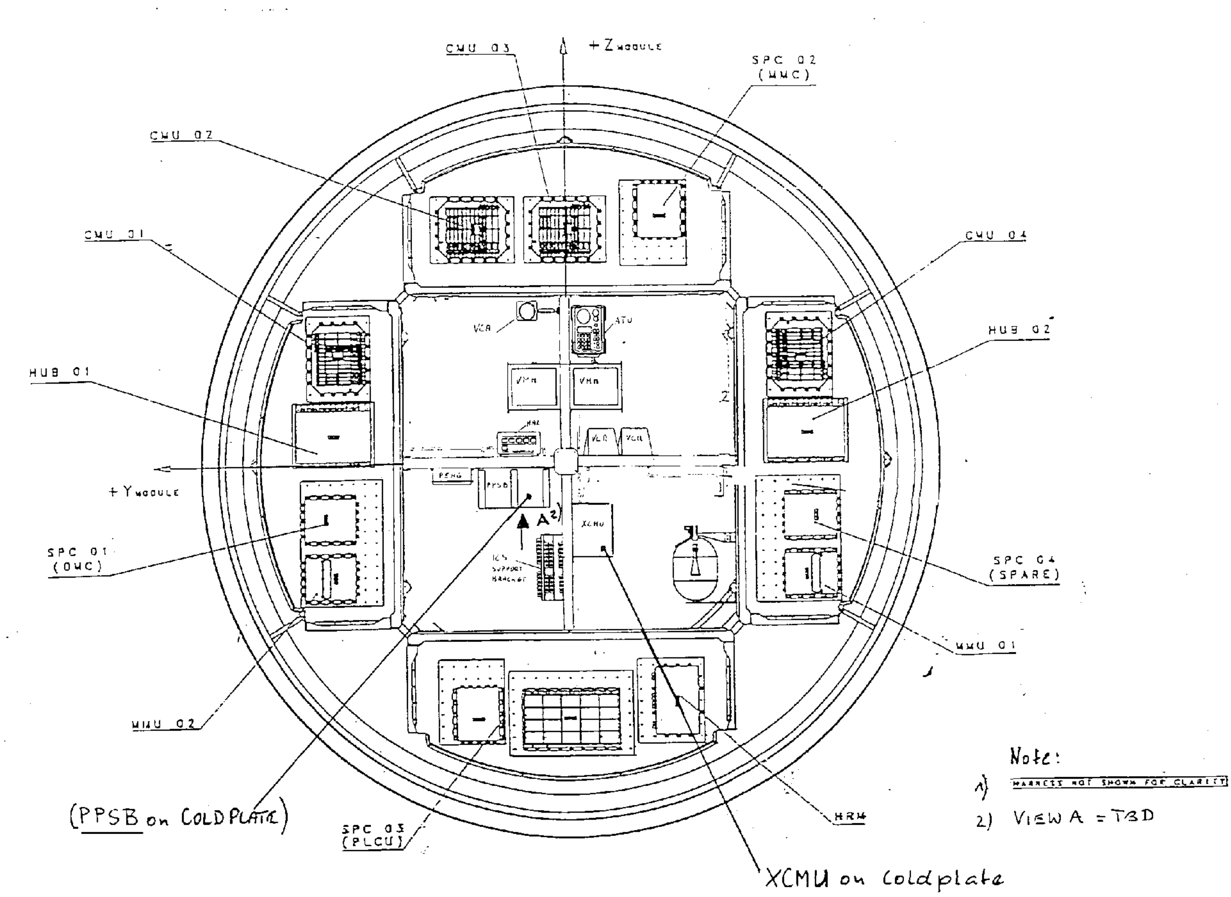
Note: Principle shown only

Figure 6.1.7.2-7 Video Camera 2 Location (Port Cone)



Note: Principle shown only

Figure 6.1.7.2-8 MAL Panel 1 Location (Port Cone)



- SDM -
PANEL ASSY

Note: Principle shown only

Figure 6.1.7.2-9 MAL Panel 2 Location (Starboard Cone)

6.1.7.3 System Stowage Provisions

6.1.7.3.1

The system stowage areas shall be equipped with attachment provisions to ensure safe stowage provisions for the APM portable items and items not installed in their final locations during launch:

1. portable foot loops at the shell to support the P/L rack exchange
2. tools caddy and tool tethers
3. restraints for paper document
4. rack tethers for temporary storage, restraint for laptop
5. portable handles to support the transport of big equipment (if any)
6. soft partitions to cover unused P/L rack positions
7. soft closures for gap between racks and stand-offs
8. labels and visual orientation cues
9. inspection tool (endoscope)
10. gloves for hot/cold item handling
11. wet and dry wipes for cleaning
12. APM tools
13. pivot points
14. rack duct jumper
15. simplified rack attachments
16. PBA mask and hose (two sets)
17. video cameras with containers (two sets)

6.1.7.3.2

The system stowage areas shall be equipped with attachment provisions (e.g. velcro tape) to ensure on-orbit intermediate stowage for all system items needed for APM operations.

NOTE:

Payload specific items will be located in P/L and stowage racks.

6.1.7.4 Support Equipment

6.1.7.4.1 Orbital Support Equipment (OSE)

6.1.7.4.1.1

A banister shall be provided along the module aisle for use in guiding large (size and/or mass) system and P/L items during transfer within the APM.

6.1.7.4.1.2

The banister shall be built in sections with a length of one double rack width and shall be removable on-orbit by one or several sections to provide full clearance and access passage.

6.1.7.4.1.3

The APM supplied OSE for APM operations/servicing shall include portable handles for large ORU handling.

6.1.7.4.2 Crew Support Equipment (CSE)

6.1.7.4.2.1

The APM shall provide the following items as basic crew mobility aids inside the APM:

- handrails mounted vertically on lateral racks
- handrails mounted along the module axis on overhead racks
- banister mounted along the module axis on the deck racks
- handholds mounted on the Stbd and Port Cone for hatch operation

6.1.7.4.2.2

The APM shall provide foot restraints and handholds/handrails as basic IVA crew restraint system.

6.1.7.4.2.3

All foot restraints, handholds and handrails shall be portable and shall be attachable to the seattracks.

6.1.7.4.2.4

The minimum clearance distance between the low surface of the handrail/handhold and the mounting surface shall be 58 mm to be compatible with EVA gloves and boots for contingency operations within the APM.

6.1.7.4.2.5

Portable foot loops shall be provided for temporary attachment at the shell for support to rack exchange.

6.1.7.4.2.6 (Intentionally left blank)

6.1.7.4.2.7

Equipment restraints shall be provided to anchor every item of use that is not permanently attached.

6.1.7.4.2.8

The APM shall provide two general purpose restraints for paper documents.

6.1.7.4.2.9

All general purpose restraints shall be removable/portable and be attachable to seat tracks to allow for reconfiguration for crew activities.

6.1.7.4.2.10

Removable hard covers shall be provided in the Port and Starboard cones to protect equipment mounted in the cones against damages by the crew and crew injuries.

6.1.7.4.2.11

End cone covers shall be removable with standard tools.

6.1.7.4.2.12

Soft partitions shall be provided for covering of unused P/L rack positions during launch and on-orbit until installation of a rack.

6.1.7.4.2.13

Partitions shall have the size of the rack frontal area and shall be attachable to the stand-offs without tools.

6.1.7.4.2.14

The CSE shall include removable soft closures for gaps existing in the habitable area between adjacent racks and gaps between racks and stand-offs in nominal position.

6.1.7.4.2.15 (Intentionally left blank)

6.1.7.4.2.16 (Intentionally left blank)

6.1.7.4.2.17

The CSE shall include soft bags and hard containers for on-orbit storage provisions to be located in the Starboard cone and in the deck area.

6.1.7.4.2.18

The CSE shall include an IVA tool set for APM activities, which cannot be performed with the standard tools available from the core station, including:

- IVA standard tool set (as listed in Tables 6.1.7-4 and 6.1.7-5)
- tools for special handling (gloves)
- inspection tools (boroscope).

6.1.7.4.2.19

A portable caddy shall be provided for transfer of tools and small equipment items within the APM.

6.1.7.4.2.20

The APM shall provide labels for equipment identification, strips and symbols painted on the interior as visual orientation to allow the crew member to quickly adjust to the orientation of the activity center.

6.1.7.4.2.21

A map of location code shall be provided and located at the APM entrance to areas where the coding scheme is not obvious to the crew member or for areas in which there is a significant amount of preparation activity such as stowage, adjustment, or maintenance of equipment.

6.1.7.4.2.22 (Intentionally left blank)

6.1.7.4.2.23

The APM interior shall have the following colours as shown in Table 6.1.7-2 to fulfil the crew comfort requirements:

Hardware Description	Color	Finish	FED-STD-595B Number
Module Pressure Shell (Interior Wall)	without	chromic anod. oxid. chemical oxidation	./.
Upper Stand-off Face Plates	white	semi gloss	27925
Lower Stand-off Face Plates	blue	semi gloss	25102
Port Cone Close-out Face Panels	light blue	semi gloss	L70G2B3[2)]
Starboard Cone Close-out Face Panels	teal	semi gloss	25275
End Cone Chamfer Panels (Port and Stbd)	blue	semi gloss	25102
End Cone Tunnel Panels (Port and Stbd)	off-white	semi gloss	27722
Hatch (Surface exposed to Aisle Way)	clear anodized	semi gloss	none
Overhead Racks[1)]	off-white	semi gloss	27722
Deck Racks/Panels[1)]	off-white	semi gloss	27722
Fwd/Aft Racks[1)]	off-white	semi gloss	27722

1) Painting of all overhead racks and deck rack D4 front cover panels are under P/L Design Integration responsibility in accordance with applicable document 2.1.2.3, FED.STD 595B and applicable document 2.1.1.24 (SSP 50008)

2) Color curve ®

Table 6.1.7-2 Interior Color Code

6.1.7.4.2.24 (Intentionally left blank)

6.1.7.4.2.25

All gaps between the habitable area in the cabin and the deck area end cones, stand-offs, and racks shall be closed by outfitting material to provide for noise attenuation and to prevent noise leakage.

6.1.7.4.2.26

The APM shall provide the following on-orbit installed EVA Mobility Aids for outside APM operations:

- one slide wire along the module axis for crew safe tethering.
- sufficient handrails located in the module axis direction in rows to support crew mobility
- sufficient handrails located on the cones along the circumference to support crew mobility taking into account the maximum dimensions of External Payloads
- sufficient Worksite Interface Fixture (WIF) adapter plates.

	TOOLS	SIZE/TYPE
A	OPEN END WRENCHES, 1/4 in.	open end / extension: 8 mm/M5 10 mm/M6 open end / box: - 8mm / L = 115 mm - 10 mm / L = 125 mm
B	(Intentionally left blank.)	
C	BIHEXAGONAL SOCKET 1/4 in. drive	8 mm/M5 10 mm/M6
	HEXAGONAL HEAD DRIVERS (bit) 1/4 in.	- 4 mm/M5 - L = 55 mm - 4 mm/M5 - L = 28 mm - 5 mm/M6 - L = 55 mm - 5 mm/M6 - L = 28 mm
	TORQUE SET DRIVERS (bit) 1/4 in.	Adapter torque bit
	TOOL FOR SCREW WITH INTERNAL SERRATION	- for M5 and M6 = TBD
D	EXTENSIONS (in length) referred to C and G	45.5 cm long, 3/8 in. drive 15 cm long, 1/4 in. drive 25 cm long, 1/4 in. drive
E	"ALLEN" WRENCHES (made from an hexagonal rod to turn screws with an axial hexagonal socket in their head) 1/4 in. drive	3 mm/M4 4 mm/M5 5 mm/M6 6 mm/M8 8 mm/M10 10 mm/M12
F	SCREW DRIVER SET	captive tip set jeweler's screw driver set

Table 6.1.7-4 APM Standard IVA Tool List

	TOOLS	SIZE/TYPE
G.	HANDLES referred to C, E and F	18 cm ratchet wrench, 1/4 in. square drive Torque wrench, 1/4 in. drive (4.0 - 20 Nm) Tee handle 3/8 in. square drive
H.	(Intentionally left blank.)	
I.	CUTTING TOOLS & ACCESSORIES	wire cutters scissors crimpers
J.	(Intentionally left blank.)	
K.	(Intentionally left blank.)	
L.	(Intentionally left blank.)	
M.	CLAMPS	vise grips long nose vise grip tweezers c-clamps hemostats
N.	PLIERS	long nose short nose round nose wire strippers
O.	MISCELLANEOUS TOOLS	magnifying glass (5x, 10x) glue gun wire brush fiber brush
P.	CONSUMABLES	duct tape wet and dry wipes velcro masking tape spare fasteners spare nuts and bolts wire
Q	ADAPTER / JOINTS	3/8 in. to 1/4 in., 1/4 in. to 3/8 in. universal joint 1/4 in. universal joint 3/8 in.

Table 6.1.7-5 APM Standard IVA Tool List

6.1.8 Station Common Equipment

The Station Common Equipment shall be accommodated inside and outside of the APM as identified in section 5.8.

6.1.9 Orbital Replacement Units (ORU) and Removable Items

6.1.9.1 General

6.1.9.1.1 "ORU" Definition

All APM constituents which

- have a lifetime of less than 10 years
- are sensitive to failure (according to their MTBF/reliability)

shall be designed as Orbital Replacement Unit (ORU).

6.1.9.1.2 "Removable Items" Definition

All APM constituents which have to be removed for

- on-orbit repair of themselves (e.g. due to possible crew failures)
- access to other items for removal and/or inspection of other items

shall be designed as Removable Items.

6.1.9.1.3

The APM design shall allow for on-orbit removal and re-attachment of the items without tools or with standard tools or with special tools specified in para. 6.1.7.4.2.18.

6.1.9.1.4

All Removable Item and ORU connections (electrical, fluid, mechanical) shall be accessible and visible by the crew for mating/demating purposes.

6.1.9.1.5

The onboard harness shall be accessible and removable to allow for

- On-orbit crimping of a failed wire/connector
- Harness Manufacturing Unit (HMU) replacement

to repair potential harness damage occurring during ORU replacement.

6.1.9.1.6

All APM replaceable items, either identified as ORU, consumables, loose items or tools which have to be handled on ground by NASA shall be marked during APM integration with an IMS label in accordance to applicable codument 2.1.1.23 SS Inventory Management System Level Specification.

6.1.9.2 ORU

6.1.9.2.1 (Intentionally left blank)

6.1.9.2.2 ORU Definition/List

The APM design shall allow for on-orbit replacement of all ORUs listed in appl. doc. 2.1.6.3, "APM ORU List".

6.1.9.3 Removable Items

6.1.9.3.1

The APM design shall allow for on-orbit removal and re-attachment of items for planned repair or inspection under normal IVA environment inside the APM (removable items see appl. doc. 2.1.6.3, "APM ORU List").

6.1.9.3.2

The APM design shall allow for on-orbit removal and re-attachment of selected removable items for contingency activities by an EVA suited astronaut inside the APM (removable items list see attachment 1).

6.1.9.4 Maintenance

6.1.9.4.1

The ORU design shall allow performance of ORU replacement by a single crew member.

6.1.9.4.2

The APM design shall provide sufficient access for in-orbit inspection and removal/re-installation of each ORU.

6.1.9.4.3

The ORU shall be exchangeable in-orbit with the utilization of APM standard tools.

6.1.9.4.4

The exchange of the ORU shall be supported by guidance and/or alignment provisions as specified in applicable document 2.1.1.7: Mechanical and Thermal Design System Support Specification, para. 3.2.5.5.

6.1.9.4.5

Planned corrective and preventive maintenance shall not cause any further degradation of the APM functionality up to the end of its specified life time.

6.1.9.4.6

APM equipment shall be designed to prevent incorrect installation.

6.1.9.4.7

All APM equipment to be handled by astronauts for on-orbit servicing shall be designed in accordance with applicable document 2.1.1.2: COLUMBUS Human Factors Engineering Requirements.

6.1.9.4.8 (Intentionally left blank)

6.1.9.4.9

The APM shall be designed such that inspection, repair and replacement procedures to recover from an impact shall be provided.

NOTE:

Requirement Clarification: Test will be performed with standard ground equipment (on-orbit equipment assumed to be available from SSMB by ESA for accessibility demonstration.)

6.1.9.5 ORU Launch and Retrieval

6.1.9.5.1 (Intentionally left blank)

6.1.9.5.2

ORUs accommodated in the Pressurized Logistics Carrier shall not require any resources until installation into the APM or after removal from the APM.

6.1.9.5.3

ORUs shall be designed to withstand a minimum of four up and down transport cycles to ISS without damage and without reduction of the ORU functionality and performance.

6.1.10 APM System Data Processing/Software Architecture

6.1.10.1 On Orbit Configuration

The APM flight configuration shall perform its overall data processing functions by on-board SW items executing in different environments as listed in Table 6.1.10-1 and shown in Figure 6.1.10-1.

6.1.10.2 Ground Configuration

6.1.10.2.1

The APM system shall allow testing of all overall data processing related functions of the APM flight configuration by simulating all specified ISS/APM interactions.

6.1.10.2.2

The APM system configuration (flight configuration with EGSE) shall also allow to connect the APM operational ground segment and the SSMB test facilities for interface compatibility testing as shown in Figure 6.1.10-2.

Data Processing Function	SW Item	Target Computer	Remarks
• Vital Cmd & Control	- VTC SW	VTC	All SW in PROM
• S/S Data Acq. & Proc.	- OS/DMS Management SW - DMS Services - Level 2 Appl. SW	Data Management Computer (DMC)	
	- OS/DMS Management SW - DMS Services - Level 1 and COAP SW	Mission Management Computer (MMC)	
• Human/Computer Interface	- POSIX compatible OS/DMS Management SW - Laptop HCI Services SW - Crew/System I/F Appl. SW	APM Laptop	
• P/L Data Acquisition and Processing	- OS - DMS Services - P/L Appl. SW and COAP SW	P/L Control Unit (PLCU)	Appl. SW P/L provided

Table 6.1.10-1 On Board SW Implementation

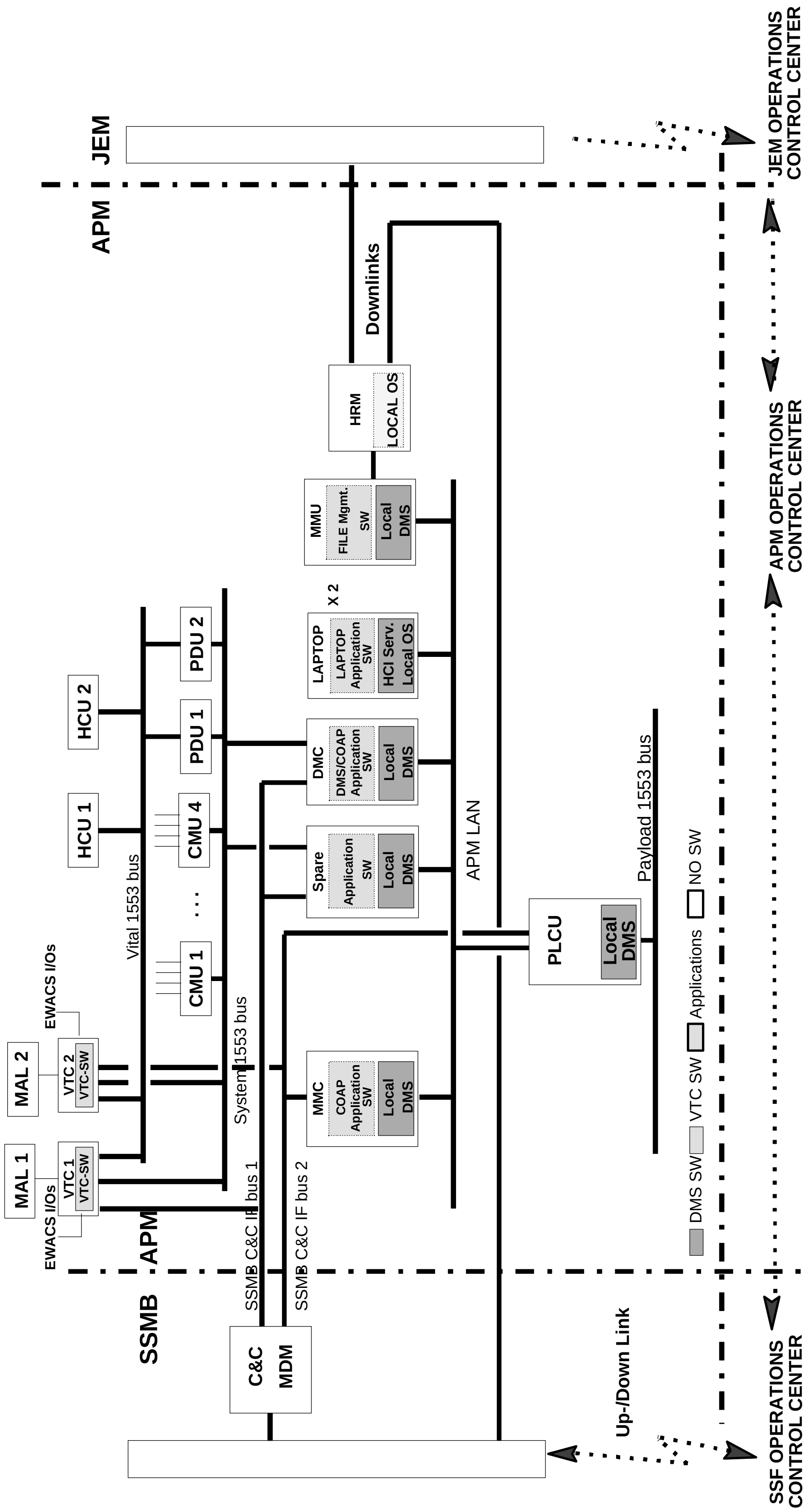


Figure 6.1.10-1 SW Mapping On-Orbit Configuration

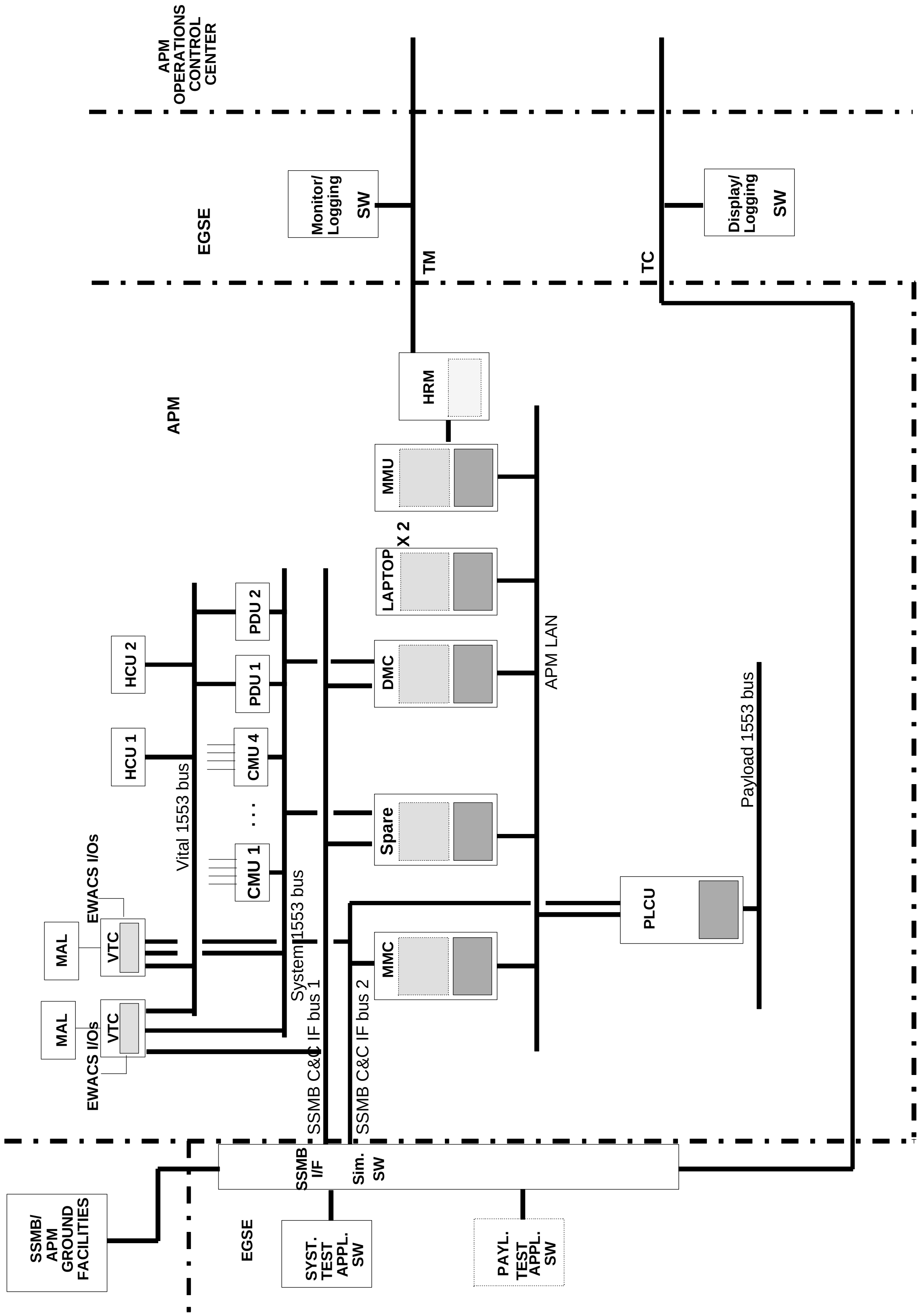


Figure 6.1.10-2 SW Mapping Ground Configuration

6.2 APM Flight Configuration Functions/Allocations

6.2.1 Functions

6.2.1.1 Function Allocation

6.2.1.1.1

The APM shall provide active system functions as identified in Tables 6.2.1-1 through 6.2.1-5 to provide for:

- Payload Accommodation — Table 6.2.1-1
- On-board Crew Support — Table 6.2.1-2
- Monitoring and Control from SSMB — Table 6.2.1-3
- Monitoring and Control from Ground — Table 6.2.1-4
- Servicing and Reconfiguration — Table 6.2.1-5

6.2.1.1.2

The APM shall provide active system support functions as identified in Table 6.2.1-6 being necessary for the selected APM design during certain mission phases.

6.2.1.1.3

The system and system support functions shall be available per mission phase as identified in Tables 6.2.1-7 through 6.2.1-11.

