Brazil and Russia space cooperation: recent projects and future perspectives in the field of GNSS monitoring and SLR stations

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Outline

Presentation outline:

- GLONASS measuring ground stations;
- GLONASS at UnB – 1st referential station in Latin America:
  - Introduction;
  - Measuring ground station capability;
  - Current work at ground station;
  - R&D GLONASS data network;
  - Cooperative activities;
  - Current research and future perspectives.
- Final remarks.

GLONASS Measuring Ground Stations

GLONASS stations in Brazil

- GLONASS Differential Correction Station starts operation in 2013 at the University of Brasília.

GLONASS Measuring Ground Stations

GLONASS stations in Brazil

- GLONASS Quantum Optical Station with OWS starts operation in 2014.

GLONASS at UnB - Introduction

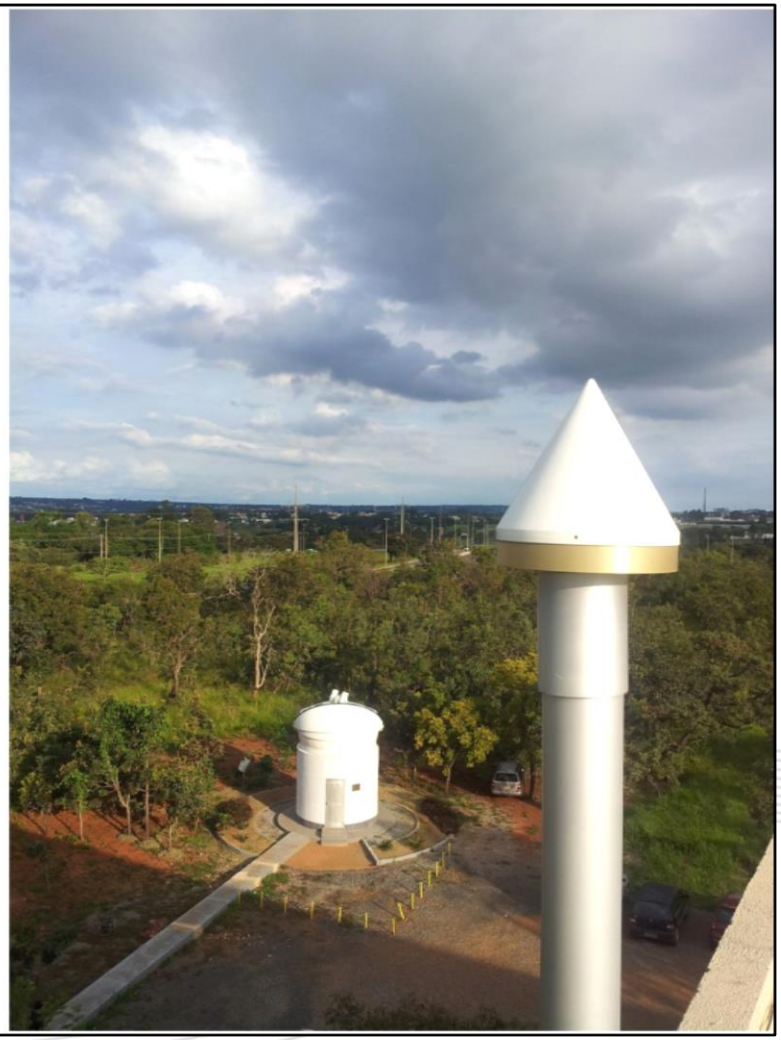
Timeline Overview:

- **2006** - Brazilian and Russian governments signed an agreement to install GLONASS reference and monitoring stations in Brazilian territory;
- **2012** - Brazilian Space Agency elected University of Brasília to receive the first station;
- **2013** - GLONASS Differential Correction Station starts operation;
- **2014** - GLONASS Quantum Optical Station with OWS starts operation.

GLONASS at UnB – Ground Station Capability

OWS and LRS:

- L1 and L2 GNSS receiver MS-GLONASS IBPA.464346.003 (BRAJ station);
- IRLS Site Code BRAL, Station #7407, DOMES #48081S001, 15.7731 S, 132.1347 W;

