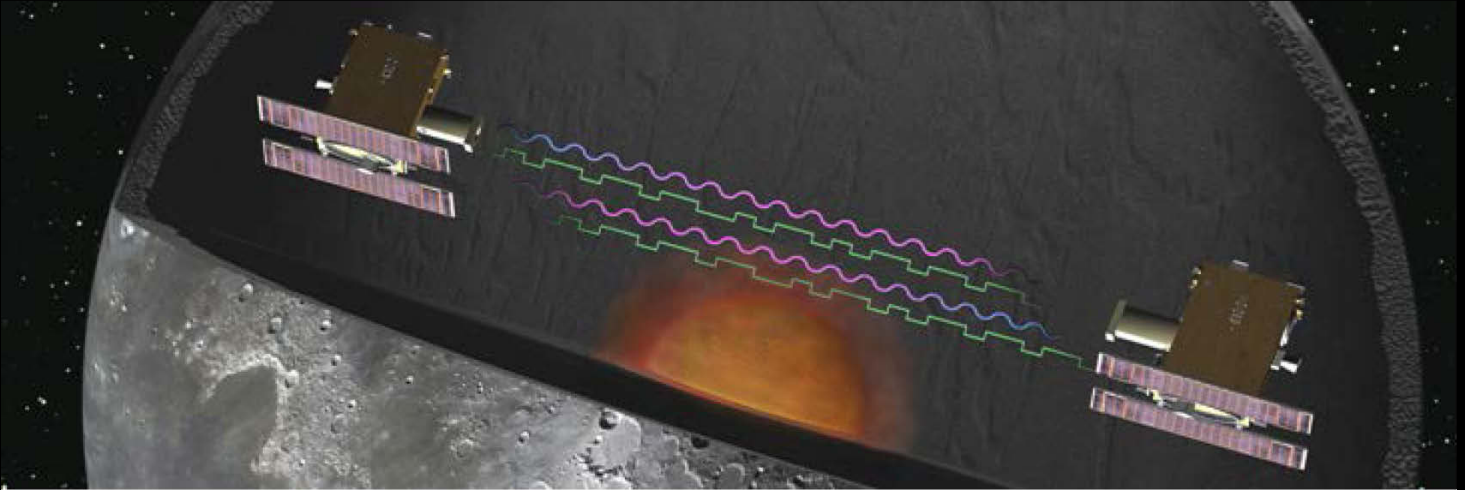

GRAIL

Gravity Recovery and Interior Laboratory

JPL D-75556

PM Briefing to the GRAIL Science Team

David H. Lehman

November 19, 2012

Jet Propulsion Laboratory, California Institute of Technology
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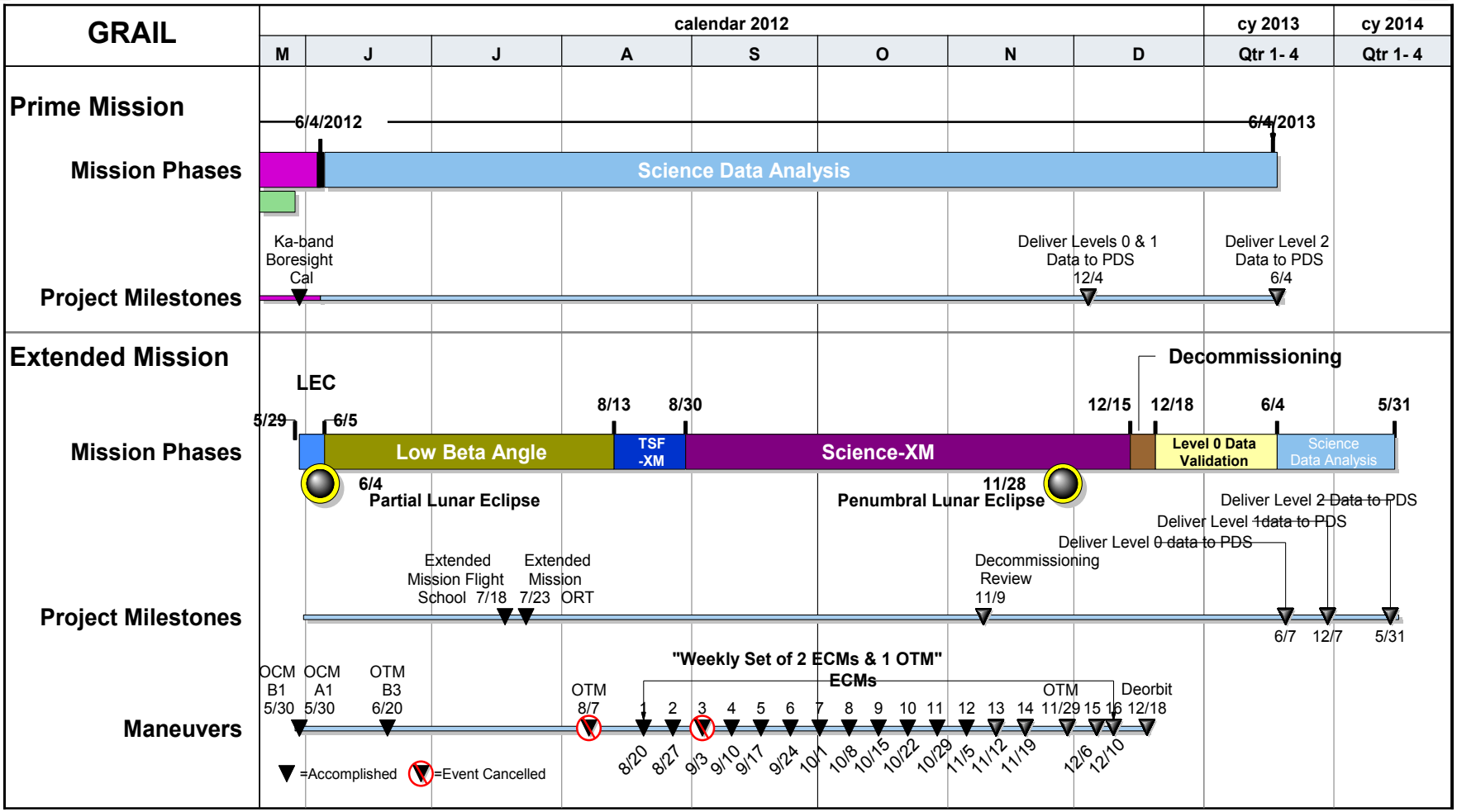
Mission Schedule

GRAIL
Discovery

11-6-2012 v1



The submitted XM proposed science phase ended on 12/3/12, but the currently planned science phase extends through 12/15/12

Significant Accomplishments
Current Month and Future Planned

GRAIL
Discovery

Planned Date	Completed Date	Status/Description
08/30/12	08/30/12	Extended mission science phase begins
09/10/12	09/10/12	ECM-A4 & ECM-B4
09/11/12	09/11/12	OTM-A4
09/17/12	09/17/12	ECM-A5 & ECM-B5
09/24/12	09/24/12	ECM-A6 & ECM-B6
09/25/12	09/25/12	OTM-A6
10/01/12	10/01/12	ECM-A7 & ECM-B7
10/08/12	10/08/12	ECM-A8 & ECM-B8
10/09/12	10/09/12	OTM-A8
10/15/12	10/15/12	ECM-A9 & ECM-B9
10/16/12	10/16/12	OTM-A9
10/17/12	10/17/12	MoonKAM Turn-on Institutional Review
10/22/12	10/22/12	ECM-A10 & ECM-B10

