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CROSS-SCALE TRS

PAYLOAD

RESOURCES

Planetary Exploration Studies Section (SCI-AP)
Science Payload and Advanced Concepts Office (SCI-A)

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1 INTRODUCTION

The Cross-scale TRS is one of ESA's Technology Reference Studies (TRS, see also http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=33170). The purpose of the TRSs is to provide a focus for the development of strategically important technologies that are of likely relevance for future scientific missions. This is accomplished through the study of several technologically demanding and scientifically interesting missions, which are not part of the ESA science programme. The TRSs subsequently act as a reference for possible future technology development activities. The TRSs will not interfere with (or replace) the standard ESA mission selection process.

The purpose of this preliminary payload resources document is to translate the typical science requirements into a payload resource budget, which is required for the first part of the system design of the Cross-scale TRS.

The document is (currently) an open document and regular updates, primarily refinements, are expected. Particularly, iterative steps with industrial study partners and the ESA TRS study manager are foreseen. Revisions will be published, as required, at the start of as well as during the system design. This document will be evolved into a straw man Payload Definition Document.

2 APPLICABLE DOCUMENTS

The payload resource document is one of the documents that constitute the complete mission profile for the Cross-scale TRS. The current list of applicable mission documents is:

CS Mission Objectives	SCI-A/2005/072/CS/MvdB	AD_MOD
CS Mission Requirements	SCI-A/2005/073/CS/MvdB	AD_MRD
CS Payload resources	SCI-A/2005/077/CS/MvdB	AD_PLR

The following documents contain general requirements for Technology Reference Studies:

Margin Philosophy for SCI-A Studies	SCI-A/2003.302/AA	AD_MARGIN
CDF Model Input Specification	CDF-IFS-001	AD_CDF
Including associated CDF Model Input Excel sheets:		
Mission	CDF-IFS- 001a Mission Issue2 Rev3.xls	
Entry element	CDF-IFS-001b Entry Element Issue2 Rev3.xls	

3 CROSS-SCALE PLASMA PHYSICS PAYLOAD

The reference plasma physics payload suite assumed for the Cross-scale Technology Reference Study consist of established, well-known, plasma field and particle instruments that have been flown (or are baselined) for numerous plasma physics missions or mission concepts, in particular Cluster II, Geotail, Themis, Magnetospheric Multi-Scale mission, and SCOPE. For more details on the instruments for these missions or mission concepts, see references [1-5].

3.1 Payload resources

Table 1 provides typical preliminary payload resources that can be used for the TRS system design study.

Table 1: Plasma physics preliminary payload resources

Instrument	**Acronym**	**Mass[1] [kg]**	**Mass margin**	**Power [W]**	**Remarks**
DC Magnetometer	DCB	1.5	10%	0.5	Incl. ~2 m boom. Electromagnetic cleanliness requirements might drive to longer boom and thus higher instrument mass.
AC Magnetometer	ACB	1.75	20%	0.1	Incl. ~1 m boom
E-field 2D	2DE	8	10%	3	4 double probe wire booms (each 30 – 50 m long)
E-field 3D	3DE	12	10%	5	Dual axial antenna for AC E-field measurements plus 4 wire booms (DC E-field)
Electron density sounder	EDS	0.2	20%	2.5	Uses E-field instrument. Instrument not operated continuously. Quoted power is peak power.
AC magnetometer and electric field processor/electronics (2D or 3D)	FPE	1.5	20%	2	
Low energy electron static analyzer	LESA	1.5	10%	1.5	< 40 keV, 3D f(v). Mass TBC as this strongly depends on geometric factor. It should be noted that mass might increase if steerable aperture beam is hard requirement.