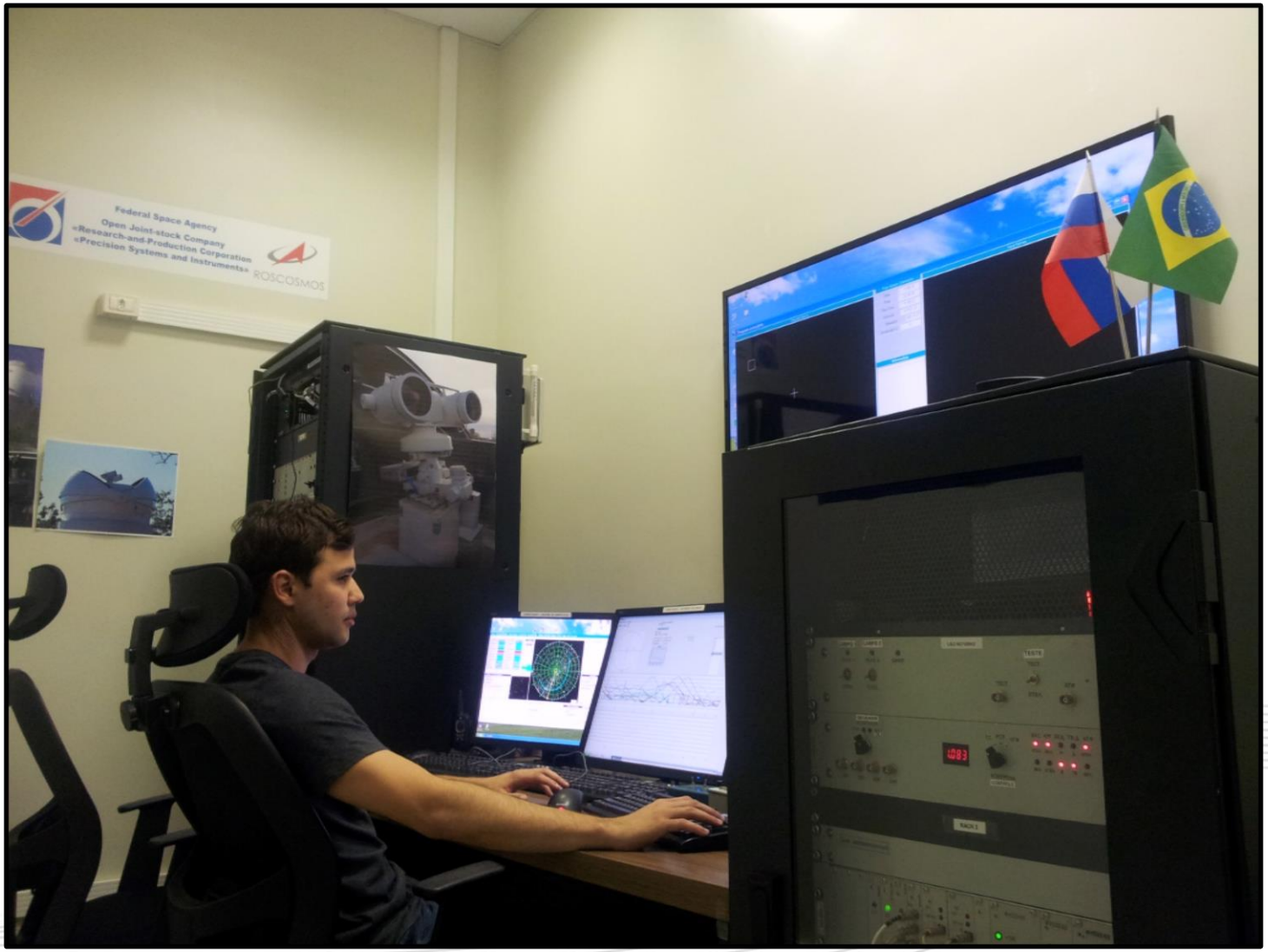


GLONASS at UnB – Ground Station Capability

Laser operation and data transfer server technical room

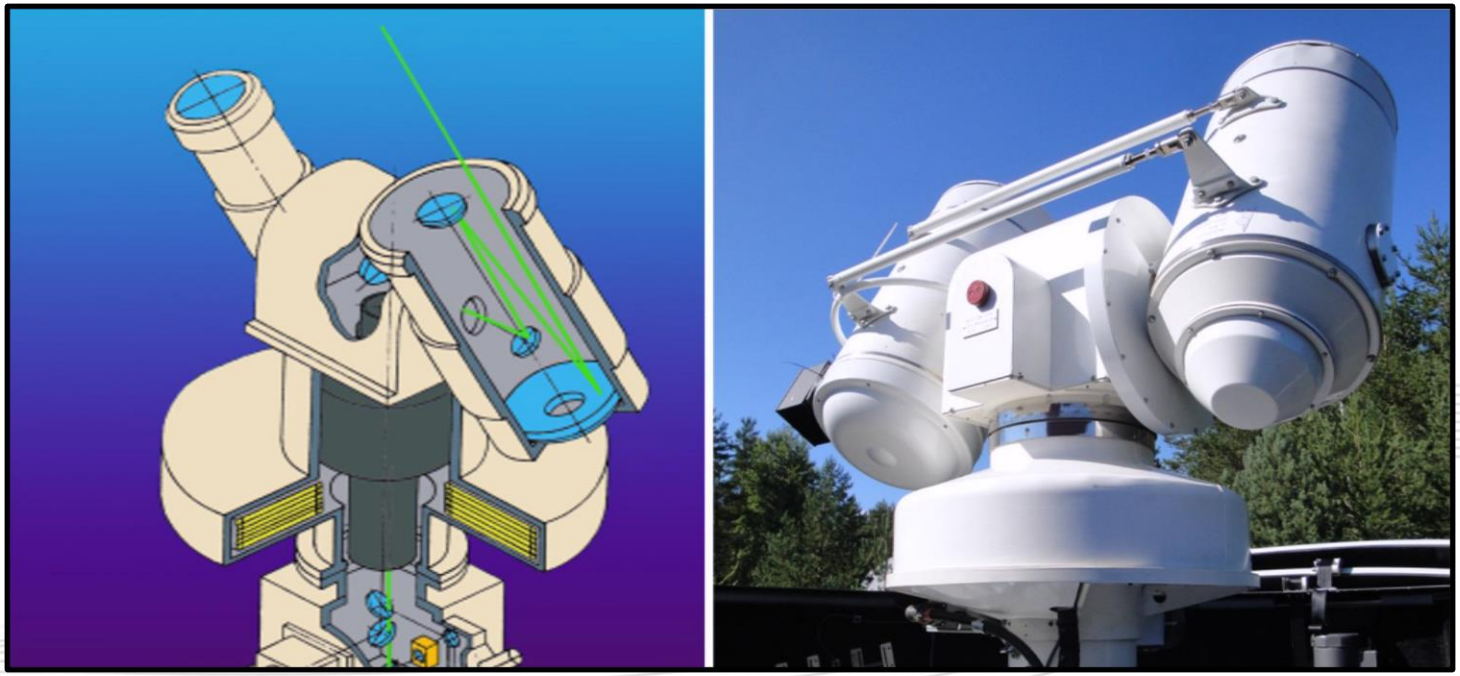
GLONASS at UnB – Ground Station Capability

