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**KAP on Ariane 5**

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**User's Manual**

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	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101	Issue 02
		June 6, 2007	Page ii

## Contents


<b>1</b>	<b>Introduction</b>	<b>1-1</b>
1.1	Scope	1-1
1.2	Applicable Documents	1-2
1.3	Reference Documents	1-2
1.4	Abbreviations	1-3
1.5	Definitions	1-6
<b>2</b>	<b>KAP General Description</b>	<b>2-1</b>
2.1	Raising Cylinder Configuration	2-1
2.2	Platform for Auxiliary Payloads Configuration	2-3
<b>3</b>	<b>KAP General Performance Data</b>	<b>3-4</b>
3.1	Mission Duration	3-4
3.2	Mission Profile	3-5
3.3	Orbit	3-6
3.4	Payload Budget Capabilities	3-7
3.4.1	Mass	3-7
3.4.2	Power	3-8
<b>4</b>	<b>Environmental Conditions for KAP Payloads</b>	<b>4-1</b>
4.1	Margin philosophy	4-1
4.2	Dynamic Environment	4-1
4.2.1	Quasi-Static and Low Frequency Loads	4-1
4.2.2	Vibration	4-2
4.2.2.1	Sinusoidal Vibration	4-2
4.2.2.2	Random Vibration	4-3
4.2.2.2.1	Acceptance Level	4-3
4.2.2.2.2	Qualification Level	4-4
4.2.3	Shock	4-5
4.3	Thermal Environment	4-6
4.3.1	Mission Phases	4-6
4.3.1.1	Ground and Pre-Launch Phase	4-6
4.3.1.2	Launch Phase	4-7
4.3.1.3	GTO Phase	4-7

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page iii

4.3.2	Thermal Design Recommendations	4-8
4.4	Radiation Environment Analysis	4-8
4.4.1	Radiation – Total Ionizing Dose	4-8
4.4.2	High Energy Particles	4-9
4.5	Contamination	4-14
4.6	Corrosion	4-15
<b>5</b>	<b>Interfaces</b>	<b>5-1</b>
5.1	Geometric Relationships	5-1
5.2	Usable Volume	5-2
5.2.1	Raising Cylinder Configuration	5-2
5.2.2	Platform for Auxiliary Payloads Configuration	5-3
5.3	Field of View	5-4
5.3.1	Raising Cylinder Configuration	5-4
5.3.2	Platform for Auxiliary Payloads Configuration	5-4
5.4	Mechanical Interfaces	5-4
5.5	Electrical Interfaces	5-5
5.5.1	Power Interfaces	5-5
5.5.2	Data Interface	5-5
5.5.3	EGSE I/F	5-7
5.5.4	Additional Features	5-9
<b>6</b>	<b>Payload Verification and Acceptance</b>	<b>6-1</b>
6.1	PA Approach for Experiments	6-1
6.2	Verification Programme	6-1
6.3	Model Philosophy	6-2
6.4	Test Philosophy	6-2
6.5	Verification by Test	6-3
6.5.1	KAP System Level Tests	6-3
6.5.1.1	Category I Tests	6-3
6.5.1.2	Category II Tests	6-4
6.5.2	Experiment Level Tests	6-4
6.6	Analyses	6-5
6.7	Acceptance and Delivery of Experiments	6-5
<b>7</b>	<b>Experiments Life Cycle and Major Milestones</b>	<b>7-1</b>

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page iv

7.1	Phase 1	7-1
7.2	Phase 2	7-1
<b>8</b>	<b>Operations</b>	<b>8-1</b>
8.1	Phase 3	8-1
8.1.1	Experiment Delivery to Integration Site	8-1
8.1.2	Integration and System Test	8-1
8.2	Phase 4	8-2
8.2.1	Delivery to Launch Site	8-2
8.2.2	Travel and Accommodation	8-3
8.3	Phase 5	8-3
8.3.1	Launch Preparation	8-3
8.3.2	Launch Operations	8-3
8.4	Operational Cycle of a KAP Campaign	8-4
<b>9</b>	<b>Deliverables</b>	<b>9-1</b>
9.1	Documentation	9-1
9.2	Mathematical Models	9-2
9.3	Hardware	9-2
<b>Annex A</b>	<b>Questionnaire</b>	<b>A-1</b>

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101	Issue 02
		June 6, 2007	Page 1-1

# 1 Introduction

## 1.1 Scope

The present document is an output of the Phase B study carried out by Kayser-Threde under a co-funding contract with the European Space Agency. It provides the required information to assess whether or not a specific experiment is an adequate candidate for a flight with KAP.


This User's Manual describes

- The environmental conditions and services,
- The design boundaries, and
- The programmatic requirements,

applicable to each individual experiment which must be satisfied in order to certify an experiment for integration and flight with KAP on Ariane 5. It is based on the previous version issued as KAP-KTH-UM-001 in February 2006 as a result of a KAP Phase A study co-funded by the DLR. It covers specifically the demonstration flight scheduled on an Ariane 5. For other European launchers, such as VEGA and SOYUZ, separate User's Manuals will be issued later. Nevertheless it can be stated that this User's manual for KAP on Ariane 5 is covering the environmental conditions and design boundaries for all other European launchers due to the fact, that Ariane 5 provides the harshest environment to the equipment.

Furthermore, a questionnaire is annexed to this Manual. This questionnaire shall be filled-out by interested experimenters for a first assessment by the KAP payload integrator whether or not a proposed experiment is a potential candidate to be accommodated with KAP.

The User's Manual has been generated with the best data currently available and is provided on informal basis to potential KAP experimenters. The data presented in this document is subject to change due to maturity issues. However, information without a firm traceable source is denoted as To Be Confirmed (TBC). TBC data are preliminary dependent on the KAP and Ariane 5 design and development process and are considered subject to possible change. Items that are -for the time being- unknown are noted as To Be Defined (TBD). These data will be supplemented in the upcoming issues of this document.


	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 1-2

## 1.2 Applicable Documents

- [AD1] Ariane 5 Users Manual, Issue 4, Revision 0, November 2004
- [AD2] CSG Safety regularities, CSG-RS-09A-CN, November 2005
- [AD3] CSG Safety regularities volume 1, CSG-RS-10A-CN, November 2005
- [AD4] CSG Safety regularities volume 2 part 1, CSG-RS-21A-CN, November 2005
- [AD5] CSG Safety regularities volume 2 part 2, CSG-RS-22A-CN, November 2005
- [AD6] CSG Safety regularities volume 3 part 3 CSG-RS-33A-SE, November 2005


## 1.3 Reference Documents

- [RD1] MAQSAT-B2 for Ariane Flight L521, Paper presented by Kayser-Threde on the DGLR Annual Congress 2005 in Friedrichshafen, Paper No. DGLR-2005-056
- [RD2] KAP and MAQSAT-B2 an experimental platform for Ariane 5 evolved from the test satellite for L521, Paper presented by Kayser-Threde on the 6th International Symposium on Launcher Technologies, Munich, Germany, 8.-11.11.2005
- [RD3] Ariane 5 Dummy Satellites and Structures, Paper presented by Kayser-Threde on 54th IAF Congress, Bremen, 29.9.-3.10.2003
- [RD4] MAQSAT-3 on ARIANE L503 - The Structural Design of a Simulated Satellite with Tuneable Performances, Paper presented by Kayser-Threde on 41st AIAA Structures, Structural Dynamics, and Materials Conference, 3.-6.4.2000, Atlanta GA, Paper A00-24515
- [RD5] The new data handling system CTS 3000 on the Kayser-Threde Ariane 5 platform, Paper presented by Kayser-Threde on DASIA Conference 2006. 22.-25.5.2006, Berlin, Germany
- [RD6] <http://www.kayser-threde.com/KAP>


	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 1-3

#### 1.4 Abbreviations


ACU	Adapteur Charge Utile (Payload Adapter)
AD	Applicable Document
ADP	Acceptance Data Package
AO	Announcement of Opportunity
AOCS	Attitude and Orbit Control Subsystem
BAF	Final Assembly Building
BMO-K	Power extern/intern and switch-on Box
CAD	Computer Aided Design
CDI	Command and isolating Module
COTE	Check-Out Terminal Equipment
CoC	Certificate of Compliance
CoG	Center of Gravity
CSG	Centre Spatial Guyanais
EAP	Étage à poudre (Boosters)
ECA	Étage supérieur Cryotechnique A
EEE	Electrical, Electronic, and Electromechanical Components
EGSE	Electric Ground Support Equipment
ELA	Ensemble de Lancement ARIANE 3
EMC	Electro-Magnetic Compatibility
EOL	End of Life
EPC	Étage Principal Cryotechnique
EPU	Experiment Control Unit
FEM	Finite Element Method
FEP	Front End Processor

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 1-4

FRR	Flight Readiness Review
DCU	Direct Converter unit
GTO	Geo-Transfer Orbit
GSE	Ground Support Equipment
GSOC	German Space Operations Centre
ICD	Interface Control Document
IPA	International Policy Association
IRD	Interface Requirements Document
I/F	Interface
KAP	Kayser-Threde Ariane (space) Platform
KTH	Kayser-Threde
LET	Linear Energy Transfer
LM	Long Mission
MFD	Multi-Purpose Fitting Dummy
MLI	Multi-Layers Insulation
MM	Medium Mission
MoS	Margin of Safety
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
OCOE	Overall Check-Out Equipment
PA	Product Assurance
PC	(Bus) Power Converter
PCDU	Power Conversion and Distribution Unit
PFM	Proto-Flight Model
POC	Plan d' Opérations Combinées
P/L	Payload
PSC	Power Supply Control unit

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 1-5

QA Quality Assurance  
 RAD Radiation Absorbed Dose  
 RCU Remote Control Unit  
 RD Reference Document  
 SEE Single Event Effects  
 SM Short Mission  
 SPENVIS Space Environment Information System  
 SRS Shock Response Spectrum  
 TC Telecommand  
 TID Total Ionizing Dose  
 TM Telemetry  
 TMA Telemetry Assembly  
 TTC Transparent Conductive Coating

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 1-6

## 1.5 Definitions

### INVESTIGATOR / EXPERIMENTER

Investigator/Experimenter is the nominated person who is responsible for the investigation and achievement of the scientific objectives. To this end, he has full decision authority within the investigation science team. He is as well the instrument supplier.

### EXPERIMENT or INSTRUMENT or EXPERIMENTAL PAYLOAD

The Experiment/Instrument/Experimental payload constitutes the specific hardware and software needed to perform the scientific measurements for the achievement of the proposed science objectives. An Experiment/Instrument/Experimental may consist of several units.

### KAP (PAYLOAD) INTEGRATOR


The KAP (payload) integrator is the authority that has the responsibility of the payload integration on KAP to achieve mission objectives.

### KAP TMA

The KAP TMA is the complete set of telemetry, power and data management unit.

### UNIT

Unit refers as one of the physical constituents ("box") of an instrument.

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 1-7

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## 2 KAP General Description

KAP shall serve as future recurrent standard kit for the European launchers family for In-Orbit-Demonstration of new technologies and scientific experiments. KAP provides the complete necessary infrastructure (power, data handling, telemetry, and supportive structure) to be fully autonomous from the launch vehicle. These features significantly ease its integration, minimizing constraints and interactions with the launcher and therefore should provide recurrent flight opportunities. Two different mission scenarios are planned, see section 3.

Different accommodations for KAP on Ariane 5 are foreseen in order to ease its integration. KAP can either be mounted on an additional load carrying raising cylinder located underneath the launcher payload adaptor, or integrated on a platform for auxiliary payloads. The accommodation of KAP on other European launchers is of course possible, depending on the mission profile, providing additional capabilities such as stabilized phases with low-gravity environment and separation. All data transfer will be done via the Ariane Ground Stations network following lift-off and via a dedicated Ground Station e.g. GSOC (Weilheim, Germany) after upper stage passivation.

### 2.1 Raising Cylinder Configuration

#### Raising cylinder with internal platform

From structural point of view the raising cylinder in this configuration serves as a metallic structure having dedicated properties and characteristics similar to the MFD (Multi-Purpose Fitting Dummy Version) already developed and manufactured by Kayser-Threde in 2002. An overview of the KAP configuration is given in the following figure.

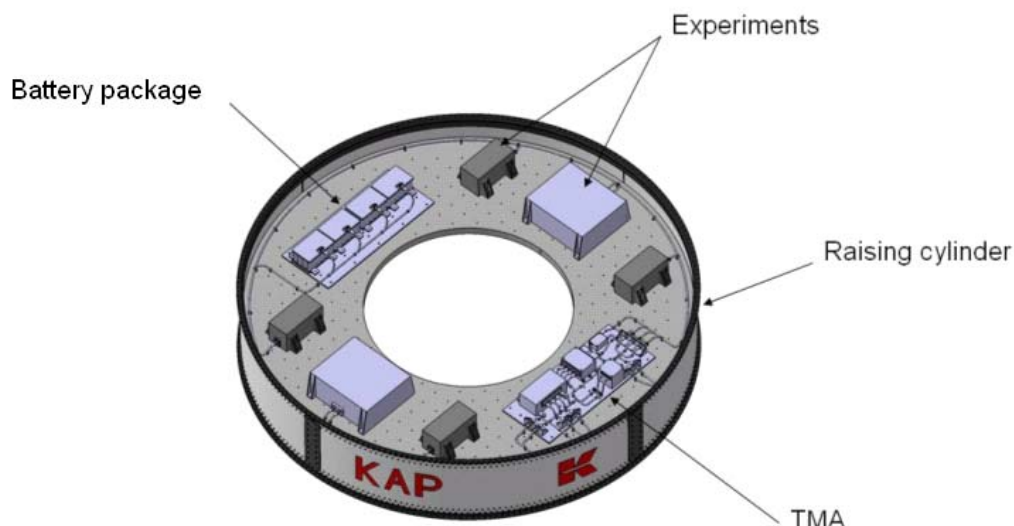


Figure 2-1: Raising Cylinder Configuration with Raising Platform

The structure is constituted by an external cylindrical shell, an internal platform supported by a conical shell and two aluminum flanges interfacing to the adjacent upper and lower structure.

### Pure raising cylinder without internal platform

This concept consists in a light-weight raising cylinder configuration without the internal platform and conical supporting structure where the payload and equipment can be mounted directly on the inside/outside wall of the raising cylinder. An overview of the KAP configuration is given in the following figure.