6.2.1.1.4

The system and system support needed for APM survival functions, which are listed in Table 6.2.1-12 shall be available also when the APM has been depressurized (atmosphere total pressure 0 to 1 bar for 90 days) fulfilling all specified functional and performance requirements and without hardware degradation of the activated equipment needed for survival functions and the other, deactivated equipment.
NOTE:

The Mass memory Unit can survive only 3 x 2 days vacuum (common item from DMS-R).

6.2.1.1.5

The APM shall allow the transition from the survival functions defined in Table 6.2.1-12 to all functions in the range of atmosphere total pressure between 69.3 kPa and normal pressure.

6.2.1.1.6

The system and system support functions as split down into main functions shall be provided by the different APM subsystems and assemblies as defined in Tables 6.2.1-13 through 6.2.1-18.

NOTES:

- The term "subsystem" is used for "contractual" subsystems being imposed by a lower level specification to a subcontractor and subsystems under the responsibility of the APM system level, for which no dedicated subsystem specifications are prepared.
- Example:
  – The Data Management System of the APM flight configuration includes application software
  – The Data Management Subsystem covers only the DMSS subcontractor responsibility, i.e. it excludes system application software.
- "Contractual" subsystems are:
  – ECLSS
  – DMSS.

SYSTEM FUNCTION		**PROVISION FOR**				
		Payload Accom-modation	Onboard Crew Support	Monitor. Control from SSMB	Monitor. Control from Grd.	Servic./ Reconfi-guration
P1	Electrical Power to P/L	x				
P2	Heat Removal from P/L	x[1)]				
P3	On-board Data Processing for P/L (including interface to on-board crew)	x				x
P4	Time distribution to P/L	x				
P5	Up-/down-links for P/L data (low and medium rate)				x	(x)
P6	Vacuum/venting for P/L	x[1)]				
P7	N2 provisions to P/L	x[1)]				
P8	Video/High Rate Data distribution for P/L	x[2)]		x	x	
P9	APM housekeeping and ancillary data distribution to P/L	x				
P10	P/L EWACS (same as C4.15)		x[1)]	x[1)]	x[1)]	

Legend:

x Primary Provision
(x) Secondary Provision
1) Internal Payload only
2) External P/L only High Rate Data Distribution

Table 6.2.1-1 System Functions Definitions: Payload Accommodation

SYSTEM FUNCTION		PROVISION FOR				
		Payload Accom-modation	Onboard Crew Support	Monitor. Control from SSMB	Monitor. Control fr.Grd.	Servic./ Recon-figur.
C1	Environmental Control (air pressure, temperature, humidity, etc.)	(x)[1]	x			x
C2	Module Lighting		x			
C3	Intercom		x	x	x	
C4	Emergency[2], Warning, Caution detection and annunciation to APM crew		x	(x)	(x)	
C5	System Monitoring and Control		x			x
C6	Fire Suppression		x			
C7	Emergency Lighting		x			x
C8	Video		x	x	x	

Legend:

x Primary Provision
(x) Secondary Provision
1) internal Payload only
2) including Fire detection

Table 6.2.1-2 System Functions Definitions: On-Board Crew Support

SYSTEM FUNCTION		**PROVISION FOR**				
		Payload Accom-modation	Onboard Crew Support	Monitor. Control from SSMB	Monitor. Control fr.Grd.	Servic./ Recon-figur.
S1	Primary (essential command and data) activation, monitoring and control (w/o crew needed inside the APM)			x	(x)	
S2	Emergency, Warning, Caution detection, annunciation and safing 1)			x	(x)	
S3	Overall mission management			x	(x)	(x)

Legend:

x Primary Provision
(x) Secondary Provision
1) including Module Depressurization and Isolation

Table 6.2.1-3 System Functions Definitions: Monitoring/Control from SSMB

SYSTEM FUNCTION		PROVISION FOR				
		Payload Accom-modation	Onboard Crew Support	Monitor. Control from SSMB	Monitor. Control fr.Grd.	Servic./ Recon-figur.
G1	Primary (essential command and data) activation, monitoring and control (without crew needed inside APM)			(x)	x	
G2	Overall Mission Management and full APM system monitoring and control (including FDIR, P/L up-/down-link data manage-ment)			(x)	x	

Legend:

x Primary Provision
(x) Secondary Provision

Table 6.2.1-4 System Functions Definitions: Monitoring/Control from Ground Segment

SYSTEM FUNCTION		PROVISION FOR				
		Payload Accom-modation	Onboard Crew Support	Monitor. Control from SSMB	Monitor. Control fr.Grd.	Servic./ Recon-figur.
R1	Check-out of on-orbit changed system configuration (including ORU replacement)	(x)	(x)	(x)	(x)	x

Legend:

x Primary Provision
(x) Secondary Provision

Table 6.2.1-5 System Functions Definitions: Servicing/Reconfiguration

SYSTEM SUPPORT FUNCTION		PROVISION FOR
SS1	APM Heating/Therm. Conditioning	APM interior temperature control during specific operational modes (as defined in Table 6.2.1-11)

Table 6.2.1-6 System Support Functions

MISSION PHASES / SYSTEM FUNCTIONS	Ground Proc.*)	Launch Ascent	Initialization			Operation under Reduced Performance					Routine Operation	
		Passive	Unberthed Surv.	Berthed Surv.	Support	Support manned	Support unmanned	House-keeping	Stand-by unmanned	Berh. Surv.	Nominal manned	Nominal unmanned
P1 Electr. power to P/L	-	-	-	-	-	-	-	-	-	-	x	x
P2 Heat removal from P/L 1)	-	-	-	-	-	-	-	-	-	-	x	x
P3 Onboard data processing for P/L (incl. interface to onboard crew)	-	-	-	-	-	-	-	-	-	-	x	x
P4 Time distribution to P/L	-	-	-	-	-	-	-	-	-	-	x	x
P5 Up-/down-links for P/L data	-	-	-	-	-	-	-	-	-	-	x	x
P6 Vacuum/venting for P/L 1)	-	-	-	-	-	-	-	-	-	-	x	x
P7 N2 provision to P/L 1)	-	-	-	-	-	-	-	-	-	-	x	x
P8 Video/High Rate Data Distribution for P/L 2)	-	-	-	-	-	-	-	-	-	-	x	x
P9 APM housekeeping and ancillary data distribution to P/L	-	-	-	-	-	-	-	-	-	-	x	x
P10 P/L EWACS	-	-	-	-	-	-	-	-	-	-	x	x

*) All Functions activated as necessary for check-out
1) Internal P/L only
2) External P/L only High Rate Data

Table 6.2.1-7 Payload System Functions vs. Mission Phases

MISSION PHASES / SYSTEM FUNCTIONS	Ground Proc.*)	Launch Ascent	Initialization			Operation under Reduced Performance					Routine Operation	
		Passive	Unberthed Surv.	Berthed Surv.	Support	Support manned	Support unmanned	House-keeping	Stand-by unmanned	Berh. Surv.	Nominal manned	Nominal unmanned
C1 Environment control (air pressure, temperature, humidity	-	x[3)]	x[3)]	x[3)]	x	x	(x)	(x)	(x)	(x)[3)]	x	(x)
C2 Module lighting	-	-	-	-	x	x	x[4)]	-	-	-	x	x[4)]
C3 Intercom	-	-	-	-	x	x	-	-	-	-	x	-
C4 Emergency, Warning, Caution detection and annunciation to APM crew[2)]	-	-	-	-	x	x	-	x	-	-	x	-
C5 System Monitoring and Control	-	-	-	x	x	x	x	x	x	x	x	x
C6 Fire Suppression[1)]	-	-	-	x	x	x	x	x	x	x	x	x
C7 Emergency Lighting[2)]	-	-	-	-	x	x	-	x	-	-	x	-
C8 Video	-	-	-	-	-	x	x[4)]	-	-	-	x	x[4)]

Legend:
(x) non-nominal conditions allowed
*) All Functions activated as necessary for check-out
1) Fire suppression by Portable Fire Extinguisher is to be possible at any manned phase
2) For ≥ 2 hours after power loss from SSMB.
3) Negative and positive pressure relief only
4) Activation possible in previous phase (i.e. to remote control)

Table 6.2.1-8 Onboard Crew Support System Functions vs. Mission Phases

MISSION PHASES / SYSTEM FUNCTIONS		Ground Proc.*)	Launch Ascent	Initialization			Operation under Reduced Performance					Routine Operation	
			Passive	Unberthed Surv.	Berthed Surv.	Support	Support		House-keeping	Stand-by	Berh. Surv.	Nominal manned	Nominal unmanned
							manned	unmanned		unmanned			
S1	Primary (essential cmd. and data) activation, monitoring and control (w/o crew needed inside APM)	-	-	-	x	-	-	-	x	x	x	-	-
S2	Emergency, Warning, Caution detection, annunciation and saf-ing	-	-	-	x	x	x	x	x	x	x	x	x
S3	Overall mission management	-	-	-	-	x[1)]	x	x	x	x[1)]	-	x	x

*) All Functions activated as necessary for check-out
1) Reduced functionality (e.g. FDIR)

Table 6.2.1-9 SSMB Monitoring/Control System Functions vs. Mission Phases

MISSION PHASES / SYSTEM FUNCTIONS	Ground Proc.*)	Launch Ascent	Initialization			Operation under Reduced Performance					Routine Operation	
						Support			Stand-by			
		Passive	Unberthed Surv.	Berthed Surv.	Support	manned	unmanned	House-keeping	unmanned	Berh. Surv.	Nominal manned	Nominal unmanned
(Ground Monitoring/Control): G1 Primary (essential cmd. and data) activation, monitoring and control (w/o crew needed inside APM)	-	-	-	x	-	-	-	x	x	x	-	-
G2 Overall Mission Mgmt. and full APM System monitoring and con-trol	-	-	-	-	x	x	x	-	-	-	x	x
(Servicing/Reconfiguration): R1 Check-out	-	-	-	-	x	x	x	-	-	-	x	x

*) All functions activated as necessary for check-out

Table 6.2.1-10 System Functions vs. Mission Phases for Ground Monitoring/Control (G) and Servicing/Reconfiguration (R)

MISSION PHASES / SYSTEM FUNCTIONS	Ground Proc.*)	Launch Ascent	Initialization			Operation under Reduced Performance					Routine Operation	
		Passive	Unberthed Surv.	Berthed Surv.	Support	Support manned	Support unmanned	House-keeping	Stand-by unmanned	Berh. Surv.	Nominal manned	Nominal unmanned
SS1 APM Heating/ Thermal Conditioning	-	x**)	x	x	x*)	x*)	x*)	x*)	x*)	x	x*)	x*)

*) When APM internal heat dissipation is lower than APM heat leaks
**) Heating during Launch

Table 6.2.1-11 System Support Functions vs. Mission Phases

System Function		Remarks
P10	P/L Safing	Via VTC commands
C7	Emergency Lighting	For limited time after loss of power
S2	Emergency, Warning, Caution Detection, Annunciation and Safing	Related data processing fully active, sensoric as applicable
SS1	APM Heating / Thermal Conditioning	

Table 6.2.1-12 System and System Functions available under Vacuum in APM

System Function/ Main Function	**SUBSYSTEM/ASSEMBLY INVOLVED**								
	ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
				Nom.	Vital			HRM 1)	Video Assy.
P1 Electrical Power to P/L									
P1.1 Power to S/Ss			(x)						
P1.2 Heat removal from S/Ss		(x)							
P1.3 S/S management				(x)		(x)			
P1.4 Nominal and Safing Power Distribution to P/L			x						
P2 Heat Removal from P/L 2)									
P2.1 Power to S/Ss			(x)						
P2.2 Heat removal from S/Ss		(x)							
P2.3 S/S Management				(x)		(x)			
P2.4 Heat removal function from P/L	x	x							
P3 Onboard Data Processing for P/L (incl. I/F to on-board crew)									
P3.1 Power to S/Ss			(x)						
P3.2 Heat removal from S/Ss		(x)							
P3.3 S/S management				(x)		(x)			
P3.4 Data and program storage				(x)					
P3.5 HCI I/F via Laptop				(x)		x			
P3.6 P/L Data Distribution (APM-int. and to/from Ground)				x				x	
P3.7 PLCU Processing Function with P/L provided appl. SW				x					

Legend:
(x) Support Main Function
1) Contractually part of DMSS
2) Internal P/L only

Table 6.2.1-13 Main Function to Subsystem/Assembly Allocation for Payload System Functions

System Function/ Main Function	**SUBSYSTEM/ASSEMBLY INVOLVED**								
	ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
				Nom.	Vital			HRM [1)]	Video Assy.
P4 Time Distribution for P/L									
P4.1 Power to S/S			(x)						
P4.2 Heat removal from S/Ss		(x)							
P4.3 S/S management				(x)		(x)			
P4.4 Time distribution (on P/L local bus)				x					
P5 Up-/downlink for P/L Data									
P5.1 Power to S/Ss			(x)						
P5.2 Heat removal from S/Ss		(x)							
P5.3 S/S management				(x)		(x)			
P5.4 P/L data distribution				x					
P5.5 P/L data formatting in PLCU				x					
P5.6 Transmission via TDRS and JEM/ICS								x	
P5.7 Reception via TDRS				x					
P6 Vacuum/Venting for P/L [2)]									
P6.1 Power to S/Ss			(x)						
P6.2 Heat removal from S/Ss		(x)							
P6.3 S/S management				(x)		(x)			
P6.4 Vacuum provision to P/L	x								
P6.5 Venting provisions to P/L	x								

Legend:
(x) Support Main Function
1) Contractually part of DMSS
2) Internal P/L only

Table 6.2.1-13: Main Function to Subsystem/Assembly Allocation for Payload System Functions (cont'd)

System Function/ Main Function	**SUBSYSTEM/ASSEMBLY INVOLVED**								
	ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
				Nom.	Vital			HRM [1)]	Video Assy.
P7 <u>N2 Provision to P/L</u>[3)]									
P7.1 Power to S/Ss			(x)						
P7.2 Heat removal from S/Ss		(x)							
P7.3 S/S management				(x)		(x)			
P7.4 N2 Supply to P/L	x								
P8 <u>Video/High Rate Data Provision for P/L</u>									
P8.1 Power to S/Ss			(x)						
P8.2 Heat removal from S/Ss		(x)							
P8.3 S/S management				(x)		(x)			
P8.4 Video signal distribution									x
P8.5 Video signal generation									x
P8.6 Video signal display									x
P8.7 Video signal processing									x
P8.8 Video/high rate data up-/downlink[2)]								x	
P9 <u>APM Housekeeping and Ancillary Data Distribution to P/L</u>									
P9.1 Power to S/Ss			(x)						
P9.2 Heat removal from S/Ss		(x)							
P9.3 S/S management				(x)		(x)			
P9.4 APM housekeeping and ancillary data distribution to P/L				x		x			
P10 <u>P/L EWACS</u>									
P10.1 Emergency and Warning Detection					x				
P10.2 Visual Annunciation				x	x				

Legend:

(x) Support Main Function

1) Contractually part of DMSS

2) Uplink via standard video interface to SSMB

3) Internal P/L only

Table 6.2.1-13: Main Function to Subsystem/Assembly Allocation for Payload System Functions (cont'd)

System Function/ Main Function	**SUBSYSTEM/ASSEMBLY INVOLVED**								
	ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
				Nom.	Vital			HRM 1)	Video Assy.
C1 Environmental Control									
C1.1 Power to S/Ss			(x)						
C1.2 Heat removal from S/Ss		(x)							
C1.3 S/S management				(x)		(x)			
C1.4 Atmospheric pressure control incl. repressurization**	x								
C1.5 Cabin temperature control	x								
C1.6 Cabin ventilation	x								
C1.7 Cabin humidity control	x								
C1.8 Trace gas sampling	x								
C1.9 PPO2, PPCO2, Ptot monitoring	x								
C2 Module Lighting									
C2.1 Power to S/Ss			(x)						
C2.2 Heat removal from S/Ss		(x)							
C2.3 S/S management				(x)		(x)			
C2.4 Illumination			x						
C3 Audio Comm.									
C3.1 Power to S/Ss			(x)						
C3.2 Heat removal from S/Ss		(x)							
C3.3 S/S management				(x)		(x)			
C3.4 Audio (ATU)							x		

Legend:
(x) Support Main Function
** repressurization via P.E.V.
1) Contractually part of DMSS

Table 6.2.1-14 Main Function to Subsystem/Assembly Allocation for On-Board Crew System Functions

System Function/ Main Function		**SUBSYSTEM/ASSEMBLY INVOLVED**								
		ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
					Nom.	Vital			HRM [2)]	Video Assy.
C4	Emergency, Warning, Caution Detection and Annunciation to Crew									
C4.1	Power to S/Ss			(x)						
C4.2	Heat removal from S/Ss		(x)							
C4.3	S/S management				(x)		(x)			
C4.4	Cabin ventilation (pre-set mode)	x								
C4.5	Water loop (circ. and accum. pressure) moni-toring		x			x				
C4.6	(Intentionally left blank.)									
C4.7	Fire detection (cabin)	x				x				
C4.8	Total pressure monitor-ing	x				x				
C4.9	PPO2 monitoring	x				x				
C4.10	PPCO2 monitoring	x				x				
C4.11	Ventilation monitoring	x				x				
C4.12	Emergency, Warning, Caution detection					x				
C4.13	Visual Annunciation					x				
C4.14	Trace Gas Sampling[1)]	x								
C4.15	P/L EWACS (same as P10)					x				
C5	System Monitoring and Control									
C5.1	Power to S/Ss			(x)						
C5.2	Heat removal from S/Ss		(x)							
C5.3	S/S management				(x)		x			
C5.4	S/S monitoring				x		x			
C5.5	S/S control				x		x			
C5.6	Data exchange onboard and to/from ground				(x)		(x)			

Legend:
- (x) Support Main Function
- 1) Only support to ISS monitoring function
- 2) Contractually part of DMSS

Table 6.2.1-14: Main Function to Subsystem/Assembly Allocation for On-Board Crew System Functions (cont'd)

System Function/ Main Function		**SUBSYSTEM/ASSEMBLY INVOLVED**								
		ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
					Nom.	Vital			HRM[1)]	Video Assy.
C6	Fire Suppression									
C6.1	Power to S/Ss			(x)						
C6.2	Heat removal from S/Ss		(x)							
C6.3	S/S management				(x)		(x)			
C6.4	Cabin depressurization	x								
C6.5	Module venting (post fire cleaning)	x								
C6.6	Fire Detection / Zone Power Kill in ISPRs			x		x				
C7	Emergency Lighting									
C7.1	Power to S/Ss			(x)						
C7.2	Illumination			x						
C8	Video									
C8.1	Power to S/Ss			(x)						
C8.2	Heat removal from S/Ss	(x)	(x)							
C8.3	S/S management				(x)		(x)			
C8.4	Video Monitoring be-tween Core Station/APM								x	x
C8.5	Video Monitoring on Ground								x	x

Legend:
(x) Support Main Function
1) Contractually part of DMSS

Table 6.2.1-14: Main Function to Subsystem/Assembly Allocation for On-Board Crew System Functions (cont'd)

System Function/ Main Function		**SUBSYSTEM/ASSEMBLY INVOLVED**									
		ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	Coms	
					Nom.	Vital			HRM[1]	Video Assy.
S1	Primary (Essential Cmd and Data) Activation, Monitoring and Control									
S1.1	Power to S/Ss			(x)						
S1.2	Heat removal from S/Ss		(x)							
S1.3	S/S Management				x	(x)[2]	(x)			
S1.4	Data Distribution				x	x				
S1.5	Data Formatting				x	x				
S1.6	Essential Data Prov.	(x)	(x)	(x)		x				
S1.7	Essential Cmd. Exec.					x				
S2	Emergency, Warning, Caution Detection, Annunciation and Safing									
S2.1	Intent. left blank									
S2.2	Power to S/Ss			(x)						
S2.3	Heat Removal from S/Ss		(x)							
S2.4	S/S Management				(x)		(x)			
S2.5	Emergency, Warning, Caution Detection and Annunciation	(x)	(x)	(x)		x	(x)			
S2.6	Safing Execution	x				(x)				

Legend:
(x) Support Main Function
1) Contractually part of DMSS
2) Executing SSMB commands

Table 6.2.1-15 Main Function to Subsystem/Assembly Allocation for SSMB Monitoring/Control System Functions

System Function/ Main Function		**SUBSYSTEM/ASSEMBLY INVOLVED**								
		ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
					Nom.	Vital			HRM [1)]	Video Assy.
S3	Overall Mission Management (incl. ISS Resource Control, FDIR, etc.)									
S3.1	Power to S/Ss			(x)						
S3.2	Heat removal from S/Ss		(x)							
S3.3	S/S management				(x)		(x)			
S3.4	Data distribution				x					
S3.5	Data processing/ formatting/FDIR				x		x			
S3.6	Data provisioning	(x)	(x)	(x)	(x)	(x)	(x)		(x)	(x)
S3.7	Command execution	(x)	(x)	(x)	(x)		x		(x)	(x)

Legend:
(x) Support Main Function
1) Contractually part of DMSS

Table 6.2.1-15: Main Function to Subsystem/Assembly Allocation for SSMB Monitoring/Control System Functions (cont'd)

System Function/ Main Function		**SUBSYSTEM/ASSEMBLY INVOLVED**								
		ECLSS	TCS	EPDS	DMSS		Appl. SW	AU-DIO	COMS	
					Nom.	Vital			HRM[1)]	Video Assy.
G1	Primary (Essential Cmd. and Data) Activation, Monitoring and Control (w/o ISS and Crew Support)									
G1.1	Power to S/Ss			(x)						
G1.2	Heat removal from S/Ss		(x)							
G1.3	S/S management					x				
G1.4	Data distribution					x				
G1.5	Data formatting					x				
G1.6	Telemetry data provisioning	(x)	(x)	(x)						
G1.7	Telecommand execution	(x)	(x)	(x)		x				
G2	Overall Mission Management and APM System Monitoring and Control									
G2.1	Power to S/Ss			(x)						
G2.2	Heat removal from S/Ss		(x)							
G2.3	S/S management				(x)		(x)			
G2.4	Data distribution				x					
G2.5	Data processing / formatting				x		x			
G2.6	Telemetry data provision	(x)	(x)	(x)	(x)	(x)			(x)	(x)
G2.7	Telecommand execution	(x)	(x)	(x)	(x)		x		(x)	(x)
G2.8	Downlink						x		x	

Legend:
(x) Support Main Function
1) Contractually part of DMSS

Table 6.2.1-16 Main function to Subsystem/Assembly Allocation for Ground Monitoring/Control System Functions

System Function/ Main Function	**SUBSYSTEM/ASSEMBLY INVOLVED**								
	ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
				Nom.	Vital			HRM[1)]	Video Assy.
R1 <u>Check-Out</u>									
R1.1 Power to S/Ss			(x)						
R1.2 Heat removal from S/Ss		(x)							
R1.3 S/S management				(x)		(x)			
R1.4 Checkout data provisioning/ command execution	x	x	x	x	x	x		x	x
R1.5 Data processing and display				x		x			
R1.6 Data distribution				x					

Legend:
(x) Support Main Function
1) Contractually part of DMSS

Table 6.2.1-17 Main Function to Subsystem/Assembly Allocation for Servicing/Reconfiguration System Functions

System Function/ Main Function	**SUBSYSTEM/ASSEMBLY INVOLVED**								
	ECLSS	TCS	EPDS	DMSS		Appl. SW	AUDIO	COMS	
				Nom.	Vital			HRM[1)]	Video Assy.
SS1 APM Heating									
SS1.1 Heater Control	x								
SS1.2 Shell Heating		x							

Legend:
(x) Support Main Function
[1)] Contractually part of DMSS

Table 6.2.1-18 Main Function to Subsystem/Assembly Allocation for System Support Functions

6.2.1.2 Functional Architecture

6.2.1.2.1 General

6.2.1.2.1.1

The APM functional architecture comprises:

• Electrical Power Distribution	para. 6.2.1.2.2
• Illumination (normal and emergency)	para. 6.2.1.2.3
• Data Management (vital and nominal)	para. 6.2.1.2.4
• Audio	para. 6.2.1.2.5
• Communications including Video and High Rate Data	para. 6.2.1.2.6
• Thermal Control/Environmental Life Support	para. 6.2.1.2.7
• Emergency, Warning and Caution	para. 6.2.1.2.8
• Failure Detection, Isolation and Recovery	para. 6.2.1.2.9

as shown in Figure 6.2.1.2-1.

6.2.1.2.1.2

The functional interface requirements shall be in accordance with the related system support specifications.

