



# The NanosatC-Br1 The First Brazilian Cubesat, and Beyond

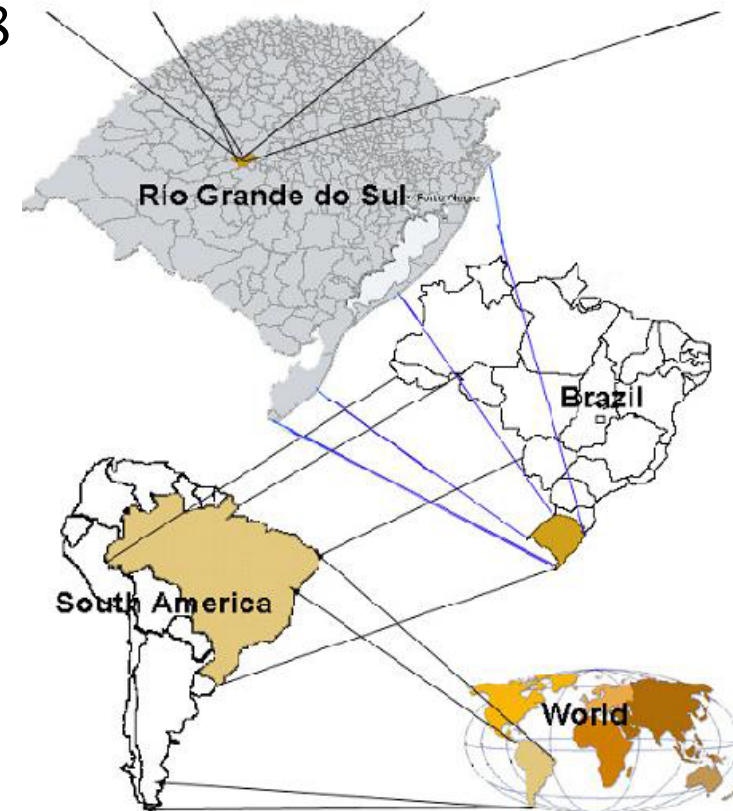
Otavio Durão and Nelson Jorge Schuch – National Institute for Space Research – INPE

Eloi Fonseca – Instituto Tecnológico de Aeronautica– ITA

# How we got here



- ▶ INPE South Regional Center
  - Located in the campus of The University of Santa Maria – UFSM
- ▶ Cooperation INPE – UFSM
- ▶ Undergrad student scholarship – 2007/8
- ▶ 2010 – decision to make it happen



# Main objective and strategy



- ▶ To provide a very low cost space mission to brazilian researchers
  - Platform and ground station purchased
  - Development of the payloads by brazilian universities and research institutions
  - Development of the mission specific ground software and interfaces (small student company)
  - AIT at INPE and s/c operation by students
  - Gradual substitution with locally made subsystems
    - Technological parks
    - Small companies

# NanosatC-Br1

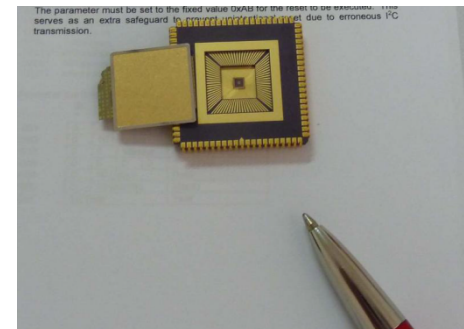
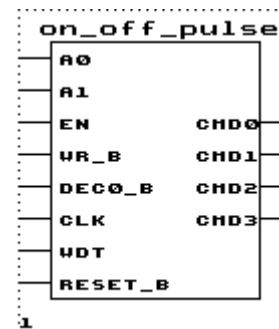
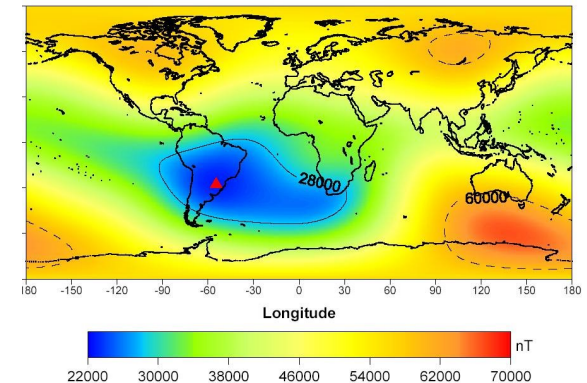


- ▶ Objectives:
  - Scientific
  - Technological
  - Student practice
- ▶ 1U platform and GS purchased from ISIS, through international bid in 2010
  - Delivery 2011
- ▶ Payloads
  - Magnetometer – INPE
  - Fault tolerant FPGA – UFRGS
  - IC on/off driver – SMDH/UFSM

# Payloads



- ▶ Magnetometer to measure the magnetic field mainly at the SAMA – South Atlantic Magnetic Anomaly – INPE
- ▶ Fault tolerant FPGA
  - Software
  - Radiation tolerant
  - UFRGS
- ▶ IC on/off driver – SMDH/UFSM
  - Radiation resistance by design
  - Software library validation
  - IC manufactured in Germany
  - Demand by INPE

