The Selection of an ESA Payload

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ESA in a few words

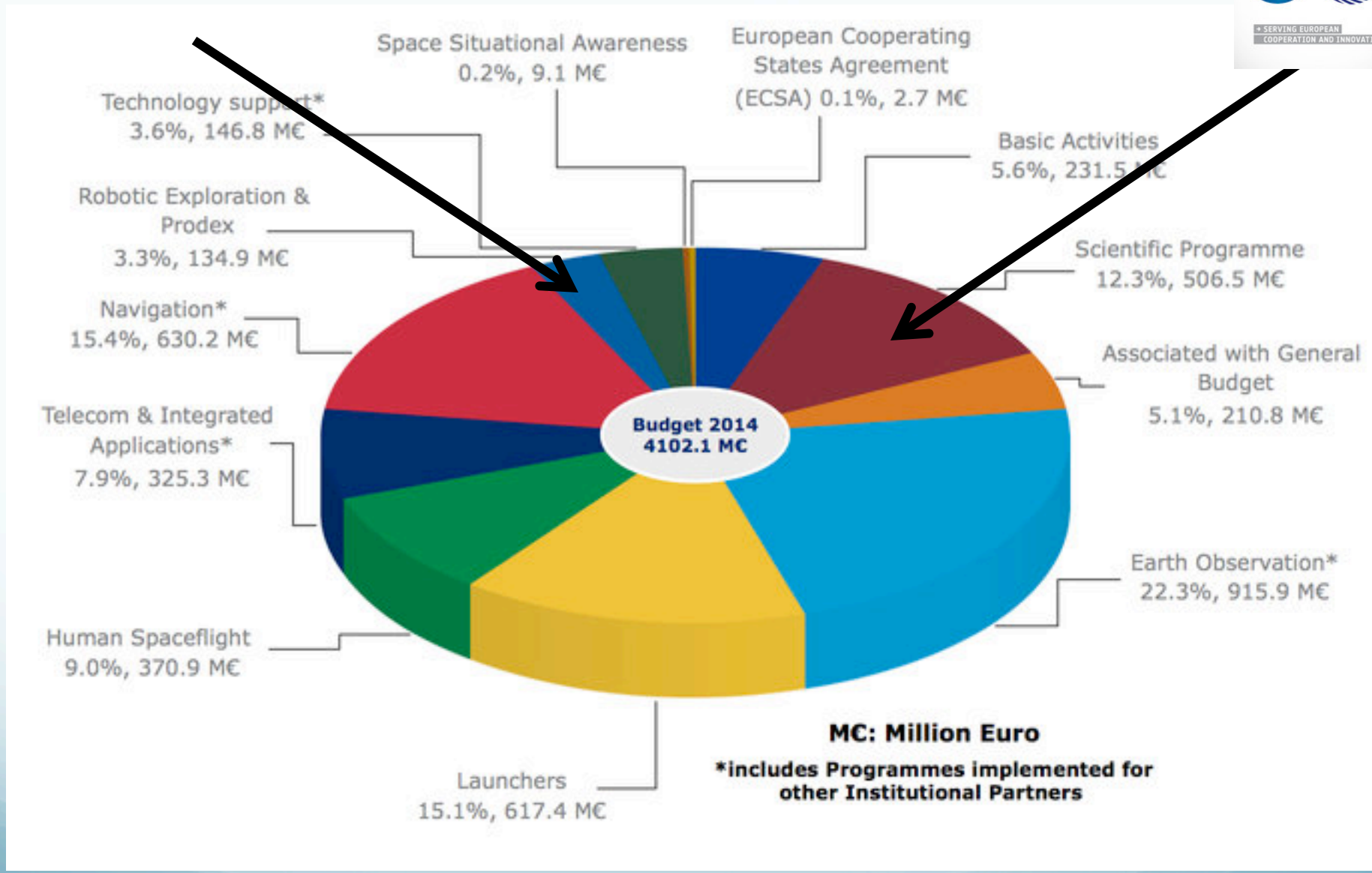
- The European Space Agency (ESA) is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world
- ESA now has 20 Member States:Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom.
- Hungary, Estonia, Latvia and Slovenia are participating in the Plan for European Cooperating States (PECS)
- Canada also sits on the Council and takes part in some projects under a Cooperation Agreement.

ESA – EU Relations

- ESA is an intergovernmental organization, whereas the is EU is supranational.
- Some 20 per cent of the funds managed by ESA now originate from the EU budget (EU is the 3rd largest funding source after G & F)
- The two institutions have indeed different ranges of competences, different Member States and are governed by different rules and procedures.
- However, in recent years the ties between the two institutions have been reinforced by the increasing role that space plays in supporting Europe's social, political and economic policies.

SOMETHING WILL CHANGE…FOR THE BETTER?

The 2014 ESA Budget



The Science Program is the Mandatory Program:
every Member States provides funding as a pro-rata of its GDP

ESA functions under the "Juste Retour" rule:
Every € given to ESA by the MS will go back to the MS, after detraction of management costs (about 15%), in the form of industrial contracts

Should we apply this rule to the funding of the payload, considerations such as industrial under-return, compensatory measures and political issues would influence the selection of the scientific payload

HENCE

ESA DOES NOT FUND PAYLOADS

Instrument Development

- Provision of instruments is national funded **BUT ESA HAS DELEGATION OF AUTHORITY FOR THEIR SELECTION**
- Consequences of SPRT/SPC recommendations on Payload development:
  - All instrument related technology preparation must be nationally funded through national funding agencies
  - Science Payload Phase A/B1 completed before entering the implementation phase
  - Move Payload selection AO at the beginning of the Definition Phase
  - Perform Instrument assessment studies before entering the Definition Phase
- Activities on instruments are in parallel with industrial activity on system level
- Purpose is to better prepare the AO of FM instruments

AO Documents and Information

- Documentation
  - AO Letter of invitation
  - Mission baseline description
  - Science Requirements Document (Sci-RD)
  - Model Payload Definition Document (PDD)
  - Experiment Interface Document Part A (EID-A)
    - Describing s/c capability and requirements on EID-B
  - Science Management Plan (SMP)
  - Mission Environment
  - Mission Analysis Baseline
- Q&A meeting after the AO
  - Q&A presentations (at meeting and via Web)

