DEGORAS PROJECT

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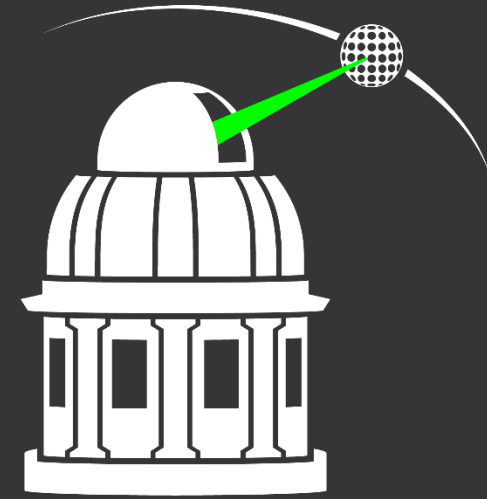
New SLR control system

DEGORAS PROJECT is a new libre modular system designed to meet the needs and tasks of any SLR station. Currently it is still under development.
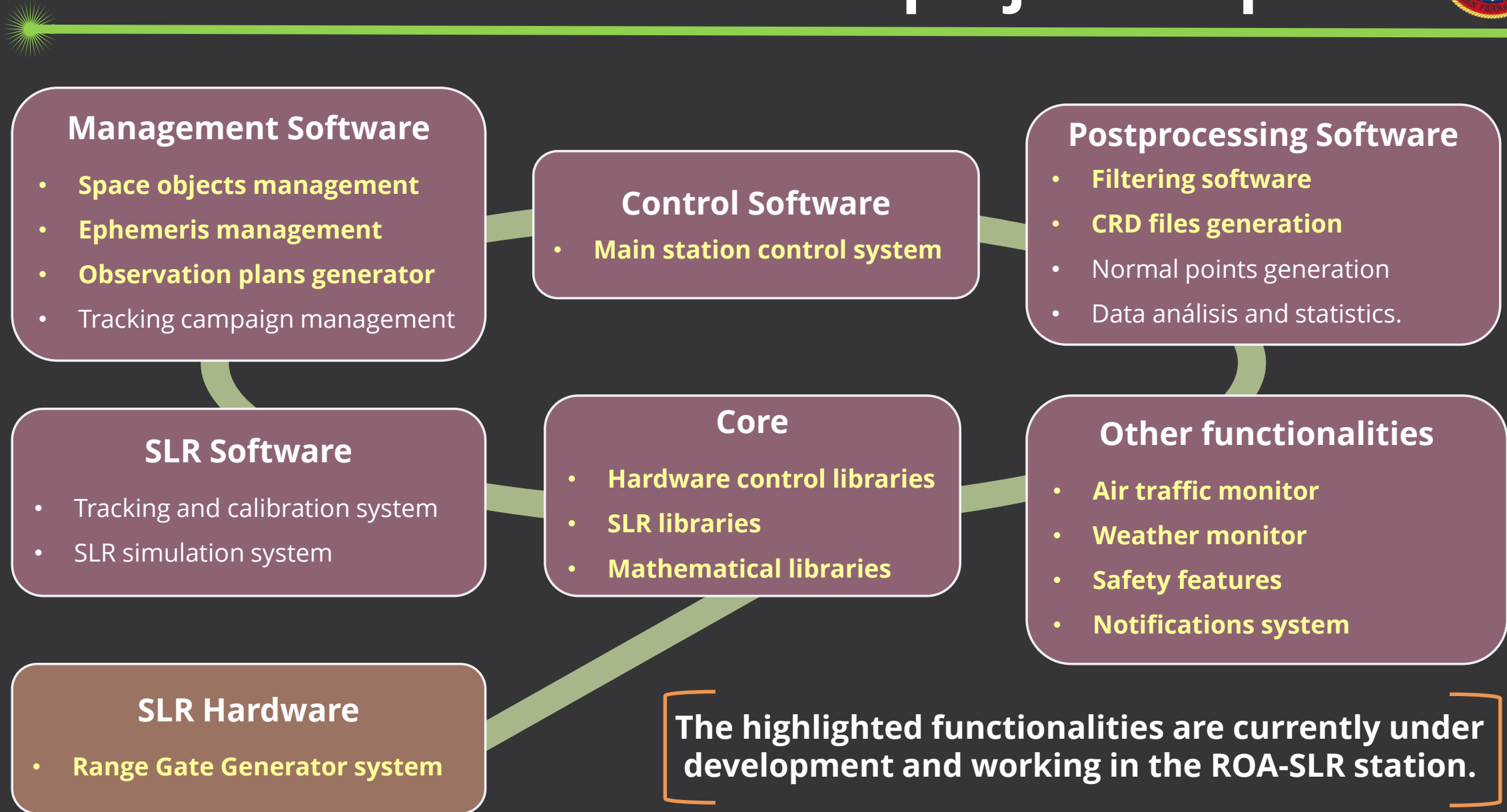
The Project covers software and hardware development.

- Libre software and hardware.

- Adaptable and modular.

- User-friendly for operators, engineers and scientists.

- Improved implementation of SLR algorithms.

- Prepared for space debris tracking.

- Development under Qt5 using C++.

- Communications based on ZMQ.

DEGORAS PROJECT

Functionalities within the project scope

Management Software

- **Space objects management**
- **Ephemeris management**
- **Observation plans generator**
- Tracking campaign management

Control Software

- **Main station control system**

Postprocessing Software

- **Filtering software**
- **CRD files generation**
- Normal points generation
- Data análisis and statistics.

SLR Software

- Tracking and calibration system
- SLR simulation system

Core

- **Hardware control libraries**
- **SLR libraries**
- **Mathematical libraries**

Other functionalities

- **Air traffic monitor**
- **Weather monitor**
- **Safety features**
- **Notifications system**

SLR Hardware

- **Range Gate Generator system**

The highlighted functionalities are currently under development and working in the ROA-SLR station.

Software currently under development

SPACE OBJECTS MANAGER

CPF FILES MANAGER

PREDICTIONS GENERATOR

DEGORAS PROJECT

STATION CONTROL

TRACKING SYSTEM

RANGE GATE GENERATOR MANAGER

ENVIRONMENTAL MONITOR

Software currently under development

SPACE OBJECTS MANAGER

TRACKING SYSTEM

CPF FILES MANAGER

RANGE GATE GENERATOR MANAGER

DEGORAS PROJECT
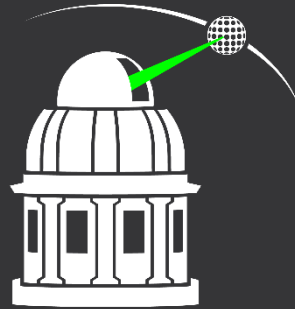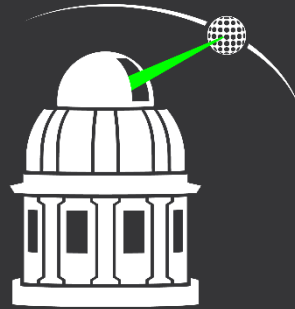
PREDICTIONS GENERATOR