NOTES:

- The interfaces between PICA and the other APM subsystems/equipments are contained in the PICA Specification.
- The interface design is agreed by Internal ICDs as identified in applicable document 2.1.4.1: ICD Identification List

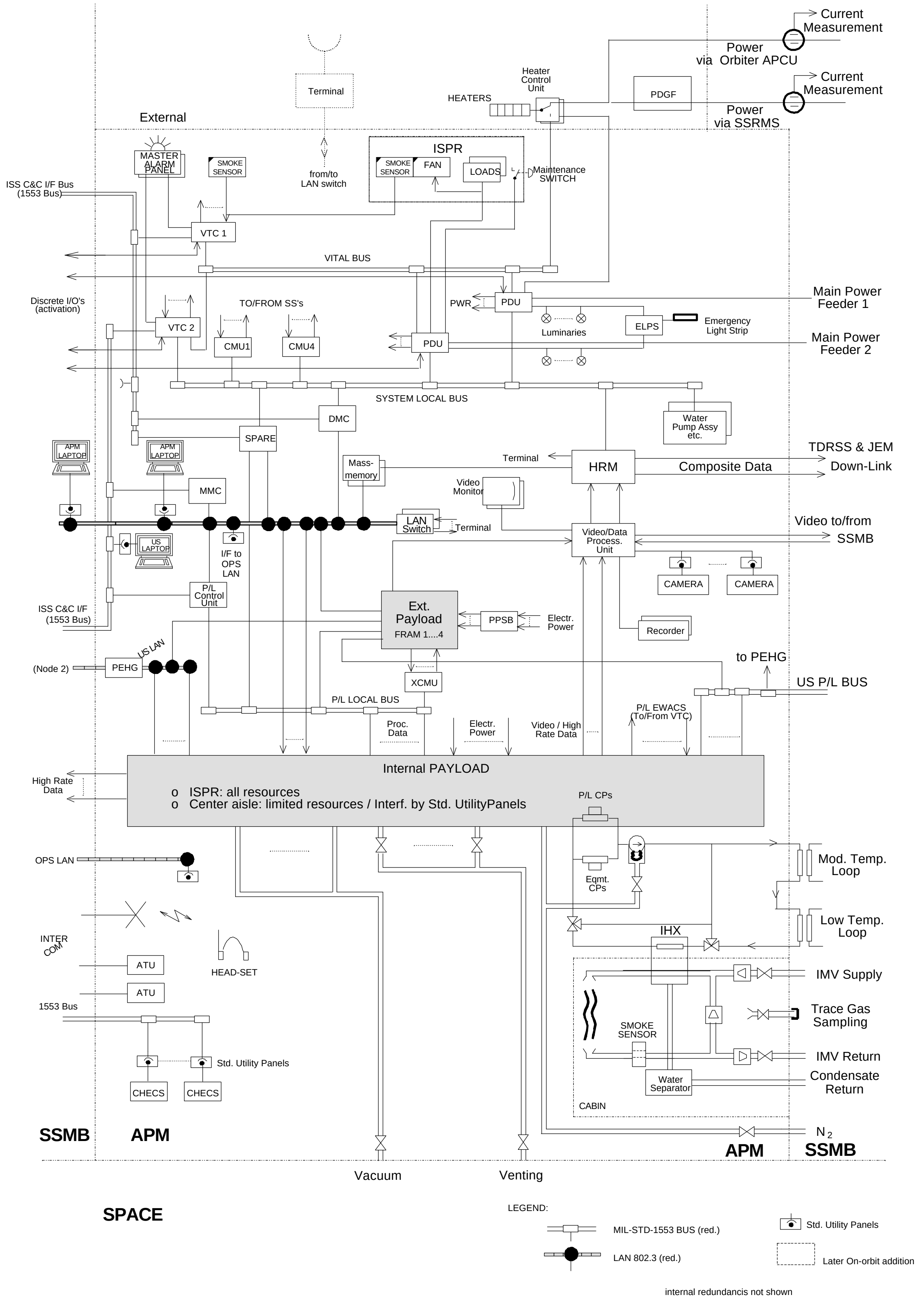


Figure 6.2.1.2-1 APM Functional Architecture

6.2.1.2.2 Electrical Power Distribution

6.2.1.2.2.1 General

6.2.1.2.2.1.1

The APM shall receive electrical power from two main feeders from the SSMB and distribute it via dedicated, separately switchable and protected 120 VDC outputs to:

- Subsystem loads
- Payload loads

and generate 28 VDC and distribute it via separately switchable and protected outputs to specific subsystem loads.

6.2.1.2.2.1.2

Each subsystem equipment, which shall be configurable to ON/OFF during different mission phases, shall have its own internal, commandable power switch.

NOTES:

- De-energizing of 120 VDC power feeders to the equipment is realized by electronic switches in the Power Distribution Units, which are controlled by remote commands which can be disabled by the Power Maintenance Switches on the ISPRs.
- Exceptions are Space Station Common Hardware (e.g. ATUs and Lighting Units) having no input protection and power activation/deactivation switches.

6.2.1.2.2.1.3

The Power Distribution to the different loads shall be realized by:

- 2 identical Power Distribution Units (PDU)
- 4 Standard Utility Panels (power outlet section)
- 1 Payload Power Switching Box (PPSB) for External P/L.

6.2.1.2.2.2 Power Distribution to Payload

The electrical power distribution system shall provide the outputs for the payload as shown in Table 6.2.1.2-1.

Type	No. of Outlets	Nom. Power	Peak Power	Remarks
High Power H/P	5	6.0 kW	6.0 kW	ISPRs and Ext. P/L
Medium Power M/P	5	3.0 kW	3.6 kW	
Essential/Auxiliary Power	10	1.2 kW	1.2 kW	
Utility Power	4 x 3	1.2 kW	1.2 kW	3 GFI protected outlets per Standard Utility Panel
Power to one EPF location	2	1.25 kW	1.25 kW	total power to complete EPF shall not exceed 2.5 kW

NOTES:

- All P/L power figures applicable at nominal voltage.
- Trip time of all output protections: $\geq$ 1.5 ms (internal P/L)
- Inrush current capability for lateral ISPRs (25 A, 10 ms) exceeds interface requirements for essential/auxiliary power.
- Inrush current capability for overhead ISPRs reduced to 18 A (specified 22 A).

Table 6.2.1.2-1 P/L Dedicated Power Outlets

6.2.1.2.2.3 Power Distribution to Subsystem Equipments

6.2.1.2.2.3.1 Power Distribution to VTC

Each VTC shall be powered from the two PDUs when the PDUs receive an ON command from SSMB.

6.2.1.2.2.3.2 Power Distribution to CMU

6.2.1.2.2.3.3 Power Distribution to Data Management Processors

Each data management processor shall be powered from two PDUs.

6.2.1.2.2.3.4 Power Distribution to Laptop

Each individual Standard Utility Panel (SUP) at a hook-up location shall be wired to one power outlet of one PDU.

NOTE:

SUP function redundancy is provided by the four panels but not on SUP level.

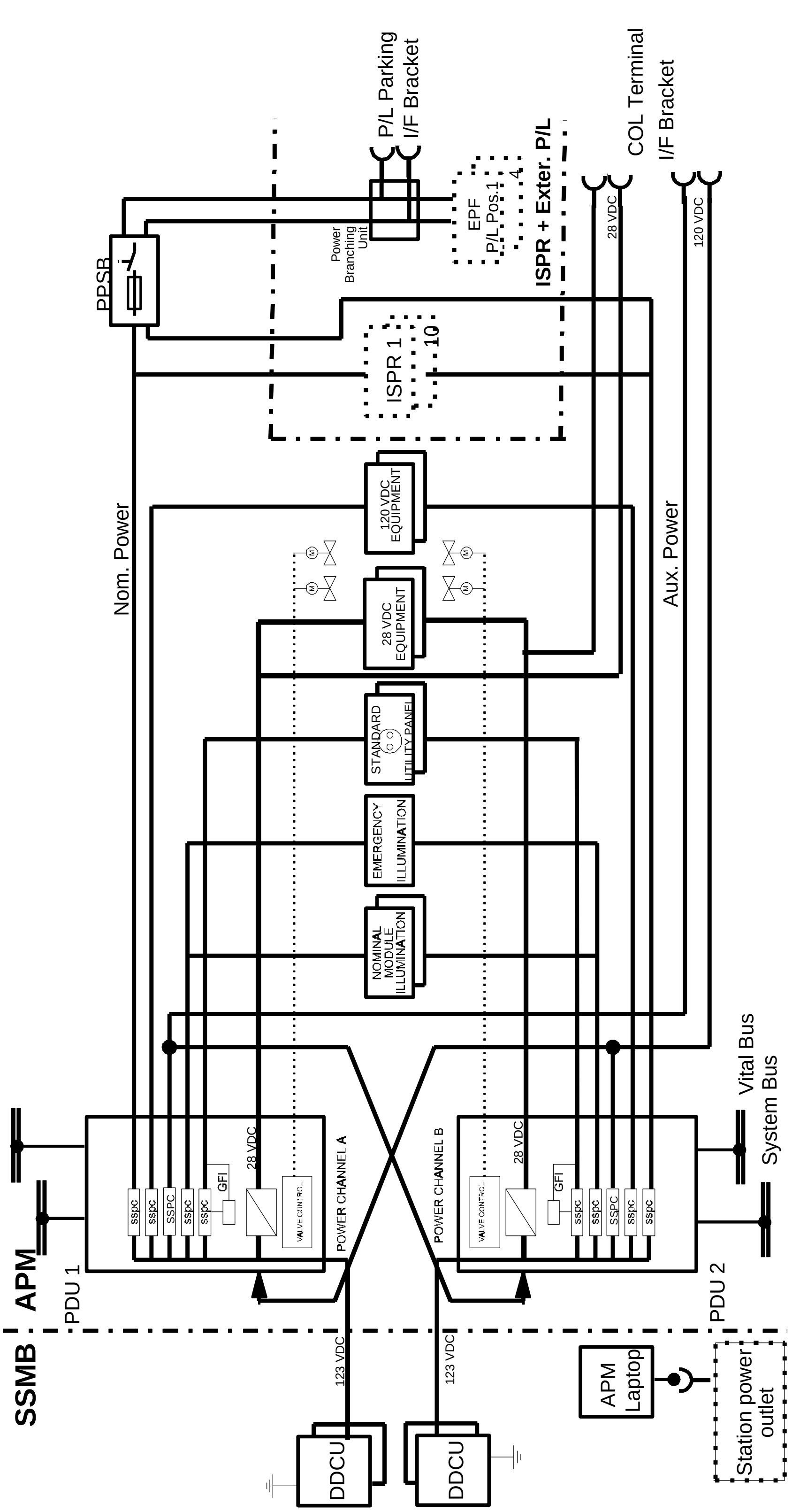


Figure 6.2.1.2-2A) Power Distribution Architecture

6.2.1.2.2.3.5 Utility Outlet ON/OFF Control

6.2.1.2.2.3.5.1

The power outlets of the Standard Utility Panels shall be remotely ON/OFF-commandable.

6.2.1.2.2.3.5.2

Local OFF-command at the Standard Utility Panel shall be possible using the Ground Failure Interruptor test button as command initiator.

NOTE:

The Standard Utility Panel does not provide local ON-command capability.

6.2.1.2.2.3.5.3

Positive power status indication shall be provided for each utility outlet on the Standard Utility Panels.

6.2.1.2.2.3.6 Power Distribution to other Subsystem Equipment

All other subsystem equipments shall be powered from the two PDU's so that loss of one PDU does not lead to loss of a unit / function.

6.2.1.2.2.3.7

Each redundant unit shall be powered from separate primary power sources (i.e. the two SSMB feeders) in such a way that loss of one power source does not result in power unavailability for the redundant power supply.

6.2.1.2.2.3.8 Power Distribution to P/L Racks

The power feeders for one lateral P/L rack group shall be derived from one power channel, the other group from the other power channel to allow for dedicated harness routing per one APM side.

6.2.1.2.2.3.9 Distribution to External Payload

6.2.1.2.2.3.9.1

The power to the External Payload shall be fed commonly from the power feeders from two ISPRs, as shown in Figure 6.2.1.2-2b).

6.2.1.2.2.3.9.2

Power switching to particular External Payload shall be possible by manual switches.

NOTE:

It must be ensured by procedure that unintentional switching with power feeder is avoided (switch not qualified for switching of 120 VDC; operation under load will damage switch).

6.2.1.2.2.4 Fire Annunciation/Power Switch Down

The APM shall monitor and control each active P/L rack by interfacing with the there included fire/smoke sensors and fire detection and suppression (FDS) panels providing the following functions:

- Power feeder status indication
- Fire annunciation (LED)
- Manual power switching (Kill Power by astronaut in case of fire in rack or maintenance of rack using the "Maintenance Power Switch" on the FDS Panel)

as shown in Figure 6.2.1.2-4.

NOTE:

P/L Design Integration Responsible must ensure these functions inside the P/L racks.

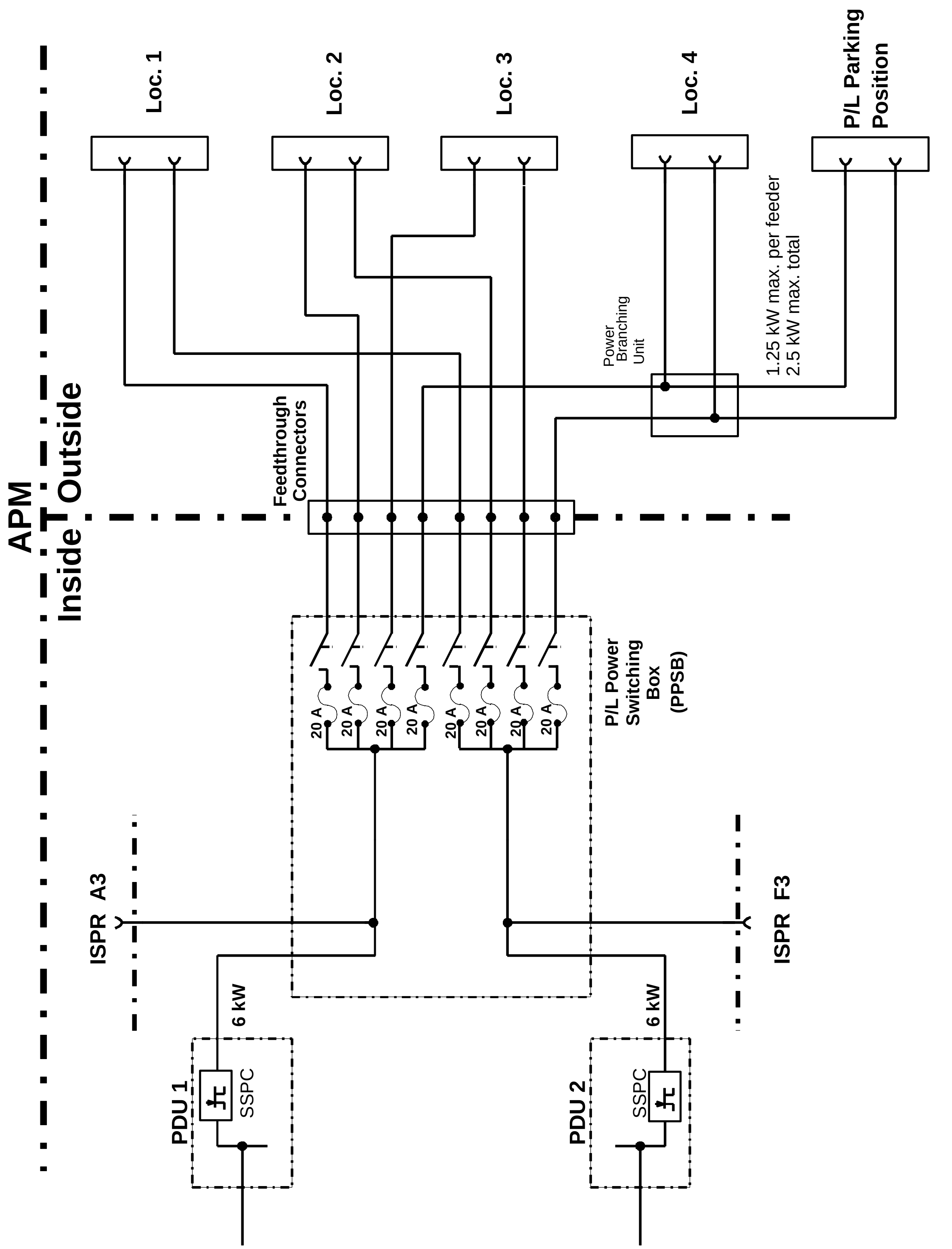


Figure 6.2.1.2-2B) Electrical Power Distribution

Figure 6.2.1.2-3 Intentionally left blank

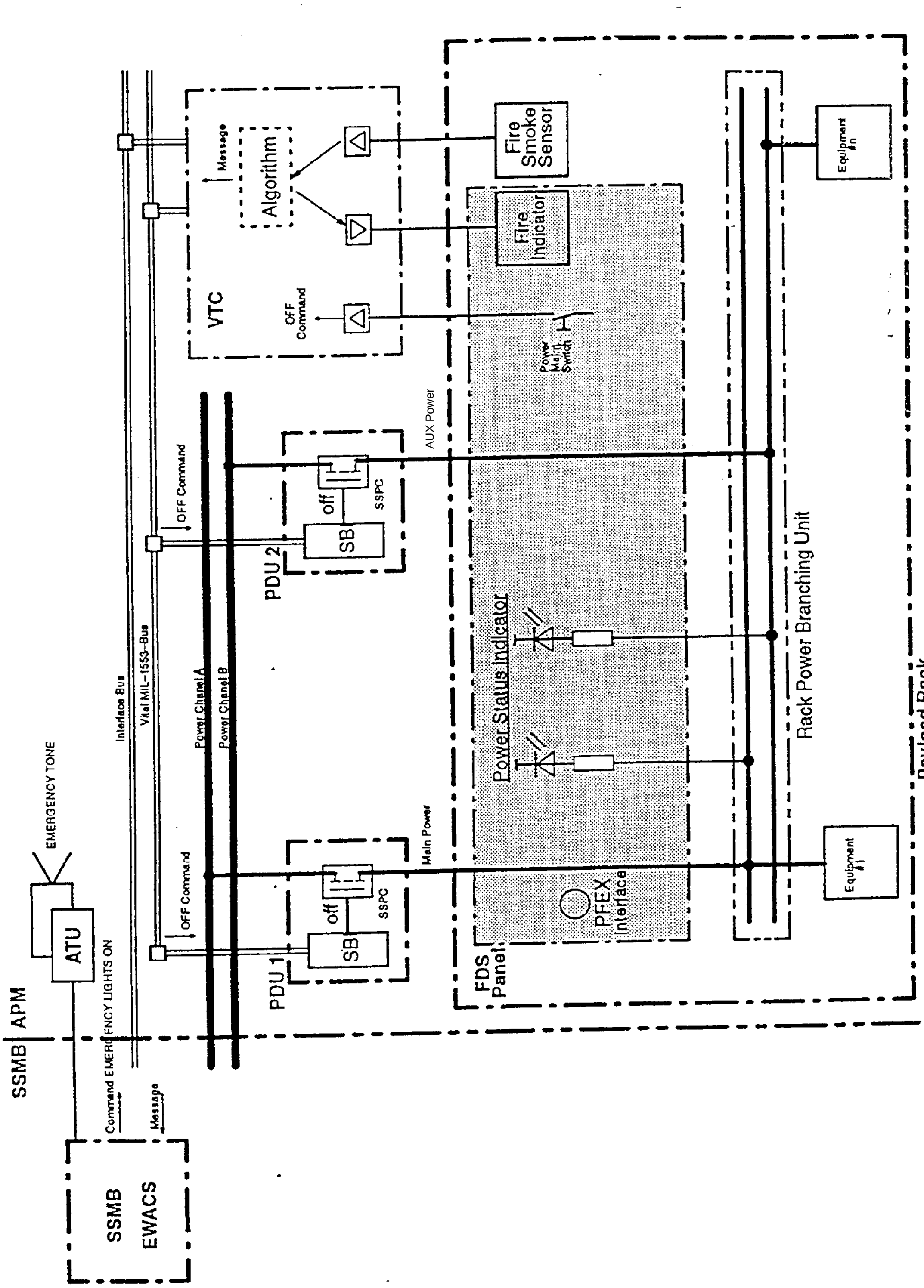


Figure 6.2.1.2-4 Fire Detection and Suppression Functional Block Diagram for ISPRs

6.2.1.2.2.5

The APM shall monitor and control the zones as defined in para. 6.2.1.2.8.1.4 inter-facing with the Fire Annunciator/Suppression (FAS) panels located there providing the following functions:

- Fire annunciation (LED)

depending on its location.

6.2.1.2.3 Illumination

6.2.1.2.3.1 Nominal Illumination

6.2.1.2.3.1.1

The APM shall provide 8 module lighting units equally connected to the two power channels for module internal illumination as visualized in Figure 6.2.1.2-5.

6.2.1.2.3.1.2 Switching of Illumination

Each group of lighting units shall be switchable by two manually operated switch panels located at the port cone.

6.2.1.2.3.2 Emergency Illumination

6.2.1.2.3.2.1

The APM shall provide independent, self-energizing emergency regress illumination by one lighting strip as shown in Figure 6.2.1.2-5.

6.2.1.2.3.2.2

The emergency illumination shall be activated automatically in the event of loss of both power feeders.

6.2.1.2.3.2.3

The lighting strips shall be placed in the port cone in a suitable manner to indicate the exit to the node within the dark APM.

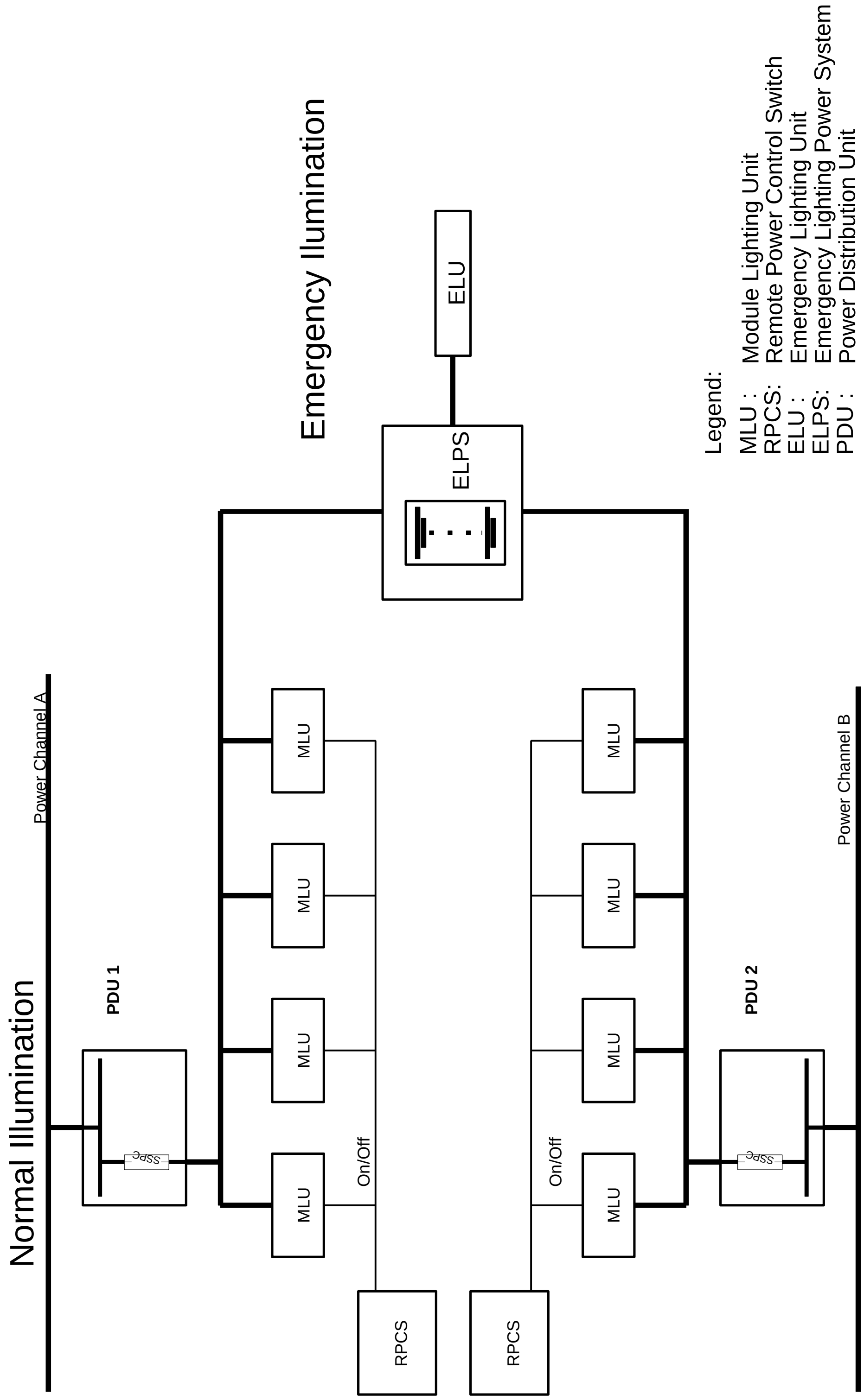


Figure 6.2.1.2-5 Module Internal Illumination - Block Diagram

6.2.1.2.4 Data Management

6.2.1.2.4.1 General

6.2.1.2.4.1.1.1

The APM shall provide for data management for

- Subsystem primary Command and Control (including Emergency, Warning, Caution and Safing)
- Subsystem nominal Command and Control and Monitoring (including FDIR)
- Payload Command, Control and Monitor Services Provision

by on-board data processing resources (hardware and software including Human Computer Interface), data transfer to/from the Core Station and data transfer to/from the SSCC and APM Ground Control Center via the Core Station.

6.2.1.2.4.1.2

The APM shall provide time data for system and P/L usage synchronized by the Core Station master clock.

6.2.1.2.4.1.3

The Data Management System (DMS) shall be realized by

- the Vital section of the Data Management System including VTC Software
- the Nominal section of the Data Management System including Application Software

as depicted in Figure 6.2.1.2-6.

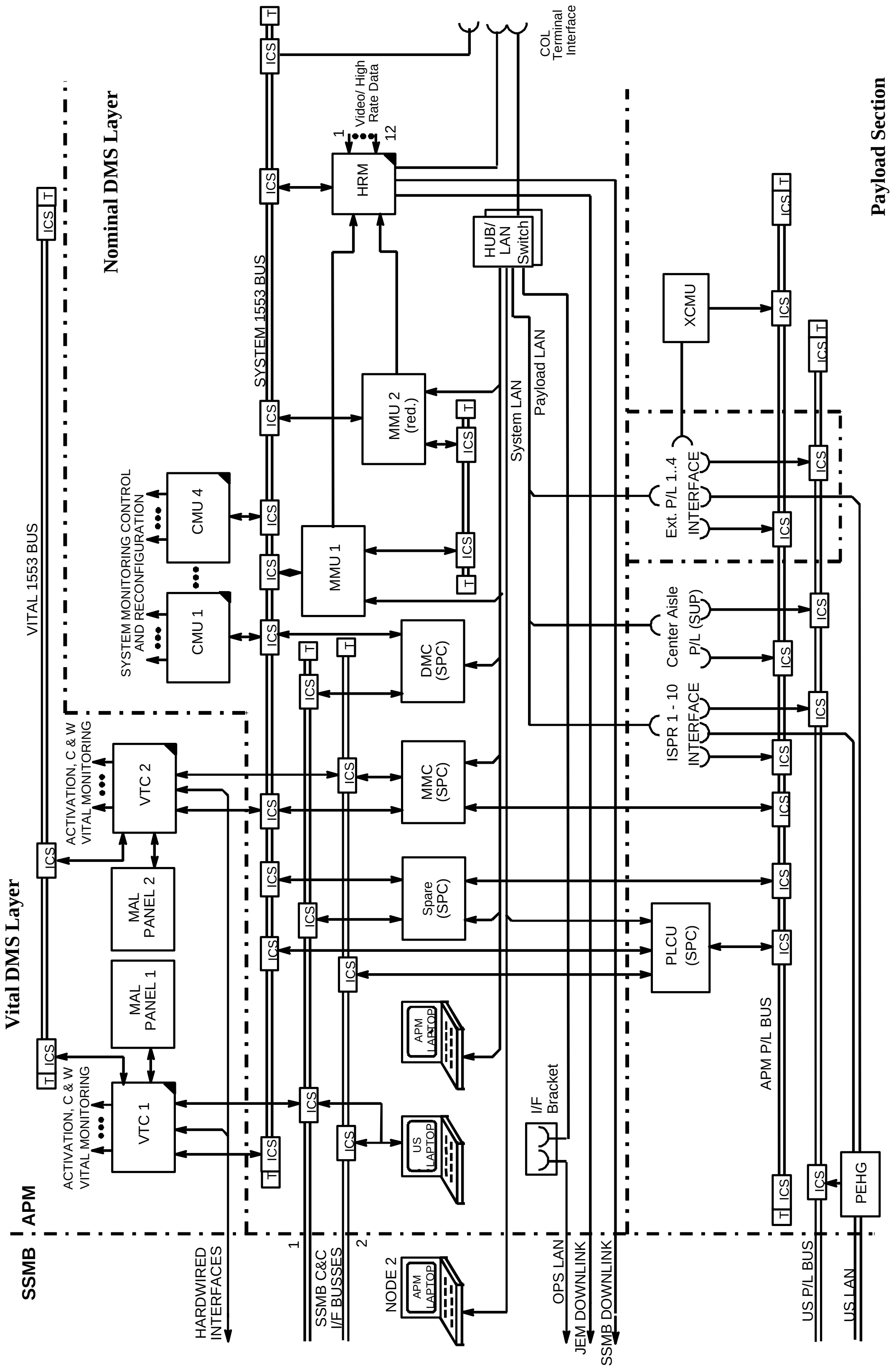


Figure 6.2.1.2-6A) Data Management System Block Diagram

6.2.1.2.4.1.4

The Vital DMS shall be fully autonomous except activation/monitoring, which is executed by the SSMB via hardwired input/output signals, and shall perform activation/monitoring and reconfiguration of the Nominal DMS via hardwired interfaces.