Laser operation and data transfer server technical room



GLONASS at UnB – Ground Station Capability

Compact Laser-Optical System for SLR, Angular Measurements and Photometry
Mount type Az-El, with two flanges for equipment mounting
Digitally controlled torque motor drive
Equipment weight on each mount flange less than 20 kg
Angular elevation rotation range from 0 to 90 degrees
Angular azimuth rotation range from -270 to 270 degrees
Maximum angular speed and acceleration are 30 deg/s and 5 deg/s^2



GLONASS at UnB – Ground Station Capability

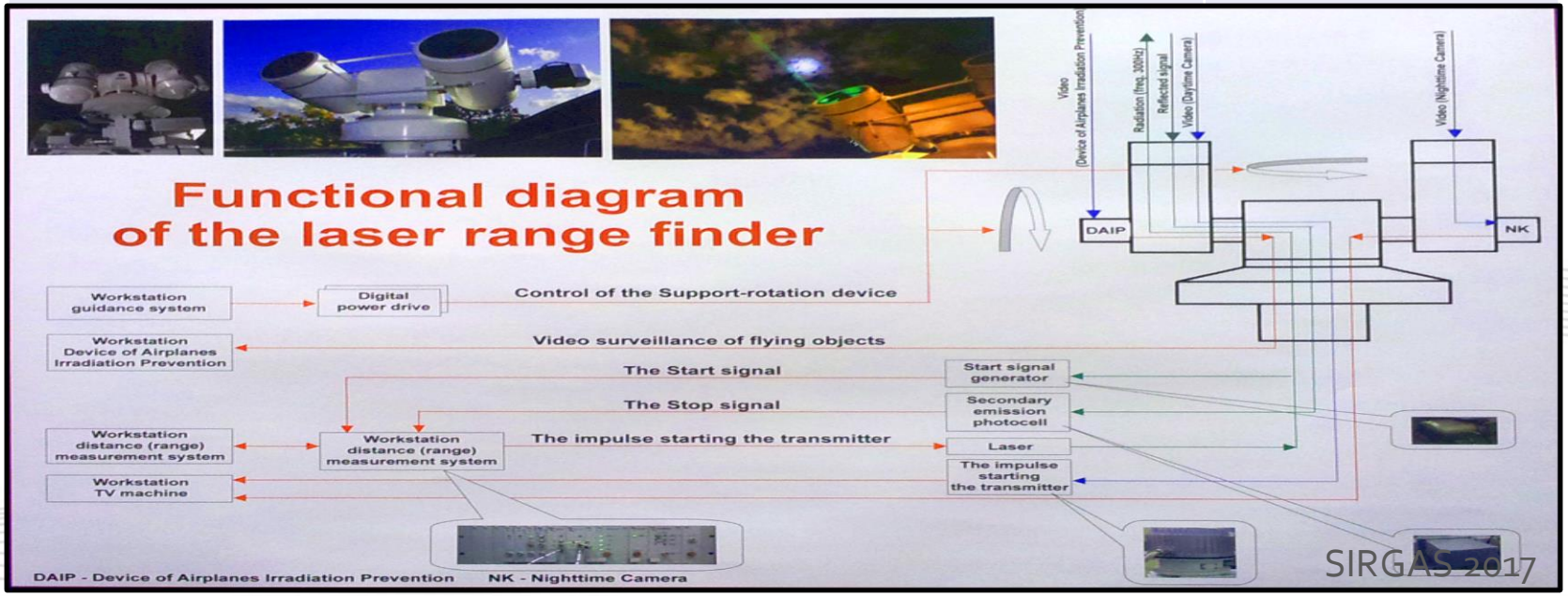
Compact Laser-Optical System Parameters: SLR of SC with retroreflectors	
Parameter Description	**Feature**
SC orbit height range	400 to 36000 km
Orbit height for SC daytime measurements	400 to 6000 km
NP RMS error (averaging interval 60s)	0.5 to 2 cm
Elevation range	20 to 85 degrees

Compact Laser-Optical System Parameters: Angular measurements	
Parameter Description	**Feature**
Visual star magnitude	less than 14^m
RMS error for SC angular velocity up to 40 arcsec	2''

Compact Laser-Optical System Parameters: Photometry	
Parameter Description	**Feature**
Visual star magnitude	less than 12^m
Brightness determination error	0.2^m

GLONASS at UnB – Ground Station Capability

Laser Ranging System Parameters	
Parameter Description	**Feature**
Operation wavelength	532 nm
Pulse repetition rate	300 Hz
Laser pulse duration	150 ps
Minimum laser pulse energy	2 mJ
Output beam divergence	5 arcsec
Receive telescope diameter	25 cm
Laser fire epochs accuracy	200 ns



GLONASS at UnB – Ground Station Capability

One Way GNSS Measurement Station
Double frequency GNSS precise receiver model MS-GLONASS IBPA.464346.003
RingAnt-G3T Javad antenna
Signal tracking of GLONASS and GPS satélites in the visibility zone of the station
Measurements of GLONASS and GPS code pseudoranges and Doppler increments of distance and carrier frequency
Record of observation and navigation messages in RINEX format

GLONASS at UnB – Current Work at Ground Station

Current work at the GLONASS measuring ground station:

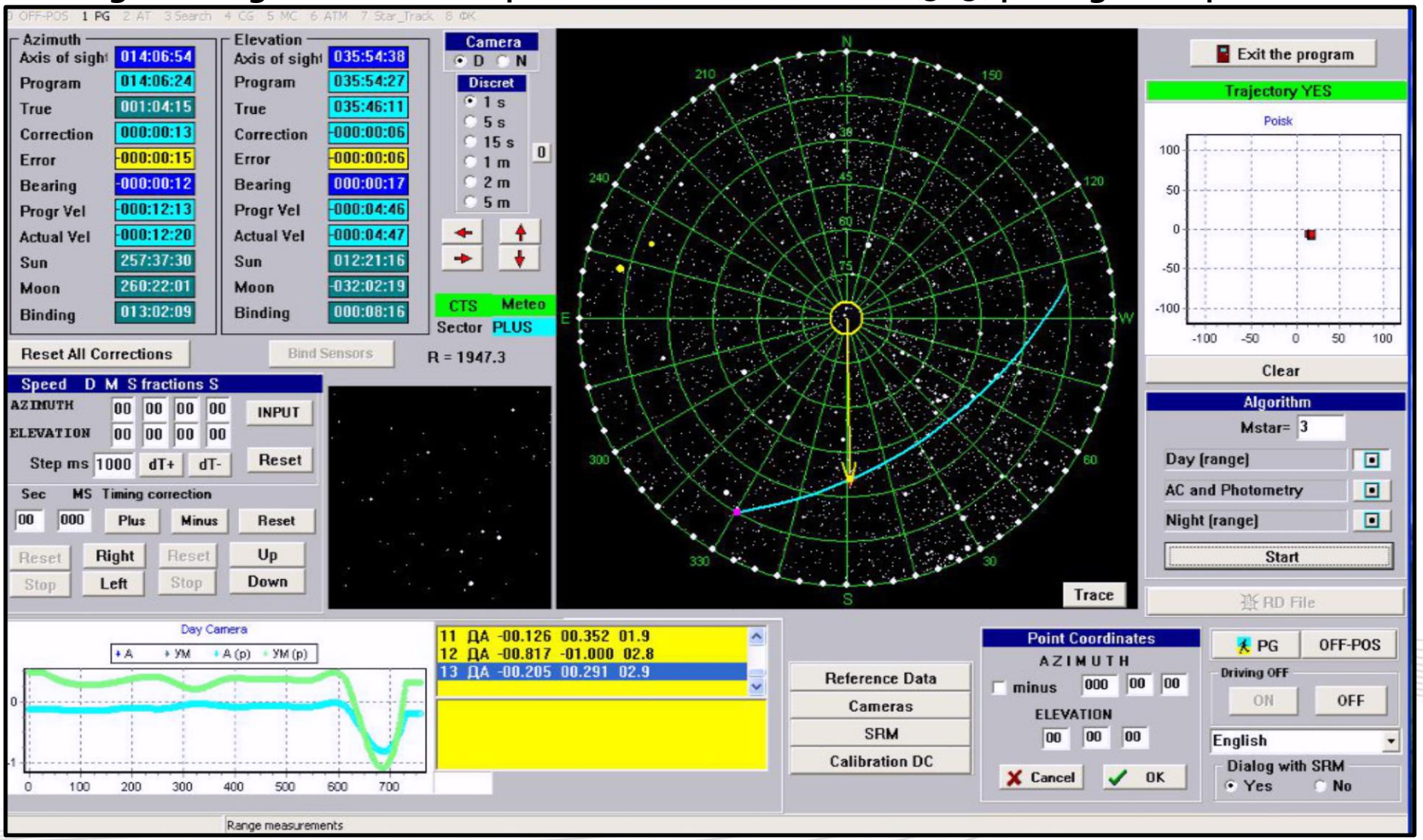
- Technical team training;
- Software and hardware update;
- Seminars about the GLONASS system and the UnB QOS;
- Authorities visits and technical tours at the station;
- Support to Russian teams visiting the station for maintenance and upgrade in the system;
- Carrying out regular sessions of measurements following the program of the Russian company (24/7 work);

Sample of the work done on April 4th 2016 – 40 success out of 74 tries.

Satellite number	Start time	Stop time	Reflected signal	Amount reflected	RMS	Calibration (%)	Trajectory		
							Rising	Zenith	Downward
551	02:33	02:43		244	3.14	9%			
859	02:49	03:02		-	-	9%			
744	03:08	03:25		-	-	8%			
742	03:28	03:34		334	4.13	9%			
716	03:49	04:03		-	-	9%			
715	04:09	04:20		206	3.44	9%			
744	04:25	04:33		182	3.44	9%			
990	04:36	04:43		2932	2.83	9%			
736	04:45	04:50		286	3.20	9%			
551	04:53	05:12		197	2.70	9%			
734	05:15	05:27		218	4.07	9%			
716	05:29	05:42		471	3.71	9%			
742	05:47	05:54		1029	3.30	9%			