Significant Accomplishments
Current Month and Future Planned

GRAIL
Discovery

Planned Date	Completed Date	Status/Description
10/23/12	10/23/12	Turned on GRAIL-B MoonKAM
10/29/12	10/29/12	ECM-A11 & ECM-B11
10/30/12	10/30/12	OTM-A11
11/05/12	11/05/12	ECM-A12 & ECM-B12
11/06/12	11/06/12	OTM-A12
11/09/12	11/09/12	Decommissioning Review/Disposal Readiness Review
11/12/12	11/12/12	ECM-A13 & ECM-B13
11/13/12		OTM-A13
11/15/12		Post- Decommissioning Review/Disposal Readiness Review CMC at JPL
11/19/12		ECM-A14 & ECM-B14
11/19/12		Science Team Meeting at NASA HQ
11/20/12		OTM-A14
11/20/12		KDP-F at NASA HQ
11/28/12		Penumbral Lunar Eclipse Transit
11/29/12		OTM-B5

Significant Accomplishments
Current Month and Future Planned

GRAIL
Discovery

Planned Date	Completed Date	Status/Description
12/06/12		ECM-A15 & ECM-B15
12/07/12		OTM-B15
12/10/12		ECM-A16 & ECM-B16
12/11/12		OTM-B16
12/14/12		ECM-A17 & ECM-B17
12/15/12		OTM-B17
12/18/12		BTD-A & BTD-B

Problem and Concern Status

Date Identified	Title of Problem or Concern	Aug 2012 Status Code	Sep 2012 Status Code	Oct 2012 Status Code
2/13/12	Occasional S-band uplink/downlink errors	C	C	C

Concern - Occasional S-band Uplink/Downlink Errors

GRAIL
Discovery

DESCRIPTION:

During lunar orbit operations, both orbiters have experienced brief episodes of uplink bit errors and/or loss of lock. During these periods, telemetry also showed reduction in received signal quality.

CURRENT STATUS:

Root Cause Assessment: Examination of evidence leads us to believe that neither flight or ground telecom configuration errors nor hardware failure are likely causes. Instead, we believe that lunar multipath is the cause. We have correlated estimated multipath impact on link margin with the observed episodes to-date; analysis strongly points to multi-path as the root cause.

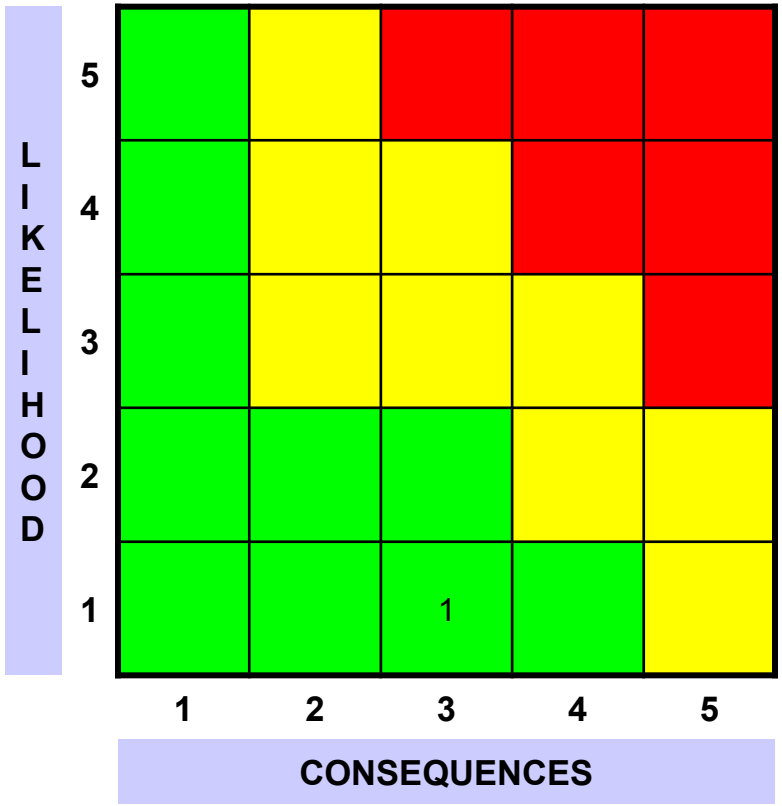
Future Mitigation: The Project is following its commanding guidelines: 1) take advantage of full DSN track for radiating commands, 2) resend commands when uplink errors occur, 3) maintain $\geq$3-day uplink margin for critical commanding, 4) critical commanding requires Spacecraft Systems engineer and ACE (real-time operator) on station, and 5) during a DSN pass, highest priority commands are sent first.

