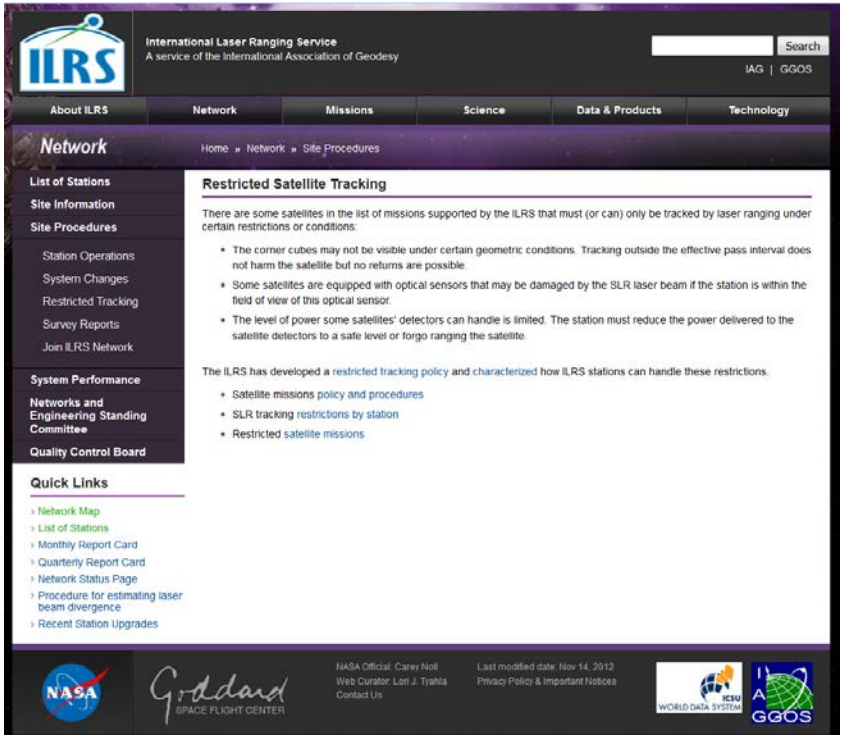
ILRS RESTRICTED TRACKING

"Safety First"
"First, do no harm"

Purpose: To prevent damage to a spacecraft's sensors or interference with spacecraft data-taking because of illumination by laser light from an ILRS laser ranging station

Types of restricted tracking

- “go/nogo” flag
- Maximum elevation restriction
- Pass segments
- Schedule segments
- Power restriction



Reference

- http://ilrs.gsfc.nasa.gov/network/site_procedures/restricted_tracking.html
- http://ilrs.gsfc.nasa.gov/network/site_procedures/restrictedtracking_policy.html