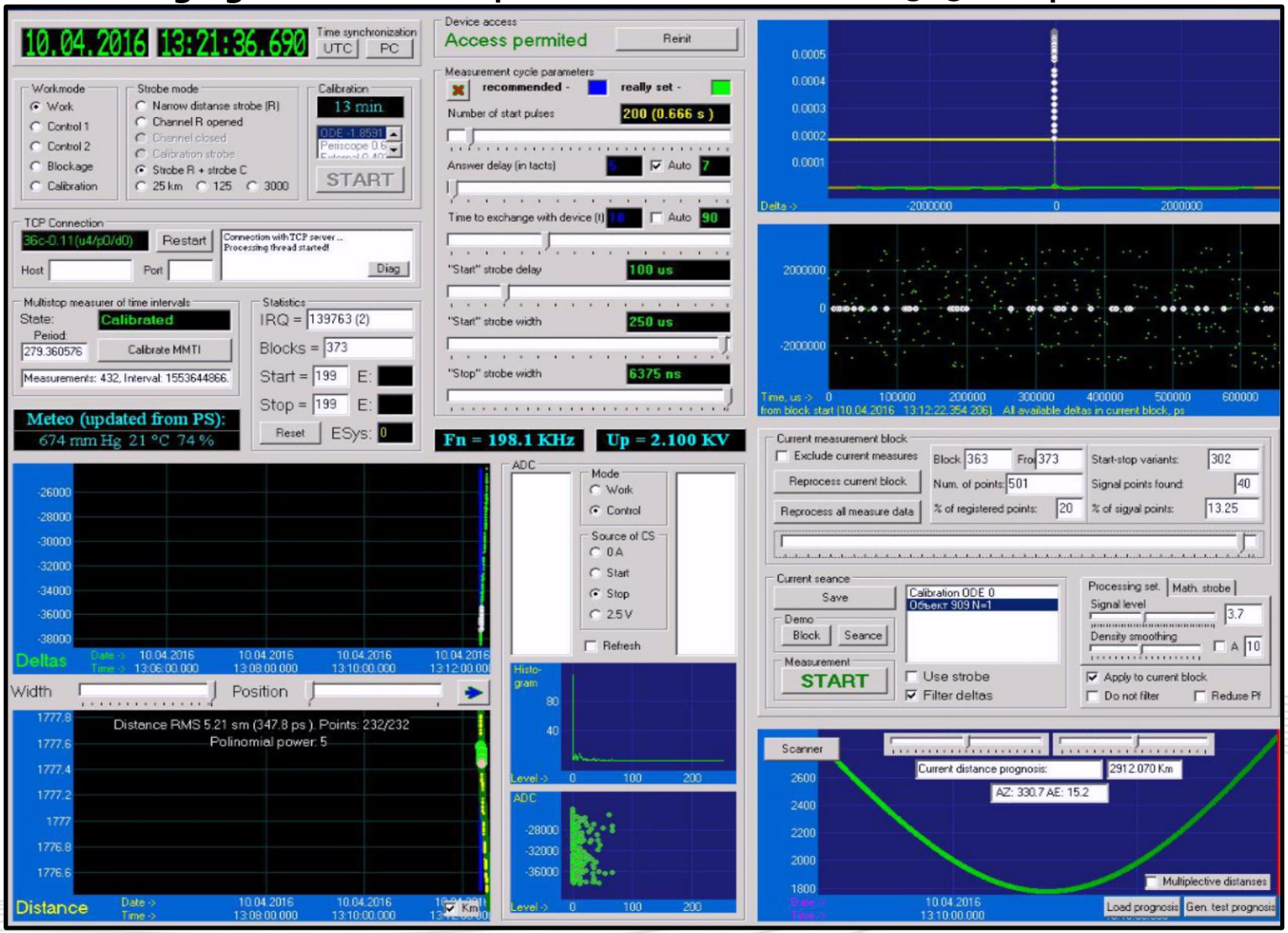
GLONASS at UnB – Current Work at Ground Station

Pointing/tracking control virtual panel – Beacon-c satellite (909) passage on April 10th 2016.



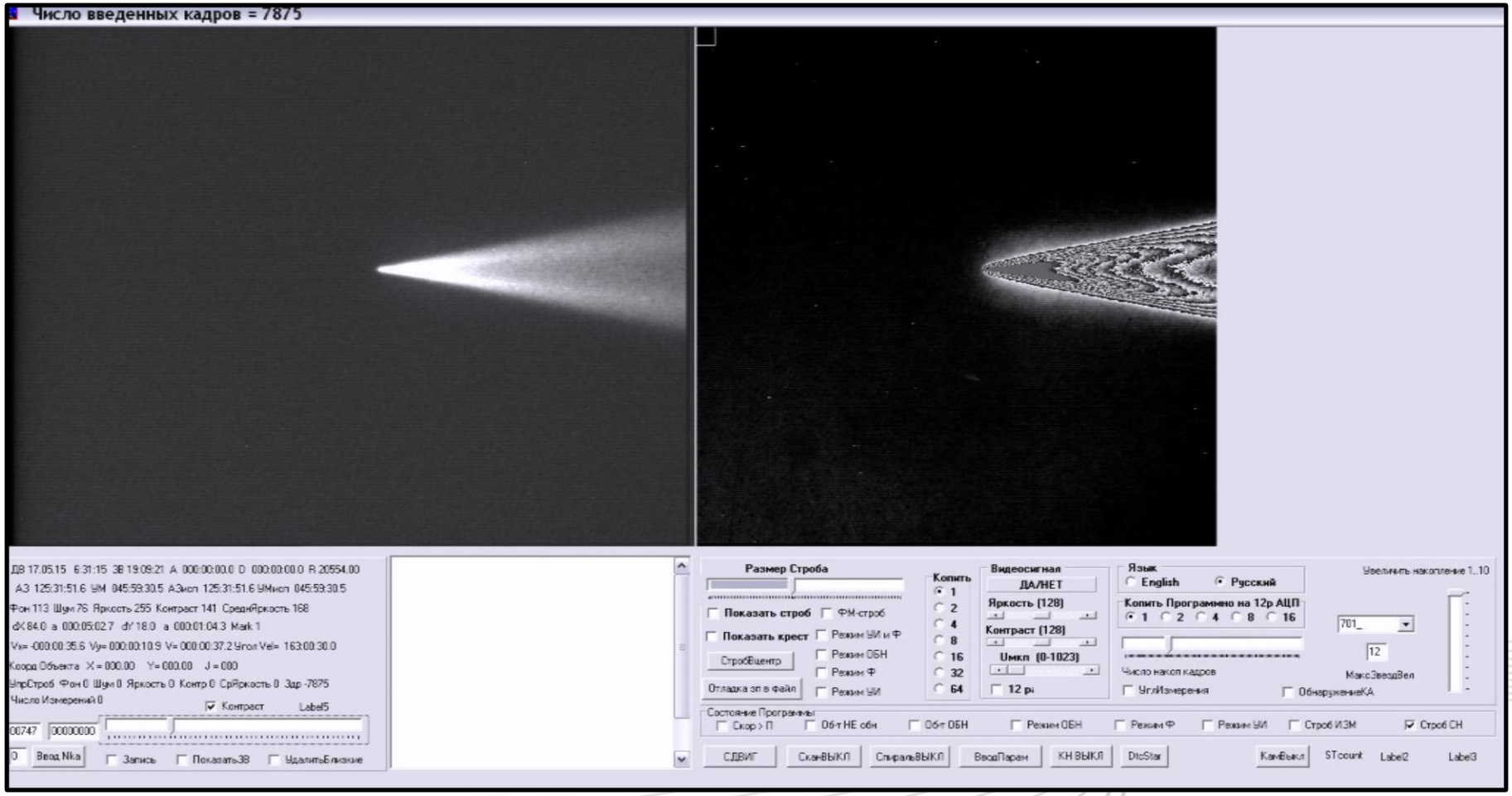
GLONASS at UnB – Current Work at Ground Station