ENVIRONMENTAL MONITOR

STATION CONTROL

Help   Edit   Configuration   Plugins   External Tools

DEGORAS PROJECT

SPACE OBJECTS MANAGER

Space Objects Data Table

EN. POLICY	NORAD	NAME	ILRS NAME	COSPAR	ILRS ID	SIC	CLASSIFICATION	LRR	DEBRIS	TRACK POLICY	PRIOR	CPF	ALTITUDE	RCS	NPI	BS
🟥 Disabled	40129	GALILEO6	GALILEO202	2014-050B	1405002	7202	Galileo	Yes	No	Always	0	All	21605		9	300	5
🟥 Disabled	40128	GALILEO5	GALILEO201	2014-050A	1405001	7201	Galileo	Yes	No	Always	0	All	21605		9	300	5
🟥 Disabled	38858	GALILEOFM4	GALILEO104	2012-055B	1205502	7104	Galileo	Yes	No	Always	0	All	23220	13.22	9	300	5
🟥 Disabled	38857	GALILEOFM3	GALILEO103	2012-055A	1205501	7103	Galileo	Yes	No	Always	0	All	23220	10.355	9	300	5
🟥 Disabled	37847	GALILEOFM2	GALILEO102	2011-060B	1106002	7102	Galileo	Yes	No	Always	0	All	23220	48.772	9	300	5
🟥 Disabled	37846	GALILEOPFM	GALILEO101	2011-060A	1106001	7101	Galileo	Yes	No	Always	0	All	23220	51.378	9	300	5
🟥 Disabled	29656	ETS8	ETS8	2006-059A	0605901	1579	Geostationary	Yes	Yes	Always	0	All	36000	11	9	300	6
🟥 Disabled	20026	COSMOS2024	ETALON2	1989-039C	8903903	4146	Glonass Constellation	Yes	No	Always	0	All	19135	1.259	9	300	6
🟥 Disabled	19751	COSMOS1989	ETALON1	1989-001C	8900103	0525	Glonass Constellation	Yes	No	Always	0	All	19105	1.084	9	300	6
🟩 Enabled	23560	ERS2	ERS2	1995-021A	9502101	6178	Earth Resources, Brightest	Yes	Yes	Always	0	All	800	9.231	3	15	9
🟩 Enabled	21574	ERS1	ERS1	1991-050A	9105001	6177	Earth Resources, Brightest	Yes	Yes	Always	0	All	780	11.009	3	15	
🟩 Enabled	27386	ENVISAT	ENVISAT	2002-009A	0200901	6179	Earth Resources, Brightest	Yes	Yes	Always	0	All	772	19.497	3	15	9
🟩 Enabled	2680	DIADEME2	DIADEME1D	1967-014A	6701401	6704	Space & Earth Science	Yes	Yes	Always	0	All	585	0.637	3	15	3
🟩 Enabled	2674	DIADEME1	DIADEME1C	1967-011A	6701101	6703	Space & Earth Science	Yes	Yes	Always	0	All	545	0.527	3	15	3
🟥 Disabled	36508	CRYOSAT2	CRYOSAT2	2010-013A	1001301	8006	Space & Earth Science	Yes	No	Always	0	All	725	2.97	3	15	
🟥 Disabled	41315	BEIDOU21	COMPASSMS3	2016-006A	1600601	2011	Beidou Navigation System	Yes	Yes	Always	0	All	21500		9	300	5
🟥 Disabled	38250	BEIDOU12	COMPASSM3	2012-018A	1201801	2004	Beidou Navigation System	Yes	No	Always	0	All	21528	5.623	9	300	5
🟥 Disabled	31115	BEIDOU1	COMPASSM1	2007-011A	0701101	2001	Experimental, ...igation System	Yes	Yes	Always	0	All	21500	5.461	9	300	5
🟥 Disabled	40549	BEIDOU17	COMPASSIS1	2015-019A	1501901	2006	Beidou Navigation System	Yes	Yes	Always	0	All	35786		9	300	5
🟥 Disabled	41434	BEIDOU22	COMPASSI6B	2016-021A	1602101	2012	Beidou Naviga...Geostationary	Yes	No	Always	0	All	35677		9	300	5
🟥 Disabled	37948	BEIDOU10	COMPASSI5	2011-073A	1107301	2005	Beidou Navigation System	Yes	No	Always	0	All	35786	7.943	9	300	5
🟥 Disabled	37763	BEIDOU9	COMPASSI4	2011-038A	1103801	2009	Geostationary...gation System	Yes	Yes	Always	0	All	42161	7.943	9	300	5
🟥 Disabled	37384	BEIDOU8	COMPASSI3	2011-013A	1101301	2003	Geostationary...gation System	Yes	No	Always	0	All	35786	25.119	9	300	5

Space Object Picture

Sets Tools

System Set: **DEBRIS ILRS + ROCKETS**
Loaded Set: **DEBRIS ILRS + ROCKETS**

Selected Set: DEBRIS ILRS + ROCKETS ▼

[Set as System Set and load]

[⊕ New Set]   [⊗ Delete Selected]

[⤓ Load Selected]   [💾 Save Selected]

[Set En. Policy]   [Disabled ▼]

Database Tools

[⊕ Add Space Object]

[✎ Edit Selected]   [⊗ Delete Selected]

[⤓ Load Database]

[💾 Save Database]

Enablement Policy: ⦿ All ◯ Enabled ◯ Disabled   Laser Retro Reflector: ⦿ All ◯ With ◯ Without   Debris: ⦿ All ◯ Is ◯ Is not   ILRS: ⦿ All ◯ Is ◯ Is Not   Search: [_____]

Database | Name: **ROASLR_Database_v2**   Date: **2020-08-31 12:29:13 UTC** | Objects | Enabled: **28**   Loaded: **505**   Displayed: **505** | [Deselect All]   [Select All]

CPF FILES MANAGER

DEGORAS PROJECT

CPF FILES MANAGER
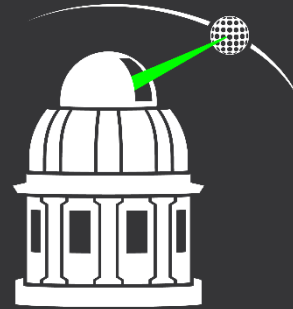
Available CPFs and Space Objects

Current CPFs | Historical CPFs | Space Objects Data Table

	SPACE OBJECT DATA		CONSOLIDATED PREDICITON FORMAT FILEDATA						
NORAD	NAME	ILRS NAME	FILENAME	CREATION TIME	START TIME	END TIME	C. DAYS	R. DAYS	SEQ. NO.
13067	COSMOS1340		7%						
1328	EXPLORER27	BEACONC	1328_cpf_200925_7691.sgf	25-09-2020 02:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 23:57:00 UTC	6.00	4.51	7691
16908	EGS	AJISAI	16908_cpf_200925_7691.sgf	25-09-2020 02:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 23:55:00 UTC	6.00	4.51	7691
			16908_cpf_200925_7691.jax	25-09-2020 03:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 00:00:00 UTC	5.00	3.51	7691
			16908_cpf_200925_7690.sdg	25-09-2020 00:00:00 UTC	25-09-2020 00:00:00 UTC	28-09-2020 00:00:00 UTC	3.00	2.51	7690
			16908_cpf_200924_7681.hts	24-09-2020 12:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 00:00:00 UTC	5.00	3.51	7681
22195	LAGEOS2	LAGEOS2	22195_cpf_200925_7691.sgf	25-09-2020 02:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 23:54:00 UTC	6.00	4.51	7691
27944	LARETS	LARETS	27944_cpf_200925_7691.sgf	25-09-2020 02:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 23:57:00 UTC	6.00	4.51	7691
31698	TERRASARX	TERRASARX	31698_cpf_200925_7691.gfz	25-09-2020 00:00:00 UTC	25-09-2020 00:59:42 UTC	30-09-2020 00:00:42 UTC	4.96	4.51	7691
33105	JASON2	JASON2							
36287	BEIDOU3	COMPASSG1							
36508	CRYOSAT2	CRYOSAT2	36508_cpf_200925_7691.esa	25-09-2020 05:00:00 UTC	25-09-2020 00:00:00 UTC	30-09-2020 00:00:00 UTC	5.00	4.51	7691
36605	TANDEMX	TANDEMX	36605_cpf_200925_7691.gfz	25-09-2020 00:00:00 UTC	25-09-2020 00:59:42 UTC	30-09-2020 00:00:42 UTC	4.96	4.51	7691
37384	BEIDOU8	COMPASSI3	37384_cpf_200919_7631.sha	19-09-2020 00:00:00 UTC	19-09-2020 00:00:00 UTC	27-09-2020 23:55:00 UTC	9.00	2.51	7631
37948	BEIDOU10	COMPASSI5	37948_cpf_200919_7631.sha	19-09-2020 00:00:00 UTC	19-09-2020 00:00:00 UTC	27-09-2020 23:55:00 UTC	9.00	2.51	7631
38077	LARES	LARES	38077_cpf_200925_7691.sgf	25-09-2020 02:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 23:57:00 UTC	6.00	4.51	7691
			38077_cpf_200924_7681.hts	24-09-2020 12:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 00:00:00 UTC	5.00	3.51	7681
38250	BEIDOU12	COMPASSM3	38250_cpf_200919_7631.sha	19-09-2020 00:00:00 UTC	19-09-2020 00:00:00 UTC	27-09-2020 23:55:00 UTC	9.00	2.51	7631
39086	SARAL	SARAL	39086_cpf_200924_7681.cne	24-09-2020 10:00:00 UTC	24-09-2020 00:00:00 UTC	28-09-2020 00:00:00 UTC	4.00	2.51	7681
39451	SWARMB	SWARMB	39451_cpf_200924_7681.esa	24-09-2020 13:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 00:00:00 UTC	5.00	3.51	7681
39452	SWARMA	SWARMA	39452_cpf_200924_7681.esa	24-09-2020 13:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 00:00:00 UTC	5.00	3.51	7681
39453	SWARMC	SWARMC	39453_cpf_200924_7681.esa	24-09-2020 13:00:00 UTC	24-09-2020 00:00:00 UTC	29-09-2020 00:00:00 UTC	5.00	3.51	7681
7646	STARLETTE	STARLETTE							

Total Objects: **20**   Total CPFs: **19**   Total Objects without CPF: **5**   Search: [   ]

Progress

State: **Downloading files from NASA Engine (FTP)...**

File: galileo221_cpf_200925_7691.jgx

File progress: [7%]

Total progress: [51%]

⊘ **Cancel**

Download Sources

Campaigns	S3TOC Engine (SFTP) ▼	**Download**
CPFs	NASA Engine (FTP) ▼	**Download**
TLEs	Celestrak Engine (HTTPS) ▼	**Download**

Discarded Files

_7691.esa - Invalid CPF filename.
ajisai_cpf_200920_7641.dgf - Outdated.
ajisai_cpf_200924_7681.hts - Already exists
ajisai_cpf_200925_7691.jax - Already exists
ajisai_cpf_200925_7691.sgf - Already exists
apollo11_cpf_200925_7681.opa - Bypassed due to filter.
apollo14_cpf_200925_7681.opa - Bypassed due to filter.
apollo15_cpf_200925_7681.opa - Bypassed due to filter.
beaconc_cpf_200925_7691.sgf - Already exists
beidou3m2_cpf_200920_7641.sha - Known disabled object.
beidou3m3_cpf_200920_7641.sha - Known disabled object.
beidou3m0_cpf_200920_7641.sha - Known disabled object.

