JUICE AO Clarifications Meeting – Technical Questions & Answers

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System Team

1. System team provided input on this presentation
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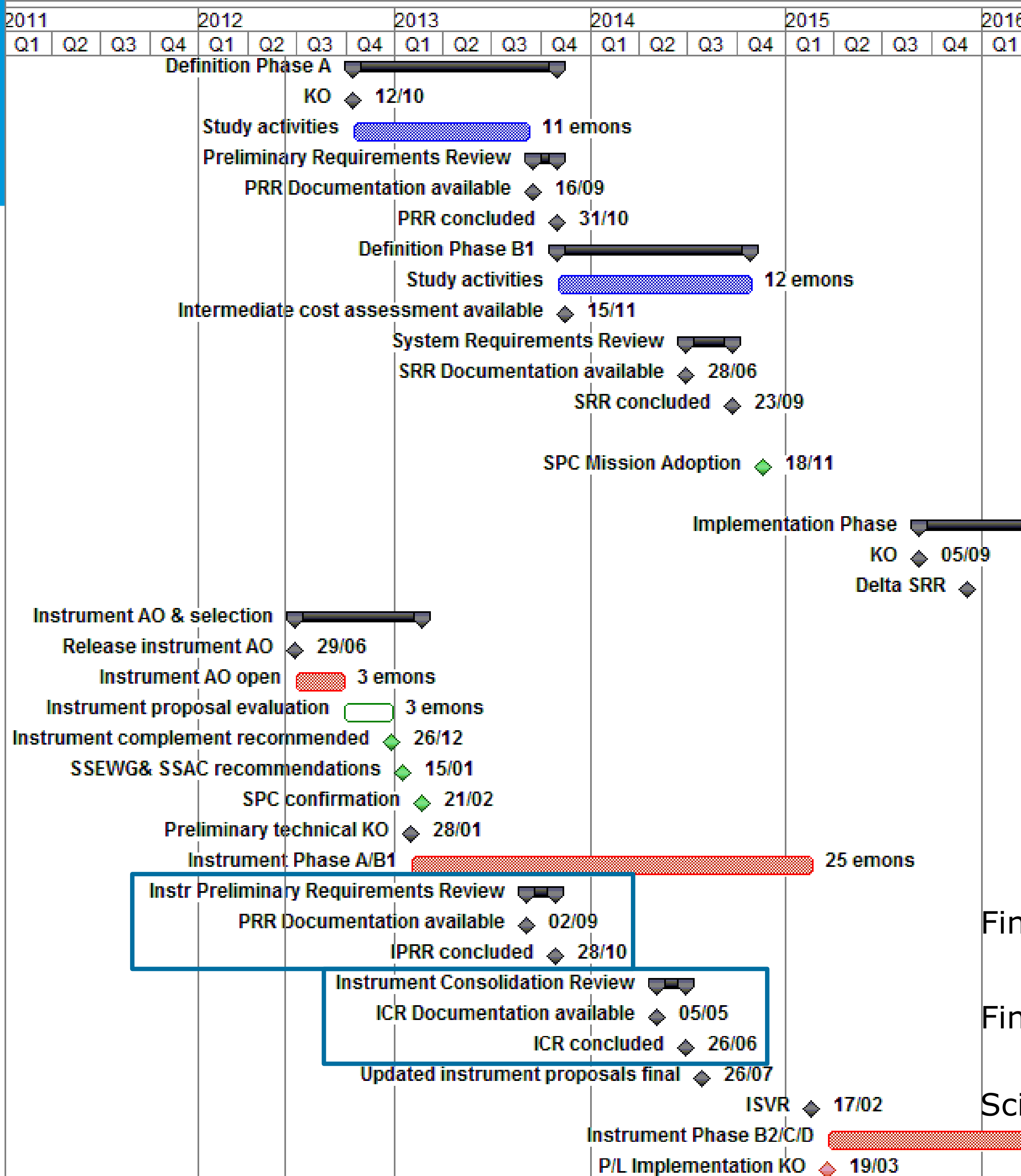
2. Questions should be sent to juice@rssd.esa.int

EID-A & EID-B

1. Documents are considered standard
2. At this stage most interface requirements (EID-A) are TBC and will be analysed up to PRR
3. PRR should serve as freezing most of the instrument interface requirements
4. Planned structure of requirements
    a. EID-A: all requirements from platform to payload
    b. SRD: all system requirements (including payload)
5. All interface specifications in the EID-B shall be substantiated by a preliminary design
6. Temporary appendix to the EID-B to serve for collecting the payload requirements at this stage (will be put into the SRD later, if agreed)
    a. All these requirements need to be justified (traceable to a performance with a corresponding budget at instrument level) – otherwise they will not be taken into consideration.
    b. All these requirements will be considered by the study team to perform a system analysis and derive requirements at SRD level and EID-A level.