[1] Without margin

Ion electrostatic analyzer	ISA	1.5	15%	2	20eV – 40 keV: 3D f(v). Up to 100 keV desirable[2] but might require higher mass. It should be noted that mass might increase if steerable aperture beam is hard requirement.
Combined Electron/Ion analyzer	EISA	2.5	20%	2	Combines above two instruments. Mass strongly depends on geometric factor and energy range. It should be noted that mass might increase if steerable aperture beam is hard requirement.
Ion composition	ICA	5	20%	6	< 100 keV, 3Df(v) and mass resolution
Energetic electron and ion composition	EICA	1	10%	0.5	100 keV – 1 MeV, 3Df(v) and limited mass resolution discrimination
High energy particle detector	HEP	1.2	20%	1	> 30 keV; Electrons and ions (energy resolution only)
Centralized payload processor	CPP	2	20%	2	Required for each spacecraft carrying science payload, including harness

As derived in Appendix A of this document, several representative payload suites can be identified from the science prioritization for typical space plasma investigations. For the baseline solution provided in table A-4, the total payload mass is 270 kg (P/L mass decreases with increasing length scale) and the maximum payload power 28.1 W (power without 20% margin).

3.2 Payload accommodation and spacecraft interface considerations

Table 2 lists the interface and accommodation requirements for the typical plasma physics science instruments. It serves as a typical reference for sizing and defining the S/C accommodation and interface requirements. The baseline payload configuration to be assumed for the Cross-scale TRS is provided in table A-4, though it is still subject to iteration if S/C design or mass budget issues would arise in the second phase of the system design study.

For payload instruments that are attached to the side panels, the sizes are in [horizontal plane and // side panel] × [horizontal plane and perpendicular to the side panel] × [vertical axis], where the vertical axis is defined as the spin axis.

[2] For reconnection and shocks on e-scale S/C.

Table 2: Typical accommodation and spacecraft interface requirements interfaces for classical space plasma instrumentation.

Instrument abbreviation	Instrument description	No. of packages / instrument	Volume per package (cm^3) (stowed)	Interface requirements	FOV	Other
DCB	Fluxgate magnetometer	2	5×5×5 (sensor size) + 2 m boom	S/C design shall allow for 2 m boom with 2 DCB sensors (one at end and one at 1 meter). Boom needs to be deployed in the spin plane perpendicular to the S/C side panel. Boom and sensor need to be mounted on top or bottom panel. Sensor head might stick out of S/C perimeter (S/C configuration design trade).		Magnetic cleanliness requirements defined in [AD_MRD]
ACB	Search coil magnetometer	1	10×10×10 (sensor only) + 1 m boom	S/C design shall allow for 1 m boom with ACB sensor that needs to be deployed in the spin plane perpendicular to the S/C side panel. Boom and sensor need to be mounted on top or bottom panel. Sensor head might stick out of S/C perimeter (S/C configuration design trade).		Magnetic cleanliness requirements defined in [AD_MRD]
3DE/2DE	Wire double probe antenna	4	20×30×15 (longest dimension in direction of deployment)	30-50 m wire boom in spin plane. Four booms in orthogonal directions on S/C side panels. Package protrudes S/C perimeter ~2 cm or less.		The last 3 meter of each wire boom antenna shall experience similar environmental conditions, i.e. both in sunlight or in eclipse (at any time during science measurements), which can be achieved by pointing the spin axis slightly off the orthogonal to the ecliptic. Electric cleanliness requirements defined in [AD_MRD]

Instrument abbreviation	Instrument description	No. of packages / instrument	Volume per package (cm^3) (stowed)	Interface requirements	FOV	Other
	Dual axial antenna (3DE only)	+1	100 × 12 Ø (longest dimension along spin axis)	2 × ~5 m axial booms along spin axis[3] (boom diameter 10 cm)	12cm Ø openings on top and bottom panel for deployment	The last 1.5 m of each antenna shall experience similar environmental conditions, i.e. both in sunlight or in eclipse (at any time during science measurements). Electric cleanliness requirements defined in [AD_MRD]
EDS	Electron density sounder	1	Inside FPE	Add-on electronics card		Makes use of 3DE/2DE
FPE	Dedicated plasma field processor	1	20×20×8	Common electronics box		Requires input from 2DE/3DE and ACB
LESA	Classical 180° single electron electrostatic analyzer with steerable aperture beam	1	10×20×15	If more than one instrument, FOV distributed evenly across S/C sides. To achieve 180° FOV in vertical direction, instrument will need to protrude 10 cm outside the S/C side panel. At instrument location, no top or down obstruction allowed (1 cm outside S/C perimeter)	180° × 45° (⊥ × // to spin plane)	Electrostatic cleanliness requirements defined in [AD_MRD]