NOTES:

- Failure management/reconfiguration of the vital DMS is fully based on SSMB and/or ground control.
- During APM activation the Vital DMS activates also subsystem equipment needed in this phase via CMUs on the system local bus, which are finally part of the Nominal DMS.

6.2.1.2.4.1.5

The nominal DMS shall be centered around a Local Area Network (LAN) for

- interconnection of all computers
- access to mass memory
- interface to APM laptop for crew interface
- interface for payload
- connection to SSMB Ops LAN (hardware provision only)

6.2.1.2.4.1.6

The Nominal DMS shall include

- a system local bus driven by the dedicated Data Management Computer (DMC) for data acquisition / distribution to/from system items
- a P/L local bus driven by the dedicated Payload control Unit (PLCU) for data acquisition / distribution to/from P/L items
- a mass memory for program/intermediate data storage.

6.2.1.2.4.1.7

The Nominal DMS shall include a dedicated Mission Management Computer (MMC) executing all system level mission management data management functions.

6.2.1.2.4.1.8

All computer functions specified above shall be one-failure tolerant by

- one spare computer, which can be configured in such a way that it can replace any dedicated computer
- each bus and the LAN having a nominal and cold redundant path.

6.2.1.2.4.1.9

The APM shall provide hook-up points/locations to connect APM laptops allowing the astronauts to communicate with the nominal data management system from within the SSMB node and in the APM interfacing with the LAN.

6.2.1.2.4.1.10

The Data Management Computer (DMC) and Payload Control Unit (PLCU) shall be realized by an MMC identical computer.

6.2.1.2.4.1.11

All local bus hardware and driving software shall be identical for the system and P/L local bus in accordance with MIL-Std. 1553B.

6.2.1.2.4.1.12

The Local Area Network (LAN) shall be in accordance with IEEE 802.3 (ETHERNET).

6.2.1.2.4.1.13

The Data Management System shall periodically distribute time data by the PLCU via the P/L local bus to the P/L items located in the active P/L racks and at the center aisle (via Standard Utility Panels).

6.2.1.2.4.1.14

The data management shall provide a stub interface (output of 1553B Bus Interconnecting Station) to each active P/L rack and center aisle provisions (at two Standard Utility Panels).

NOTE:

Data processing for P/L items connected to these interfaces is not under APM responsibility but the P/L Design Integrator.

6.2.1.2.4.1.15 External Payload

6.2.1.2.4.1.15.1

The external P/L shall be connected to the APM P/L Bus and APM LAN or US P/L Bus and US LAN, as shown in Figure 6.2.1.2.6.b).

6.2.1.2.4.1.15.2 (Intentionally left blank)

6.2.1.2.4.2 Data Management System Software

6.2.1.2.4.2.1 General

6.2.1.2.4.2.1.1

The Data Management System software shall be realized by the following software entities:

- Vital DMS software executing in the VTC
- Nominal DMS software executing in the DMS computers and the Laptop.

6.2.1.2.4.2.1.2

The APM software shall support a hierarchical operation and control capability including automated functions allocated to APM system level and extending down to equipment level as necessary.

NOTE:

It is assumed that the SSMB software performs APM primary activation and control in combination with the VTC software.

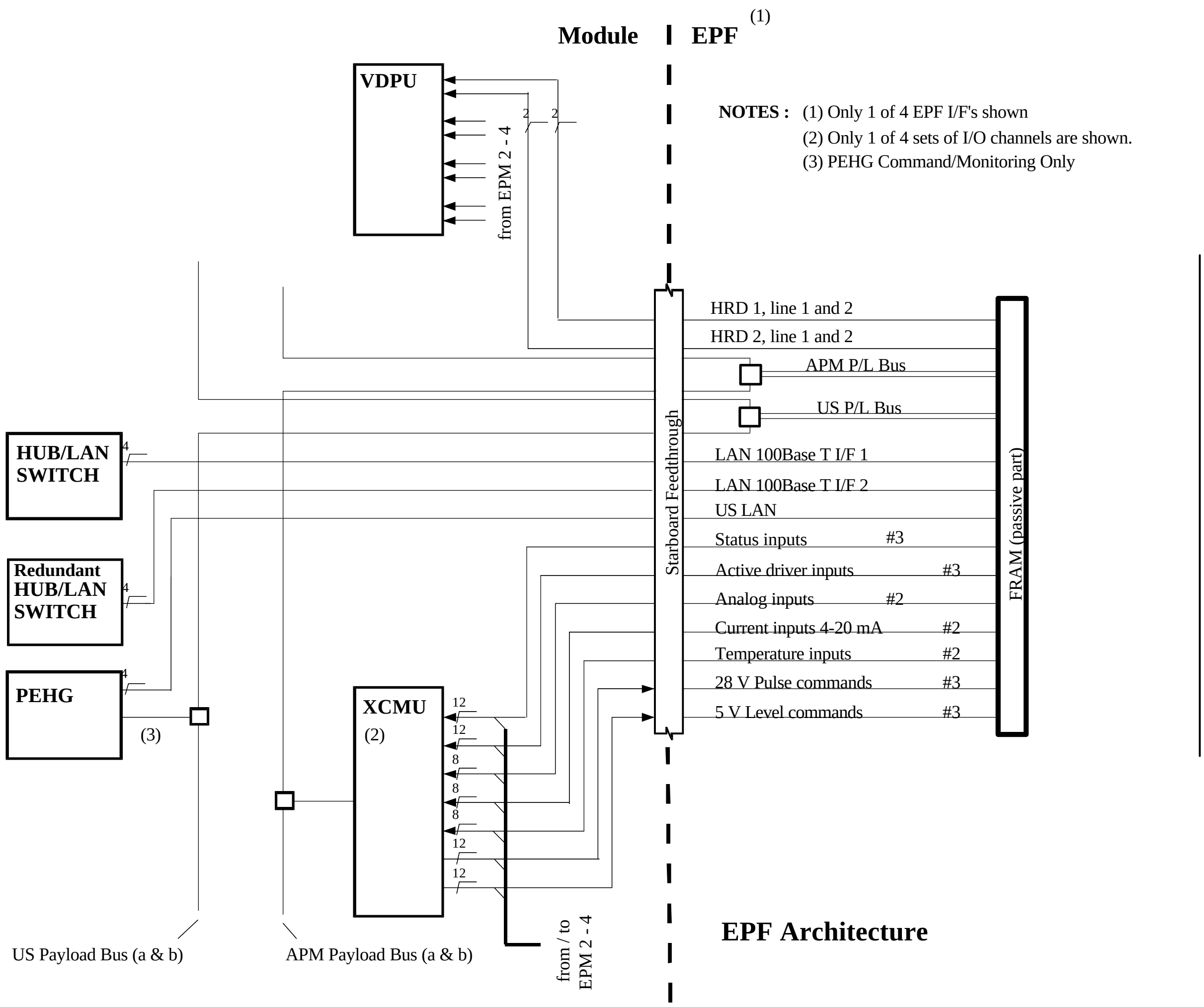


Figure 6.2.1.2-6B) External Payload Functional Architecture (1 EPF I/F shown only, in example configuration)

6.2.1.2.4.2.2 Vital DMS SW

6.2.1.2.4.2.2.1.1

The VTC SW shall be fully autonomous, i.e. not relying on the SSMB or nominal DMS section.

6.2.1.2.4.2.2.2

The VTC SW shall be contained in a non-eraseable memory of the VTC requiring no external activities for start-up of all continuous VTC functions.

6.2.1.2.4.2.2.3

The VTC SW shall perform the following functions after activation:

- Emergency Warning & Caution condition detection and status transfer to SSMB
- Emergency Warning & Caution commanded annunciation on MAL Panel
- Fire detection by:
– air circulation fan monitoring (for ISPRs)
– fire/smoke sensor output signal processing (for cabin zone, ISPRs and center aisle payload interfacing at SUPs).

6.2.1.2.4.2.2.4

The VTC SW shall perform the following functions when receiving an external command via the 1553B interface bus:

- Nominal DMS activation/monitoring
- Nominal DMS computer reconfiguration
- Depressurization control
- Heater system/configuration control
- Safing procedures execution.

6.2.1.2.4.2.3 Nominal DMS SW

6.2.1.2.4.2.3.1

The nominal DMS SW shall comprise of the following items:

- DMS Operating System (OS)
- DMS user Support Services (USS)
- Laptop Operating System/Basic Software
- DMS Management Software(MSW)
- DMS Application Software Packages
  - Core Application Software(COAP)
  - COLUMBUS Laptop Applications(LAPAP)
  - System/Subsystem Level Automated Procedures (FLAP)
- HCI Software Services

6.2.1.2.4.2.3.2

The SW executed in the nominal DMS computers shall be stored/loaded to/from the Mass Memory Unit except for Laptop Applications which shall be stored on each local Laptop disc.

6.2.1.2.4.2.3.3

The SW design shall allow for software reconfigurations without complete stop/reload of one or all of the Nominal DMS computers.

NOTE:

Not all software reconfigurations can be performed without reload, in particular these related to interactions between DMS computers such as new data pool configurations.

6.2.1.2.4.2.3.4

The SW design shall support a ground data base with an end-item concept which structures all reconfigurable items into a hierarchical name tree notation reflecting the hierarchical and functional decomposition of the APM.

6.2.1.2.4.2.3.5

The data base shall support the generation of onboard data tables used for the configuration of flight software.

6.2.1.2.4.2.4 DMS Operating System/DMS User Support Services

6.2.1.2.4.2.4.1

The Operating System (OS) used in DMS standard processors shall be VxWorks® or a POSIX based operating system (applicable document 2.1.2.6: POSIX Standards) or equivalent performance.

6.2.1.2.4.2.4.2

The execution environment shall support the linking between Dynamic Link Libraries and Programs at program run-time.

6.2.1.2.4.2.4.2.1

User support services of the DMS shall provide the following functions:

- CCSDS packet routing service
- Data storage and retrieval
- Monitoring services
- User Control Language (UCL) execution
- Trend/mean analyses
- Logging services
- Failure management services.

6.2.1.2.4.2.5 DMS Management Software

The DMS Management Software shall perform configuration and resource management of DMS hardware and software items and non-DMS software items by providing the following functions:

- S/W configuration management and control
- DMS resources allocation and monitoring
- DMS overall configuration control
- DMS housekeeping and logging
- DMS command processing
- DMS failure management
- DMS memory dump
- Network management.

6.2.1.2.4.2.6 Core Application Software (COAP)

6.2.1.2.4.2.6.1

The COAP shall provide the following functions for APM system and P/L Management:

- Master Time Line (MTL) Processing
- Command Checking
- Interface Data Function
- MTL Data Server.

6.2.1.2.4.2.6.2

The MTL Processing shall allow for up to 30 activities in parallel, each with a given start time and composed of one or more entries.

6.2.1.2.4.2.6.3

The entries shall be accepted as CCSDS packets, which are to be issued to the final end items using DMS services.

6.2.1.2.4.2.6.4

The time of execution of each entry shall be related to the time of that entry, which is relative to the start of the activity to which it belongs.

6.2.1.2.4.2.6.5

The COAP shall provide the function to edit information associated with the activity for:

- Start time of activity
- Stop time of activity (manual activity only)
- Duration (manual activity only)
- Assigned operator/team
- Trigger mode
- Enable flag.

6.2.1.2.4.2.6.6

The COAP shall provide the following interfaces for MTL control purposes:

- Add activity from a predefined on-board list
- Add new activity / block of activities
- Delete activity
- MTL execution stop
- MTL execution start.

6.2.1.2.4.2.6.7

The COAP MTL processor software shall provide feedback information on the execution of the MTL to the SSMB at the level of activity (i.e. advice of activity start when all the entries for a given activity have been completed / activity finished, the corresponding feedback is sent via the 1553 Interface Bus to the SSMB).

6.2.1.2.4.2.6.8

The COAP MTL processor software shall provide and update MTL display data concerning the execution of the MTL to the APM Laptops containing all related information (i.e. both activities and entries).

6.2.1.2.4.2.6.8.1

The COAP Command Checker software shall provide the capability to check the APM environment status prior to the execution of commands coming from any source:

- MTL
- CPL
- APM crew command
- Command from SSMB (by SSMB crew or APM Control Center).

6.2.1.2.4.2.6.9

The COAP Command Checker shall take the following parameters into account:

- System and Payload parameters contained in data pool
- Software variables in data pool

ensuring that the parameter actuals are within the specified ranges before execution of the command takes place.

6.2.1.2.4.2.6.10

In case the parameter actuals are not within the ranges defined in the System Command Check Descriptor, the COAP Command Checker shall reject the command.

6.2.1.2.4.2.6.11

COAP shall provide the function to unpack CCSDS packets according to the Packet Descriptor and place the data in the APM data pool as a set of software variables being available to any DMS user (including the Payload Control Unit).

6.2.1.2.4.2.6.12

COAP shall provide a function to receive and distribute multiple CCSDS packets contained within a single "Carrier" CCSDS packet.

6.2.1.2.4.2.6.13

COAP shall provide a function to initiate an APM reconfiguration to a mode compatible with the Station Mode in the command.

6.2.1.2.4.2.7 COLUMBUS Laptop Applications (LAPAP)

6.2.1.2.4.2.7.1

The COLUMBUS laptop applications shall provide the following functions for APM system and P/L operation:

- Access to help files and crew documentation
- Interpretation and execution of crew procedures including Logic Flow Diagram and checklist procedure execution
- Procedures monitoring and control (SWOPs, APs, CPLs)
- Display of system notifications (detected failure exceptions, wrong crew-provided inputs, etc.)
- Date and time display
- Master Timeline display.

6.2.1.2.4.2.7.2

The LAPAP shall provide a Human Computer Interface (HCI) in accordance with applicable document 2.1.1.12: APM HCI Flight Standard.

6.2.1.2.4.2.8 System/Subsystem Level Automated Procedures

6.2.1.2.4.2.8.1

The Automated Procedures shall be implemented in the User Control Language (UCL) supporting the control and operation of the APM by the commanding of individual end items and single subsystem reconfigurations to the overall system operations.

6.2.1.2.4.2.8.2

The Automated Procedures shall be responsible for

- Reconfiguration incl. Failure Management and Load Shedding
- Activation/deactivation
- Checkout

of the APM flight configuration.

6.2.1.2.4.2.9 Human Computer Interface (HCI) Software

6.2.1.2.4.2.9.1

The HCI software shall provide all necessary services (HCI services) to be used by the HCI applications related to monitoring and control of the APM system and the P/L by the crew.

6.2.1.2.4.2.9.2

The HCI software shall provide a run-time environment to animate synoptic displays based on the commercial tools SAMMI and/or MOTIF.

6.2.1.2.5 Audio

6.2.1.2.5.1

The APM shall accommodate two station common Audio Terminal Units (ATUs) for Emergency, Warning and Caution tone transmission and local voice communication as visualized in Fig. 6.2.1.2-7.

6.2.1.2.5.2

The APM shall accommodate one station common Audio Antenna for communication with wireless head-sets within the APM as visualized in Figure 6.2.1.2-7.

6.2.1.2.6 Communications including Video and High Rate Data Distribution

6.2.1.2.6.1

The APM shall provide for:

- video signal and high rate data switching and distribution
- APM overview/video signal generation
- APM/SSMB/payload generated video display
- video signal processing/compression for downlinking
- video signal recording
- data multiplexing and distribution to SSMB (TDRS I/F and JEM/ICS I/F) for downlinking

NOTE:

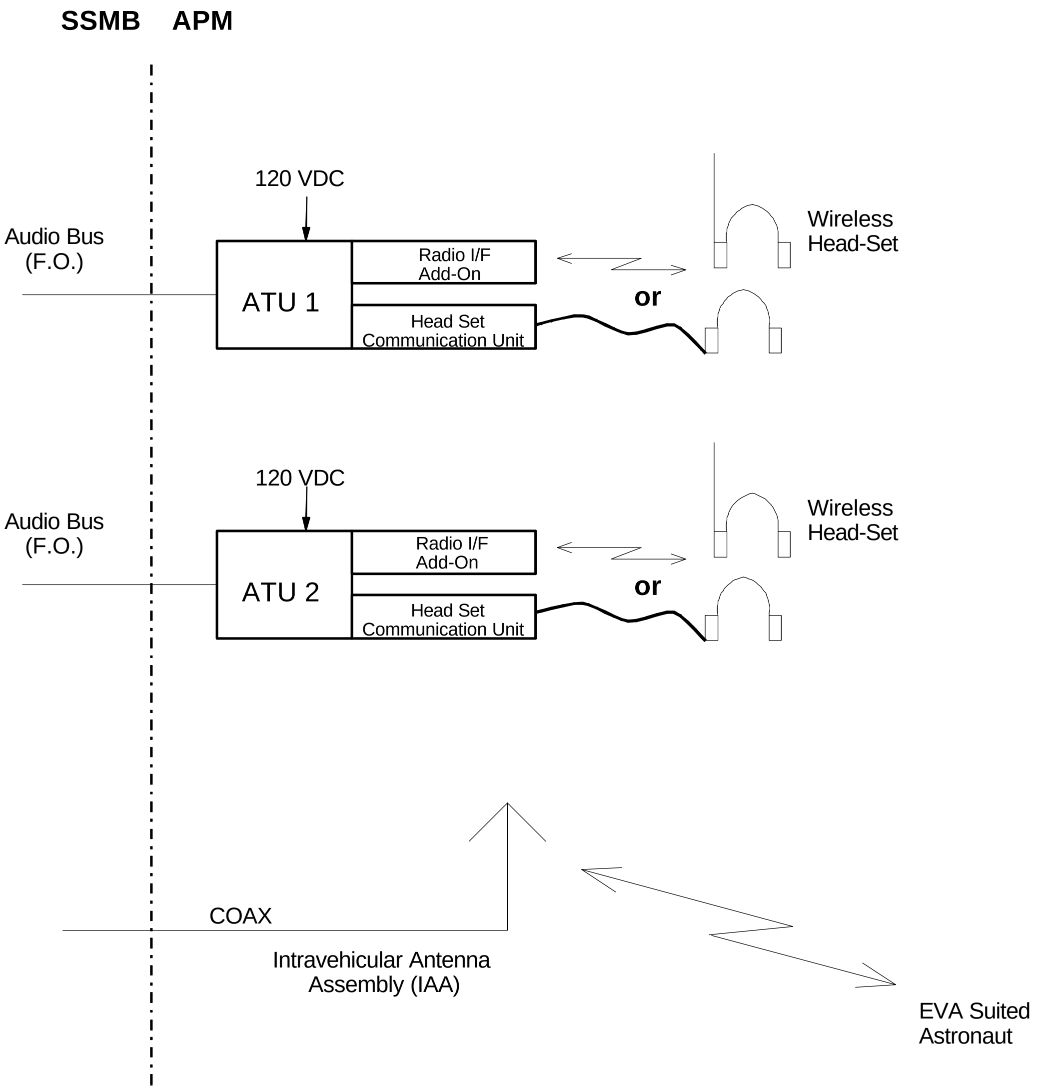
APM external P/L has only high rate data, no video interfaces.

6.2.1.2.6.2

The Communications System shall be realized by the following items/subsystem functions:

- 2 Video Monitors
- 2 Video Cameras for portable useage or fixed locations (see Figures 6.1.7.2-6 and 6.1.7.2-7)
- Video/Data Processing Unit (VDPU)
- 2 Video Recorders (one cold redundant)

as shown in Figure 6.2.1.2-8.



Note: ISS common Radio I/F Add-On, Head Set Communication Units, and Head Sets not part of APM program

Figure 6.2.1.2-7 Audio System Block Diagram

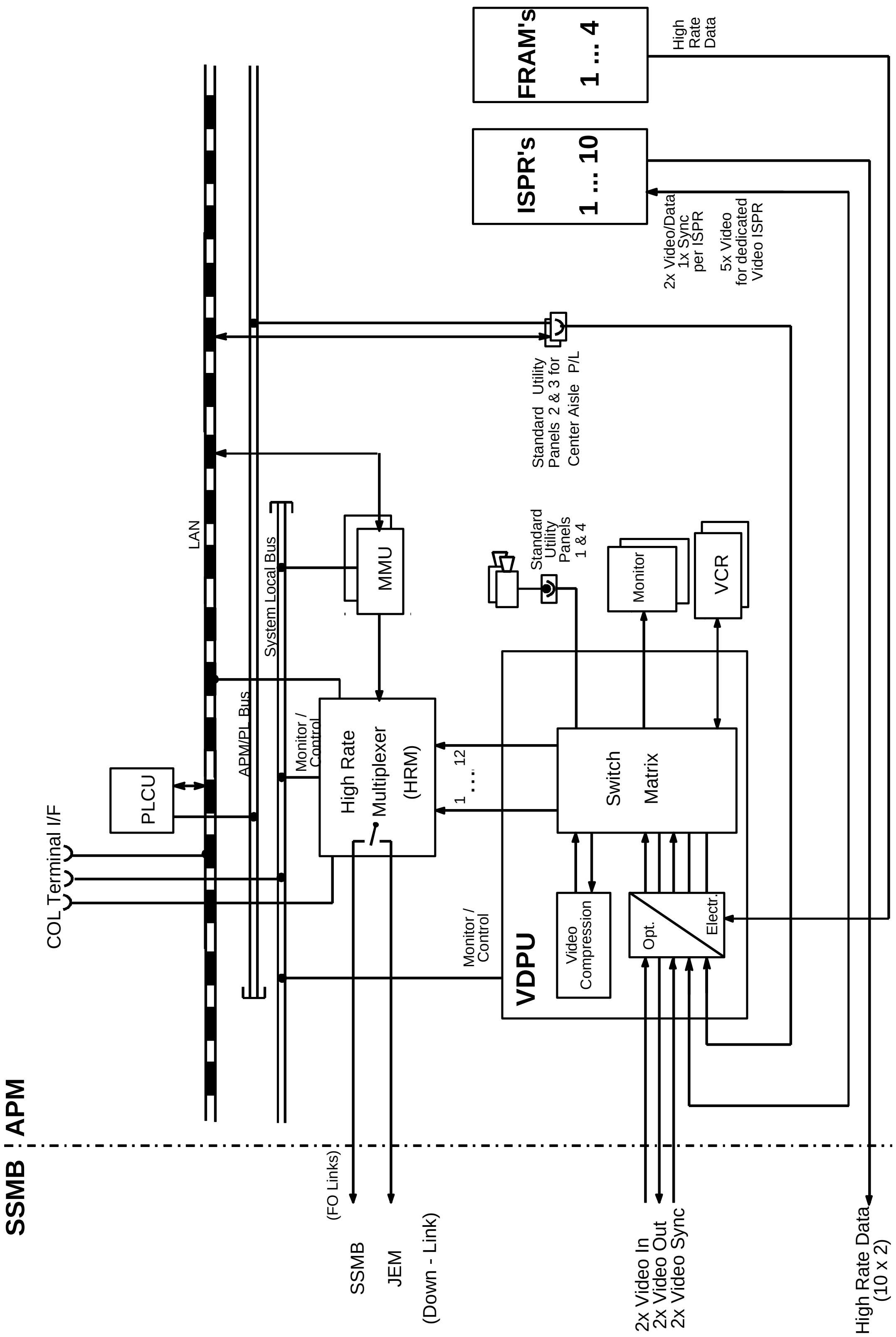


Figure 6.2.1.2-8 Communication including Video and High Rate Data Districution

6.2.1.2.6.3

The communication system shall provide for the onboard distribution of at least two video signals simultaneously.

6.2.1.2.6.4

The communication system shall provide for down-linking of at least 12 data streams (including one compressed video as a maximum).

6.2.1.2.6.5

The VDPU shall be able to de-interleave digital data from the analog video signal, code them and multiplex them with the compressed video signal before transmission as one digital data stream to the High Rate Multiplexer.

6.2.1.2.6.6

The video cameras shall provide the following functions and controls:

- Focussing (automatic and manually)
- Zoom (manual)
- Viewfinder.

NOTE:

Remote control and monitoring is not foreseen.

6.2.1.2.6.7

The APM shall include the wiring to exchange the FO video/data interfaces provided for all active ISPR's by an electrical interface, which are activated when the VDPU is exchanged by the VDPU mark II on-orbit

6.2.1.2.6.8

The APM shall provide the necessary volume for a Payload Adapter Kit (PAK) located at the ISPR UIP's converting FO signals to electrical signals for compatibility with the digital video system when later implemented.