Clear discarded

Tools

Download from All Sources

Rename All CPFs

Clean Outdated

Delete All Current CPFs

Keep only with extension

Delete by extension

Software currently under development

SPACE OBJECTS MANAGER

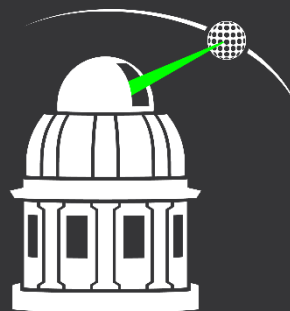TRACKING SYSTEM

CPF FILES MANAGER

RANGE GATE GENERATOR MANAGER

PREDICTIONS GENERATOR
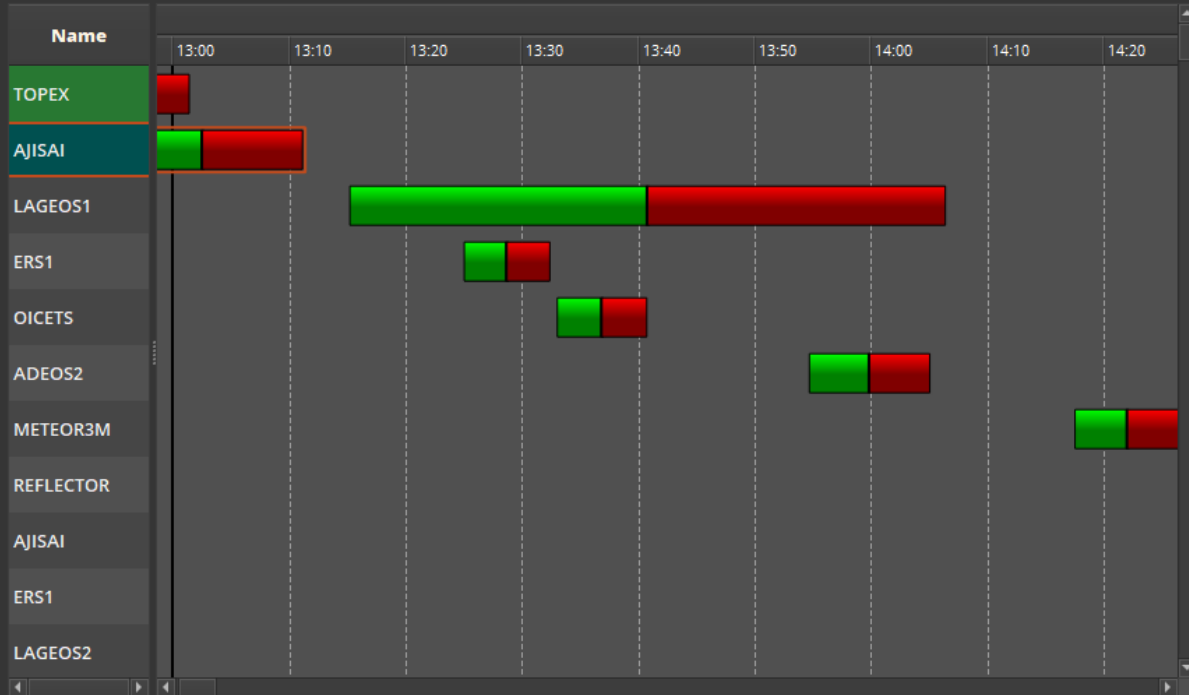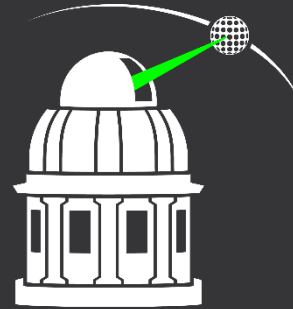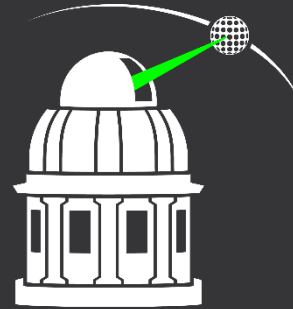
ENVIRONMENTAL MONITOR

DEGORAS PROJECT

STATION CONTROL

PREDICTIONS GENERATOR

Help   Edit   Configuration   Plugins   External Tools

DEGORAS PROJECT — PREDICTIONS GENERATOR

Predictions Calculation Options

Sunset Start (UTC):	21:00	Start Time (UTC):	25-09-2020 11:47	Start Elevation (altitude < 15000 km) (°):	9
Sunset End (UTC):	01:00	End Time (UTC):	30-09-2020 00:00	Start Elevation (altitude >= 15000 km) (°):	40
Dawn Start (UTC):	06:00	Calculation Time (days):	4.50	Minimum Elevation With LRR (°):	20
Dawn End (UTC):	08:00	Interpolation Inc. (s):	10	Minimum Elevation Without LRR (°):	40

Current Predictions Summary

Creation Time: 25-09-2020 11:48:16 UTC
Start Time: 25-09-2020 11:47:57 UTC
End Time: 29-09-2020 23:13:16 UTC
Objects: 13 — Passes: 149 — Excluded: 51

ILRS Normal:	13	Passes:	149
ILRS Debris:	0	Passes:	0
With LLR:	13	Passes:	149
Without LRR:	0	Passes:	0

Campaign Summary

Active Campaign:
Last Opportunities:
Space Object Set:
Total Objects: Total Passes:

CPF Provider Selection And Predictions Generator

Mode: Most current   Provider: All   ☐ Force Provider   ☐ TLE Lowest Priority

NORAD	NAME	ILRS NAME	CPF FILENAME	C. D.	R. D.	T.D.	PROV.	STATE
37948	BEIDOU10	COMPASSI5	37948_cpf_200919_7631.sha	2.50	2.50	9.00	SHA	Finished
38250	BEIDOU12	COMPASSM3	38250_cpf_200919_7631.sha	2.50	2.50	9.00	SHA	Finished
36287	BEIDOU3	COMPASSG1						CPF not found
37384	BEIDOU8	COMPASSI3	37384_cpf_200919_7631.sha	2.50	2.50	9.00	SHA	Finished
13067	COSMOS1340							CPF not found
36508	CRYOSAT2	CRYOSAT2	36508_cpf_200925_7691.esa	4.51	4.51	5.00	ESA	Finished
16908	EGS	AJISAI	16908_cpf_200925_7691.jax	3.51	3.51	5.00	JAX	Finished
1328	EXPLORER27	BEACONC	1328_cpf_200925_7691.sgf	4.51	4.51	6.00	SGF	Finished
33105	JASON2	JASON2						CPF not found
8820	LAGEOS1	LAGEOS1						CPF not found
22195	LAGEOS2	LAGEOS2	22195_cpf_200925_7691.sgf	4.50	4.50	6.00	SGF	Finished
38077	LARES	LARES	38077_cpf_200925_7691.sgf	4.51	4.51	6.00	SGF	Finished
27944	LARETS	LARETS	27944_cpf_200925_7691.sgf	4.51	4.51	6.00	SGF	Finished
39086	SARAL	SARAL	39086_cpf_200924_7681.cne	2.51	2.51	4.00	CNE	Finished
7646	STARLETTE	STARLETTE						CPF not found
39452	SWARMA	SWARMA	39452_cpf_200924_7681.esa	3.51	3.51	5.00	ESA	Finished
39451	SWARMB	SWARMB	39451_cpf_200924_7681.esa	3.51	3.51	5.00	ESA	Finished
39453	SWARMC	SWARMC	39453_cpf_200924_7681.esa	3.51	3.51	5.00	ESA	Finished
36605	TANDEMX	TANDEMX	36605_cpf_200925_7691.gfz	4.51	4.51	4.96	gfz	Finished

