ESA's Gravitational Observatory Advisory Team (GOAT)

Robin Stebbins, GSFC

Presentation to the Astrophysics Subcommittee

Telecon, 21 July 2015

Topics

- Basics
  - Terms of Reference (Charge)
  - Membership
  - Term and Meetings
- Activities
  - Alternate technical approaches
  - Technology development
  - Schedule
  - Scientific performance
- Products
  - Internal documents
  - Intermediate report (15 June 2015)
- Future activities

The Basics: Terms of Reference, Membership, Meetings

Terms of Reference

"To evaluate and recommend on possible scientific and technical approaches for a gravitational wave observatory envisaged for a planned launch date in 2034."

- The objectives of the committee are:
  - To identify promising technologies for the detection of gravitational waves from space and their use as 'astrophysical messengers' in the context of L3;
  - To recommend on the technological activities and milestones needed to develop and eventually choose between the most promising technologies;
  - To identify possible scientific and technological milestones that should be achieved (either by ESA or independently) and the relevant decisions linked to these milestones;
  - To engage with the gravitational wave scientific community to ensure that the most recent information and promising approach are considered.

Membership

- Michael Perryman (University College Dublin), Chair
- Pierre Binetruy (AstroParticule et Cosmologie, Paris)
- Philippe Bouyer (Laboratoire Photonique, Numérique et Nanosciences (LP2N)
- Michael Cruise (University of Birmingham)
- Reinhard Genzel (Max Planck Institüte für Extraterrestrische Physik, Munich)
- Mark Kasevich (Stanford University)
- William Klipstein (Jet Propulsion Laboratory)
- Guido Müller (University of Florida)
- Benard Schutz (Albert Einstein Institute, Golm and University of Cardiff)
- Stefano Vitale (Universitá degli Studi di Trento)
- Observers
  - Masaki Ando (JAXA)
  - Robin Stebbins (NASA)
- ESA support
  - Luigi Cacciapuoti
  - Fabio Favata
  - Martin Gehler
  - Oliver Jennrich
  - Frédéric Safa

Meetings and Term

- Meetings to date
  - Kick-off telecon – 26 September 2014
  - GOAT #1 – 14-15 October 2014, ESA Headquarters, Paris
  - GOAT #2 – 8-9 December 2014, ESA Headquarters, Paris
  - GOAT #3 – 25-26 March 2015, ESA Headquarters, Paris
  - GOAT #4 – 1-2 June 2015, ESA Headquarters, Paris
- Scheduled future meetings
  - GOAT #5 – 16-17 September 2015, ESTEC, Noordwijk NL
  - GOAT #6 – 15-16 December 2015, ESA Headquarters, Paris
- Term
  - Mid 2016 with report on LISA Pathfinder

GOAT Activities

Initial Range of Activities

- Technical feasibility: are there fundamental issues
- Science goals: configuration trade-off
- Data analysis: Are there risks/problems?
- System view
- Technology: Laser vs atom interferometry, immature items
- Partners
- Cost: recurring costs, descope options
- Schedule: establish a consolidated timeline

Reported Activities (1/4)