EXPECTED RESOLUTION/IMPACT:

Extended mission science operations are at a lower altitude and we are experiencing higher frequency of uplink errors compared to the prime mission. However, by following the commanding guidelines, the operations are proceeding as planned, with acceptable risk.

Top Risk List & Risk Matrix

GRAIL
Discovery



Rank & Trend	Risk ID	Approach	Risk Title	Risk Type
1 ⇩	157-14	M	Delayed Eccentricity Correction Maneuver	M

Criticality	LxC Trend	Approach
High Med Low	⇩ Decreasing (Improving) ⇧ Increasing (Worsening) ⇨ Unchanged ☐ New since last Month	M - Mitigate W - Watch A - Accept An - Analyze
	Risk Type I - Implementation M - Mission	

From the GRAIL Risk Management Board meeting held Oct. 29, 2012.

PM's Assessment

- GRAIL has successfully completed more than 2 mapping cycles of the Moon during the XM Science Phase; weekly cadence of ECMs and OTMs are proceeding per plan
- Monitoring occasional S-Band uplink and downlink errors
- Successfully completed the Nov. 9 Decommissioning Review.
- Final preparations in progress for the CMC on Nov. 15 and KDP-F on Nov. 20
- Final preparations in progress for the end-game
- Project has adequate reserves at this time

Back-Ups

- Project mission success criteria – meeting level-1 requirements
- More risk charts

Project Mission Success Criteria
Meeting Level-1 Requirements for the **Prime Mission**

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Discovery

Criterion (Baseline Science)	Full	Date	Minimum	Date
1. Global gravity to surface resolution 30 km and accuracy +/- 10 mGal	Completed	May 2012	Completed	May 2012
2. Large regional gravity to surface resolution 30 km and accuracy +/- 2 mGal	Completed	May 2012	Completed	May 2012
3. Small regional gravity to surface resolution 30 km and precision +/- 0.5 mGal	Completed	May 2012	Completed	May 2012
4. High resolution gravity to a precision of +/- 0.1 mGal	Completed	May 2012	Completed	May 2012
5. Constrain deep interior: Love Number k2 acc. 6E-4	Work in Process	June 2013	N/A	N/A
6. Limit on size of core: k2 acc.2E-4, C21 acc. 1E-10	Work in Process	June 2013	N/A	N/A

Criterion met

Criterion will not be met

Project Mission Success Criteria
Meeting Level-1 Requirements for the **Extended Mission**

GRAIL
Discovery

Criterion	Baseline	Date	Minimum	Date
1. Structure of impact basins: Baseline: 0.02 mGal at 12 km Minimal: 0.02 mGal at 18 km	**Work in Process**	**Apr. 2014**	**Work in Process**	**Apr. 2014**
2. Near surface magmatism: Baseline: 0.01 mGal at 30 km Minimal: (same)	**Work in Process**	**Apr. 2014**	**Work in Process**	**Apr. 2014**
3. Mechanics/Timing of deformation: Baseline: 0.005 mGal at 12 km Minimal: 0.005 mGal at 18 km	**Work in Process**	**Apr. 2014**	**Work in Process**	**Apr. 2014**
4. Causes of crustal magnetization: Baseline: 0.002 mGal at 12 km Minimal: 0.002 mGal at 18 km	**Work in Process**	**Apr. 2014**	**Work in Process**	**Apr. 2014**
5. Estimation of Upper Crustal Density: Baseline: 0.005 mGal at 12 km Minimal: 0.005 mGal at 18 km	**Work in Process**	**Apr. 2014**	**Work in Process**	**Apr. 2014**
6. Mass bounds on polar volatiles: Baseline: 0.002 mGal at 30 km Minimal: (same)	**Work in Process**	**Apr. 2014**	**Work in Process**	**Apr. 2014**