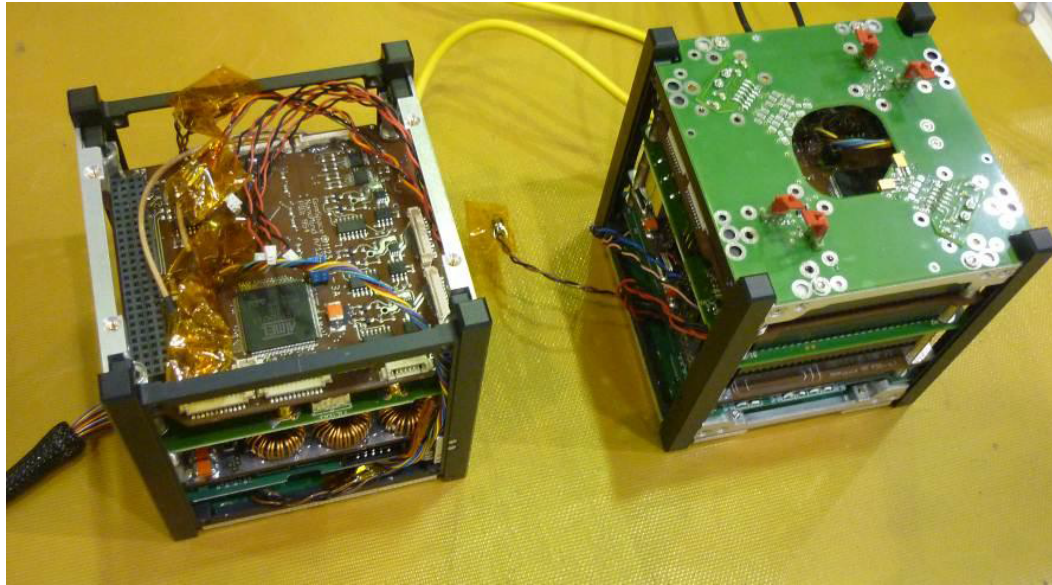




# P/L board mfg and AIT

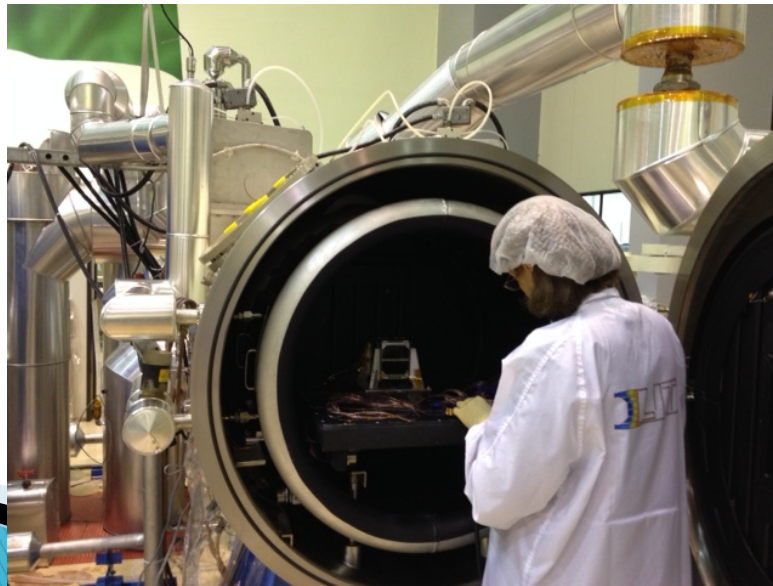
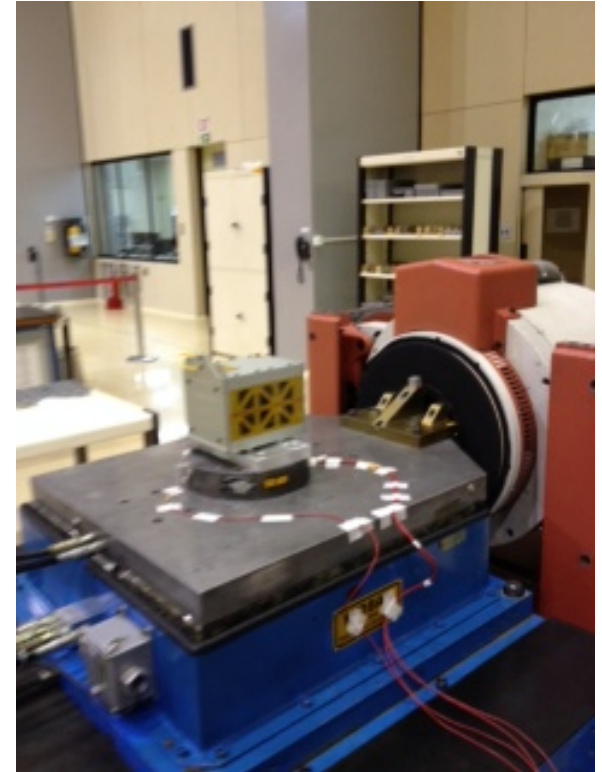
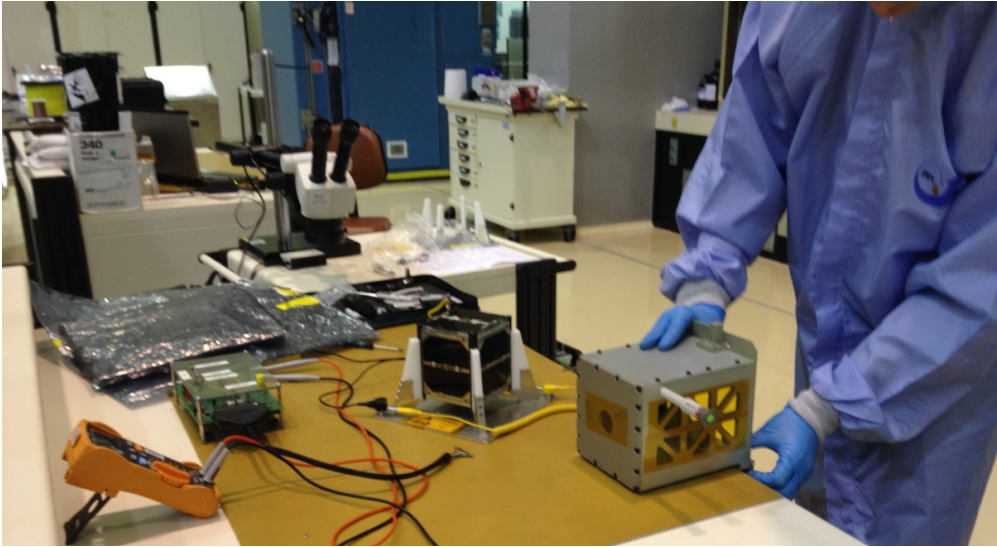