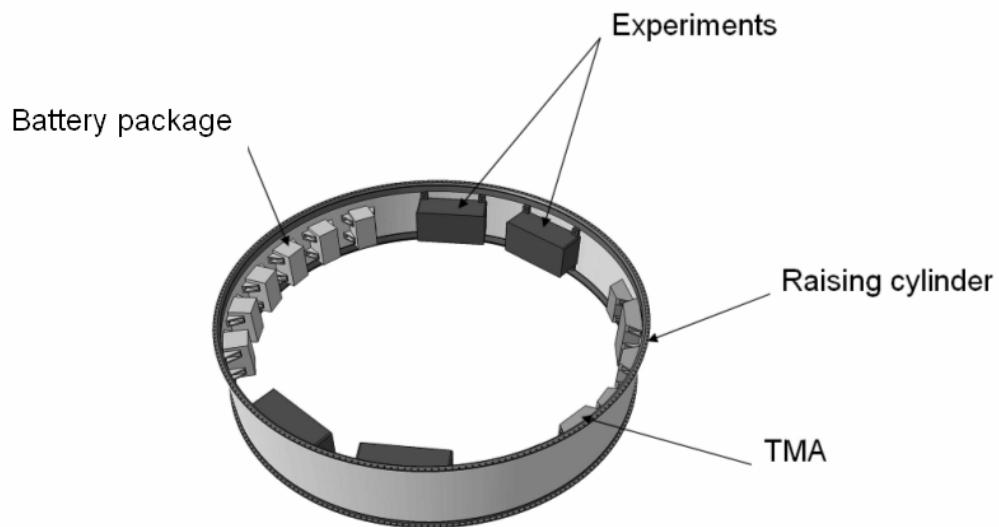


Figure 2-2: Raising Cylinder Configuration without Internal Platform

Note: Accommodation of experiments and equipment on the outside cylinder wall is also possible.

### Accommodation on Ariane 5

In addition to that, the raising cylinder serves as a trimming structure and shock damper to the overall launch configuration. This combination of auxiliary payload accommodation and improvement of primary passenger accommodation and launch environment is an optimum starting point to consider KAP as a possible flexible and recurrent flight opportunity. To facilitate the recurrent KAP accommodation for Arianespace, each cylinder will be designed, manufactured and trimmed, in such a way, that it has always identical mechanical characteristics.

Both raising cylinder configurations are foreseen to be accommodated underneath the Payload Adapter "ACU". Several accommodations are feasible: with SYLDA or SPELTRA, with a long or a short fairing (COIFFE). The following figures show possible KAP accommodations on the launch vehicle.

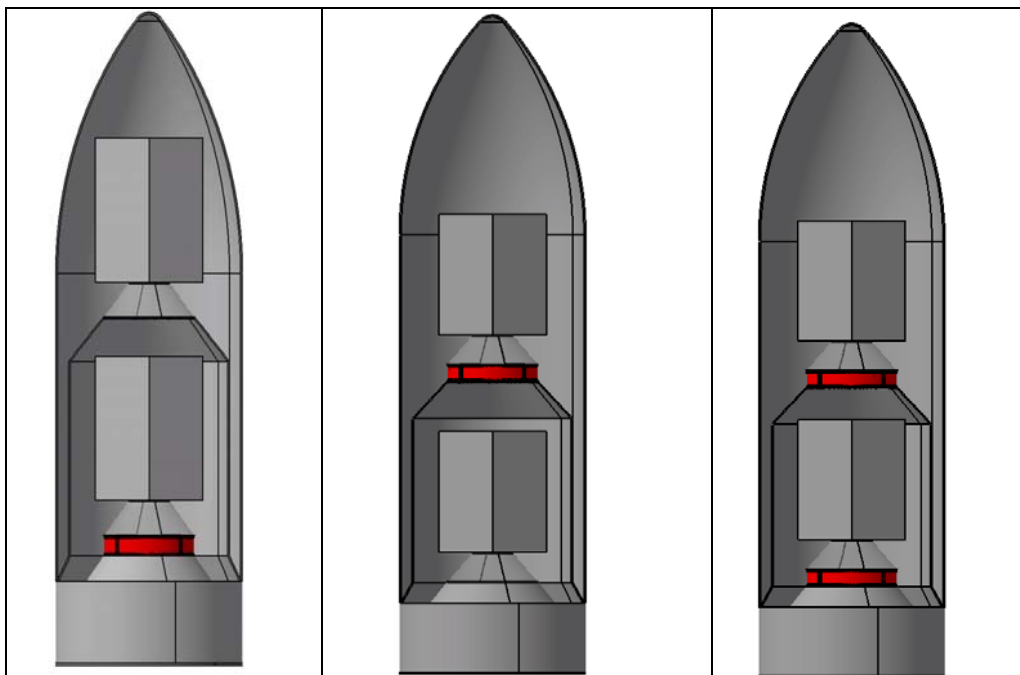


Figure 2-3: Possible accommodations on Ariane 5 - Raising cylinder configuration

## 2.2 Platform for Auxiliary Payloads Configuration

KAP can also be mounted on any platform for auxiliary payloads providing additional flexibility. Typically such kind of platform will be accommodated underneath the payload adaptor of the lower passenger (refer to Figure 2-3, left illustration).

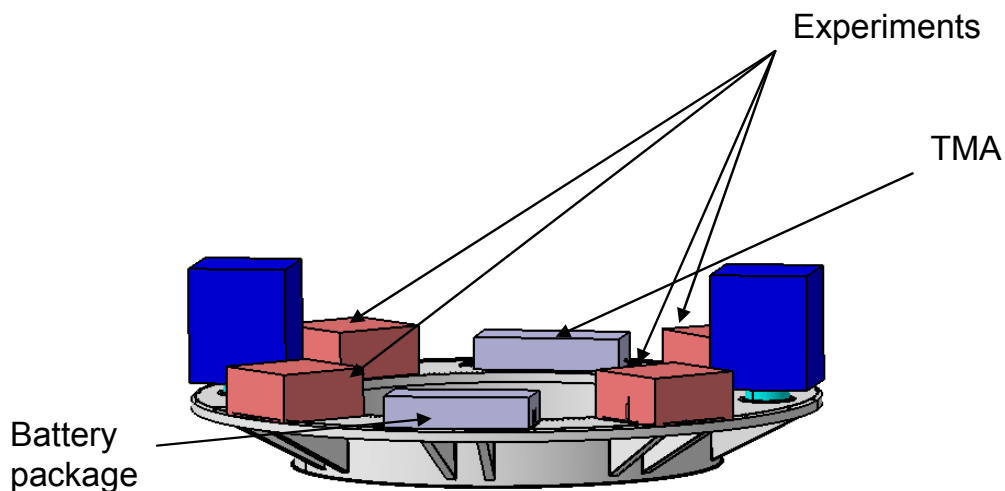


Figure 2-4: Platform for auxiliary payloads configuration

### 3 KAP General Performance Data

#### 3.1 Mission Duration

Two types of missions are planned to be realized for experiment flying with KAP:

- Short Mission (SM), and
- Medium Mission (MM).

Name	Duration	Major characteristics
KAP-SM	3 h	Online data transfer with data rate up to 5 Mbps, power via batteries, 25W* total average payload power (250W peak power manageable)
KAP-MM	3 days nominal 7 days maximum	Data storage and data transfer during playback with data rate up to 5 Mbps, power via batteries, 25W* total average payload power (250W peak power manageable)

Table 3-1 : KAP Baseline Mission duration

- \*) Payload capacity can be substituted by additional battery on demand
- \*\*) Utilization of other ground stations under investigation

After separation of the main passenger(s) approximately 32 min after lift-off, KAP remains on the Ariane 5 upper stage:

- GTO-orbit,
- Attitude to the sun adjustable, to be arranged with Arianespace,
- Spin-rate around launcher longitudinal axis at approximately 7-8 rpm.

Note that the KAP will not be separated from the Ariane 5 upper stage and therefore it will not be equipped with any separation nor jettisoning system.

Table 3-1 shows an overview of the sequence of events of the two types of KAP missions. It has to be noted that also a combination of, for instance, KAP-SM and KAP-MM is feasible. The final mission scenario will be defined after selection of the KAP payload together with Arianespace and the experimenters.

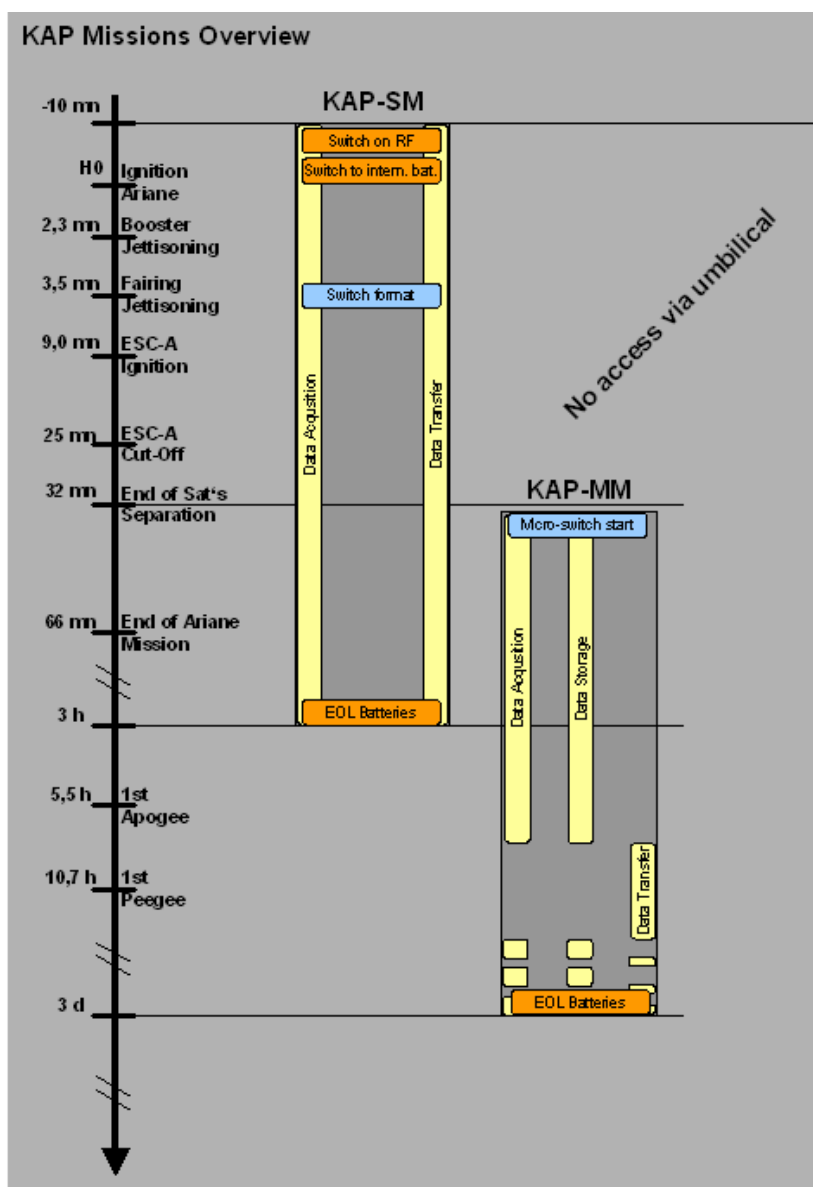



Figure 3-1: KAP Missions Sequence Overview

### 3.2 Mission Profile

During its first life phase, the KAP will be submitted to the following phases from its acceptance after manufacturing till the end of the separation and jettisoning of the main passenger(s) from the launch vehicle:

- Delivery of experiments and associated support equipments in Munich, Germany
- Integration and test in Munich, Germany
- Acceptance in Munich, Germany
- Storage in Munich, Germany
- Transport within Europe and from Munich to Kourou in French Guyana,

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 3-6

- Storage in Kourou,
- Removal from storage and preparation for integration in the BAF of ELA3,
- Optional experiments integration,
- Final integration on the launch vehicle in the BAF,
- Waiting period on top of the launch vehicle in the BAF,
- Transport of the launch vehicle from the BAF to the launch pad,
- Launch preparation,
- Waiting period with the launch vehicle before launch,
- Possible return to the BAF,
- Synchronized sequence and EPC engine ignition,
- Possible aborted launch,
- EAP's ignition and lift off,
- Propulsive flight phase,
- EAP's burn out,
- Separation EAP/EPC,
- Separation and jettison of the fairing,
- EPC engine shut down and separation,
- ECA Stage ignition,
- Propulsive flight phase of the ECA stage, until ECA stage shut down,
- SCAR sequence including the orientation of the upper composite,
- Separation of the main passenger(s),
- SCAR sequence including the orientation of the ECA stage,
- Activation of KAP and its payload,
- Passivation of ECA stage.
- Due to the fact that KAP is a fully autonomous system, the mission duration is typically beyond the passivation of the ECA upper stage.

### 3.3 Orbit

The following orbital data is only relevant for short and medium missions.

The orbital elements of KAP are:

- Apogee Altitude: 35,950 km
- Perigee Altitude: 250 km
- Inclination: 6°

The apogee and perigee altitudes as well as the inclination and argument of perigee values are defined by the standard Ariane 5 ECA GTO trajectory. This revised set of standard parameters was released by Arianespace on September 21st 2006 and will be included in the next version of the user's manual to be published early 2007.

The above given values may slightly differ depending on the mission since the orbital parameters are mainly driven by the main payload passenger(s) of Ariane 5. Therefore, orbital requirements have to be discussed and to be agreed with Arianespace prior to the set-up of the KAP mission sequence.

Thermal and radiation environments requirements for the KAP payloads are documented in the following chapters.

The baseline KAP mission does not include any AOCS or orbit determination system.

### 3.4 Payload Budget Capabilities

#### 3.4.1 Mass

Baseline scenarios		
Payload Mass *)	KAP-SM	KAP-MM
Raising cylinder with internal platform	200 kg	180 kg
Raising cylinder without internal platform	120 kg	80 kg
Platform for auxiliary payloads	200 kg	200 kg

Table 3-2 : Payload Mass

\*) Payload capacity can be substituted by additional battery on demand


### 3.4.2 Power

Baseline scenarios		
Payload Power *)	KAP-SM	KAP-MM
Experimental payload	25 W average	
	250 W peak	
	28 V	

Table 3-3: Power Budgets for KAP Missions

\*) Average Current

The available power is determined by the available battery power for Short and Medium Missions. The table above shows that it has been assumed that for Short Mission and Medium Mission, approximately 25 Watt total power in average will be available (250 W peak power manageable) for KAP experiments.

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 4-1

## 4 Environmental Conditions for KAP Payloads

The following requirements shall be fulfilled to guarantee experiment's accommodation on Ariane 5. It can be discussed with the experimenter to introduce further means to limit the local environment (mainly shock) for the experiments when needed. Furthermore it is planned to equip KAP with environmental sensors for measuring the local experiment environment, in order to provide the experimenters with the required data in order to validate and correlate their results.

### 4.1 Margin philosophy

In order to reduce the amount of system tests, the margin of safety for all structural parts of the experimental payload must be

$$\text{MoS} > 1$$

If lower margins are not to be avoided by the payload/experiments, additional tests on experiment side must be performed, or it must be validated that in case of failure, a danger for either Ariane 5 or KAP can be excluded.

The following paragraphs give an overview of the dynamic environmental loads for experimental payload

In case of sensitive equipment/experiments to be accommodated on KAP not able to withstand the environmental conditions and not foreseen to be exposed to the full launcher environment specified hereafter, specific means for damping can be introduced on request.

### 4.2 Dynamic Environment

This section is applicable to the different configurations, either for KAP mounted on a raising cylinder with or without internal platform, or for KAP mounted on the platform for auxiliary payloads.

