MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Projeto UbatubaSat

Curso de Inverno 2018

Me. Auro Tikami
Dr. Walter Abrahão dos Santos

Agenda

- Padrões de satélites pequenos
- Projeto UbatubaSat
- TubeSat
- Reengenharia
- Requisitos com uso da ISS
- Lançamento
- Resultados
- RaioSat

Padrões de Satélites Pequenos

Classificação (massa)

Classe	Massa (kg)
Microssatélite	10 a 100
Nanossatélite	1 a 10
Picossatélite	0,1 a 1
Femtossatélite	0,01 a 0,1

Fonte: Jakhu, R.S; Pelton J.N. **Small Satellites and Their Regulation** (2014)

Padrões de Satélites Pequenos

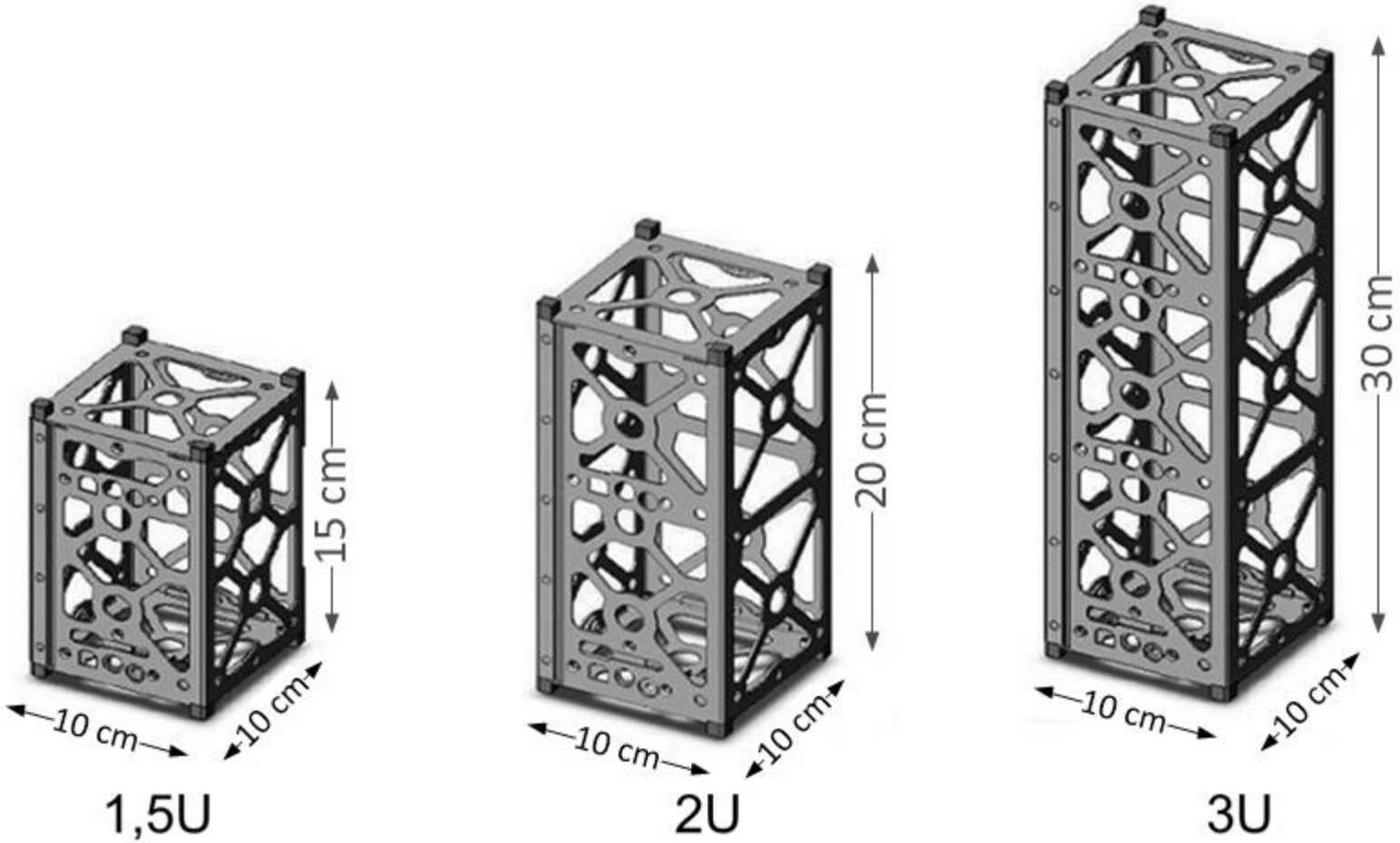
CubeSat

Desenvolvido em 1999 por:

- BobTwiggs (Stanford University)
- Jordi Suari (CalPoly)

Padrão: 1U (10 cm x 10 cm x 10 cm)

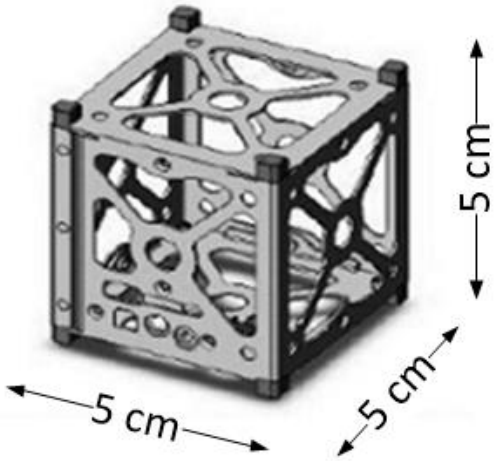
CubeSats derivados do 1U



Source: Caltech

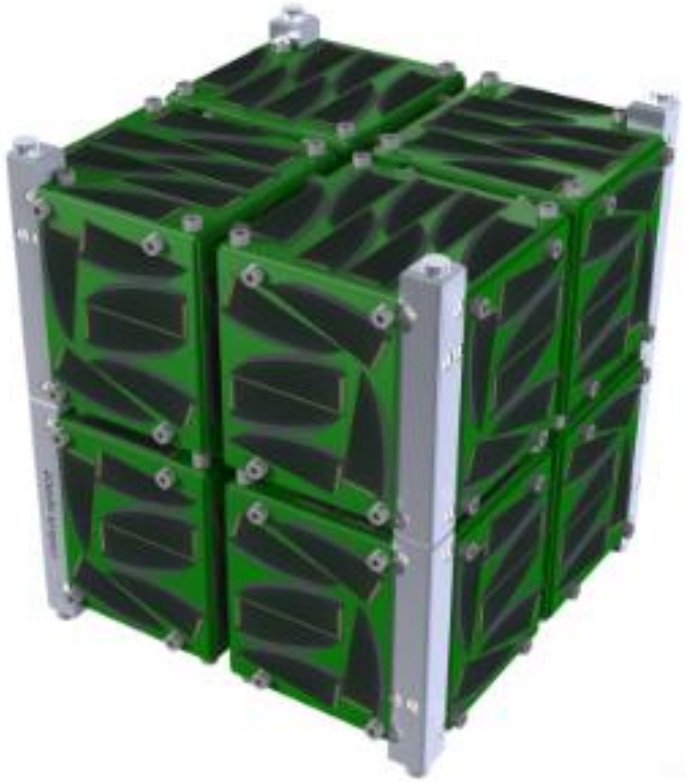
PocketQube

Padrão 1P : 5 cm x 5 cm x 5 cm



1 P

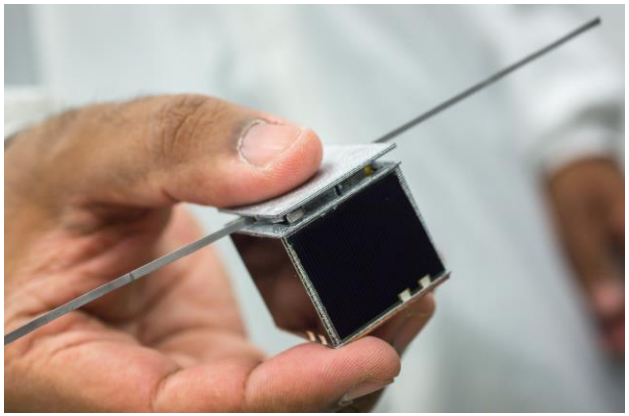
8 PocketQubes into CubeSat 1 U



SunCube

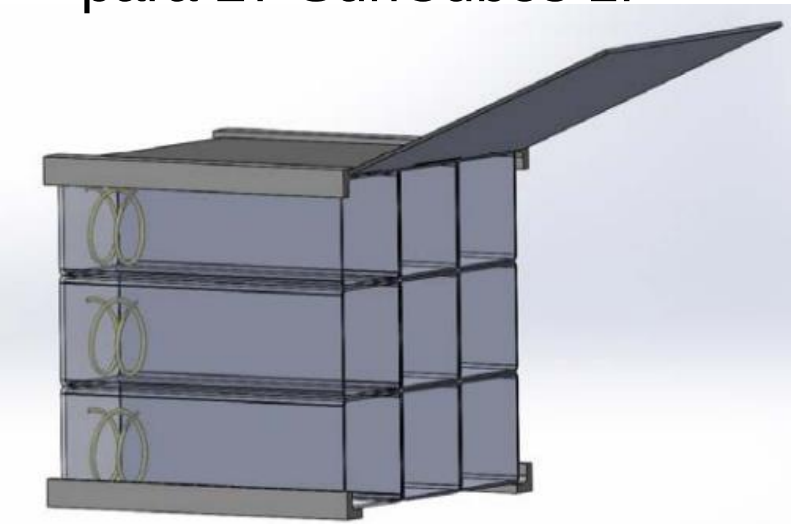
(Arizona State University pattern)

Padrão 1F : 3 cm x 3 cm x 3 cm



Source: Arizona State University

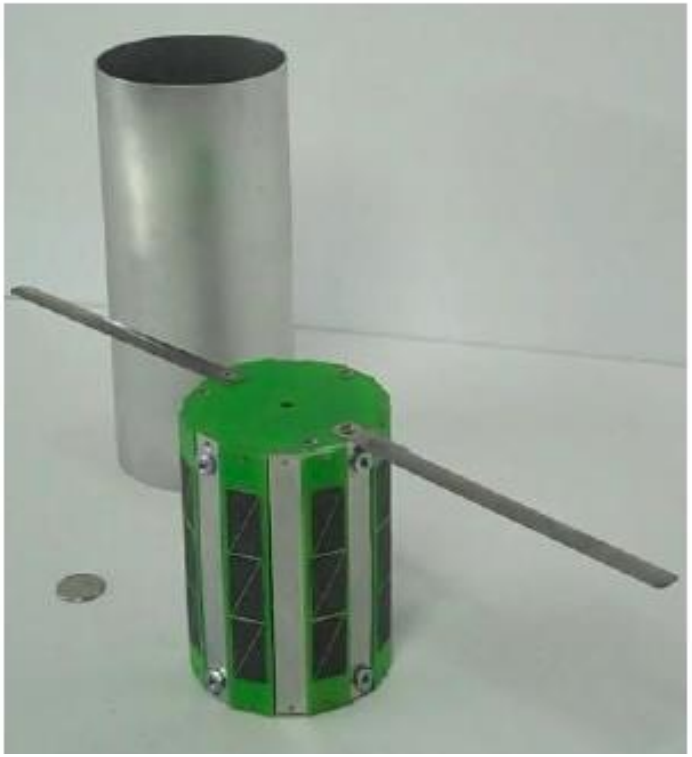
Ejetor CubeSat 1U
para 27 SunCubes 1F



TubeSat

(Interorbital Systems)

Diameter: 92.5 mm
Length: 127 mm
Weight: 0.75 kg



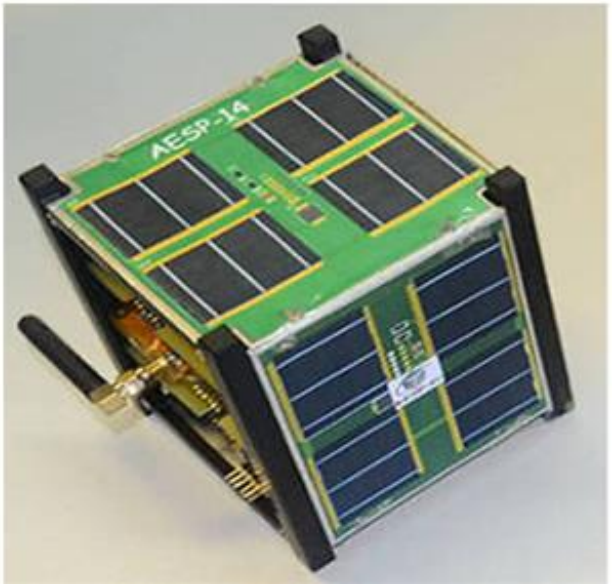
Source: IOS

Exemplos de satélites pequenos

Exemplo: CubeSat 1U

AESP-14

(ITA / INPE)



- Dimensão: 10 x 10 x 10 cm
- Massa < 1 kg
- Missão: Validar plataforma
- Lançamento (2015): Falcon 9 / Cápsula Dragon

Exemplo: CubeSat 3U

SERPENS:
UnB / Universidade de Vigo
Outras Universidades: Sapienza (Roma),CalPoly, Morehead, UFSC, UFMG, UFABC, IFF

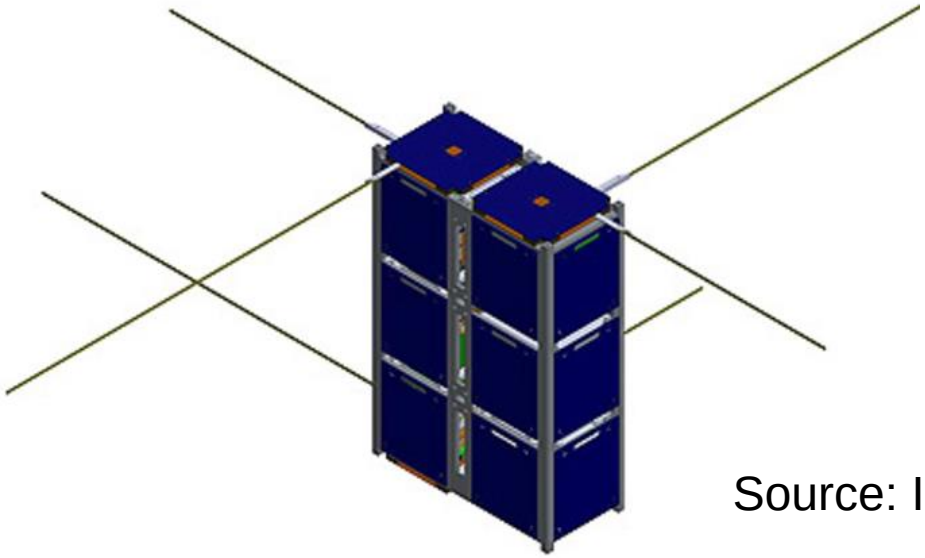
Fonte: UnB

Missão: RH
Cargas Úteis:
- transponder de Coleta de Dados
- transponder digital
- micropropulsor de plasma

Lançamento(2015): H-IIB / Cápsula: HTV-5

Exemplo: CubeSat

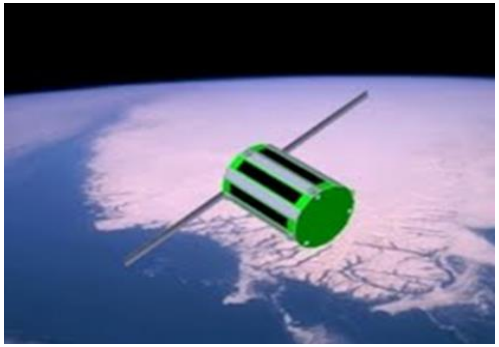
ITASAT



Source: ITA

CubeSat 6U (10 x 22,6 x 34 cm)
Massa: 8kg
Missão: Capacitar RH, comunicações e imageamento
Lançamento: ?

