

Laser Ranging to the Lunar Reconnaissance Orbiter (LRO-LR)

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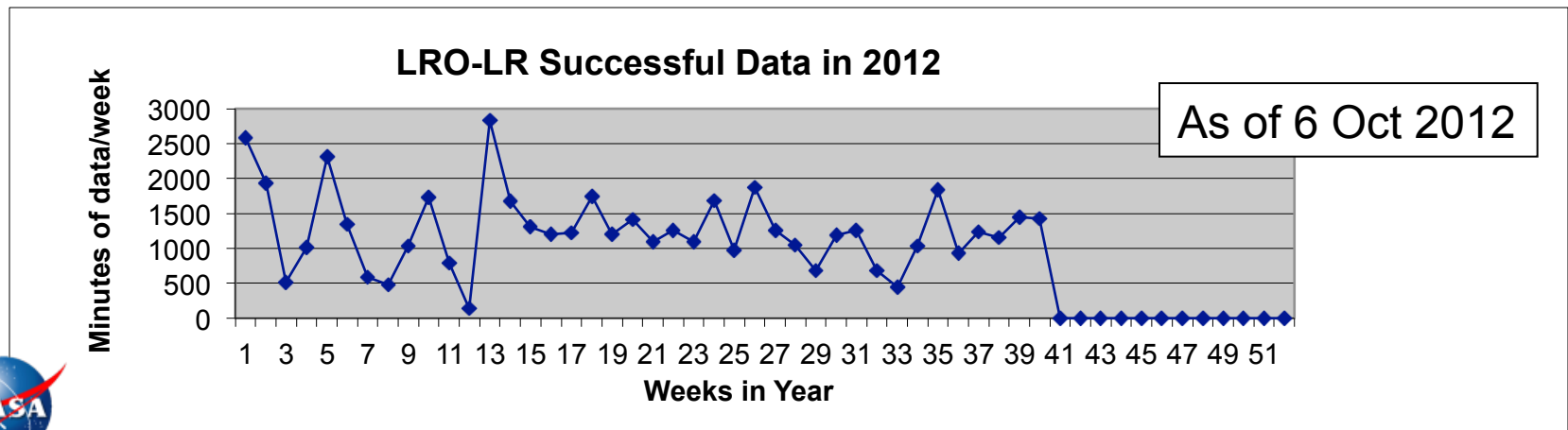
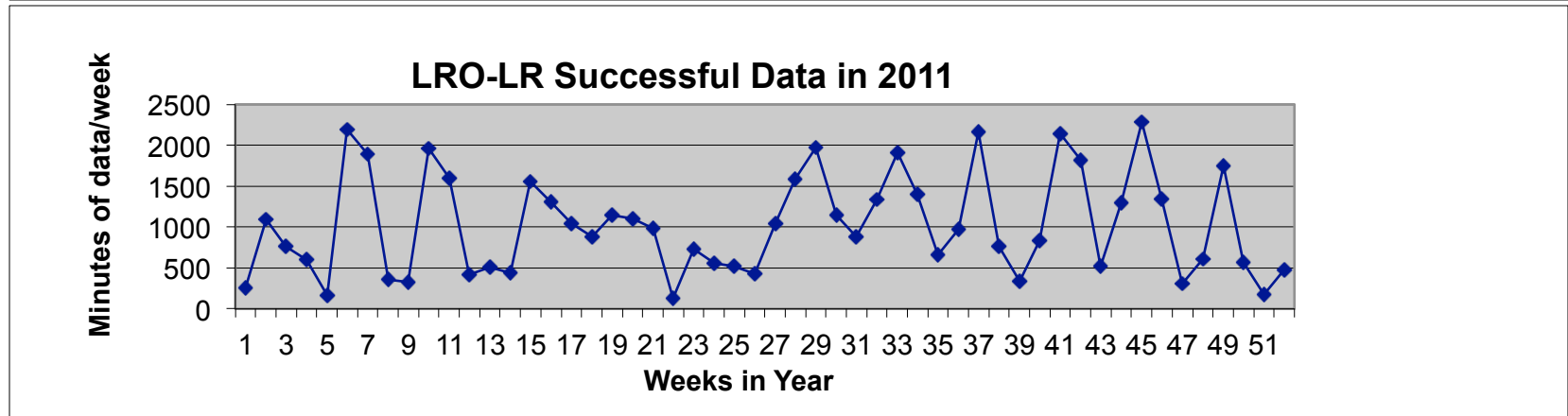
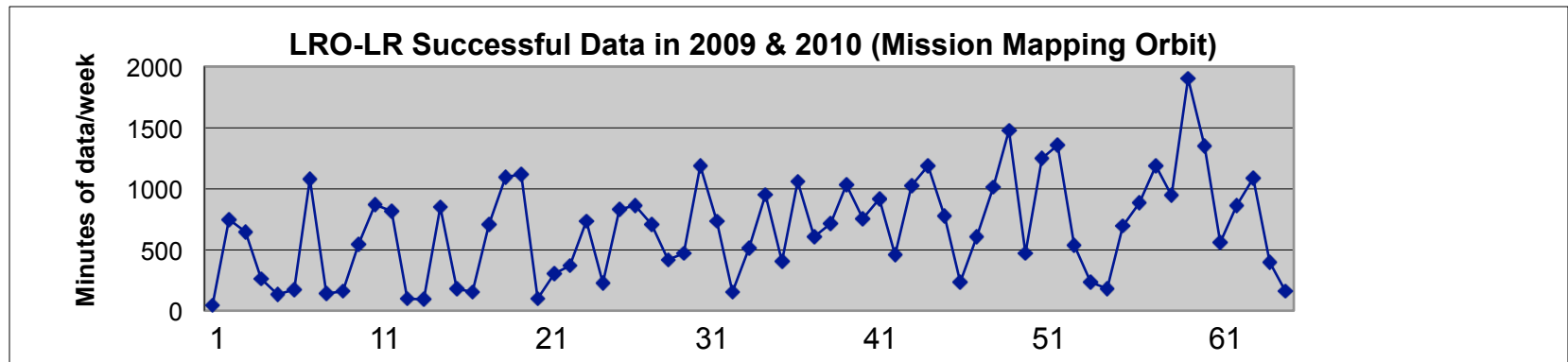
- Over **2500** hours of 1-way laser ranging data collected since launch June 2009.
- NASA will be funding LRO-LR at least through FY13.
- Ten participating stations:

Units are minutes	GO1L NGSLR	GODL MOB-7	MDOL MLRS	HERL Herst.	ZIML Zimmer.	WETL Wetzell	HARL MOB-6	YARL MOB-5	MONL MOB-4	GRSM Grasse
TOTAL minutes in 2012	12400	7044	4394	474	394	47	686	7227	17703	299
Fraction of data in 2012	0.2447	0.1390	0.0867	0.0094	0.0078	0.0009	0.0135	0.1426	0.3494	0.0059
TOTAL min since launch	52354	12133	16398	1747	1355	161	1584	23533	37696	1676
Fraction of ALL data	0.3522	0.0816	0.1103	0.0118	0.0091	0.0011	0.0107	0.1583	0.2536	0.0113

- TOTALS to October 6, 2012:
 - + Total hours in 2012: 845.
 - + Hours since launch: 2521.

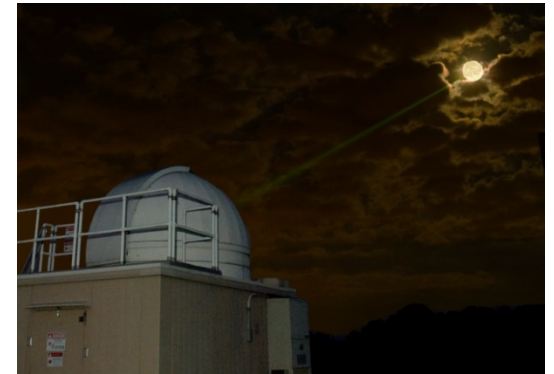


Minutes of Successful Data at LRO per Week since Launch



LRO-LR Analysis and Related Activities

- LR data analysis performed by Mao. LR data used to determine onboard oscillator drift which supports orbit determination. Orbit determination work ongoing (Rowlands).
- Lasercom work complete – paper submitted to OpticsExpress. X. Sun and team successfully transferred Mona Lisa image from NGSLR to LRO.
- In-house NASA R&D award given to X. Sun to do Time Transfer using LRO.
 - One year effort started October 2012.
 - Team includes Skillman, Gaebler, Hoffman, McGarry.
 - Initial transfer between NGSLR & MOBILAS-7. Then with MLRS. If time and resources permit, with Wettzell.
- Geometric solution of spacecraft location using 3-way simultaneous ranges will also be worked this year (Skillman) under NASA R&D.



Time Transfer using LRO-LR

- Time transfer involves highly stable frequency sources (Cesium or Hydrogen Maser) and 2 frequency GPS receivers.
- DICOM All View GPS receiver (Czech Republic) promises CV accuracy to 1 nanosecond GPS time.
- Measure transmit delay of each participating station to reduce problem to single biased range at LRO.
- Significantly increase accuracy of one way laser ranging data to LRO.
- Tie USNO master clock to NGSLR time via GPS, transfer master clock to other stations via LRO clock.



LRO Orbit Determination with GRAIL420c1a

Orbital Solutions for 14 days

LR only

S-band only

S-band plus LR

	rms (m)	num	rms (cm/sec)	num	rms (m)	num	rms (cm/sec)	num	rms (m)	num	rms (m)	num	
20090831	0.29	5203	0.05	64679	1.16	57407	0.05	64742	1.22	57407	0.41	5203	20090831
20091023	0.30	15954	0.08	76259	1.09	70984	0.10	76261	2.21	70984	0.39	15954	20091023
20091120	0.22	16613	0.05	74957	0.77	68530	0.06	75124	0.80	68530	0.23	16613	20091120
20100309	0.17	10338	0.05	72156	1.32	67421	0.06	72424	1.54	67421	0.20	10338	20100309
20100405	0.27	9859	0.05	69298	1.39	63528	0.06	69632	1.72	63528	0.29	9859	20100405
20100419	0.28	21185	0.06	70072	1.44	64602	0.08	70627	1.71	64602	0.30	21185	20100419
20100530	0.29	19306	0.05	78974	0.79	74166	0.07	79600	1.41	74166	0.30	19306	20100530
20100614	0.22	20554	0.06	64239	0.96	60551	0.07	64304	1.16	60551	0.23	20554	20100614
20110507	0.38	17397	0.70	66540	1.93	59389	0.72	66540	1.51	59389	0.39	17397	20110507
20110520	0.16	11978	1.02	66650	2.22	60286	1.03	66650	1.66	60286	0.22	11978	20110520
20110630	0.32	11524	0.71	65279	2.66	57984	0.72	65279	2.64	57984	0.36	11524	20110630
20110810	0.69	20800	0.08	79229	1.18	71040	0.11	79229	1.50	71040	0.70	20800	20110810
average	0.30	15059	0.25	70694	1.41	64657	0.26	70868	1.59	64657	0.34	15059	average

Average RMS 30 cm (1 nsec)

2.5 mm/s

3.0 mm/s

34 cm

More on this in Mark Torrence's talk on Friday