The Science Management Plan

Mission Summary
1 Summary and scope
2 Mission Overview
2.1 Introduction
2.2 Scientific Objectives
2.3 Payload
2.4 System Requirements
2.5 Mission Scenario
3 Programme participation
3.1 Introduction
3.2 Schedule
3.3 Status of the Project
3.4 Further Scientific Participation in the Mission
3.5 Potential International Collaboration
4 Science and Project Management
4.1 Science Working Team Composition
4.2 Science Working Team Tasks
4.3 The Project Scientist
4.4 The Project Team
4.5 The Mission Manager
4.6 Monitoring of Instrument Development
5 Operations and Scientific Data
5.1 Mission Operations
5.2 Mission Operations Centre
5.3 Science Operations Centre
5.4 Data Rights and Scientific Data Archive
5.5 Communications and Public Relations Plan
6 Acronyms
7 References
8 Appendices
A. 1 Instruments for Spacecraft
A. 2 Responsibilities of Principal Investigators and Experiment Managers

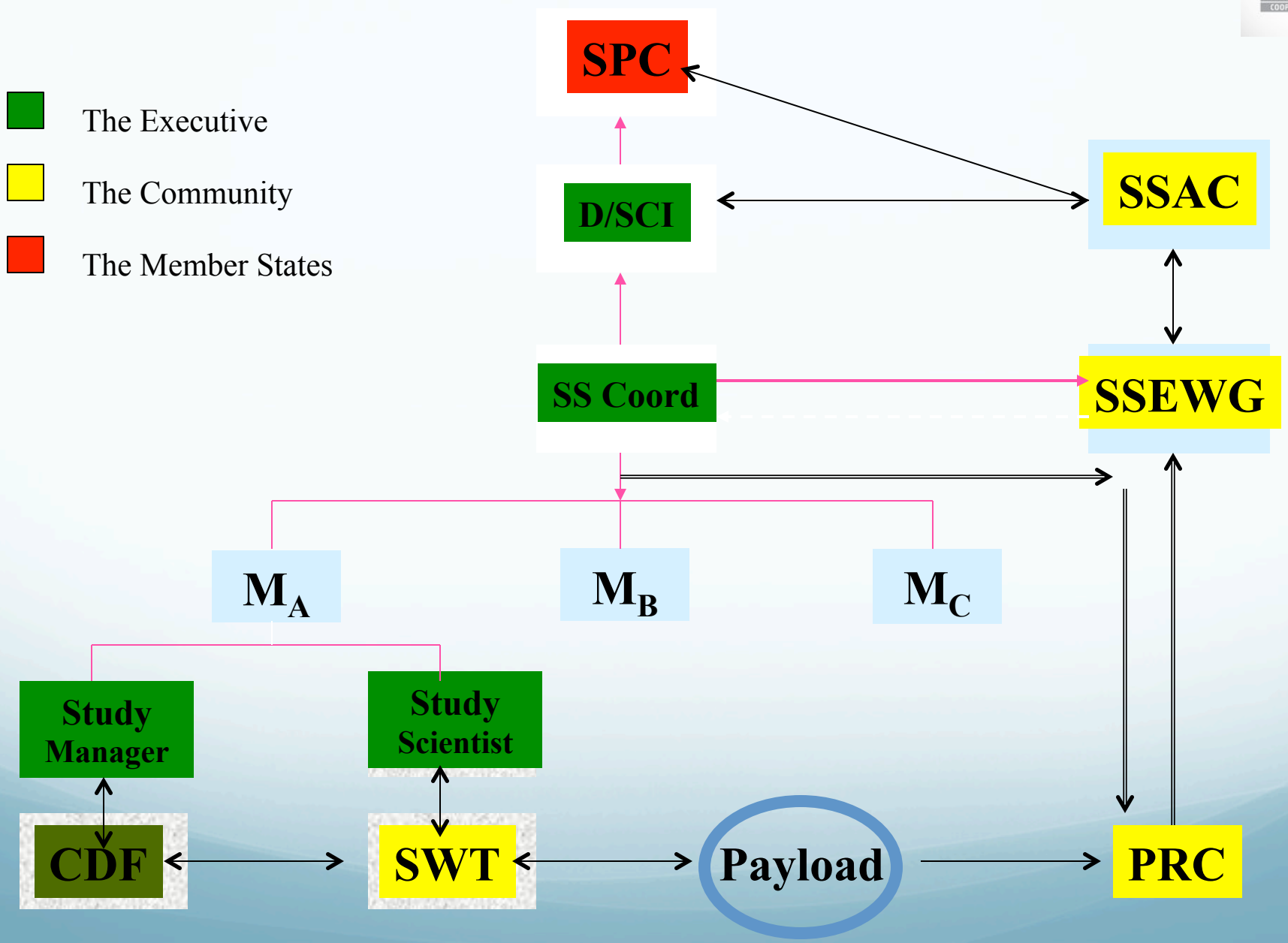
Expected AO Proposal Content

- Preliminary list of input based on previous proposals
  - Scientific and Technical plan
  - Experiment Interface Document part B (EID-B)
    - Describing instrument requirements to s/c
  - Engineering plan
  - Product assurance plan
  - Management & cost plan
  - Letter of Endorsement by funding agency (LOE)