Exemplos: TubeSat e PocketQube

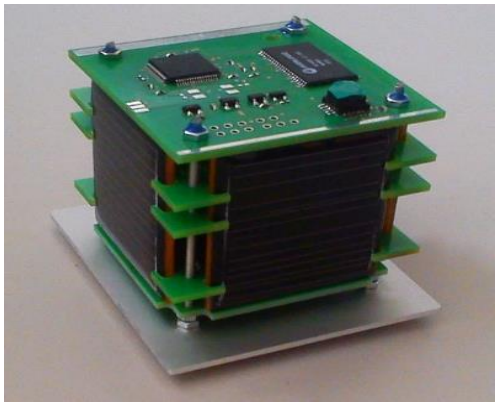


Fonte: Escola Tancredo Neves

TubeSat

Tancredo-1 (UbatubaSat)

- diâmetro: 10 cm
- altura: 13 cm
- Massa: 570g
- Lançamento (2017): H-IIB / HTV-6



Source: WREN Stadoko

PocketQube

Padrão: 1P (5 cm x 5 cm x 5 cm)

WREN

5 x 5 x 5cm

Massa: 250g

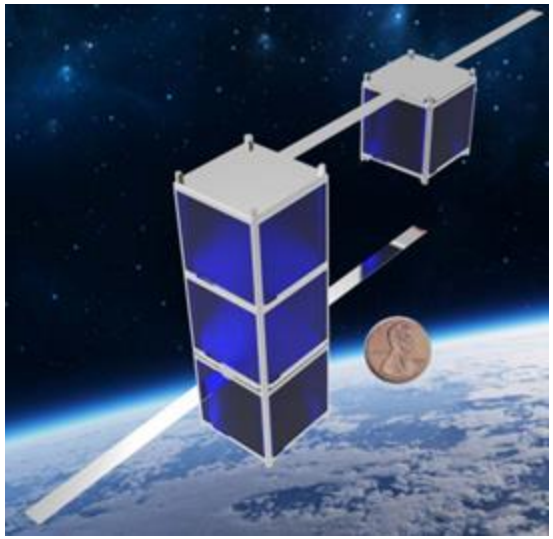
Lançamento (2013): DNEPR/UniSat-5

Exemplo: SunCube

Femtosat SunCube

1F
Volume= 3 cm x 3 cm x 3 cm
Mass = 35 g

3F
Volume= 9 cm x 3 cm x 3 cm
Mass = 100 g



Source: Arizona State University

Projeto UbatubaSat

Projeto UbatubaSat

Escola Municipal Tancredo Neves
Ubatuba – SP

Prof. Candido

Kit TubeSat da Interorbital Systems

$8,000 TubeSat KIT INCLUDES FREE LAUNCH!

Source: IOS

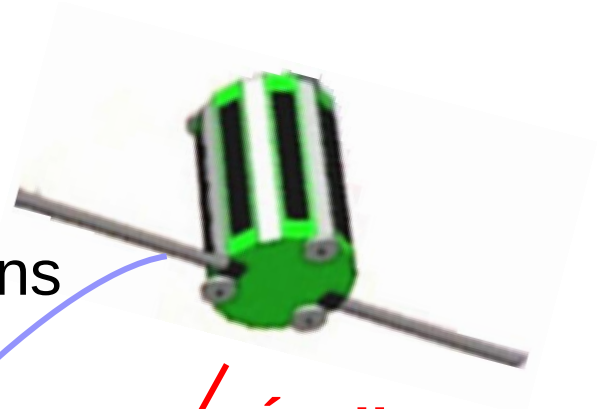
UbatubaSat - Equipe

•Alunos do 6º ano do ensino fundamental e professores.

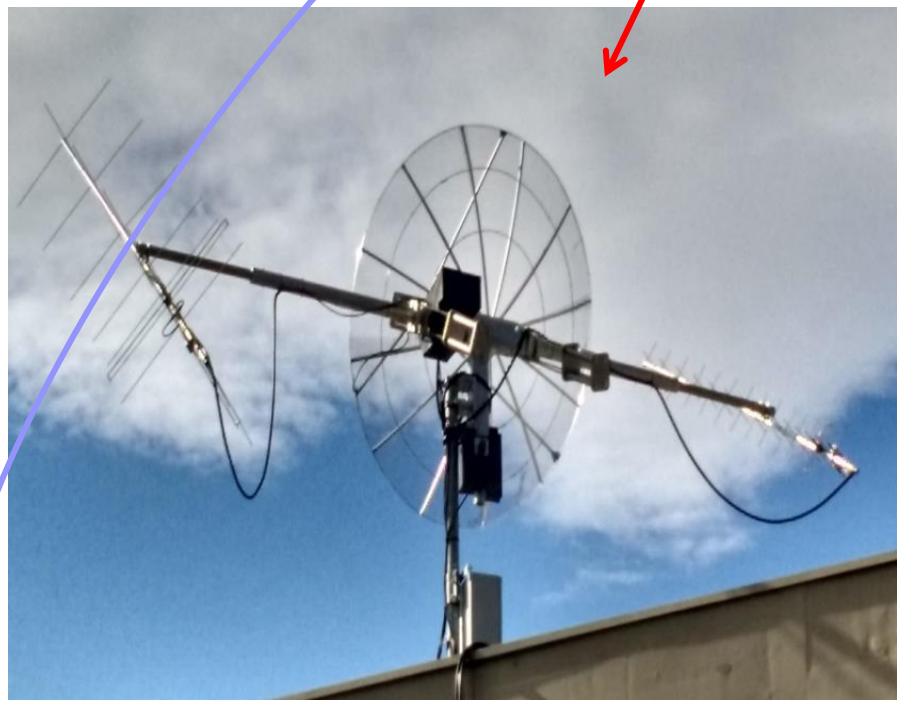
Missão inicial do Projeto

Radiodifusão em órbita de mensagens gravadas em

- Português
- Espanhol
- Inglês



Áudio gravado



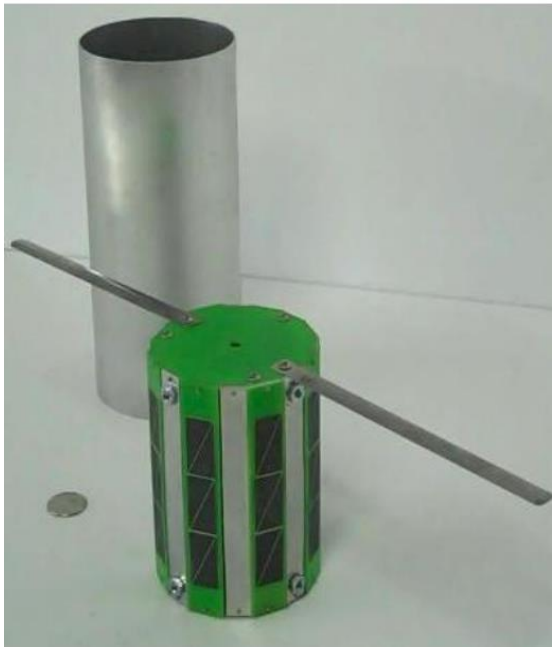
TubeSat Personal Satellite Kit

Source: IOS

Kit Contents:

- PCB Gerber Files;
- Transceiver and Transceiver Amplifier (Radiometrix);
- Battery;
- Solar Cells (50);
- Microcontroller and Development Kit;
- Antennas;

INTERORBITAL SYSTEMS



Source: IOS

De acordo com o fabricante:
Alternativa ao CubeSat de baixo custo

Massa: até 0,75 Kg
Diâmetro: 8,9 cm
Altura:12,7 cm

Órbita polar: 310 Km (com Neptune 30)
Período: 90 min

Lançador Neptune

(Em desenvolvimento)

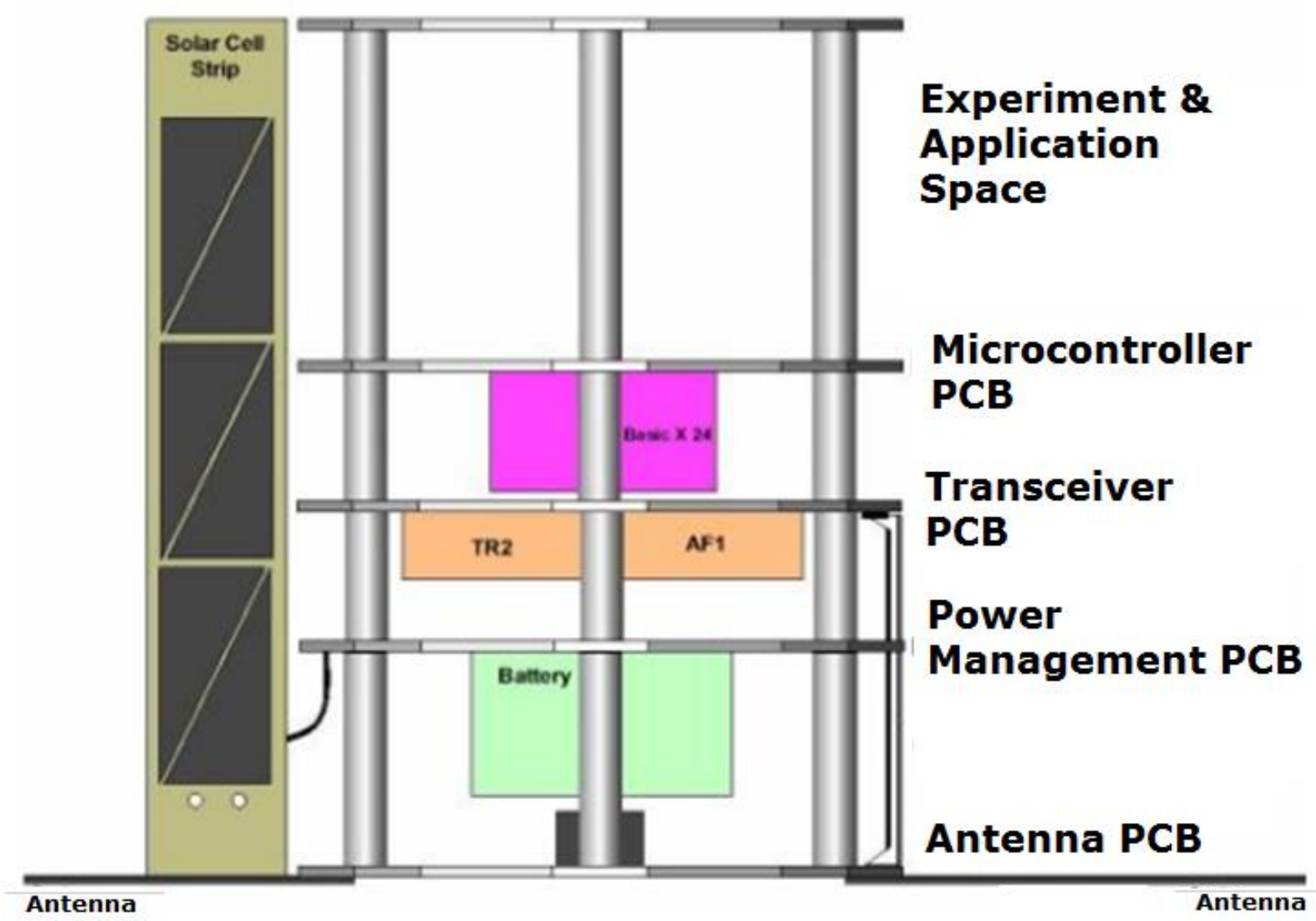
Source: IOS

TubeSat longevity

IOS (Interorbital Systems):

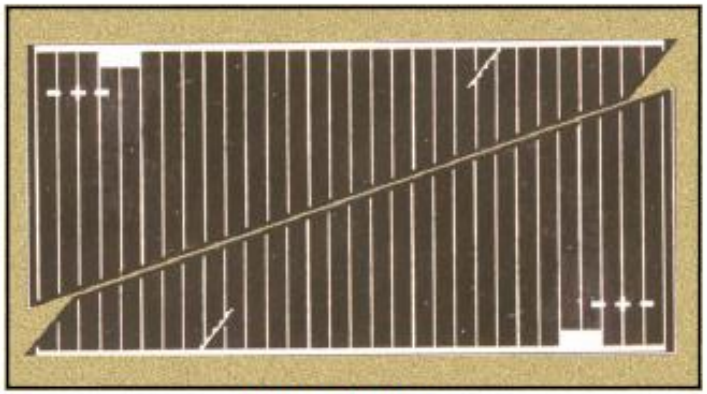
TubeSats using low cost COTS are designed to operate for up to 2 months.
They will be launched into a 310-km orbit with an orbital longevity of three weeks to two months depending on the solar weather.

Layout



Source: IOS

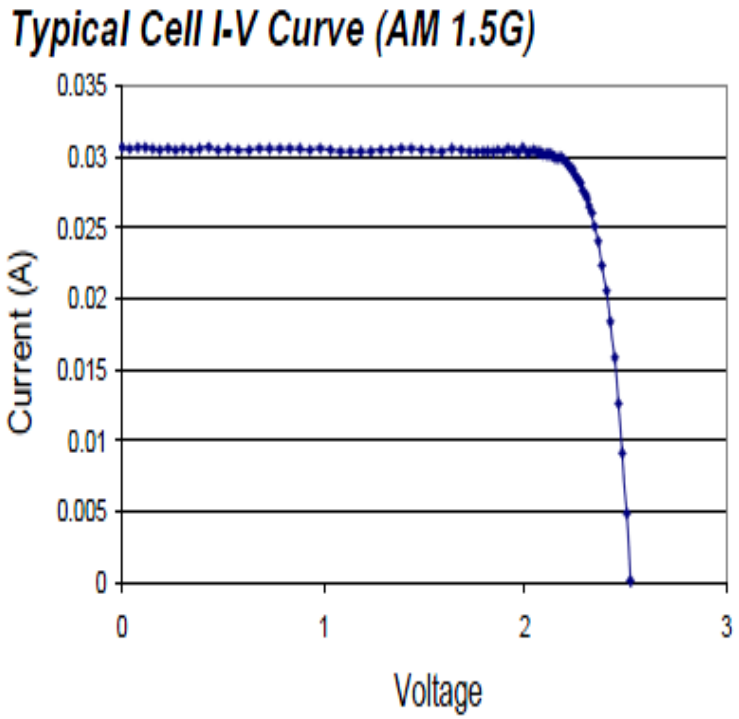
Solar Cell



Not Actual Size

Typical Cell Electrical Parameters *1 Sun, AM1.5G (100.0 mW/cm²) 25°C*	
I_{sc}= 31 mA	I_{mp}= 28 mA
V_{oc}= 2.52 V	V_{mp}= 2.19 V
P_{mp}= 0.027 W/cm²	Cff= 80 %
Efficiency= 27 ± 3% Absolute	Temp. Coeff. V_{mp} = -6.2 mV/°C

Spectrolab
Photovoltaic Products
www.spectrolab.com

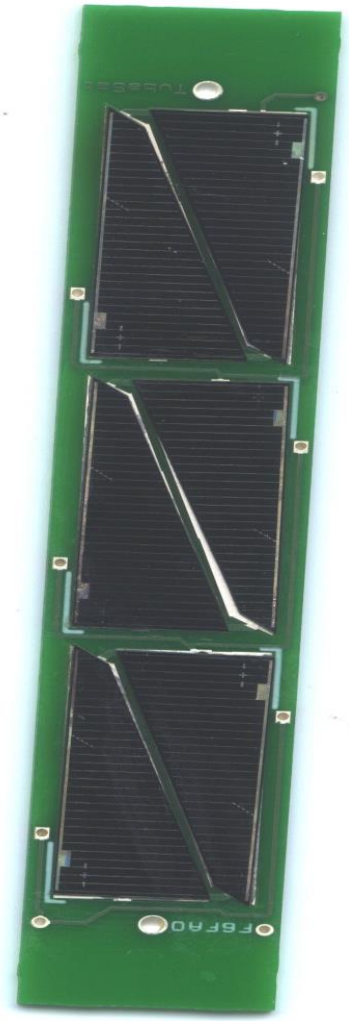


Source: IOS

Solar Panel

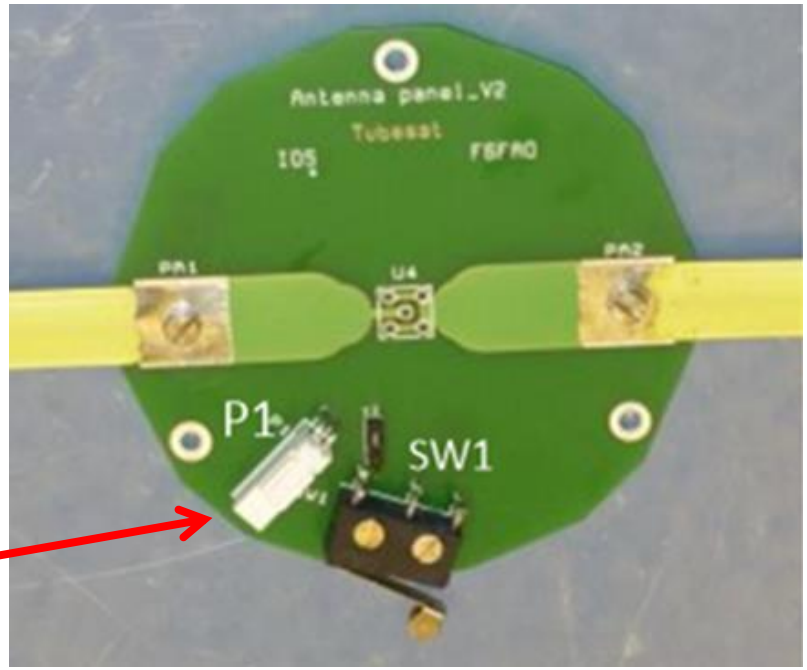
6 células por painel

Total: 8 painéis
(48 células solares)