Request for Restricted Tracking

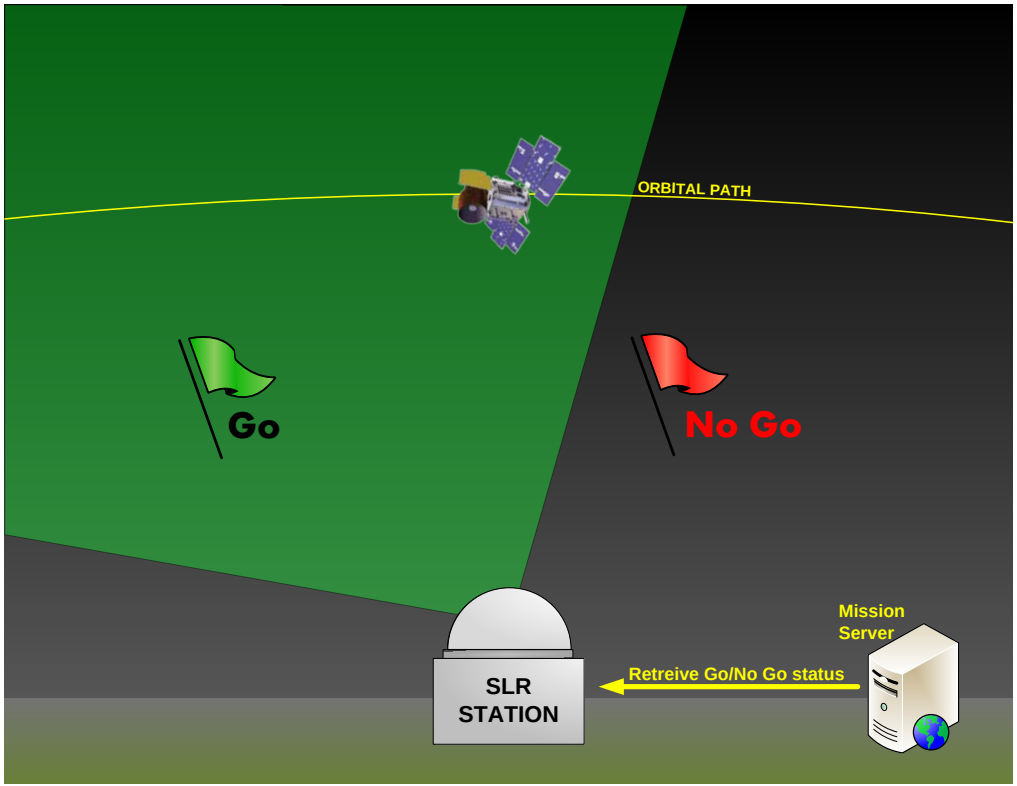
- The spacecraft mission must request restricted tracking in the Mission Support Request form that requests laser tracking
- The mission must vet stations they want to provide restricted tracking to insure the station can handle the restriction
  - *Conducting tracking tests with candidate stations and a non-vulnerable satellite is appropriate*
- The mission must, as usual, provide satellite predictions in CPF format, but must also provide:
  - *Tracking restriction files as needed (go/nogo flag file, segmentation file)*
  - *A web/ftp site to host the go/nogo flag file; CPF prediction files, pass segment, and schedule segment files can be on a protected web/sfp site or emailed to selected stations*