Finalisation of interfaces

Finalisation of requirements

Science performance of design

Radiation Modelling

1. Detailed radiation simulations are needed
    a. 3d Monte Carlo simulations
    b. Simplified geometry model needs to be available
2. Report on star tracker analysis is made available as example in AO package (RP__00002033_C__D5)
3. A canonical geometry case will be distributed soon for GRAS and RestSIM (G. Santin)
4. Shielding mass and unit tolerance to be provided separately
    a. Is required as input to system optimisation
5. Please let us know, if you need support with setup of radiation transport simulations!

Additional Information on JUICE Trajectory

1. **Geometrical derived quantities have been computed from the JUICE trajectory**
2. **The table contains the following quantities for Jupiter, Europa, Ganymede and Callisto, with one hour time resolution**
   a. S/C Altitude
   b. Sub S/C Solar Elevation
   c. Sub S/C Local Time
   d. Sub S/C Latitude
   e. Sub S/C Longitude
   f. Target True Anomaly (around the body that the target is orbiting)
   g. Solar Longitude (LS)
   h. Target Distance
   i. Target Angular Diameter
   j. Target Solar Elongation
   k. Target Solar Phase Angle
   l. Velocity Angle (angle between S/C velocity and Nadir)
3. **The table is in CSV format and can be opened with Excel**
4. **The file is at ftp://juice:jupiter2022@sci2.esa.int/SOLab_juice_all_data_2030-2033_step_60min_v1.2.xlsx**

Questions and Answers Technical

Accommodation

Q: Spacecraft accommodation: Figure 3 of the EID-A document corresponds to one of the three spacecraft architectures studied by industries; others are different. Does Figure 3 indicate a favoured configuration for the spacecraft architecture ?

1. This figure does not correspond to a specific s/c configuration; it is only schematic.
2. The figure caption indicates that the information is TBC
3. There is no favoured s/c configuration
4. Its purpose is to describe a coordinate system

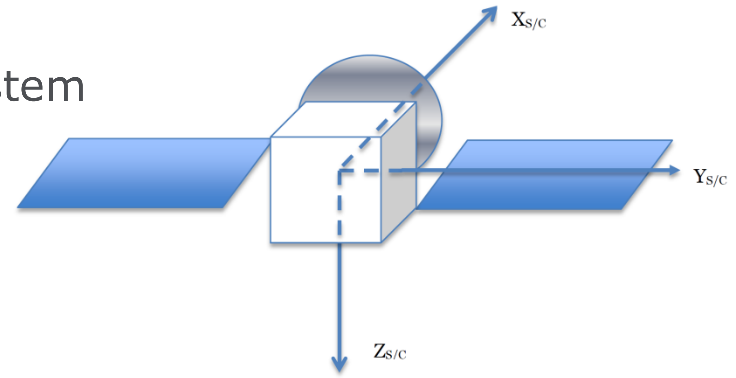


Figure 3 S/C Coordinate system (TBC).

Spacecraft Configuration & Instrument Accommodation

Q: At the time of the DOI studies, we were considering several configurations of the spacecraft with different possible allocation of the instruments.

a. What is the assumption now for the AO ?
b. Do we still consider the same possibilities ?
c. In particular, for the thermal design of the instrument, are there specific constraints or we are free to propose the most efficiency allocation ?

1. We suggest that the proposing team to provide the preferred interface description being optimised for their instrument.
2. Teams are not expected to propose for a specific location on the s/c. (Requirements toward the S/C have to be clearly given in appendix EID-B).
3. Several units or other additional h/w shall be described and the interface requirements be specified. This includes thermal requirements, where the interface shall be specified.

Radiation Shielding

Q: What is the status and assumption about the availability of a vault in the spacecraft ?

1. It is foreseen to optimize the shielding for the entire s/c, including instruments. It is not confirmed that a vault may be the best option.
2. The instrument teams are required to specify their radiation tolerance at unit level and the required shielding.
3. This will be then taken as input to the optimisation process. This optimisation will include radiation transport simulations with 3-d geometric mathematical models.
4. It is therefore essential that potential PI's provide such a model suitable for radiation transport simulations.