Antena

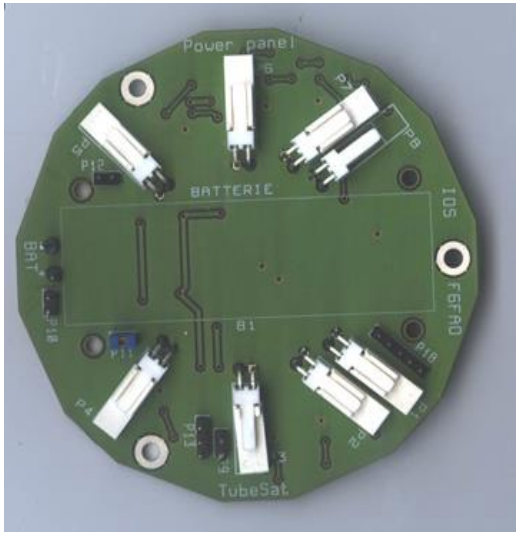
Frequência: 436,5 MHz
Dipolo meia onda: ~33 cm



Source: IOS

P1: “PBF”
(Put Before Flight)

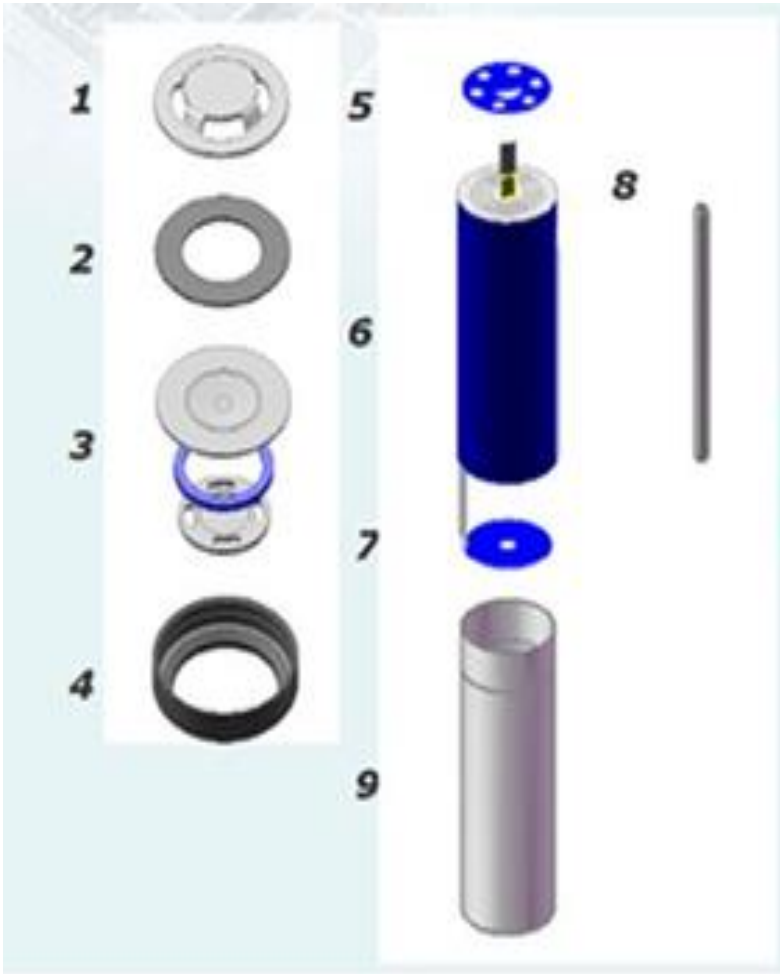
Gerenciamento de Potência



Source: IOS

Bateria de íons de lítio
2 células 18650 em paralelo
3,7 volts
5200 mAh

Estrutura da Célula



No.	part
1.	Cap up
2.	PTC
3.	CID
4.	Gasket
5.	Insulator Top
6.	Jelly Roll
7.	Insulator Bottom
8.	Center Pin
9.	CAN

Transceiver and Power Amplifier

Source: IOS

Radiometrix Transceiver:

Operating frequency: 436 MHz band

Transmit power: +20dBm (100mW)

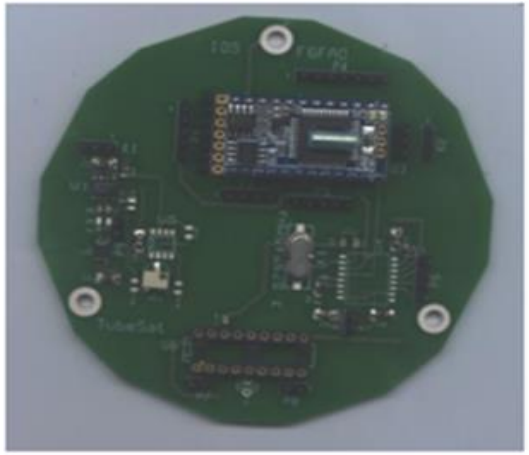
Operating temperature: -10 to +60°C

Power Amplifier

Tx power with ampl: +27 dBm (500mW)

Operating temperature: -20 to +70°C

Computador de Bordo



Source: IOS

Módulo BX 24
CPU ATMEL: ATMEGA 8535

Environmental Specifications:
-40ºC to +85ºC
Eeprom:32k
RAM: 400 Bytes

Projeto Inicial

KIT

Source: IOS

?

Alunos da escola fundamental pública

Recepção

Radiodifusão

Carga Útil

Source: IOS

Netune 30

ACORDO DE COOPERAÇÃO

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

EXTRATO DE ACORDO

Espécie: Acordo de Parceria RD Nº 01.01.029.0/ 2011;
Partícipes: A União, representada pelo Ministério da Ciência e Tecnologia - MCT, por intermédio do Instituto Nacional de Pesquisas nEspaciais - INPE, CNPJ Nº 01.263.896/0005-98 e o Município de Ubatuba, SP, CNPJ Nº 46.482.857/0001-96;
Objeto: Estabelecer e regulamentar um Acordo de Parceria para assessorar as atividades, sem ônus ao INPE, na área de Engenharia e Tecnologia Espacial, voltadas para a programação, montagem, integração e Testes (AIT) e operação de um kit de picosatélite Tubesat;
Fundamento Legal: Lei Nº 10.973, de 02 de dezembro de 2004, regulamentada pelo Decreto Nº 5.563, de 11 de outubro de 2005 e, no que couber, pela Lei Nº 8.666, de 21 de junho de 1993;
Vigência: 12 meses contados desta publicação;
Data da assinatura: 17/06/2011;
Assinaturas: Pelo INPE: Gilberto Câmara Neto - Diretor, CPF Nº 019.351.598-95, e pelo
Município de Ubatuba: Eduardo de Souza César - Prefeito, CPF Nº 073.226.038-85;
Data: Em 17/06/2011

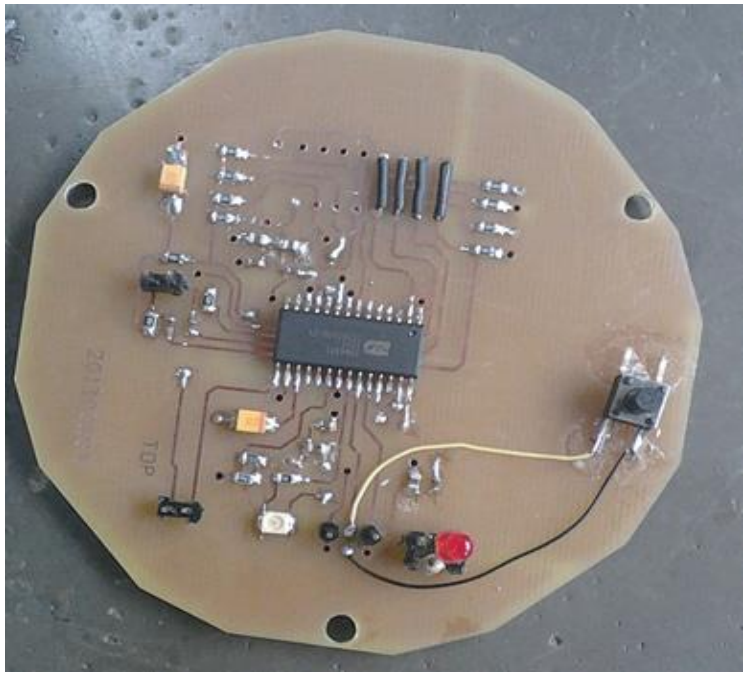
Fonte: Diário Oficial da União (DOU) - pág. 13 - 20/06/2011

Treinamentos:

- Soldagem
- Eletrônica básica
- Informática

Carga Útil do UbatubaSat

Radiodifusão de mensagens gravadas



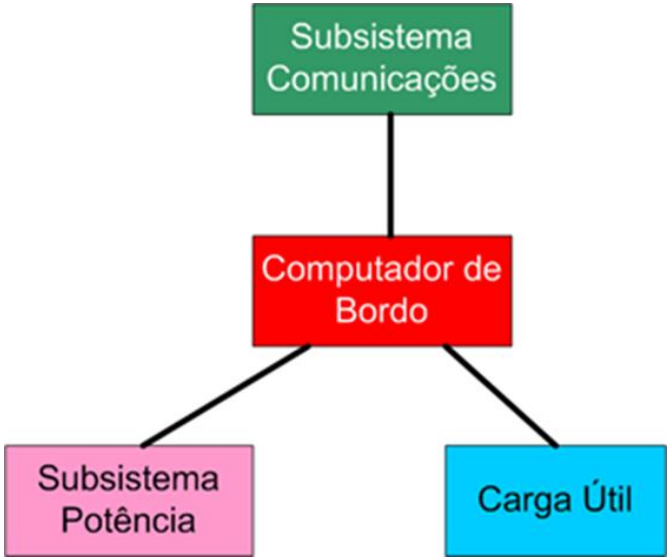
Primeira versão do gravador

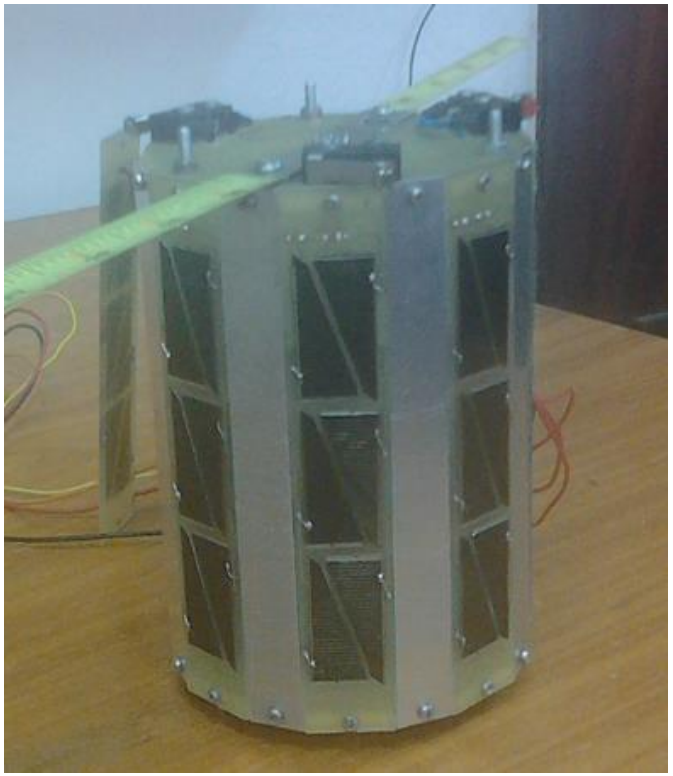
ISD1964SYI NUVOTON
Voice record/Playback Device

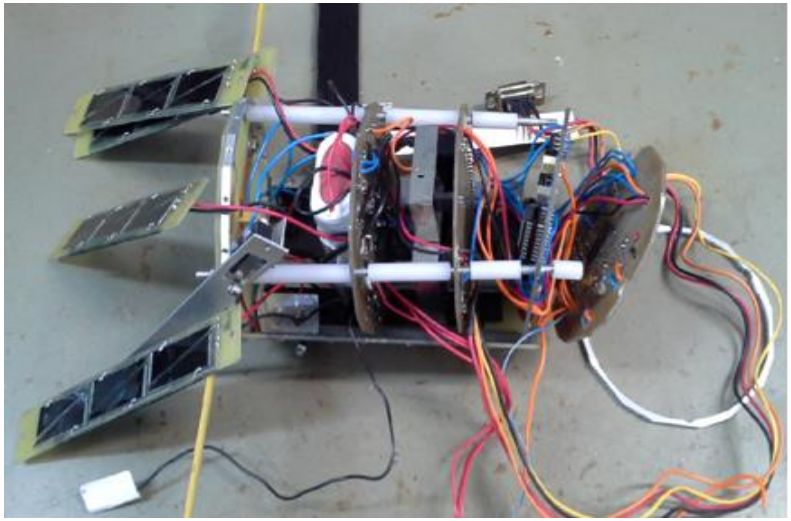
Gravação: duração de 42 seg
Freq. amostragem: 12 kHz

Temperatura: -40 a +85 ^{o}C

Primeiro Protótipo do projeto: Tancredo-1







Apresentação do trailer UbatubaSat

https://www.youtube.com/watch?v=yMgn4bu9P5o

Atraso do desenvolvimento do Lançador Neptune

Source: modified IOS figure

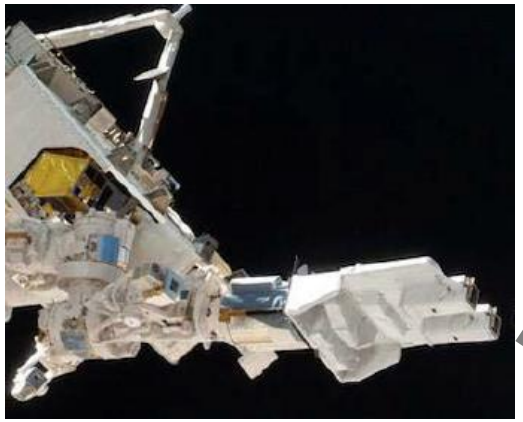
Lançamentos: Ofertadas pela AEB

Antares

Cygnus

Falcon 9

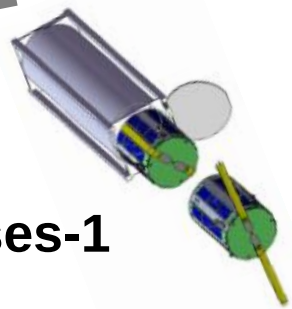
Dragon



ISS

P-POD
(NRCSD)

TuPOD



Ulises-1

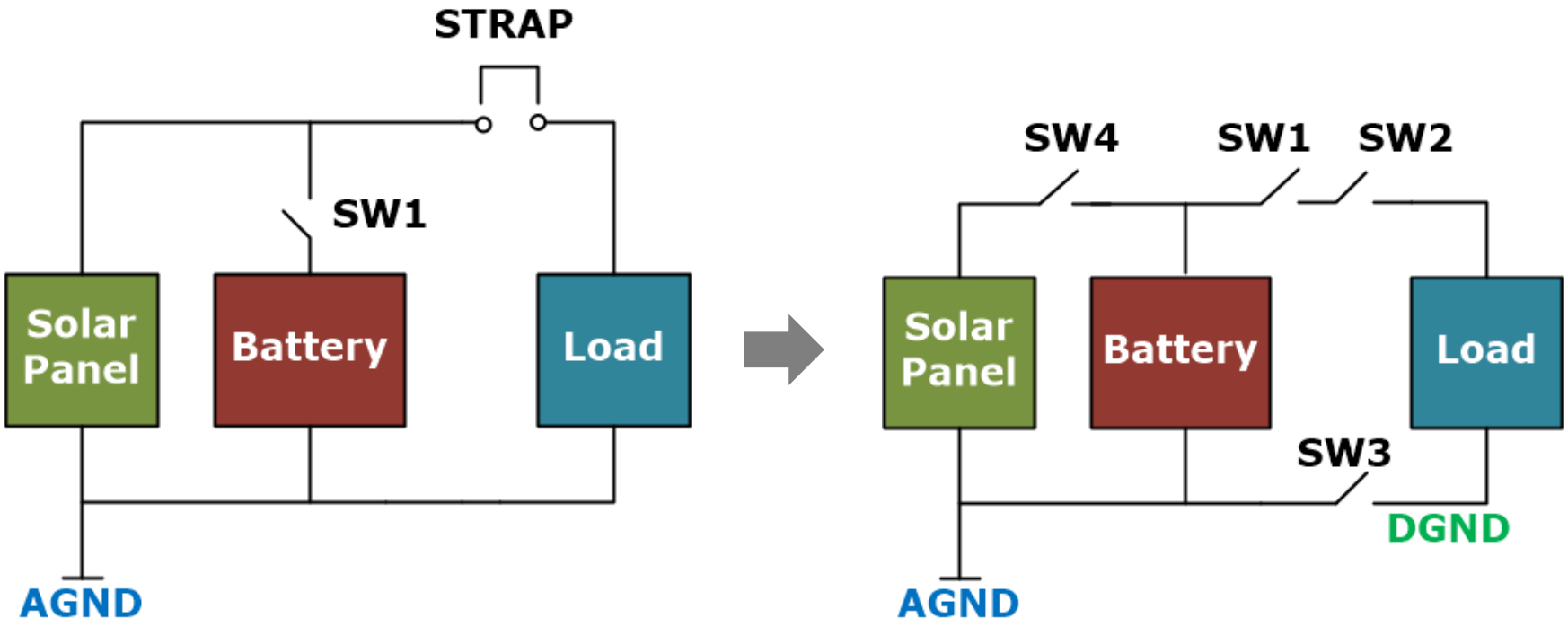
Tancredo-1

Source: Orbital Sciences / SpaceX / NASA

Novos Requisitos com lançamentos ofertados:

Source: NASA

Desacoplamento total do sistema de alimentação



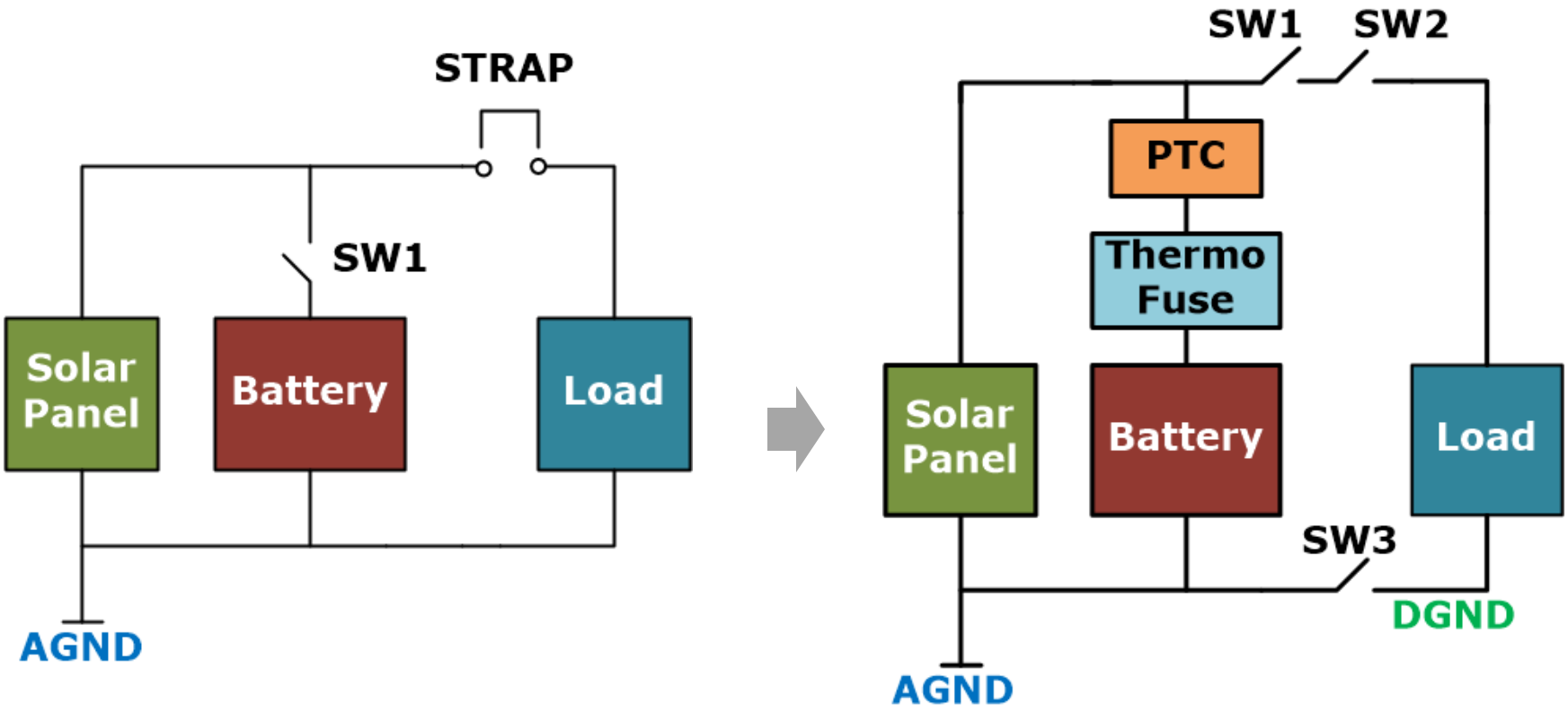
Alimentação original do TubeSat

As is

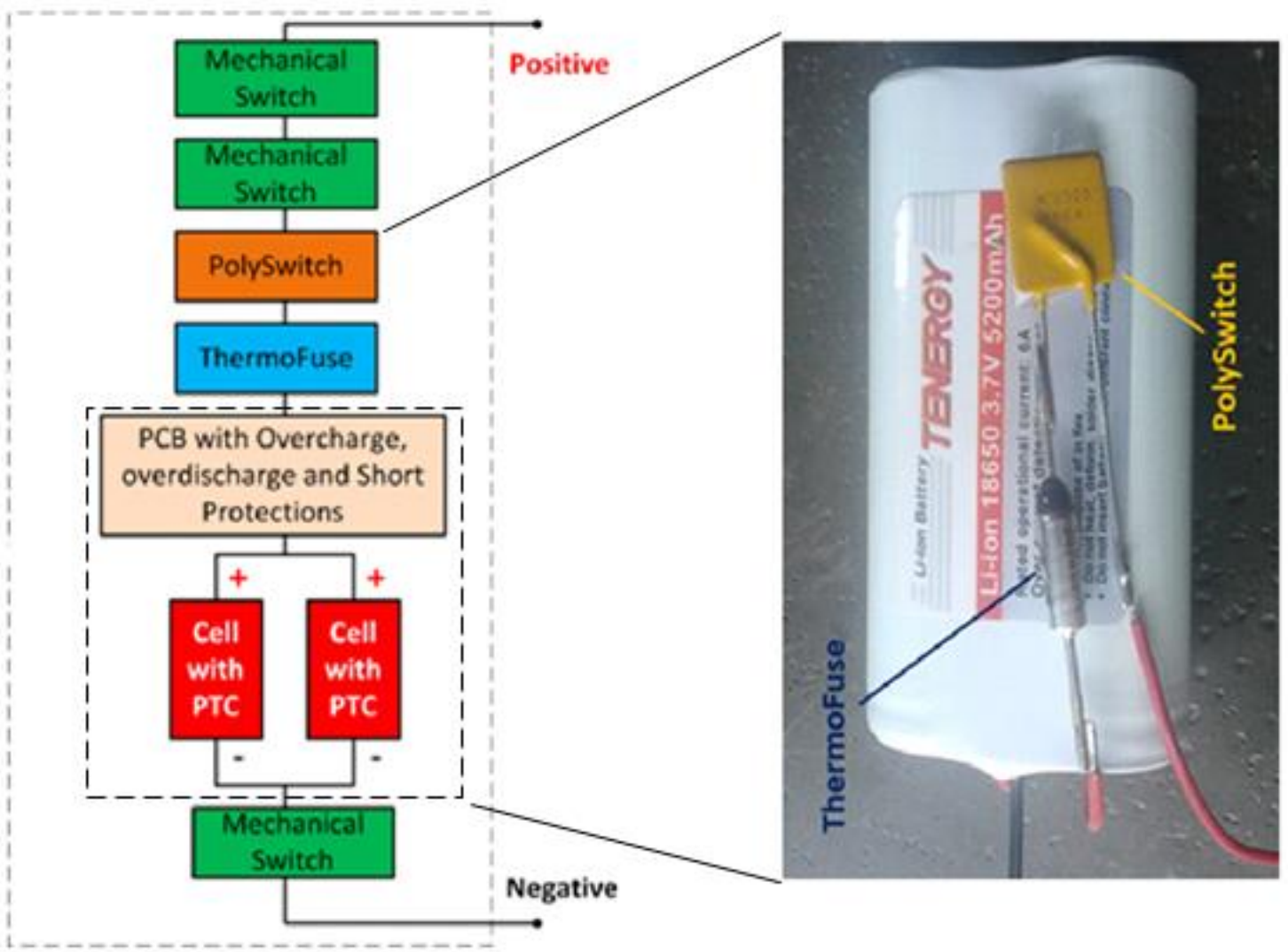
Requisitos

To be

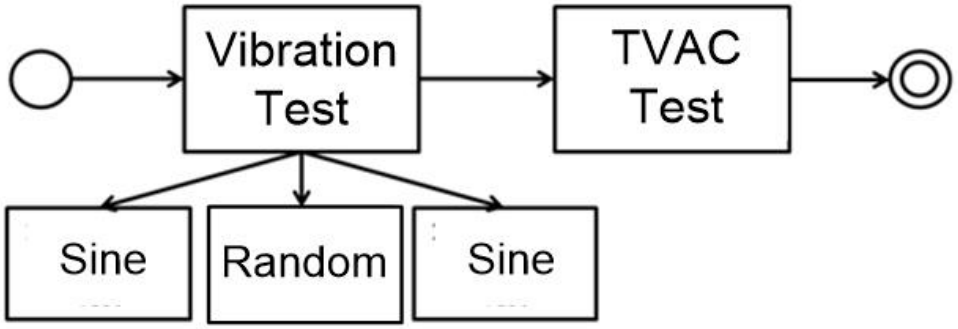
Alterações aceitas para TubeSat

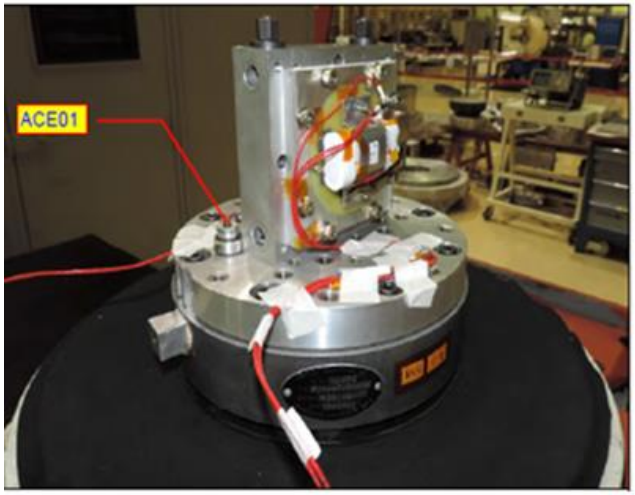


Proteção Redundante: (7 níveis de HW em série)