# AIT





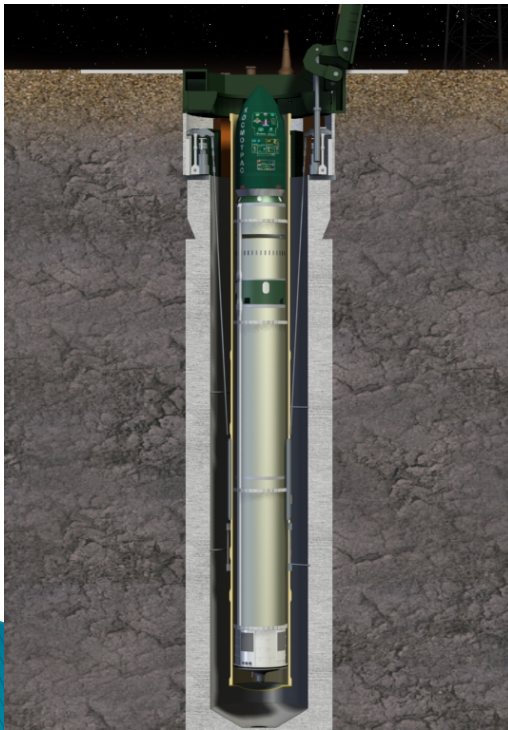
# Tests



# Launch



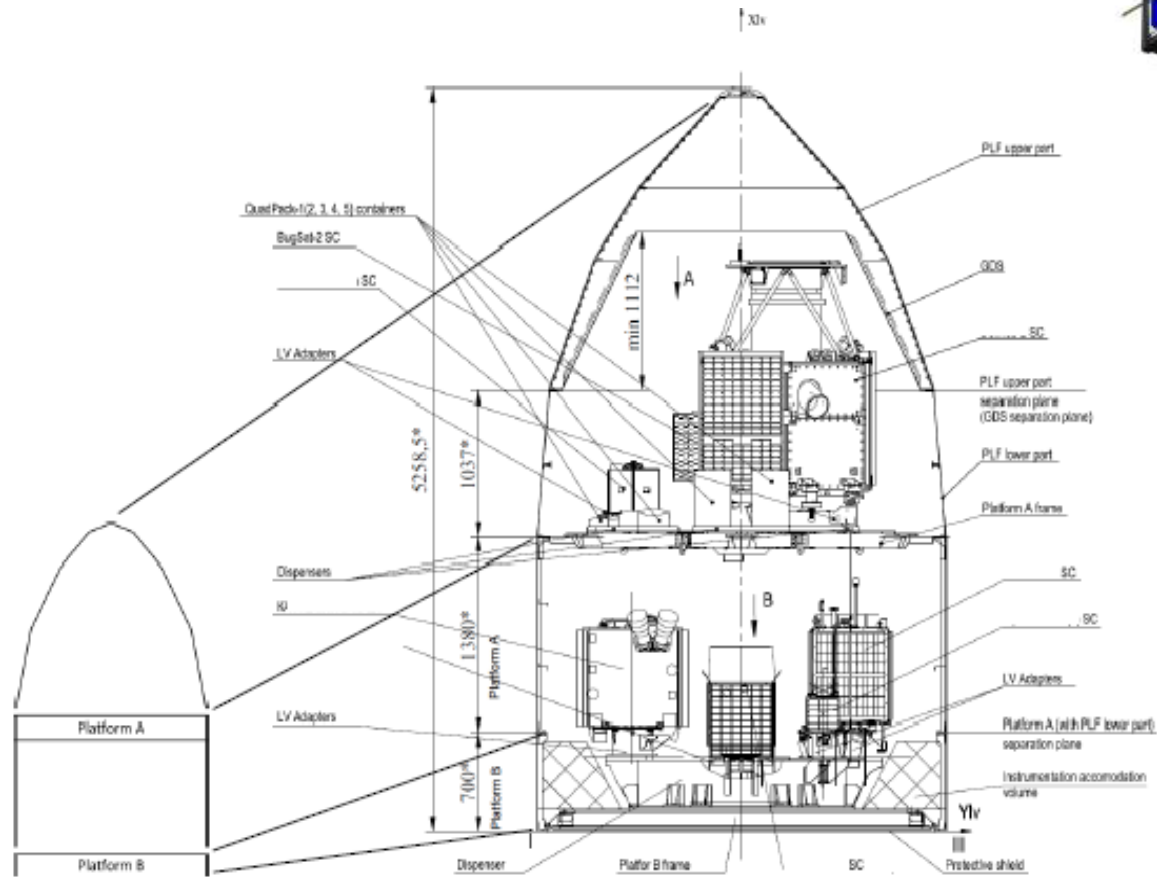
- ▶ June 19th
- ▶ Yasnny launch center
  - DNEPR



# Launch



# Launch

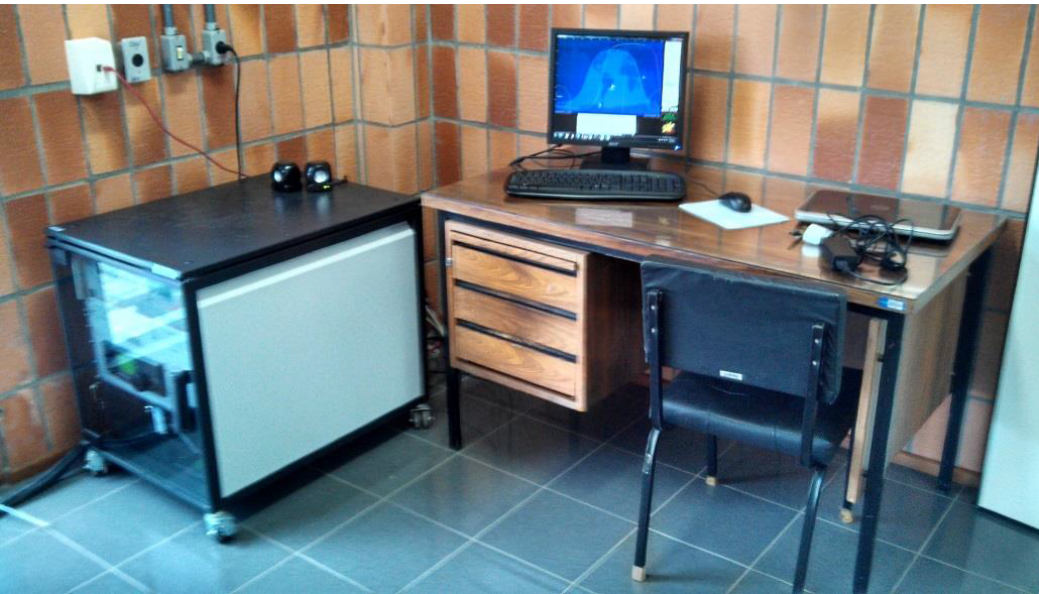
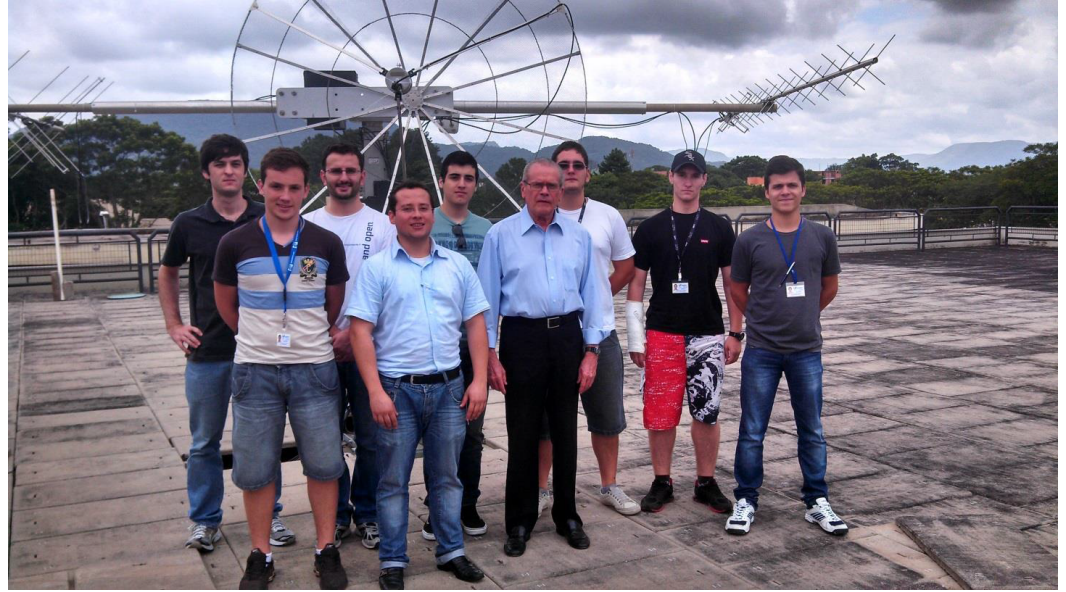


# Launch sequence



Dep. #	QuadPack [nr.]	Door [nr.]	Satellite(s)	Delay after separation of platform A [sec]	T+ [sec]	UTC [HR:MIN:SEC]
<b>1</b>	1	2	QB50p-2 & DTU-2	300	1256	19:32:07
<b>2</b>	1	1	QB50p-1 & NCBR-1	320	1276	19:32:27
<b>3</b>	2	1	PolyITAN-1	340	1296	19:32:47
<b>4</b>	1	3	PACE & Duchifat-1	360	1316	19:33:07
<b>5</b>	1	4	POPSAT-HIP1	380	1336	19:33:27
<b>6</b>	5	1	PERSEUS-M1	400	1356	19:33:47
<b>7</b>	5	2	PERSEUS-M2	420	1376	19:34:07
<b>8</b>	2	4	Flock1c-3	440	1396	19:34:27
<b>9</b>	4	2	Flock1c-9	460	1416	19:34:47
<b>10</b>	3	4	Flock1c-7	480	1436	19:35:07
<b>11</b>	4	3	Flock1c-10	500	1456	19:35:27
<b>12</b>	2	3	Flock1c-2	520	1476	19:35:47
<b>13</b>	3	2	Flock1c-5	540	1496	19:36:07
<b>14</b>	4	1	Flock1c-8	560	1516	19:36:27
<b>15</b>	3	3	Flock1c-6	580	1536	19:36:47
<b>16</b>	4	4	Flock1c-11	600	1556	19:37:07
<b>17</b>	2	2	Flock1c-1	620	1576	19:37:27
<b>18</b>	3	1	Flock1c-4	640	1596	19:37:47