Radiation Modelling

Q: To what extent should or shall we model radiation doses in our instrument preliminary design in the proposal? At what development phase the reference to a report regarding the star trackers is applicable? The same is valid for charging processes.

1. Ideally a 3d model should be setup and the required shielding mass should be derived using this model
2. Shielding mass should be specified separately in the mass budget together with assumptions taken
3. The star tracker radiation report is not applicable, but was included for reference to provide an example and guidelines.
4. Typical case ("simple box") for GRAS and RestSIM will be provided asap

Shielding Definition

Q: EIDA-R003890 states 1mm Al equivalent S/C shielding for internal units at this phase. What shielding is available for external units, for preliminary calculations during the AO? The external units are mounted on the spacecraft body and, at least, one hemisphere is fully blocked

1. For external no further shielding shall be assumed.
2. It is however important that shielding mass be specified separately (including assumptions!)

Shielding Mass

Q: Shielding of internal units: The required amount of shielding mass at component level depends on the radiation environment outside the unit. Whereas the environment of protruding sensors can be derived from the radiation environment specification, the shielding around internal units such as electronics boxes is presently undefined. Is there a baseline Aluminium-equivalent thickness of shielding for internal units which should be assumed to define the spot shielding mass in the proposal, or which other procedures are foreseen during the proposal writing and evaluation phase to ensure fair comparisons between mass numbers of different proposals? **According to EIDA-R0010** The PI shall be responsible for the optimization of the local shielding inside each unit for those components sensitive to Total Ionisation Dose (TID) effects, assuming a uniform, spherical radiation shielding provided by the spacecraft of 1 mm equivalent Al (TBC). In that case how this 1 mm requirement is related to the shield mass in the s/c mass budget ?

1. Masses to be provided separately:
    a. Unit mass (including housing and spot shielding of sensitive components)
    b. Radiation shielding (shielding required in addition to 1 mm Al provided by the s/c)
2. Provide the radiation tolerance of the unit at the surface of its housing (i.e. inside the additional calculated radiation shielding outside the housing)
3. Spot shielding (local shielding for components) shall be included in the unit mass (without shielding)

Definition of Internal-/External Units

Q: Definition of internal/external unit given in EID-A to be clarified (e.g. for a remote sensing instrument)

1. Protruding equipment needs to be specified (for remote sensing instruments this is typically optics & baffles) and radiation exposure and charging shall be assessed

Mass Contingency & Margin

Q: How are the percent mass and power contingency and margin to be calculated? For instance, in EID-A, R00560, we are required to have 25% mass margin at SRR. If we have an instrument with a basic mass (CBE) of 10 kg. Assuming it was a all just minor modification of previous designs, we would need to have a contingency of 10%. Is that 1 kg more (10% of basic mass of 10 kg) or 1.11 kg (10% of nominal mass, which is basic plus contingency)? Similarly, if my nominal mass is 11 kg, and I am required to have 25% margin, is that 25% of the nominal mass or 25% of the total mass? On previous missions I have seen the margins calculated both ways, so it is not clear what is required here. A detailed example would be helpful.

Q: Can you clarify mass requirements regarding bookkeeping of margin and contingency in the EID and the Q&A response?

Mass & Mass Margins – An Example

Example Units	Basic Mass	Maturity contingency	Nominal Mass
Off the shelf unit very mature	5	8% (>5%)	5.4
Off the shelf + modifications	5	13% (>10%)	5.65
New design	5	27% (>20%)	6.35
Total	**15**		**17.4**
Allocated mass			23.2
Mass margin			**25%**

- For proposals the Allocated Mass = Proposed Mass:
  Proposed Mass = Nominal Mass / (1-0.25)
- We need 25% margin even for existing instruments (copy from previous mission), to account for several unknowns: location, interfaces (mechanical, thermal, electric, etc)
- MPDD masses are Nominal Masses

Physical Properties – Volume

Q: Is there a volume envelope requirement? (There's one in the MPDD but that's now a reference document and doesn't impose requirements.)