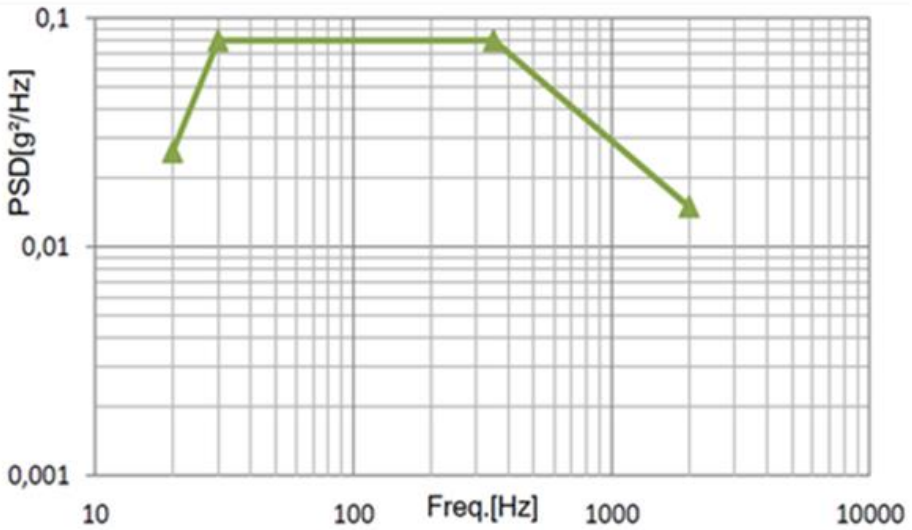


Teste Ambiental do EPS: Nível de Aceitação





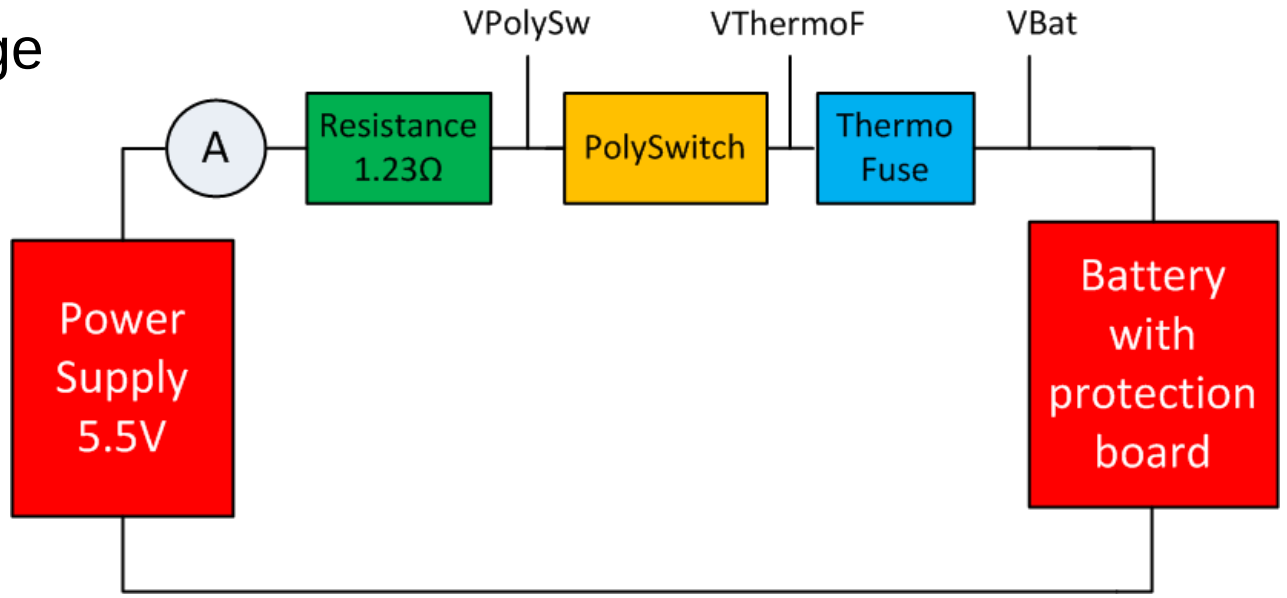
Vibration test

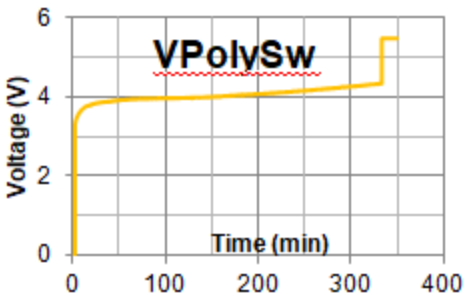


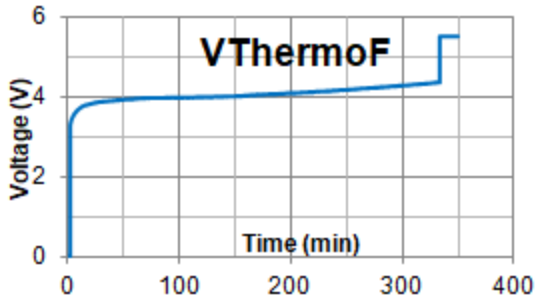
Random vibration profile

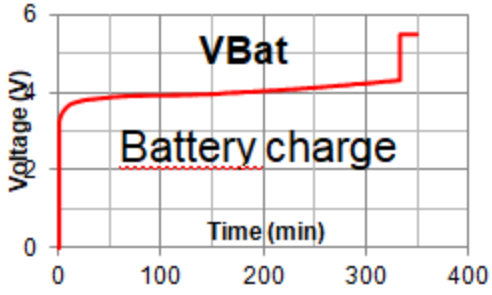
Battery signature

charge



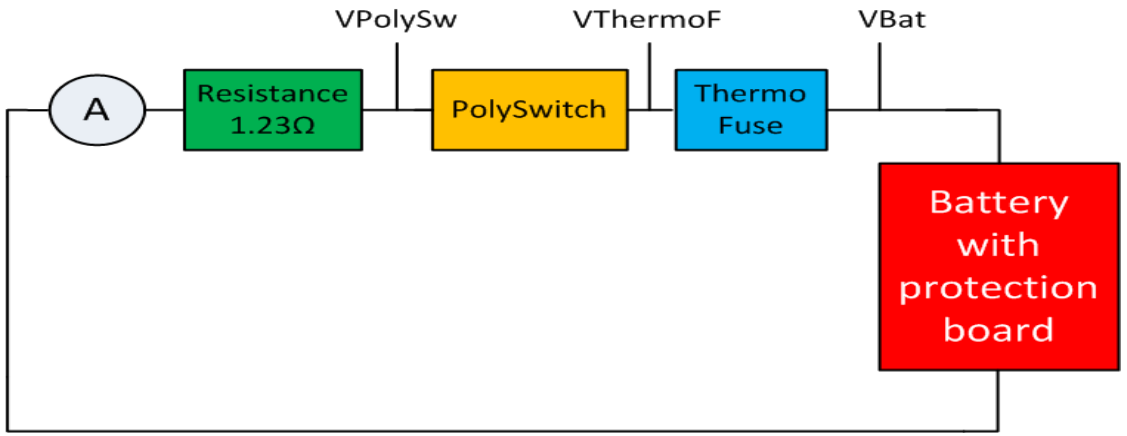


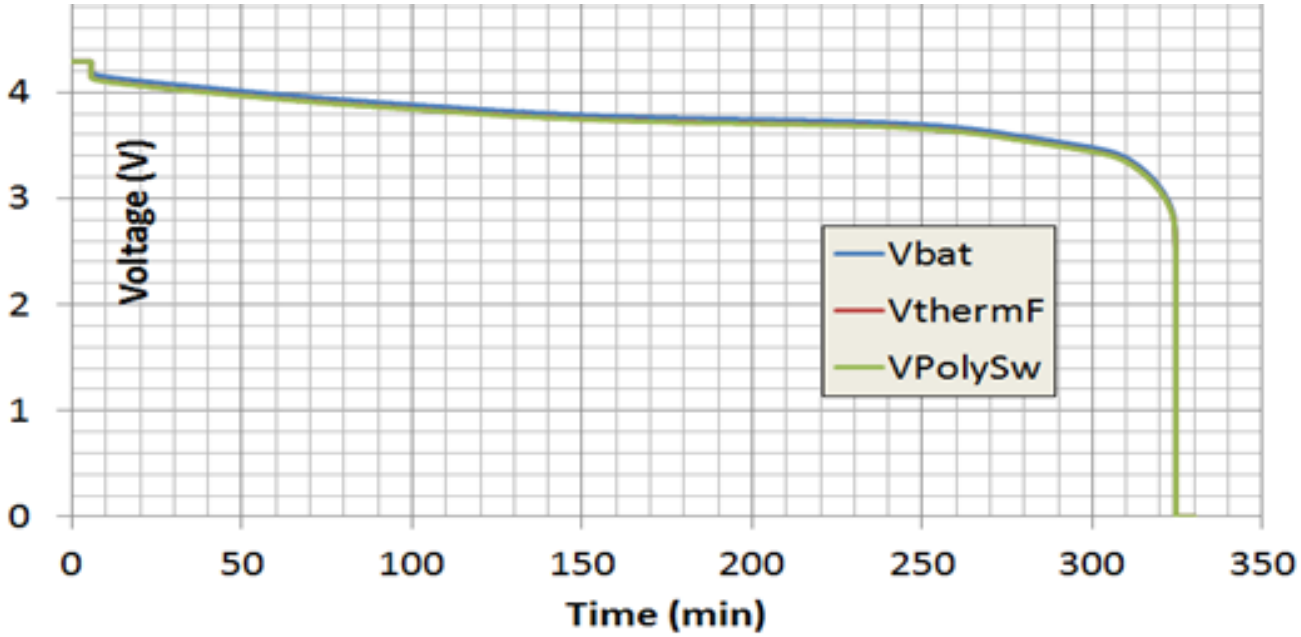




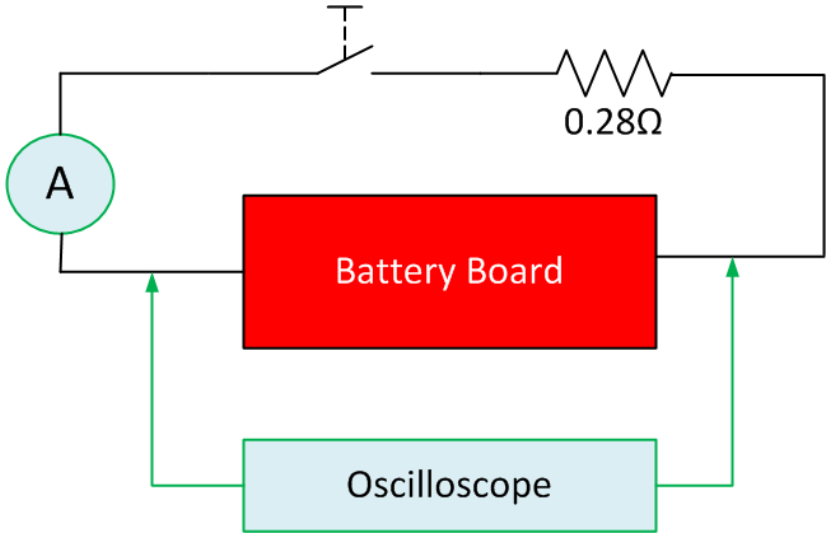
Battery signature

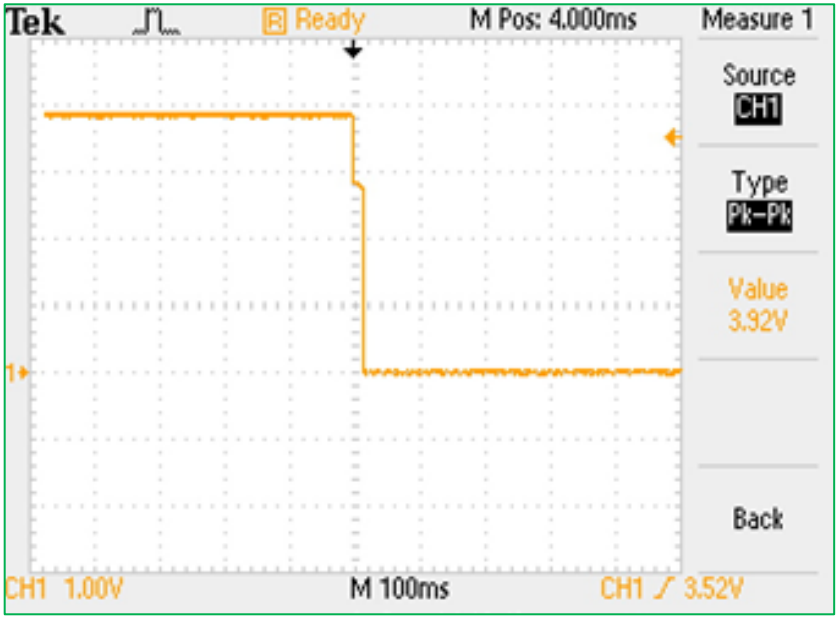
discharge



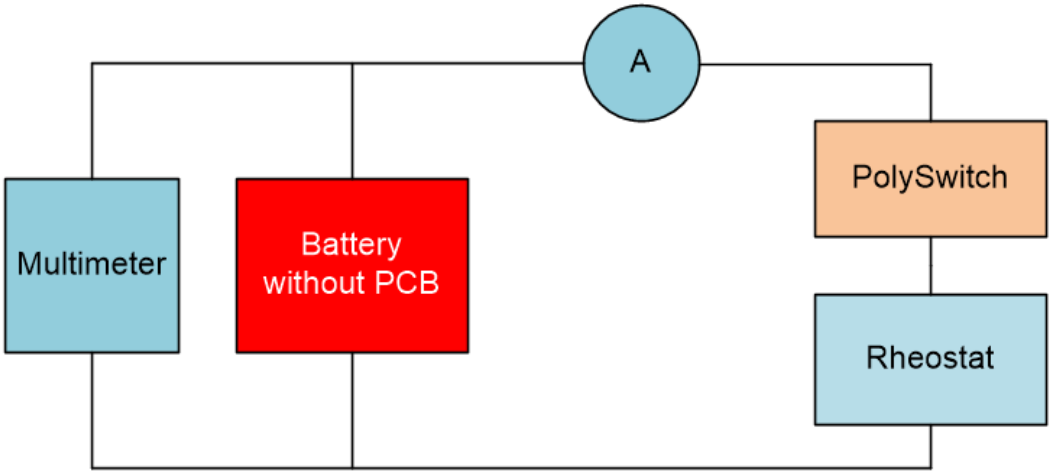


Teste do circuito de proteção da bateria contra curto-circuito

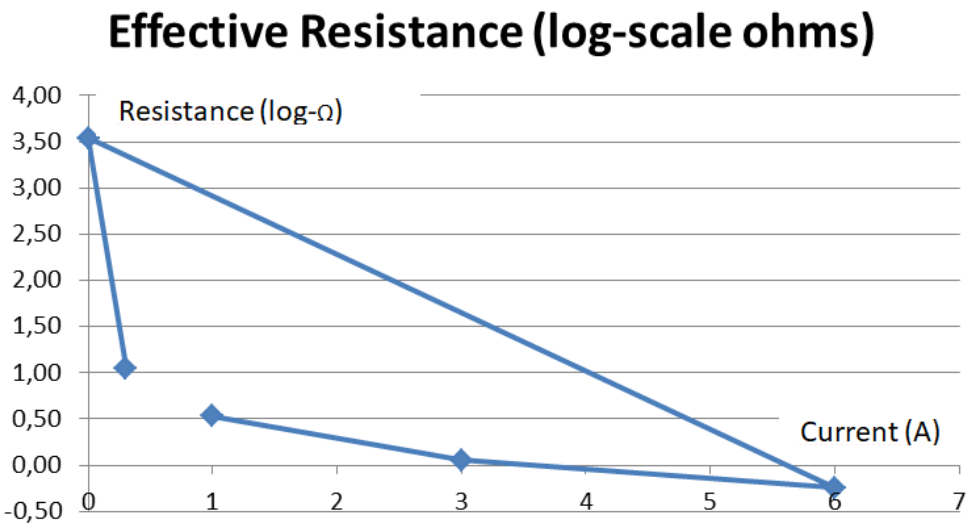




Teste de proteção do PolwSwitch



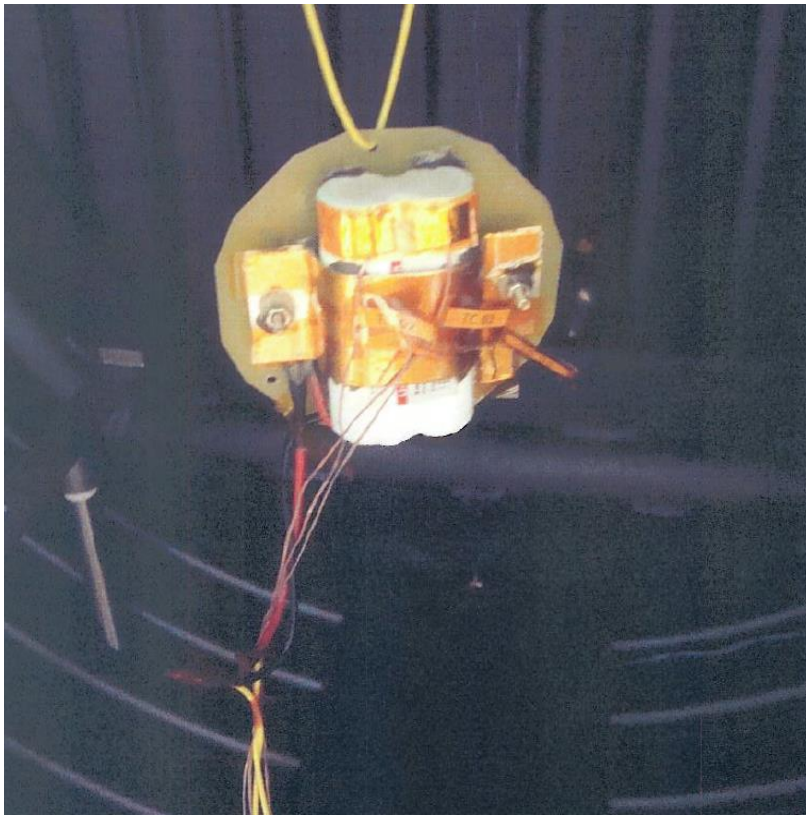
PSR-25280



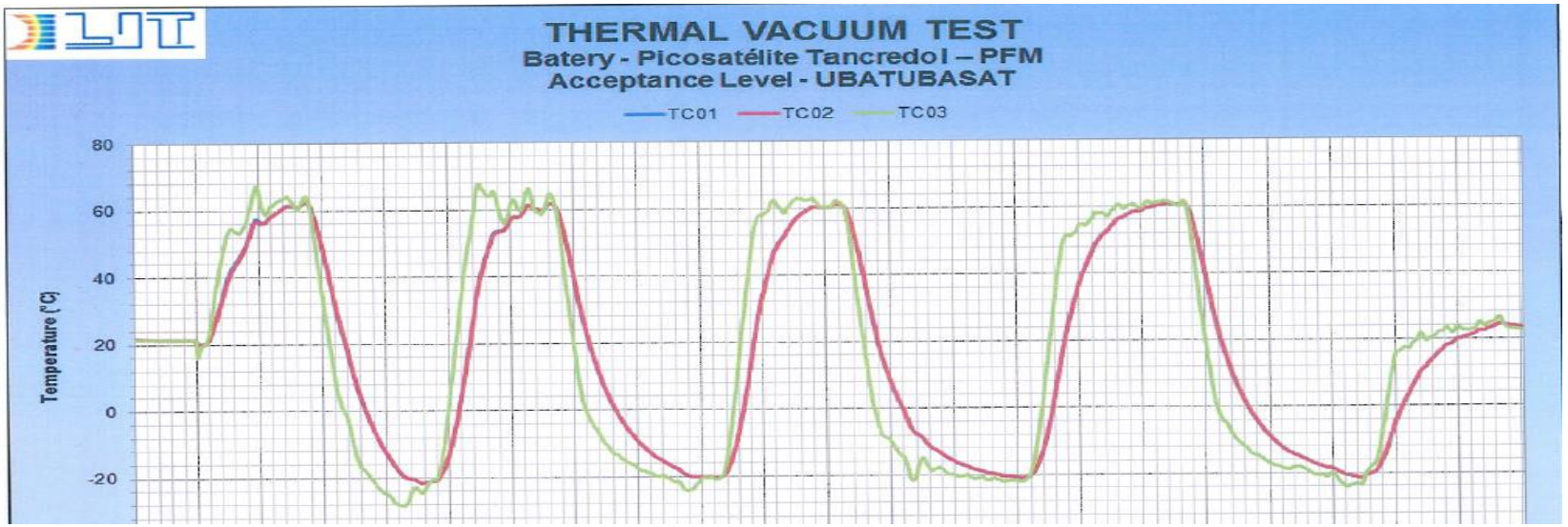
Teste TVAC do EPS: Nível de Aceitação

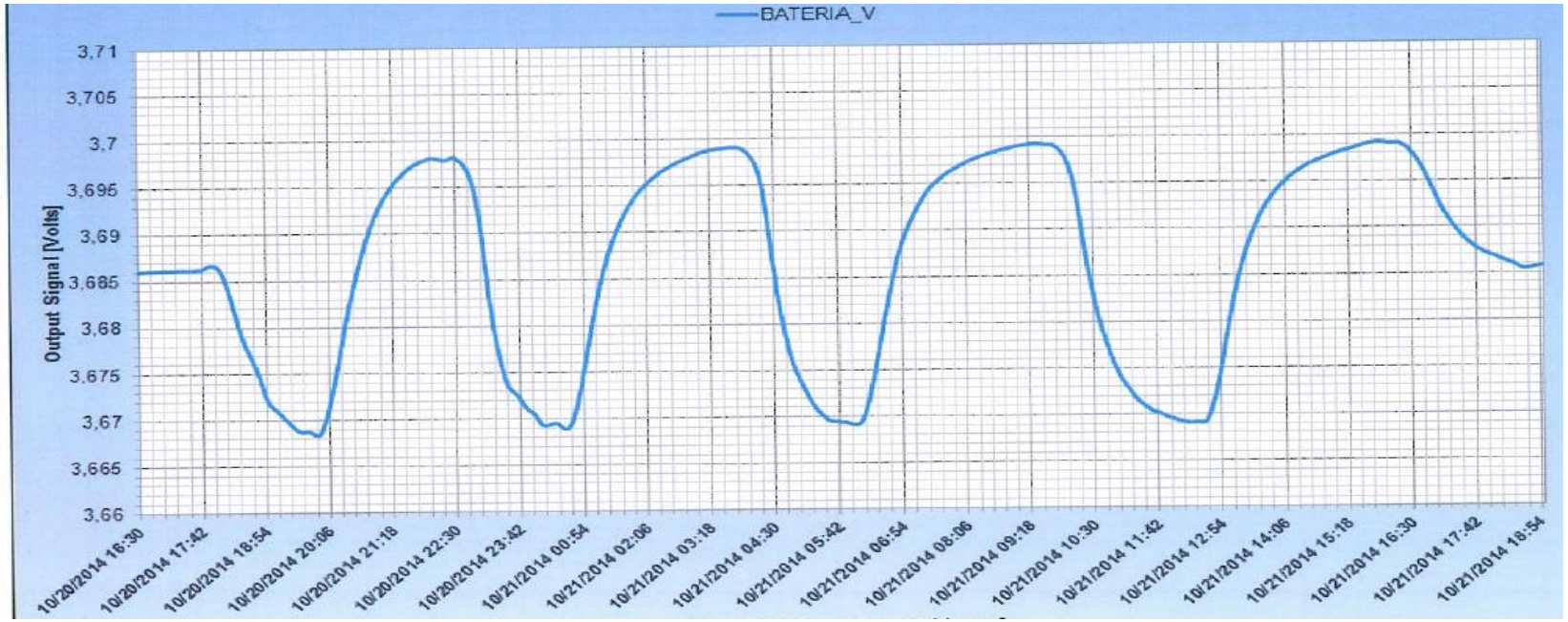
Vacuum pretest for degas.