6.2.1.2.7 Thermal Control/Environmental Life Support

6.2.1.2.7.1

The APM Thermal Control/Environmental Life Support System shall provide for

- heat rejection from subsystem and internal payload equipment
- atmosphere crew environment
- fire detection and suppression (end-to-end definition see para. 6.2.1.2.8.2)
- vacuum/venting for internal P/L
- N_2 supply to internal P/L and Water Pump Assy Accumulator
- negative/positive pressure relief
- support to the Space Station for atmosphere pressure and composition control
- APM heater control.

6.2.1.2.7.2

The Thermal Control/Environmental Life Support System shall be realized in accordance with Figure 6.2.1.2-9 and 6.2.1.2-10.

6.2.1.2.7.3

The mean radiant temperature of habitable areas shall not exceed 35 °C based on a P/L rack front panel means radiant temperature of 35 °C.

6.2.1.2.7.4

For the launch/unberthed phase the APM shall provide a heater system powered from the PDGF/SSRMS or from APCU/Orbiter as depicted in Figure 6.2.1.2-11.

6.2.1.2.7.5

For the berthed phase the APM heater system specified in para. 6.2.1.2.7.4 above shall be powered from the APM power system as shown in Figure 6.2.1.2-11 (automatic switch-over to APM supply when APM power is supplied).

6.2.1.2.7.6

The APM shall accommodate two Portable Breathing Apparatus on orbit as defined in section 5.8.14 and shown in figure 5.8.12-1.

$\geq 100\ W/m^2 \cdot K$.

6.2.1.2.7.7 (Intentionally left blank)

6.2.1.2.7.8

The APM shall accommodate two Portable Breathing Apparatus on orbit as defined in section 5.8.14 and shown in Figure 5.8.12-1.

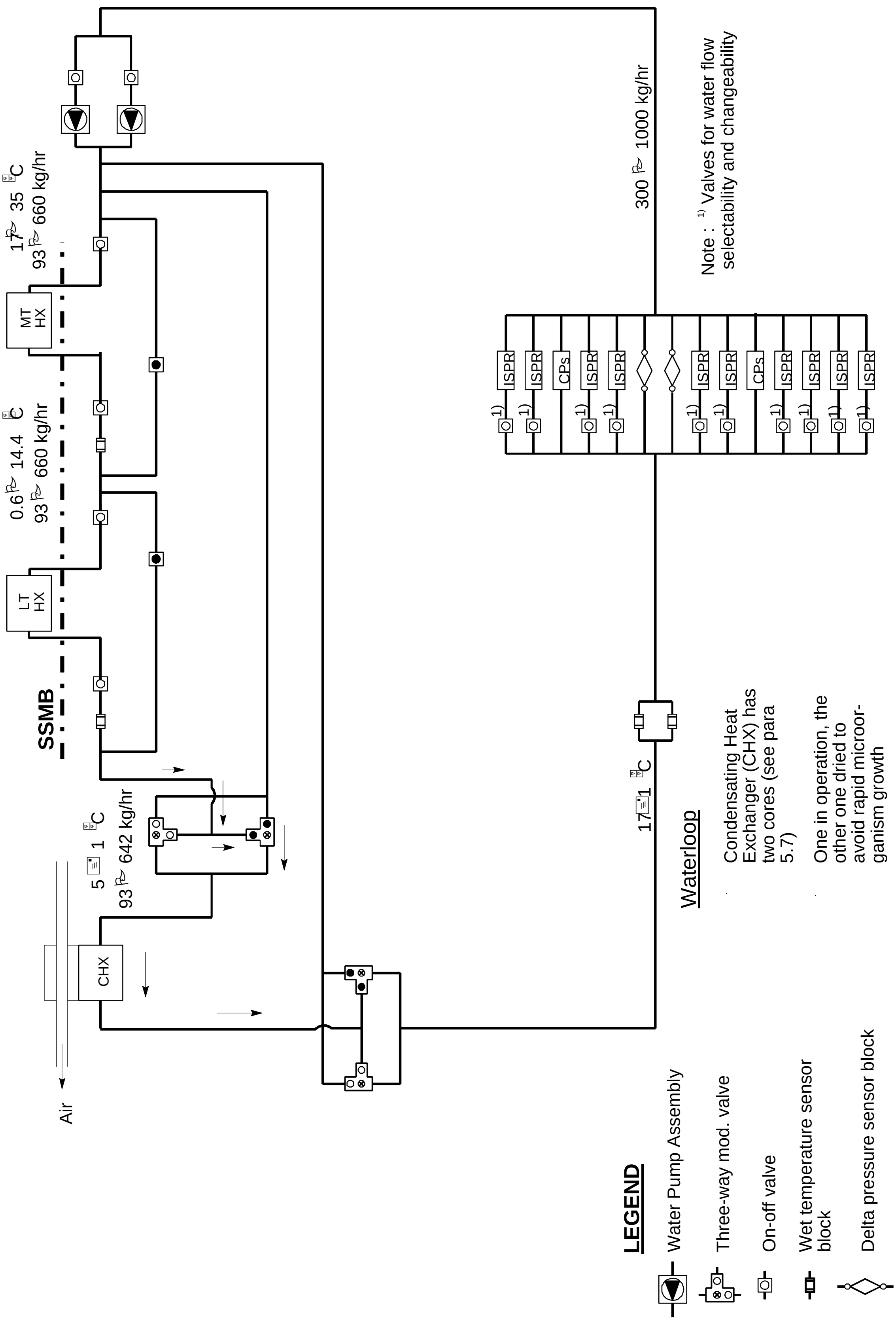


Figure 6.2.1.2-9 APM Thermal Control System

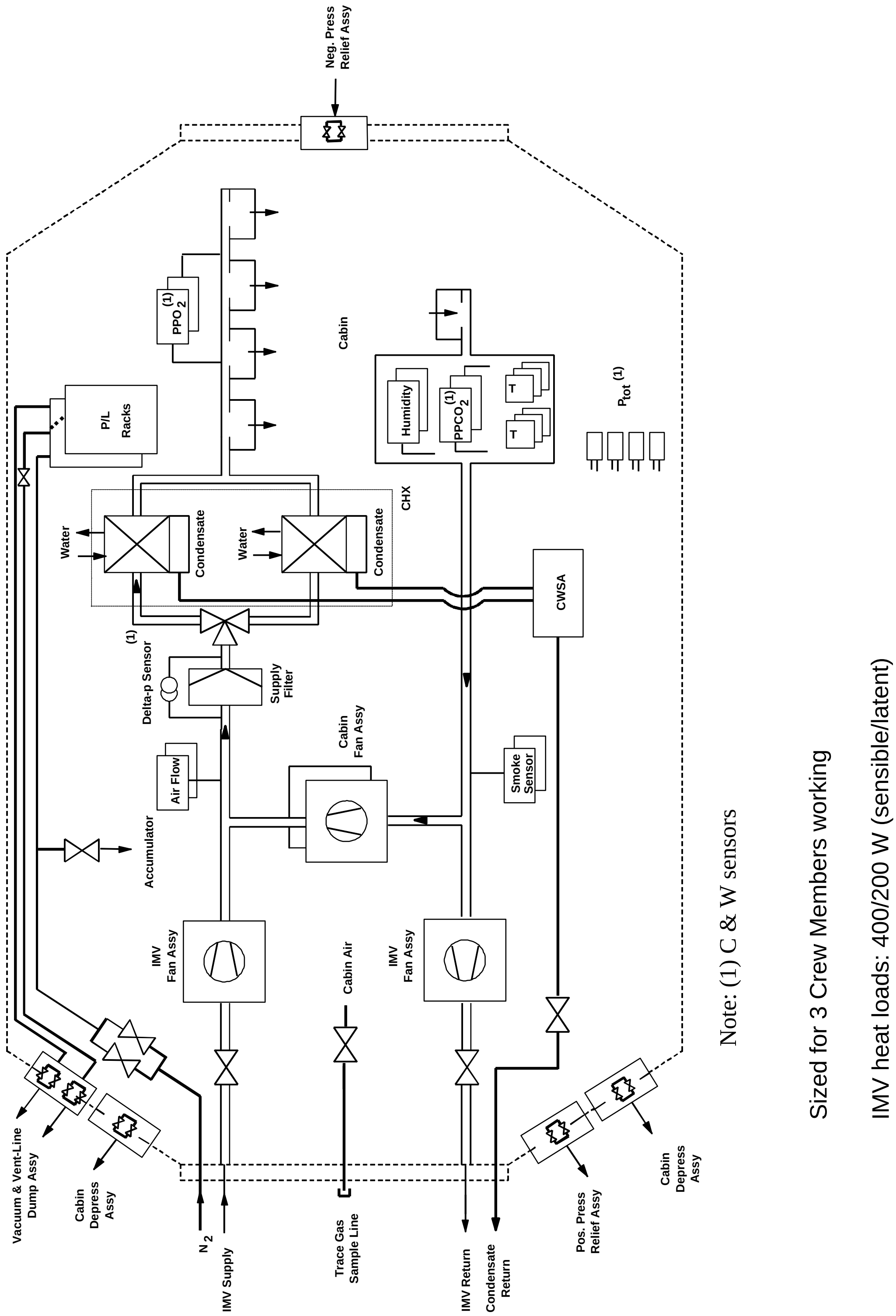


Figure 6.2.1.2-10 Environmental Control/Life Support System

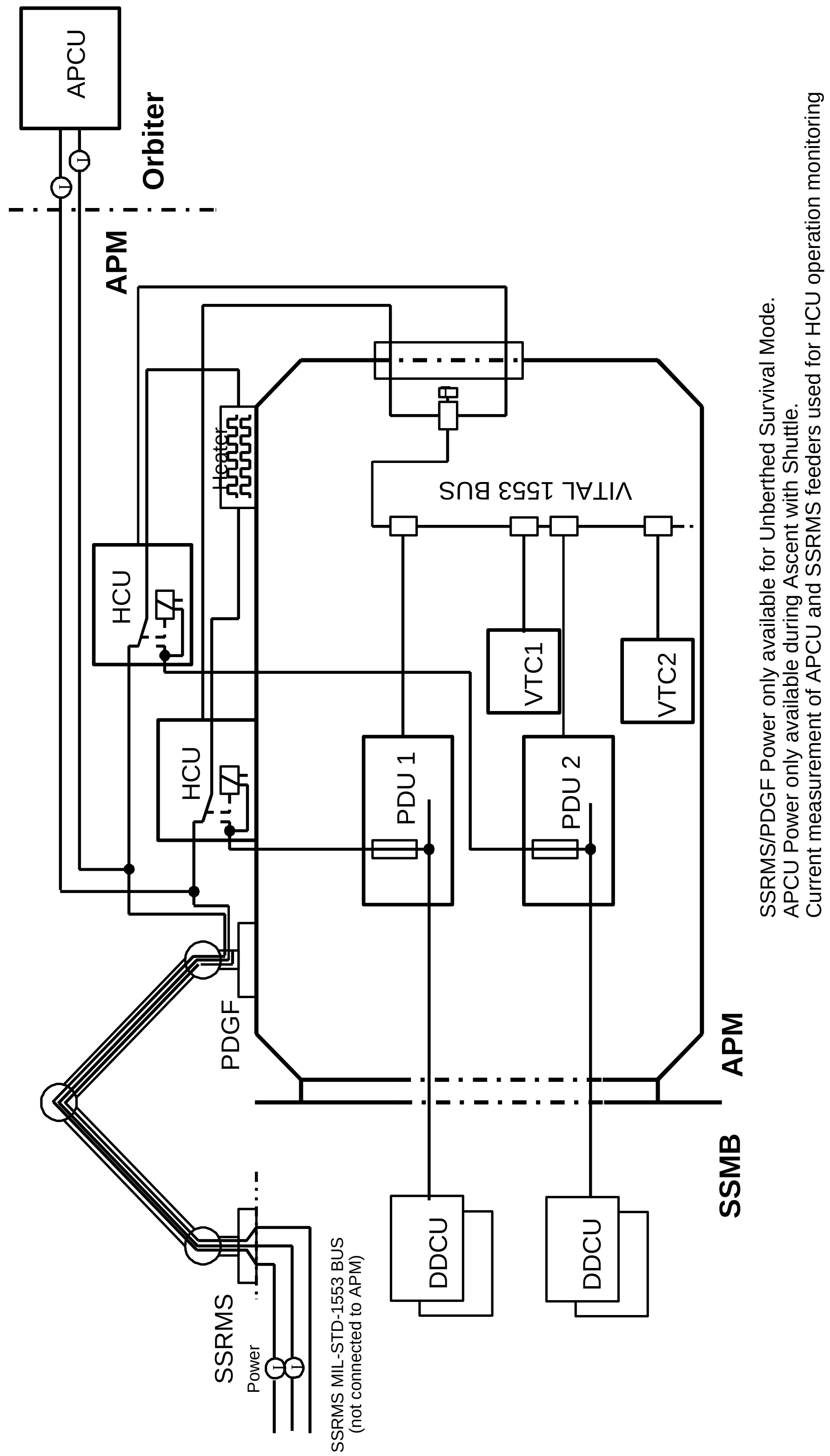


Figure 6.2.1.2-11 APM Heater System (Power from SSRMS or APM or Shuttle/Orbiter)

NOTE:
The simultaneous power provision from both sources is excluded by operational procedure

6.2.1.2.8 Emergency, Warning and Caution and Safing (EWACS)

6.2.1.2.8.1 General

6.2.1.2.8.1.1

The APM shall include instrumentation for detection of Emergency, Warning and Caution (EWACS) situations to protect the on-board crew from potentially hazardous events.

6.2.1.2.8.1.2

The APM shall provide the Fire Detection function, which shall become active when power is supplied to the cabin fans, for the following zones (see Figure 6.2.1.2-12):

Zone	Implementation	Fire Detect. Time
Cabin zone, consisting of - Cabin - Open Center Area STBD Cone - Central Air Grid Housing	Smoke sensor in air duct	≤ 3 min in the cabin
ISPRs	Smoke sensor/fan in ISPR	to be defined by P/L Design Integrator

NOTES:

- Performance is fully ensured only if the APM is nominally operating, i.e. 2 VTC, 2 PDUs are providing nominal support.
- Fire Detection Time excludes the time necessary for sensor signal validation (e.g. BIT execution).
- When the APM is in isolated conditions the fire detection time shall be ≤ 5 min in the cabin considering that the MLUs are switched off.

6.2.1.2.8.1.3 (Deleted)

6.2.1.2.8.1.4

Fire Annunciator/Suppression (FAS) Panels shall be provided for the following APM fire suppression zones:

ZONE	IMPLEMENTATION
Overhead FWD Stand-off	1 FASP1
Overhead AFT Stand-off	1 FASP1
Deck FWD Stand-off	1 FASP1
Deck AFT Stand-off	1 FASP1
Deck Rack D1	1 FASP1
Deck Rack D2	1 FASP1
Deck Rack D3	1 FASP1
STBD Cone, Module Side	
- SA	1 FASP1
- SD	1 FASP1
- SF	1 FASP1
- SO	1 FASP1
Port Cone, Module Side	
- PF	1 FASP1
- PA/PD	1 FASP1
STBD Cone, Cone Side	
- SA	1 FASP1
- SD	1 FASP1
- SF	1 FASP1
- SO	1 FASP1
Port Cone, Cone Side	
- PF	1 FASP1
- PA	1 FASP1
- PD	1 FASP1
Sensor Housing	1 FASP1
Cabin	1 FASP2

6.2.1.2.8.1.5

The FAS Panel shall provide the following features depending on their location:

	PFEX I/F	FIRE INDICATOR
FASP1	X	
FASP2		X

Table 6.2.1.2.8.1.5-1 FAS Panel Versions

NOTE:

Each ISPR will have a Fire Detection/Suppression Panel including

- PFEX interface
- Fire Indicator
- Power Status Indicator
- Kill-Power Switch.

6.2.1.2.8.1.6

The FASP2 panels shall interface with the Vital Data Management System as shown in Figure 6.2.1.2-13, i.e. switching ON the Fire Indicators on the cabin zone, which indicate Fire by the related Fire/Smoke sensor.

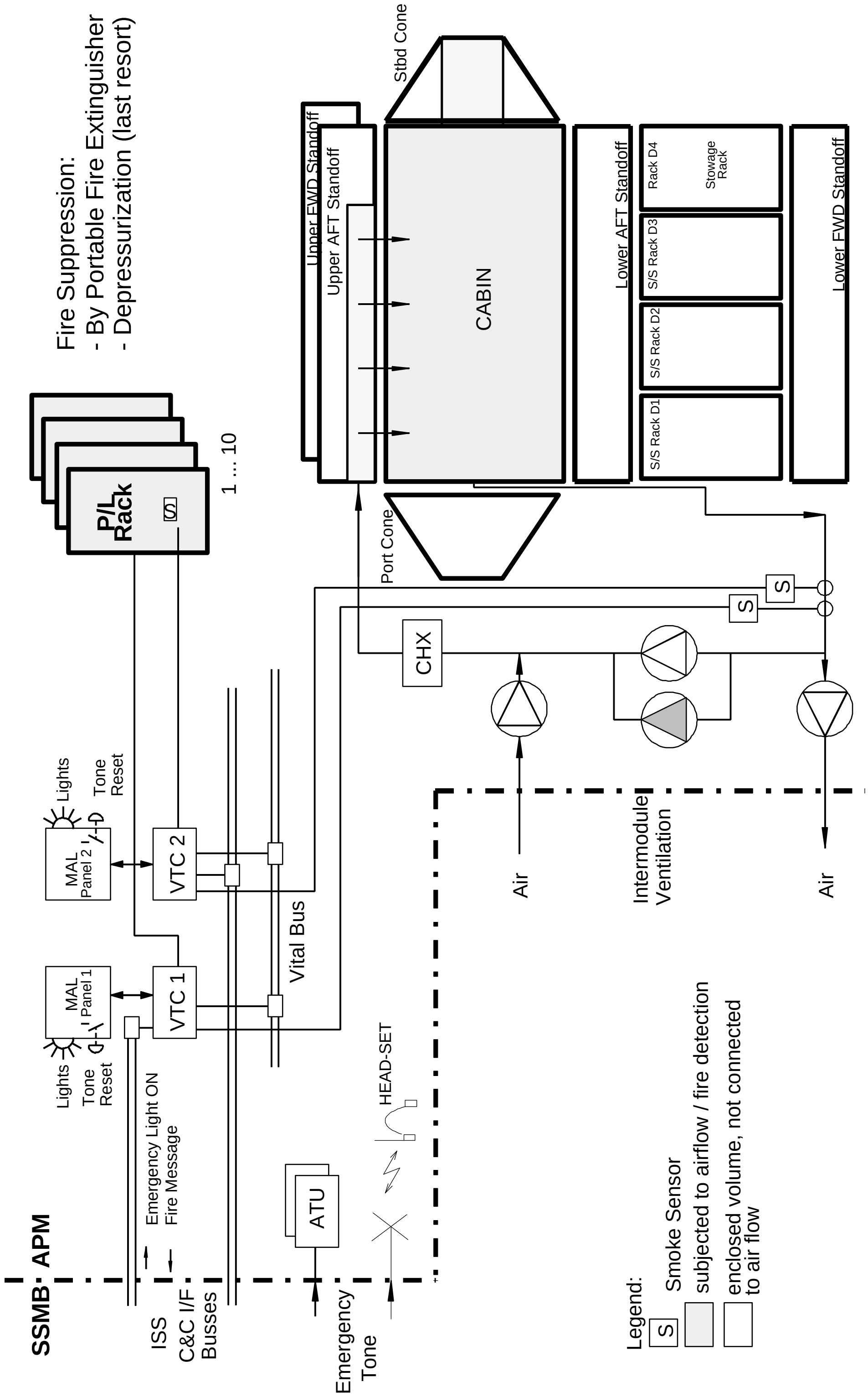


Figure 6.2.1.2-12 Fire Detection and Annunciation System

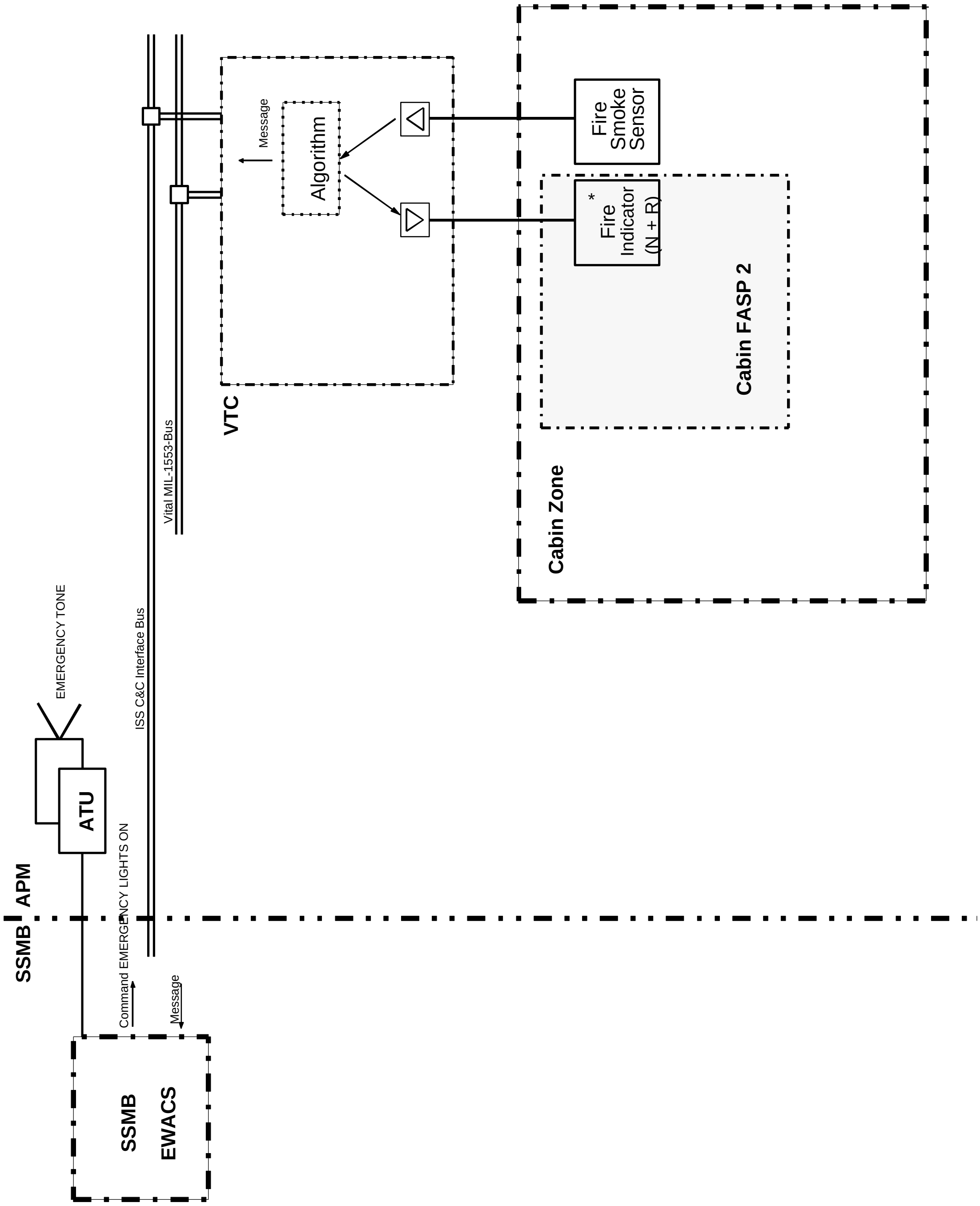


Figure 6.2.1.2-13 Fire Annunciaton for Cabin Zone

6.2.1.2.8.1.7

The APM EWACS shall provide input/output interfaces for each active P/L rack (as detailed in para. 5.5.1.5 to 5.5.1.7); one set processed/annunciated as Emergency, the other one as Warning.

6.2.1.2.8.1.8

The EWACS shall provide visual annunciation to the crew by three separate continuous lights labeled:

- Emergency: RED
- Warning: RED
- Caution: YELLOW

on the two Master Alarm Light (MAL) panels when receiving the related command from SSMB.

NOTES:

- The acoustic annunciation is assumed to be ensured by the station common audio equipment to be accommodated in the APM (see para. 6.2.1.2.5).
- Triggering of the acoustic annunciation is by the SSMB EWACS system based on the APM EWACS messages received via the SSMB/APM interface buses.

6.2.1.2.8.1.9

The parameters listed in Table 6.2.1.2-2 shall be made available to the SSMB for further processing (e.g. acoustic warning via the ISS Audio/Radio Interface and/or annunciation on all SSMB displays).

6.2.1.2.8.1.10

The alarm lights of the MAL panel shall not be directly resettable within the APM (except by removal of APM alarm condition and consequential disappearance of the LIGHT-ON command from SSMB).

6.2.1.2.8.1.11

The MAL panel shall include push-buttons to request reset of the tone by the SSMB EWACS.

NOTE:

Actual tone reset will be performed by the core station system or crew responding to the request.