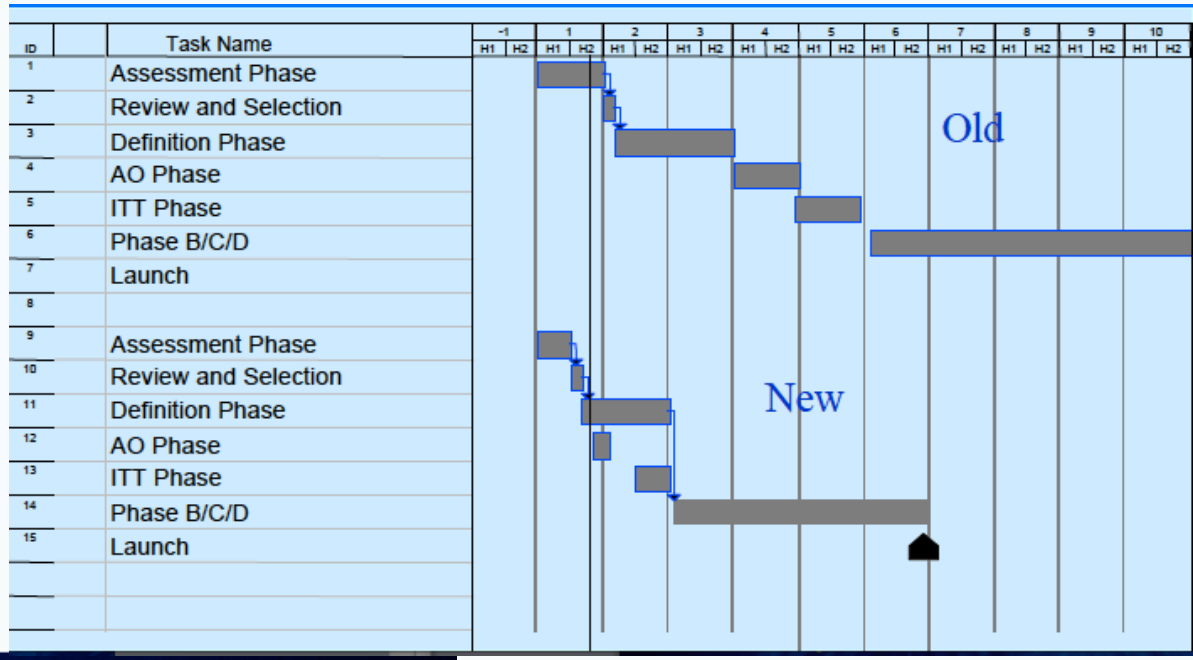
AO Proposal Evaluation

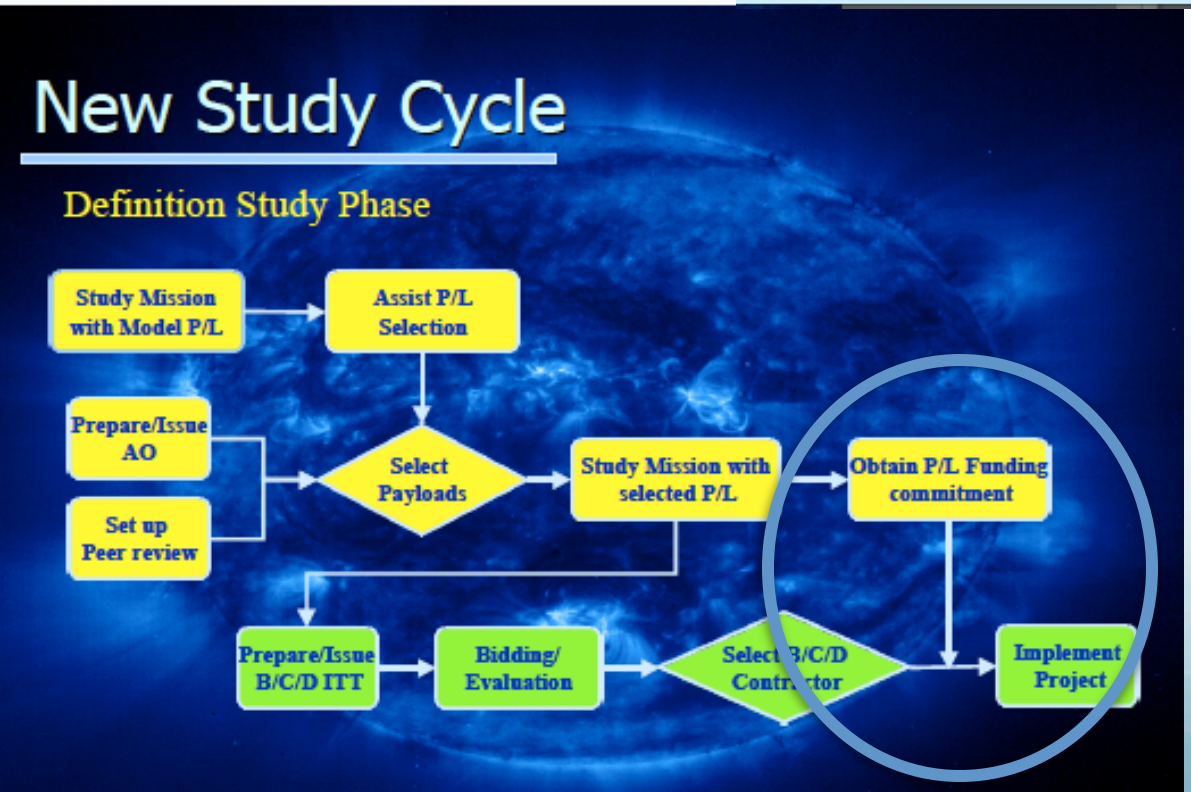
- Review process
  - Science panel
    - External team of scientists
  - Technical panel
    - ESA evaluation
- Review report and recommendation
- Instrument selection by ESA upon binding recommendation of the advisory structure
- Confirmation by SPC

SS Mission & P/L selection process



Mission studies evolve





And payloads start creating problems

Payload Funding

- **Issues**
  - ESA schedule impacted by external parties without any contractual obligations to ESA or FA's.
  - P/L funding crises during mission forces ESA contributions.
  - P/L cost analysis often inadequate at Institute & FA level.
  - Multi-national, multi institutional teams drive infrastructure & management overheads.
  - P/L maturity and Technology Readiness Level drives cost.

Payload Funding

- Mitigation
  - Detailed model P/L design must be derived in Assessment Phase.
  - Detailed P/L cost & risk analysis performed during Assessment & Definition phases.
  - ESA + FA's team together for cost analysis and share technology development.
  - Optimized instrument for cost effective design *[Technical choices and programmatic actions to develop the strengths of institutes & reduce the weaker riskier areas]*.
  - No commitment to implementation (B2/C/D) without Formal Agreement of Funding Agencies/ instrument consortium and ESA *[FA's funding confirmed with adequate margin, management/ reporting line to ESA and identification of who covers system risk]*.
  - Verify that the consortium is capable of handling its undertaking: if instrument size/complexity is beyond consortium capabilities then programmatic decision to handle the development under ESA management/industrial contract.