Generated Predictions And Space Objects Data

Generated Predictions | Space Objects Data Table

NORAD	NAME	WEEK DAY	DATE	START	MAX. ELE.	END	DUR.	PASS	AZIMUTHS	CPF SOURCE	ampa
38250	BEIDOU12	Friday	25-09-2020	11:47	76 - 12:07	13:45	117	NO/SO	294 261 193	38250_cpf_200919_7631.sha	false
22195	LAGEOS2	Friday	25-09-2020	12:41	74 - 13:14	13:48	67	SO/NE	236 323 55	22195_cpf_200925_7691.sgf	false
16908	EGS	Friday	25-09-2020	13:34	39 - 13:43	13:51	17	NO/NE	307 14 83	16908_cpf_200925_7691.jax	false
27944	LARETS	Friday	25-09-2020	13:59	32 - 14:03	14:08	8	NE/SE	32 98 162	27944_cpf_200925_7691.sgf	false
16908	EGS	Friday	25-09-2020	15:36	84 - 15:46	15:55	19	NO/SE	308 49 127	16908_cpf_200925_7691.jax	false
27944	LARETS	Friday	25-09-2020	15:37	21 - 15:40	15:44	7	NO/SO	341 293 240	27944_cpf_200925_7691.sgf	false
39451	SWARMB	Friday	25-09-2020	16:25	43 - 16:29	16:33	7	SE/NE	158 89 13	39451_cpf_200924_7681.esa	false
38077	LARES	Friday	25-09-2020	16:53	21 - 16:59	17:06	13	SE/NE	144 97 50	38077_cpf_200925_7691.sgf	false
22195	LAGEOS2	Friday	25-09-2020	16:54	63 - 17:28	18:04	69	NO/SE	295 21 106	22195_cpf_200925_7691.sgf	false
31698	TERRASARX	Friday	25-09-2020	17:37	42 - 17:41	17:45	7	SE/NE	146 75 1	31698_cpf_200925_7691.gfz	false
36605	TANDEMX	Friday	25-09-2020	17:37	42 - 17:41	17:45	7	SE/NE	146 75 1	36605_cpf_200925_7691.gfz	false
16908	EGS	Friday	25-09-2020	17:39	28 - 17:47	17:54	15	NO/SE	290 235 178	16908_cpf_200925_7691.jax	false
39086	SARAL	Friday	25-09-2020	17:54	31 - 17:59	18:04	9	NE/SE	34 96 160	39086_cpf_200924_7681.cne	false
39453	SWARMC	Friday	25-09-2020	18:22	61 - 18:26	18:29	6	NO/SO	352 276 189	39453_cpf_200924_7681.esa	false
39452	SWARMA	Friday	25-09-2020	18:23	54 - 18:26	18:29	6	NO/SO	349 271 192	39452_cpf_200924_7681.esa	false
38077	LARES	Friday	25-09-2020	18:47	74 - 18:56	19:05	18	SO/NE	209 295 20	38077_cpf_200925_7691.sgf	false
39086	SARAL	Friday	25-09-2020	19:34	27 - 19:38	19:43	8	NO/SO	349 293 233	39086_cpf_200924_7681.cne	false
36508	CRYOSAT2	Friday	25-09-2020	20:00	24 - 20:04	20:09	8	NE/SE	32 86 144	36508_cpf_200925_7691.esa	false
22195	LAGEOS2	Friday	25-09-2020	21:01	55 - 21:33	22:06	64	NO/SE	311 243 170	22195_cpf_200925_7691.sgf	false

Clear Predictions   Generate Predictions   Save Predictions   ☐ Automatic notifications   Send Notifications   Search:

External Tools

DEGORAS PROJECT

STATION CONTROL

Planning

Name
TOPEX
AJISAI
LAGEOS1
ERS1
OICETS
ADEOS2
METEOR3M
REFLECTOR
AJISAI
ERS1
LAGEOS2

13:00　13:10　13:20　13:30　13:40　13:50　14:00　14:10　14:20

Go to Current Time　■ Real Time　■ Pass Notices

WEEKDAY	DATE	NAME	NORAD	LRR	DEBRIS	START TIME	MAX. ALT.	END TIME	PASS	AZIMUTHS
Monday	28-09-2020	TOPEX	22076	Yes	Yes	12:48h	24 - 12:54h	13:01h	↻ SO/NE	262 315 10
Monday	28-09-2020	AJISAI	16908	Yes	No	12:53h	40 - 13:02h	13:11h	↻ NO/NE	307 17 86
Monday	28-09-2020	LAGEOS1	8820	Yes	No	13:15h	35 - 13:40h	14:06h	↻ SO/NO	194 257 324
Monday	28-09-2020	ERS1	21574	Yes	Yes	13:24h	21 - 13:28h	13:32h	↺ SE/NE	115 65 15
Monday	28-09-2020	OICETS	28809	Yes	Yes	13:32h	47 - 13:36h	13:41h	↻ NE/SE	24 99 175
Monday	28-09-2020	ADEOS2	27597	Yes	Yes	13:54h	87 - 13:59h	14:05h	↻ SE/NO	166 271 346
Monday	28-09-2020	METEOR3M	27001	Yes	Yes	14:17h	20 - 14:22h	14:26h	↻ NE/SE	45 93 142
Monday	28-09-2020	REFLECTOR	27005	Yes	Yes	14:27h	40 - 14:42h	14:49h	↻ NE/SE	20 98 160

Control Cameras

Laser Room

Working Mode

STOP

SYSTEM WARM

WAIT

CALIBRATION

TRACKING

MINIMUM ENERGY	MAXIMUM ENERGY
MANUAL CONTROL	ADJUSTMENT

Laser System State

Connections

Laser Device:	Yes	Calibration Flipper:	Yes
Filter Wheel:	Yes	Motorized Stage:	Yes

Configuration and State

Laser State:	Fire On	Laser Mode:	Max
Laser Warm:	Warmed Up	Laser Amplification	1%
Sync Mode:	External	Calibration Filter:	No
Cooling 1:	24.79°C	Filter Wheel Positio	No. 1
Cooling 2:	24.88°C	Stagel Position:	0/-108

Station State

Controller State: Connected	Laser State: CONNECTED

Laser System Plugins

Controller ROAN_317 (ns)　Connect　Disconnect

Laser Fire

Tiro Permitido　More Info.

Start Firing　　Stop Firing

Range Gate Config

| 500 ns	Send Upper Offset
-500 ns	Send Lower Offset
0 ns	Send Time Bias
0 ns	Send Custom Delay
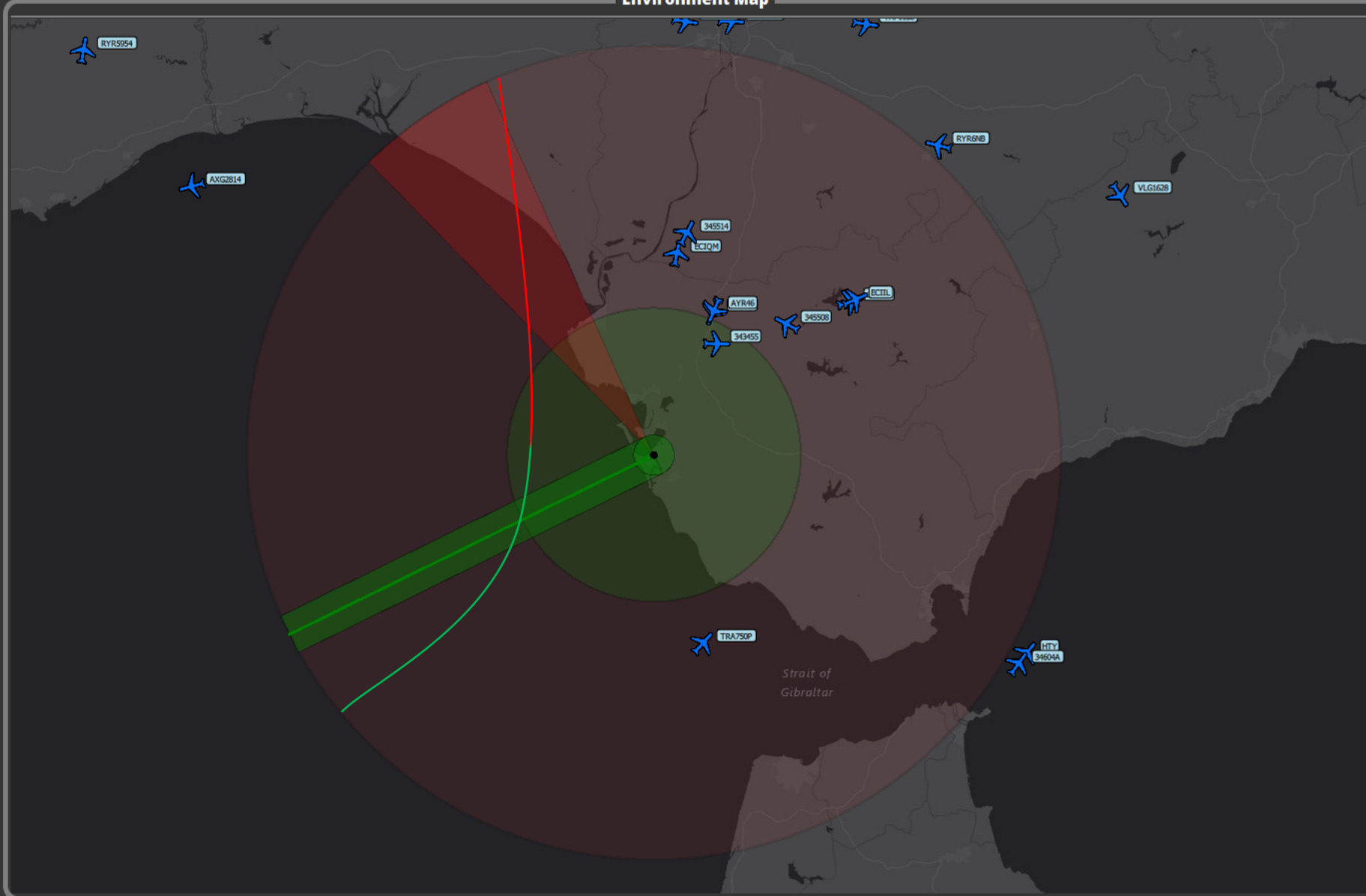
Hardware currently under development