[3] Please note that the axial boom antenna might conflict with a main central engine (assuming the axial boom antenna is centred)

Instrument abbreviation	Instrument description	No. of packages / instrument	Volume per package (cm^3) (stowed)	Interface requirements	FOV	Other
ISA	Classical 180° single ion electrostatic analyzer with steerable aperture beam	1	10×20×15	If more than one instrument, FOV distributed evenly across S/C sides. To achieve 180° FOV in vertical direction, instrument will need to protrude 10 cm outside the S/C side panel. At instrument location, no top or down obstruction allowed (1 cm outside S/C perimeter)	180° × 45° (⊥ × // to spin plane)	Electrostatic cleanliness requirements defined in [AD_MRD]
EISA	Combined 180° ion-electron electrostatic analyzer with steerable aperture beam	1	15×20×15	If more than one instrument, FOV distributed evenly across S/C sides. To achieve 180° FOV in vertical direction, instrument will need to protrude 10 cm outside the S/C side panel. At instrument location, no top or down obstruction allowed (1 cm outside S/C perimeter)	180° × 45° (⊥ × // to spin plane)	Electrostatic cleanliness requirements defined in [AD_MRD]
ICA	360° top-hat ion electrostatic analyzer with a time-of-flight analyzer	1	25×45×25	At least 6.5 cm (of 45 cm) needs unobstructed 360° FOV // to side panel	360° × 10° (// × ⊥ to S/C surface) (TBC)	Electrostatic cleanliness requirements defined in [AD_MRD]
EICA	Energetic electron and ion composition by microchannel plate time-of-	1	10×15×15	If more than one instrument, FOV distributed evenly across S/C sides. To achieve 180° FOV in vertical direction, instrument will need to	180° × 20° (⊥ × // to spin plane)	

Instrument abbreviation	**Instrument description**	**No. of packages / instrument**	**Volume per package (cm^3) (stowed)**	**Interface requirements**	**FOV**	**Other**
	flight analyzer			protrude 7.5 cm outside the S/C side panel. At instrument location, no top or down obstruction allowed (1 cm outside S/C perimeter)		
HEP	High-energy particle solid state particle detector	2	15×5×15 (for 2 packages)	Two packages next to each other with opposite viewing directions (along S/C surface). Package sticks completely, i.e. 5 cm, outside S/C perimeter Unobstructed view to the sides, both forward and backwards looking (each 135°). Upwards, the requirements are less stringent: top 45° and bottom 45° can be obstructed.	120° × 25° (// × ⊥ to S/C surface)	
CPP	Centralized payload processor	2	10×20×5	Common digital electronics box		

3.3 Thermal requirements

Typical payload temperature range requirements are -20°C and +40°C (operational) and -50°C and +65°C (non-operational).

3.4 Data rates

To be written.