Category	Seq. No.	Parameter	Limits	MAL Panel Ann.	Remarks
Emergency	E-001	Fire in APM	-	Fire	Additionally by APM Cabin loop fire indicator
	E-002	Fire in P/L Rack		Fire	Location by dedicated ISPR fire annunciators
	E-003	P/L Emergency		Atmosphere	Spillage
Warning	W-001	Total Pressure Low	≤ 700 hPa	Warning	
	W-002	Intent. blank			
	W-003	Intent. blank			
	W-004	Loss of Cabin Air Circulation	≤ 240 m^3/h	Warning	
	W-005	Loss of Cooling Water Circulation	≥ 160 hPa	Warning	one of two delta-pressure sensors low
	W-006	Carbon Dioxide Partial Pressure High	≥ 7 hPa	Warning	
	W-007	Water Accum. Pressure High	≥ 3 bar	Warning	
	W-008	Cooling Water Temperature High	≥ 28 °C	Warning	
	W-009	P/L Warning		Warning	Prov. for P/L
Caution	C-001	Water Cooling Loop Failure		Caution	Loss of one of two Water Pump assemblies
	C-002	Cabin Fan Failure		Caution	Loss of one of two Cabin Fan assemblies
	C-003	Loss of IMV Supply Function		Caution	
	C-004	Loss of IMV Return Function		Caution	
	C-005	Heater Control Unit Failure		Caution	Loss of one of two Heater Control Units
	C-006	DMC Failure		Caution	Loss of norminal DMC
	C-007	MMC Failure		Caution	Loss of norminal MMC
	C-008	MMU Failure		Caution	Loss of MMU1 or MMU2
	C-009	HUB/LAN Switch Failure		Caution	Loss of HUB1 or HUB2
	C-010	System Bus Failure		Caution	
	C-011	CMU Failure		Caution	
	C-012	Vital Bus Failure		Caution	
	C-013	PDU1 Failure		Caution	
	C-014	PDU2 Failure		Caution	
	C-015	Failure in Depress. Assy		Caution	one valve of two open
	C-016	Failure in PPRA		Caution	one valve of two open
	C-017	PPSB Temperature High		Caution	
	C-018	Loss of Water Separator 1 Function		Caution	
	C-019	Loss of Water Separator 2 Function		Caution	

	C-020	P/L Caution		Caution	There is one Caution bit per each P/L remote terminal connected to APM P/L Bus (transfer via P/L lateral packet).
	C-021	Loss of CTCU Redundancy		Caution	
	C-022	VARMV open		Caution	
	C-023	VERMV open		Caution	
	C-024	PDU1 Output Trip		Caution	
	C-025	PDU2 Output Trip		Caution	
	C-026	XCMU Failure		Caution	
	C-027	P/L Bus Failure		Caution	
	C-028	PLCU Failure		Caution	Loss of nominal PLCU
	C-029	Delta Pressure Sensor Failure		Caution	Cooling Loop DP Sensors high limit exceedance
	C-030	Cabin Air Return Grid Clogging		Caution	Detection of cabin air flow degradation
	C-031	Oxygen Part. Press. LOW	<170h Pa	-"-	
	C-032	Oxygen Part. Press. HIGH	>250h Pa	-"-	At 25 %

Table 6.2.1.2-2 Emergency/Warning/Caution Parameter List

NOTES:

- It is assumed that the SSMB emergency includes "depressurization" and "toxic" conditions within the SSMB elements.

- For the following sensors periodic check-out shall be provided:
  - Fire/Smoke sensors (BIT)
  - Partial oxygen pressure (health status)
  - Partial carbon dioxyde pressure (health status)

6.2.1.2.8.1.12

If an APM emergency, warning or caution parameter is out-of-limit, the following steps shall be initiated:

- Initiation of safing command (for closed loop channels)
- Message transmission to SSMB
- Related alarm light ON on MAL panel upon SSMB command
- Related tone via ATU ON (Note: SSMB activity)
- Logging of out-of-limit emergency, warning and caution events (Note: SSMB activity)

NOTE: The SSMB EWACS will also activate the alarm on the MAL panel and via the ATU when there is a hazardous situation elsewhere in the station.

6.2.1.2.8.1.13

The EWACS system shall be able to execute all safing commands, which are foreseen by the APM design automatically for closed loop input/output Payload channels or as initiated by a core station or ground command.

NOTE:

The following safing commands are provided automatically:

- Cabin fire: IMV valves closed.
- ISPR fire: Switch off power to ISPR
- Both waterloop delta pressure sensors low: switch off power to all ISPRs.

6.2.1.2.8.1.14

The EWACS system shall provide inhibit capability for all automated safing commands.

6.2.1.2.8.1.15

Sampled data of all Emergency, Warning and Caution channels shall be made available to the SSMB after ≤ 1 second after data acquisition.

6.2.1.2.8.1.16

The visual annunciation by the Emergency, Warning and Caution lights on the MAL panels shall occur in less than 1 second after reception of the command from the SSMB.

6.2.1.2.8.1.17

Redundant EWACS sensors shall be connected to either VTC unit, in order to ensure at least a zero-failure tolerant function even when one VTC is removed for servicing.

6.2.1.2.8.1.18

For cases, where a parameter enters first the caution, then the warning and then the emergency range, the different exception messages related to these ranges shall be transmitted incrementally.

NOTE:

The same transducer is used (differentiation implemented by different software limits within VTC).

6.2.1.2.8.2 Fire Detection and Suppression

6.2.1.2.8.2.1

Fire detection shall be implemented for the cabin (see paragraph 6.2.1.2.8.1.2); fire suppression shall be implemented for the cabin and the fire suppression zones (see paragraph 6.2.1.2.8.1.4).

NOTE:

The P/L racks are also separate fire detection/suppression zones but not under APM responsibility.

6.2.1.2.8.2.2

The local fire suppression shall be based on station common portable fire extinguishers (PFEX) accommodated within the APM (see para. 5.8.12) requiring the following amounts of agent:

FIRE PROTECTION ZONE	NUMBER OF PFEX
Overhead FWD Stand-off	1
Overhead AFT Stand-off	1
Deck FWD Stand-off	≤ 2
Deck AFT Stand-off	≤ 2
Deck Rack D1	1
Deck Rack D2	1
Deck Rack D3	1
STBD Cone, Module Side	
- SA	1
- SD	1
- SF	1
- SO	1
Port Cone, Module Side	≤ 2
- PF	
- PA/PD	
STBD Cone, Cone Side	
- SA	1
- SD	1
- SF	1
- SO	1
Port Cone, Cone Side	
- PF	1
- PA	1
- PD	1
Sensor Housing	1

6.2.1.2.8.2.3

The CO_2 injection from the PFEX shall be possible via an interface orifice on the identical APM FASPs to the FP zones to provide fire suppression as per para. 6.2.1.2.8.1.4.

NOTE: For the cabin zone no piping network is foreseen.

6.2.1.2.8.2.4

For the P/L racks the fire suppression shall be based on the station common portable fire extinguisher (PFEX) accommodated within the APM (see para. 5.8.12).

NOTE:

The P/L rack FDS panel compatibility with PFEX is to be ensured by the P/L Design Integration responsible.

6.2.1.2.8.2.5

If local fire suppression is not successful, the APM design shall allow fire suppression by depressuriza-tion after crew egress and SSMB node hatch closure.

6.2.1.2.9 Failure Management Support

6.2.1.2.9.1 General

6.2.1.2.9.1.1

The APM design shall include automated functional mechanisms providing Failure Detection, Identification and Recovery (FDIR), as well as Fault Containment

- during steady-state operations
- during reconfigurations

for credible failures of functional paths as identified in the APM FDIR Analysis.

6.2.1.2.9.1.2

FDIR activities activation status reporting shall be included in the down-link and reported to the crew (on lap-top) within 5 seconds after start.

6.2.1.2.9.1.3

FDIR activities results shall be reported to the crew. The status of the system following FDIR recon-figurations shall be made available to the crew on request using nominal synoptic displays.

6.2.1.2.9.1.4

In case of non-recoverable or multiple failures[1)] the APM shall be automatically configured to safe, stable conditions, so that nominal performance can be later re-established - in the worst case by ORU replacement.

[1)] Note: Multiple failures in this case means two or more individually anticipated and recoverable failures which, when occurring together, are non-recoverable. In this sense, independent, multiple failures may be recovered by the failure management system.

6.2.1.2.9.1.5

FDIR shall be capable of differentiating between transducer and functional failures by transducer redundancy or function availability/performance evaluation.

6.2.1.2.9.1.6

Failure Identification, Failure Recovery and Fault Containment shall have priority over nominal operations.

6.2.1.2.9.1.7

Because of potentially safety related consequences for the payload the vital DMS layer shall automatically switch-off all power feeders to the ISPRs, if a water loop failure cannot be recovered by FDIR within 2 minutes.

6.2.1.2.9.2 FDIR Mechanisms

6.2.1.2.9.2.1 System Level Failure Management

6.2.1.2.9.2.1.1

The APM default failure management mechanism shall be exception monitoring based, i.e. a software-based decision mechanism that associates unambigously exceptions occurred in the system to predefined failure cases and points to an appropriate recovery.

6.2.1.2.9.2.1.2 (Intentionally left blank)

6.2.1.2.9.2.1.3 (Intentionally left blank)

6.2.1.2.9.2.1.4 (Intentionally left blank)

6.2.1.2.9.2.1.5 (Intentionally left blank)

6.2.1.2.9.2.1.6

Associated with the identified failure there shall be an action, ranging from annunciation to full automatic recovery, as necessary.

6.2.1.2.9.2.1.7 (Intentionally left blank)

6.2.1.2.9.2.1.8 (Intentionally left blank)

6.2.1.2.9.2.2 Reflex Reactions (RR)

6.2.1.2.9.2.2.1

Local mechanisms reacting as by reflex to particular conditions shall be implemented for time-critical (< 15 sec) failure management, where involvement of system S/W would be too slow.

6.2.1.2.9.2.2.2

Reflex Reactions shall be implemented by hardware or software on equipment level.

6.2.1.2.9.2.3 Built In Test /BIT) Function

6.2.1.2.9.2.3.1

The APM equipment with local data processing capability shall implement Built-In Test (BIT functions), in order to provide health status reports based on the equipment internal checks.

6.2.1.2.9.2.3.2

BIT shall generate the equipment health status report automatically upon equipment power on.

6.2.1.2.9.2.3.2.1

BIT shall generate the equipment health status report automatically upon equipment reset.

6.2.1.2.9.2.4 Checks in Automated Procedures (APs) during Reconfiguration

6.2.1.2.9.2.4.1

During system reconfigurations parts exception monitor shall be disabled to avoid false alarms produced not by failures, but by the intermediate reconfiguration status.

6.2.1.2.9.2.4.2

Reconfiguration APs shall include failure management tasks that are necessary during their execution and that cannot be provided by the system itself.

6.2.1.2.9.2.4.3

Reconfiguration APs shall be able at least to detect a failure, to contain faults as necessary and to invoke standard FDIR as necessary.

6.2.1.2.9.2.4.4

If necessary due to time/system availability constraints, the reconfiguration APs shall also include recovery capabilities.

6.2.1.2.9.3 Time Critical FDIR

6.2.1.2.9.3.1

Failures that require a recovery containment to be performed or started in a time limit not compatible with TFM (up to 15 sec) shall be covered by reflex reactions.

6.2.1.2.9.3.2

Wherever fault containment is time critical but failure recovery is not, Reflex Reactions shall be used only for the time critical tasks.

6.2.1.2.9.4 Operational Utilization of FDIR

The different operational utilizations of FDIR mechanisms shall be implemented as per Table 6.2.1.2.9-1:

	APM MODES WITH FULL DMS**		**OTHER MODES WITH PARTIAL ACTIVE APM**
	STEADY STATE	**RECONFIGURATION**	
Function under reconfiguration	N/A	AP checks, Reflex	"External" FDIR*, Reflex
Other functions	Exception monitoring based, Reflex	Exception monitoring based, Reflex	"External" FDIR*, Reflex

* "External" = SSMB or Ground Segment
** "Full DMS" mode as specified in Table 6.2.1-9

Table 6.2.1.2.9-1 FDIR Mechanism Utilization vs. APM Operation Modes

6.2.1.2.9.5 Failure Management of Data Management

6.2.1.2.9.5.1

FDIR of the overall APM Data Management System itself shall comply with the on-board hierarchy:

- Core Station performs FDIR over the Vital DMS
- Vital DMS performs FDIR over Data Management Computer
- Data Management Computer performs FDIR over the other items of the nominal DMS.

6.2.1.2.9.5.2

The diagnosis at the upper level shall be based on data produced by watchdog functions of the lower level computer.

6.2.1.2.9.5.3

Data Management Computer reconfiguration shall be implemented as a Reflex reaction at VTC level.

6.2.1.2.9.6 Crew/Ground Involvement

6.2.1.2.9.6.1

Exception monitoring based recovery actions shall be individually setable into one of the following modes at any point in time:

- Fully automated, autonomous recovery;
- Recovery disabled; released after crew/ground endorsement;
- Complete recovery disabled.

6.2.1.2.9.6.2

The exception monitoring based FDIR configuration setting shall be possible remotely from ground and by the crew.

6.2.1.2.9.6.3

All exceptions shall be available to crew and ground.

6.2.1.2.9.6.4

Exceptions shall be automatically displayed to crew on the APM Laptop if after 30 seconds the FDIR function is not successfully executed.

6.2.1.2.9.6.5

Identified failures and recovery status shall be displayed automatically to the crew.

6.2.1.2.9.6.6

The crew and the ground segment shall have override capability over failure management by:

- disabling it partially or completely
- changing of limit values
- uploading of new tables (connection matrices).

6.2.2 Failure Tolerance and Hazard Control

6.2.2.1

The APM design shall provide for each system/main and system support function as specified in para. 6.2.1.1 the failure tolerance as identified in Table 6.2.2-1 to Table 6.2.2-6.

6.2.2.2

The APM system shall control the potential hazards by failure tolerances as identified in Table 6.2.2-7.

System Function/ Main Function		**FAIL. TOL.**	**REMARKS**
P1	Electrical Power to P/L		
P1.1	Power to S/Ss	1	
P1.2	Heat removal from S/Ss	1	
P1.3	S/S management	1	
P1.4	Nominal and Safing Power Distribution to P/L	0	Rack Level for either type
P2	Heat Removal from P/L[1)]		
P2.1	Power to S/Ss	1	
P2.2	Heat removal from S/Ss	1	
P2.3	S/S management	1	
P2.4	Heat removal function from P/L	0	Rack Level
P3	Onboard Data Processing to P/L (including I/F to onboard crew)		
P3.1	Power to S/Ss	1	
P3.2	Heat removal from S/Ss	1	
P3.3	S/S management	1	
P3.4	Data and program storage	1	
P3.5	HCI I/F via Laptop	0	
P3.6	P/L Data Distribution (APM-int. and to/from ground up to SSMB I/F)	1**	
P3.7	PLCU Processing Function with P/L provided SW	1*	
P4	Time Distribution to P/L		
P4.1	Power to S/S	1	
P4.2	Heat removal from S/Ss	1	
P4.3	S/S management	1	
P4.4	P/L time distribution (on P/L local bus)	1*	

*) using system spare computer
**) up-/downlink functions except the inputs of the Multiplexer
1) internal P/L only

Table 6.2.2-1 Failure Tolerance of System/Main Functions for Payload Accommodation

System Function/ Main Function		**FAIL. TOL.**	**REMARKS**
P5	Up-/downlink for P/L Data		
P5.1	Power to S/Ss	1	
P5.2	Heat removal from S/Ss	1	
P5.3	S/S management	1	
P5.4	P/L data distribution	1*	
P5.5	P/L data formatting in PLCU	1*	
P5.6	Transm./Reception via TDRS or JEM	1	(up to SSMB I/F)
P6	Vacuum/Venting for P/L[1)]		
P6.1	Power to S/Ss	1	
P6.2	Heat removal from S/Ss	1	
P6.3	S/S management	1	
P6.4	Vacuum provisions to P/L	0	Rack Level
P6.5	Venting provisions to P/L	0	Rack Level
P7	N2 Provision to P/L[1)]		
P7.1	Power to S/Ss	1	
P7.2	Heat removal from S/Ss	1	
P7.3	S/S management	1	
P7.4	N2 Supply to P/L	0	Rack Level
P8	Video[1)]/High Rate Data Provision for P/L		
P8.1	Power to S/S	1	
P8.2	Heat removal from S/Ss	1	
P8.3	S/S management	1	
P8.4	Video signal distribution	0	Rack Level
P8.5	Video signal generation	1	Two Cameras
P8.6	Video signal display	1	Two Monitors
P8.7	Video signal processing	1	VDPU intern. redundant
P8.8	Video/High Rate Data downlink	1	up to SSMB I/F

*) using system spare computer
1) internal P/L only

Table 6.2.2-1: Failure Tolerance of System/Main Functions for Payload Accommodation (cont'd)

Main Function		**FAIL. TOL.**	**REMARKS**
P9	APM Housekeeping and Ancillary Data Distribution to P/L		
P9.1	Power to S/Ss	1	
P9.2	Heat removal from S/Ss	1	
P9.3	S/S management	1	
P9.4	APM housekeeping and ancillary data distribution to P/L	1	
P10	P/L EWACS		
P10.1	Emergency and Warning detection	0	Back-up by normal data flow
P10.2	Visual Annunciation	1	On MAL Panels

Table 6.2.2-1: Failure Tolerance of System/Main Functions for Payload Accommodation (cont'd)

System Function/ Main Function	**FAIL. TOL.**	**REMARKS**
C1 Environmental Control		
C1.1 Power to S/Ss	1	
C1.2 Heat removal from S/Ss	1	
C1.3 S/S management	1	
C1.4 Atmospheric pressure and composition control		
- atmospheric pressure equalization and repressurization	(1)	via PEV, back-up by IMV
- negative/positive pressure relief	1	
C1.5 Cabin temperature control	1	
C1.6 Cabin ventilation	1	
C1.7 Cabin humidity control	1[1)]	
C1.8 Trace gas sampling	1	back-up by manual override for "Open" or via PEV
C1.9 Air cont. monitoring and control support		? p monitoring FT
- PP02, PPCO2, P_{tot} monitoring	1	see note [2)].
- Cabin air contamination monitoring and control	1	
C2 Module Lighting		
C2.1 Power to S/Ss	(1)	Degr. (4 lamps of 8 off after one failure)
C2.2 Heat removal from S/Ss	1	
C2.3 S/S management	1	
C2.4 Normal Illumination	(1)	Degr. (1 lamp) after one luminary failure
C3 Crew Communication (Audio)		
C3.1 Power to S/Ss	1	
C3.2 Heat removal from S/Ss	1	
C3.3 S/S management	1	
C3.4 Audio (ATU)	1	

1) - The CHX needs a dry-out after one week of continuous operation lasting 8 hours.
- In case of failure of one branch after one week the function is lost (best case).

2) Failure tolerance achieved indirectly by signal observation of the two parallel sensors by the crew and/or Ground Segment.

Table 6.2.2-2 Failure Tolerance of System/Main Functions for Crew Support

NOTE:

For the design of the pressurized items, lines, pressure vessels, fittings, primary and secondary structure, the failure tolerance requirements do not apply, instead these items shall be controlled by "Design to Minimum Risk" in accordance with Structural and Fracture Control require-ments (e.g. safety factors, safe life, design stress analysis, etc.).

REMARK:

1. Leakage due to structural failure is covered by above

2. In general, seals are not considered to be structural items, however, in certain cases non-redundant metallic seals may be accepted providing the design demonstrates that:

- seals can follow and are designed in accordance with the structural and fracture control require-ments
- all operational environmental conditions are covered
- no fatigue occurs during the operational lifetime.

System Function/Main Function		FAIL. TOL.	REMARKS
C4	Emergency, Warning, Caution Detection and Annunciation to Crew		
C4.1	Power to S/Ss	1	
C4.2	Heat removal from S/Ss	1	
C4.3	S/S management	1	
C4.4	Cabin ventilation (pre-set mode)	1	
C4.5	Water loop monitoring (circulation and pressure)	1	
C4.6	(Intentionally left blank.)		
C4.7	Fire detection	1	Cabin zone
C4.8	Total pressure monitoring	1	
C4.9	PP02 monitoring	1	
C4.10	PPCO2 monitoring	1	
C4.11	Ventilation monitoring	1	
C4.12	Emergency, Warning, Caution detection	1	
C4.13	Visual Annunciation	1	
C4.14	Trace Gas Sampling (Opening Function)	0	
C4.15	P/L EWACS	1	Back-up via nominal data flows/ processing
C5	System Monitoring and Control		
C5.1	Power to S/Ss	1	
C5.2	Heat removal from S/Ss	1	
C5.3	S/S management	1	
C5.4	S/S monitoring	1	
C5.5	S/S control	1	
C5.6	Data exchange on-board and to/from ground	1*	up to SSMB I/F
C6	Fire Suppression		
C6.1	Power to S/Ss	1	
C6.2	Heat removal from S/Ss	1	
C6.3	S/S management	1	
C6.4	Cabin depressurization	1	
C6.5	Module venting	0	
C6.6	Fire Detection/Zone Power Kill in ISPRs	0	up to ISPR I/F
C7	Emergency Lighting		
C7.1	Power to S/Ss	1	
C7.2	Illumination	0	incl. emergency storage
C8	Video		
C8.1	Power to S/Ss	1	
C8.2	Heat removal from S/Ss	1	
C8.3	S/S management	1	
C8.4	Video monitoring between Core Station/ APM	1	
C8.5	Video monitoring on ground	1	up to SSMB I/F

*) Up-/downlink functions except the inputs of the Multiplexer

Table 6.2.2-2: Failure Tolerance of System/Main Functions for Crew Support (cont'd)

System Function/Main Function	FAIL. TOL.	REMARKS
S1 Primary (Essential Cmd and Data) Activation, Monitoring and Control		
S1.1 Power to S/Ss	1	
S1.2 Heat Removal from S/Ss	1	
S1.3 S/S Management	1	
S1.4 Data Distribution	1	
S1.5 Data Formatting	1	
S1.6 Essential Data Provision	1	
S1.7 Essential Command Execution	1	
S2 Emergency, Warning, Caution Detection, Annunciation and Safing		
S2.1 ((Intentionally left blank.))		
S2.2 Power to S/Ss	1	
S2.3 Heat Removal from S/Ss	1	
S2.4 S/S Management	1	
S2.5 Emergency, Warning, Caution Detection and Annunciation	1	
S2.6 Safing Execution	1	
S3 Overall Mission Management (incl. ISS Resource Control, FDIR, etc.)		
S3.1 Power to S/Ss	1	
S3.2 Heat Removal from S/Ss	1	
S3.3 S/S Management	1	
S3.4 Data Distribution	1	
S3.5 Data Processing/Formatting/FDIR	1	
S3.6 Data Provisioning	1	
S3.7 Command Execution	1	

Table 6.2.2-3 Failure Tolerance of System/Main Functions from ISS Monitoring/Control

System Function/Main Function	FAIL. TOL.	REMARKS
G1 Primary (Essential Cmd. and Data) Activation, Monitoring and Control		
G1.1 Power to S/Ss	1	
G1.2 Heat removal from S/Ss	1	
G1.3 S/S management	1	
G1.4 Data distribution	1	
G1.5 Data formatting	1	
G1.6 Telemetry data provisioning	1	
G1.7 Telecommand execution	1	
G2 Overall Mission Management and APM System Monitoring and Control		
G2.1 Power to S/Ss	1	
G2.2 Heat removal from S/Ss	1	
G2.3 S/S management	1	
G2.4 Data distribution	1	
G2.5 Data processing/formatting	1	
G2.6 Telemetry data provision	1	
G2.7 Telecommand execution	1	
G2.8 Up-/downlink	1	up to SSMB I/F for using TDRS and JEM links

Table 6.2.2-4 Failure Tolerance of System /Main Functions for Ground Monitoring/Control

System Function/ Main Function	**FAIL. TOL.**	**REMARKS**
R1 Checkout		
R1.1 Power to S/Ss	1	
R1.2 Heat removal from S/Ss	N/A	Covered by nominal function
R1.3 S/S management	1	
R1.4 Checkout data provisioning/ command execution	0/1	0 = On equipment level without internal redundancy
R1.5 Data processing and display	1	with 2 Laptops
R1.6 Data distribution	1	

Table 6.2.2-5 Failure Tolerance of System/Main Functions for Servicing/Reconfiguration

System Function/Main Function		**FAIL. TOL.**	**REMARKS**
SS1	Thermal Heating / Thermal Conditioning		
SS1.1	Heater Control	1	Required only during certain phases
SS1.2	Shell heating	1	Required only during certain phases

Table 6.2.2-6 Failure Tolerance of System Support/Main Functions for Thermal Control

Hazard Condition	Hazard Severity Category	Control
Unwanted APM depressurization via depressurization assembly	I	o Two S/O valves in series o Single failure of the valve control function shall not invalidate (open) more than one valve o Provide PP02/P_{tot} measurement via C&W
Module Depressurization during NSTS/APM return to ground failure	I	o 1 FT negative pressure relief capability o 1 FT against inadvertant depressurization via venting systems
Unwanted opening of V & V when no P/L connected	I	o 1 FT with respect to unwanted opening of S/O valves o Monitoring by EWACS
Unwanted opening of air sampling valves	II[1)]	
Structure/Feedthroughs air leakage	I	o 1 FT against loss of sealing capability (two seals on bulkhead and feedthroughs)

1) - One valve on APM side plus pressure cap during launch
- One valve on APM side plus one valve on SSMB side during on-orbit phase

Table 6.2.2-7 Residual Hazard/Failure Tolerance List

6.2.3 Budget Allocation Requirements

The budget allocation requirements reflect the specified allocation of resources to subsystems/assem-blies considering the variations with the applicable mission phases and the appropriate system margins.

The allocation requirements include all deliverable items to fulfill the P/L interface requirements as specified in para. 5.7 of this specification. Exceptions and detailization to this general rule are given in the following sub-paragraphs, where necessary.

6.2.3.1 Mass

6.2.3.1.1

The APM mass allocations for the different phases shall not be exceeded in accordance with Table 6.2.3.1-1.

NOTES:

- This table is only provided for mass allocation purposes.
  Industry commits only to the line item "P/L Mass" to be provided as a minimum.
- The mass of the interface jumpers used for mating checks with APM are not contained in the APM mass budget.

SUBSYST./ASSY	Specified Mass/ kg per MISSION PHASE Launch	On-Orbit	Remarks
Structure	6404	6404	
FDS	85	85	
Harness[1)]	588	588	
Illumination	32	32	
Thermal Control Items	749	749	
ECLSS	548	548	
Outfitting compl.	268	268	
Subtotal 1	**8674**	**8674**	
Margin 1	195	195	For PICA Subcontractor
Station Common Items			
- ATU/Cold Plate (2)	5	5	
- Passive CBM	177	177	
- Hatch	109	109	
- PDGF	39	39	Incl. PDGF supplied harness
- Passive FRAM parts/ H-Fixtures/Targets	46	46	
Subtotal 2	**9449**	**9449**	PICA Spec. Mass (dry)
EPDS Items	186	186	
DMSS	289	289	
Video	113	113	
Amateur Antennae	3	3	
COL Terminal	-	120	
Station Common Items			
- PEHG	12	12	
- PBA (2 x)	16	16	transport outside APM
- PFEX (2 x)	16	16	transport outside APM
- MAL (2 x)	6	6	
- Laptops (2 x)	10	10	transport outside APM
- ATU (2 x)	18	18	
- Audio Antenna (1 x)	1	1	
Air	92	92	
Water	112	112	
APM System Mass	10114	10234	
Margin 2	152	152	for System Responsible
Payload	2500	9926	On-orbit: 9000 kg internal Launch.: 2500 kg internal
Launcher Capability/ APM Interface	12775	20435	On-orbit capability limited by I/F forces

[1)] Excluding APM-Shuttle/Orbiter cables as agreed in APM/Orbiter ICD

Table 6.2.3.1-1 APM Mass Allocation

6.2.3.2 Electrical Power

6.2.3.2.1

The electrical power allocations for the different mission phases shall not be exceeded in accordance with Table 6.2.3.2-1.