Management of Big Consortia Providing Instruments

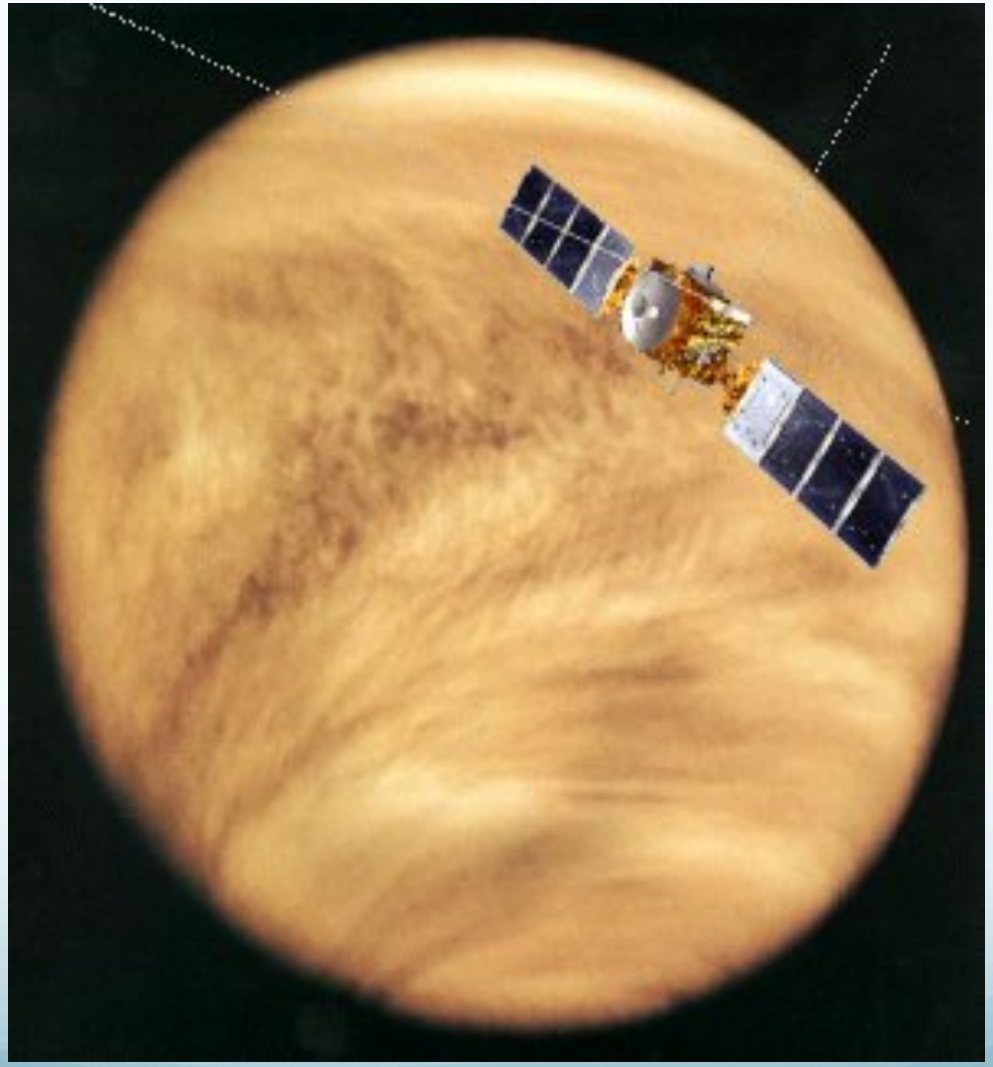
- Issues
  - Funding constraints force consortia structure to be overly complex & multinational
  - Large consortia increase infrastructure/admin & management overhead to FA's & ESA
  - Payload maturity and technology readiness level drives costs
  - PI is focal point to ESA but has no clear firm consortium management authority
  - Institute consortia can form based on funding constraints, not on clear technical or scientific expertise & without ESA or FA's guidance and involvement

Management of Big Consortia Providing Instruments

- **Mitigation**
  - Management structure with minimum interfaces forms key element of selection process.
  - P/L cost & risk analysis must be highly visible to ESA & FA's before selection process. *[Note the correct instrument budget must be assigned by FA's with a proper contingency as a prerequisite for ESA to carry the system risk]*
  - Funding agreement to be signed between FA's & ESA with budget made available to a single agreed consortium manager/ESA. *[Consortium manager reports to ESA project manager. ESA represented in consortium steering group. ESA to carry the system risk with budget apportionment as part of ESA CaC].*
  - For large/expensive/risky instruments avoid consortium structure & use an industrial development approach (PI-type teams acting as Science Consultant team)

A Simple Successful Case

VEX



Venus Express Payload Assessment

- High level of recurrence with Mars Express and Rosetta
  - Electrical interface: OK
  - Mechanical interfaces: VIRTIS & VeRA to accommodate; others are OK
  - Thermal interfaces: critical point, under analysis both by PI's and Astrium

- Payloads available as existing spares of these programmes
  - Minor modifications to detectors for some instruments

- Point to state during this meeting: complementary payload & VENSIS

Venus Express - Payload and Heritage

PAYLOAD	Instrumental concept	Heritage
VIRTIS	UV-Visible-near-IR imaging Spectrometer	ROSETTA
VERA	Radio Science	(RSI) ROSETTA
ASPERA	Energetic Neural Atoms Analyser	MARS EXPRESS
PFS	Atmospheric High Resolution Fourier Spectrometer	MARS EXPRESS
SPICAM	UV & IR Atmospheric Spectrometer	MARS EXPRESS
VENSIS	Radar Altimeter	(MARSIS) MARS EXPRESS