Laser ranging control virtual panel (Beacon-c satellite 909 on April 10th 2016).



GLONASS at UnB – Current Work at Ground Station

Night camera virtual panel (GLONASS satellite 747).



GLONASS at UnB – Current Work at Ground Station

BRAJ RINEX Observation Mixed File of April 8th 2016.

```
     2.11           OBSERVATION DATA    M (MIXED)           RINEX VERSION / TYPE
JPS2RIN v.2.0.91    JAVAD GNSS          20160409 015044 UTC PGM / RUN BY / DATE
-Unknown-           -Unknown-                               OBSERVER / AGENCY
BRAJ                                                        MARKER NAME
03V6WE19VFR4T30TRR2WJAVAD TRE_G3T       3.4.10 Jul,04,2013  REC # / TYPE / VERS
  4119499.3074 -4553620.9961 -1722828.9085                  APPROX POSITION XYZ
-Unknown-           RingANT-G3T                             ANT # / TYPE
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
    21     C1     P1     L1     D1     S1     C2     P2     L2     D2# / TYPES OF OBSERV
            S2     C5     L5     D5     S5     C7     L7     D7     S7# / TYPES OF OBSERV
            C8     L8     S8                                  # / TYPES OF OBSERV
    30.000                                                  INTERVAL
  2016     4     8     0     0    0.0000000      GPS         TIME OF FIRST OBS
  2016     4     8    23    59   30.0000000      GPS         TIME OF LAST OBS
    17                                                      LEAP SECONDS
    65                                                      # OF SATELLITES
   G 1   754   754   754   754   754   754   754   754   754PRN / # OF OBS
         754   754   754   754   620     0     0     0     0PRN / # OF OBS
           0     0     0                                    PRN / # OF OBS
   G 2   743   743   743   743   743     0   743   743   743PRN / # OF OBS
         743     0     0     0     0     0     0     0     0PRN / # OF OBS
           0     0     0                                    PRN / # OF OBS
   G 3   960   960   960   960   960   960   960   960   960PRN / # OF OBS
         960   960   960   960   953     0     0     0     0PRN / # OF OBS
           0     0     0                                    PRN / # OF OBS
   G 4  1268  1255  1255  1268  1255     0  1255  1255  1255PRN / # OF OBS
```

GLONASS at UnB – R&D GLONASS Data Network

Summarized timeline overview:

- **Sep. 22nd 2015 –** CPD/UnB FTP server for data transfer set up;
- **Sep. 25th 2015 –** Measurement data transfer protocol signed;
- **Oct. 01st 2015 –** UnB regular data transfer started;
- **Feb. 16th 2016 –** ITEP regular data transfer started;
- **Apr. 20th 2016 –** UFSM regular data transfer started;

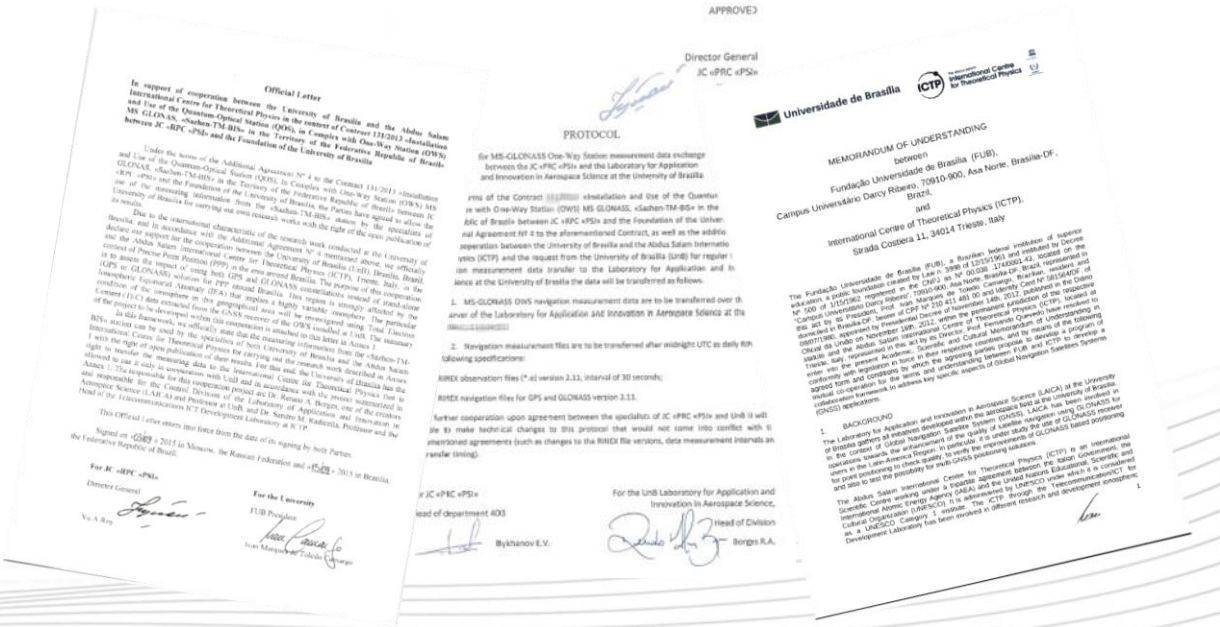
Current data transfer protocol:

- **Data format:**
  - RINEX observation file version 2.11, interval of 30 seconds, including approximation position header field;
  - RINEX navigation file for GLONASS and GPS version 2.11;
- **Data period:**
  - Daily starting on Oct. 01st 2015 from UnB station;
  - Daily starting on Feb. 16th 2016 from ITEP station;
  - Daily starting on Apr. 20th 2016 from UFSM station;
  - RINEX navigation file for GLONASS and GPS version 2.11;
  - Other periods: March, April, June and July of 2015 (UnB station only).

GLONASS at UnB – Cooperative Activities

Cooperation between UnB and The Abdus Salam International Centre for Theoretical Physics - ICTP (Trieste/Italy):

- **May 18th 2015 –** ICTP and UnB representatives first talk during the Workshop on Applications of GNSS at Krasnoyarsk, Russia;
- **Sept. 15th 2015 –**Official Letter in support of the cooperation enters into force;
- **Jan. 26th 2016 –** MoU formalizes the scientific research cooperation between the UnB and the ICTP in the field of PPP in the region of Brasilia.



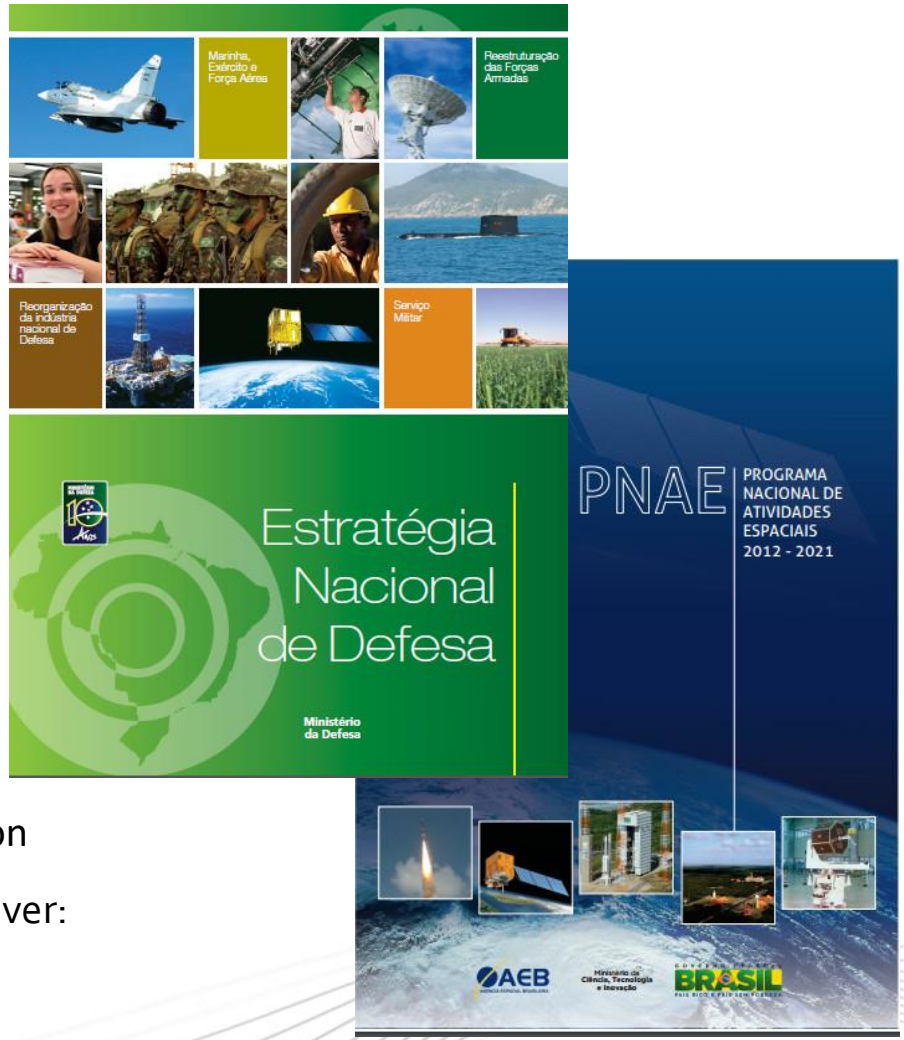
GLONASS at UnB – Current Research and Perspectives

Current team at LAICA in the field of GNSS :

- 5 professors;
- 6 undergraduate students;
- 1 master student;
- 7 technical operators and support staff.

GNSS related topics under investigation :

- GNSS single frequency module:
  - Impact point prediction;
  - Attitude determination;
  - High altitude ballons experiments (LAICAnSat);
  - Advanced filtering solutions for GNSS/INS integration
- MS-GLONASS IBPA.464346.003 dual frequency receiver:
  - Precise Point Positioning (PPP).