#### 4.2.1 Quasi-Static and Low Frequency Loads

The quasi-static and low frequency flight limit accelerations that the experiments will encounter during launch and early orbit phase are compiled in Figure 4 1.

The quasi-static loads of Figure 4-1 have to be applied:

- At the unit CoG,
- Along the worst spatial direction with respect to resulting reactions/stresses.
- Structural dimensioning of units shall consider critical effect of combined acting loads.

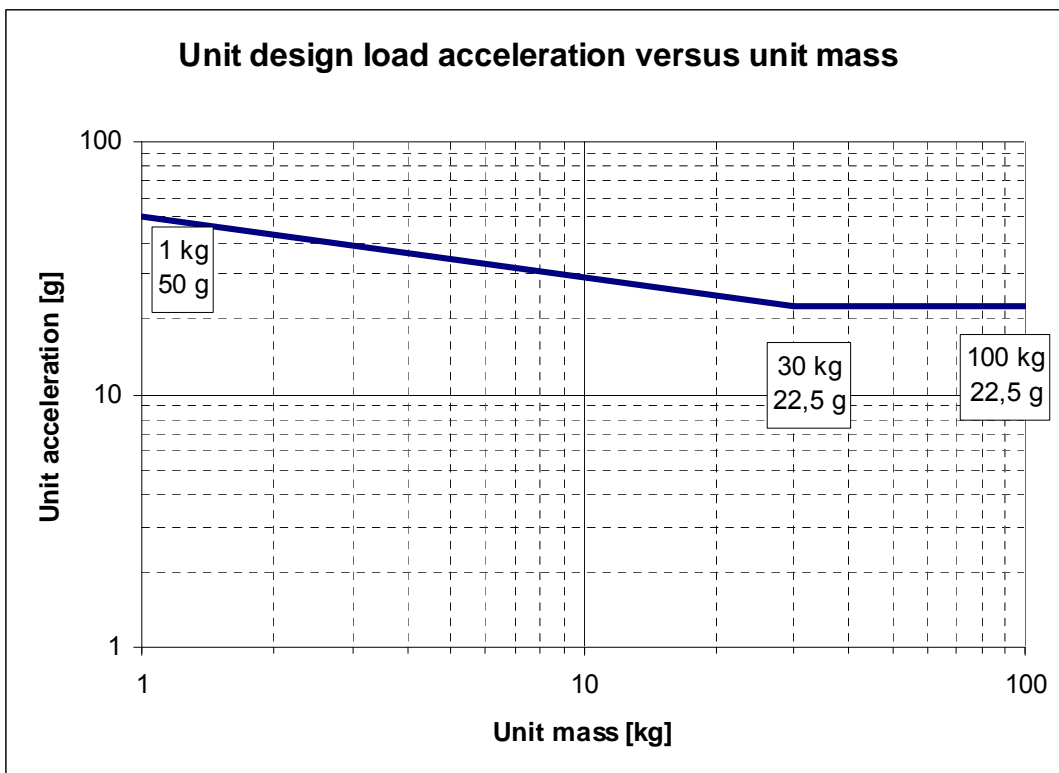


Figure 4-1: Quasi-static loads on KAP equipment depending on KAP equipment mass

## 4.2.2 Vibration

The launch will induce dynamic vibration loads at the experiment interfaces. The level of these dynamic excitations depends on the dynamic couplings between the launcher and the KAP on which the units are mounted.

The dynamic (vibration) levels applied at units interface are defined:

- In Table 4-1 for sinusoidal vibration,
- In Table 4-2 for random vibration.

During sinus and random tests of experiment units, notching may be negotiated but must be approved by the KAP payload integrator.

### 4.2.2.1 Sinusoidal Vibration

Units mounted on KAP shall be designed to withstand without degradation the sinusoidal environment as defined in Table 4-1

The sinusoidal vibration level must be applied in each of the 3 axes.

Frequency range [Hz]	Acceleration amplitude (0 to peak)	Sweep rate
5 - 16	10.0 mm	1/3 oct./min duration 11.4 min
16 - 60	10.0 g	
60 - 70	22.5 g	
70 - 200	22.5 g	2 oct./min duration 2.4 min
200-2000	10.0 g	

Table 4-1: Sinusoidal vibration level

#### 4.2.2.2 Random Vibration

Experiments mounted on KAP shall be designed to withstand without degradation the random environment as defined in the following sections.

##### 4.2.2.2.1 Acceptance Level

Axis	Frequency range [Hz]	Power Spectral Density [g <sup>2</sup> /Hz]	Input approximately [grms]	Duration [min/axis]
All	20 to 2000	0.0727	12.0	1

Table 4-2: Random vibration acceptance level

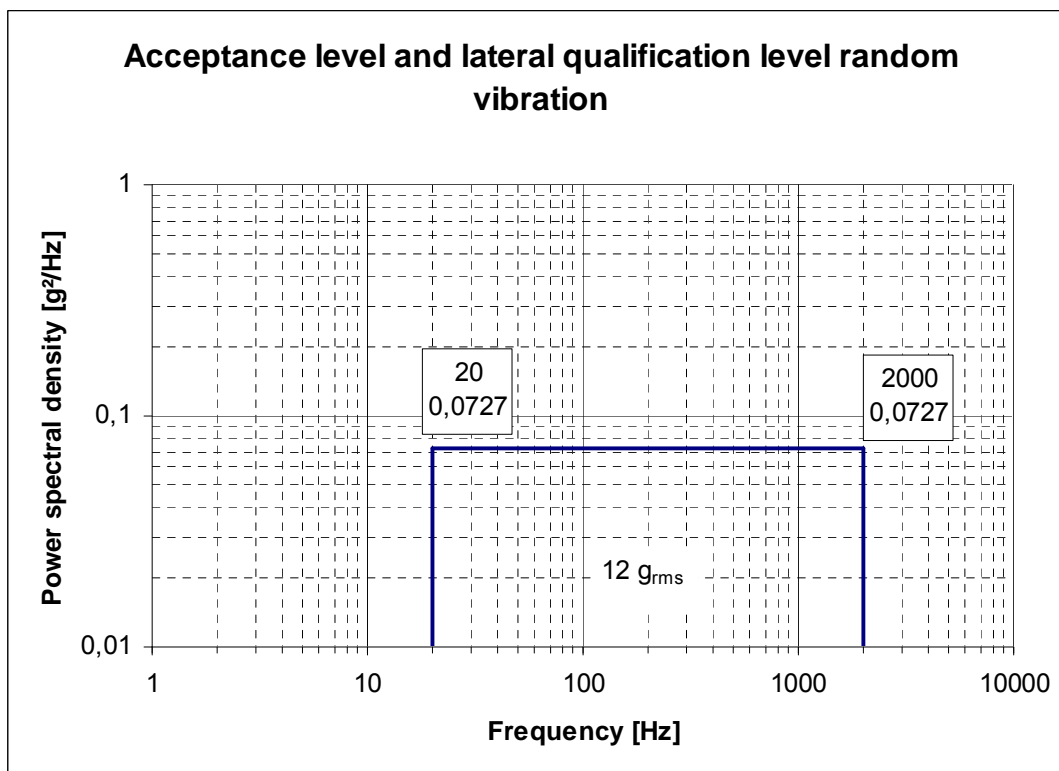


Figure 4-2 : Acceptance level and lateral qualification level random vibration

#### 4.2.2.2.2 Qualification Level

Axis	Frequency range [Hz]	Power Spectral Density	Input approximately [g <sub>rms</sub> ]	Duration [min/axis]
Longitudinal	20 to 60	+3db/Oct	20.0	2
	60 to 1000	0.273 g <sup>2</sup> /Hz		
	1000 to 2000	-6db/Oct		
lateral	20 to 2000	0.0727 g <sup>2</sup> /Hz	12.0	2

Table 4-3: Random vibration qualification level

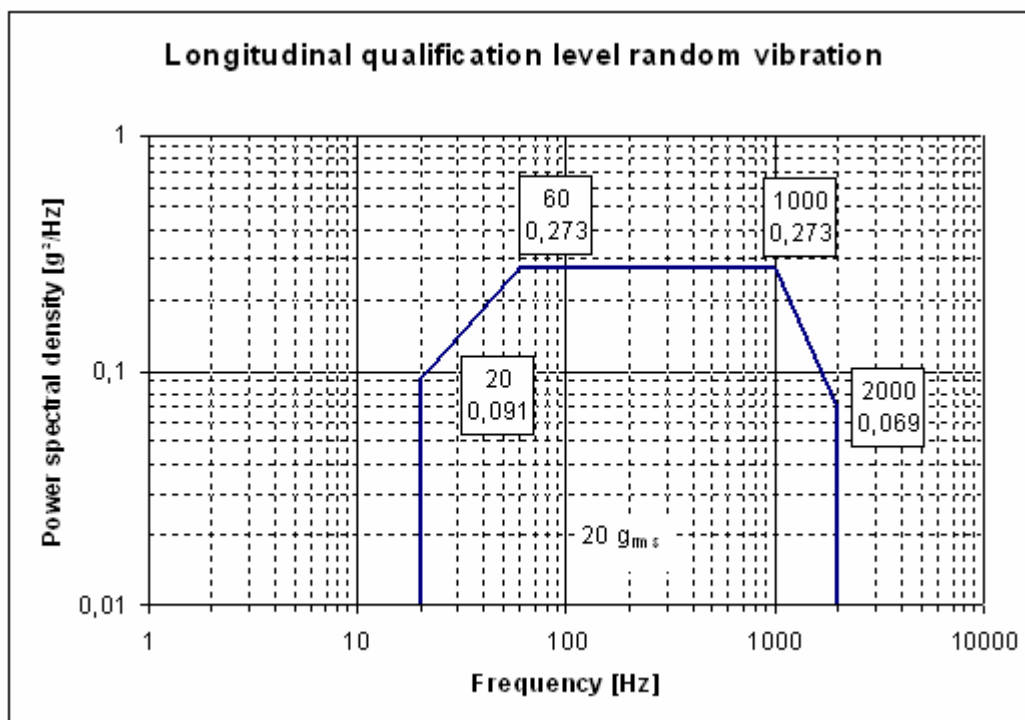


Figure 4-3: Longitudinal qualification level random vibration

### 4.2.3 Shock

The unit is subjected to shocks during inter-stages separations, fairing and carrying structures jettisoning and on actual payload separation. The equipment must therefore demonstrate its ability to withstand the shock specified below.

Frequency [Hz]	SRS (g) qualification
200	60
2000	3200
8000	3200
10000	4300

Table 4-4: Shock

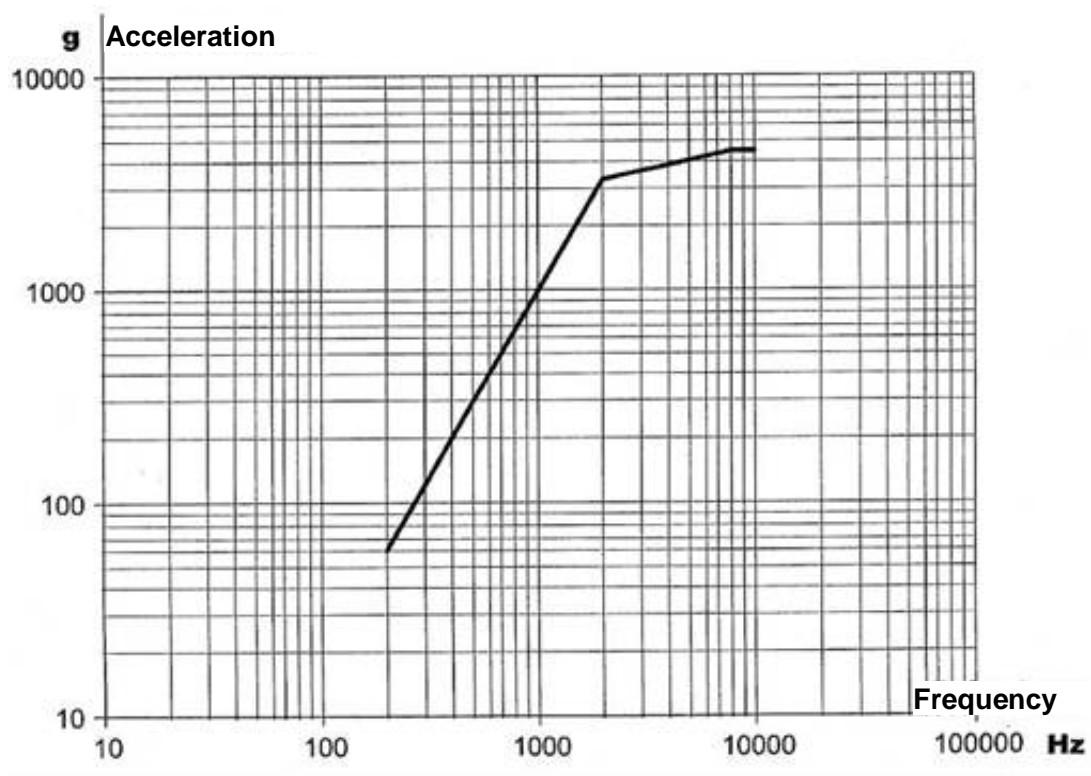


Figure 4-4: Shock specification

### 4.3 Thermal Environment


#### 4.3.1 Mission Phases

##### 4.3.1.1 Ground and Pre-Launch Phase

All the information about the thermal environment during all phases from ground operations to fairing jettisoning are derived from the [AD1]. For additional information regarding the Platform for auxiliary payloads configuration refer to [AD2].

Three phases have to be considered:

- The spacecraft preparation phase within the EPCU buildings and transport between these buildings (refer to EPCU Manual),
- The spacecraft encapsulated inside the fairing or SYLDA 5 and mated to the launch vehicle within the Final Assembly Building (BAF), and
- The transfer to the launch pad and the final pre-launch phase.
- During the encapsulation phase and once mated to the launch vehicle, the spacecraft is air-conditioned by a ventilation system provided through the pneumatic umbilical. This class 100000 cleanliness system has the following characteristics:

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 4-7

- Inlet temperature of injected air: adjustable between 10°C and 25°C in the BAF and on the launch pad and for the transfer phase to the launch pad,
- Relative humidity  $\leq 50\%$ ,
- Filtration: 0,3  $\mu\text{m}$ ,
- Main air velocity within the fairing  $\leq 2$  m/s (locally this value can be exceeded), and
- The noise generated by the ventilation system does not exceed 90 dB.
- Note: Outlet temperature of air (fairing venting holes)  $\leq 25^\circ\text{C}$ .

#### 4.3.1.2 Launch Phase

##### **In-flight thermal flux within the payload compartment**

The flux density radiated by the fairing and the VEB does not exceed  $1000\text{W}/\text{m}^2$  at any point. This figure does not take into account any effect induced by the spacecraft dissipated power.

Based on some measurements derived during flight, a temperature decrease of 2K on the average temperature from launch until fairing jettisoning is expected.

