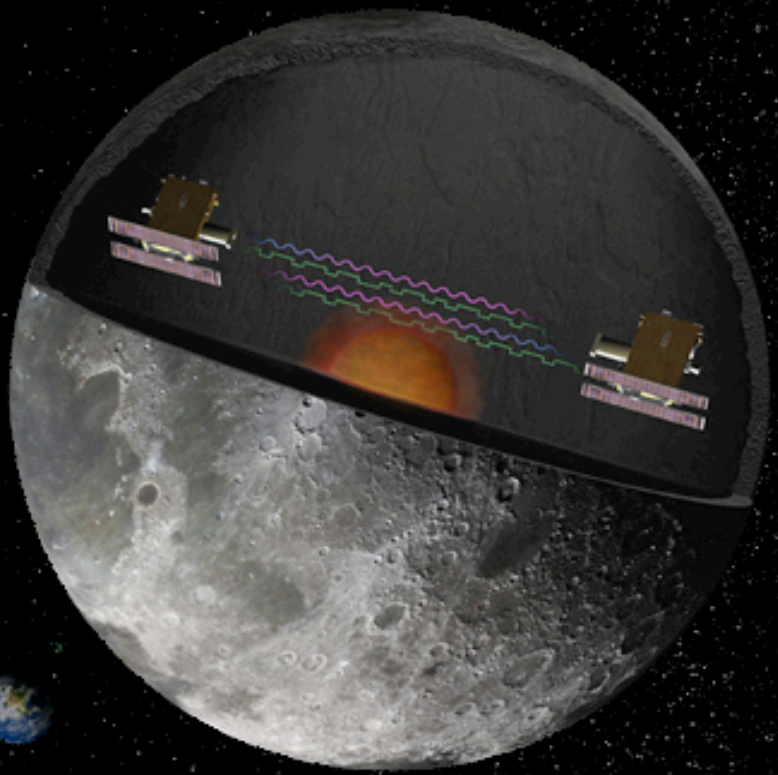


GRAIL Discovery Mission

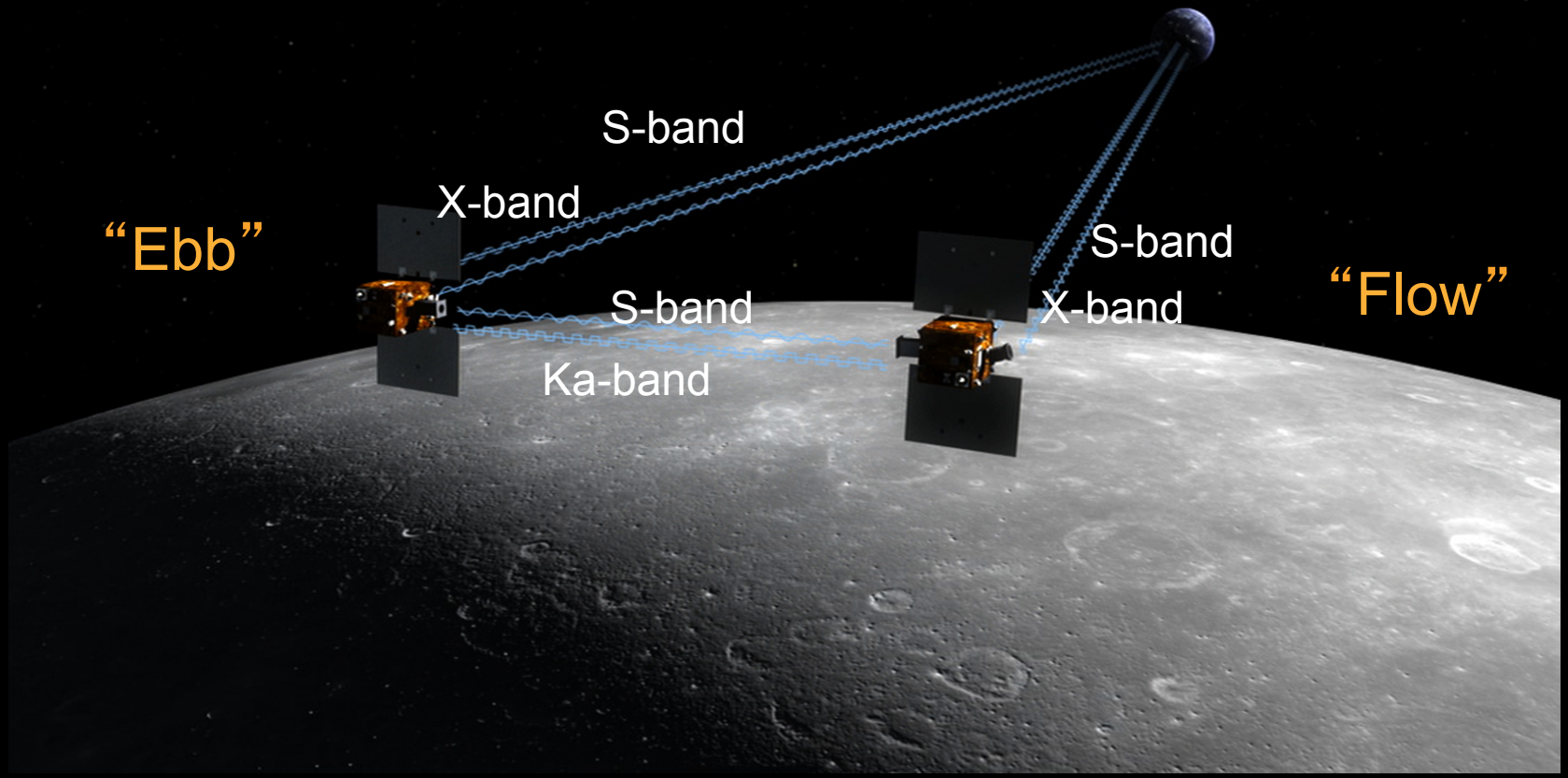
Launched: Sept 10, 2011

Lunar orbit Insertion:
31/12/11, 1/1/13

Impacted: Dec 17, 2012

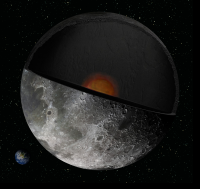
Principal Investigator: Maria Zuber, MIT

Gravity Recovery and Interior Laboratory (GRAIL)



GRAIL is a 2-spacecraft mission that senses the Moon's gravity field by measuring the change in distance between 2 spacecraft 60 to 225 km apart in the same ~55 km altitude orbit for a period of ~3 months. The Extended Mission added ~3 months of mapping at 25-75 km distance @ an average altitude of 23 km. The Endgame added 10 days of mapping @ an average altitude of 11 km.

NASA/MIT/JPL/GRAIL



GRAIL's Measurement Requirements

Primary Mission measurement requirements:

Science Objective	Science Investigation	Area (10^6 km^2)	Resolution (km)	Requirements (30-km block)
Determine the structure of the lunar interior	1. Crust & Lithosphere	~10	30	±10 mGal
	2. Thermal Evolution	~4	30	±2 mGal
	3. Impact Basins	~1	30	±0.5 mGal
	4. Magmatism	~0.1	30	±0.1 mGal
Advance understanding of the thermal evolution of the Moon	5. Deep Interior	N/A	N/A	k_2 ±6 × 10^{-4} (3%)
	6. Inner Core Detection	N/A	N/A	k_2 ±2.2 × 10^{-4} (1%)
				$C_{2,1}$ ±1 × 10^{-10}

Measurement achieved

GRAIL: A Few Facts

- Two almost identical spacecraft
  - Launched side by side, separated shortly after launch
  - Each flew separately to the Moon on three-month cruise
  - Arrived at the Moon 1 day apart.

- Discovery cost limit $425M (FY09)
  - Cost as submitted for Step 1 375M
  - Cost as submitted for Step 2 375M
  - Final Cost: 375M, with some funds returned to NASA

- Guest Scientist Program funded separately
  - 10 GS's for a total of 10M, managed by HQ

- Privately managed EPO activity by Sally Ride Science

Confirming Your Science Objectives in the Step 2 Proposal

- Last chance to make changes to what you plan to accomplish scientifically
- Designing the spacecraft system to accomplish the science objectives
- GRAIL's instrumentation challenges