# Santa Maria GS



# ITA GS



# Contact!





# Operation

- ▶ VHF/UHF
  - Amateur radio frequencies
- ▶ Two ground stations in Brasil for the project
  - UFSM and ITA – São José dos Campos, SP
  - Both operated by students
  - Suport from the amateur radio community in Brazil and abroad.
- ▶ Data basis for NanosatC–Br1 at INPE hdq.
  - Data uploaded from the two stations (P/L + HK)
  - Access through the site of the project restricted area

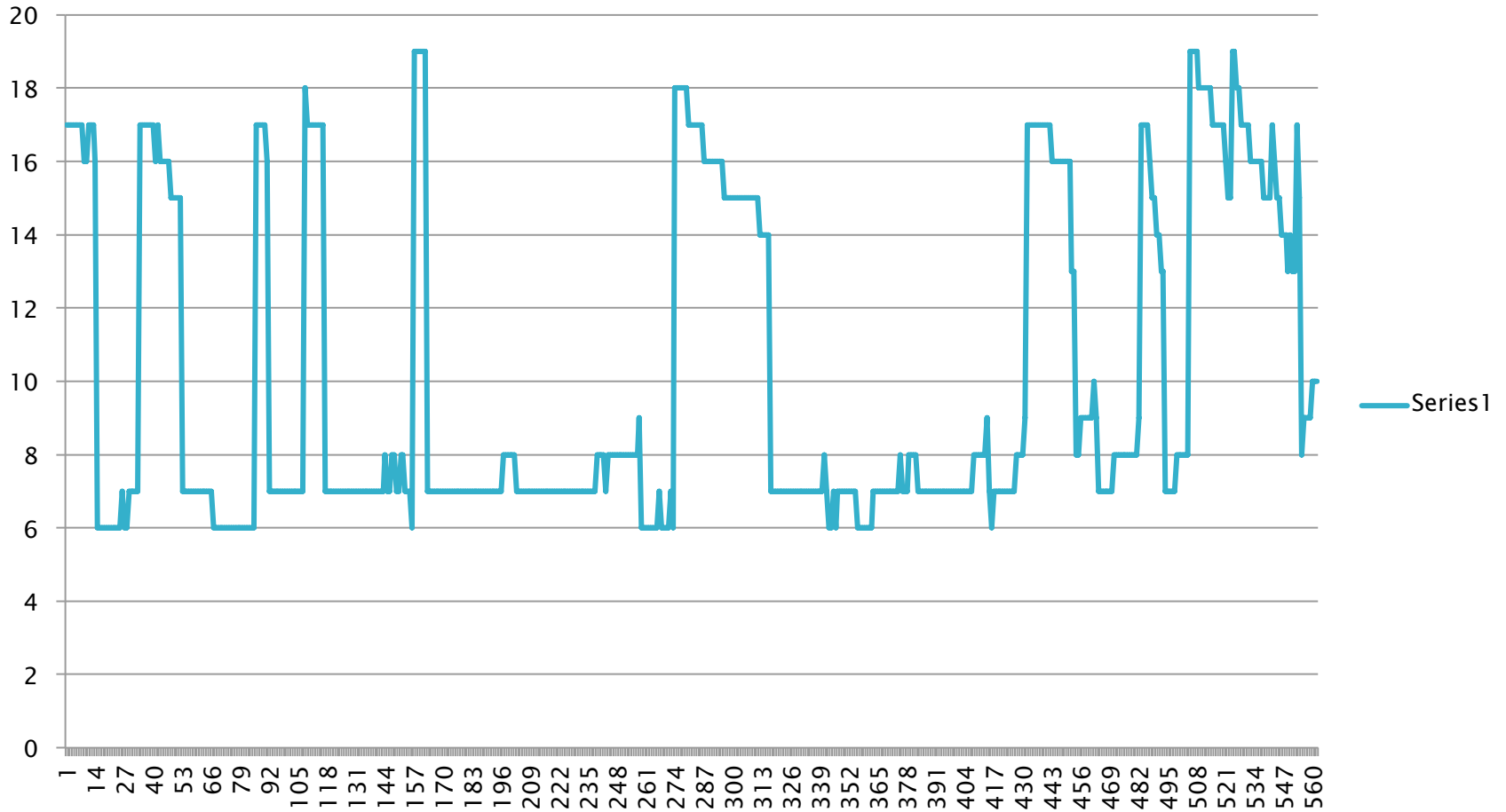


# Operation

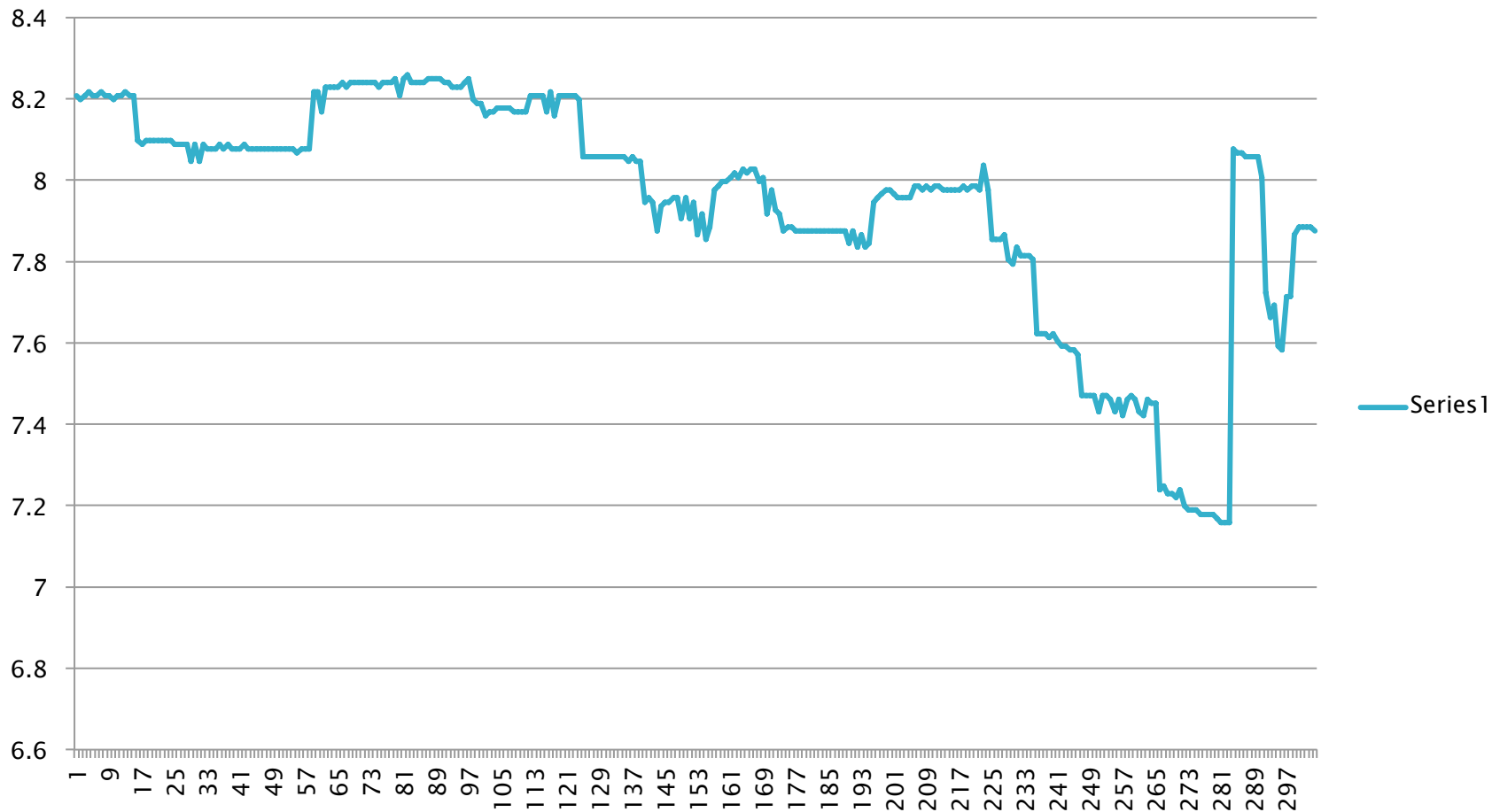
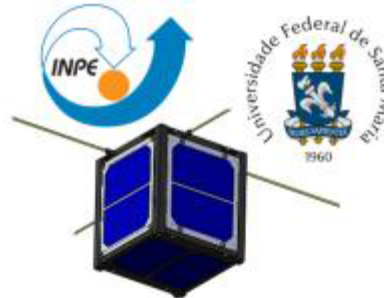
- ▶ Safe mode – Morse code
  - Initial condition
  - Beacon w. 10 info
  - Amateur radio decoding
- ▶ Nominal mode – Digital BPSK
  - Beacon with 60 columns
- ▶ HK + P/L log files
- ▶ Spinning
  - Detumbling mode



