Laser Ranging to NASA's Lunar Reconnaissance Orbiter (LRO): Ranging Data Results

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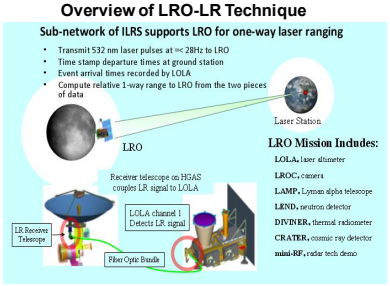
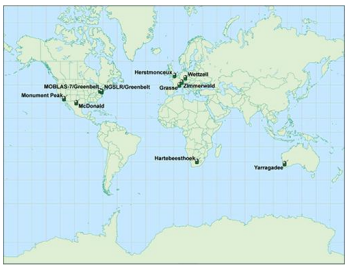
Overview of LRO-LR Technique



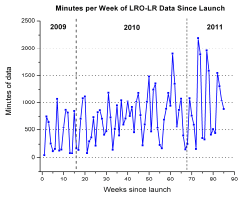
Participating ILRS Stations

	Station	Location	Synch to LOLA?	Firerate (Hz)	Max # / sec in LOLA window	Expected energy at LRO (fJ / sq/cm)	Station Frequency Source	Date of first successful ranging to LRO	LR Status
GO1L	NGSLR	Maryland, US	Yes	28	28	1 to 5	Maser (18-Oct-2010)	30-Jun-2009	Operational
MDOL	MLRS, McDonald	Texas, US	No	10	2 to 4	1 to 10	Cesium	02-Jul-2009	Operational
GODL	MOBLAS-7, Greenbelt	Maryland, US	No	10	2 to 4	1 to 3	Cesium	02-Jul-2009	Engineering testbed
HERL	Herstmonceux	Great Britain	Yes	14	14	1 to 3	Maser (13-May-2010)	13-Jul-2009	Operational
ZIML	Zimmerwald	Switzerland	Yes	14	14	1 to 3	Oven,ized crystal oscillator	20-Jul-2009	Operational
WETL	Wettzell	Germany	No	7	7	1 to 10	Cesium	30-Oct-2009	Operational
HARL	MOBLAS-6, Hartebeesthoek	South Africa	No	10	2 to 4	1 to 3	Maser	05-Dec-2009	Operational
YARL	MOBLAS-5, Yarragadee	Australia	No	10	2 to 4	1 to 3	Maser (14-May-2010)	25-Jan-2010	Operational
MONL	MOBLAS-4, Monument Peak	California, US	No	10	2 to 4	1 to 3	GPS steered Rubidium	03-Feb-2010	Operational
GRSM	Grasse/MEO	France	No	10	2 to 4	1 to 10	Cesium	18-May-2010	Operational



Total LR data from all stations (as of 7 May 2011): 62074 mins = 1078 hrs

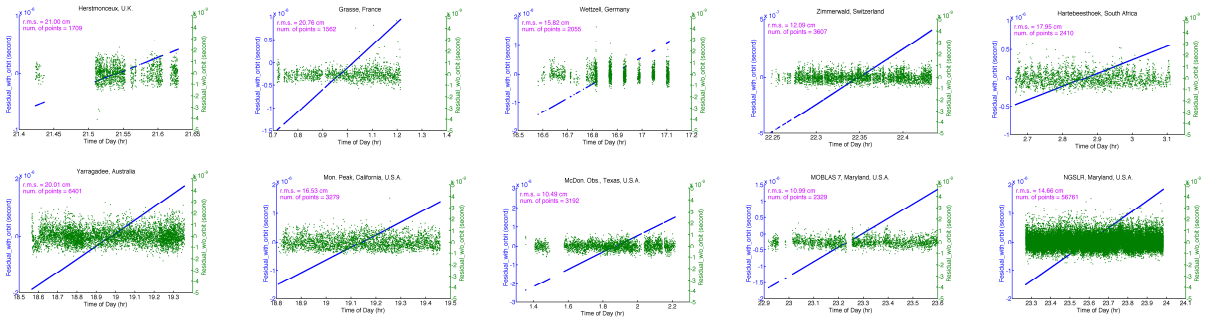
FIRSTS
- Ranging to LRO: GO1L 30 Jun 2009 on first attempt!
- 3-way simultaneous: 1 Nov 2010 (GO1L,MDOL,MONL)
- 4-way simultaneous: 11 Mar 2011 (GO1L,GODL,MDOL,MONL)
- Lasercom over LR: 10 May 2011 (GO1L)