##### **Aerothermal flux after fairing jettisoning**

The nominal time for jettisoning the fairing on all flights is determined in order not to exceed the aerothermal flux of  $1135\text{W}/\text{m}^2$ . Solar radiation flux, albedo, and terrestrial infrared are not accounted in this flux.

Based on some measurements derived during flight, a temperature decrease of 2K on the average temperature from fairing jettisoning until insertion into orbit is expected.

##### **Maximum dissipated power of the spacecraft**

During all phases from encapsulation to the separation of the spacecraft, the maximum dissipated power considered has to be agreed with the launch authority. For the Platform for auxiliary payloads configuration, the maximum dissipated power has to be  $\leq 5\text{W}$  for each micro auxiliary payload. This requirement does not apply to the MM and LM, the KAP equipment being switch off until main passenger(s) separation.

#### 4.3.1.3 GTO Phase

Following main passenger(s) separation, the Ariane 5 upper stage is spin-stabilized along its longitudinal axis (about 7-8 rpm). The attitude pointing at separation will be defined by Arianespace according to mission requirement. A steadily increasing nutation perturbs the upper stage motion post passivation. Therefore experimenters have to consider for the experiment thermal design that the attitude of the upper stage is not controlled along its trajectory.

According to Mission Analysis, the selected orbit has its first apogee in full sunlight, therefore solar eclipse occurs at perigee. The eclipse duration will vary between 0 minutes and a maximum value, depending on actual orbital parameters. Under this consideration and the relative short mission duration, the maximum eclipse time expected is given in the following table.

Eclipse	Perigee
Maximum eclipse duration	23 min

Table 4-5: Maximum eclipse duration

Additional data regarding the thermal environment are available on request

### 4.3.2 Thermal Design Recommendations

The experimenter is responsible for the thermal control system of the experiment of interest, implementing passive or active solution in order to provide suitable temperature range and variation for the experiment during the entire mission. The thermal design shall be documented as outlined in the Acceptance Data Package.

For the conductive and radiative couplings, the thermal design has to be in line with the following baseline requirements:

- Raising cylinder configuration: The thermal control system of each experiment shall be designed in such a way to minimize thermal coupling with the supportive structure.
- Platform for auxiliary payloads configuration: The thermal control system of each experiment shall be designed in such a way to minimize thermal coupling with the supportive structure.

Note: Specific thermal constraints may be accommodated by providing particular thermal control means when requested by the experimenter.

### 4.4 Radiation Environment Analysis

Due to the very short duration of the SM mission, it has been considered that radiation was not presenting any concern on a design point of view.

The radiation environment analysis has been performed for the MM mission, assuming a 7-days mission, dealing mainly with radiation Total Ionizing Dose (TID) and high energy particles. Spacecraft charging effects are not discussed in details in this document. Some general recommendations are listed in last section. This analysis has been performed using ESA SPENVIS software programme for the radiation environment calculation for a 7-days mission. Two extreme scenarios have been considered in order to cover a wide range of possible launch dates: the present solar minimum in 2008 and the next solar maximum in 2011.

#### 4.4.1 Radiation – Total Ionizing Dose

The radiation total dose has been calculated for the entire mission duration using the SHIELDDOSE computer code. The total dose absorbed in GTO for various aluminum thicknesses is presented in the figure hereafter. This figure illustrates that increasing the wall thickness will significantly reduce the total absorbed dose behind this wall. Above 10 mm of aluminum shield thickness there is no more shield effect benefit compared with the mass increase.

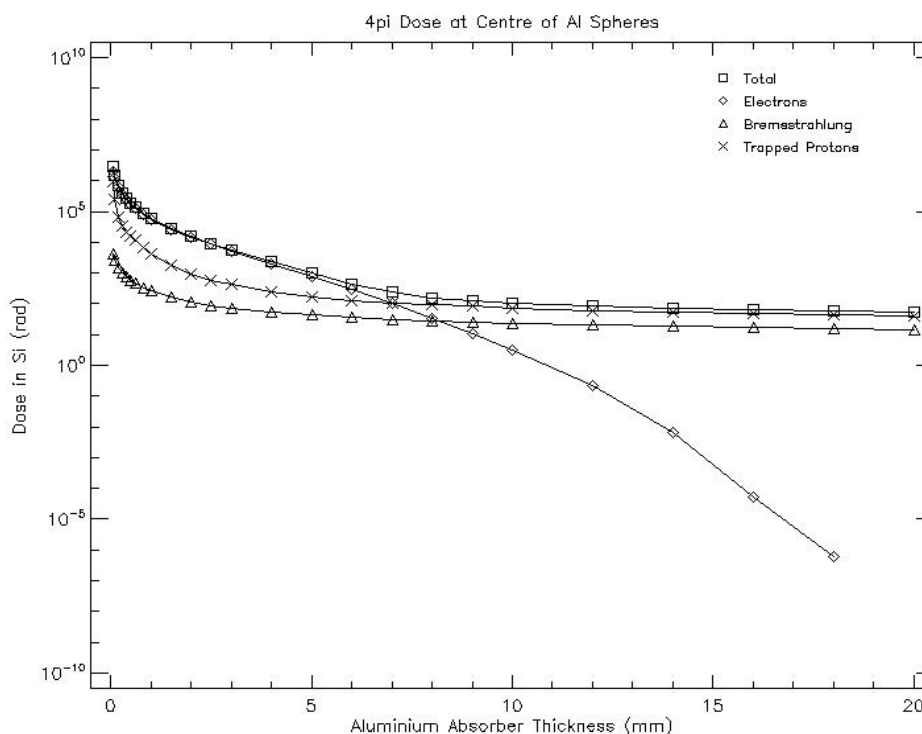


Figure 4-5: KAP GTO TID shield spectrum for a 7 days mission - MM Mission

Typical TID withstanding threshold for commercial-off-the-shelf electronics lies between 2 krad and 10 krad. For the MM mission, if a 5 mm aluminum shield thickness is used to protect the experiments electronics, the total dose radiation will be between approximately 0.98 krad (solar maximum) and 0.75 krad (solar minimum). Therefore it is possible to use commercial-off-the-shelves electronics on the KAP-MM mission without exceeding their maximum withstanding TID threshold. In the following section only the more constraining scenario (solar maximum) is considered.

#### 4.4.2 High Energy Particles

The trapped proton and electron environment, together with the cosmic heavy ion irradiation, are responsible for the so-called Single Event Effects (SEE). The LET spectrum for the KAP mission is shown in the figure hereafter. The LET spectrum provides the required information in order to evaluate if Single Event Effects of EEE components occur, by taken into consideration their respective cross section ( $\sigma$ ) at a specific LET threshold.

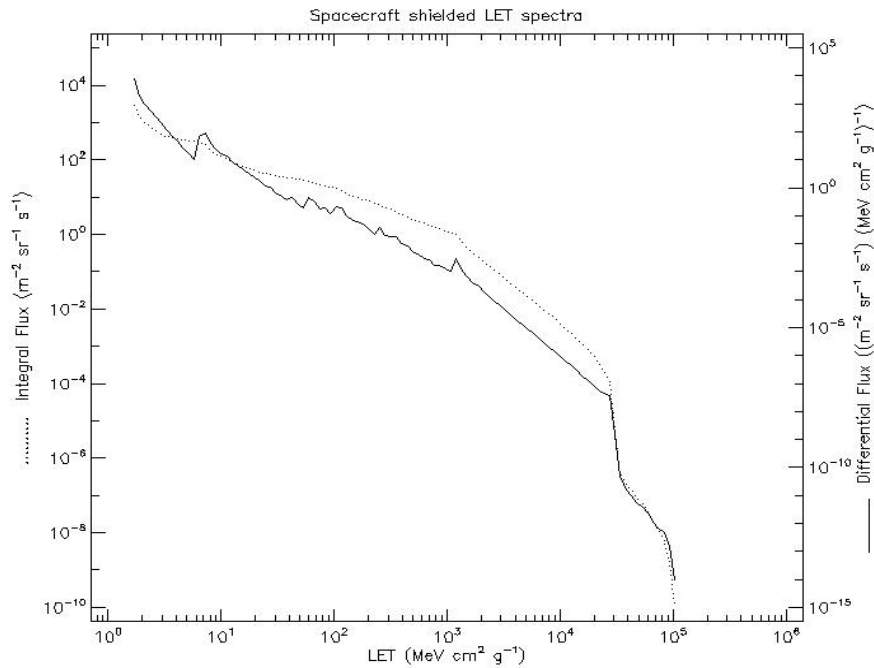


Figure 4-6: LET spectrum calculated for a 7 days mission - MM Mission

For the MM mission, as can be seen from the LET spectrum here above, the integral and the differential fluxes vary significantly around a LET threshold of approximately 30 MeV•cm<sup>2</sup>/mg. If EEE components are selected with the hereafter listed LET thresholds recommendations, the probability of upset or latch-up event is approximately three orders of magnitude lower than for devices with SEE thresholds below 30 MeV•cm<sup>2</sup>/mg. EEE components selected for mission critical aspects should at least respect the following recommendations to do not jeopardize the mission success.

LET thresholds recommendations	
Single Event Upset	LET Threshold ≥ 36 MeV•cm <sup>2</sup> /mg
Single Event Latch up	LET Threshold ≥ 60 MeV•cm <sup>2</sup> /mg (36MeV•cm <sup>2</sup> /mg should be acceptable if SEL mitigation design rules* have been implemented)
Single Event Burnout Single Gate Rupture	In case of considered Single Event Burnout/Gate Rupture, the certified threshold for selected Power MOSFETs should be at least ≥ 28 MeV•cm <sup>2</sup> /mg
Single Event Transients	LET Threshold ≥ 36 MeV•cm <sup>2</sup> /mg. Transient behavior shall be considered for all triggering and fast signal processing systems

Table 4-6: LET thresholds recommendations

It has been demonstrated in section 4.1 that a 5 mm aluminum thickness is required in order to be able to use commercial-off-the-shelf electronics on the KAP-MM mission with respect to radiation total dose. For high energy particles such as trapped protons, electrons and heavy ions these values dependent on their respective kinetic energy. An aluminum shield thickness of 5 mm protects electronic items from proton irradiation below 30 MeV and from electron irradiation below 2.5 MeV according to the figure presented hereafter.

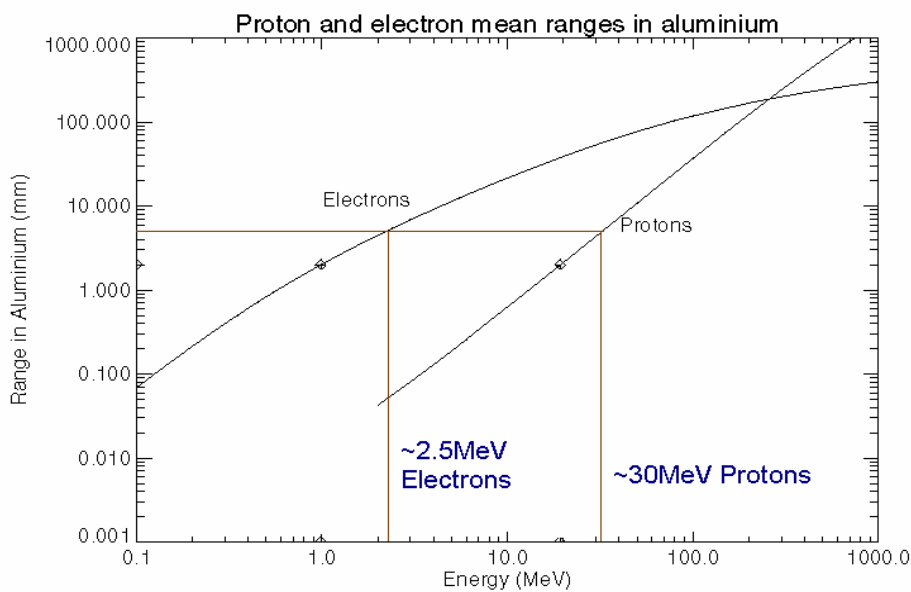


Figure 4-7: Required aluminum shielding to stop high energetic particles  
\*) red line corresponds to a 5 mm aluminum shielding

A shielding thickness of 10 mm aluminum will shift these thresholds to 50 MeV for protons irradiation and 4 MeV for electrons irradiation, inducing however a significant mass penalty. All protons and electrons with energy above these limits will not be shielded by housing or satellite structure and electronic parts might experience SEE's. SEE mitigation technique can be implemented.

It appears that this radiation environment is extremely inhomogeneous.

The KAP orbit versus proton and electron irradiation fluxes has been derived and is presented hereafter. On one hand, it can be observed that the period of the orbit, where proton irradiation flux is able to trespass 5 mm aluminum thickness (protons of energy higher than 30 MeV) is relatively short. On the other hand, a nearly continuous electron irradiation flux is experienced most of the time. This phenomenon is consistent with the large radiation total dose collected during the MM mission (refer to section 4.4.2). Therefore, the electron irradiation flux dominates the radiation environment during the MM mission. It can be noticed that due to the relatively short time exposure to high proton irradiation flux (protons of energy higher than 30 MeV), SEE sensible components can be used for the design respecting some specific operating recommendations.