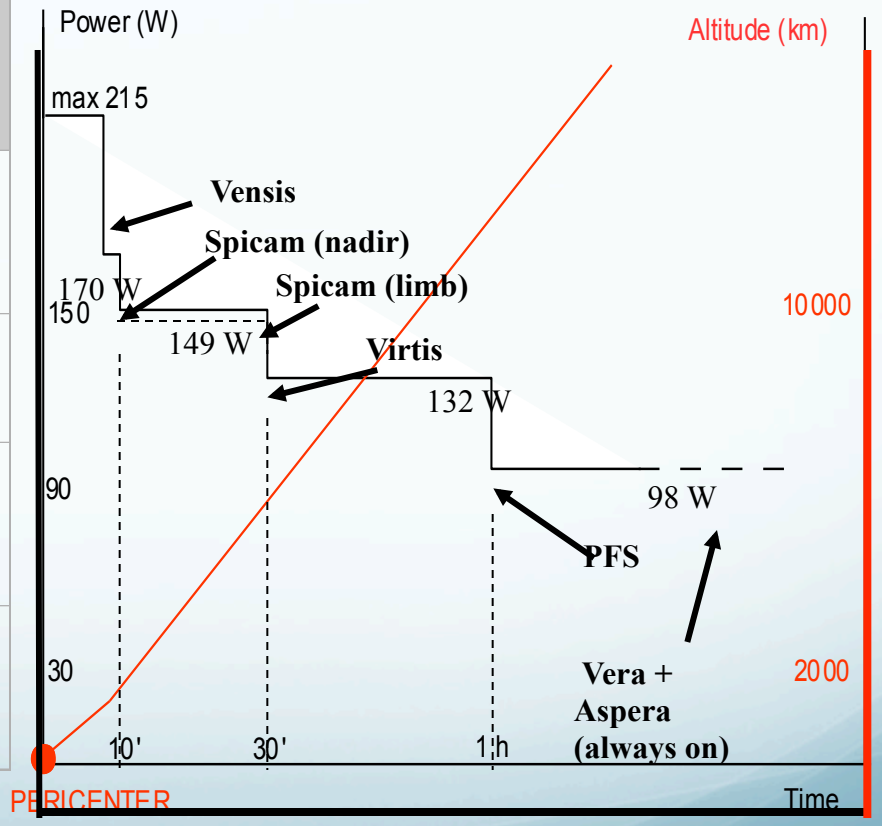
Venus Express - Interface main characteristics

Payload	Size cm	Mass kg (Incl. ~5%)	Power W (max)	Thermal control	Data rate	Observations at
VIRTIS	59x65x38, 22x25x10, 20x25x19	33.1	66 St.by 49	Cold radiator (130 K TBC)	~40kbps	Nadir: 500 – 5000 km (~1h) Nadir on the Apocenter part
VERA	15.2x12.2x13	2	5 Always on	Ambient	NA	Earth occultations (6 to 8')
SPICAM	40x24x12 15x10x7	5.2	21 Off 0	Ambient	~3.2 Mb/ orbit ~5 kbps	Nadir <1000km (~20') Limb 500-5000km (~1h) Occultations anywhere
PFS	45x35x27, 20x20x15	31.5	45 St.by 11	Cold radiator (200 K)	24-64 kbps	Nadir < 12000 km (~2h)
ASPERA	23.2x34.8x25 18.6x28x15.1	9.3	15 Always on	Ambient	0.6 – 18.2 kbps	Entire orbit ; Nadir <12000km (~2h), or Sun pointing
VENSIS	25.4x15.4x21 .5 47.1x15 x9 166.5 x20 x30	18.3	63 Silent 18	Ambient	10-80 kbps	Nadir < 800 km (~15') Ionospheric sounding: anywhere on the orbit
TOTAL		**99.1 kg**	**Max 215 mean 110**			

Venus Express - Power profiles scenarii

SCENARIO	Power (W) (max)	Comments
Earth pointing (Communication & Earth occultation)	98	Virtis(49W) + Vera(5W) + PFS(11W) + Aspera(15W) + Vensis(18W)
Solar/Stellar Occultation	112	+ Spicam (14W)
High altitude Nadir pointing (Apocenter part)	194	All instruments except Spicam (21W)
Nadir pointing near Pericenter (day or night)	215	All instruments

Power profile near Pericenter



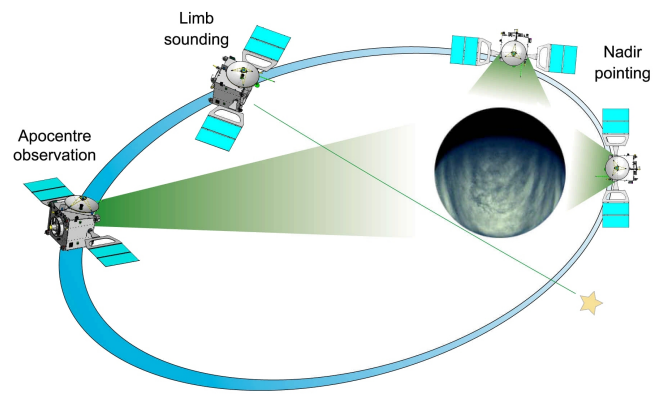
Venus Express – Pointing Requirements

Payload	Reference frame	Requirement	Pointing	Stability	Remark
VIRTIS	Nadir	No sun in FOV	Absolute : ±1° Relative : +/- 16 arcsec	+/- 20 arcsec/ sec	Scanning mirror: +/- 1.8 dg (optical) in 256 steps
VERA	Inertial	HGA pointing to Venus or Earth			
ASPERA	Inertial		±1° all axes		Nadir or sun pointing required
PFS	Nadir	No sun in FOV	0.5 deg/nadir		No requirement, but 0.5 deg mechanism pointing said sufficient
SPICAM	Inertial (Star mode)		0.2 deg/inertial	0.04deg/1s, 0.1deg/2mn	Star mode
	Inertial (Sun mode)		0.1 deg/inertial	0.1 deg/2 mn	Sun (Limb) mode
	Nadir	15° away from sun	1 deg/nadir	0.1 deg/5 mn	Nadir mode
VENSIS	Nadir		Roll: 1 deg, Pitch: 2deg		