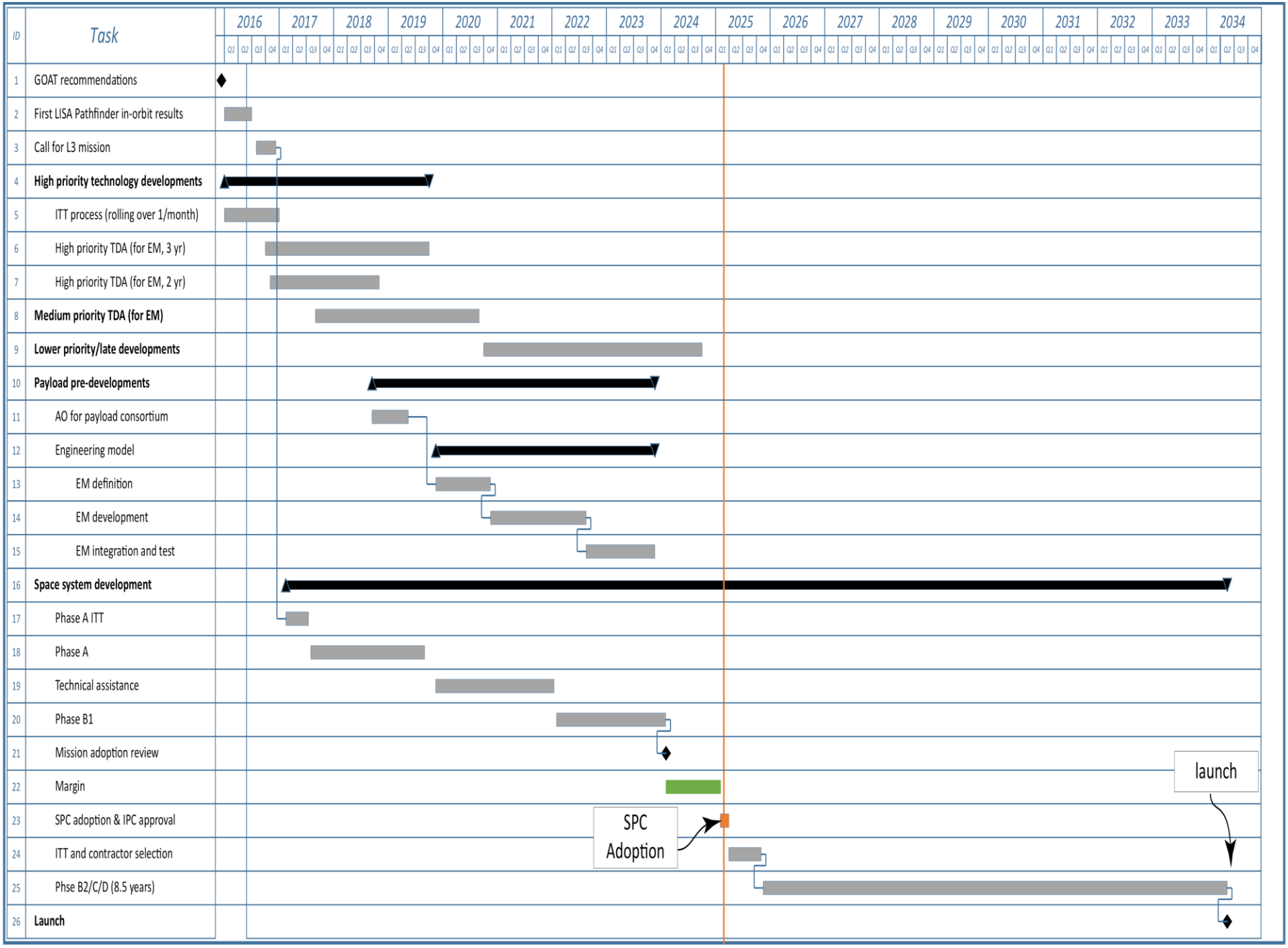
- Science objectives
  - Compiled an expanded statement of target science
- Detection technologies
  - Compiled a long list from the literature
  - Only 2 detection technologies address the science recommended by the Senior Selection Committee
  - Laser interferometry responds to the science goals set out in the 2013 report of the Senior Science Committee, and is sufficiently well advanced to offer a realistic prospect of implementation according to the 2034 launch schedule.
  - Committee is still seeking a full mission proposal based on atom interferometry.

Reported Activities (2/4)

- Scientific performance trade-off: assess the science that can be performed with a particular architecture.
  - 24 mission configurations
    - 2 or 3 measurement arms
    - 2 or 5 years of science observations
    - LISA or 10X worse/LISA Pathfinder low frequency acceleration noise
    - 1, 2 or 5 million kilometer arm lengths
  - Performed by European researchers, with some input from US colleagues
- Data analysis
  - No fundamental or conceptual issues with the data analysis. Recommend renewed effort, in part, because of impact on mission design

Reported Activities (3/4)