# Temperatures



# Battery voltage



# Results



## ▶ Academic

- Two students hired permanently by INPE as civil servants
- Four others in Ph.D. programs
- About 15 undergraduate students per year
- Other students in other projects
- Five other projects in other universities/institutions

# Results



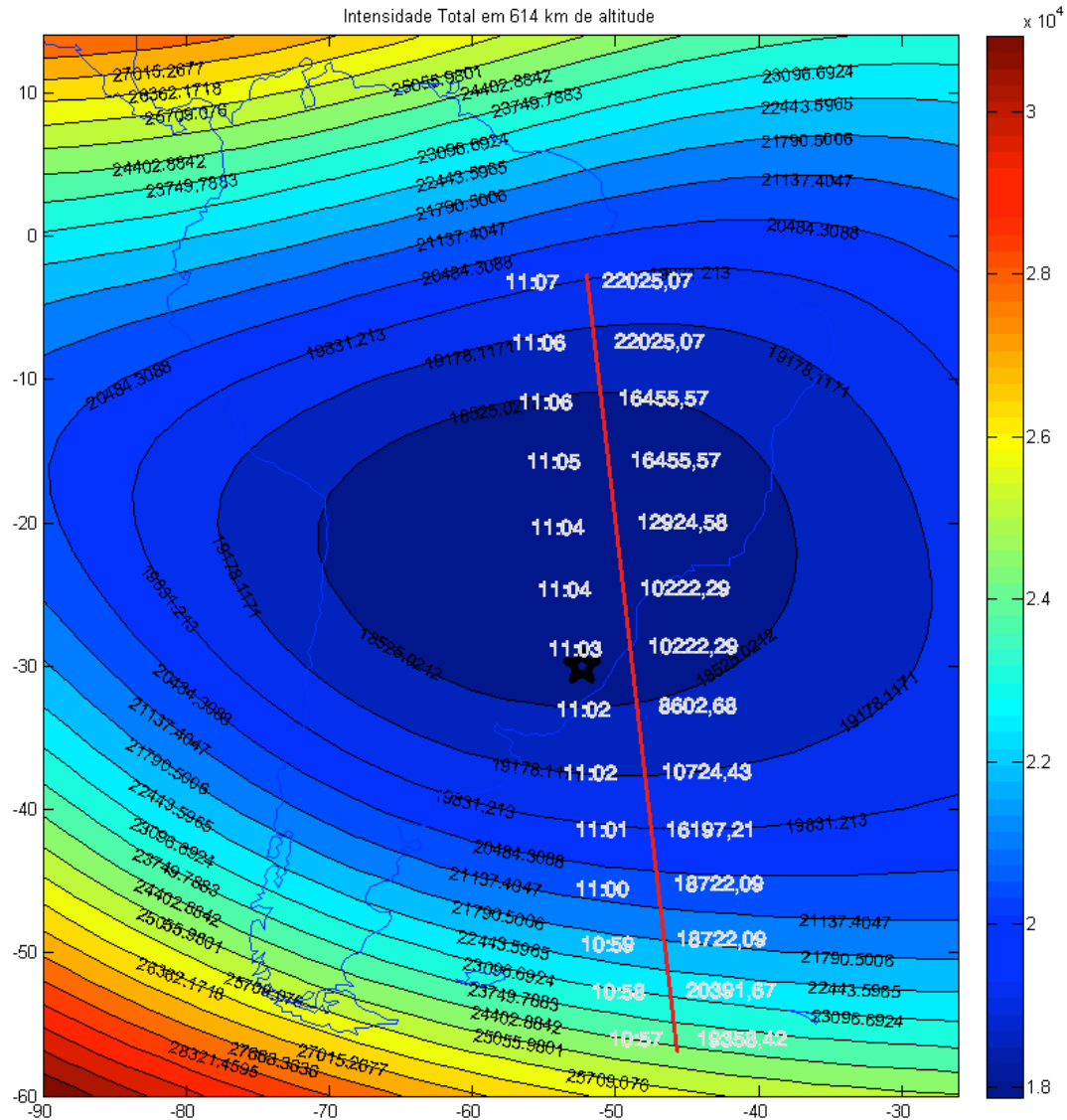
## ▶ Scientific

- Three months of data available for the Earth magnetic field – three components of each vector.