Types of Restricted Tracking

Quick Summary of Concept

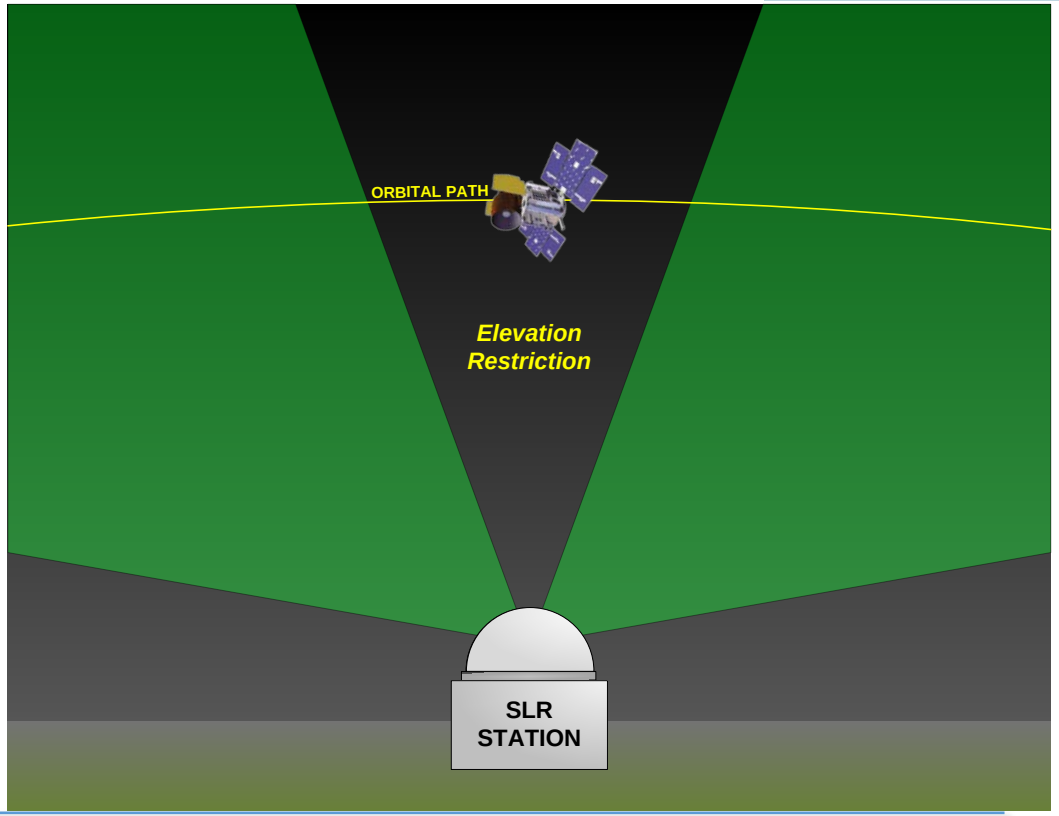
Restriction Type: Go/NoGo Flag

- Allows mission to quickly “turn off” tracking of satellite in case of safe mode, undesirable geometry, etc.
- Go/nogo Flag file contains the time span after which the satellite's go/nogo flag is re-read from the web/ftp site, usually every 1-5 minutes
- If the flag reads “nogo” or the flag file cannot be read due to system or internet problems, the satellite MUST NOT be fired upon.
- Examples: ICESat-I, LROLR



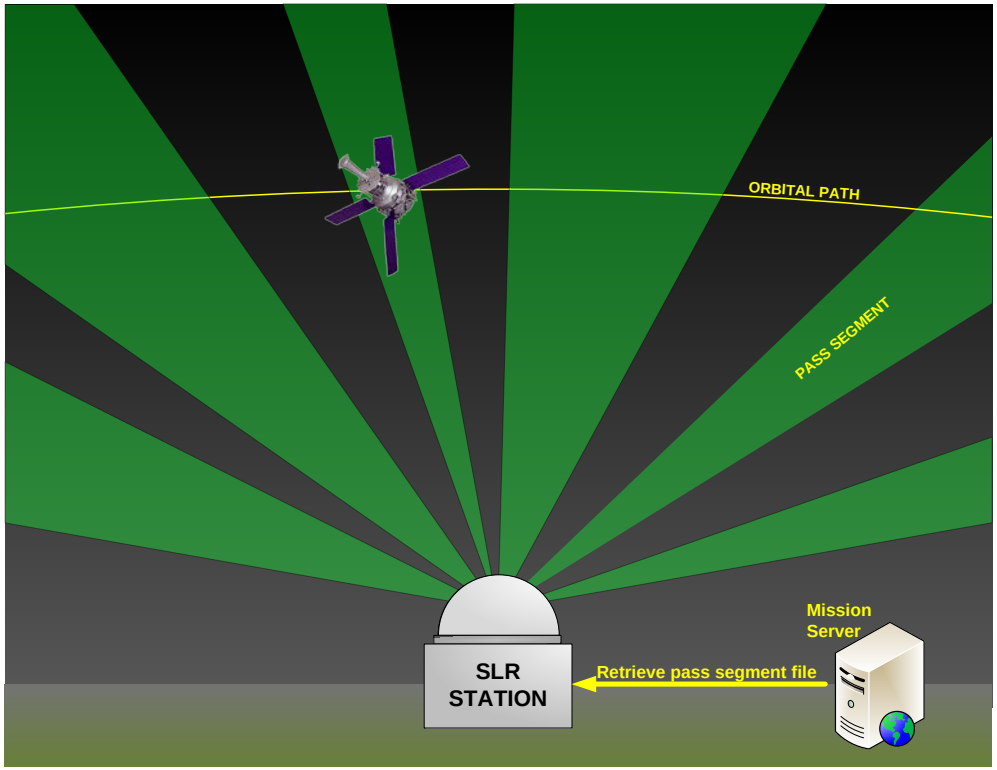
Restriction Type: Upper Elevation Limit

- Certain nadir-pointing satellites have sensors that can be damaged by direct illumination from tracking station lasers
- This can often be controlled by restricting the maximum elevation at which a tracking station can fire at the satellite.
- Typical maximum elevations are 70-80 degrees.
- Examples: ICESat-I