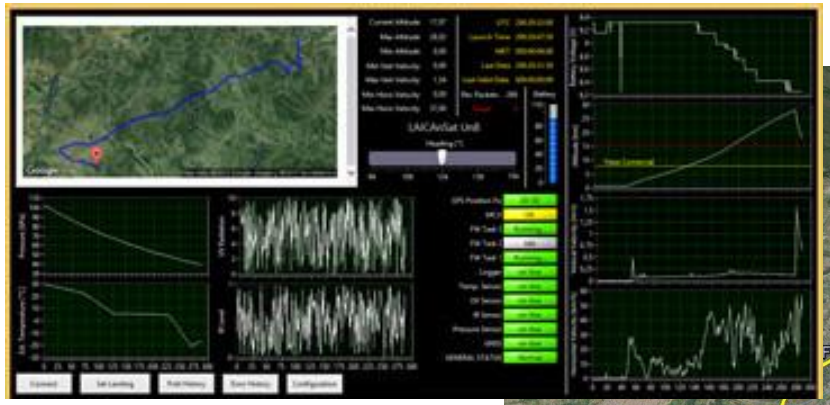


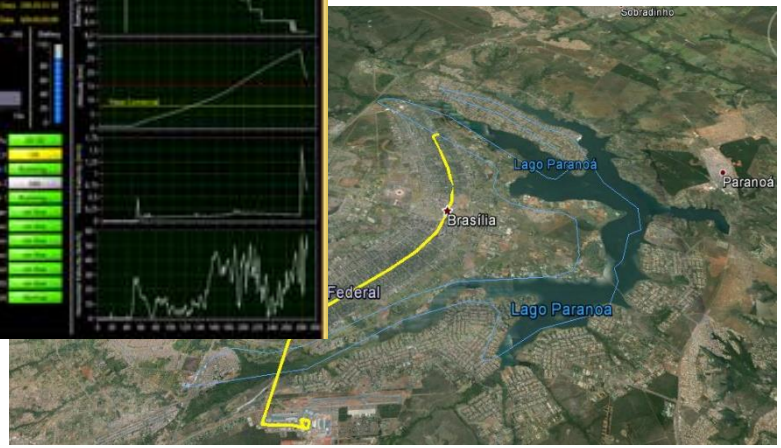
Brazilian national defense strategy and space activities :

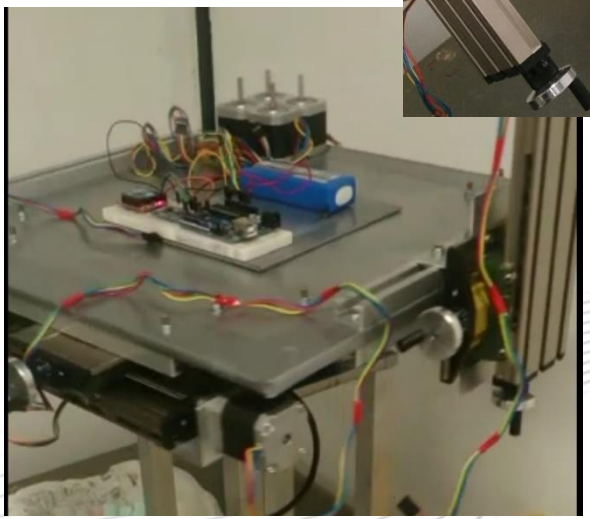
- Project aligned with the interests of the Defense and Science and Technology ministries;
- Improve and develop national capability in the field geo location and positioning within the field of aerospace systems.

GLONASS at UnB – Current Research and Perspectives

Possible applications and test facilities at LAICA/UnB

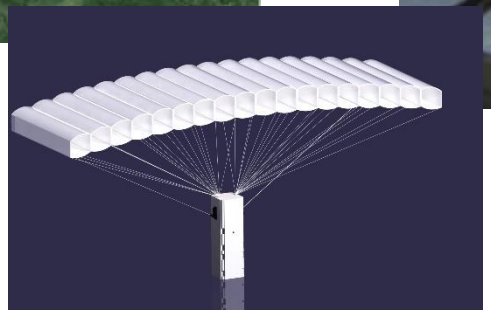


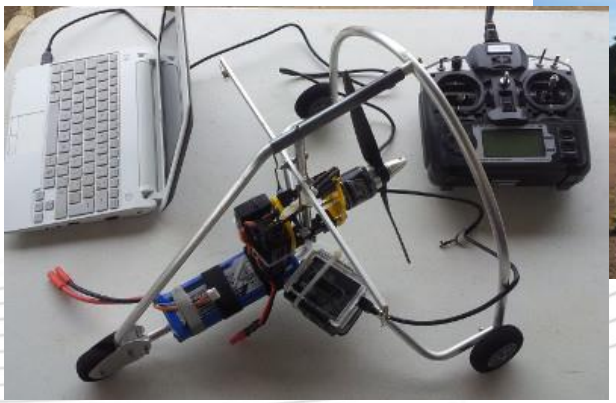




GLONASS at UnB – Current Research and Perspectives

Possible applications and test facilities at LAICA/UnB





Final Remarks

In conclusion:

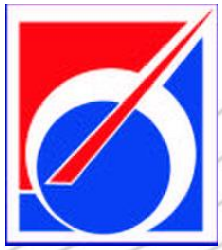
- The GLONASS station in Brazil represents an **excellent opportunity for the advancement of research on GNSS in Brazil** and also **to improve the accuracy of PNT in South America**;
- These first years operating the station was important for **technical team training, adjustment of the station equipment, providing a better understanding of the weather condition, collecting data for post processing and establish new research partners** in the field of GNSS;
- Investigation within the PPP Project is going to continue in the region of Brasilia, Brazil using the data from the R&D GLONASS data network.

Future perspectives include:

- Practical applications on HASP (LAICAnSat);
- Onboard attitude determination;
- Impact point prediction;
- High precision applications with UAVs and mobile robots.

Thank You For Your Attention!

Acknowledgements:



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