THE THESEUS "YELLOW BOOK"

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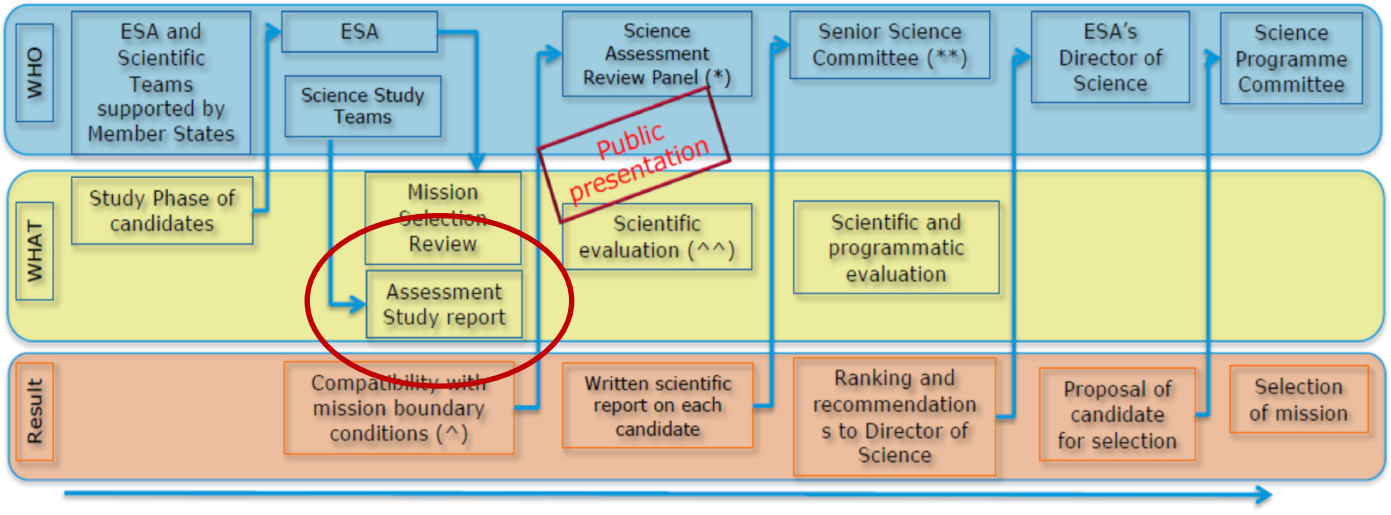
On behalf of the THESEUS Yellow Book Editorial Board (TEB)

3 June 2020

Main task: science sections of «Yellow Book»

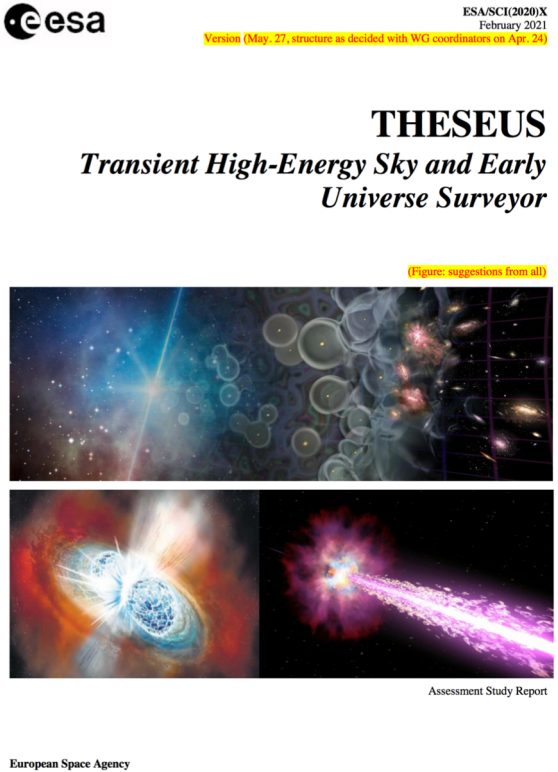
M5 Mission – selection process



(*) From Advisory Working Groups (exclusion of strongly conflicted members) + additional experts
(**) From Space Science Advisory Committee (exclusion of strongly conflicted members) + experts
(^) Including financial envelope, TRL of mission elements and readiness of Funding Agencies to fund mission elements proposed not to be under ESA's responsibility
(^^) Including demonstrated capability to obtain the scientific objectives declared at the time of candidate selection

cf. McNamara's presentation

“Yellow Book” (YB)



- At MSR, the THESEUS Science Study Team must submit an **Assessment Study Report** (a.k.a. *“Yellow Book”*)
- ESA Document, public (even if not selected!)
  - Main Editor is the Study Scientist (me)
  - Content is primary responsibility of the Consortium/Science Community
- Aiming at describing (primarily) the science, as well as various aspects of the mission implementation (see next slide)
- To be ready by **15 January 2021**.