4 LIST OF ABBREVIATIONS

AIV	Assembly, Integration & Verification
AME	Absolute Measurement Error
APE	Absolute Pointing Error
CS	Cross-scale, an ESA Technology Reference Study
CoG	Centre of Gravity
ESA	European Space Agency
TBC	To be confirmed
TBD	To be determined
TRL	Technology Readiness Level
TRS	Technology Reference Study

5 REFERENCES

[1] The cluster and Phoenix missions, C.P. Escoubet, C.T. Russell, and R. Schmidt (eds.), Kluwer Academic Publishers, 1997. (reprinted from Space Sci. Rev. vol. 79, 1997 (issue 1/2)
[2] See e.g. http://directory.eoportal.org/pres_GEOTAIL.html
[3] See e.g. http://sprg.ssl.berkeley.edu/themis/Flash/THEMIS_flash.htm
[4] See e.g. http://mms.space.swri.edu/
[5] M. Fujimoto, Y. Tsuda, et al., The scope mission, Proc. 39th ESLAB Symposium, ESA SP-588, pp. 249, December 2005.

APPENDIX A

Appendix A provides three examples of typical P/L configurations, which are considered to be of scientific interest (and how they are derived). Table A-4 provides the baseline configuration for the Cross-scale TRS system design study. The other configurations in this appendix illustrate that there is room for a trade-off between payload resource requirements and other mission requirements (such as e.g. number of S/C).

Assumptions:

- In the tables below, the instruments are denoted by the acronyms provided in Table 1
- Subsystem mass margins have been applied
- The column 'P' renders the typical science priority level for each scale distance
- The column 'N' renders the number of S/C needed to carry the instrument (for each scale distance)
- In the column 'N' (number of S/C), 'A' denotes all S/C on that scale
- For particles detectors, it is assumed that a time resolution of 10 Hz or more requires 8 sensors or 4 packs of 2 sensors/spacecraft. For a time resolution of 0.5 Hz, 2 sensors/spacecraft are baselined (this depends from the spin rate of the S/C), 'Spin' resolution means 1 sensor/ spacecraft

Table A-1 Typical instrument Requirements
(Black: turbulence, pink: shocks, red: reconnection)

Instrument	Electron scale	P	N	Proton scale	P	N	Fluid scale	P	N
DCB+ACB (+FPE)	dc-200Hz	5	A	dc-200Hz	5	A	dc-50 Hz	5	A
	200 Hz- 2 kHz	5	A	200 Hz- 2kHz	5	A	50 Hz- 2 kHz	3	A
	dc-500 Hz	5	2	dc-50 Hz	5	3	dc-10 Hz	5	A
	> 500 Hz	4	2		3	A			
		3	3	50- 500 Hz	3	2			
	dc-1000Hz	5	1	dc-1000 Hz	5	3	dc- 100 Hz	5	3
	-100 Hz	3	A		4	A		4	A
ISA				3D f(v) 1 Hz	5	2	3D f(v) spin	5	A
	3D f(v) 1 Hz	5	1	3D f(v) 1 Hz	5	3	3D f(v) 0.2Hz	5	A
		3	2		3	A			
	3D f(v) 10 Hz	5	1	3D f(v) 1 Hz	5	3	3D f(v) 0.1 Hz	5	3
				3D f(v) 0.5 Hz	4	A	3D f(v) 0.5 Hz	4	A
				2x0.5Hz+2x10Hz	4	A			
ICA				Spin	4	2	Spin period	4	A
	0.1 Hz	5	1	0.1 Hz	4	2	0.1 Hz	3	1
	1 Hz	4	1		3	A			
	0.5 Hz	5	1	0.5Hz	4	1	0.1Hz	4	1
	10 Hz	3	1		4	A		3	A
LESA: 3DF(v)	10 Hz	5	2				Spin	5	A
	1 Hz	5	2	0.1 Hz	4	3	0.1 Hz	4	2
		3	3	1 Hz	5	1		3	A
	10 Hz	5	1		3	A			
	100 Hz	4	2						
	10 Hz	5	2	0.5 Hz	4	A	0.1 Hz	5	1
	100 Hz	5	1	1 Hz	5	3	0.5 Hz	4	3
		4	A	2x0.5+2x100 Hz	3	A		3	4