DEGORAS Range Gate Generator (DRGG)

o Free Software/Hardware.

o Gating accuracy < 10 ns.

o Dynamic configuration.

o Fully configurable and modular.

o Intel Cyclone SoC V SX SoC (FPGA + ARM Cortex-A9 MPCore processor).

o Development using VHDL and C++.

o   Uses CPF files internally to interpolate range gate at a given time.
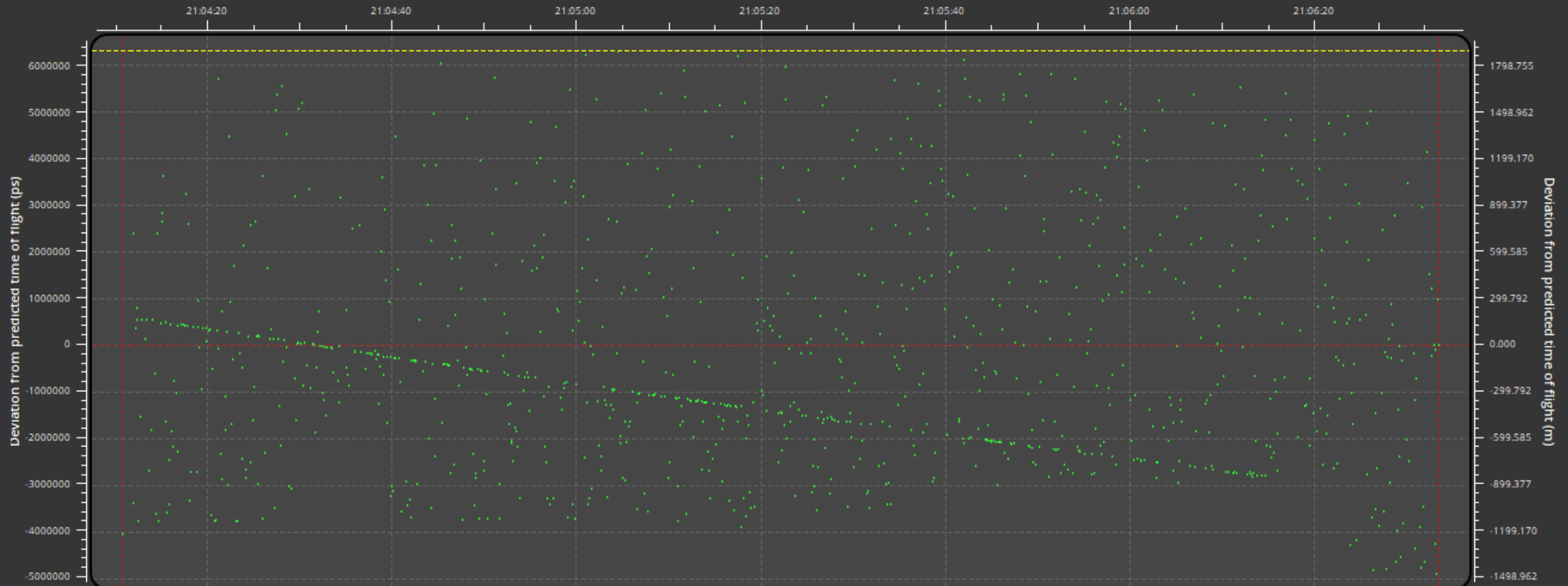
DRGG functional block diagram
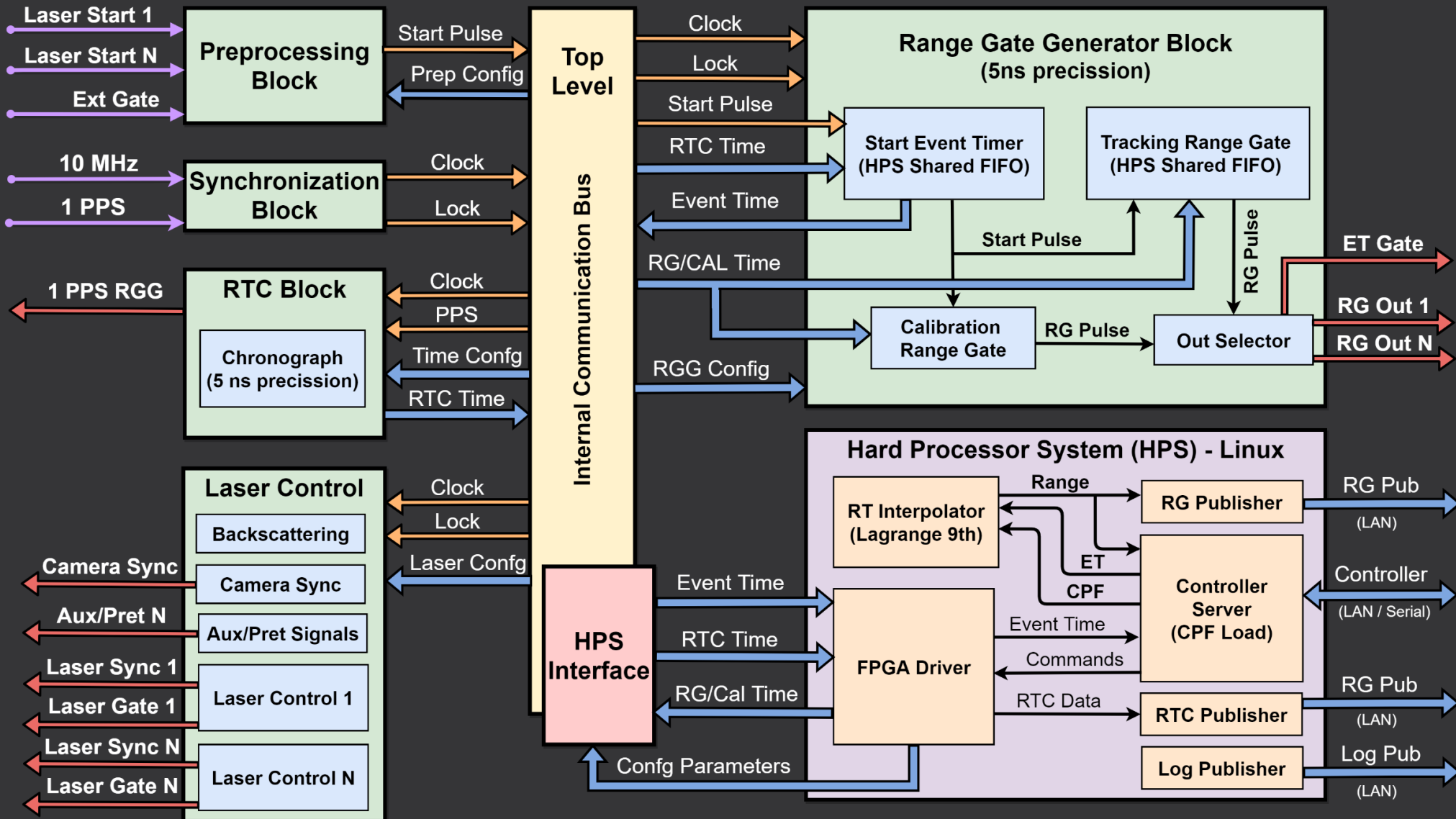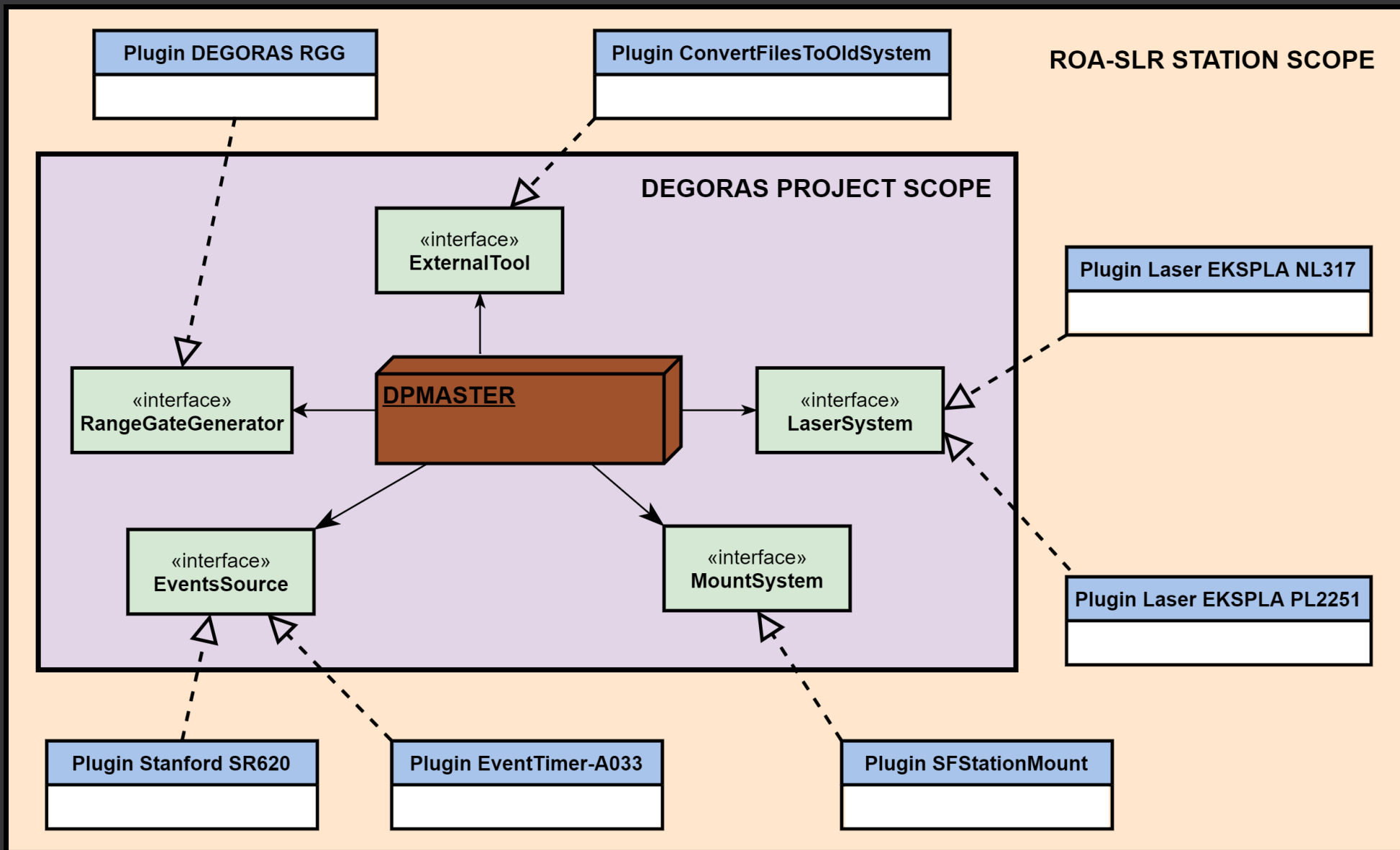
Space debris without LRR tracking