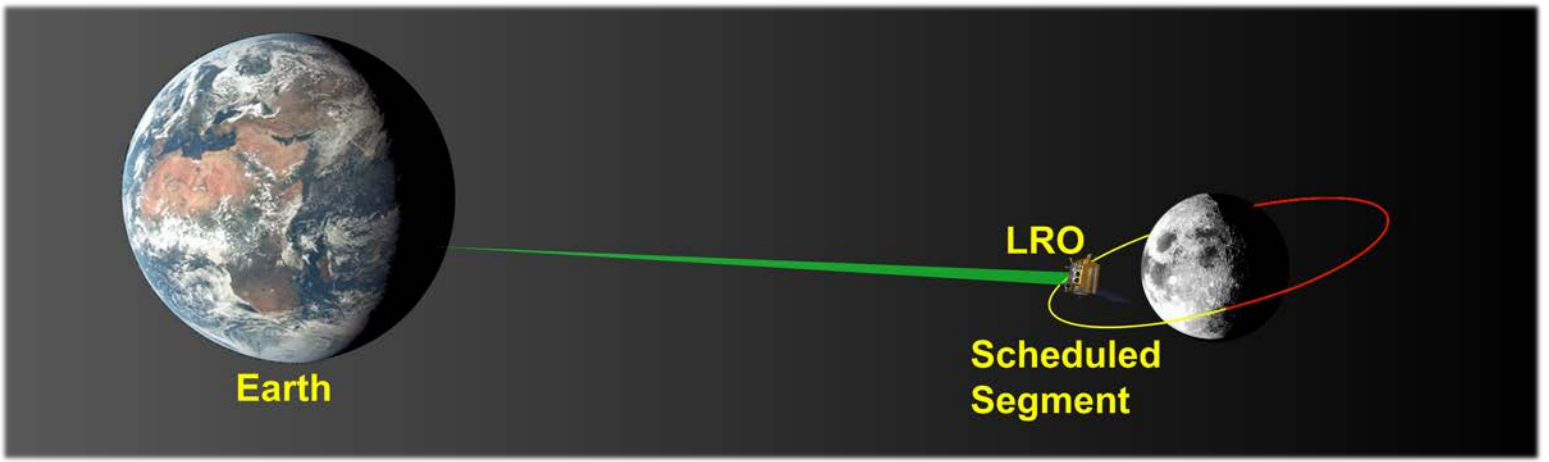
Restriction Type: Pass Segments

- Certain satellites have sensors that scan across track, making the elevation restriction ineffective
- If such a satellite's sensor(s) can be damaged by laser illumination, restrictions by pass segment are needed
- In other cases, there is no danger of damage, but because of the unfavorable retro-reflector array orientation, a laser station may not get returns from the satellite, wasting valuable tracking time
- In either case, the mission provides files giving the acceptable laser illumination start and stop times and dates by station
- Examples: ALOS (damage); GPB (visibility)