Power requirements

Worst case power demand in daylight		
User needs (W)	552	W
+ 3.3% Power Loss and 90% PCU efficiency	634	W
+ 10% system margin (W)	697	W

Earth vicinity



Around Venus

Worst case power demand in daylight		
User needs	578	W
+ 3.3% Power Loss and 90% PCU efficiency	664	W
+ 10% system margin	730	W

Worst case power demand in eclipse		
User needs	569	W
+ 3.3% Power Loss 90% BDR efficiency and 90% PCU efficiency	653	W
Time duration without Sun	4429	s
Battery DoD	52	%
Power for Battery charging incl. 90% BCR efficiency and 10% system margin	149	W

Satellite power budget

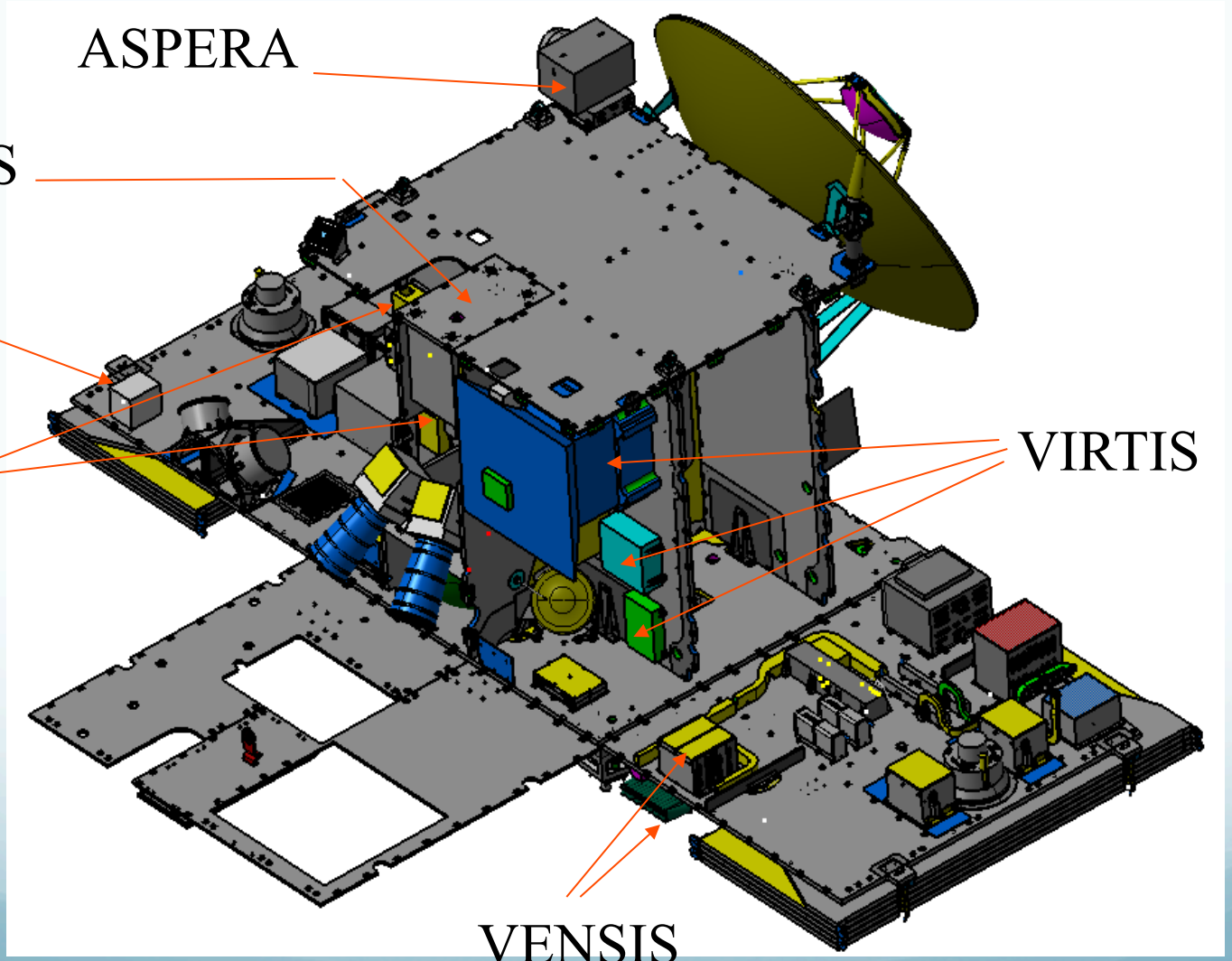
Power (W)	ASPERA	PFS	SPICAM	VeRA	VIRTIS	VENSIS	Total
Maximum (obs)	15	45	21	5	66	65	217
Stand-by (Comms)	15	11	0	5	50	18	99
Mean	15	18	2	5	50	20	110

Payload

Power (W)	Bus	Payload	Total
Observation/night	352	217	569
Comms	479	99	578

Satellite

Payload Accommodation



Payload mass budget

	ASPERA	PFS	SPICAM	VeRA	VIRTIS	Total	Total with VENSIS
Basic Mass (kg)	8.9	31.1	5	1.9	31.5	78	96
Current Mass with MEX or with5% margin (kg)	9.3	31.5	5.2	2.0	33.1	81	99

Model Philosophies

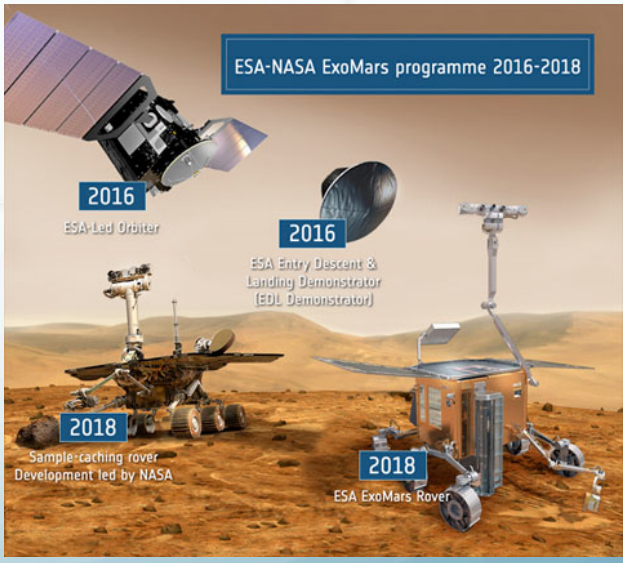
- The satellite Model philosophies are adapted to the Mars Express level of recurrence