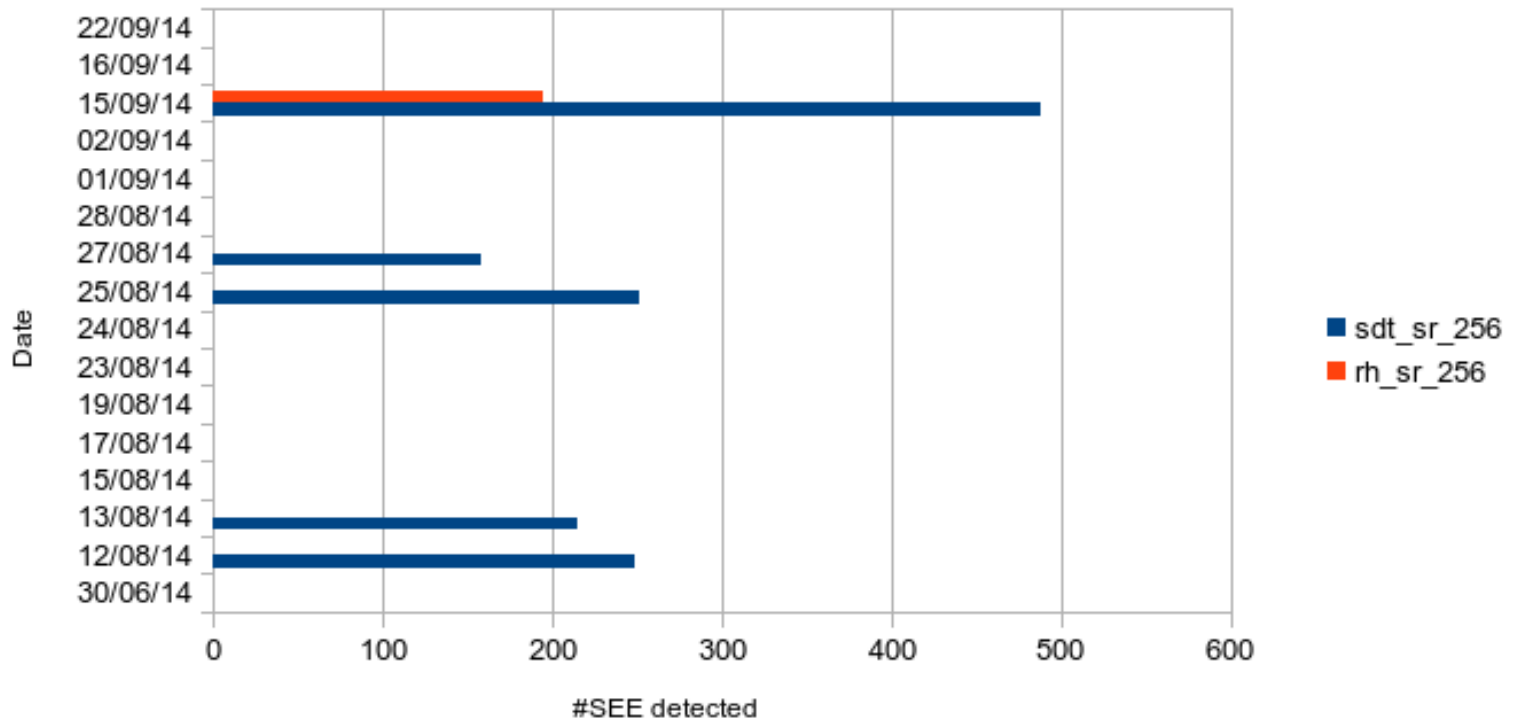
## ▶ Extended life

- Command it in North hemisphere
- Change to nominal beacon

# Earth magnetic field data over SAMA



# Results – technological



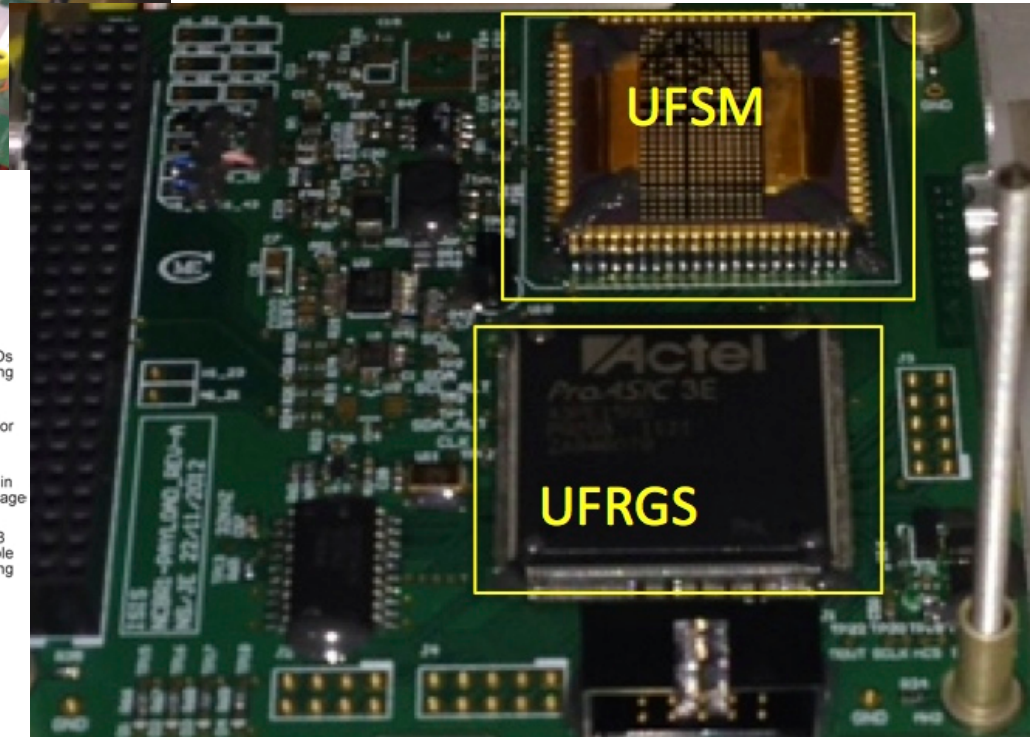
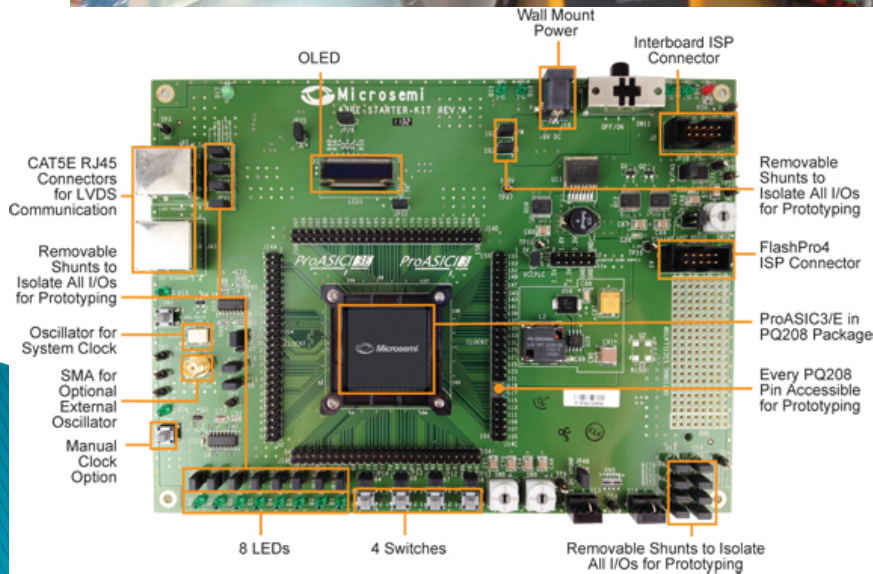