- Technology development
  - Compiled all required technology developments
  - Technology challenges are significant, but should not be overstated. LPF will retire many of the space-specific risks.
  - Recommend four high priority technology development activities for immediate start
- Cost
  - European cost studies suggest a budget of 1.0-1.2 B€, only weakly dependent on system architecture.
- Schedule (next chart)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1 GOAT recommendations
2 First LISA Pathfinder in-orbit results
3 Call for L3 mission
4 High priority technology developments
5 ITT process (rolling over 1/month)
6 High priority TDA (for EM, 3 yr)
7 High priority TDA (for EM, 2 yr)
8 Medium priority TDA (for EM)
9 Lower priority/late developments
10 Payload pre-developments
11 AO for payload consortium
12 Engineering model
13 EM definition
14 EM development
15 EM integration and test
16 Space system development
17 Phase A ITT
18 Phase A
19 Technical assistance
20 Phase B1
21 Mission adoption review
22 Margin
23 SPC adoption & IPC approval
24 ITT and contractor selection
25 Phse B2/C/D (8.5 years)
26 Launch
SPC Adoption
launch

GOAT Products

- Internal documents
  - Scientific trade-off report
  - Technology development spreadsheet
  - List of detection technologies
  - Propulsion technologies summary
- Intermediate GOAT report
  - Public document, released 15 June 2015
  - Distributed to ESA advisory structure and the Science Programme Committee
  - Major findings summarized in previous 4 charts
  - Used to notify European national agencies that “expressions of interest” in the mission will be sought by ESA Headquarters at the “end of the summer.”

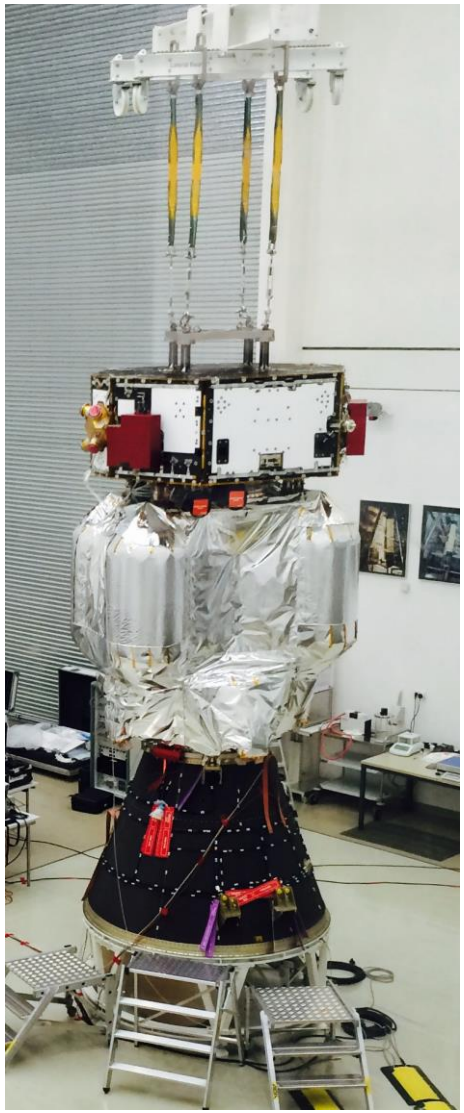
Future GOAT Activities

- Complete assessment of scientific performance as a function of mission configuration
- Formulating some considerations on configuration choices to balance cost and scientific performance
- Advancing the definition and scope of the Payload Engineering Model
- Assessing the technical and scientific risks of LPF
- Summarizing the technologies validated by LPF
- Detailing any fundamental risks associated with gravitational wave detection
- Reviewing the prospects and status of atom interferometry
- Responding to specific requests on costing from ESA Executive or its advisory committees

Status of LISA Pathfinder (1/2)

- Launch date
  - Official launch contract puts launch between 15 November and 14 December 2015
  - Target day to be determined in mid-August. November 26th is favored.
- Spacecraft/payload/propulsion module/launch adaptor integration complete.
- On schedule to pack for shipping to launch site (Kourou) on August 18th
- Expect to store for 6 weeks
- Operations should start at the end of January 2016.

Status of LISA Pathfinder (2/2)



Summary

GOAT has made significant progress on several topics.

- Laser interferometry is the only detection technology shown to be viable, but the search isn't over.
- Science trade-offs have been investigated.
- Technology recommendations enable ESA and the member states to start investments as early as the end of the year.
- No fundamental technical obstacles found, in either technology or data analysis.
- A preliminary schedule has been developed, but remains under study.
- The concept of an engineering payload model remains problematic.