1. No, the shape should however be optimised
2. Volume is constrained by mass (also shielding mass!)
3. Obviously extreme volumes/shapes would be difficult to accommodate

Spacecraft pointing

Q: Stereo capability for cameras: is this capability guaranteed by S/C off-pointing during multiple passage or spot pointing during fly-bys? In other words, can we exclude autonomous pointing capability for the cameras?

a. Hard for several regions during flyby
b. Coordination with other instruments

Q: S/C Pointing performances: we would like to clarify some issues related to the pointing knowledge and also the relative pointing error on long time scale (about one second)

Q: Specification of spacecraft stability when not in Ganymede orbit. How stable is the spacecraft when viewing a remote target (e.g. a star) when in Jupiter orbit?

Spacecraft pointing

1. The spacecraft has the following pointing performance/knowledge, for both nadir(-like) and celestial pointing

EIDA-R00440 *The PI shall ensure that the instrument performances are compatible with the spacecraft performances given in Table 8:*

Quantity	Value (at 95% confidence)
APE	20 arcsec (TBC)
AKE	10 arcsec (TBC)
RPE	1 arcsec over 1.6 msec (TBC) 3.3 arcsec over 16 msec (TBC) 10 arcsec over 500 msec (TBC)

Table 8 Pointing performances of the JUICE spacecraft

Thermal Interface

Q: Reason of quite large range for thermal I/F also for internal instruments; are these values linked to specific mission phases?

1. The thermal interfaces are not linked to specific mission phases
2. The cold case refers to the science mission phase in the Jovian system.
3. Since the power and therefore heating are restricted in this phase a lower temperature has been set for the cold case.
4. If an instrument or subsystem can not accept this requirement, this shall be identified with a proper proposed solution. (also please keep in mind that this range is TBC and may be updated during s/c definition in the next phase).

Data Rate & TM Allocations

Q: Can you confirm the specified (and severely limiting) telemetry rate for streaming from DPU to SSR via Spacewire?

Q: Question on TM allocation What are the telemetry allocations in EID-A R00530 Table 16? Specifically, are these the communications rates allowed between the instrument and the SSR? The description says telemetry allocations, but this can not be the case, since the NAC would use the total 1.4 Gbit/day downlink in just 280 seconds.

1. Table 16 shows the maximum instantaneous (peak) data rate that each instrument can send to the mass memory; i.e. if an instrument processes data and sends it in a periodic "burst", this is the maximum rate (for example, sending 1 Mbit of data in 0.2s = rate of 5 Mbps during the 0.2s). This does not have any connection to the total data volume that will be downlinked to ground: the allocation between instruments is TBD.
2. The instrument teams are requested to provide the maximum (peak) data rate to the SSR in their proposal.
3. Remember: the total data volume is limited by the downlink capability

Data Rate UVIS

Q: In the MPDD, table on page 14 it states 30kb/s for the UV imaging spectrometer. On page 111 however it states 30kbytes/s. Which is the correct number?

1. The UVIS in the PDD has two modes resulting in different data rates: the spectroscopy mode produces the lower rate (30 kb/s), whereas the imaging spectroscopy mode may produce up to 300 kb/s. This is however the maximum datarate the instrument produces and has no link to the overall data per day expected in the mission. The table at the beginning only lists the rate related to spectroscopy.

Fault Tolerance & Single Point Failures

1. Questions on the fault tolerance
   a. The requirements dealing with fault tolerance in sections 4.1.5 and 4.1.6 of EID-A (see below) are confusing. In all of our previous instruments, there were always a number of single point failures, because there are never enough resources to build completely redundant hardware. It appears from the requirements for JUICE, however, that the hardware must not only be tolerant of single point failures, but also some dual failures (that could affect interfaces). How should we handle this?
2. *From EID-A 4.1.5 Single Point Failure*
   a. EIDA-R00120 *: The instrument design shall avoid, unless agreed with the JUICE project office, single point failure. If single point failures are part of the design, this shall be clearly identified along with the likelihood of failure and any strategies to mitigate the failure.*
3. *From EID-A 4.1.6 Fault Tolerance*
   a. EIDA-R00130 *The PI shall ensure that no single instrument failure or single operator error shall have level 1 or level 2 effect severity as defined in EIDA-R006810*
   b. EIDA-R00140 *The PI shall ensure that no combination of:*
      – *two independent instrument failures,*
      – *an instrument failure and an operator error, or*
      – *two independent operator errors.*

      Shall have level 1 effect severity as defined in EIDA-R006810 ?
   c. EIDA-R006810 *The following Failure Effect Severity Categories shall be used in the FMEA:*
      – *Level 1: - Propagation of failure to other subsystems / assemblies / equipment*
      – *Level 2: - Complete Loss of functionality*
      – *Level 3: - Degradation of functionality*
      – *Level 4: - Any other effect.*

Fault Tolerance & Single Point Failures

Q: Can you clarify the requirement of no single-point failures?