	500 Hz	3	1						
EICA	0.1 Hz 0.5Hz	5 5	1 1	0.1 Hz 0.5 Hz	4 4	2 1	0.1 Hz 0.1 Hz	4 3	2 1
HEP	Spin; <100 keV 0.1 Hz 0.5 Hz 0.5 Hz 10 Hz 	5 5 3 4 5 4 3	2 1 2 1 1 1 2	Spin; < 100 keV 0.1 Hz; > 30 keV 0.5 Hz 	3 4 3 4 4	2 1 3 1 4	Spin; < 100 keV 0.1 Hz 0.1 Hz 0.5 Hz	3 4 3 4 3	A 1 4 1 A
EDS	1Hz	5	A	1Hz	5	A	1 Hz	3	A
E-field E-field E-field	2D dc-50 kHz 3D dc-50 kHz 3D dc-10 kHz 3D dc-1 kHz 2D dc-10 kHz 3D dc-100 kHz 2D dc-100 kHz	5 5 5 4 5 5 4 3 4	2 2 1 2 2 1 2 A A	2D dc-50 kHz 3D dc-1 kHz 2D dc-10 kHz 2D dc-100 kHz 2x2D+2x3D	5 3 5 4 5 4 4	A 2 1 3 3 A A	2D dc-50 Hz 2D 50 Hz – 50 kHz 3D dc-1 kHz 2D dc-10 kHz 2D 100 Hz	5 3 3 4 4 3	A A 2 2 1 A

Table A-2 translates the common high-level requirements of table A-1 into payload resources per S/C (without margin). Some additional mass-saving alternatives are also provided, which do not completely satisfy the Science Priority Document requirements but are nonetheless considered to be of interest in view of the trade between science payload with number of satellites and mission cost. A suggested **minimum** baseline P/L is indicated in **bold**. Table A-2 does not make use of a combined electron-ion static analyzer.

Table A-2: An example of a model payload distribution (suggested minimum baseline in bold)

Measurement	**Instrument**	**Electron scale (kg per S/C)**	**N**	**Proton scale (kg per S/C)**	**N**	**Fluid scale (kg per S/C)**	**N**
Magnetic field	DCB+ACB DCB	**3.25**	**A**	**3.25**	**A**	 **1.5**	 **A**
Electric field	3DE 2DE *Alternative*: 3DE 2DE	**12** **8** 12 8	**2** **A-2** 1 A-1	 **8** 12 8	 **A** 2 A-2	 **8**	 **A**
Electron density	EDS	**0.2**	**A**	**0.2**	**A**		
Field processor / electronics	FPE	**1.5**	**A**	**1.5**	**A**	**1.5**	**A**
Electrons	LESA *Alternative:*	8x1.5 4x1.5 **8x1.5** **4x1.5**	2 A-2 **1** **A-1**	**4x1.5** **2x1.5** 4x1.5	**3** **A-3** A	**1.5**	**A**
Ions	ISA *Alternative*	**8x1.5** 4x1.5	**1** 1	**4x1.5** **2x1.5** 4x1.5	**3** **A-3** A	**1.5**	**A**
Ion composition	ICA	**2x5**	**1**				
Energetic e^-/ion composition[4]	EICA	**2x1**	**1**				
Energetic particles	HEP	**2x1.2** 1x1.2	**1** 1	2x1.2	A	1x1.2	1
Payload processor	CPP	**2**	**A**	**2**	**A**	**2**	**A**

[4] EICA has been moved to ion scale in some of the following payload tables.

Table A-3 to A-5 provides illustrations of how the payload could be distributed over a sample of possible S/C configurations.

Table A-3 assumes a 10 S/C configuration with the **bold** payload in Table A-2. The apparent drawback of Table A-3 is the significant higher payload mass and power for one electron scale S/C, which is not optimal for identical S/C design. Total payload mass is 281 kg.