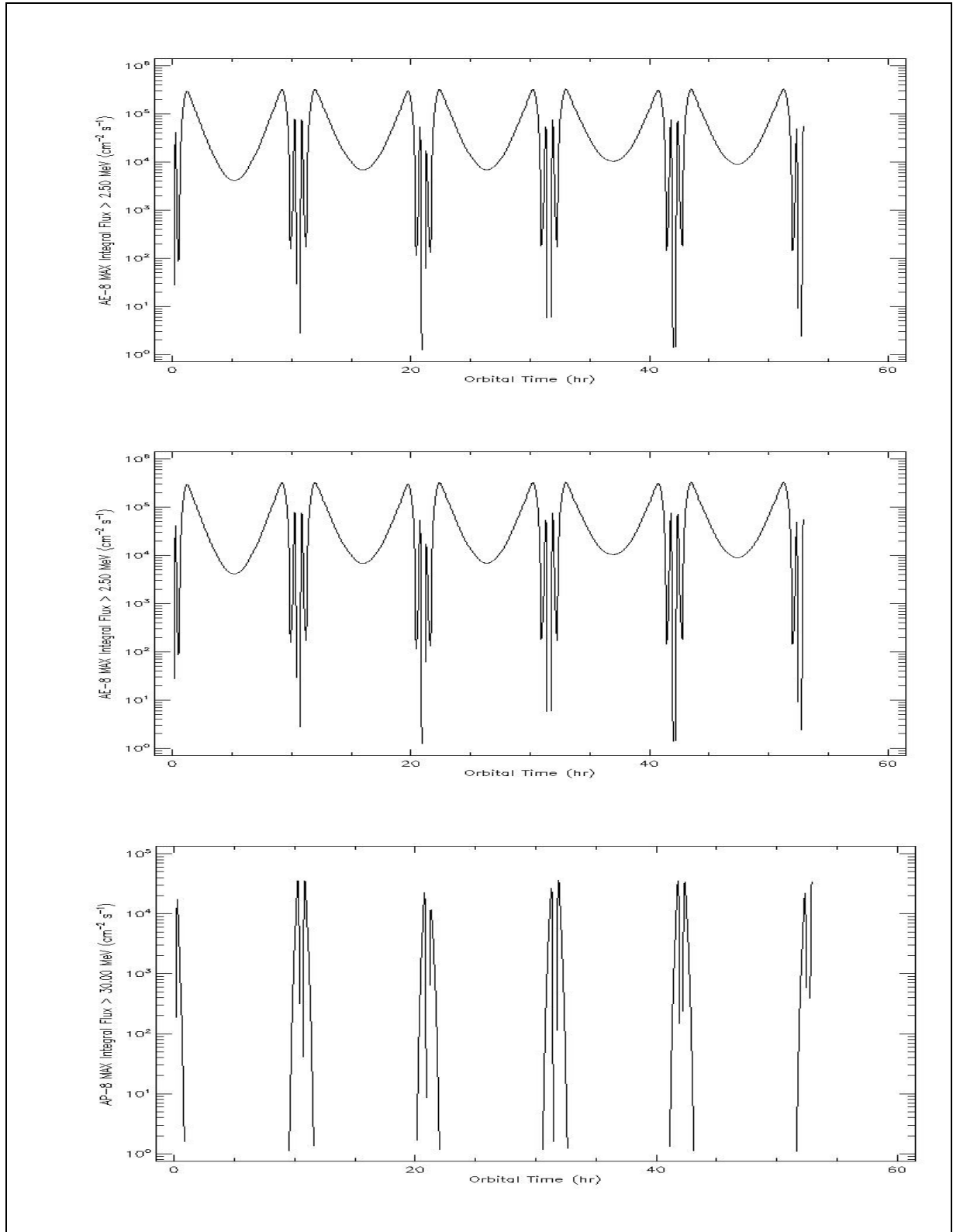


Figure 4-8: Irradiation fluxes distribution over the KAP orbit

KAP-MM is a relatively short mission – 7 days in GTO – and the radiation distribution is well known by experience and prediction. The key information provided by such viewgraph here above is that it is possible to use SEE sensitive items as long as these items are not operated when the threshold for radiation protection is overtaken (between 800 to 10,000 km altitude).

For specific system such as communication payloads (which required operating in the vicinity of the Earth in order to do not require too much power to perform their task) or Earth observation payloads (which can required operating in the vicinity of the Earth) and others, a window is available and presented in the figure hereafter. However it has to be noticed that during this brief period, the spacecraft is near the Perigee and therefore orbiting at its maximum orbital velocity.

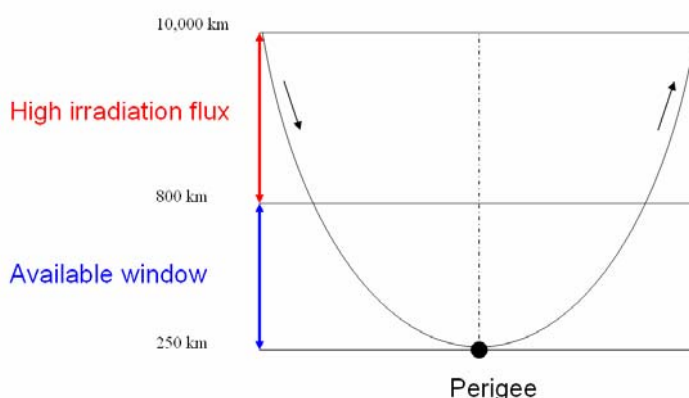


Figure 4-9: Irradiation fluxes over the KAP orbit


The time spent in the altitude regions defined above has been calculated in the table hereafter for the first orbit.

KAP altitude	Duration [sec]		
250-800 km	840 sec	14 min	2.2 %
800-1,500 km	475 sec	7 min 55 sec	1.2 %
1,500-10,000 km	4,143 sec	1 h 9 min	10.9 %
> 10,000 km	32,643 sec	9 h 04 min	85.7 %
Orbital period	38,101 sec	10h 35 min	100.0 %

Table 4-7: Time spent at different altitudes per orbit

If the operation of such devices is mandatory, two options can be implemented each with their specific draw-back:

- Increasing the shielding thickness, this can induce a significant mass penalty, or
- Implementation of radiation mitigation techniques, this can increase the system complexity.

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 4-14

#### 4.4.3 Spacecraft Charging Effects

Spacecraft charging may cause the following adverse effects:

- Biasing of spacecraft instrument readings,
- Arcing, which may cause upsets to sensitive electronics,
- Increased current collection,
- Ion sputtering, which may cause accelerated erosion of materials,
- Re-attraction of contaminants, or/and
- Multipaction in radio frequency circuitry and its surroundings like boxes or cabling.

These effects have serious engineering concerns, because sensitive surfaces will be contaminated, the scientific mission can be compromised, physical damages harm the instruments, and operational anomalies can often occur ranging from “minor irritations” to fatal breakdowns for the spacecraft electronics.

The KAP orbit is heavily influenced by high plasma densities, because it passes throughout all Earth’s radiation belts. The high plasma density can lead to a severe effect of spacecraft charging, which should be taken into account during the design of the EMC/EMI bonding and grounding concept.

#### 4.5 Contamination

ESA PSS-01-702 and ESA PSS-01-705 are the applicable and reference documents regarding contamination issue. A brief description of these standards is presented hereafter. For further information, please refer directly to these documents.

##### **ESA PSS-01-702 (A thermal vacuum test for the screening of space materials – ESTEC – Issue 2, October 1994)**


As a minimum requirement, the following regulation shall be followed:

- Materials with low outgassing values shall be used. Materials which are listed in PSS-01-701 do fulfill this requirement.
- Electronic boards shall be coated with a ESA approved coating material to prevent outgassing of components with unknown characteristics.
- In case the above design rules cannot be met, a dedicated out-baking shall be applied (96h at a temperature >60°C and a pressure < 10<sup>-2</sup> Pa).

##### **ESA PSS-01-705 (The detection of organic contamination of surfaces by infrared spectroscopy – ESTEC – Issue 1, October 1982)**

As a minimum requirement, the following regulation shall be followed:

- All items shall be cleaned with appropriate cleaning agents before integration (using IPA, acetone, etc.) to remove organic contamination.

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 4-15

- After cleaning, the items shall be handled with gloves and stored in visible clean areas (Cleanliness class 100,000 or better).
- Final cleaning shall be performed for KAP experiments before the packing for delivery.

#### **4.6 Corrosion**

The corrosion of metallic parts that are exposed to the environment shall not lead to the degradation of the materials. A suitable surface treatment shall be applied on the metallic surfaces when applicable.

## 5 Interfaces

### 5.1 Geometric Relationships

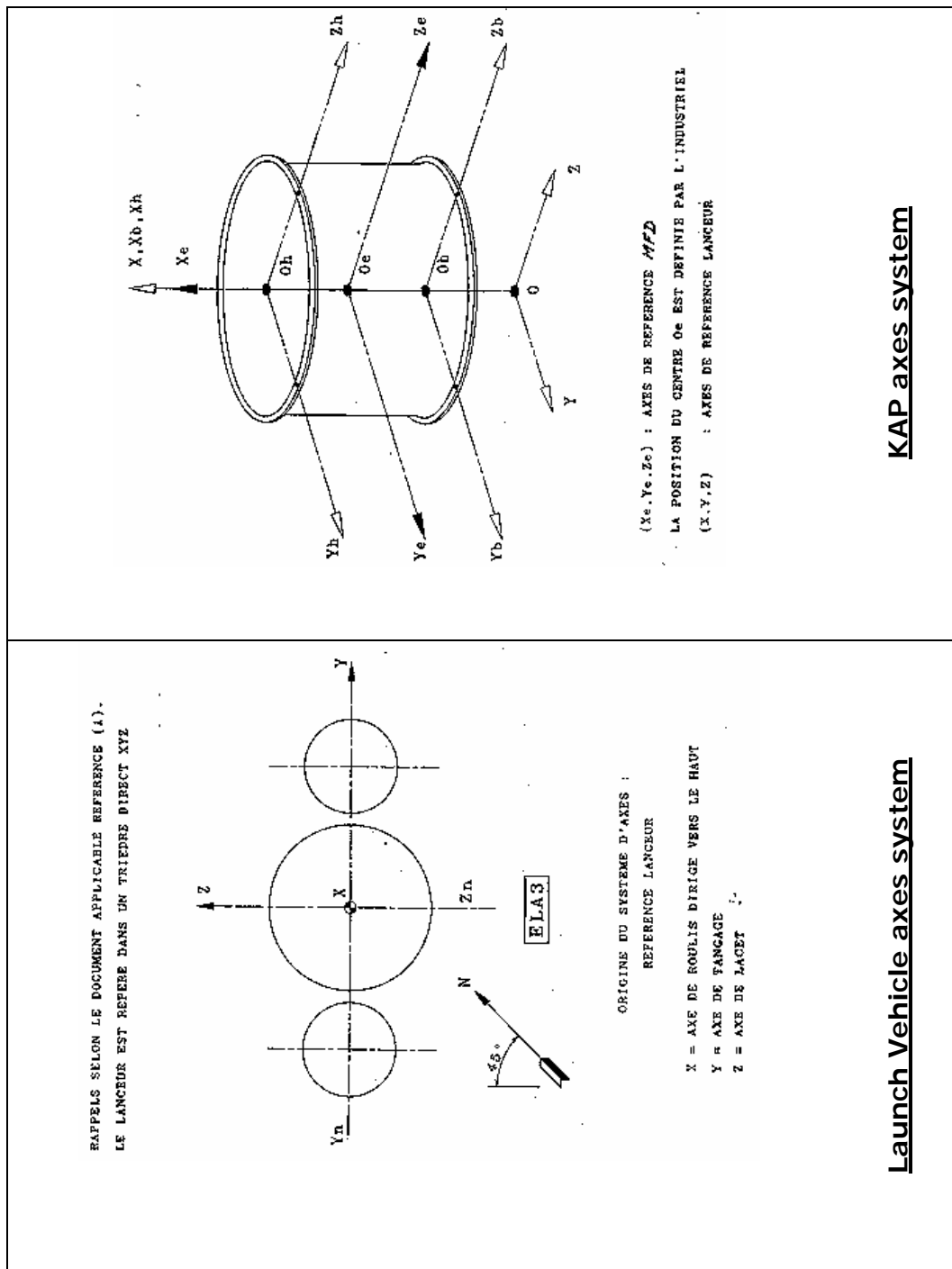


Figure 5-1: Launch vehicle and KAP coordinate systems

## 5.2 Usable Volume

### 5.2.1 Raising Cylinder Configuration

Raising cylinder with internal platform

The following figure is illustrating the raising cylinder configuration for Ariane 5 usable volume available for the experiments and the KAP equipments.

The available space on the KAP platform has to be shared between the KAP equipment and the experiments. Accommodation of experiments is planned on the upper surface of the KAP platform, however limited space may also be available on the lower and outer surface of the cylindrical shell surface of the platform.