1. Single Point Failures are tolerated in the design
2. SPF's need to be identified and agreed with the ESA project office including –
    a. description of the SPF
    b. likelihood of failure
    c. impact & mitigation strategy wrt other subsystems.
3. Failure isolation shall protect against Level 1 effects (EIDA-R00140)

STM Build Standard

Q: EID-A p137 EIDA-R005620: The PI shall ensure that the instrument STM units have the following build standard … representative for mass, CoG, first Eigen-frequency, interface mounting
The requirement to deliver an STM which has a representative first Eigen-frequency is extremely difficult, unless a FM exists already which has been characterized by vibration testing. Even then it is difficult. The requirements needs to be rewritten.

1. EIDa-R00870: all fundamental resonance frequencies >120 Hz (TBC) for each unit
2. If this is satisfied, the STM need not be representative; merely **at least** 120 Hz.
3. If any unit has a **lower** first frequency, this must be declared and the STM must be representative in Eigenfrequency.

Approved Materials List

Q: Approved materials list – Will there be an ESA specific set of guidelines for material selection for JUICE, given the high radiation dose, and if so, when will this set of guidelines be available?

1. No this is not foreseen
2. We have a few technical activities addressing material properties in the JUICE environment. The results will be shared when available.

Coordinated Parts Procurement

Q: Common parts procurement: Does ESA expect a common parts procurement for JUICE instruments?

1. A coordinated parts procurement is planned for platform and instruments.
2. There are no specific provisions foreseen for "common parts for instruments"

Schedule

Q: What is the project schedule? I did not see anything that specified when hardware must be delivered, when I&T must be supported, etc.

1. Please refer to EID-A sections 9.3 & 9.4
2. Note that all dates for the Implementation Phase are TBC and will be established during the Definition Phase

Schedule & Input for IPRR

Q: Programme from selection to IPRR – The EID-A shows the IPRR in Sept 2013, 7 months after SPC selection. In our experience funding will not be available until up to 3 months after selection. The EID-A specifies a large number of detailed design documents to be delivered at IPRR. On this basis the design maturity will be very low at IPRR. Can ESA please provide guidance on how to deal with this?

1. This schedule was put on the assumption that DOI activities were in place and therefore some enhanced maturity be available
2. The proposal documentation shall be in good quality

Schedule – Delivery Dates

Q: EID-A p209 reads "The PI shall deliver, in line with the baselined instrument model philosophy, the following models, by the following deadlines - (Proto) Flight Model, (P)FM: Date: Nov. 2018-Nov. 2019 (TBC)

The period one year seems too long (normally 3 months), putting it in the schedule will affect the whole development schedule.

1. The period foresees a staggered delivery of payload instruments.
2. PI teams should plan for the beginning of this period

Document References & Numbering System

Q: The currently proposed document reference scheme (JUI-EST-SYS-PR-001_i1.1_document_configuration) has one major flaw which would make our book keeping unnecessarily difficult.
Our situation: we are several institutes working in parallel on the same project. We may have industrial partners on board who also will have to prepare project documents. Currently, there are two possible solutions foreseen in JUI-EST-SYS-PR-001_i1.1_document_configuration:

a. Each institute and industry uses their own originator and ensures that document numbers for each document type are unique and sequential. Problem: most institutes and companies are involved with more than one JUICE project, and the project teams do often NOT share a common book keeping.
b. Each instrument may get assigned their own originator code, like PEP for PEP. In order to ensure unique and sequential document numbering, one central person/database would have to assign document references to all institutes and industrial partners. This is not practical.

Q: We propose to extent ESA's proposed document reference system as such:

a. *There should be TWO additional leading digits in front of the already foreseen 3 digits. The meaning of these two digits can be defined by each instrument team, for example such that whole blocks of free references are given to one institute or company, who can assign individual numbers inside their block independently. This would ensure that - all 5-digit combinations are unique (and thus is the document reference)*
b. *the first two denote the document block that was assigned to one author, company, institute, unit, project phase, whatever*
c. *the last 3 digits are sequential*

Document References & Numbering System – Response

1. Yes we agree with the suggestion of adding additional digits to the reference number, if needed
    a. This would allow for independence of configuration control
2. Other options could also be considered – we could discuss this after the AO