Table A-3: Possible payload distribution assuming one large S/C (in green) and several smaller ones

Instruments	**Electron scale (P/L mass per S/C)**		**Proton scale (P/L mass per S/C)**				**Fluid scale (P/L mass per S/C)**			
DCB+ACB	3.75	3.75	3.75	3.75	3.75	3.75				
DCB							1.65	1.65	1.65	1.65
3DE/2DE	3 D 13.2	3 D 13.2	2 D 8.8	2 D 8.8	2 D 8.8	2 D 8.8	2 D 8.8	2 D 8.8	2 D 8.8	2 D 8.8
EDS	0.2	0.2	0.2	0.2	0.2	0.2				
FPE	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
LESA		(4x1.5) 6.6 0.5 Hz								
EISA	(8x2.5) 24 100 Hz		(2x2.5) 6 0.5 Hz	(4x2.5) 12 1 Hz	(4x2.5) 12 1 Hz	(4x2.5) 12 1 Hz	(1x2.5) 3 0.25 Hz	(1x2.5) 3 0.25 Hz	(1x2.5) 3 0.25 Hz	(1x2.5) 3 0.25 Hz
ICA	(2x5) 12 0.5 Hz									
EICA			(2x1.1) 2.2 0.5 Hz							
HEP	(2x1.2) 2.9 0.5 Hz	(1x1.2) 1.4 0.25 Hz	(2x1.2) 2.9 0.5 Hz				(1x1.2) 1.4 0.25 Hz	(1x1.2) 1.4 0.25 Hz	(1x1.2) 1.4 0.25 Hz	(1x1.2) 1.4 0.25 Hz
CPP	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
TOTAL (kg)	60	29.4	28.1	29	29	29	19	19	19	19
TOTAL (W)	*42*	*21*	*17*	*18*	*18*	*18*	*11*	*11*	*11*	*11*

Table A-4 shows a configuration where all S/C could be designed identical with 'maximum payload slots,' see also appendix B. As not all slots will be used, the maximum payload mass is different for each S/C scale (43.25kg for electron scale, 35 kg for ion scale and 12.4 kg for fluid scale). The maximum payload power is 28.1 W (excluding 20% margin). The total payload mass is 270 kg. If the S/C mass budget has sufficient margin, the fluid scale P/L could be promoted to that indicated in table A-3 (i.e. 2DE instead of ACB).

Table A-4 Possible payload distribution for identical spacecraft design.

Instruments	**Electron scale (P/L mass per S/C)**		**Proton scale (P/L mass per S/C)**				**Fluid scale (P/L mass per S/C)**			
DCB+ACB DCB	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**
3DE/2DE	**3 D** **13.2**	**3 D** **13.2**	2 D **8.8**	2 D **8.8**	2 D **8.8**	2 D **8.8**				
EDS	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**				
FPE	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
LESA/ISA	**(4x1.5)** **6.6** **LESA**	**(4x1.5)** **6.9** **ISA**								
EISA	**(4x2.5)** **12**	**(4x2.5)** **12**	**(2x2.5)** **6** 0.5 Hz	**(4x2.5)** **12** 1 Hz	**(4x2.5)** **12** 1 Hz	**(4x2.5)** **12** 1 Hz	**(1x2.5)** **3** 0.25 Hz	**(1x2.5)** **3** 0.25 Hz	**(1x2.5)** **3** 0.25 Hz	**(1x2.5)** **3** 0.25 Hz
ICA			**(2x5)** **12** 0.5 Hz							
EICA				**(2x1.0)** **2.2** 0.5 Hz	**(2x1.0)** **2.2** 0.5 Hz	**(2x1.0)** **2.2** 0.5 Hz				
HEP		**(2x1.2)** **2.9** 0.5 Hz		**(2x1.2)** **2.9** 0.5 Hz	**(2x1.2)** **2.9** 0.5 Hz	**(2x1.2)** **2.9** 0.5 Hz	**(1x1.2)** **1.4** 0.25 Hz	**(1x1.2)** **1.4** 0.25 Hz	**(1x1.2)** **1.4** 0.25 Hz	**(1x1.2)** **1.4** 0.25 Hz
CPP	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**
TOTAL (kg) ***TOTAL (W)***	**40** *28*	**43** *28*	**35** *26*	**34** *21*	**34** *21*	**34** *21*	**13 / 19**[5] *8 / 11*	**13 / 19**[5] *8 / 11*	**13 / 19**[5] *8 / 11*	**13 / 19**[5] *8 / 11*

[5] If the mass budget allows, the fluid scale carries the payload shown in table A-3 (19.1 kg per S/C, total payload mass becomes 297 kg).