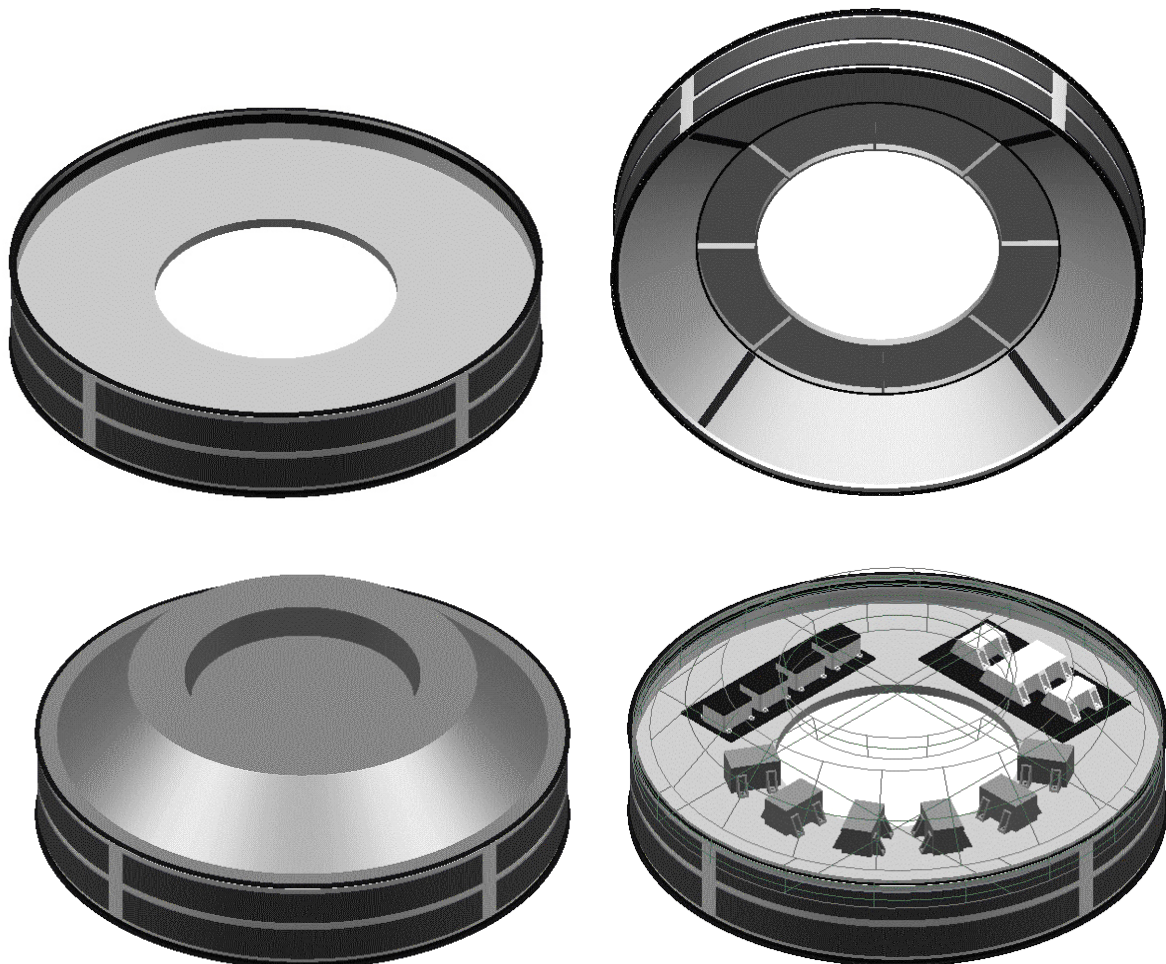


Figure 5-2: KAP design and equipment accommodation

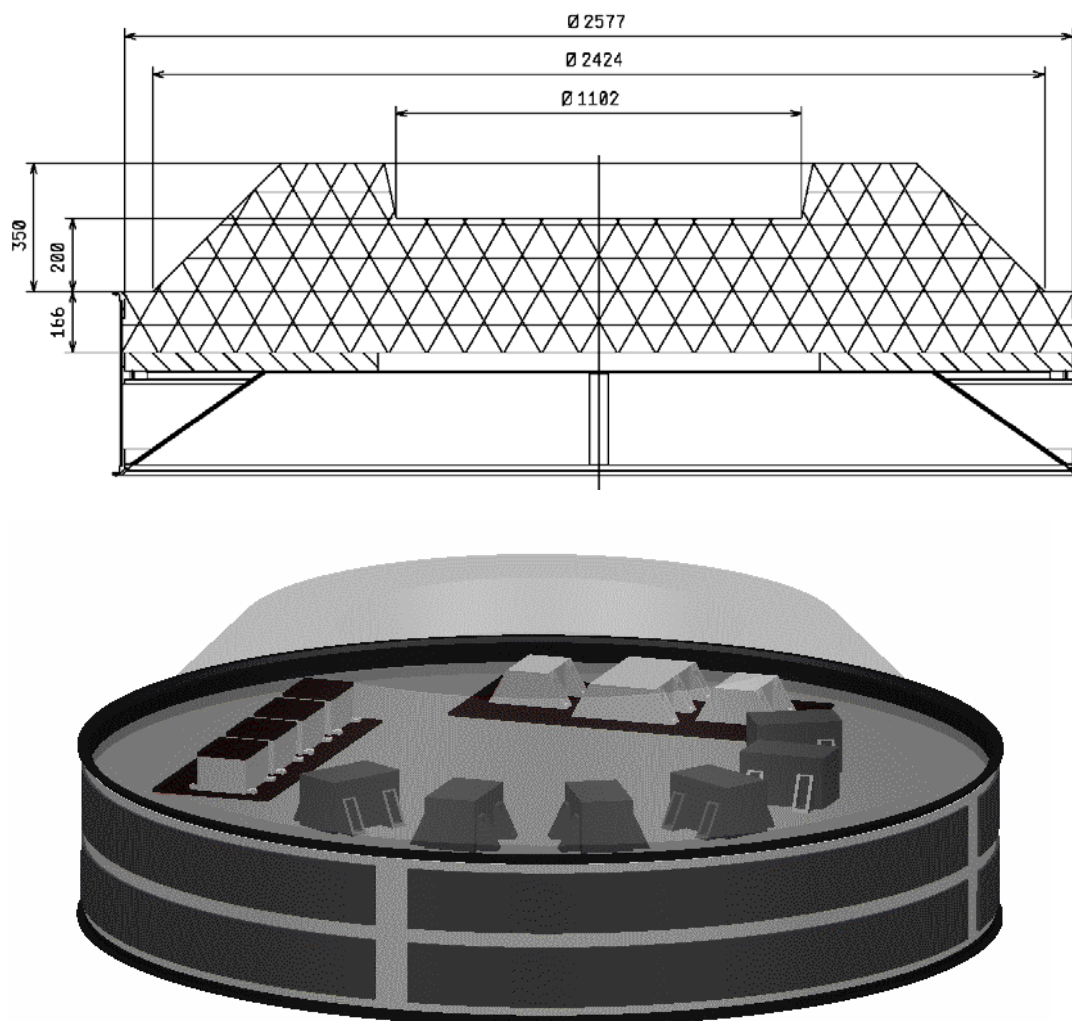



Figure 5-3: KAP available volume for experiments and equipment (crosshatched area)

### Pure raising cylinder without internal platform

Accommodation of experiments is planned on the outer/inner surface of the cylinder, using a dedicated mounting plate presented in the mechanical interface section. The maximum envelope is 500 x 400 mm<sup>2</sup> with a maximum height of 300 mm.

### 5.2.2 Platform for Auxiliary Payloads Configuration

The available space for the Platform for auxiliary payload configuration has to be shared between the KAP equipment and the experiments. The total usable volume depends on the type of platform considered. Refer to dedicated user manual. The standard maximum envelope is 600 x 600 mm<sup>2</sup> with a maximum height of 300 mm.

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 5-4

### 5.3 Field of View

#### 5.3.1 Raising Cylinder Configuration

A limited field of view to free space can be achieved by looking through the hole of the ACU located above KAP.

#### 5.3.2 Platform for Auxiliary Payloads Configuration

A limited field of view to free space can be achieved by looking through the hole of the ACU located above KAP.

### 5.4 Mechanical Interfaces

In general, the following points are under responsibility of the experiment supplier:

- Definition of the mechanical design of the experiment and of its interfaces, in compliance with the requirements of this manual and a to be written IRD and experiment ICD,
- All structural analyses at experiment level to ensure integrity of all its parts, including interface fastener,
- Analysis of interface loads for hard mounted interfaces, and
- Delivery of CAD and FEM models (see section 8).

The KAP mounting structure is illustrated in:

- Figure 5-3 for the Raising cylinder with internal platform configuration, and in
- Figure 5-4 for the Raising cylinder without internal platform configuration and Platform for auxiliary payload configuration.

The platform are designed, showing a standard 50 mm M5 mounting point pattern, however, the actual mounting points pattern shall be agreed between the experimenters and the KAP integrator. The I/F bolts and washers are considered a deliverable item together with the experiment. Properties of the interface bolts and washers (length, material) are TBD.

The attachment points shall be nominally coplanar. The surface shall be flat to less than 0.05 mm in 100 mm, shall have a surface roughness of Ra 1.6 µm maximum and edge radius of 0.5 mm. Mounting faces shall be paint free and any protective coating applied to mounting faces shall be electrically conductive.

If applicable, the experiment bonding lug position shall be coordinated with the KAP integrator.



Figure 5-4: KAP Structural design

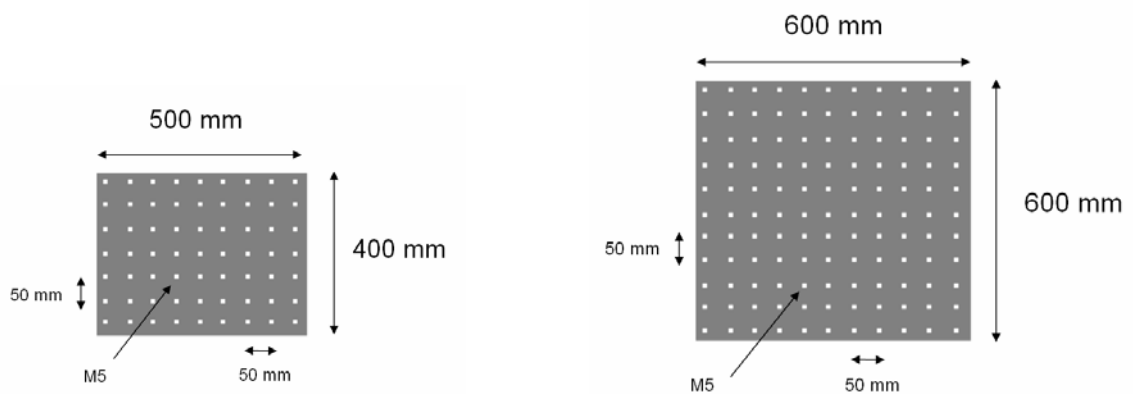


Figure 5-5: Mounting plate for experiments on inner/outer side cylinder wall (right) and for standard Platform for auxiliary payload (left)

## 5.5 Electrical Interfaces

### 5.5.1 Power Interfaces

The following table lists the baseline power interfaces for the Short and Medium Mission.

I/F Item	SM	MM	Remark
Power I/F	28 V 25W average for experiments (250 W peak manageable)		Ni/Cd for SM
	6 outlets 2 x PCDU (increment of 4)		Li-ion for MM
			Includes current protection

Table 5-1: Experiment power interface overview

### 5.5.2 Data Interface

The following table lists the baseline data interfaces for the Short and Medium Mission.

I/F Item	SM	MM	Remark
Data I/F	<b>CMA 2000</b> 2 serial async. lines (up to 6 possible, 1 x MilBus possible) 16 analog channels (with conditioning) 20 digital in 80 standard analog channels 1 serial synchr <b>Baseline 1 unit (2 units max)</b>	<b>CTS 3000</b> 6 serial async. lines with 1 master and 2 slaves (each slave increases by 2) 64 analog channels (with conditioning) 96 digital in / 72 digital out 8 analog channels out 1 serial synchr <b>Baseline 2 slaves (12 slaves max)</b>	RS-422 (max rate 38.4 k Baud) Data handling can be upgraded (more mass and power needed, reducing payload resources)

Table 5-2: Experiment data interface overview

The following figure illustrates the overall instrumentation architecture of different types of KAP missions including the necessary ground station.

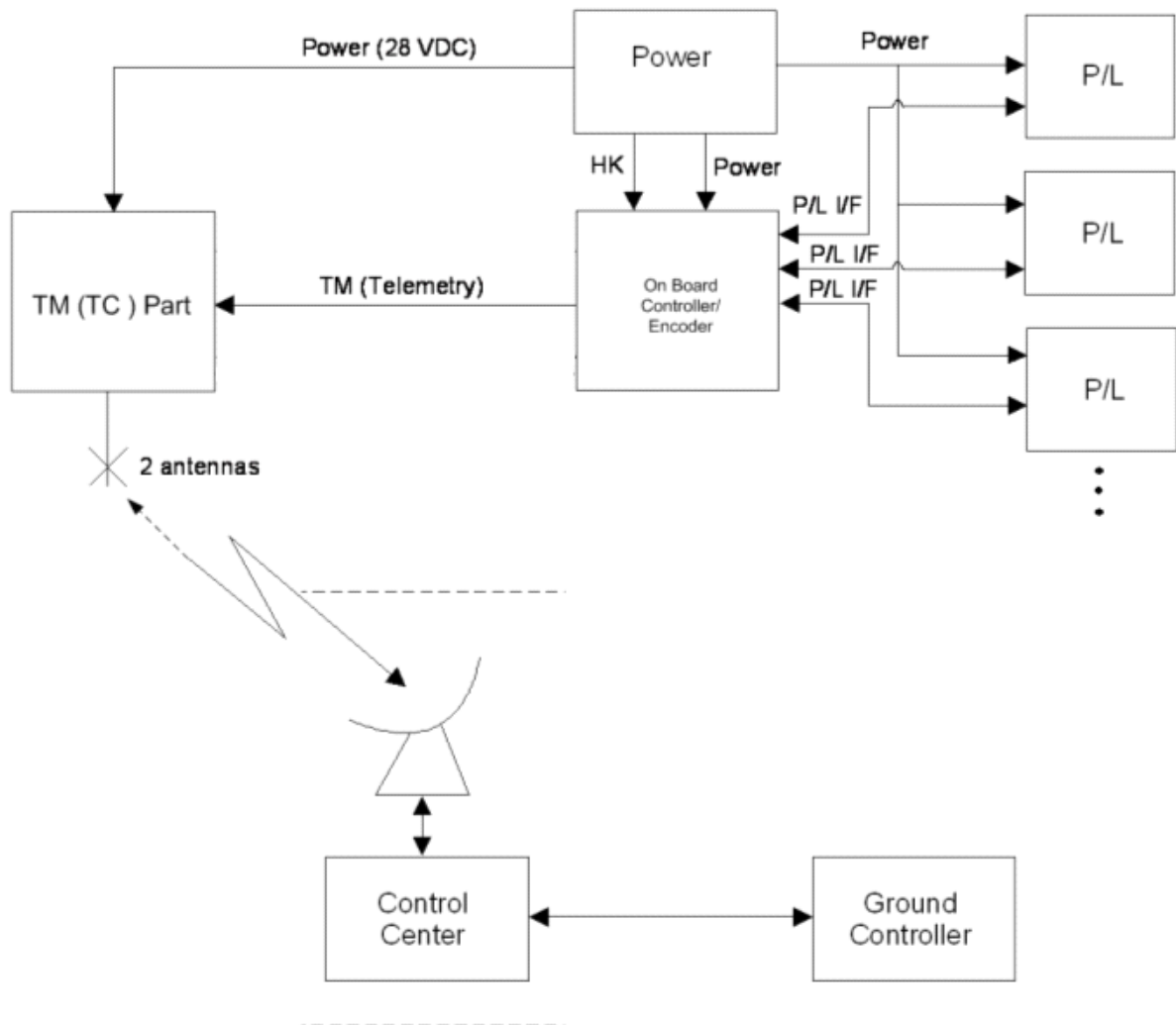


Figure 5-6: Instrumentation overview

### 5.5.3 EGSE I/F

The Electrical Ground Support Equipment (EGSE) consists of the following items:

I/F Item	SM	MM	Remark
EGSE I/F	Laptop for each experiments - Ethernet for Data  Check-out Terminal Equipment (COTE) for the Telemetry Assembly (TMA) and the experiments  Overall Check-out Equipment (OCOE)  Interface cables to the TMA and the range		

Table 5-3: Experiment EGSE interface overview

The OCOE – COTE test / range configuration is illustrated hereafter.

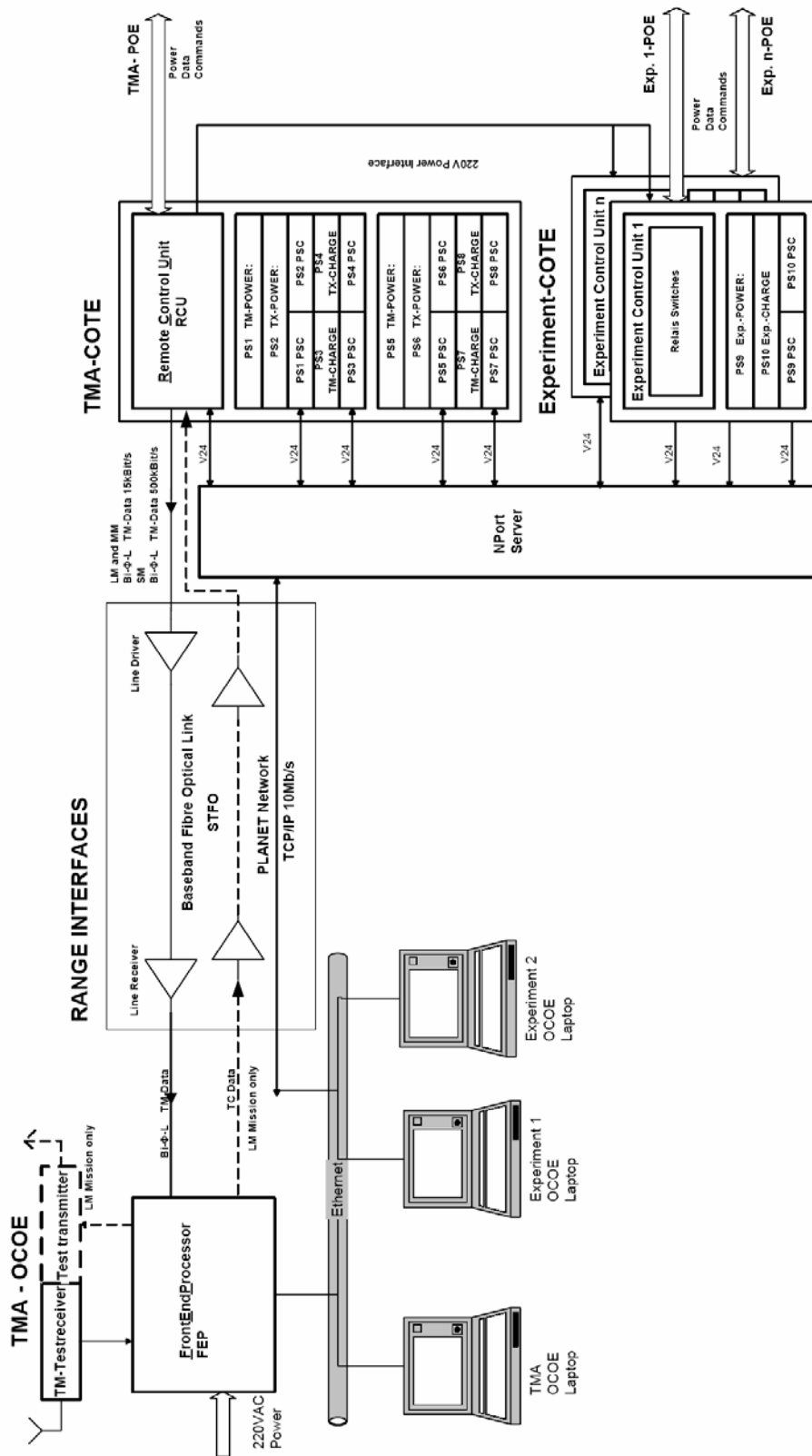


Figure 5-7: OCOE - COTE test/range configuration

The TMA COTE consists of a Remote Control Unit (RCU), power supplies for external power as well as battery charging power supplies and power supply control units (PSC).