- Target: SL16 Rocket Body - NORAD ID 19120 - RCS 10.673 m²
- Laser: EKSPLA NL317-SH - 10 Hz - 532 nm - 6 ns pulse - 25 W
- Post-processing RMS: 5.8 m

Tracking result using our developed DRGG and software, connected to the old system of the ROA-SLR Station

Adaptability scenario

Aims of the Project

o Replace the remaining old components of the ROA-SLR station using this Project.

o Make DRGG compatible with KHz' s systems.

o Continue working in the development of Degoras Project.

Let's get in touch!

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- jrelinque@roa.es

Any questions?

F. Della Prugna & A. Vera Herrera

Updates at GRSM

NESC Meeting
30/09/2020

Monitoring the invariant point and the impact of temperature change.

Two system implemented:
a crown of corner cube in 2019 / an automated rotating corner cube in 2020
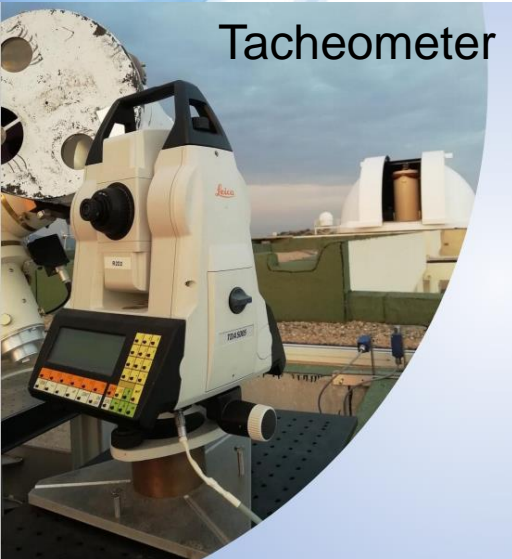
Tacheometer

Couronne de prismes
Mesure de l'axe d'azimut

Prismes pendulaires
Mesure de l'axe d'élévation

Photos: Mémoire M. Germerie - 2019

Mise en place

Capteur initialisation — Coin de cube

Moteur pas à pas

Boîtier avec circuit Arduino
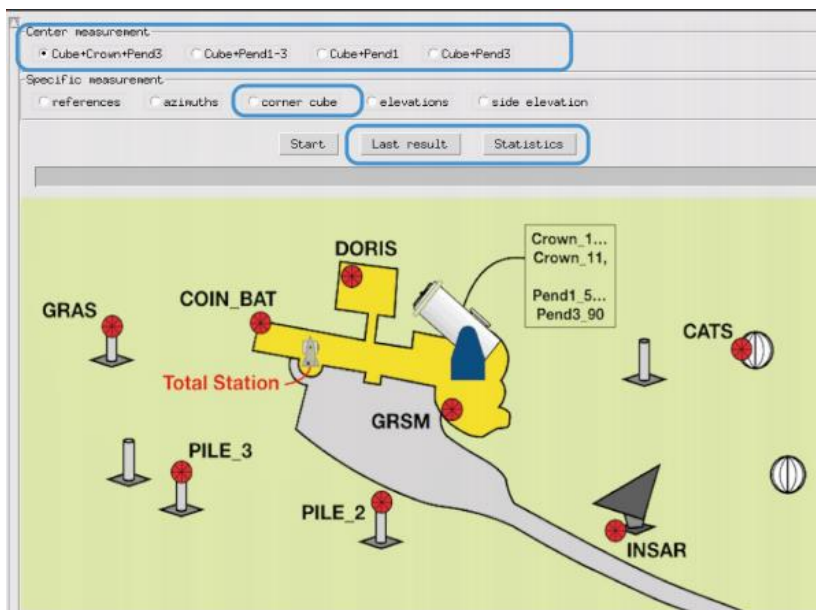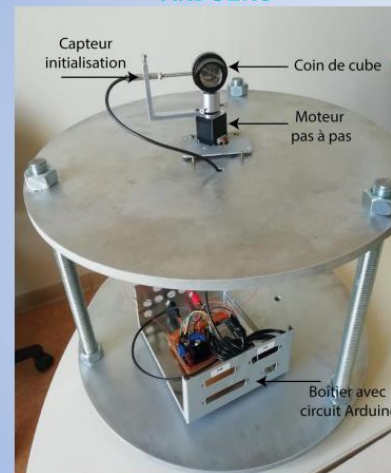
Coin de cube motorisé, sur son support

Coin de cube motorisé

Couronne de prismes
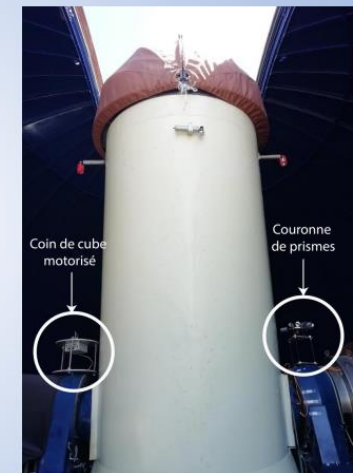
Disposition sur le télescope

Monitoring the invariant point and the impact of temperature change.