Mission	Electrical & Functional Model	Structural Model	Proto-Flight model
Venus Express	NO	NO	YES
Cosmic DUNE	YES Payload early interface validation	NO	YES
SPOrt Express	YES Payload early interface validation	NO	YES Includes cryo-test at CSL

ExoMars P/L : a very complex story

ExoMars mission's scientific objectives as per SMP
To search for signs of past and present life on Mars;
To characterise the water/geochemical environment as a function of depth in the shallow subsurface;
To study the surface environment and identify hazards to future human missions;
To investigate the planet's surface, subsurface and deep interior to better understand the evolution and habitability of Mars.

PCR Evaluation Criteria
The evaluation criteria will be:
Elimination of duplication
Relevance of the instrument to address
the ExoMars scientific objectives
Technical assessment of maturity and flight feasibility
Compatibility with spacecraft/mission resources.
Financial affordability/feasibility within project schedule



Peer Review Process

All instrument will be reviewed for scientific merit by a panel of independent experts drawn from the international scientific community. All peers will utilise the same criteria for their evaluation, and all panel meetings will be conducted using identical review guidelines.

For every instrument, the peers will assign a score, which will be based on the instrument's relevance to the ExoMars science objectives and on its scientific merit. However, in their critique the panel is also requested to comment on the instrument's technical feasibility and level of readiness.

Technical assessment of each experiment will be provided by the ExoMars project office and by other ESA or external technical experts depending on necessities. The PRC will have the right to request further technical analysis when doubts need to be eliminated.

Duties of Reviewers

The reviewers are responsible for conducting the evaluation of the instruments. Their duties include:

Evaluate the instruments assigned to them by ESA, signalling promptly any potential conflict of interest.

Prepare a comprehensive (minimum 2 page) Review of each instrument, assigning scores and/or any other documentation as required by ESA.

Be prepared to discuss key points of their written review and scores with other panel members with the goal to arrive, as much as possible, to a consensus.

Be prepared to lead the presentation of an instrument to the panel to initiate discussions, as assigned by ESA.

Be prepared to write an Instrument Review Summary during the meeting, as assigned by ESA.

Provide feedback to other peers to write their Instrument Review Summaries.

Participate to the joint activities required to formulate a payload complement for the mission.

Evaluation Criteria

To arrive at the final assessment, the peers will consider:

a) ***"Search for life" and "hazard to humans" relevance:***

How and to what extent will the proposed instrument contribute to the search for past or present life on Mars?

How does the proposed instrument complement or enhance the results provided by other instruments?

Is the proposed instrument capable to provide an independent verification of the scientific outcome —positive or negative— derived from other instruments? If yes, from which and how?

Those few instruments that do not contribute directly to the search for life must, at least, be enabling instruments: instruments that increase the likelihood of obtaining the desired search for life information;

Does the proposed instrument address an important problem connected to life on Mars, or with surface hazards to future human missions?

EVALUATION CRITERIA CNTD

b) "Habitability" relevance:

Does the proposed instrument contribute to increase our knowledge of planetary evolution processes, either having taken place or presently on-going on Mars, that could have conditioned the planet's habitability?

c) Further Assessment Criteria

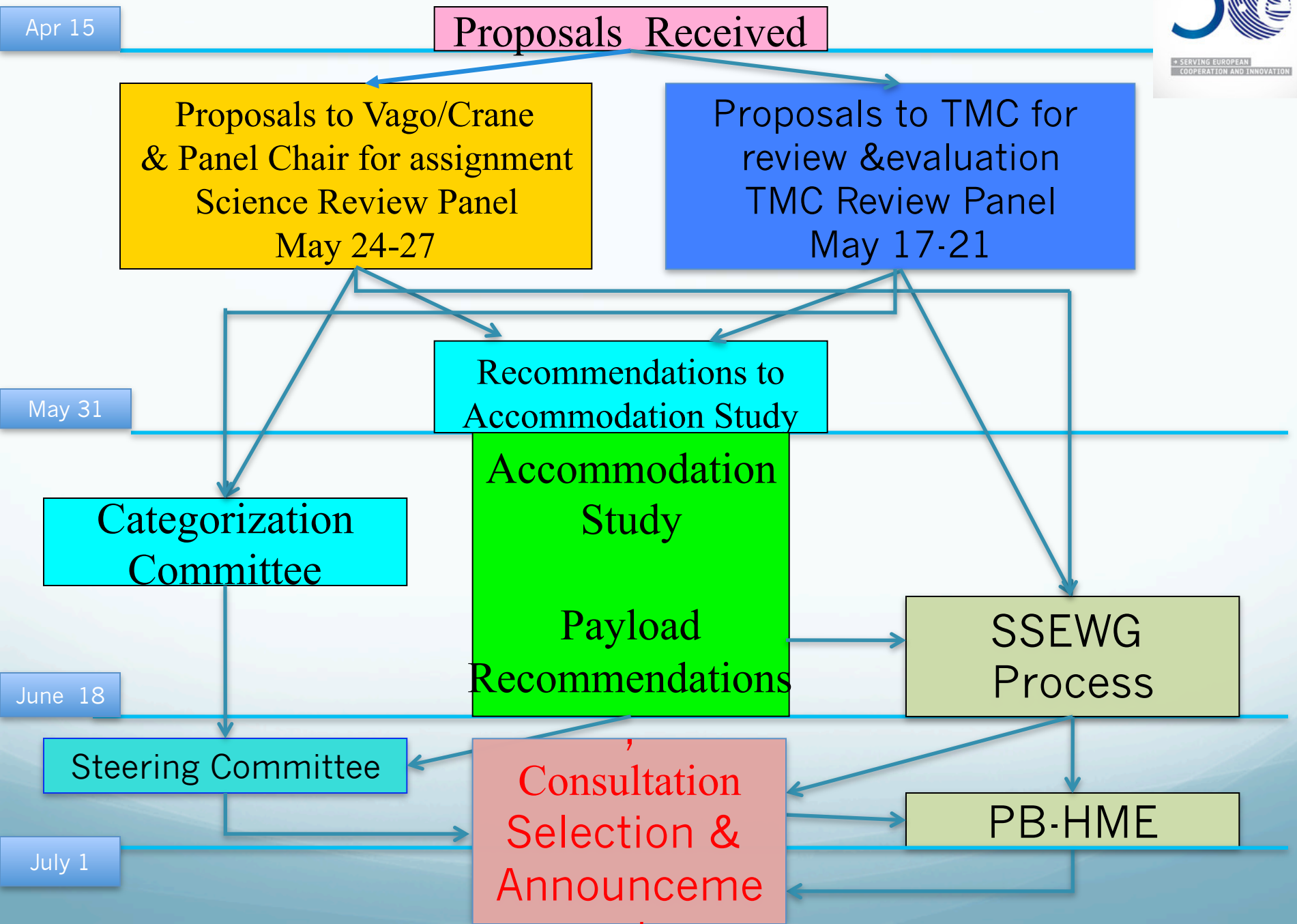
Does the team acknowledge potential problem areas (i.e. mass, volume, deployment)? If so, do they propose a sound plan to resolve them?