# And beyond



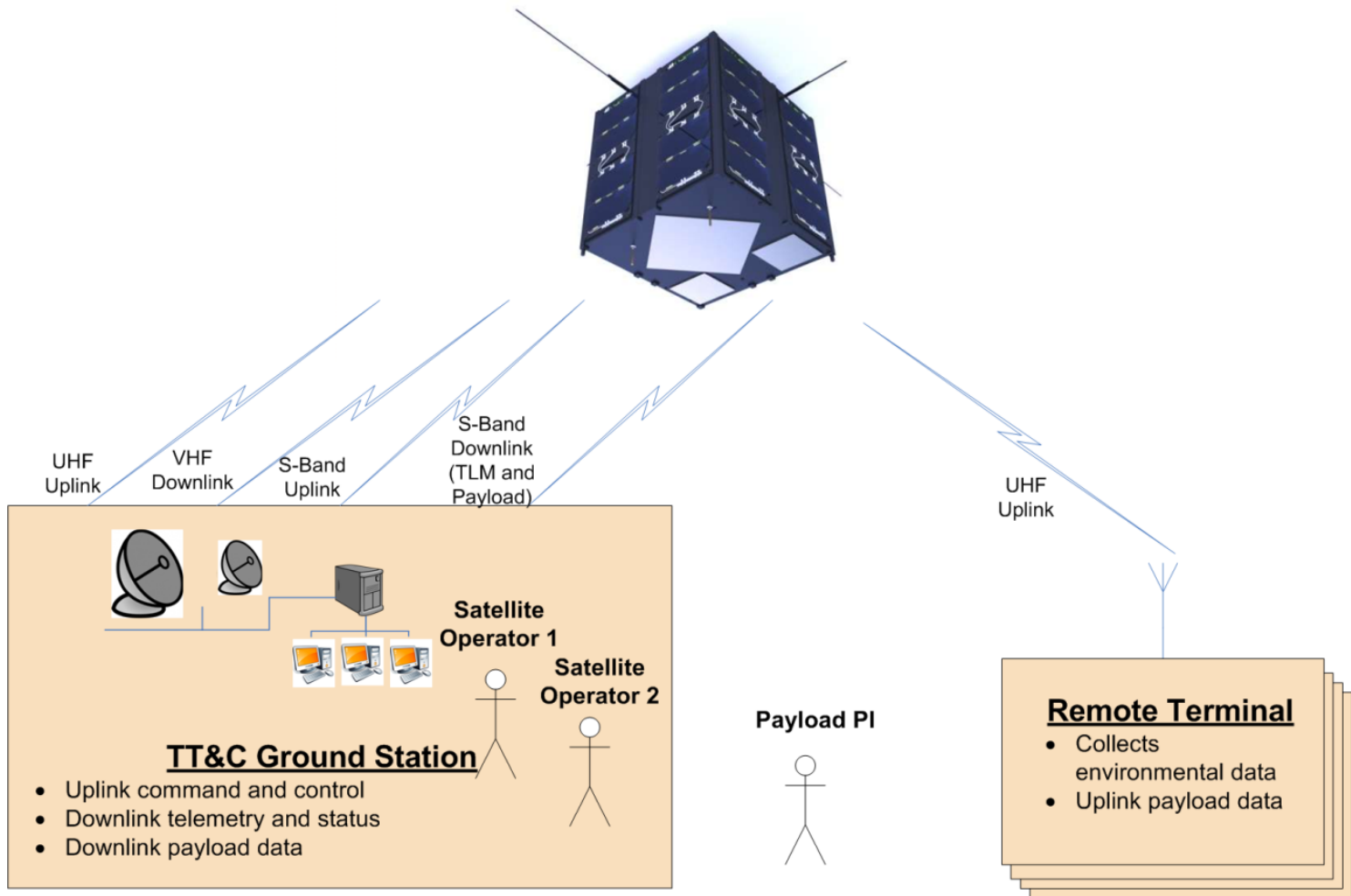
- ▶ **NanosatC–Br2 (2U)**
  - Langmuir probe
  - Attitude determination system
  - Other ICs
  - Launch – 1stQ – 2016 – Falcon 9
- ▶ **CONASAT**
  - 8U (8.4kg.) – total redundancy
  - Data collection mission
  - Payload transponder EM in tests
  - Plataforma delivered in October
  - 6 to 8 cubesats constellation