Difference on the determination of the azimuth axis between the 2 technics

Residuals from circular regression
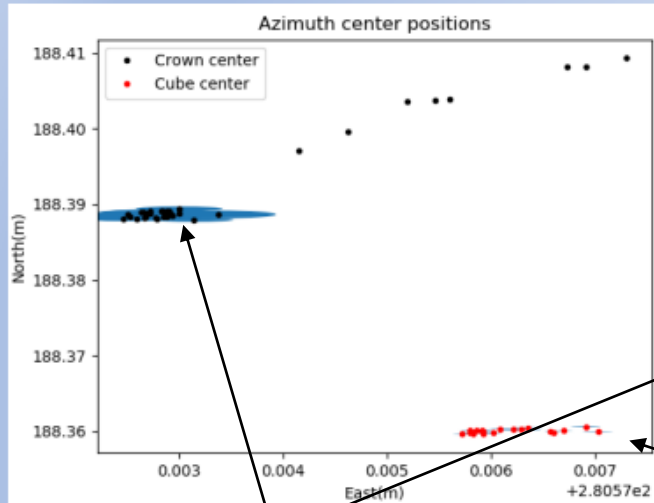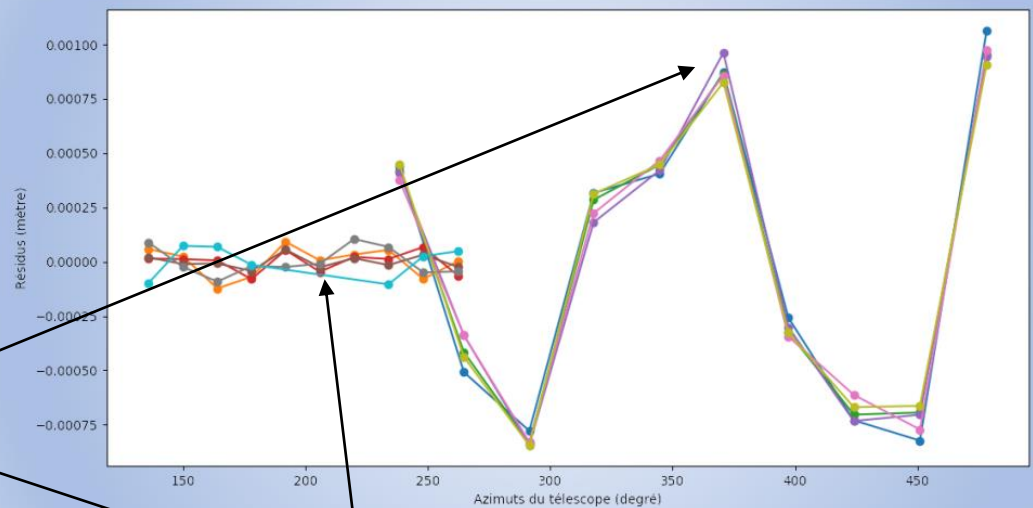
With the crown

With the rotating cc

Results:
- Residuals from circular regression with the crown are 10 times bigger than ones with the rotating cc
- With the rotating cc, residuals are about the tenth of mm
- Automation of the entire treatment chain
- Determination of the center

High count rate SLR

New laser integration
COHERENT Hyper-rapid NXT:
100 W, 400 kHz, 250 µJ/pulse, 12 ps FWHM

Big step from 10 Hz to 400 kHz

$\Rightarrow$ Different problems with software and
  event-timer

Figure 1: location of safety labels laser head - front
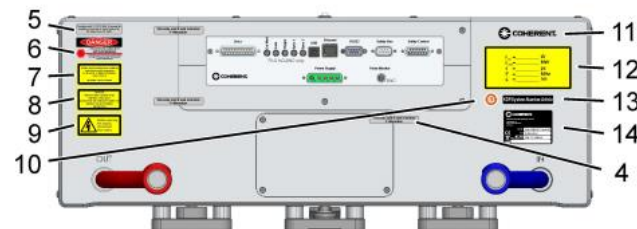
Figure 2: location of safety labels laser head - rear

How do you manage the communication between the PC and the
event-timer to avoid the lost of data during the data transfer ?

Implementation of a new clock:
T4S passive H-maser

pHMaser 1008
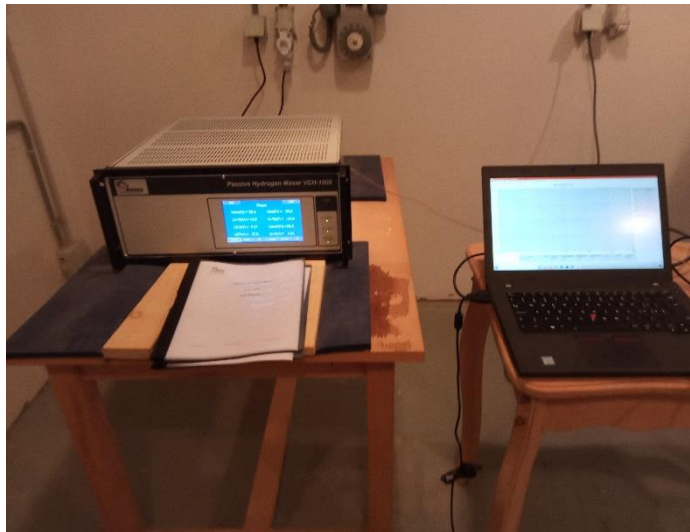
FREQUENCY STABILITY

Allan Deviation	
1Hz bandwidth	
1 s	$5 \cdot 10^{-13}$
10 s	$2 \cdot 10^{-13}$
100 s	$5 \cdot 10^{-14}$
1 h	$9 \cdot 10^{-15}$
1 d	$4 \cdot 10^{-15}$

PHASE NOISE

Output Hz	5 MHz [dBc/Hz]
1	-105
10	-130
100	-145
1k	-155

ENVIRONMENTAL

Temperature sensitivity	$<2 \cdot 10^{-14}$ /°C
Magnetic sensitivity	$<4 \cdot 10^{-14}$/G

OUTPUTS

Sine 50 Ω / 1Vrms ± 0.2				
5 MHz	10 MHz	100 MHz	1 MHz	2.048 MHz
2	2	1	1	1 (square)

60 k€

One publication

Mazarico, E., Sun, X., Torre, J. M., Courde, C., Chabé, J., Aimar, M., ... & Cremons, D. R. (2020). First two-way laser ranging to a lunar orbiter: infrared observations from the Grasse station to LRO's retro-reflector array. *Earth, Planets and Space*, *72*(1), 1-14.

The 2020 Updates of Wuhan SLR Station

Jie Zhang，*Bobi Peng*，*Xinghua Hao*

Innovation Academy for Precision Measurement Science and Technology, CAS

Wuhan National Geodetic Observatory, Jiu Feng SLR station (JFNL)

CONTENTS

1. System introduction

1.1 Basic information

We began the research of laser ranging and related technologies from 1970s at Wuhan SLR station，and the first SLR system (7231) is a 60cm aperture telescope. A new 1m aperture telescope (7396) was built in 2018, and this SLR system obtained the first ranging data at September 28, 2018.

1.2 Key performance

- **Fork mount**

Maximum speed: 10^0/s (AZ), 5^0/s (EL).

Maximum acceleration: 1^0/s^2 (AZ), 0.5^0/s^2 (EL).

Track accuracy: <1″.

Pointing accuracy: <3″.

- **Telescope**

1010mm aperture.

10 arcminute receiving view.

- **Laser**

1kHz to 4kHz repetition rate

2.5mJ per pulse

2.1 Passes and Ranging Precision

LAGEOS RMS
(2019-09-01 to 2020-08-31)

JFNL SLR
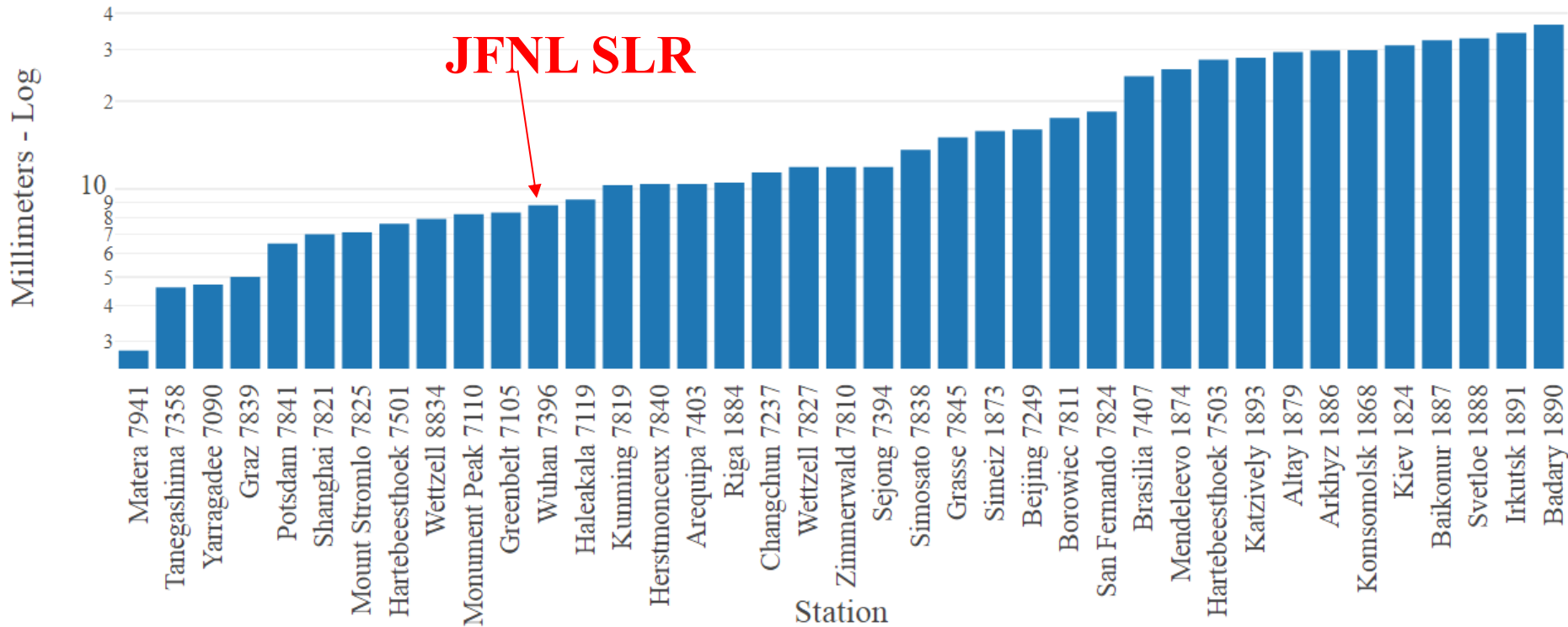
Problem:
Calibration mean value of target is not stable.