6.2.3.2.2

The allocated power consumptions shall not be exceeded for any combination of specified interface voltages and environment temperatures.

6.2.3.3 Thermal Budgets

6.2.3.3.1 Cabin Loop Heat Load

The heat load dissipated by the various sources into the cabin loop shall not exceed the values of Table 6.2.3.3-1 for the different APM operation modes.

6.2.3.3.2 Water Loop Heat Load

The heat load dissipated by the various sources into the water loop shall not exceed the values of Table 6.2.3.3-2 for the different operational modes.

Subsystem/ Assembly	Power Budget [W]							Remarks
	Launch	Operation under Reduced Performance				Routine Operation		
		Unberthed Survival	Berthed Survival	Support (manned)	House-keeping	Unmanned	Manned	
Lighting	0	0	5	245	245	5	245	Nom./Emerg. Lighting
Thermal Control Items	1710	1710	725	281	281	543	543	
ECLSS	90	90	681	970	970	1050	1050	incl. Fire Detection Items
Subtotal	1800	1800	1411	1496	1496	1598	1838	
Margin 1	0	0	140	125	125	159	157	for PICA Subcontractor
Subtotal 1	**1800**	**1800**	**1551**	**1621**	**1621**	**1757**	**1995**	**PICA Spec. power**
Harness	0	0	19	47	38	328	339	load-dependent losses
PDU/PPSB	0	0	57	361	115	329	586	incl. load-dependent losses
DMSS	0	0	50	633	543	588	688	incl. 2 APM laptops/ 2 MAL panels
Video	0	0	0	[1] 232	0	[2] 222	[3] 270	
Audio	0	0	0	69	69	0	69	
Div. Equipment	0	0	0	109	109	29	159	CHeCS equipment, US laptop, PHEG
Subtotal 2	**1800**	**1800**	**1677**	**3072**	**2495**	**3253**	**4106**	
Margin 2	0	0	323	158	185	422	394	
APM System Power	**1800**	**1800**	**2000**	**3230**	**2680**	**3675**	**4500**	
Payload	0	0	0	0	800	8000	13500	
Required Power	**1800**	**1800**	**2000**	**3150**	**3480**	**11675**	**18000**	**APM with Payload**
Available Power	3600	1800	20000	20000	20000	20000	20000	from SSRMS/SSMB

[1] 1 Camera, 1 Monitor, 1 Recorder active
[2] 2 Cameras, 1 Recorder active
[3] 2 Cameras, 2 Monitors, 1 Recorder active

Table 6.2.3.2-1 APM Electrical Power Consumption Allocation

HEAT LOAD SOURCE	HEAT LOAD CASES [W]												REMARKS
	NOMINAL MODE				SUPPORT MODE				STAND-BY MODE		SURVIVALMODE		
	CASE A (Manned)		CASE B (Unmanned)		CASE A (Manned)		CASE B (Unmanned)		Min.	Max.	Unberthed	Berthed	
	18°	27°	18°	27°	18°	27°	18°	27°	18°	27°			
HEAT LEAKS INTO AIR	1263	336	918	23.6	130	-420	-92	-463	-343	-282	0	0	TBC by IOTMM
DMS	100	100	0	0	100	100	0	0	0	100	0	0	
VIDEO	160	160	70	70	0	0	0	0	0	0	0	0	incl. Illumination
EPDS	0	0	0	0	0	0	0	0	0	0	0	0	
AUDIO	0	0	0	0	0	0	0	0	0	0	0	0	
ECLSS (fans)	677	677	677	677	677	677	677	677	677	677	0	0	
TCS	0	0	0	0	0	0	0	0	0	0	0	0	
SUBSYSTEMS TOTAL	2199	1273	1665	770	906	357	585	214	334	495	0	0	
SYSTEM MARGIN	220	127	166	77	-91	-36	-58	-21	-33	49	0	0	
SUBTOTAL 1	2419	1400	1831	847	816	321	526	192	300	544	0	0	
PAYLOADS:													
LEAK FROM P/L RACK WALLS	540	254	40	19	0	0	0	0	0	0	0	0	NOTE 1
VARIOUS P/L EQUIPMENT	0	0	500	500	0	0	0	0	0	0	0	0	
SUBTOTAL 2	540	254	540	519	0	0	0	0	0	0	0	0	
CREW													
SENSIBLE	330	202	0	0	330	202	0	0	0	0	0	0	
LATENT	154	294	0	0	154	294	0	0	0	0	0	0	
SUBTOTAL 3	484	496	0	0	484	496	0	0	0	0	0	0	
INTER MODULE VENTILATION													
SENSIBLE	220	110	0	0	220	110	0	0	-160	230	0	0	
LATENT	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL SENSIBLE	3509	2260	2371	1366	1520	927	526	192	140	774	0	0	
TOTAL LATENT	154	294	0	0	154	294	0	0	0	0	0	0	
TOTAL REQUIRED	3663	2554	2371	1366	1674	1221	526	192	140	774	0	0	
TOTAL IMPLEMENTED	3800	3800	3800	3800	2000	2000	2000	2000	1500	1500	0	0	

NOTE 1:
Includes Central Aisle P/L, CHeCS, US Laptops, Portable Equipment, PEHG

NOTE:
The actual power dissipation values related to the individual operational modes are controlled by the dedicated parts of the APM external ICDs and the APM internal thermal ICD.

NOMINAL MODE CASES:
- CASE A:Max. sensible/latent heat loads (hot, CHX max. load)
- CASE B:Max. sensible heat loads without crew and IMV contributions (min. dew point)

SUPPORT MODE CASES:
- CASE A:Max. sensible/latent heat loads (no P/Ls on)
- CASE B:Min. sensible/latent heat loads (cold, CHX min. load)

Table 6.2.3.3-1 Cabin Loop Heat Dissipation

WATER LOOP: Revised CCBL									
HEAT LOAD SOURCE	**HEAT LOAD CASES [W]**								**REMARKS**
	NOMINAL MODE		**SUPPORT MODE**		**STAND-BY MODE**		**SURVIVAL MODE**		
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Unberthed**	**Berthed**	
HEAT LEAKS Into Water	-200	200	-200	200	-50	50	0	0	TBC by IOTMM
DMS	623	623	568	568	478	478	0	0	
VIDEO	190	190	190	190	0	0	0	0	
PDU	303	320	114	120	111	115	0	0	
PPSB	25	25	0	0	0	0	0	0	
AUDIO	0	68	0	68	0	68	0	0	
ECLSS	0	0	0	0	0	0	0	0	
TCS	130	390	130	130	130	130	0	0	
SUBSYSTEMS TOTAL	1071	1816	802	1276	669	841	0	0	
SYSTEM MARGIN	-107	182	-80	128	- 67	84	0	0	
SUBTOTAL 1	964	1998	722	1404	602	925	0	0	
CHX	1366	3800	192	2000	140	1500	0	0	
PAYLOADS	0	14500	0	0	0	0	0	0	
TOTAL REQUIRED	2330	20298	914	3404	742	2425	0	0	
TOTAL IMPLEMENTED	22000	22000	22000	22000	6000	6000	0	0	

NOTE: The actual power dissipation values related to the individual operational modes are controlled by the dedicated parts of the APM external ICDs and the APM internal thermal ICD.

Table 6.2.3.3-2 Water Loop Heat Dissipation Allocation

6.2.3.4 Data Processing Resources and SW Categorization

6.2.3.4.1

The categorization of APM onboard data processing items and related SW shall be in accordance with Table 6.2.3.4-1.

ITEM	SW CAT.
VTC (Vital Telemetry and Cmd Computer)	B
MMC (Mission Management Computer)	C
DMC (Data Management Computer)	C
Spare (Computer for MMC or DMC or PLCU)	C
PLCU (P/L Control Unit Computer)	C
MMU (Mass Memory Unit)	C
Laptop	C

Table 6.2.3.4-1 Categorization of APM Data Processing Items and Related SW

6.2.3.4.2

The budgeting of required and allocated data processing resources shall be as defined in Table 6.2.3.4-2.

6.2.3.4.3

The budgeting of required and allocated mass memory unit storage resources shall be as defined in Table 6.2.3.4-3.

Item	SW Allocation	
	MEM/kbyte	**KIPS**
VTC • System • VTC SW		
Total per VTC	**512**	**864**
DMC • DMS Services/OS • System	 6656 2643	 5088 24
Total DMC	**9299**	**5112**
MMC • DMS Services/OS • COAP • System	 6143 1788 1368	 4032 700 380
Total DMC MMC	**9299**	**5112**
Laptop • DNS/OS • System Data • Appl. SW • COTS	 32768 63120 20480 70000	 w/o Netscape 60000
Total Laptop	**186368**	**60000**
PLCU • DMS Services/OS • COAP • System P/L	 6143 433 5712	 4608 150 2442
Total PLCU	**12288**	**7200**

Table 6.2.3.4-2 Onboard Data Processing Resources Allocation

A) Mass Memory unit (MMU)

Item	Size [Mbytes]	Remarks
Total implemented	250	1 MMU (plus 1 red.)
Allocated for P/L S/W	100	
Remaining	150	
Allowed at FAR	100	2/3 as requested by Customer
Allocations - COAP S/W and Data - DMS S/W and Data - System Data	 8 8 60	
Subtotal	76	
Margin/Reserve	24	
Total	100	Max. APM S/W size

B) Laptop Mass Memory

Item	Size [Mbytes]	Remarks
Total implemented	2150	per laptop
Allocated for P/L S/W	100	
Remaining	2050	
Allowed at FAR	1367	2/3 as requested by Customer
Allocations - OS - LAPAP S/W and Data - System Data	 40 8 10	
Subtotal	58	
Margin/Reserve	1309	
Total	1367	Max. APM Laptop S/W size

Table 6.2.3.4-3 Mass Memory Unit Storage Allocations

6.2.3.5 (Intentionally left blank)

6.2.3.6 Reliability

In order to satisfy the APM availability requirement, the following quantitative reliability and maintain-ability requirements have been assigned to the APM on-board subsystems and assemblies (excl. accommodated station common equipment without full design responsibility as ATU, CHECS, PFEX defined in para. 5.8).

<table>
<tr><th colspan="2" rowspan="2">Subsystem/
Assy</th><th rowspan="2">Reliability
(P/L Support)/
90 Days</th><th colspan="3">Maintainability/
360 Days (hrs)</th><th rowspan="2">Reliability
(EWACS)/
90 Days</th></tr>
<tr><th>IVA</th><th>EVA</th><th>RMS</th></tr>
<tr><td colspan="2">Structure incl. FRAM passive parts</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td colspan="2">Harness</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td colspan="2">Thermal Control Items</td><td>0.997</td><td>12.5</td><td>N.A.</td><td>N.A.</td><td>0.9995</td></tr>
<tr><td colspan="2">Fire Detect. Items [1)]</td><td>0.998</td><td>1</td><td>N.A.</td><td>N.A.</td><td>0.9995</td></tr>
<tr><td colspan="2">ECLSS</td><td>0.992</td><td>10.0</td><td>2</td><td>N.A.</td><td>0.9995</td></tr>
<tr><td colspan="2">Outfitting compl.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td colspan="2">Hatch</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td colspan="2">PDGF</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td rowspan="2">Illumination:</td><td>ELA</td><td>0.999</td><td rowspan="3">3</td><td rowspan="3">N.A.</td><td rowspan="3">N.A.</td><td rowspan="3">N.A.</td></tr>
<tr><td>MLU</td><td>0.9992</td></tr>
<tr><td>EPDS Items</td><td>PDU</td><td>0.998[3)] / 0.997[3)]</td></tr>
<tr><td colspan="2">DMSS</td><td>0.99</td><td>2[4)]</td><td>N.A.</td><td>N.A.</td><td>0.9995</td></tr>
<tr><td colspan="2">MAL Panel</td><td>0.994</td><td>2</td><td>N.A.</td><td>N.A.</td><td>0.9995</td></tr>
<tr><td colspan="2">Video[6)]</td><td>0.980</td><td>2</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td colspan="2">Laptops, PEHG[2)]</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td colspan="2">EPF Items[5)]</td><td>0.992</td><td>0.5</td><td>0.5</td><td>N.A.</td><td>N.A.</td></tr>
</table>

[1)] Including FAS panels and Smoke Sensors
[2)] Reliability to be ensured by NASA (ISS common item)
[3)] 0.998 per power outlets; 0.997 for all valve driver outlets
[4)] Corresponding to two box exchanges per year (ref. DMS Spec.)
[5)] Incl. XCMU, PPSB
[6)] Including VDPU, 1 video camera, 1 video recorder

NOTE: On flight configuration level the maintainability requirements are
$\leq$ 46 hrs/360 days for IVA
$\leq$ 2 hrs/360 days for EVA
$\leq$ 3 hrs/360 days for RMS

Table 6.2.3.6-1 Reliability Allocations

6.2.3.7 Microgravity

In order to satisfy the APM overall microgravity requirement, the following microgravity budget allocation requirements shall not be exceeded to the APM on-board subsystems and assemblies.

Subsystem/Assy	Time Domain Budget		Frequency Domain Budget	
	Percentage of total Linear Sum [%]	Factor n of Acc. Limit [-]	Percentage of total Acc. Power [%]	Factor m of Acc. Limit [-]
ECLSS	45	0.45	44	0.7
Thermal Control Items	20	0.2	35	0.6
PDU, MLU, SPI, UCP	0	0	0	0
Laptop (2)	0	0	1	0.1
DMSS MMU (2)	2	0.02	1	0.1
DMSS (Other Items)	0	0	0	0
Structure Items	5	0.05	5[1)]	0.22
Video Recorder	5	0.05	1	0.1
Video (Other Items) [2)]	0	0	0	0
Audio Terminal Units	0	0	0	0
Illumination	0	0	0	0
PEHG	0	0	0	0
Margin	23	0.23	13	0.36
Total	**100**	**1**	**100**	**1**

1) Design to preclude Stick/Slip
2) VDPU, Camera

Table 6.2.3.7-1 Microgravity Allocations

6.2.3.8 Audible Noise/Human Vibration

6.2.3.8.1

In order to satisfy the APM overall audible noise requirement, the following cabin sound power budget allocation requirements shall not be exceeded by the APM onboard subsystems and assemblies.

Subsystem/Assembly	Cabin Sound Power (L_w) Budget	
	Percentage of Total [%]	Total L_w + n dB
ECLSS	55	-2.6
Thermal Control Items	35	-4.6
PDU, MLU, SPI, UCP	0	0
Laptops	2	-17
DMSS MMU	1	-20
DMSS (Other Items)	0	0
Structure Items	5	-13
Video Recorder	2	-17
Video (Other Items)[1)]	0	0
Audio Terminal Units	0	0
Illumination	0	0
PEHG	0	0
Margin	0	0
Total	**100**	**LW**

1) VDPU, Camera

Table 6.2.3.8-1 Sound Power Allocations

6.2.3.8.2

In order to fulfill the Human Vibration requirement, the following budget allocation requirements shall not be exceeded the onboard subsystems and assemblies.

Subsystem/Assembly	**Percentage of Total [%]**	**Factor m of Accel. Level**
ECLSS	44	0.7
Thermal Control Items	35	0.6
PDU, MLU, SPI, UCP	0	0
Laptops	1	0.1
DMSS MMU	1	0.1
DMSS (Other Items)	0	0
Structure Items	5[1)]	0.22
Video Recorder	1	0.1
Video (other Items)	0	0
Audio Terminal Units	0	0
Illumination	0	0
Margin	3	0.36
Total	**100**	**1**

1) Design to preclude stick/slip

Table 6.2.3.8-2 Human Vibration Allocations

6.2.3.9 Leakage Budget

The leakage allocation for APM shall not be exceeded in accordance with Table 6.2.3.9-1.

	kg/day	
- ECLSS	0.01	- feedthroughs
- Structure	0.05	- CBM, structure, seals
- TCS	0.01	
- Avionic	0.01	- incl. connectors
Total	0.08	
Margin	0.01	
APM total	0.09	

Table 6.2.3.9-1 Leakage Allocation

7. PREPARATION FOR DELIVERY

7.1 Transport to Launch Site

7.1.1

The APM shall be transported to the launch site in its transport configurations as specified in para. 6.1.5.

7.1.2 (Intentionally left blank)

7.1.3

Preparation for delivery shall include the provision of relevant transportation/handling equipment as required by the transportation mode.

7.1.4

Commercial packaging in accordance with applicable document 2.1.2.1: MIL-D 116 shall be provided for all loose/removed APM items.

7.1.5

Additionally required parts to be included in the APM transport configuration shall be clearly marked and identified.

7.1.6

ORUs, which are not installed in the Flight Unit transport configuration, shall be packed for transport in reusable containers designed for multiple use and using road, mail and air transport compliant with the ORU's life cycle.

7.1.7

The cleanliness level during loading of the Flight Configuration and individual ORUs into the dedicated transportation container shall meet class 100.000 as defined in applicable document 2.1.2.2: FED-STD-209. This cleanliness level shall also cover any support equipment which is in physical contact with the flight hardware.

7.1.8

All support equipment which is in physical contact with the FC H/W shall be visibly clean.

7.2 Environmental Conditions

7.2.1

The transport containers for the Flight Configuration shall be designed to withstand the specified environmental loads during all phases of handling, loading, transportation and storage from the integration sites up to arrival at the launch site and ensure that the environments within the containers against APM hardware are not exceeding the levels specified in applicable document 2.1.1.10: GSE System Support Specification, para. 3.6.4, 3.6.5 and 3.6.6.

7.2.2

Continuous monitoring of critical environmental parameters shall be provided during all phases of handling, loading, transportation and storage.

Attachment 1:

(Intentionally left blank)

Attachment 2:

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Attachment 3:

List of Abbreviations

Acronyms	Meaning
ADA	(Name of Computer Language)
AFE	Agency Furnished Equipment
AFT	Aft
APM	Attached Pressurized Module
ASE	Airborne Support Equipment
ATC	Active Thermal Control
ATCS	Active Thermal Control Section
ATU	Audio Terminal Unit
CBM	Common Berthing Mechanism
CFA	Cabin Fan Assy
CMU	Control/Monitoring Unit
COL	COLUMBUS
COM	Center of Mass
CPU	Central Processing Unit
CSA	Condensate Separator Assembly
CSE	Crew Support Equipment
C&W	Caution and Warning
DMC	Data Management Computer
DMS	Data Management System
DMSS	Data Management Subsystem
ECLS	Environment Control/Life Support System
ECLSS	Environment Control/Life Support Subsystem
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPDS	Electrical Power Distribution System
EVA	Extravehicular Activity
EWACS	Emergency, Warning and Caution System
FDIR	Failure Detection, Isolation and Recovery
FDS	Fire Detection System
FMECA	Failure Mode Effect and Criticality Analyses
FRAM	Flight Releasable Attachment
FWD	Forward
GSE	Ground Support Equipment
H/W	Hardware
HCI	Human Computer Interface
HRD	High Rate Demultiplexer
HRM	High Rate Multiplexer / High Rate Demultiplexer
I/F	Interface
ISPR	International Standard Payload Rack
ISS	International Space Station
IVA	Intravehicular Activity
LAN	Local Area Network

Acronyms	Meaning
LAPAP	Laptop Application Software
LED	Light Emitting Diode
MAL	Master Alarm Light
MASE	Mechanical Airborne Support Equipment
MCE	Mechanisms Control Electronics
MDPS	Micrometeoroid/Debris Protection System
MGSE	Mechanical Ground Support Equipment
MIPS	Mega Instructions Per Second
MLU	Module Luminary Unit
MMC	Mission Management Computer
MPLM	Mini Pressurized Logistics Module
MTBF	Mean Time Between Failure
NSTS	National Space Transportation System
ORU	On-Orbit Replacement Unit
OS	Operating System
OSE	Orbital Support Equipment
P/L	Payload
PA	Product Assurance
PDGF	Power/Data Grapple Fixture
PDU	Power Distribution Unit
PFEX	Portable Fire Extinguisher
PFM	Pulse Frequency Modulation
PICA	Pre-Integrated Attached Pressurized Module
PLCU	Payload Control Unit
PLM	Pressurized Logistics Module
PROM	Programmable Read-only Memory
PTCS	Passive Thermal Control Section
RF	Radio Frequency
ROD	Review of Design
S/S	Subsystem
SCOE	Special Checkout Equipment
SDE	Software Development Environment
SF	Simulation Facilities
SLM	Structural Latching Mechanism
SSMB	Space Station Manned Base
SSRMS	Space Station Remote Manipulator System
STE	Special Test Equipment
STS	Shuttle Space Transportation System
SUP	Standard Utility Panel
SW	Software
SWRU	SW Replaceable Unit
TCS	Thermal Control System
TDRS	Tracking and Data Relay System
TFM	Table Driven Failure Management
UBM	Unpressurized Berthing Mechanism
UCL	User Computer Language

Acronyms	Meaning
VICOS	Verification, Integration and Check-out Software
VTC	Vital Telemetry and Command Computer
WPA	Water Pump Assembly

Attachment 4:

Traceability and Verification Matrix

NOTES:

- System support requirements qualification on system level is shown in para. 4
- The traces refer all to ESA-RQ-001 if not stated differently.
- The legend to the different additions to the qualification entries is shown at the end of this attachment.

PARAGRAPH	TRACE	QUALIFICATION METHOD
1.5.1	M 8.4.2.3	DEF
1.6	M 8.4.3	DEF
5.2	M 11.2.1.1	DEF
5.2.1.6	-	ROD
5.2.2.1	M 5.2.2.2.1, M 8.4.1.2	DEF
5.2.2.2	M 8.2.4.1, SSMB/APM IRD: M 3.1.2.2	A
5.2.3.1.1	SSMB/APM IRD: M 3.1.3.2	ROD
5.2.3.1.2	SSMB/APM IRD: T 3.1.3.2	ROD
5.2.3.1.3		ROD
5.2.3.3.1	M 11.2.1.1/SSMB/APM IRD: M 3.1.1.5	ROD
5.2.3.3.5	M 8.4.1.2/SSMB/APM IRD: M 3.1.4.2	ROD
5.2.3.3.6	M 8.4.1.1, M 4.5.7.3	ROD
5.2.3.3.7	-	ROD
5.2.4.1.1	M 8.2.2.1, SSMB/APM IRD: M 3.1.7.1.7	A
5.2.5.1.1	SSMB/APM IRD: M 3.1.5.1.1, M 3.1.5.1.2	ROD
5.2.5.2.1.1	SSMB/APM IRD: M 3.1.5.2	ROD
5.2.5.2.1.2	SSMB/APM IRD: M 3.1.5.2.1	ROD
5.2.5.2.1.3	-	DEF
5.2.5.2.1.4	-	ROD
5.2.5.2.2.1	-	DEF
5.2.5.2.2.3	-	T
5.2.5.2.3.1	SSMB/APM IRD: M 3.1.5.3.1	DEF
5.2.5.2.3.2	-	ROD
5.2.5.2.3.3	SSMB/APM IRD 3.1.5.13.1	ROD
5.2.5.2.3.4	SSMB/APM IRD 3.1.5.14	ROD
5.2.5.3.1.1	SSMB/APM IRD: M 3.1.6.1.2	ROD
5.2.5.3.2.1	-	ROD
5.2.5.3.2.2	-	DEF
5.2.5.3.2.3	-	ROD
5.2.5.4.1.1	M 5.10.3, M 5.10.4, M 5.10.2.5	ROD
5.2.5.4.1.2	M 5.10.1 M 5.8.4.5 SSMB/APM IRD: M 3.1.5.7.2	ROD
5.2.5.4.1.3	M 5.10.3	T
5.2.5.4.1.4	M 5.8.4.2 M 5.8.4.4	ROD
5.2.5.4.1.5	M 5.8.4.7	ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
	M 5.8.4.6	
5.2.5.4.1.6	M 5.10.1	T
5.2.5.4.1.7	-	A
5.2.5.4.1.8	-	A
5.2.5.4.2.1	M 8.4.1.3.1	ROD
5.2.5.4.2.2	SSMB/APM IRD: M 3.1.5.9.1	ROD
5.2.5.4.2.3	M 8.4.1.3.2 SSMB/APM IRD: M 3.1.5.9.2	ROD
5.2.5.4.2.4	-	ROD
5.2.5.4.3.1	M 5.11.1.2 SSMB/APM IRD: M 3.1.5.10.1	ROD
5.2.5.4.3.2	M 5.11.1.2 SSMB/APM IRD: M 3.1.5.10.2	T
5.2.5.4.3.4	M 5.11.1.5, M 5.11.1.13	ROD
5.2.5.4.3.5		ROD
5.2.5.5.1	SSMB/APM IRD: M 3.1.7.1	ROD
5.2.6.1.1	SSMB/APM IRD: M3.1.5.3.1.1	DEF
5.2.6.1.2	-	DEF
5.3	-	DEF
5.3.1.1	M 11.1.2, 4.5.15.1	A
5.3.1.2	M 8.1.2.5	A,T
5.3.1.3	-	A
5.3.1.4	-	A[1)]
5.3.2.1	M 11.1.1	A
5.3.2.2	-	A
5.3.3.1	M 11.1.1	ROD
5.3.3.2	-	ROD
5.3.4	M 11.1.1	A
5.3.5	-	DEF
5.3.5.3.1	M 7.2.1.3	A[1)]
5.3.5.3.2	-	A[1)]
5.3.5.3.3	M 7.2.1.3	A[1)]
5.3.5.3.4	M 7.2.1.3	A[1)]
5.3.5.3.5	-	A[1)]
5.4.1.1	M 10.1.2	ROD, A[2)]
5.4.1.2	M 10.1.1	ROD
5.4.2.1	M 10.1.4	ROD
5.4.3.1.1	-	ROD
5.4.3.2.2	-	DEF