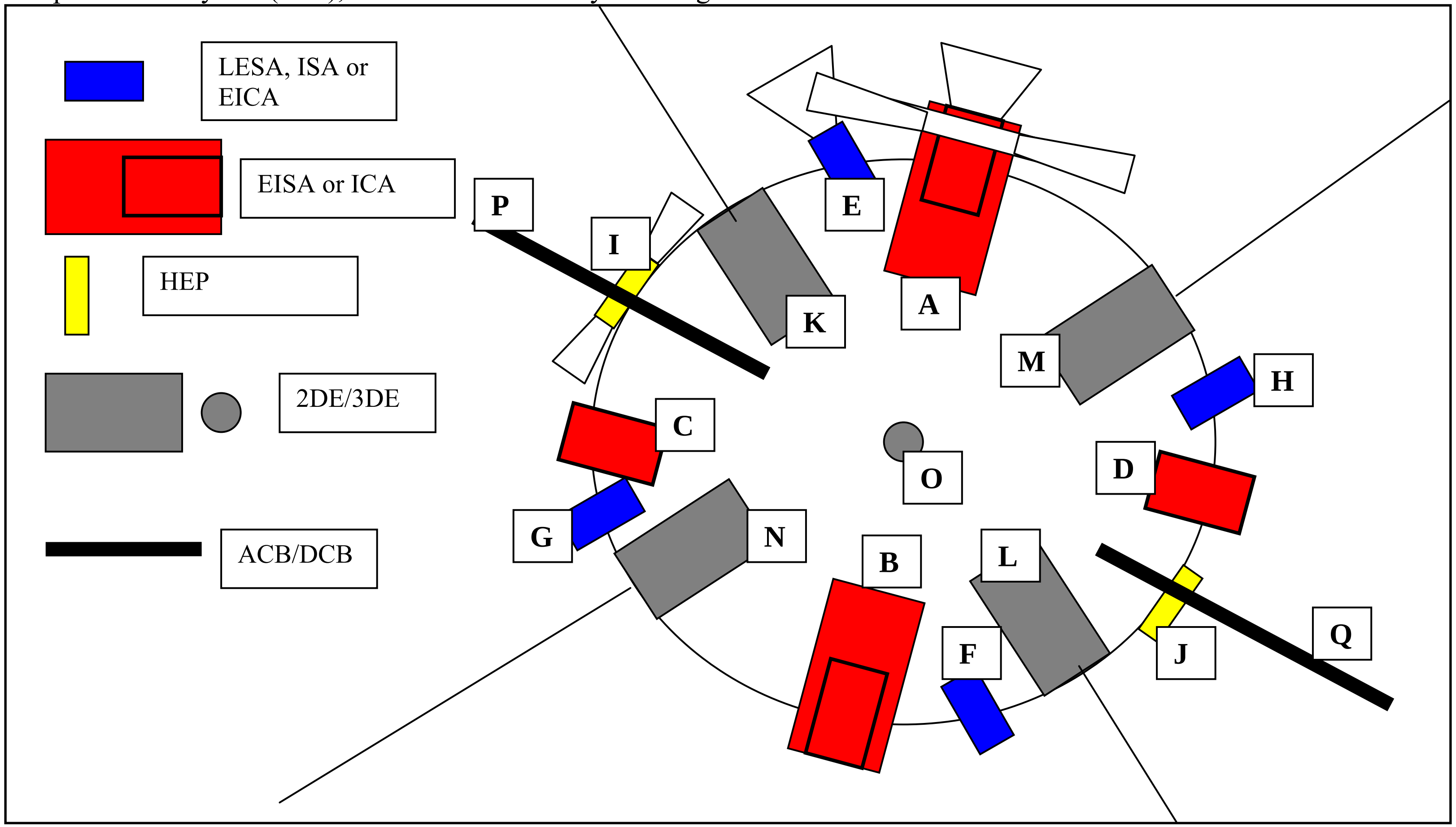
Table A-5 shows the minimum configuration that would still be of scientific interest. Key difference with table A-4 is that that there are less high energetic particle instrument and additionally less temporal resolution on the electron/ion measurements. Total payload mass is 222 kg.