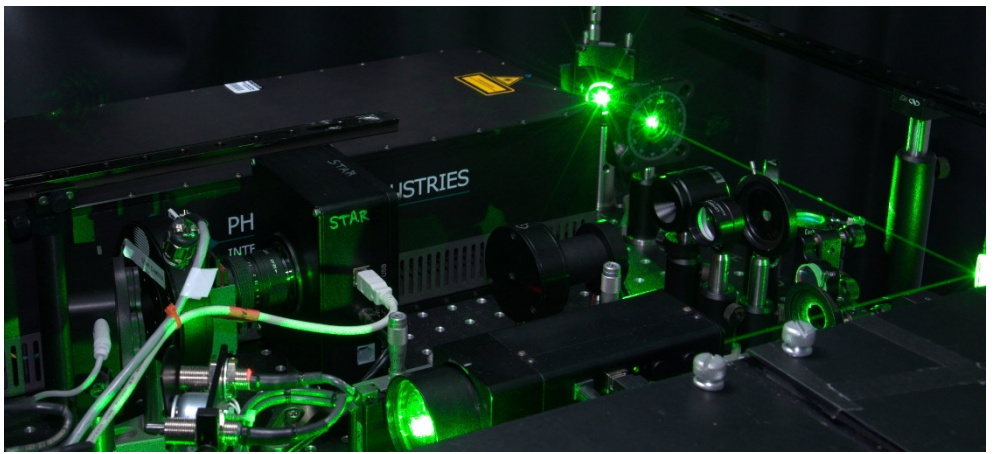
Restriction Type: Schedule Segments

- Certain satellites are not visible or their LRA is tilted away from the station at certain times
- In some of the cases, the mission will provide a file used at prediction processing time rather than at tracking time to remove un-wanted pass segments
- Use this to eliminate entire passes rather than small segments
- Examples: LRO-LR, Radioastron



Restriction Type: Laser Power

- Certain satellites have sensors that will not be damaged by laser illumination UNLESS the incident laser power is too high.
- The spacecraft mission must provide a maximum power figure to candidate stations, who must determine whether they can comply
- Software control of power is preferred to manual changes
- Example: LRO-LR



Liability

During the negotiation of the Mission Tracking Request, the spacecraft mission must agree to relieve the accepted tracking stations of any liability or financial consequence in case a component of the satellite is unintentionally damaged by the laser beam.

Conclusion

- Restricted tracking keeps satellites safe
- As the number of satellites the ILRS tracking increases, there will be more interesting missions that will require us to restrict the ways they are tracked
- It is in the ILRS's and stations' best interest to have hardware, software, and policy in place to accommodate these and possibly new tracking restrictions

Backup Slides

ILRS Station Restricted Tracking Readiness

SLR Tracking Restriction Summary by Station

TYPE OF RESTRICTION																
Site Information			Elevation				Go/Nogo Flag				Pass Segment				Notes	
Site	ID	Code	Y/N/M	Tests	Missions	Plans?	Y/N/M	Tests	Missions	Plans?	Y/N/M	Tests	Missions	Plans?	Last Updated	Comments
Golosiiv	1824	GLSL	Y				N			Y: months	N			Y: months		
Lviv	1831	LVIV	N			Y: 2-3 mon	N			Y: 6 mon	N			Y: 2-3 mon		Power restrictions “impossible”
Maidanak 1	1863	MAID	-												*No response*	
Maidanak 2	1864	MAIL	-												*No response*	
Komsomolsk	1868	KOML	-												*No response*	
Mendeleevo	1870	MDVL	-												*No response*	
Simeiz	1873	SIML	N			Y: 1 mon	N			Y: 1 mon	N			Y: 1 mon	2009-03-18	
Riga	1884	RIGL	N			N	Y	ALOS	ALOS	-	Y	ALOS	ALOS	-		Elevation and Power restrictions possible to add
Katsively	1893	KTZL														
McDonald	7080	MDOL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat	-	Y	simulation	none	-		
Yarragadee	7090	YARL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Manual control over power and divergence
Greenbelt	7105	GODL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Manual control over power and divergence
Monument Peak	7110	MONL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Manual control over power and divergence
Haleakala, HI	7119	HA46	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Manual control over power and divergence
Tahiti	7124	THTL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Manual control over power and divergence
Wuhan	7231	WUHL													*No response*	
Changchun	7237	CHAL													*No response*	
Beijing	7249	BEIL	N			Y	N			Y	N			Y		Must finish daylight and kHz upgrades before restrictions.
Koganei	7308	KOGC	N				M	Ajisai	ALOS		M	Ajisai	ALOS			Restriction implemented for ALOS only; no automated restrictions
Tanegashima	7358	GMSL	M			Y	Y	ALOS tests	ALOS	-	M			Y		Manual control over power and divergence
Arequipa	7403	AREL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		two manual power settings; no plans for other implementation
Concepcion	7405	CONL	Y	Visual test of shutter	all		N			Y: 3-6 mon	N			Y: 3-6 mon		
San Juan	7406	SJUL	N			Y: 1.5 yr	N			Y: 1.5 yr	N			Y: 1.5 yr	2009-06-09	
Hartebeesthoek	7501	HARL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Manual control over power and divergence
Metsahovi2	7806	METL													*No response*	
Zimmerwald	7810	ZIML	Y		ICESat	-	Y		ICESat	-	Y			-		Software-controller attenuator in laser beam
Borowiec	7811	BORL	N			Y end 2009	N			Y end 2009	N			Y end 2009		Manual control currently; station undergoing modernization
Kunming	7820	KUNL													*No response*	
Shanghai	7821	SHA2													*No response*	
San Fernando	7824	SFEL	N			N	N			N	N			N		
Mt. Stromlo	7825	STL3	N			Y TBD	Y	1)JAXA demo; 2)formal tests	1)ALOS; 2)Debris tracking	-	Y	1)JAXA demo; 2)formal tests	1)ALOS; 2)Debris tracking	-		