Is the proposed instrument / work method in line with best laboratory research practices worldwide?

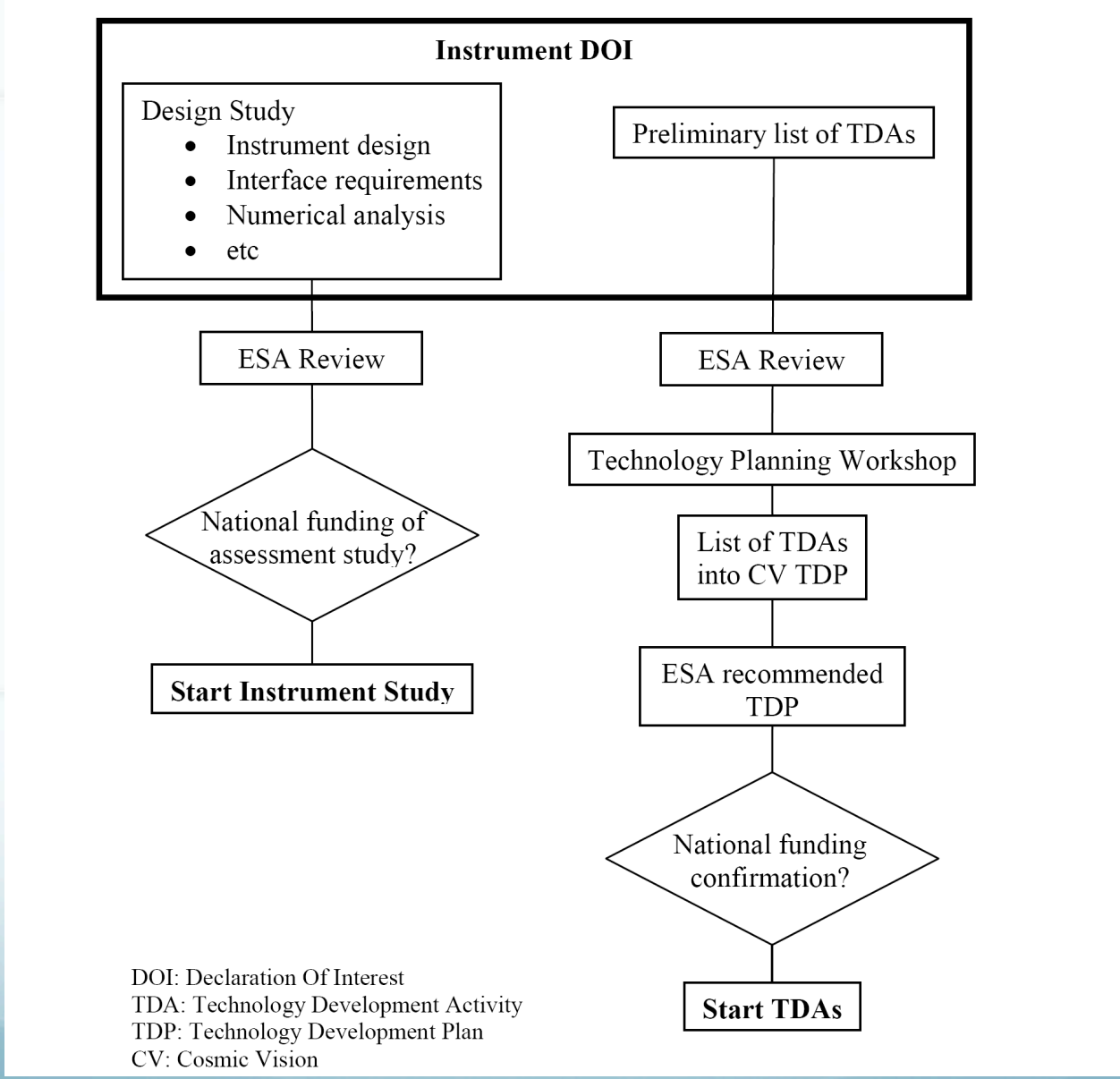
Questions the PCR had to answer

- Does the value of the proposed instrument's scientific output justify the required level of mission resources?
- Is there a significant gap in the knowledge of the team?
- Is the scientific team appropriately trained and well suited to carry out the work?
- Is the evidence of the personnel's productivity satisfactory?
- Are the functions and responsibilities of the Team Members adequately described and appropriate?
- Does the instrument project employ useful collaborative arrangements?

DRAFT Review Flow



Juice Instrument Assessment Studies



Conclusions

Selecting a P/L is a very complex process that involves:

Scientific understanding
Technical skills
Political awareness
Managerial capabilities

The P/L selection and its successive implementation requires continuous monitoring of totally different communities.

A ***Bad P/L*** kills a mission

The ***Best P/L***? Still to come!