Table A-5 Minimum nearly-identical payload distribution.

Instruments	**Electron scale (P/L mass per S/C)**		**Proton scale (P/L mass per S/C)**				**Fluid scale (P/L mass per S/C)**			
DCB+ACB DCB	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	 **1.65**	 **1.65**	 **1.65**	 **1.65**
3DE/2DE	**3 D** **13.2**	**3 D** **13.2**	2 D **8.8**	2 D **8.8**	2 D **8.8**	2 D **8.8**				
EDS	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**				
FPE	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**				
LESA	**(8x1.5)** **13.2** 100 Hz									
EISA		**(4x2.5)** **12** 1 Hz	**(2x2.5)** **6** 1 Hz	**(4x2.5)** **12** 1 Hz	**(4x2.5)** **12** 1 Hz	**(4x2.5)** **12** 1 Hz	**(1x2.5)** **3** 0.25 Hz	**(1x2.5)** **3** 0.25 Hz	**(1x2.5)** **3** 0.25 Hz	**(1x2.5)** **3** 0.25 Hz
ICA			**(1x5)** **6** 0.25 Hz							
EICA			**(1x1.0)** **1.1** 0.25 Hz							
HEP		**(2x1.2)** **2.9** 0.5 Hz					**(1x1.2)** **1.4** 0.25 Hz	**(1x1.2)** **1.4** 0.25 Hz	**(1x1.2)** **1.4** 0.25 Hz	**(1x1.2)** **1.4** 0.25 Hz
CPP	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**
TOTAL (kg) ***TOTAL (W)***	**35** *28*	**36** *22*	**30** *21*	**29** *18*	**29** *18*	**29** *18*	**9** *6*	**9** *6*	**9** *6*	**9** *6*

APPENDIX B

This appendix discusses a potential payload accommodation configuration using Table A-4 as a baseline. A possible configuration is shown schematically in the figure below. The direction of the FOVs are also shown. The width of the FOV beams in this schematic are not exactly sized to reflect the required beam width. The direction of the FOVs of ABCDEFGH are 360/8 = 45° apart, except when AB are Ion composition analyzers (ICA), which have a sideways looking 360° FOV.



The payload slot accommodation across the different scales (for the payload table in A-4) is shown in the table below:

Instrument	Location of instruments				
	e - scale #1	e - scale #2	ion scale #1	ion scale #2-4	Large scale
DCB	P	P	P	P	P
ACB	Q	Q	Q	Q	Q[6]
2DE	KLMN	KLMN	KLMN	KLMN	[KLMN][7]
1DE	O	O	-	-	-
LESA	EFGH	-	-	-	-
ISA	-	EFGH	-	-	-
EISA	ABCD	ABCD	CD	ABCD	A
ICA	-	-	AB	-	-
EICA	-	-	-	EF	-
HEP	-	IJ	-	IJ	I

Note: The payload accommodation shown in this appendix is purely meant for illustrative purposes and possibly as a starting point for iteration with the S/C design (confirmation of available area, volume, FOV requirements).

[6] Current baseline only ACB. If mass budget allows, ACB on the fluid scale is replaced with 2DE (see also table A-3, fluid scale)