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.4.3.3.1	M 10.3.3.2.1	ROD
5.4.3.3.2	M 10.3.3.2.3	T
5.4.3.3.3	M 10.3.3.2.3	T
5.4.3.3.4	M 10.3.3.2.3	ROD
5.5	M 11.2.1.2.1	DEF
5.5.1.1	M 8.2.3.4, ISPR IRD: M 3.1.1	ROD
5.5.1.2	M 8.2.3.1, M 8.2.3.2	ROD
5.5.1.3	-	ROD
5.5.1.4	M 4.5.3.1	ROD
5.5.1.5	M 4.5.3.1, ISPR IRD 3.3.4.3.1	ROD
5.5.1.6	M 4.5.3.1	T
5.5.1.7	M 4.5.3.1	A
5.5.1.8	M 8.2.2.1, ISPR IRD 3.3.4.3.1	T
5.5.2.1	M 8.2.3.3, M 8.1.2.8 ISPR IRD: M 3.2.3.1	A
5.5.2.2	M 8.2.3.1, ISPR IRD: M 3.2.3.1	ROD, A
5.5.3.1	M 8.2.3.1	ROD
5.5.3.2	M 8.2.3.1	ROD, T[3)]
5.5.3.3	M 8.2.3.1	ROD
5.5.3.5	M 8.2.3.1	ROD
5.5.4.1	-	DEF
5.5.5.1.1	M 8.2.5.2, ISPR IRD: M 3.3.1.2.1, 3.3.1.2.2	T
5.5.5.1.2	M 8.2.5.2, ISPR IRD: M 3.3.1.3	T
5.5.5.1.3	M 5.7.4	ROD, T
5.5.5.1.4	M 5.7.5	ROD, T
5.5.5.1.6	-	T (Demo)
5.5.5.1.7	M 5.7.5	T
5.5.5.2.1	ISPR IRD: M 3.3.4.3	ROD
5.5.5.2.2	M 4.5.14.11, ISPR IRD 5.3.4.3.1	ROD
5.5.5.2.4.1	M 5.8.1.4, M 5.8.2.2.5, M 8.2.7.1 ISPR IRD: M 3.3.4.5	ROD
5.5.5.2.4.2	ISPR IRD: M 3.3.4.5	ROD
5.5.5.2.4.3	M 5.8.2.2.4, M 8.2.7.1, ISPR IRD 3.3.4.3	ROD, T
5.5.5.2.4.4	M 5.8.1.2, M 8.2.7.1	ROD
5.5.5.2.4.5.1	M 8.2.7.1, ISPR IRD: M 3.3.4.5.1	ROD
5.5.5.2.4.5.2	ISPR IRD: M 3.3.4.5.1	ROD
5.5.5.2.4.6		ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.5.5.3.1	ISPR IRD: M 3.3.2.1	ROD
5.5.5.4.1	M 5.11.1.7, ISPR IRD: M 3.3.5.1, M 3.3.6	ROD
5.5.5.4.2	M 5.11.1.1, ISPR IRD: M 3.3.6	ROD
5.5.5.4.4	M 5.11.1.4	ROD, T
5.5.5.4.5	M 5.11.1.5	ROD
5.5.5.4.6	M 5.11.1.13	DEF
5.5.5.5.1	M 4.5.10.1	DEF
5.5.5.5.2.1	M 8.2.7.3	ROD
5.5.5.5.2.2	-	DEF
5.5.5.5.4.1	M 8.3.1.1, ISPR IRD: M 3.3.7	ROD
5.5.5.5.4.2	M 8.3.1.4	ROD
5.5.5.5.5.1	M 8.3.1.1	ROD
5.5.6.1	-	DEF
5.5.7.1	-	ROD
5.5.7.2	-	ROD
5.5.7.3	-	ROD
5.7.1.1	-	DEF
5.7.1.2	-	DEF
5.7.1.3	M 10.1.3	DEF
5.7.3.1	M 8.2.3.2	ROD
5.7.4.1.1	M 8.1.2.9, M 8.1.2.10	ROD
5.7.4.2.1	M 8.2.7.2	ROD
5.7.4.2.2	-	A (EQ)
5.7.4.3	-	DEF
5.7.4.4.1.1	M 8.1.2.10	T
5.7.4.4.1.2	M 8.1.2.12, M 8.1.2.13	T
5.7.4.4.1.3	-	T
5.7.4.4.2.1	M 8.1.2.10	ROD
5.7.4.4.2.2	M 8.2.7.2	ROD
5.7.4.4.2.3	-	ROD
5.7.4.4.4.1	M 8.1.2.10	ROD
5.7.4.4.4.2	-	T
5.7.4.4.4.3	-	ROD
5.7.4.4.5.1	M 8.2.6.4	DEF
5.7.4.4.5.2	-	A
5.7.4.6	-	ROD
5.7.7.1	M 8.1.2.10	ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.7.8.1	-	DEF
5.7.8.2.2	M 8.2.4.1	A
5.7.8.3.2.1	-	DEF
5.7.8.3.2.2	-	A, T
5.7.8.3.2.3	M 4.1.11.1	DEF
5.7.8.4.1	M 8.2.5.1	A
5.7.8.4.4.1	M 5.8.2.1.3	T
5.7.8.4.4.2	M 5.8.2.1.3	T
5.7.8.4.5.1	M 5.8.2.2.5	T
5.7.8.4.5.2	-	ROD
5.7.8.4.5.3	-	ROD
5.7.8.4.5.4	-	T
5.7.8.4.6.1	M 8.2.6.1	A
5.7.8.4.7.1.1	M 5.10.1	ROD
5.7.8.4.7.2.1	M 5.8.2.2.10, M 5.10.1	T
5.7.8.4.7.3.2	M 5.8.4.2	ROD
5.7.8.4.8	M 8.2.6.4	DEF
5.7.8.5.1	M 5.8.2.2.1, M 5.8.2.2.2	ROD
5.7.8.5.2	-	Title
5.7.8.5.2.1	M 6.1.1.1, M 6.2.2.14	A
5.7.8.5.2.2	-	A
5.7.8.5.3	-	ROD
5.7.8.5.4	-	A, T
5.7.8.5.5	-	T
5.7.8.5.6	M 5.8.2.2.1	A
5.7.8.5.7	M 5.8.2.2.7, M 5.8.2.3.7	A, T
5.7.8.5.8	-	ROD
5.7.8.5.9	M 5.8.2.4.1	ROD
5.7.9.1	-	DEF
5.7.9.2	M 8.1.2.7	T
5.7.9.3.1	M 10.1.3	ROD
5.7.9.3.2	-	ROD
5.7.9.3.3	-	DEF
5.7.9.3.4	M 10.1.3	ROD
5.7.9.4	-	DEF
5.8	M 8.4	DEF
5.8.5.1.1	M M8.4.1.3.1	DEF

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.8.5.1.1.1	-	ROD
5.8.5.2.1	M 8.4.1.3.2	DEF
5.8.5.2.1.1	-	ROD
5.8.11.1	M 8.4.1.2	DEF
5.8.11.2	-	DEF
5.8.12.1	M 8.4.1.5	DEF
5.8.12.1.1	-	ROD
5.8.12.1.2	-	ROD
5.8.12.1.5	-	DEF
5.8.12.2.1.1	-	ROD
5.8.12.2.2.1	-	ROD
5.8.12.2.2.2	-	A
5.8.13.1.1	-	DEF
5.8.13.1.2	-	DEF
5.8.13.2.1	-	DEF
5.8.13.3.1	-	DEF
5.8.13.4.1	-	DEF
5.8.13.5.1	-	DEF
5.8.13.5.2	-	DEF
5.8.13.5.3	-	DEF
5.8.13.5.3.1	-	ROD
5.8.13.5.3.2	-	ROD
5.8.13.6.1	-	DEF
5.8.13.7.1	-	DEF
5.8.14.1	M 8.4.1.6	DEF
5.8.14.1.1	-	ROD
5.8.14.1.2	-	ROD
5.8.14.1.3	4.5.14.4	ROD
5.8.14.1.4	-	DEF
5.8.14.2.1.1	-	ROD
5.8.14.2.2.1	-	A
5.8.14.2.2.2	-	A
5.8.15.1		ROD
5.8.15.1.1		ROD
5.8.15.2.1		A
5.8.15.2.2		A
5.8.15.2.3		A

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.8.15.3.1		ROD
5.8.15.4.1		ROD
5.8.15.4.2		ROD
5.8.16.1		ROD
5.8.16.1.1		ROD
5.8.16.2.1		A
5.8.16.2.2		A
5.8.16.2.3		A
5.8.16.3		ROD
5.8.16.4.1		ROD
5.8.16.4.2		ROD
5.8.17.1		ROD
5.8.17.2		ROD
5.8.17.3		ROD
5.9.1.1	M 7.1.1.1	ROD
5.9.1.2	M 7.1.1.1	ROD
5.9.2.1	M 7.1.1.1	ROD
5.9.2.2	-	ROD (PICA, EQ)
5.9.2.3	M 7.1.1.1	A
5.9.2.4	M 7.1.1.2	A
5.9.3.2	-	ROD (PICA, EQ)
5.9.3.3.1	M 7.1.1.2	ROD
5.9.3.3.2	-	A
5.9.3.4	-	A
5.10	M 11.3.1.1	DEF
5.10.1.1	M 7.1.4.5, M11.3.1.1	A (EQ)
5.10.1.3	M 11.3.1.1	ROD
5.10.2	M 11.3.2.1	DEF
5.11.1.1	8.2.3.5	ROD
5.11.1.3	8.2.3.7	ROD
5.11.1.4		ROD
5.11.1.5		ROD
5.11.1.6		ROD
5.11.1.7		ROD
5.11.1.8		ROD
5.11.1.9		ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.11.2	8.2.4.2	ROD, A
5.11.2.1		A
5.11.2.3		ROD
5.11.3.1		ROD, A
5.11.4.1		A
5.11.4.2		A
5.11.4.3		Def
5.11.4.4		A
5.11.4.5		Def
5.11.5.1.1		T
5.11.5.1.3	-	ROD, T
5.11.5.1.4	M 5.7.5	ROD, T
5.11.5.1.6	-	T (Demo)
5.11.5.1.7		ROD
5.11.5.2.4.1	M 5.8.1.4, M 5.8.2.2.5	ROD
5.11.5.2.4.2	-	T
5.11.5.2.4.3	M 5.8.2.2.4	ROD, T
5.11.5.2.5	-	ROD
5.11.5.4.1	M 5.11.1.7	ROD
5.11.5.4.4		ROD, T
5.11.6.1	-	DEF
5.12.1.1	M 8.4.1.1	ROD
5.12.1.2	-	ROD
5.12.1.3	-	ROD, A
5.12.1.4	SSMB/APM IRD M 3.1.3.6	ROD
5.12.2.1	-	A
5.12.2.2	-	A
5.12.3	-	DEF
5.12.4.1.1	-	ROD
5.12.4.1.2	SSMB/APM IRD: M 3.2.4.1.2	DEF
5.12.4.3.1	-	ROD
5.12.4.3.2	-	ROD
5.14.1		ROD
5.14.2		A
5.14.2.4	-	ROD
5.15.1		Def
5.15.1.1		ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
5.15.1.2		ROD
5.15.1.3		DEF
5.15.1.4		I
5.15.1.5		A
5.15.2.1.1		A
5.15.2.2.1		A
6.1.1.1	-	DEF
6.1.1.3	-	ROD
6.1.1.4	-	ROD
6.1.1.5	M 7.2.6.7	ROD
6.1.1.7	-	ROD
6.1.1.9	-	DEF
6.1.2.1	8.2.3.6	ROD
6.1.2.2		DEF
6.1.3	M 11.1.1	ROD, A
6.1.4	M 11.1.1	ROD
6.1.5	M 7.1.1.1	DEF
6.1.5.1	-	ROD
6.1.5.2	-	ROD
6.1.6.1.1	-	DEF
6.1.6.1.2	M 10.3.1.5	ROD
6.1.6.1.3	M 10.3.1.5	ROD
6.1.6.1.5	-	ROD
6.1.6.2.1	-	A
6.1.6.2.2	M 7.1.3.3, M 7.1.4.1	DEF
6.1.6.4	-	ROD
6.1.7.1.1	-	DEF
6.1.7.1.2	-	DEF
6.1.7.1.3	-	DEF
6.1.7.1.5	-	DEF
6.1.7.1.6	-	DEF
6.1.7.2.1	M 4.8.2.1, M 8.1.2.3	ROD
6.1.7.2.2	M 4.5.14.1	ROD
6.1.7.2.3	-	ROD
6.1.7.2.4	-	ROD
6.1.7.2.5	M 8.2.3.1	ROD
6.1.7.2.6	M 8.2.7.2, M 8.1.2.9, M 8.1.2.11	ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.1.7.2.7		ROD
6.1.7.2.8		ROD
6.1.7.2.9	M 8.2.7.2	ROD
6.1.7.2.10	M 4.8.2.2	ROD
6.1.7.2.11	-	ROD
6.1.7.2.12	-	T[3)]
6.1.7.2.13		ROD
6.1.7.2.14		ROD
6.1.7.2.15		ROD
6.1.7.2.16		ROD
6.1.7.2.17		ROD
6.1.7.3.1	M 8.1.2.6	ROD
6.1.7.3.2	M 7.2.6.18	ROD
6.1.7.4.1.1	M 4.8.3.2	ROD
6.1.7.4.1.2	-	ROD, T[3)]
6.1.7.4.1.3	-	ROD
6.1.7.4.2.1	M 4.8.3.2	ROD[18)]
6.1.7.4.2.2	-	ROD
6.1.7.4.2.3	-	ROD
6.1.7.4.2.4	M 4.8.3.1	ROD
6.1.7.4.2.5	-	ROD
6.1.7.4.2.6	-	ROD
6.1.7.4.2.7	-	ROD
6.1.7.4.2.8	-	ROD
6.1.7.4.2.9	-	T[3)]
6.1.7.4.2.10	-	ROD
6.1.7.4.2.11	-	T (Demo)
6.1.7.4.2.12	-	ROD
6.1.7.4.2.13	-	ROD
6.1.7.4.2.14	-	ROD
6.1.7.4.2.17	-	ROD
6.1.7.4.2.18	-	ROD
6.1.7.4.2.19	-	ROD
6.1.7.4.2.20	-	ROD
6.1.7.4.2.21	M 4.8.2.3	ROD
6.1.7.4.2.23	M 5.1.5	ROD
6.1.7.4.2.25	-	ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.1.7.4.2.26	M 4.8.3.4	ROD
6.1.8	-	DEF
6.1.9.1.1	-	ROD
6.1.9.1.2	M 4.2.2	ROD
6.1.9.1.3	-	A, T 3)21)
6.1.9.1.4	M 7.2.6.11, M 4.5.6.5	ROD, T 3)
6.1.9.1.5	M 7.2.6.11, M 4.7.3, M 4.7.6.3	A
6.1.9.1.6		I
6.1.9.2.2	M 4.2.1, M 4.5.1.3	ROD, T 3)21)
6.1.9.3.1	-	ROD, T 3)
6.1.9.3.2	-	ROD, A
6.1.9.4.1	-	T 3)21)
6.1.9.4.2	M 7.2.6.11	T 3)
6.1.9.4.3	-	A, T 3)21)
6.1.9.4.4	M 7.2.6.4	ROD, T 3)
6.1.9.4.5	-	A
6.1.9.4.6	M 7.2.6.4	ROD
6.1.9.4.7	M 4.8	DEF
6.1.9.4.9	M 4.5.6.5	A, T 3)21)28)
6.1.9.5.2	-	A (EQ)
6.1.9.5.3	M 7.2.6.7	A,T (EQ)
6.1.10.1	M 5.8.1.1	ROD
6.1.10.2.1	-	DEF
6.1.10.2.2		ROD
6.2.1.1.1	-	DEF
6.2.1.1.2	-	DEF
6.2.1.1.3	-	DEF
6.2.1.1.4	M 4.5.17.4	A, ROD
6.2.1.1.5	-	A, ROD
6.2.1.1.6	-	A
6.2.1.2.1.1	M 5.7.3	DEF
6.2.1.2.2.1.1	-	ROD
6.2.1.2.2.1.2	M 5.7.5	ROD
6.2.1.2.2.1.3	-	ROD
6.2.1.2.2.2	M 5.7.6, M 8.2.5.2	ROD, T
6.2.1.2.2.3.1	M 4.6.3	ROD
6.2.1.2.2.3.2	M 4.6.3	ROD, T

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.2.1.2.2.3.3	M 4.6.3	ROD
6.2.1.2.2.3.4	M 4.6.3; M 8.2.5.3	ROD
6.2.1.2.2.3.6		A
6.2.1.2.2.3.5.1	-	T
6.2.1.2.2.3.5.2	-	T
6.2.1.2.2.3.5.3	-	ROD, T
6.2.1.2.2.3.6	M 4.6.3	ROD
6.2.1.2.2.3.7	M 4.6.3	ROD, T
6.2.1.2.2.3.8	M 4.6.3	ROD
6.2.1.2.2.3.9.1		ROD
6.2.1.2.2.3.9.2		ROD
6.2.1.2.2.4	M 4.5.14.11	ROD, T
6.2.1.2.2.5	M 4.5.14.10	ROD
6.2.1.2.3.1.1	M 4.6.3, M 8.4.2.4	ROD
6.2.1.2.3.1.2	M 4.8.2.2	ROD, T
6.2.1.2.3.2.1	M 8.4.2.4	ROD
6.2.1.2.3.2.2	M 4.5.4.2, M 4.5.12.1	T
6.2.1.2.3.2.3	M 4.5.4.2	ROD
6.2.1.2.4.1.1	M 5.8.1.1, M 4.4.2.1, M 5.8.3.12	ROD
6.2.1.2.4.1.2	M 5.8.2.1.3	ROD
6.2.1.2.4.1.3	M 5.8.1.1, M 8.4.1.9; M 8.4.3	ROD
6.2.1.2.4.1.4	M 4.5.3.3	ROD
6.2.1.2.4.1.5	-	ROD
6.2.1.2.4.1.6	-	ROD
6.2.1.2.4.1.7	-	ROD
6.2.1.2.4.1.8	M 4.6.3	ROD
6.2.1.2.4.1.9	M 5.8.2.4.1	ROD
6.2.1.2.4.1.10	-	ROD
6.2.1.2.4.1.11	M 5.8.1.4	ROD
6.2.1.2.4.1.12	M 5.8.1.2	ROD
6.2.1.2.4.1.13	M 5.8.2.1.3	ROD
6.2.1.2.4.1.14	-	ROD
6.2.1.2.4.1.15.1		ROD
6.2.1.2.4.1.15.2		ROD
6.2.1.2.4.2.1.1	-	DEF
6.2.1.2.4.2.1.2	-	ROD
6.2.1.2.4.2.2.1	M 4.5.3.3	ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.2.1.2.4.2.2.2	-	ROD, T
6.2.1.2.4.2.2.3	M 4.5.3.3	T
6.2.1.2.4.2.2.4	-	T
6.2.1.2.4.2.3.1	-	DEF
6.2.1.2.4.2.3.2	-	T
6.2.1.2.4.2.3.3	M 6.2.2.3	T
6.2.1.2.4.2.3.4	-	A, R
6.2.1.2.4.2.3.5	M 6.2.4.1	A, T
6.2.1.2.4.2.4.1	M 6.1.2.1	ROD
6.2.1.2.4.2.4.2	-	T
6.2.1.2.4.2.4.3	-	ROD
6.2.1.2.4.2.5	-	ROD
6.2.1.2.4.2.6.1	M 7.2.3.6	DEF
6.2.1.2.4.2.6.2	-	A, T
6.2.1.2.4.2.6.3	M 5.8.1.5	ROD, T
6.2.1.2.4.2.6.4	-	ROD, T
6.2.1.2.4.2.6.5	M 5.8.2.3.8, M 7.2.3.35	T
6.2.1.2.4.2.6.6	M 5.8.2.3.8, M 7.2.3.31	T
6.2.1.2.4.2.6.7	M 7.2.3.34	T
6.2.1.2.4.2.6.8	-	T
6.2.1.2.4.2.6.9	M 7.2.3.6	T
6.2.1.2.4.2.6.10	-	ROD, T
6.2.1.2.4.2.6.11	-	A, T
6.2.1.2.4.2.6.12	-	ROD, T
6.2.1.2.4.2.6.13	-	ROD, T
6.2.1.2.4.2.6.14	-	ROD, T
6.2.1.2.4.2.7.1	M 7.2.4.7	T
6.2.1.2.4.2.7.2	M 6.2.1.1	DEF
6.2.1.2.4.2.8.1	M 6.2.1.4.1, M 6.1.1.2	ROD
6.2.1.2.4.2.8.2	-	ROD
6.2.1.2.4.2.9.1	-	DEF
6.2.1.2.4.2.9.2	-	ROD
6.2.1.2.5.1	M 8.4.1.3.1, M 4.5.3.6	ROD
6.2.1.2.5.2	M 8.4.1.3.2	ROD
6.2.1.2.6.1	M 5.8.4.1, M 5.8.4.2, M 5.10.2, M 5.8.4.4	ROD, T
6.2.1.2.6.2	M 4.6.3, M 5.10.2, M 5.10.4, M 5.11.1.2	ROD
6.2.1.2.6.3	M 5.11.1.3	ROD

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.2.1.2.6.4	-	ROD, T
6.2.1.2.6.5	M 5.11.1.12	ROD, T
6.2.1.2.6.6	-	T
6.2.1.2.6.7		ROD
6.2.1.2.6.8		ROD
6.2.1.2.7.1	M 5.4.3, M 5.6.1	ROD
6.2.1.2.7.2	M 4.5.18.1	ROD
6.2.1.2.7.3	-	A
6.2.1.2.7.4	M 5.3.1	ROD
6.2.1.2.7.5	M 5.3.1	ROD
6.2.1.2.7.6	-	A
6.2.1.2.7.8	M 8.4.1.6	DEF
6.2.1.2.8.1.1	M 4.5.3.1	ROD
6.2.1.2.8.1.2	M 4.5.14.11	ROD, T
6.2.1.2.8.1.4	M 4.5.14.11	ROD
6.2.1.2.8.1.5	-	ROD
6.2.1.2.8.1.6	-	ROD
6.2.1.2.8.1.7	-	DEF
6.2.1.2.8.1.8	M 4.5.3.6, M 8.4.1.9	ROD, T
6.2.1.2.8.1.9	M 4.5.3.7	ROD, T
6.2.1.2.8.1.10	-	T
6.2.1.2.8.1.11	-	T
6.2.1.2.8.1.12	M 4.5.14.7	ROD, T
6.2.1.2.8.1.13	-	T
6.2.1.2.8.1.14	M 4.5.3.12	T
6.2.1.2.8.1.15	M 4.5.14.9	T
6.2.1.2.8.1.16	M 4.5.14.9	T
6.2.1.2.8.1.17	M 4.6.3, M 4.4.3	ROD, T
6.2.1.2.8.1.18	-	T
6.2.1.2.8.2.1	M 4.5.14.8, M 4.5.14.2	ROD
6.2.1.2.8.2.2	M 8.4.1.5	A
6.2.1.2.8.2.3	M 4.5.14.14, M 4.5.14.22, M 4.5.14.21	ROD
6.2.1.2.8.2.4	M 8.4.1.5	ROD
6.2.1.2.8.2.5	M 4.5.4.1, M 4.5.5.5, M 4.5.14.17	ROD
6.2.1.2.9.1.1	M 7.2.5.1, M 7.2.5.2	ROD, A
6.2.1.2.9.1.2	M 7.2.5.7	T
6.2.1.2.9.1.3	-	T

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.2.1.2.9.1.4	M 7.2.5.3	ROD, A
6.2.1.2.9.1.5	M 7.2.5.5	ROD, A
6.2.1.2.9.1.6	M 7.2.5.4	ROD, A
6.2.1.2.9.1.7	-	T
6.2.1.2.9.2.1.1	-	ROD
6.2.1.2.9.2.1.2	-	ROD
6.2.1.2.9.2.1.3	-	-
6.2.1.2.9.2.1.4	-	-
6.2.1.2.9.2.1.5	-	-
6.2.1.2.9.2.1.6	-	A, T
6.2.1.2.9.2.2.1	-	ROD, A
6.2.1.2.9.2.2.2	-	ROD
6.2.1.2.9.2.3.1	-	ROD
6.2.1.2.9.2.3.2	-	T
6.2.1.2.9.2.3.3	-	T
6.2.1.2.9.2.4.1	-	T
6.2.1.2.9.2.4.2	-	ROD, A
6.2.1.2.9.2.4.3	-	A
6.2.1.2.9.2.4.4	-	A
6.2.1.2.9.3.1	M 7.2.5.2	ROD, A
6.2.1.2.9.3.2	-	ROD
6.2.1.2.9.4	-	DEF
6.2.1.2.9.5.1	-	ROD
6.2.1.2.9.5.2	-	ROD
6.2.1.2.9.5.3	-	ROD
6.2.1.2.9.6.1	-	ROD, T
6.2.1.2.9.6.2	-	T
6.2.1.2.9.6.3	-	T
6.2.1.2.9.6.4	-	A, T
6.2.1.2.9.6.5	-	A, T
6.2.1.2.9.6.6	-	T
6.2.2.1	M 4.6.3	A
6.2.2.2	M 4.5.1.1	A
6.2.3	-	DEF
6.2.3.1.1	M 8.1.2.5, M 8.2.4.1, M 8.1.2.15	A, T
6.2.3.2.1	M 5.7.1, M 5.7.10	A, T
6.2.3.2.2	-	DEF

PARAGRAPH	TRACE	QUALIFICATION METHOD
6.2.3.3.1	M 5.6.1, M 8.2.6.4	A
6.2.3.3.2	M 8.2.6.1	A
6.2.3.4.1	-	DEF
6.2.3.4.2	M 5.8.3.7, M 5.8.3.9	A
6.2.3.4.3	M 5.8.2.2.7, M 5.8.3.6	A, T
6.2.3.6	M 4.3.1, M 4.4.6.2, M 7.2.6.13	A
6.2.3.7	M 8.2.2.1, M 8.2.2.2	A, T
6.2.3.8.1	M 4.8	A, T
6.2.3.8.2	M 4.8	A, T
7.1.1	M 7.1.1.1	DEF
7.1.3	-	A
7.1.4	-	ROD
7.1.5	-	I
7.1.6	-	A (EQ)
7.1.7	M 5.9.3.1	I
7.1.8		I
7.2.1	M 7.1.1.2	T (EQ)
7.2.2	M 7.1.1.2	I

Legend for notes to qualification methods

1) Analysis using a passive APM thermal model
2) Analysis for 1-g element floor GSE load carrying capability
3) Test on APM level means demonstration on mock-up (1-g)
18) Applicable only for hand-holds and banister
21) Selected cases only
28) Test with shell repair for accessibility only