Improvement :
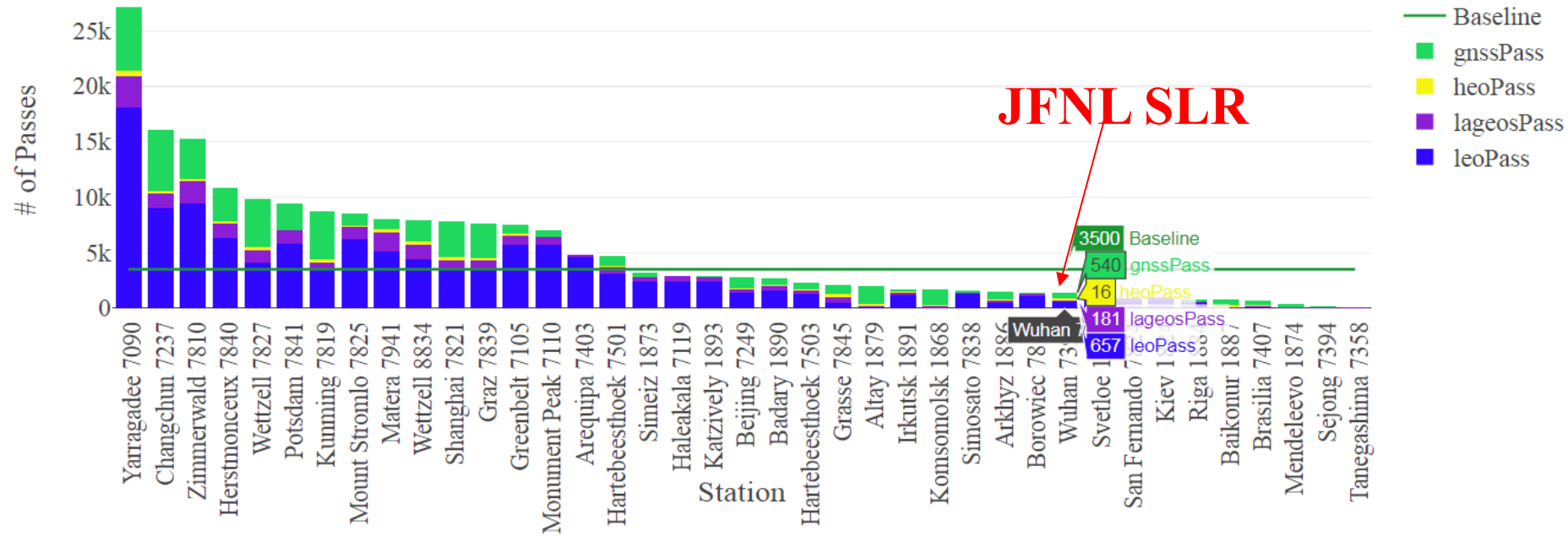Replace better stable cable for echoes signal, and monitor laser energy

2.1 Passes and Ranging Precision

Total Number of Passes (All Satellites)
(2019-09-01 to 2020-08-31)

Problem:
Ranging passes is little.

Solution:
Employ two full-time observers

JFNL SLR

Legend:
- Baseline
- gnssPass
- heoPass
- lageosPass
- leoPass

3500 Baseline
540 gnssPass
16 heoPass
181 lageosPass
657 leoPass

Wuhan

# of Passes

Station

Stations: Yarragadee 7090, Changchun 7237, Zimmerwald 7810, Herstmonceux 7840, Wettzell 7827, Potsdam 7841, Kunming 7819, Mount Stromlo 7825, Matera 7941, Wettzell 8834, Shanghai 7821, Graz 7839, Greenbelt 7105, Monument Peak 7110, Arequipa 7403, Hartebeesthoek 7501, Simeiz 1873, Haleakala 7119, Katzively 1893, Beijing 7249, Badary 1890, Hartebeesthoek 7503, Grasse 7845, Altay 1879, Irkutsk 1891, Komsomolsk 1868, Simosato 7838, Arkhyz 1886, Borowiec 78, Wuhan 73, Svetloe 1, San Fernando, Kiev 1, Riga 1, Baikonur 188, Brasilia 7407, Mendeleevo 1874, Sejong 7394, Tanegashima 7358

2.2 Renew Laser (20200830)

Power of PI laser is not stable which lead to the precision degradation of ranging.
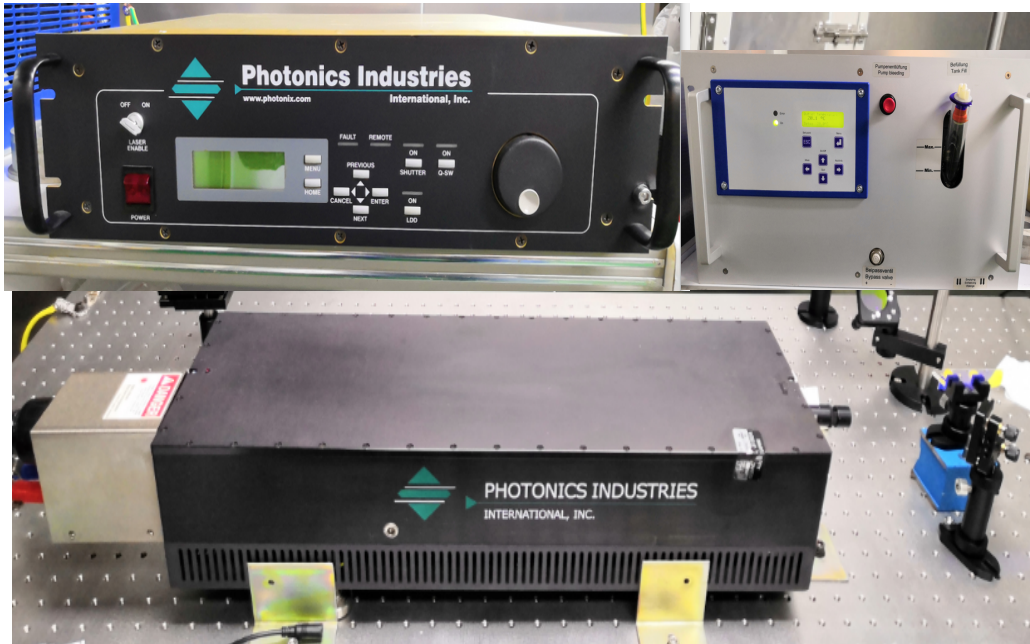
1mj@pulse, 1kHz Laser
Photonics industries

2.5mj@pulse, 1kHz~4kHz Laser
Daheng Optics

2.3 Renew time and frequency equipment

The clock of Endrun had the problem about time stamp, and GNSS rubidium clock of GTS-P1901 made by ourself was used from 2020-06-19 to 2020-08-30.

Meridian II	US-Rubidium	HS-OCXO
short-term stability	1.5E-11/1s	1.0E-12/1s
	5E-12/10s	1.3E-12/10s
	1.4E-12/100s	1.7E-12/100s
Time Accuracy	< 10ns	

GTS-1901	Rubidium
short-term stability	1.7E-12/1s
	5.3E-13/10s,
	1.6E -13/100s
Time Accuracy	< 8ns (SD)
Short baseline Synchronization	<1ns (SD)

3. Technical Research

3.1 Time measurement

3. Technical Research

3.2 Data process

Precise orbit determination based on SLR ranging data, calculation of station coordinates and so on.

	X	Y	Z
SHAO (201903-201904)	-2279756.003	5004737.465	3219791.640
Prof. Toshimichi Otsubo (201907-201909)	-2279755.6807	5004737.4341	3219791.7385
Wuhan SLR station (201907)	-2279755.6905	5004737.4123	3219791.7292

Thanks for your attention

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Things about Changchun Station 7237

Changchun Station 7237 - Recent Events

- Refurbished 60-cm telescope
  - Repainted the outside to white
  - Wrap up cables

- Hired new staffs as operator

Changchun Station 7237 - Development Plans

- Upgrade major equipment:
  - laser, timing devices, single photon detector
  - change to 2kHz for regular operation
  - the upgrade will be done gradually from 2021 to 2022
  - implement better calibration target and procedure

- Improve stability of calibration

Changchun Station 7237 - Problems

- Better or newer type of single photon detector
- Need more guidelines towards millimeter precision
  - For example, the normal-point guidelines may need more lines for kHz
  - Need more detailed standard for calibration instruments and operations