ESA Template (ESAT) versus examples

	Science case	Req.ts	Payload	Mission design	Ope.ns	Man.nt	Com.on
ESAT	38%	11%	16%	16%	11%	5%	2%
LOFT	43%	13%	17%	11%	10%	5%	1%
XIPE	42%	12%	18%	11%	12%	5%	1%
ARIEL	**44%**	**12%**	**14%**	**14%**	**8%**	**5%**	**2%**

YB Table of Content

For comparison, in the proposal:
10 pages for the **science case**
5 pages for the **requirements**

Table of contents

Science objectives: ≤35 pages

Science requirements: ≤10 pages

Payload: ≤15 pages

Mission design: ≤15 pages

Operations and Ground Segment: ≤10 pages

Management: ≤5 pages

Communication & Outreach: ≤2 pages

Scientific priorities already embedded in the YB

Chapters mostly empty. However, scientific priorities already sketched

2.2 Exploring the Early Universe with GRBs (Tanvir, 10 pages)

NOTE: This section should include Theseus contribution to long GRB physics and progenitors, as well as a subsection on the Theseus GRB population model

p1.1 Define as best as possible the expected advancements in the next decade and identify the areas where high-z GRBs will provide most relevant contribution (unique measurements, complementarity and synergy with measurement with other facilities);

p1.2 Quantify as best as possible the accuracy in the measurement of key physical parameters of the early Universe (SFR, metallicity evolution, faint-end of primordial galaxies luminosity function, key parameters for re-ionization like UV escape fraction and ro_{ion}, identification of Pop-III stars) between the number of GRBs at $z > 6$ detected, localized and with measured z by Theseus (current requirement of >50 GRBs at $z>6$ needs to be better justified).

p1.3 Assess the scientific return of Theseus for early universe science as a function of the fraction of the 50 GRBs at $z>6$ for which it will be possible to perform also on-board "High-resolution" spectroscopy and/or follow-up from the ground with very large telescopes of the future like ELT or TMT (very high-z GRBs, e.g. at $z>8$) or large telescopes like VLT (high-z GRBs, e.g. at $6<z<8$). For instance, assess scientific return of: a) no high-resolution spectroscopy; b) IRT high-resolution spectroscopy for 1/3, 1/2 and 2/3 of $z>6$ GRBs; c) sensitive by follow-up by on-ground large / very large telescopes for 1/3, 1/2 and 2/3 of $z>6$ GRBs.

p1.4 Further assess the possibility of identifying GRBs produced by pop-III stars through peculiar properties (especially, very long duration) of their prompt emission (and possibly early afterglow).

Additional points to exploit:

- What more can we learn from abundances in afterglow studies (early chemical enrichment)
- Line variability (absorption lines)
- Determination of the IGM neutral fraction – how often can we get sufficiently good measurements telling us about the evolution of reionization
- Looking for accompanying SNe that could be associated to Pop-III stars

2.4 Further insights on the time-domain Universe (Osborne, 4 pages)

p3.1 Identification of the classes of X-ray transients and variable sources to the study of which theseus is expected to provide a relevant contribution at the beginning of the '30s (accounting for expected progress in the next decade)

p3.2 Expected SXI (and, possibly, XGIS) yearly detection rates for these classes of sources for the two reference pointing strategies to which the exposure maps included in the scientific simulation tools refer (possibly, also investigate an optimal pointing strategy for every class of sources of interest)

p3.3 For the classes of transients / variables of interest, assess the relevance and uniqueness of spectral and timing measurements by SXI (and possibly XGIS), as well as possible NIR characterization and redshift measurement with IRT. In particular, it is important to identify those cases for which, based on the on board real time analysis of SXI ad XGIS data, it will be possible to recognize the class of transient (eg., TDE, SGR, AGN flare, …) and request the slew for a prompt observation with IRT (X/gamma-ray characteristics allowing transient identification, as well as the actual need of a prompt IRT observation, need to be assessed).