- Knowing when to back off performance specs or science objectives

Staying on Schedule

- Schedule: One of the biggest issues in controlling cost and performance

- Select your own Project Team and ensuring that the PI is in charge

- Needing to be tough on yourself on your science team and on the prime contractor, and on everbody else

- Working with the NASA Center or organization managing the mission

- What if delays in approval at HQ are affecting the schedule?

Cost and Staying within Budget

- Step 1 committed you (almost) to a cost for your mission
- Managing cost is a day-to-day activity even for the PI
- The PI must have the final word on when and how funds are spent
- Let's hope your Step 1 cost plan had room for small growth or maneuvering – the unexpected WILL occur.
- Do not cut corners – they will come back to haunt you.
- Working with the Project Manager and his/her team

Management, Yours and NASA's

- This may be your first real management job! The responsibilities are very different teaching.

- Essential to handling all problems: Build a good working relationship with NASA HQ Prog Exec, Program Scientist, Finance staff (if possible), and the NASA Center Director and Senior staff

- The Mission Center want you to win and be successful, but frequently think they, not you the PI, are in complete charge of your mission.

- Success depends on building personal and professional relationships with management such that there is a level of trust and understanding of each others role.

- Visit the Prime Contractors site; offer to give a talk on the mission, and do it regularly.

Your Standing Review Board and other Advisers

- Get to know your Review Board Chairperson and what are their expectations.

- Listen to them and take their advice if possible

- External Review Boards:
  - They do not spent much time on reviewing your mission and can be wrong in their conclusions; and their report goes straight to NASA HQ.

  - This is where personal relationships between the PI and HQ can be very important.

  - HQ needs to be able to trust the PI's judgement.