The experiments COTE, consist of the Experiments Control Unit (ECUs), power supplies for external power, battery charging power supplies and power supplies control units.

RCU, ECUs and the PSCs are controlled via V24 interfaces, with means of a Nport servers through the PLANET network from either the TMA OCOE laptop or the experiments OCOE laptops.


The FEP computer contains a bit synchronizer and a TM format decoder, for decoding the telemetry signal. The TM signal is received as a radio silence signal directly from the TMA via optical link (STFO) or from a telemetry test receiver.

#### 5.5.4 Additional Features

The following table lists the some additional features of interest for the experimenters. The interfaces may be increased in terms of numbers (e.g. outlets, data lines etc.) taking into account that the overall resources such as power, mass storage, data processing and communication performance are limited to fixed values and have to be shared between the experiments.

I/F Item	SM	MM	Remark
Timer	Timer	Timer	By programming
Telecommand	No	Optional on request	
Telemetry	5 Mbps S-Band link 1.4 GByte via Malindi	5 Mbps S-Band link 1.4 GByte via Malindi	Baseline scenario
Mass memory	None	32 MByte per slave	

Table 5-4: Additional features overview

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 6-1

## 6 Payload Verification and Acceptance

All experiments must verify their compliance to the KAP and Ariane 5 requirements (refer to [AD1]) to finally demonstrate flight readiness to the launcher authority. Furthermore Ariane 5 launcher shall not be influenced or damaged due to malfunction of experiments or due to non-compliance to Ariane 5 requirements. Again, Kayser-Threde will provide maximum support on demand to the experimenters.

### 6.1 PA Approach for Experiments

In order to ensure that the Ariane 5 PA requirements are adopted as applicable for each experiment, the following PA approach has been defined:

- All experiment teams are requested to fill out a supplier survey checklist in order to assess the general compatibility of their PA or quality system. In case of any doubts, a more detailed survey shall be performed.
- Verification and test requirements are called out in the respective ICD documents for each experiment including verification and test requirements. For this purpose, parts of the technical requirements for the KAP will be made applicable to the experiments.
- Electrical interface and EEE part specifications (mainly connectors) for all external interfaces of the experiments have to be defined in the respective experiment ICD.
- Mechanical integrity of the experiments shall be verified by structural analysis (including mathematical model) and environmental/vibration tests either at experiment level or at system level.
- Safety documentation will be required containing a safety survey questionnaire, a structural analysis report and an electrical safety analysis.
- A delivery review and release for integration with KAP review shall be held for each delivered experiment to check conformance and completeness of hardware and documentation in accordance with the ICD including the PA/QA and verification requirements.
- Compliance to the above listed requirements shall be certified in a Certificate of Conformance (CoC) at delivery of each experiment.

### 6.2 Verification Programme

The experiment developers shall implement a programme for the verification of its instrument, including qualification/acceptance of the developed instrument.

The following verification methods may be employed:

- Analysis,
- Review of design,
- Inspection, and
- Test.

The following figure shows the KAP Verification Approach and the integrated experiment Verification Approach. It is requested to have a verification plan agreed between experimenter, KAP integrator and launcher authority per each experiment in-line with the overall verification logic of KAP described hereafter.

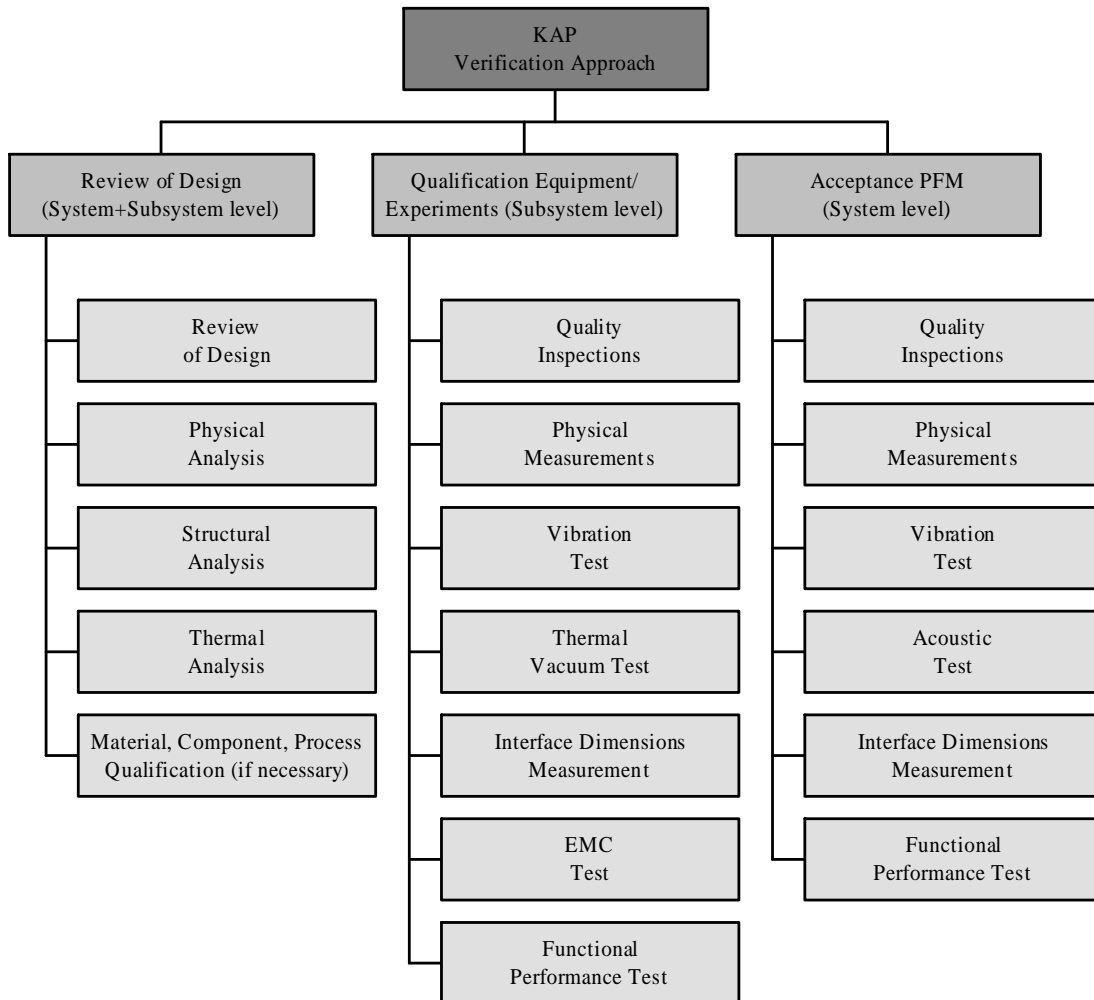



Figure 6-1: Verification approach

### 6.3 Model Philosophy

The recommended development approach for experiments is the Proto-Flight Model (PFM) philosophy. A unique experiment flight model will be built on which proto-qualification will be performed (with low levels or stress duration).

### 6.4 Test Philosophy

As a minimum, the following tests have to be foreseen for the experiment PFM; however, more tests may be required to verify the experiment compliance with the applicable documents:

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 6-3

- Physical measurement (dimension, mass, CoG),
- Interface verification (mechanical and electrical I/Fs),
- Performances & functional tests (as applicable),
- Vibration test (resonance search, random vibration, if applicable shock) including functional checks,
- Thermal vacuum/Thermal cycling tests including functional checks, and
- EMC test.

For the EMC qualification, the instrument shall be subjected to the following sequences:

- Bonding, grounding, isolation measurement,
- Conducted emission,
- Conducted susceptibility,
- Radiated emission, and
- Radiated susceptibility.

## 6.5 Verification by Test

### 6.5.1 KAP System Level Tests

The structure dimensioning and the evaluation of strength shall establish margins and surflux for the KAP system but also for the adjacent structures and for that analysis and/or tests will be defined. In this section we refer as KAP system, the combination of the KAP equipments and the experiments on the support structure (either internal platform of the raising cylinder or dedicated mounting plates).

It can be discussed with the KAP integrator to combine some of the experiment level tests with the KAP system level tests. The tests possible to combine are described hereafter.

#### 6.5.1.1 Category I Tests


##### Vibration Tests:

A vibration test in axial and two lateral directions shall be performed to qualify the primary and secondary structures and damping.

A modal survey test shall be performed to characterize the main eigenfrequencies and modal shapes of the KAP system and especially of the internal experimental platform.

The eigenmodes (frequency, damping) shall be determined. The sweep measurements shall be performed up to 350 Hz. The KAP system will be clamped during test. Test predictions and models correlation are mandatory.

Note: Repetition of sweep at low level before and after each load test is required.

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 6-4

#### Acoustic tests:

A test is required for the KAP system (either equipped with the experiment or with the representative dummies). This test can be skipped in case of no acoustic critical items are installed on the KAP support structure.

#### **6.5.1.2 Category II Tests**

The KAP support structure must guaranty a resistance of 10 mOhms under 10 mAmps across each interface (TBC).


The harness must be checked after integration in terms of continuity (pin to pin) check and insulation at interface connector level.

Mass +/- 0.2% measurement test, calculation for center of gravity position and moment of inertia must be performed.

#### **6.5.2 Experiment Level Tests**

All tests required as per Verification Approach and not mentioned under section 6.7 have to be performed on experiment level. Mainly:

- Physical measurement (dimension, mass, CoG),
- Interface dimension measurement of experiment,
- Performances & functional rests (as applicable),
- Vibration test
- Thermal vacuum/Thermal cycling tests including functional checks, and
- EMC test.
- 
- For the EMC qualification, the instrument shall be subjected to the following sequences:
- Bonding, grounding, isolation measurement,
- Conducted emission,
- Conducted susceptibility,
- Radiated emission,
- Radiated susceptibility, and
- Interface Verification (mechanical and electrical I/Fs).
- 
- As previously stated, it can be discussed with the KAP integrator to combine equipment level tests with KAP system level tests.

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 6-5

## 6.6 Analyses

During design phases, a consistent simulation analysis programme has to be performed to predict the structural and thermal behavior of the experiment and to prove the experiments capability to withstand the environmental loads. The following analyses will be performed:

- Physical analysis of properties to predict the mass, CoG and moment of inertia (on basis of adequate numerical modeling),
- Structural analysis:
  - Eigenfrequency analysis to compare stiffness of the design with the requirements and to identify dynamic environment for the equipment and experiments,
  - Strength Analysis to evaluate the margins of safety, and
- Thermal analysis to evaluate the temperatures and heat fluxes and to predict thermal behavior of the experiment.

A correlation assessment between test and simulation analysis shall be done after testing respectively.

## 6.7 Acceptance and Delivery of Experiments

The acceptance of the experiment will be performed according to the following sequence of events:

- Completion of all verification activities, including in particular the acceptance tests, to verify that the experiment and associated equipment meet all interfaces and environmental specifications and that the experiment is ready for integration with KAP on the Raising cylinder/Platform for auxiliary payloads, and
- Delivery of the experiments and associated support equipments and software to the integration site (following shipment under the experiment supplier responsibility) and performance of an incoming inspection of the experiment supplier with the system integrator witnesses. The experiment incoming inspection will be performed following the relevant agreed procedure, to be prepared by the experiment supplier. It shall include visual and electrical functional tests.

Following successful completion of the above activities, the experiment will be released for integration with KAP on the Raising cylinder/Platform for auxiliary payloads.

## 7 Experiments Life Cycle and Major Milestones

The experiments life cycle varies from experiment to experiment, and depends strongly on the complexity of the hardware. Experiments handover to Kayser-Threde should take place as early as possible, but this has to be compatible with the maximum storage period and should be done at latest 4 months prior launch.

This section covers all activities from experiments approval following submission of a proposal in answer to an Announcement of Opportunity (AO) to experiment delivery on the integration site. Two phases have been defined and are described hereafter:

- Phase 1: Customer acquisition, and
- Phase 2: Experiment development to delivery.

### 7.1 Phase 1

The customer acquisition phase starts with the Announcement of Opportunity (AO) and ends with the selection of experiments for the next mission(s). This phase typically lasts 3 months.


Time	Event
D-12M to D-10M	Announcement of Opportunity (AO)
D-12M to D-10M	Experiments submission proposal
D-10M to D-9M	Experiment selected for flight opportunity with KAP

Table 7-1: Typical timeline for customer acquisition phase  
 "D" delivery date of the experiment to Kayser-Threde

### 7.2 Phase 2

The second phase starts with the selection of the experiments and ends with experiment and associated support equipments and software, and Acceptance Data Package delivery at the integration site (refer to section 9). During this phase, the experimenter will submit as much information as is available and, in conjunction with the KAP team will describe the procedures of the applicable tests. This phase typically lasts 9 months.

Following experiment and associated support equipments and software delivery at the integration site and before integration with KAP, the experiment has to undergo the acceptance and delivery procedure as described in section 6.7. After successful acceptance, the Certificate of Conformity for Acceptance Review Experiments will be signed and ends the Phase 2.

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 8-1

## 8 Operations

This section describes the operational constraints experienced by the experiments, KAP and the Ariane 5 launcher, to be considered by the experiment developers for the design of their instruments with respect to launch operations. Some information related to the ground facilities and logistics are illustrated. This section covers all activities from experiments delivery on the integration site to the end of the mission operations. Three phases have been defined and are described below:

- Phase 3: From delivery to completion of the system level tests,
- Phase 4: Delivery to Launch site including optional storage, and
- Phase 5: From delivery to Launch site to end of mission operations.