# Br-2 EM platform and one P/L



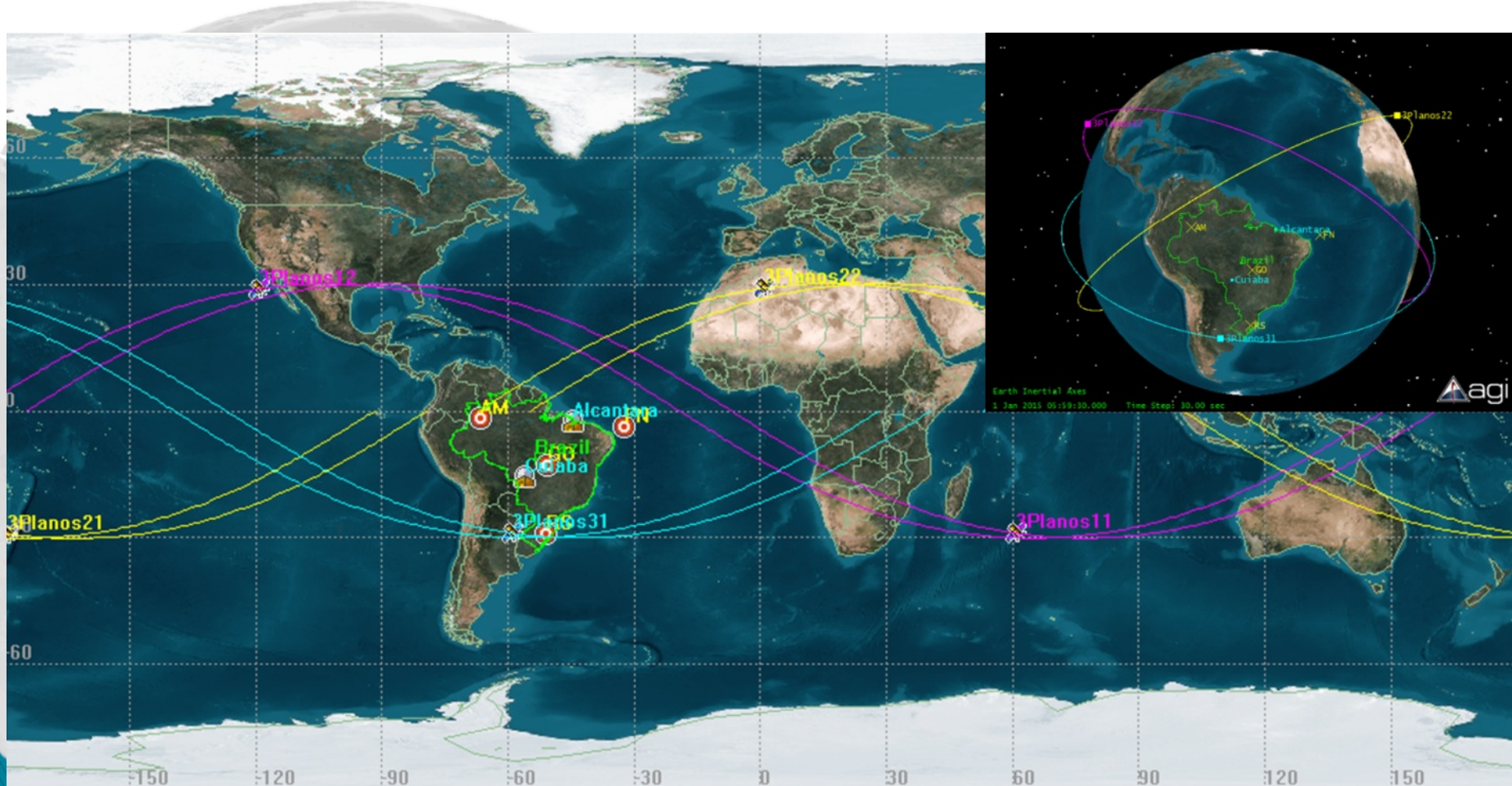
# CONASAT

8U satellite operational in orbit

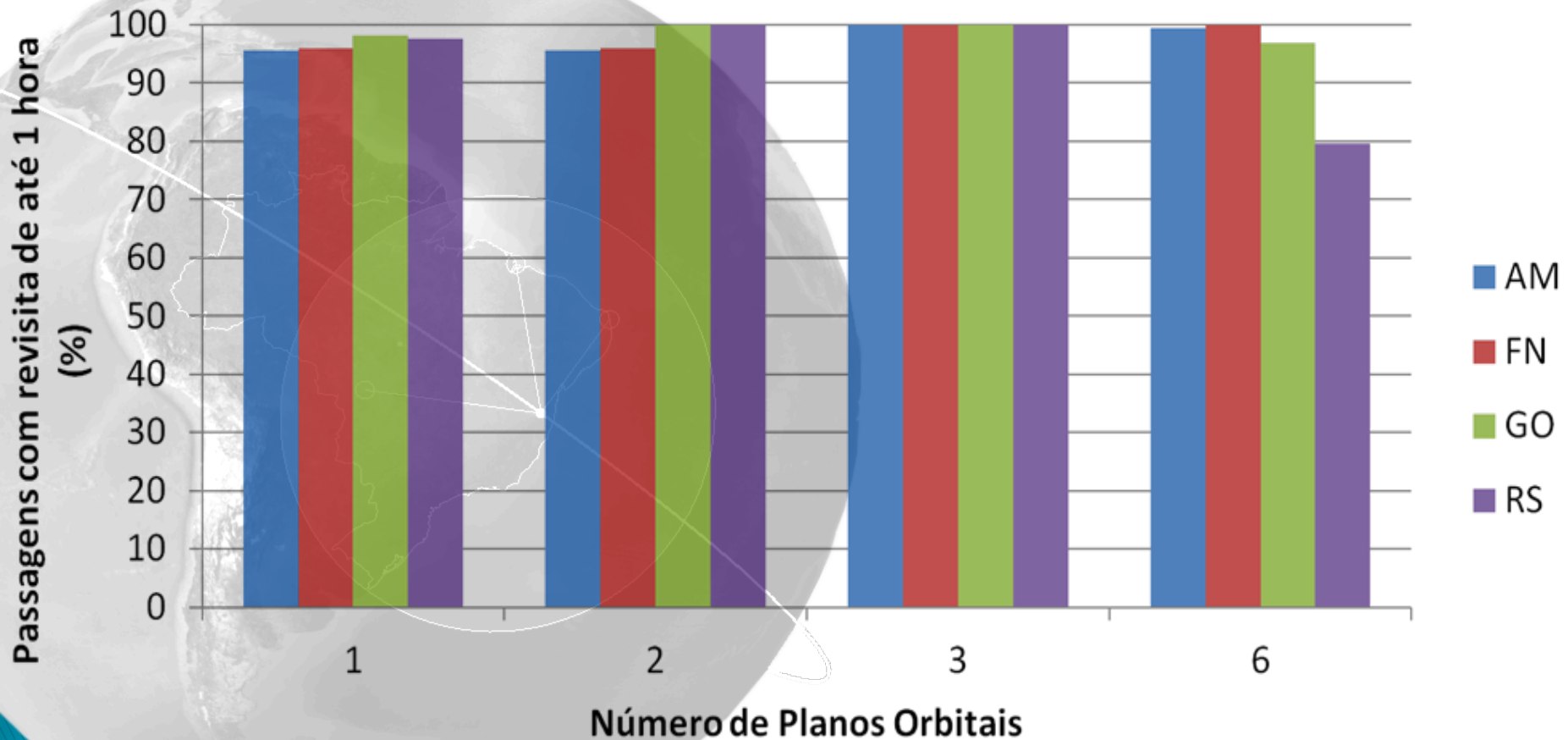


# Coverage em Revisit Times

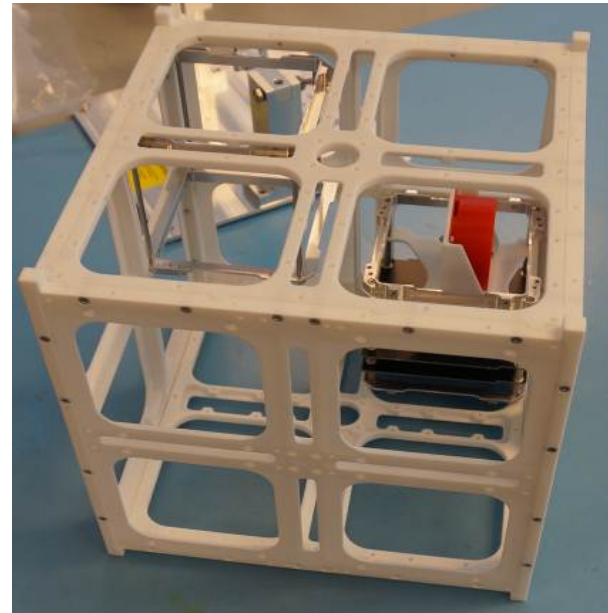
- 3 orbital planes with 2 sats in each



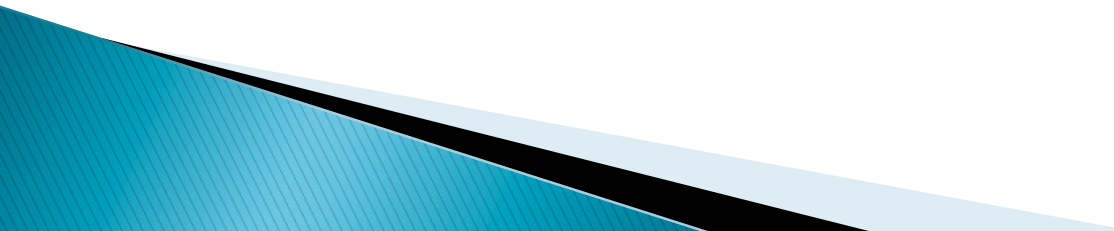
## One hour revisit time X no. of orbital planes



# CONASAT



# And beyond

- ▶ SERPENS – 3U – Univ. of Brasilia
    - Launch to the ISS in August
  - ▶ ITASAT– 1 – 6U
    - Launch together with NanosatC–Br–2 with a Falcon–9 in 1stQ2016
  - ▶ Possible international cooperations ongoing
  - ▶ Strong program at INPE for scientific cubesats
  - ▶ Possibility of private ventures
- 

# Conclusions

- ▶ Support from the Brazilian Space Agency, funding agencies and federal budget.
  - ▶ Skepticism had to be overcome
  - ▶ Cube and nanosats seem to have their path opened to new and more demanding missions in the country.
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