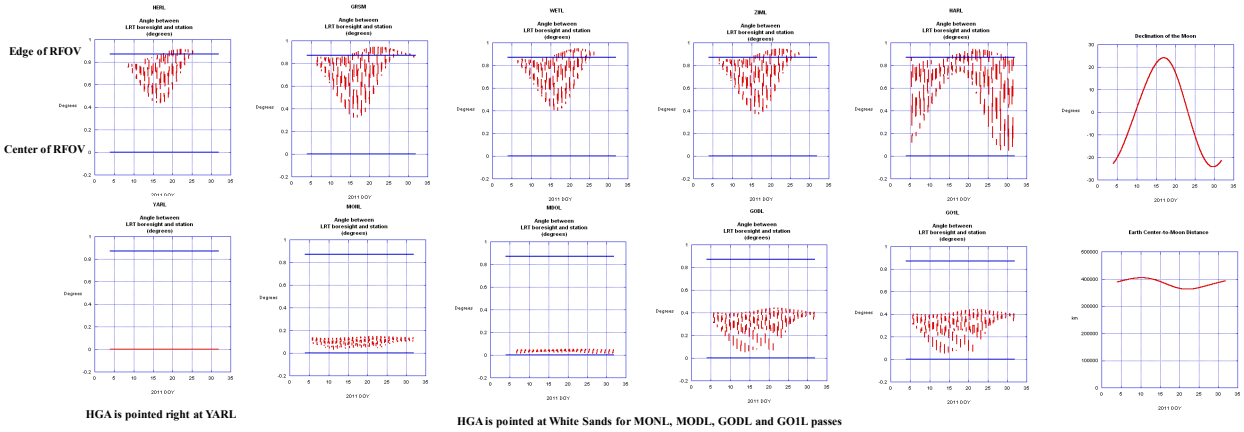
TOTAL MINUTES PER STATION SINCE LAUNCH

	GO1L	GODL	MDOL	HERL	ZIML	WETL	HARL	YARL	MONL	GRSM
# mins	28334	2524	8203	776	533	66	341	11038	9192	1067
fraction of total	0.456	0.041	0.132	0.013	0.009	0.001	0.005	0.178	0.148	0.017

Residuals of station LR data to orbit. RMS of LR data is 10 - 20 cm.



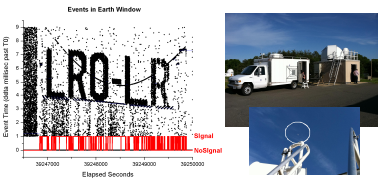
Location of laser pulses in LR Receiver FOV for January 2011
European and South African stations can have issues due to HGA pointing at center of Earth. If HGA is mis-pointed even 0.1 deg, many of passes would be impossible.

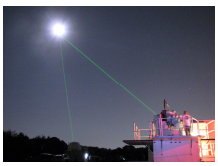


HGA is pointed right at YARL

HGA is pointed at White Sands for MONL, MODL, GODL and GO1L passes

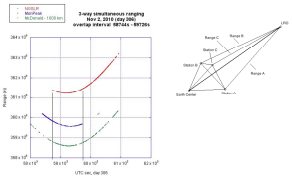
Preliminary lasercom over LR at NGSLR: 10 May 2011
NGSLR writes "LRO-LR" in Earth Window.





Simultaneous LR from GO1L & GODL

Geometric solution of spacecraft location using 3-way simultaneous LR: work in progress



Accuracy of solution using GO1L-MDOL-MONL baseline:
- range ~0.5 meters
- cross-range RA direction ~ 50 meters
- cross-range Dec direction ~ 350 meters (due to weak north-south baseline).

If we had 6000km baselines we would get 5 meters in the cross-range directions (Ra/Dec) and about 0.5 meters in range.