### 8.1 Phase 3

#### 8.1.1 Experiment Delivery to Integration Site

The experiment and associated support equipments and software delivery takes places at the integration site in Kayser-Threde GmbH, Munich, Germany, at latest 4 months prior launch and is under the responsibility of the experimenters. Section 9 provides further information on the Acceptance Data Package including the set of documents and records for further integration, testing, operation and procedures. If it has been agreed to combine the experiment level tests with the system level tests, the experiment has to be delivered at latest 5 months prior launch.

#### 8.1.2 Integration and System Test

Following delivery at the integration site and before integration with KAP, the experiment has to undergo the acceptance and delivery procedure as described in section 6.7. After successful acceptance, the experiment will be released for integration with KAP either on their dedicated mounting plate or on the raising cylinder internal platform (refer to section 5.2). The experimenter can request to be present during the integration, but do not have to interfere anymore with the experiment hardware; all preparation work shall be finalized.

After successful integration, a final check-out test has to be performed. Any further preparation work to be done on the experiment for participation in the system tests has to be defined by the experiment supplier in detail in the experiment ICD and User's manual. The operation sequence has to be approved by the responsible prior to integration.

Accommodated with KAP on the dedicated mounting plate or on the raising cylinder internal platform, the experiments will undergo the system tests required to be performed. The system level tests are described in detail in section 6.6 for the raising cylinder configuration and in the dedicated User's Manual for the Platform for auxiliary payloads configuration.

## 8.2 Phase 4

### 8.2.1 Delivery to Launch Site


The experiments will be transported in a temperature and humidity monitored container together with KAP equipments provided by Kayser-Threde. Regarding transportation, if specific requirements need to be achieved outside the baseline solution, the experimenters will have to provide their own transport container. The transport will take place first from Munich to Le Havre by trucks, from Le Havre to Kourou by boats, and from Kourou to the launch site by trucks.

If transport containers are provided by the experimenters, they have to be conformed to the specific transport regulations. A specific agreement between Kayser-Threde and experimenters is necessary.

Maximum storage periods are defined in the table here after. However, it is assumed that the maximum period from experiment integration to KAP mission start will be not longer than 1 year. Therefore, the experiment supplier has to demonstrate that the experiment life time is in line with the maximum storage period (non-operational) plus the operational time (3h to 1 year). Environmental boundary conditions and loads described in section 4 are including the transportation conditions.

LIFE PHASES	Natural environment	Duration Max	Temperature (°C)	Hygrometry (%)	Cleanliness class
Eventual storage in Europe	In container, in a building	5 years	0° to 40°	Container	Container
Eventual unpacking	Clean room	15 months	22° ± 3°	50 ± 10	100 000
Transport from Europe to Guyana	In container	15 months	-10° to 40°	Container	Container
Storage in Guyana	In container, in a building in Guyana	15 months	25° ± 2°	Container	Container
Integration with L/V	in BAF,	15 months	24° ± 1°	55 ± 10	100 000
Launch Pad transfer and waiting phase prior lift off	Ventilation via fairing	1 month	Air inlet from 10° to 25°	< 50	100 000

Table 8-1: KAP environmental conditions and maximum storage duration

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page 8-3

### 8.2.2 Travel and Accommodation

Experimenters who wish to be present in Kourou for late (minor) preparation and launch of the experiment need to send a specific request to Kayser-Threde 4 months prior to launch, including all data requested by CSG personnel. Requests will be evaluated on a case by case basis. Experimenters will travel by their own means to Kourou. There are a number of accommodation possibilities in and around Kourou. Kayser-Threde will support the arrangements to be made in Kourou.

### 8.3 Phase 5

Phase 5, formally the launch campaign, begins with the delivery in CSG of the equipments and its associated GSE and software, and concludes with GSE shipment after launch. Prior to the launch campaign, a preparation phase takes place, during which all operational documentation is issued and the facilities compliance with Customer needs is verified. The launch campaign is divided in two major parts: launch preparation and launch operations.

All procedures and documentation required to perform the launch activities being delivered during the Acceptance Data Package, it is not necessary that the experimenters are present during the launch preparation in Kourou.

All activities in CSG are under the responsibility of the CSG authorities. For further information regarding the launch campaigns, refer to [AD1].

#### 8.3.1 Launch Preparation

Launch preparation will start approximately 27 days prior to launch. The experiment launch preparation activities have to be described in detail in the Experiment User's Manual. The activities have to be synchronized with the activities of all other experiments as well as with the KAP preparation scenario.

At least, the experiment shall perform a health check or final functional check-out tests. Simplified checks or health check may be performed by the KAP integrator. This can be negotiated on a case by case basis.

The launch preparation ends with the Flight Readiness Review (FRR).

The final integration into the launch vehicle will be done approximately 13 days prior to launch. Following final integration, no further access to the experiments is possible.

#### 8.3.2 Launch Operations

For Short Missions, KAP will be switched on shortly before lift-off. Necessary experiment operations will be initiated and performed by timer signals. As soon as the telemetry signal is available (post fairing or SYLDA separation depending on the selected configuration), house keeping data and experiments data are downloaded.

For Medium Missions, KAP will be switched-off during launch (baseline scenario). Therefore no launch operations are foreseen. Experiment operations will be initiated and performed by timer signals, following main passenger(s) separation.

The activities in Kourou ends with the shipment of the equipment back to Munich, not later that 3 days following launch according to CSG regulations. The expected 7-days mission operations ends with the signing in Munich of the Contract Close-out between Kayser-Threde and Experimenters. This signature ends all contractual activities between Kayser-Threde and the Experimenters, prior future agreement.

#### 8.4 Operational Cycle of a KAP Campaign

The following provides a general outline of the major events that take place during the operational cycle of a KAP campaign. Experimenters should use this as a reference and should keep in mind that the list below may vary from mission to mission.

Time	Event
Up to H-60 days	Experiments hand over to Kayser-Threde (KTH) in Munich
H-60 days	Certificate of Conformity for Acceptance Review Experiments signature
H-60 days to H-45 days *)	Experiments inspection and integration on KAP support structure
H-45 days to H-5 days	System tests (refer to section 7.1)
H-5 days	KAP System Acceptance provided only in successful test run
<b>H = H0-**</b>	Experiments and associated GSE (provided by experimenters) packed for storage in Munich.
H0-60 days	Experiments, KAP equipments and GSE are transported to "Le Havre" by truck(s), under the responsibility of KTH where they will be shipped to Kourou
H0- 30 days	Departure of KTH personnel to launch site in Kourou, together with the experiments
H0- 27 days *)	Customs control in Kourou, French Guiana
H0- 27 days to H0- 15	Hardware is removed from storage, prepared and inspected for integration within

Time	Event
days *)	the EPCU-PPF (Payload Processing Facility) – Health check or final functional check-out tests performed
H0- 15 days to H0-13 days	Hardware is integrated onto supporting structure (on selected configuration) within the EPCU-HPF (Hazardous Processing Facility) – Flight Readiness Review
H0-13 days to H0-7 days	Main passenger(s) is mated onto payload adaptor
H0-7 days to H0-5 days	Hardware is encapsulated inside the fairing or SYLDA 5 and mated to the launch vehicle within the BAF
H0-4 days to H0-1 days	Launch rehearsal and final check out
H0-1 day	Launch vehicle is transferred to the launch pad (possible return to BAF in case of aborted launch)
H0- 7s	Synchronized sequence and EPC engine ignition (possible return to BAF in case of aborted launch)
<b>H0</b>	EAP engine ignition and lift off of ARIANE 5 ECA with KAP on board Activation of KAP SM mission
H0 + 2,3min	EAP burn out
H0 + 2,3min	Separation EAP
H0 + 3,2min	Separation and jettison of the fairing
H0+ 9min	EPC engine shut down and separation
H0 + 9min	ECA Stage ignition
H0 + 27min	Separation of the upper passenger (if any)
H0 + 32min	Separation of the SYLDA 5
H0 + 32min	Separation of the lower passenger(s)

Time	Event
H0 + 32min	Activation of KAP MM mission
H0 + 98min	Passivation of ECA stage End of KAP SM mission
H0+ 3 days	All experiments' equipments have to be sent out from French Guiana (30 days maximum)
H0+7days	Ground activity during flight: Monitoring of the experiments and house keeping telemetry data. End of KAP MM mission

Table 8-2: Major event in the KAP operational cycle

“H” refers to the time of successful completion of the system level tests

“H0” refers to the time of launch

\*) Access to experiments is possible but limited

Only working days are considered in the here above table

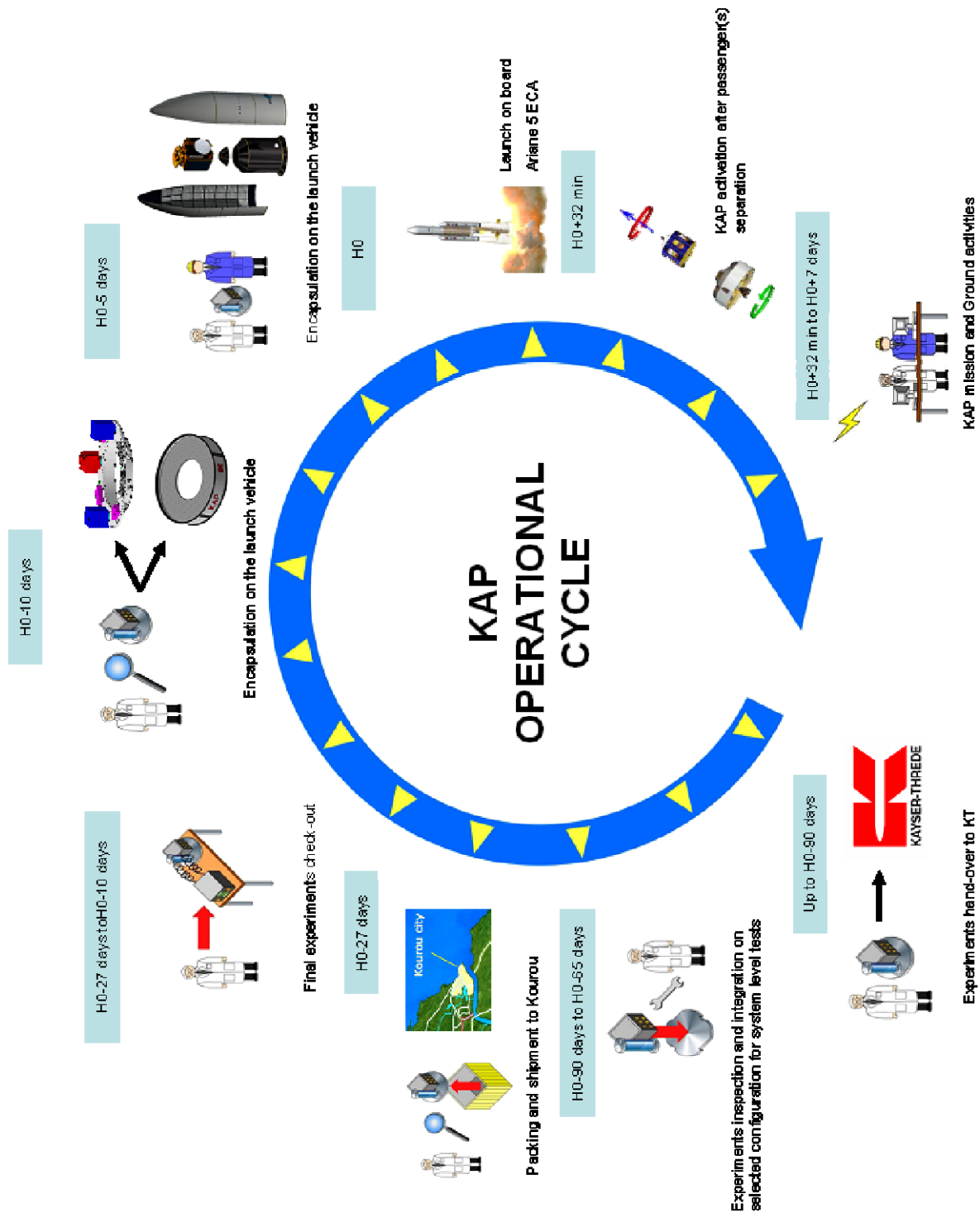



Figure 8-1: Schematic of the KAP operational cycle

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 9-1

## 9 Deliverables


### 9.1 Documentation

The experimenter shall provide an Acceptance Data Package (ADP) prior to or at the delivery of the experiment. The ADP shall constitute the basis for the formal acceptance and shall provide the set of documents and records for further integration, testing and operation.

As a minimum, the following documentation has to be submitted to Kayser-Threde:

1. Design Documentation:
  - Design Report (including Electrical Circuit Diagrams, Grounding Diagram)
  - Interface Control Document
2. Test Report:
  - Vibration Test Report
  - Thermal Vacuum/Thermal Cycling Test Report
  - EMC Test Report
  - Mass Properties Test Report
  - Interface Verification Test Report (mechanical, electrical)
  - Performances & Functional Test Report
3. Verification Analyses Reports:
  - Structural Analysis Report (including test prediction analysis)
  - Thermal Analysis Report
4. PA & Safety Documentation:
  - Qualification Status Report
  - As-built Configuration List
  - Certificate of Conformance
  - Logbook
  - Safety Questionnaire (to be filled out)
5. User's Manual:
  - For ground operations and launch campaign preparation
  - For in-orbit operation

The documentation has to be delivered in minimum three paper copies and as electronic files (stored at CD-ROM or equivalent storage means).

	<b>KAP on Ariane 5</b> <b>User's Manual</b>	KAP-KTH-UM-0101 June 6, 2007	Issue 02 Page 9-2

## 9.2 Mathematical Models

As minimum the following mathematical models have to be delivered to Kayser-Threde:

- Reduced structural mathematical model in line with [AD1]
  - Derived from and correlated with the complex overall structural mathematical model used for structural analysis, and
  - In NASTRAN format.
- Reduced Thermal Mathematical Model in line with [AD1]
  - Derived from and correlated with the complex overall thermal mathematical model used for thermal analysis, and
  - In ESATAN format or EXCEL tabular format.
- CAD model
  - Geometrical representative model in CATIA V5 format or compatible file format (e.g. Step File).


## 9.3 Hardware

The following hardware has to be delivered to the integration site:

- Experiment (Proto-)Flight Model including flight software,
- Associated cables, harnesses, I/F-bolts, I/F-washers, bonding stud,
- Required GSE for integration, testing and performance, and
- Tools (for handling and integration) as applicable.

According to the ARIANE 5 safety requirements each experiment must be compliant with a replacement before final upper composite integration onto the launcher by a representative dummy that has to be provided by the experimenter. As a minimum, the representative dummy must have the following properties:

- Experiment mass,
- Experiment CoG, and
- Representative electrical interfaces for harness connections (optional representative power dissipation, to be discussed with KAP payload integrator).

	<b>KAP on Ariane 5</b>	KAP-KTH-UM-0101	Issue 02
	<b>User's Manual</b>	June 6, 2007	Page A-1

## Annex A Questionnaire

Please find attached the Questionnaire for Potential KAP Experiments KAP-KTH-QE-0101.