Additional points:

- Argument to make to persuade readers of the unique science of THESEUS after eROSITA, Einstein Probe and – if approved – GAMOW Explorer
- Synergistic usage of high-energy monitors and IR
- Table of detection rates in the Proposal needs to be included in the YB and revised/consolidated
- Try to predict science in the 2030s (hard)

2.6 Synergies with the large facilities of the '30s (Rosati, 4 pages)

p5.1 For future facilities that operate at other wavelengths and will likely start observing a few years before Theseus: a) quantify at best the expected progress that they will provide without Theseus in the fields relevant to the core science of our mission (e.g., early Universe studies with JWST, SKA, ELT; transients and multi-messenger astrophysics with CTA); b) quantify and emphasize their need of a GRB and transient machine like Theseus for fully accomplishing their core science.

p5.2 Synergies with ESA L2 and L3 missions, with a timeline similar to Theseus, is of high importance: for Athena, a restricted WG is already at work in collaboration with the Athena science study team, for preparing a dedicated session of the Athena synergies white paper. Synergy with Athena for both early universe science (eg., pop III stars, WHIM, …) and multi-messenger astrophysics need to be emphasized as much as possible. Possible synergies of Theseus with LISA need to be deeply investigated, also exploiting the investigations done for the Athena – LISA synergy.

p5.3 Reliability and expected dedicated observing time, of follow-up observations by large facilities like ELT, SKA, CTA, etc. need to be supported and clarified at best;

p5.4 Assess at best the programmatic status of updated second generation, and new third generation (ET, CE) GW facilities, in order to have a reliable picture of the timelines and overlapping with Theseus operations; clarify the relevance / need of TOO observations by Theseus for fully exploiting the synergies.

p5.5 Same as above for neutrino detectors

Additional points:

- Priority: Athena, ELT, SKA
- Figures with specific simulations of MICADO and HARMONI NIR of M~27-28 sources at z~5
- Figure with high-resolution second-generation ELT/HIRES instrument …
- SKA: 21cm absorption forest, small-scale structure of the IGM; cross-correlate GRB host galaxy with hot bubbles in HI maps; Physics with GRB radio afterglows (N.B.: Ghirlanda looked at radio emission with SKA)

THESEUS YB Editorial Board (TEB)

- The TSST has appointed an **Editorial Board** for the YB
  - Lorenzo Amati (co-Chair), Andrew Blain, Enrico Bozzo, Diego Götz, Matteo Guainazzi (co-Chair), Sandro Mereghetti, Paul O'Brien, Julian Osborne, Piero Rosati, Giulia Stratta, Nial Tanvir
- The members of the TEB are responsible for:
  - Collect and edit inputs for one/more sections of the YB
  - Participate in the revision/review of each major version of the YB
  - Present the content of the YB at meetings like this
- A dense calendar of deadlines and TEB meetings (6+2) has been set-up
- The TSST and an external review panel (to-be-appointed) will also review the YB
- First submission: **15 January 2021**; final submission: **15 February 2021**

YB preparation schedule

- ≤24 July 2020: deadline for the inputs on Sect.2 and Sect.3 by the SWGs
- ≤18 September 2020: first draft of Sect.2 and Sect. 3 by the TEB
- ≤16 October 2020 (TSST#5): TSST review of the draft Sect.2 and Sect.3
    - Comments sent to the SWGs
- ≤30 October 2020: deadline for the inputs on the other sections
- ≤30 October 2020: revised version of Sect.2 and Sect.3 by the SWGs
- ≤20 November 2020: first complete draft of the YB by the TEB
- ≤11 December 2020: Review of the YB by an external advisory panel
- ≤11 December 2020 (TSST#6): TSST review of the complete YB draft
- 21-23 December 2020/11-12 January 2021: physical meeting of the TEB
- ≤15 January 2020: YB first submission

General guidelines to present THESEUS science

- The Yellow Book **shall be based on the THESEUS SciRD**
  - Available from the THESEUS web portal. Reference in case of doubts
  - Last scientifically-relevant trade-offs are being evaluated by the TSST
  - Ultimate THESEUS configuration for the YB known by June 2020
- Alternative pointing strategies are consistent with the Mission
  - Contributors may consider the impact of different strategies
  - The TEB/TSST will ensure that they are presented in a self-consistent way
- Stress the unique contribution(s) that THESEUS can bring to your field
- Do not bother of the formatting of your contribution (the TEB will do for you)
- Use Word, no LATEX (ESA rules) – High-quality graphical products are key!