			TYPE OF RESTRICTION													
Site Information			Elevation				Go/Nogo Flag				Pass Segment				Notes	
Site	ID	Code	Y/N/M	Tests	Missions	Plans?	Y/N/M	Tests	Missions	Plans?	Y/N/M	Tests	Missions	Plans?	Last Updated	Comments
Helwan	7831	HLWL														
Riyadh	7832	RIYL													*No response*	
Simosato	7838	SISL	N			Y-week	N			Y – week	Y	Ajisai	ALOS	-		beam div used to equalize signal strength. Changes will be made when resources are available
Graz	7839	GRZL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat	-	N			N		
Herstmonceux	7840	HERL	Y	Ajisai	ICESat	-	Y	Ajisai	ICESat ALOS	-	Y	Ajisai	ALOS	-		Power controlled by choice of laser and beam divergence
Potsdam	7841	POT3	N			*TBD*	N			*TBD*	N			*TBD*		Will consider implementation after major station upgrade starting mid-2009
Grasse	7845	GRSM	N			Y	N			Y	N			Y		To implement in “some months”
Matera	7941	MATM	Y	Ajisai (simulation)	none	-	Y	Etalon1 (simulation)	LRO Avoidance	-	Y	LAGEOS (simulation)		-	Updated	Reported addition of go/no-go restriction March '11
Wettzell	8834	WETL	Y	Simulation & LRO w/ closed dome			Y	Simulation & LRO w/ closed dome			Y	Simulation & LRO w/ closed dome				
FTLRS	--	--	N			Y	N			Y	N			Y		To implement in “some months”
TROS	--	--													*No response*	
Stafford			Y	Day-long detailed tests		-	N			unknown	N			*TBD*		DoD clearinghouse certification; manual go/no-go possible;

Site Information			TYPE OF RESTRICTION: Maximum Power						Notes	
Site	ID	Code	Y/N/M	Tests	Missions	Plans?	S/W control of laser power?	S/W control of divergence?	Last Updated	Comments
Golosiiv	1824	GLSL	N			N: >year	N	N		
Lviv	1831	LVIV	N			N	N	N		Power restrictions “impossible”
Maidanak 1	1863	MAID							*No response*	
Maidanak 2	1864	MAIL							*No response*	
Komsomolsk	1868	KOML							*No response*	
Mendeleevo	1870	MDVL							*No response*	
Simeiz	1873	SIML	N			N	N	N	2009-03-18	
Riga	1884	RIGL	N			N				Elevation and Power restrictions possible to add
Katsively	1893	KTZL								
McDonald	7080	MDOL	M	simulation	LRO	Y	Soon	Y		
Yarragadee	7090	YARL	N			N	N	N		Manual control over power and divergence
Greenbelt	7105	GODL	N			N	N	N		Manual control over power and divergence
Monument Peak	7110	MONL	N			N	N	N		Manual control over power and divergence
Haleakala, HI	7119	HA46	N			N	N	N		Manual control over power and divergence
Tahiti	7124	THTL	N			N	N	N		Manual control over power and divergence
Wuhan	7231	WUHL							*No response*	
Changchun	7237	CHAL							*No response*	
Beijing	7249	BEIL	N			Y				Must finish daylight and kHz upgrades before restrictions.
Koganei	7308	KOGC	N			N	N Manual	N		Restriction implemented for ALOS only; no automated restrictions
Tanegashima	7358	GMSL	M			Y	Y	Y		Manual control over power and divergence
Arequipa	7403	AREL	N			N	N	N		two manual power settings; no plans for other implementation
Concepcion	7405	CONL	N			Y: 1-2 mon	Y (control of ND's)	Y		
San Juan	7406	SJUL	N			N	N	Y: 1.5 yr	2009-06-09	
Hartebeesthoek	7501	HARL	N			N	N	N		Manual control over power and divergence
Metsahovi2	7806	METL							*No response*	
Zimmerwald	7810	ZIML	Y		LRO		Y	N		Software-controller attenuator in laser beam
Borowiec	7811	BORL	N			Y end 2009	N	N		Manual control currently; station undergoing modernization
Kunming	7820	KUNL							*No response*	
Shanghai	7821	SHA2							*No response*	
San Fernando	7824	SFEL	N			N	N	N		
Mt. Stromlo	7825	STL3	N			not planned	manual; preconfigured	Y; needs study		