Criterion met

Criterion will not be met

Risk Focus Charts, 1 of 1

GRAIL
Discovery

Rank & Trend	Risk ID	Risk Statement (Title & Description)	Approach & Plan	Status
1 ⇩	157-14	**Delayed Eccentricity Correction Maneuver** Execution of an ECM will be delayed long enough for one of the orbiters to impact the lunar surface	The mission design provides a minimum of 10 days to implement through ECM-14 should a planned maneuver be missed or delayed. Using the standard 5-day maneuver development template, this provides a minimum of 5 days of margin in the event of a missed maneuver. Should there be a safe mode event, recovery is worked in parallel with the maneuver implementation to further reduce risk.	Mission design implementation and missed ECM recovery plans are in place and operational. Contingency strategies have been defined and are in place. ECMs are being executed successfully.
Criticality	**Planned Closure Date**			
1/3	11/19/2012			

Full Active Risk List

GRAIL
Discovery

ID #	Title	Likeli-hood	Conse-quence	SRL	Status
25	Spacecraft thermal distortion knowledge	1	3		Mitigate
27	Non-gravitational force modeling	2	2		Analyze
103	Simulation Fidelity	2	2		Watch
140	Challenging Navigation	2	2		Mitigate
143	Operational Errors Because of Two Spacecraft	1	3		Mitigate
153	Time Correlation Performance	1	3		Mitigate
155	Star Tracker Lockup When f.o.v. Blocked	2	2		Mitigate
156	Loss of IMU function due to current control hybrid	1	3		Analyze
157	Delayed Eccentricity Correction Maneuver	1	3	√	Mitigate
158	Delayed Extended Mission Activities Affecting Sci.	2	3		Mitigate
159	Staff Retention for Extended Mission	1	3		Mitigate
161	S-band Telecom Degradation in XM due to Multipath	2	2		Mitigate
162	Undetected LGRS state changes cause multi-day loss	2	2		Mitigate
163	USC Switch Failure	1	3		Analyze
164	Lack of Propellant for EOM Maneuvers	2	1		Mitigate

ID #	Title	Likeli-hood	Conse-quence	SRL	Status
4	Single-String System	2	3		Accepted
5	Parts SEE Susceptibility	ε	3		Accepted
7	Coax Switch Failure	1	2		Accepted
14	Loss of data in SFC DRAM	3	1		Accepted
31	Center of Mass Knowledge	1	2		Accepted
50	EEPROM page failure on MIMU	ε	3		Accepted
74	Battery Open-Cell Failure	ε	3		Accepted
77	Blackjack ASIC parts risk	2	3		Accepted
79	BWG Loss at Goldstone during Science Phase	3	1		Accepted
80	EEPROM Page Failure on A-STR	ε	3		Accepted
88	Data gaps in Science Phase	1	2		Accepted
109	Paint Degradation In-Flight	1	2		Accepted
115	MWA multiplier board blisters	1	3		Accepted
116	RWA Flight Failure	2	2		Accepted
117	AD590 Failure	2	2		Accepted
118	VCO Cracks Causes Loss of Both RSBs	ε	3		Accepted
123	Loss of one RSB	2	2		Accepted
125	MoonKAM Lockup	2	1		Accepted
135	RWA Outages During High Ramp Rates	1	2		Accepted
136	RSB VCO Lot 2 Life Test 2 Anomaly	ε	3		Accepted
139	MoonKAM Interference with Science Investigations	1	2		Accepted
141	Loss of LGRS S-band tracking	2	2		Accepted
144	Warm Gas Generator Valve Failure on Other Program	1	3		Accepted
149	RWA Comparator Part Failure on Another Program	1	2		Accepted
151	Juno DTCI Impact on GRAIL	4	1		Accepted