			TYPE OF RESTRICTION							
Site Information			Maximum Power						Notes	
Site	ID	Code	Y/N/M	Tests	Missions	Plans?	S/W control of laser power?	S/W control of divergence?	Last Updated	Comments
Helwan	7831	HLWL								
Riyadh	7832	RIYL							*No response*	
Simosato	7838	SISL	N	measured beam div on ground		Y – soon	N	Y		beam div used to equalize signal strength. Changes will be made when resources are available
Graz	7839	GRZL	N			Y when needed	For cal; automation possible	Y; automation possible		
Herstmonceux	7840	HERL	N				20mj@ 10Hz; 40mJ@ 1kHz	yes		Power controlled by choice of laser and beam divergence
Potsdam	7841	POT3	N			*TBD*	yes, now	yes		Will consider implementation after major station upgrade starting mid-2009
Grasse	7845	GRSM	N			Y	Y	Y		To implement in “some months”
Matera	7941	MATM	N			Y; tbd	N	Y	Updated	Reported addition of go/no-go restriction March '11
Wettzell	8834	WETL	Y	Simulation & LRO w/ closed dome	LRO		N	Y		
FTLRS	--	--	N			Y	Y	N		To implement in “some months”
TROS	--	--							*No response*	
Stafford			N				Y (control of Nds; laser manual)	Manual (lengthy setup)		DoD clearinghouse certification; manual go/no-go possible;

Restricted Tracking File Formats

File formats by type

Go/nogo Flag File Format

Filename

'*satellitename*'.gng (official ILRS satellite name)

Examples

- Icesat.gng
- lro.gng

```
Fixed read format: A10,1X,I7,1X,I4,1X,I2,1X,A4
A10: ILRS satellite name
I7: ILRS (COSPAR) ID
I4: SIC
I2 Minutes between go/nogo filre reads
A4: Literal “go” or “nogo”
```

Examples

```
     ICESAT     0300201 8201  5 go
     LRO        0903101 0059  5 nogo
```

Pass Segment File Format

- Descriptive file header: 4 lines
- Table headers: 4 lines each
- Read Format (data record):

I4,1X,A10,1X,I7,1X,I4,1X,2(I4,1X,5(I2,1X)),I2,1X,F5.1

I4: Station Pad number

A10: ILRS satellite name

I7: ILRS (COSPAR) ID

I4: SIC

I4,1X,5(I2,1X): start year, month, day, hour, min, sec

I4,1X,5(I2,1X): stop year, month, day, hour, min, sec

I2: Maximum elevation in segment (degrees)

F5.1: Length of segment (minutes)

Pass Segment File Format

EXAMPLE

```
Satellite : GP-B
Generation Date : 2004-07-23 19:07:00 [UTC]
Generated by : GP-B Mission Operations / Stanford University
Minimum Elevation : 5 deg
-------------------------------------------------------------------------
Start Date/Time End Date/TimeMaxEl Dur
ID SAT COSPAR SIC [UTC] [UTC][deg][min]
-------------------------------------------------------------------------
1824 GP-B 0401401 8603 2004-07-24 00:46:57 2004-07-24 00:53:51 80 6.9
1824 GP-B 0401401 8603 2004-07-24 02:23:59 2004-07-24 02:28:26 10 4.4
1824 GP-B 0401401 8603 2004-07-24 11:51:43 2004-07-24 11:55:45 27 4.0
1824 GP-B 0401401 8603 2004-07-24 13:29:21 2004-07-24 13:33:19 27 4.0
-------------------------------------------------------------------------
Start Date/Time End Date/TimeMaxEl Dur
ID SAT COSPAR SIC [UTC] [UTC][deg][min]
-------------------- ----------------------------------------------------
7810 GP-B 0401401 8603 2004-07-24 00:47:15 2004-07-24 00:52:53 13 5.6
7810 GP-B 0401401 8603 2004-07-24 02:25:23 2004-07-24 02:32:23 67 7.0
7810 GP-B 0401401 8603 2004-07-24 04:02:14 2004-07-24 04:05:52  7 3.6
7810 GP-B 0401401 8603 2004-07-24 13:28:30 2004-07-24 13:32:27 27 3.9
```

Schedule Segment File Format

Header (optional):
02/09/2016 07:20 - 10:20 UTC
I2,1x,I2,1x,I4,1x,I2,1x,I2,3x,I2,1x,I2
Month/day/year start hour:minute – stop hour:minute

Data:
7501 2016246 7:20 2016246 7:26 HARL
I4,2x,I4,I3,2x,I2,1x,I2,2x,I4,I3,2x,I2,1x,I2,2x,A4
I4: ILRS pad ID
I4: Tracking start year
I3: Tracking start day
I2: Tracking start hour
I2: Tracking start minute
I4: Tracking stop year
I3: Tracking stop day
I2: Tracking stop hour
I2: Tracking stop minute
A4: ILRS station ID

Schedule Segment File Format

Example (Radioastron)

```
Keldysh Institute of Applied Mathematics RAS

02/09/2016 07:20 - 10:20 UTC
7501  2016246   7:20  2016246   7:26  HARL
7090  2016246   7:20  2016246   9:47  YARL
7124  2016246   8:42  2016246  10:20  THTL
7308  2016246  10:14  2016246  10:20  KOGC
7825  2016246   7:20  2016246  10:20  STL3
7826  2016246   7:20  2016246  10:20  STRK
7838  2016246  10:12  2016246  10:20  SISL

11/09/2016 06:40 - 08:55 UTC
7090  2016255   6:40  2016255   8:40  YARL
7124  2016255   7:41  2016255   8:55  THTL
7825  2016255   6:40  2016255   8:55  STL3
7826  2016255   6:40  2016255   8:55  STRK
```

Schedule Segment File Format

Example (LRO)

```
7090  2014269  03:31  2014269  04:06  YARL
7090  2014269  05:17  2014269  06:15  YARL
7090  2014269  07:15  2014269  08:14  YARL
7501  2014269  07:15  2014269  08:14  HARL
7501  2014269  09:25  2014269  09:44  HARL
7845  2014269  09:44  2014269  10:00  GRSM
8834  2014269  09:48  2014269  10:00  WETL
7810  2014269  11:24  2014269  11:59  ZIML
7845  2014269  11:24  2014269  11:59  GRSM
8834  2014269  11:24  2014269  11:59  WETL
```

Schedule Segment File Format

Example (Radioastron)

```
Keldysh Institute of Applied Mathematics RAS

02/09/2016 07:20 - 10:20 UTC
7501  2016246   7:20  2016246   7:26  HARL
7090  2016246   7:20  2016246   9:47  YARL
7124  2016246   8:42  2016246  10:20  THTL
7308  2016246  10:14  2016246  10:20  KOGC
7825  2016246   7:20  2016246  10:20  STL3
7826  2016246   7:20  2016246  10:20  STRK
7838  2016246  10:12  2016246  10:20  SISL

11/09/2016 06:40 - 08:55 UTC
7090  2016255   6:40  2016255   8:40  YARL
7124  2016255   7:41  2016255   8:55  THTL
7825  2016255   6:40  2016255   8:55  STL3
7826  2016255   6:40  2016255   8:55  STRK
```