TVAC



Teste TVAC do EPS: Nível de Aceitação





Requisito: Material utilizado

NASA-STD-6001B:
FLAMMABILITY, OFFGASSING, AND COMPATIBILITY REQUIREMENTS AND TEST PROCEDURES

- Offgassing:

An organic or inorganic compound evolved as a gas from a liquid or solid material or assembled article into an atmosphere.

- Outgassing: occurs in vacuum conditions

Outgassing

(Packaging considerations for Vacuum of Space)

. **Two main parameters to characterize outgassing:**

(Sample of material is vacuum baked at 125^{o}C, 10^{-6} Torr)

- Total Mass Loss (TML) ≤ 1.0%

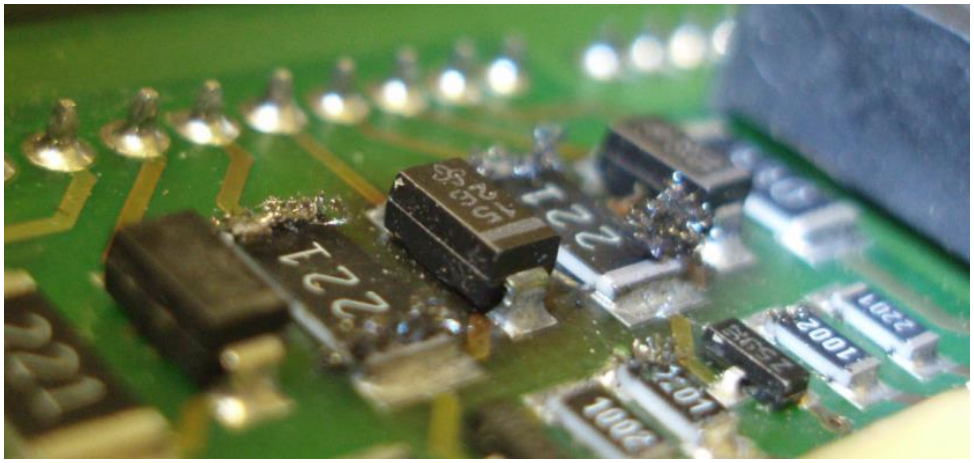
- Collected Volatile Condensable Material (CVCM) ≤ 0.1%

Space Vacuum – Tin Whiskers

RoHS (Restriction of Certain Hazardous Substances)

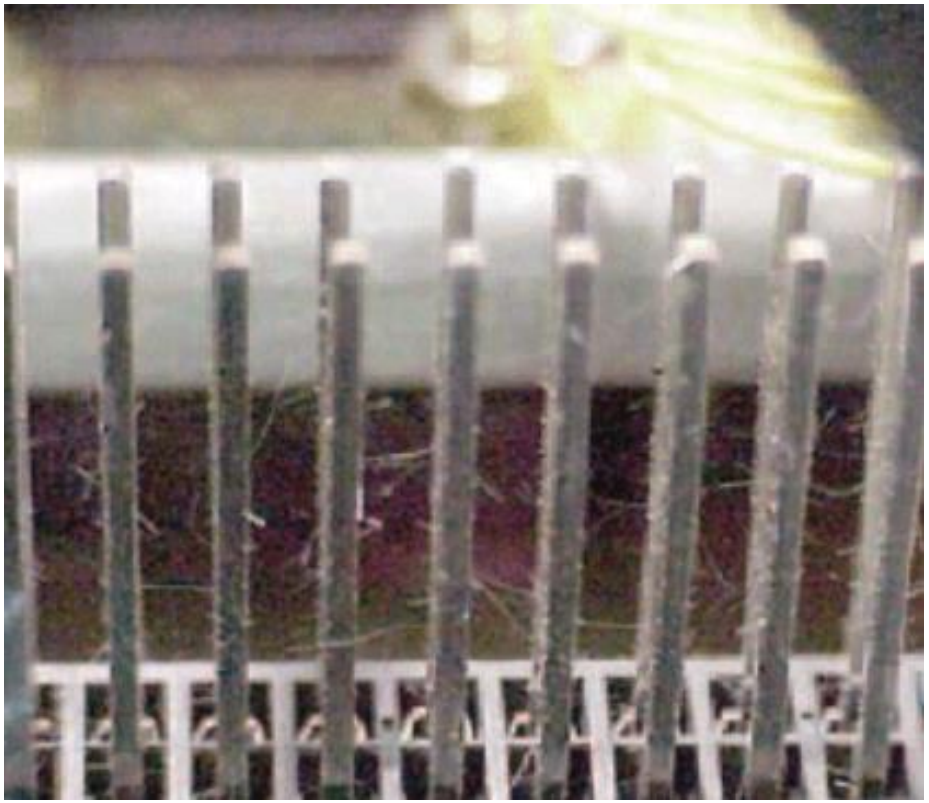
Proibição na fabricação com Cd, Hg, Pb e outras substâncias).

Problems using pure-tin surfaces (lead free) under high stress: Tin whiskers



Tin whisker source: Zach Allen (ECEN 5004: Fundamentals of microsystems packaging)

Tin whisker

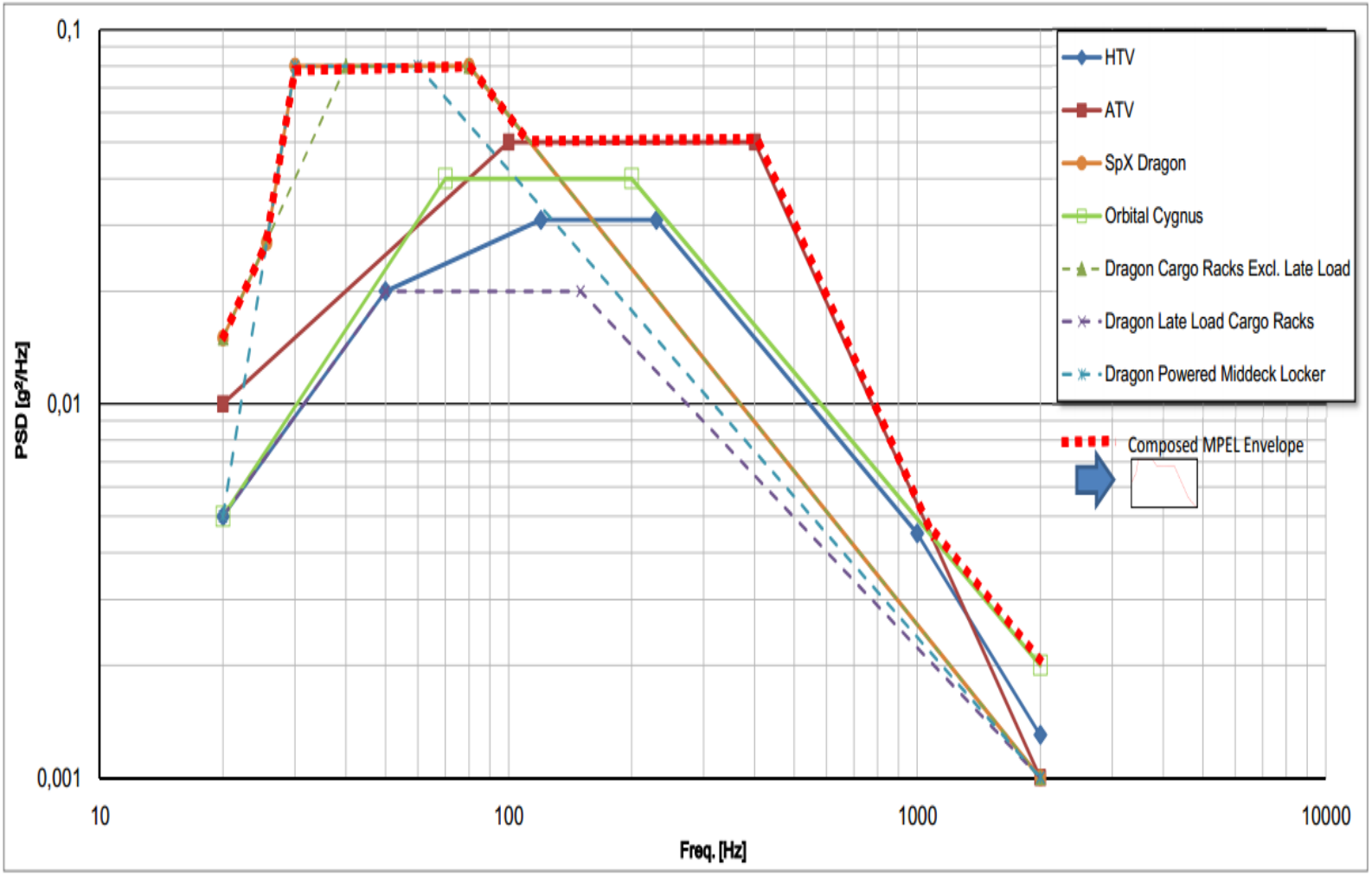


Source: NASA

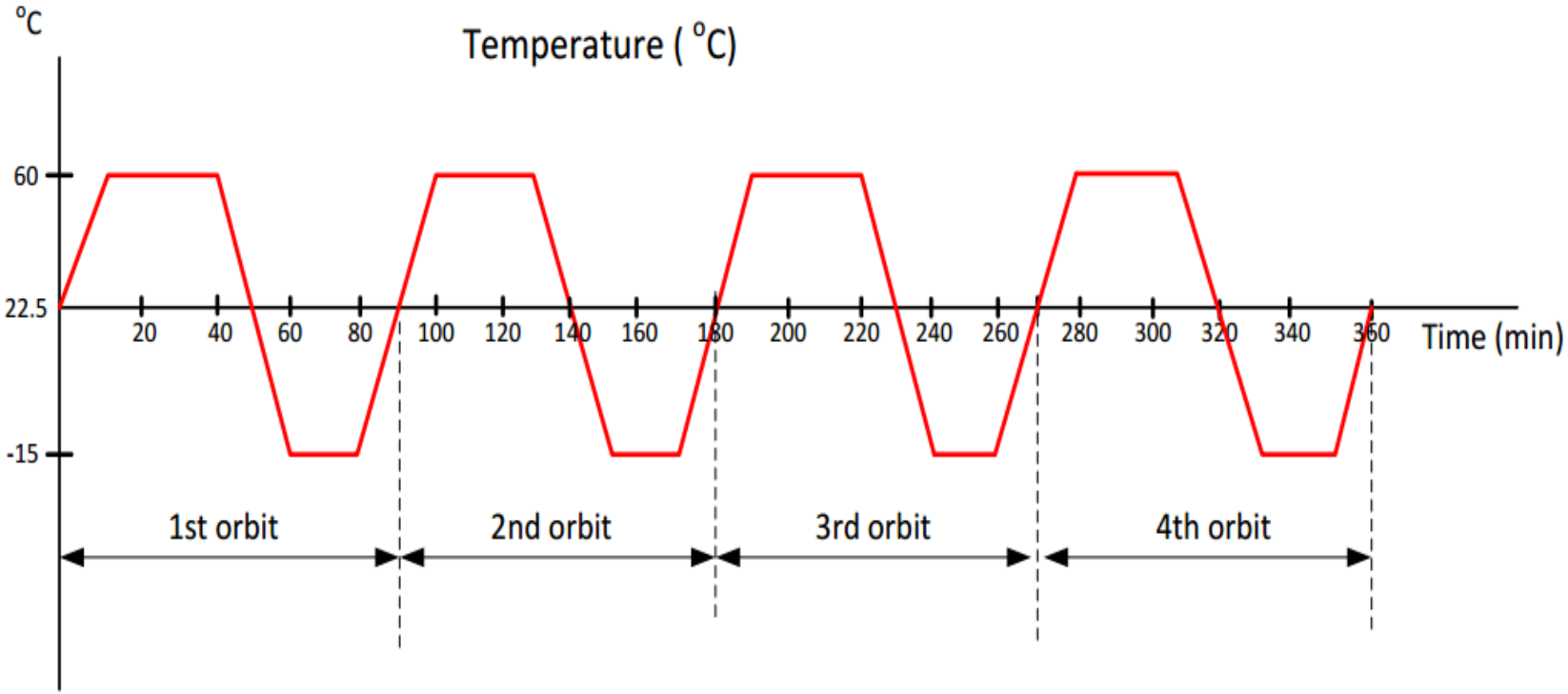
Pure tin plated connector pins displaying many short circuits due to tin whisker growth

Requisito: Testes ambientais do satélite

Vibração



Termovácuo


°C
Temperature (°C)
60
22.5
-15
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
Time (min)
1st orbit
2nd orbit
3rd orbit
4th orbit

Requisitos: Uso da Frequência

Ter frequência de operação coordenada

UHF

IARU International Amateur Radio Union

ITU International Telecommunication Union

Anatel AGÊNCIA NACIONAL DE TELECOMUNICAÇÕES

NASA **Johnson Space Center**

Requisitos primordiais dos órgãos reguladores de frequência e lançadores:

Desligar a transmissão do SAT quando solicitado

TC

Após a ejeção do SAT no espaço:
30 min sem transmissão (áudio ou TM)

Estrutura de quadro de telecomando/telemetria

Padrão ESA

Byte Sync1	Byte Sync2	Msg Length	TC or TM	Data 1	Data 2	. . .	Data N	Check Sum

Exemplo: Dados em Hexadecimal

EB 90 1C A5 28 30 . . . 3F 86

Exemplos de TM&TC implementados

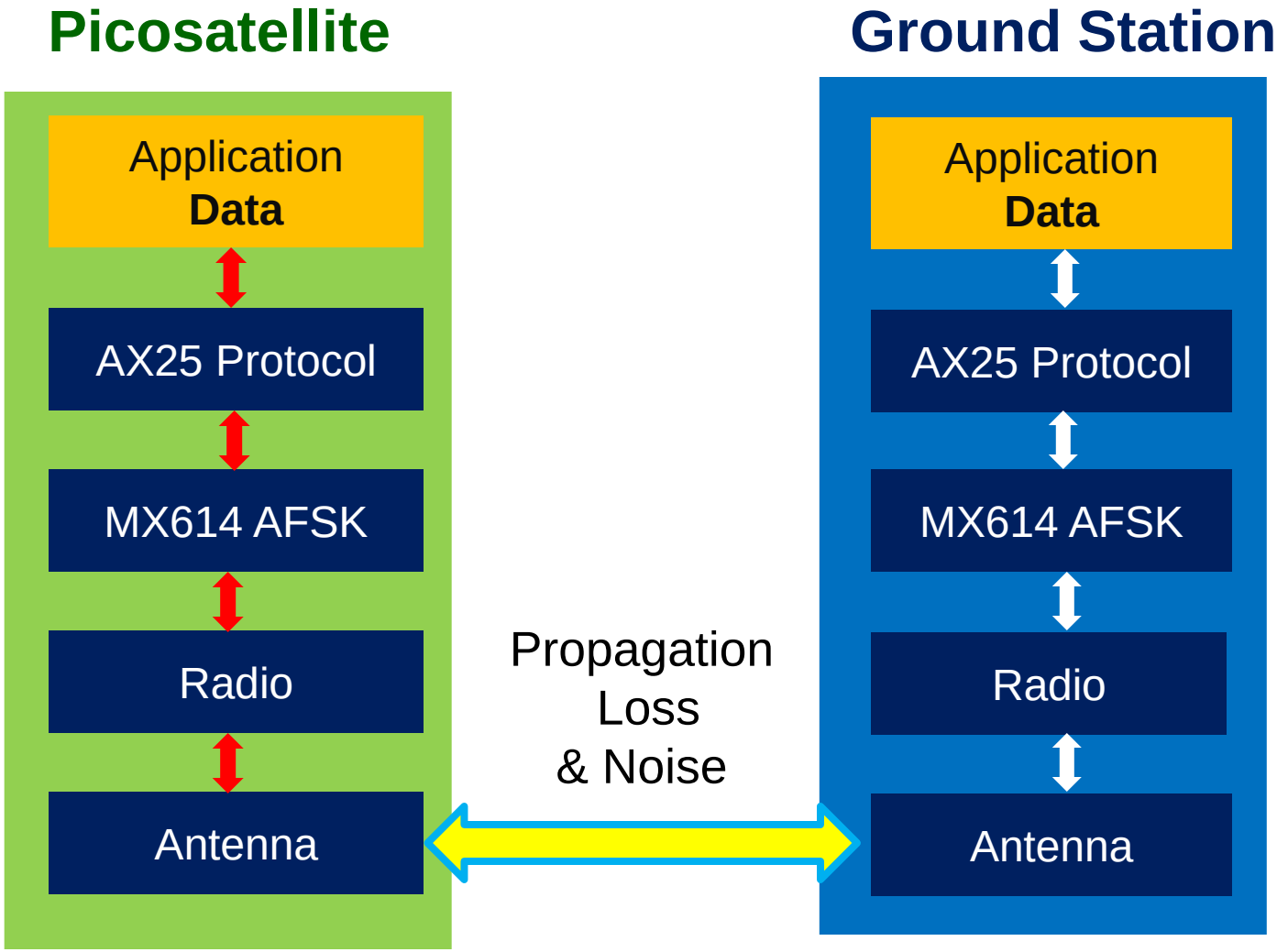
TC básicos:

- Ligar/Desligar Tx
- Selecionar Potência de Tx
- Modo de operação
- Atualização de horário de bordo
- Reset

TM básicas:

- Potência Tx
- Nível da bateria
- Horário de bordo
- Temperatura (inclusão de sensor)

Communication System Overview



Conceito de operações (CONOPS)

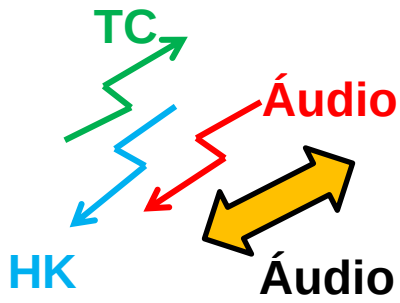
TC

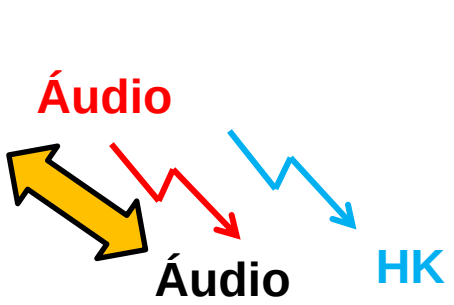
Áudio

HK (TM da plataforma)

Novas funcionalidades

Frequência: Banda de Radioamador via satélite





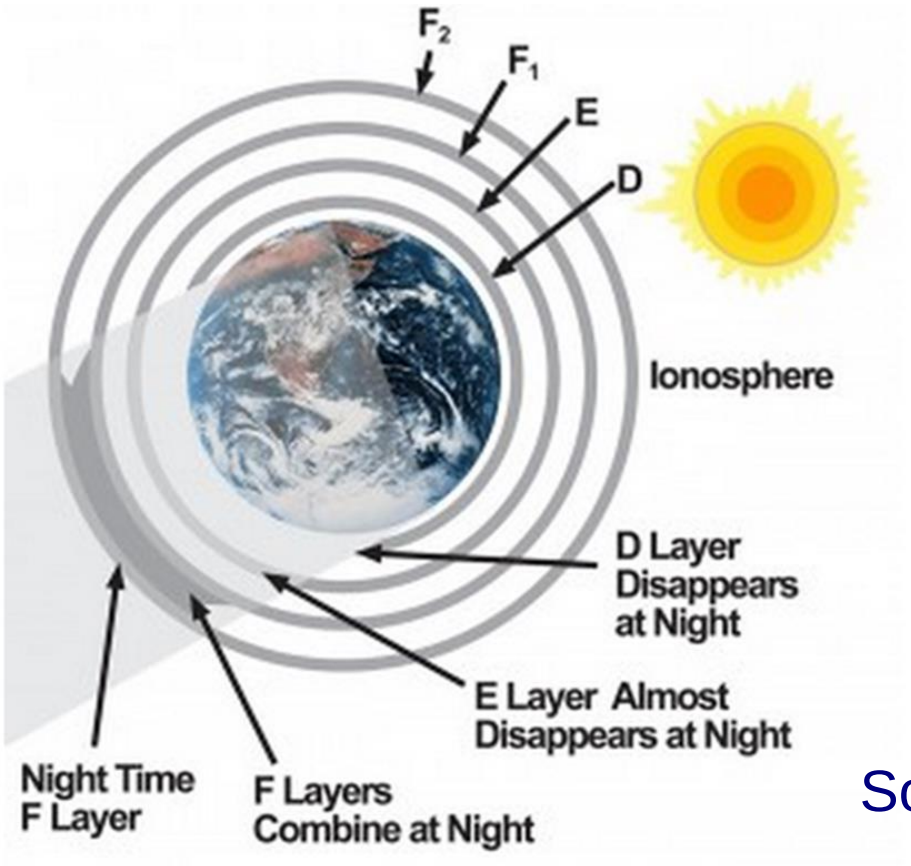
Radioamador

Estação Terrena

Radioamador

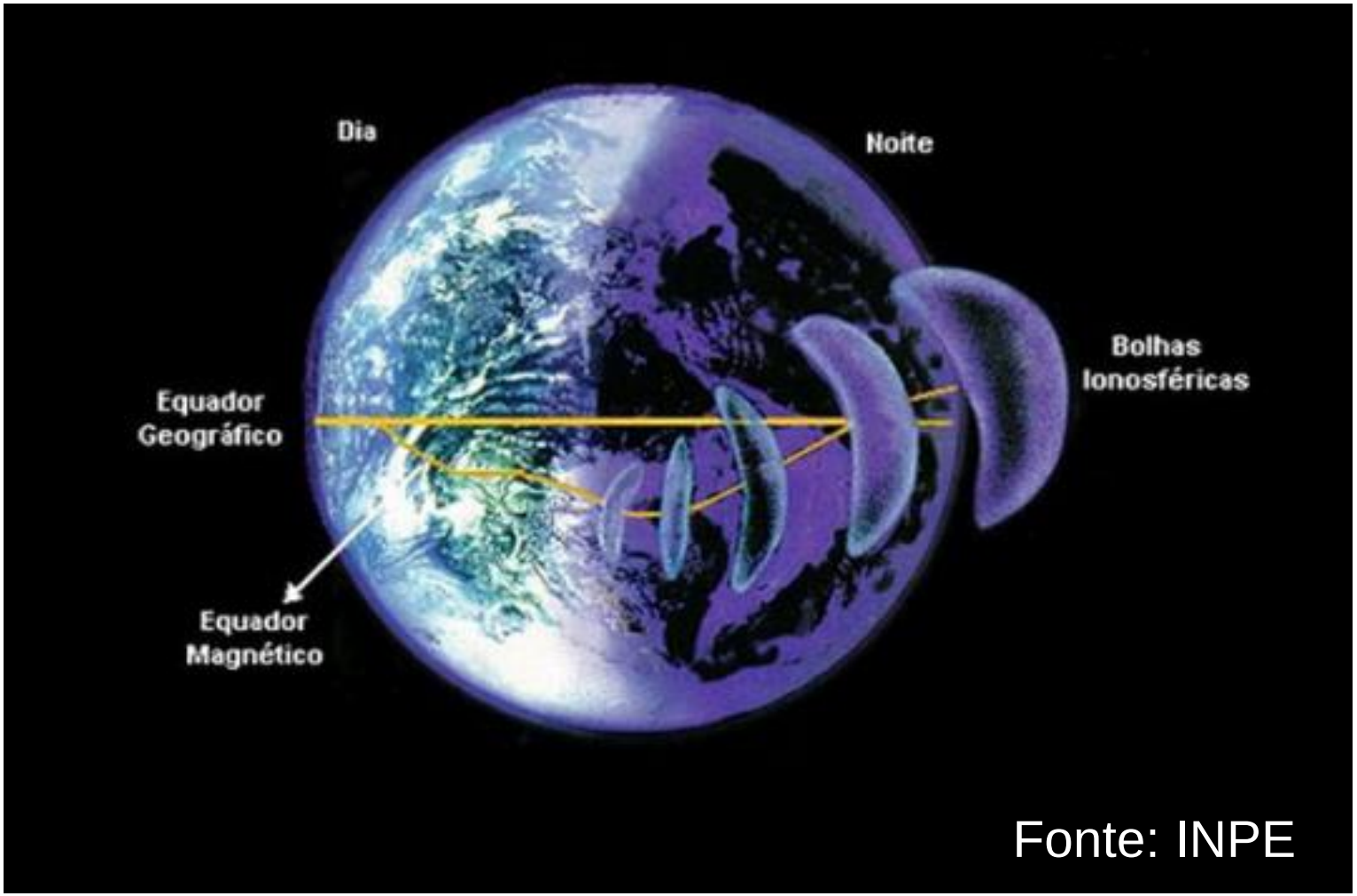
Contrapartida ao acordo de cooperação:
Carga Útil Científica

Inclusão de experimento da Divisão de Aeronomia do INPE para estudo de bolhas de plasma da Ionosfera

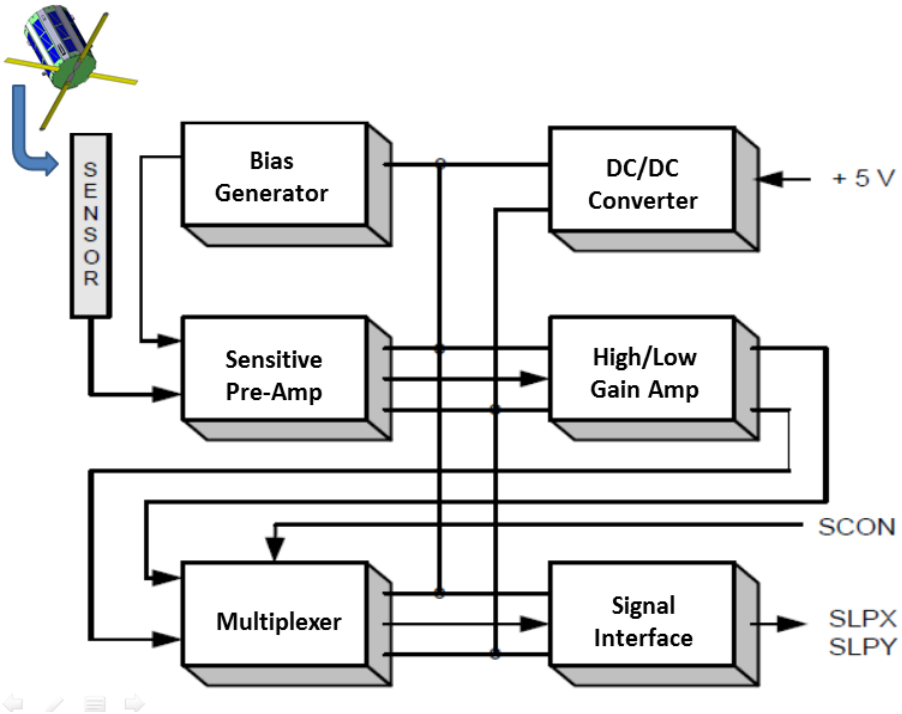


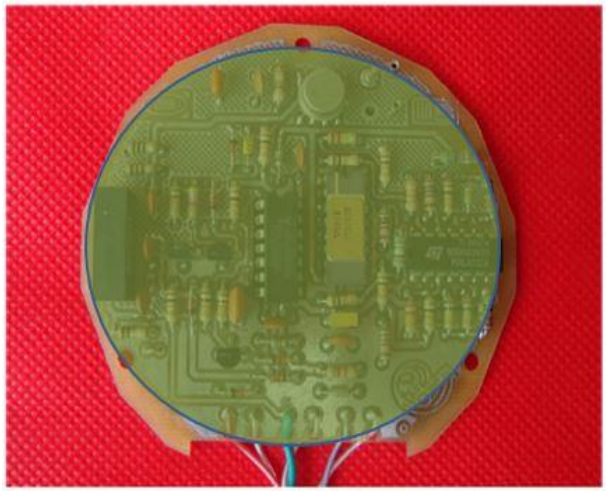
Source: NASA

Bolhas Ionosféricas



The Simplified Langmuir Probe (SLP)





- The INPE-provide Langmuir probe is kept at a positive potential with respect to the satellite. Its current is collected by a metal sensor exposed to the ionosphere

CONOPS

Experimento científico

Sonda

Ionosfera

PYL

PYL

PYL

Radioamador

Radioamador

Divisão de Aeronomia - DAE

CONOPS

Tancredo-1

Sonda

Ionosfera

Áudio TC Áudio TM PYL

Áudio TC Áudio TM PYL

Áudio PYL TM Áudio

Radioamador

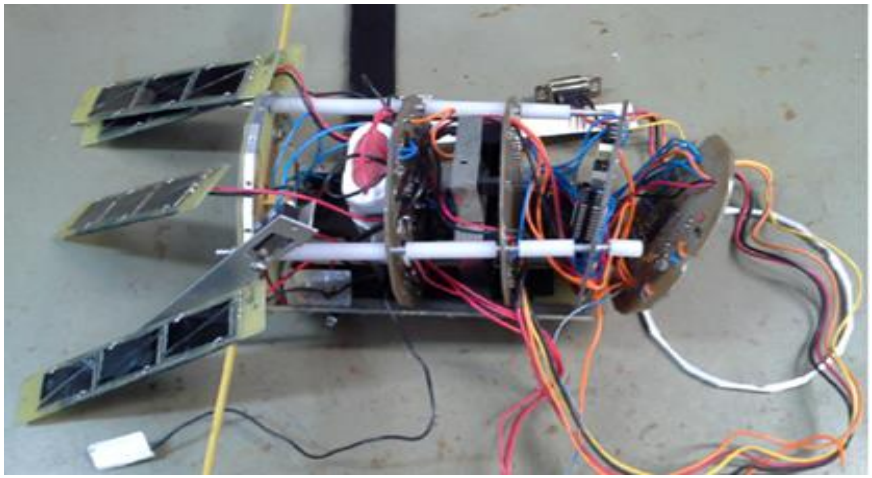
Radioamador

Divisão de Aeronomia - DAE

DEA

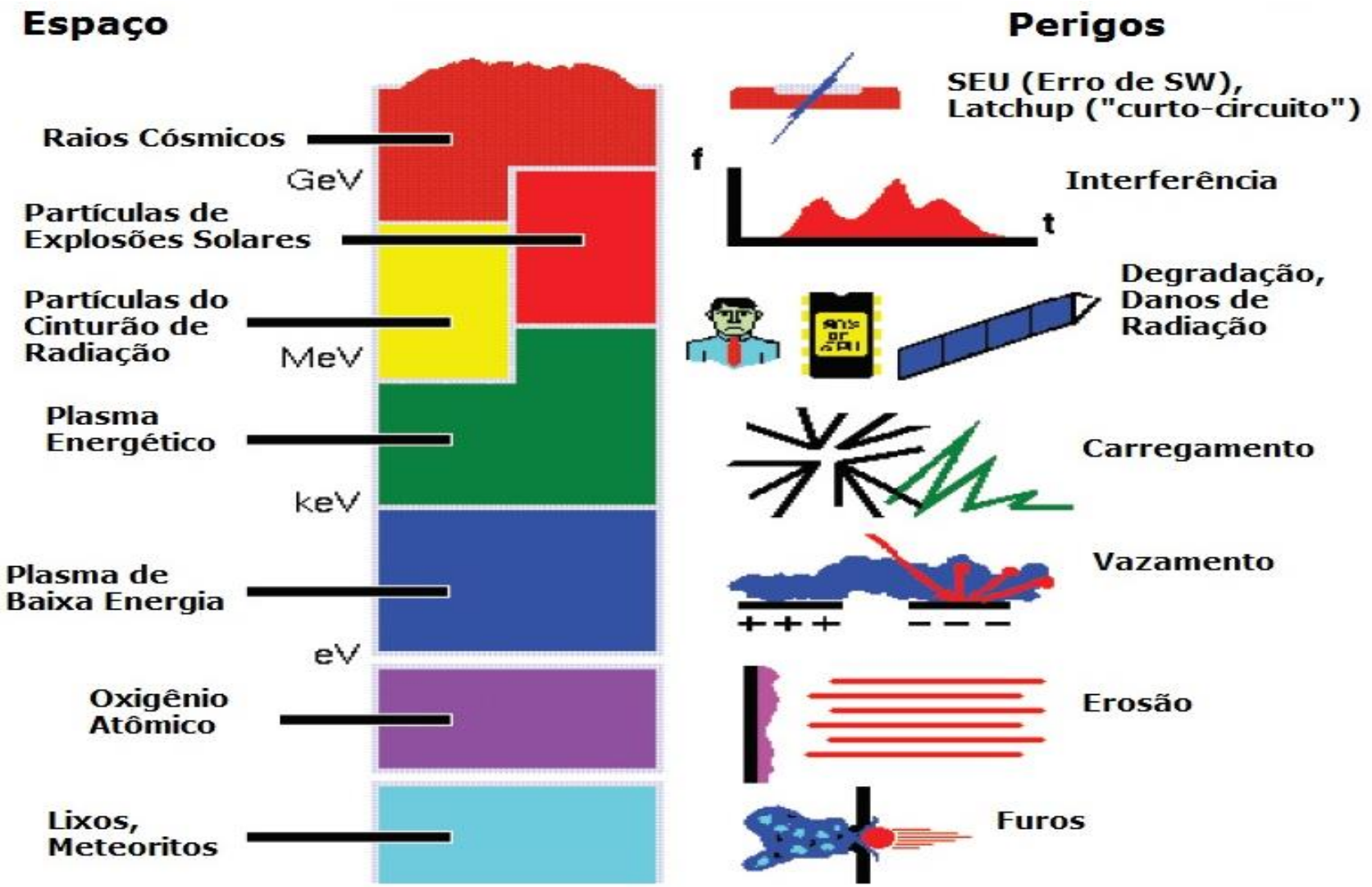
Picosat 1a versão: Não cumpre requisitos para voar a partir da ISS, além de:

- Montagem e manutenção: complicada
- Cablagem: crítica
- Testes ambientais: Alta probabilidade de insucesso
- Ambiente de operação: espaço



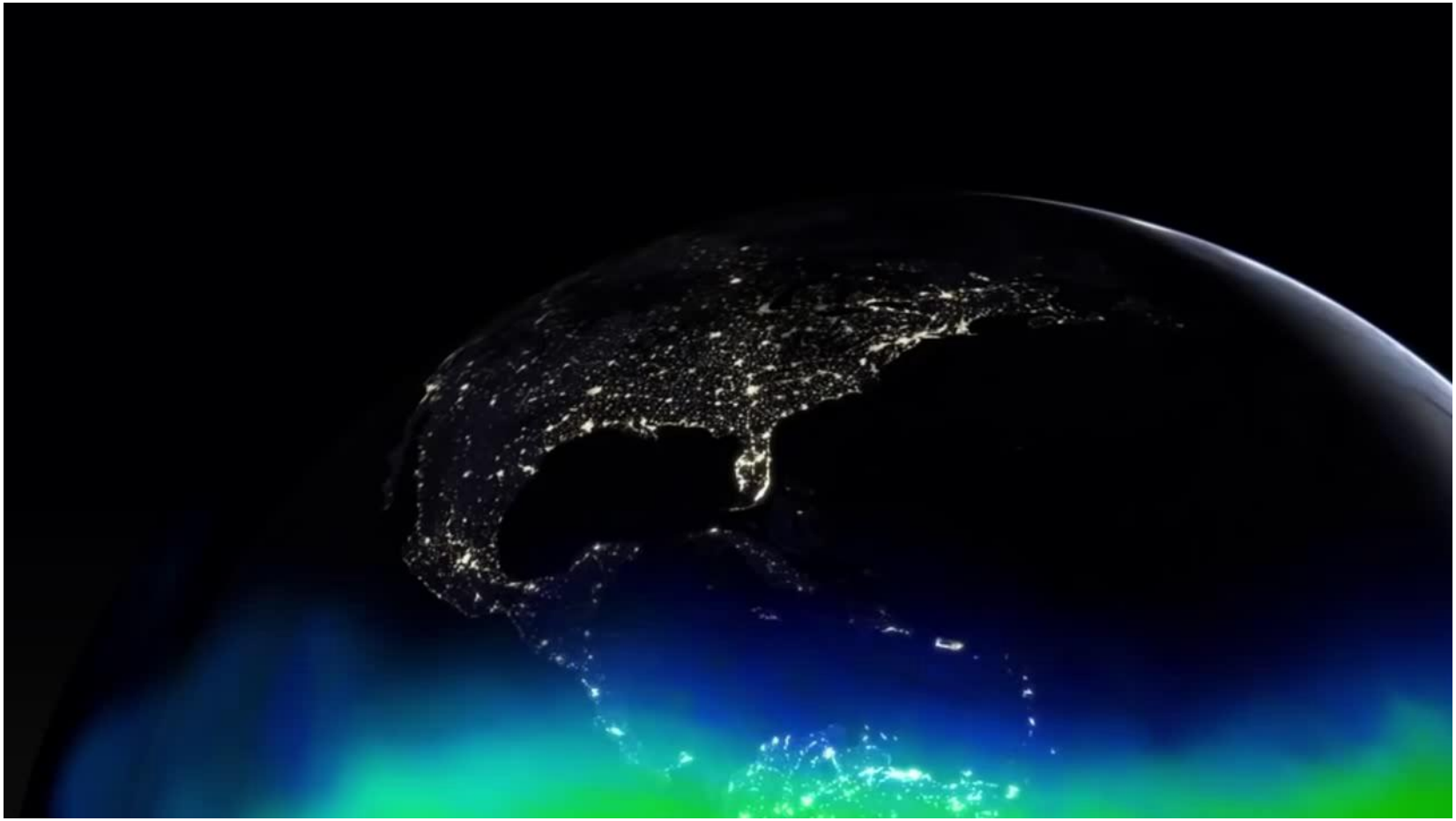
Source: INPE

Ambiente Espacial



Fonte: Adaptada de Bussu (2016).

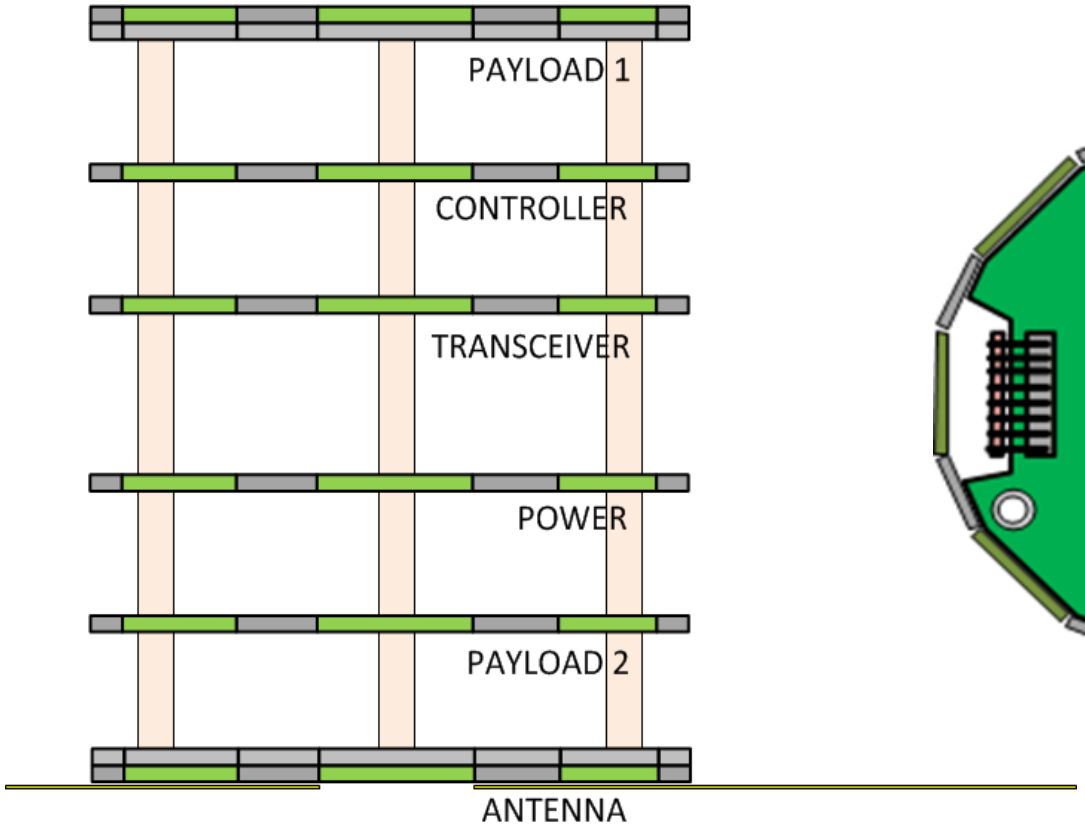
Anomalia Magnética da América do Sul
Anomalia do Atlântico Sul

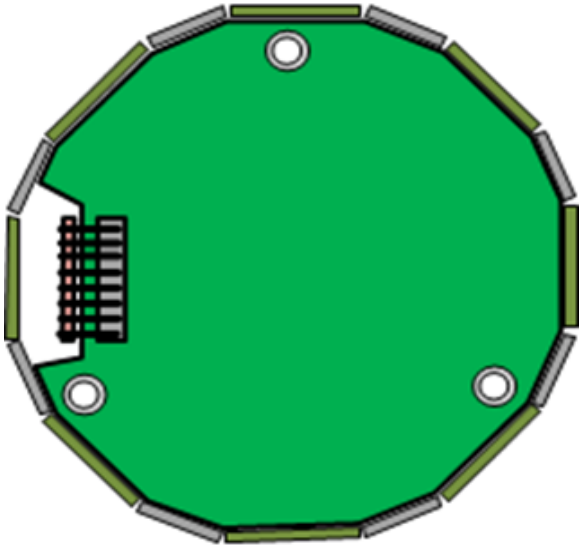


https://www.youtube.com/watch?v=wy1vFVo_2PE

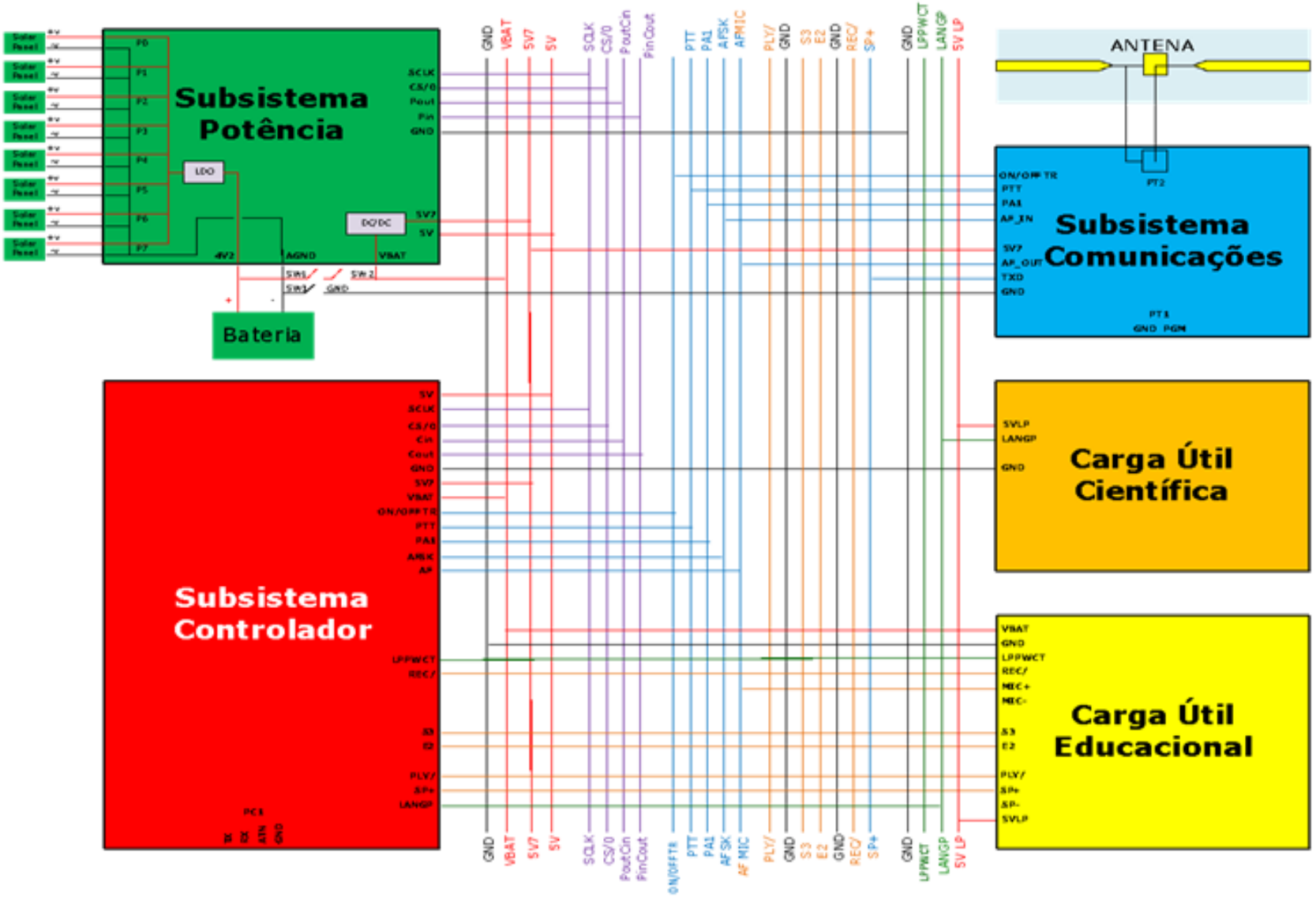
Reengenharia para atendimento dos requisitos

Nova estrutura de empacotamento de PCBs
Facilitar: montagem, manutenção, integração e testes





Reengenharia (Nova arquitetura elétrica)



Conectores dos subsistemas e cargas úteis

CARGA ÚTIL EDUCACIONAL

VBAT	1	2	LANGP
GND	3	4	**GND**
REC/	5	6	ON/OFF TR
AFMIC	7	8	PTT
AFSK	9	10	PA1
S3	11	12	5V
GND	13	14	**LPPWCT**
E2	15	16	**5VLP**
GND	17	18	PoutCin
PLY/	19	20	PinCout
SP+	21	22	CS/0
5V7	23	24	SCLK

CARGA ÚTIL CIENTÍFICA

VBAT	1	2	**LANGP**
GND	3	4	**GND**
REC/	5	6	ON/OFF TR
AFMIC	7	8	PTT
AFSK	9	10	PA1
S3	11	12	5V
GND	13	14	LPPWCT
E2	15	16	**5VLP**
GND	17	18	PoutCin
PLY/	19	20	PinCout
SP+	21	22	CS/0
5V7	23	24	SCLK

CONTROLADOR

VBAT	**1**	**2**	**LANGP**
GND	**3**	**4**	**GND**
REC/	**5**	**6**	**ON/OFF TR**
AFMIC	**7**	**8**	**PTT**
AFSK	**9**	**10**	**PA1**
S3	**11**	**12**	**5V**
GND	**13**	**14**	**LPPWCT**
E2	**15**	**16**	5VLP
GND	**17**	**18**	**PoutCin**
PLY/	**19**	**20**	**PinCout**
SP+	**21**	**22**	**CS/0**
5V7	**23**	**24**	**SCLK**

COMUNICAÇÕES

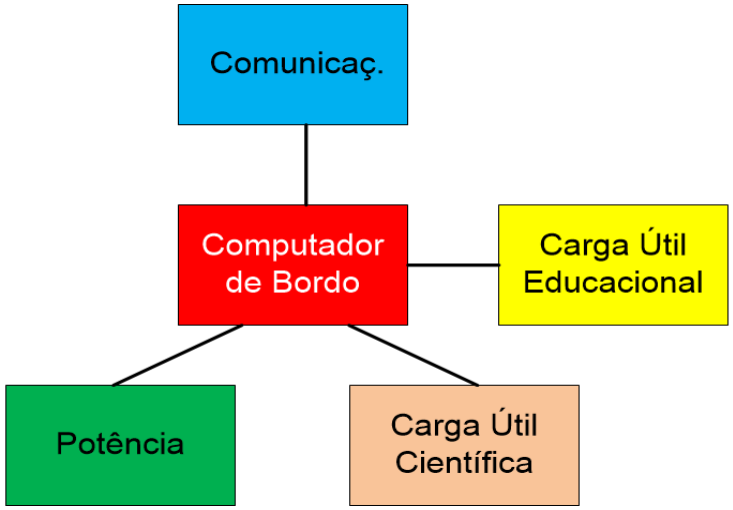
VBAT	1	2	LANGP
GND	3	4	**GND**
REC/	5	6	**ON/OFF TR**
AFMIC	7	8	**PTT**
AFSK	9	10	**PA1**
S3	11	12	5V
GND	13	14	LPPWCT
E2	15	16	5VLP
GND	17	18	PoutCin
PLY/	19	20	PinCout
SP+	21	22	CS/0
5V7	23	24	SCLK

POTÊNCIA

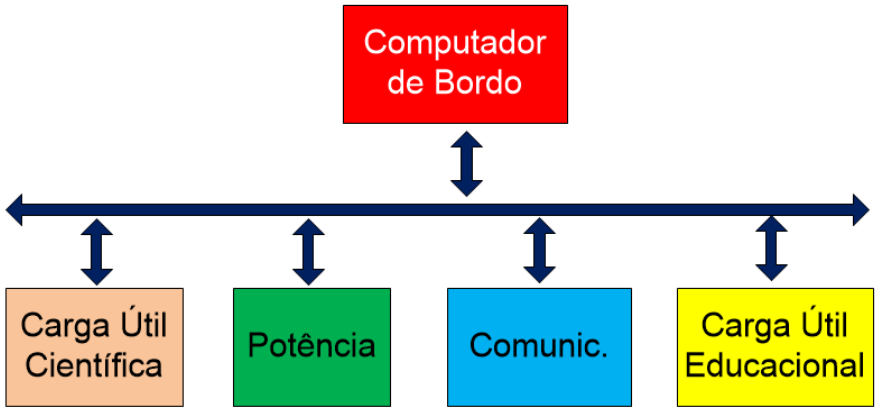
VBAT	1	2	LANGP
GND	3	4	**GND**
REC/	5	6	ON/OFF TR
AFMIC	7	8	PTT
AFSK	9	10	PA1
S3	11	12	**5V**
GND	13	14	LPPWCT
E2	15	16	5VLP
GND	17	18	**PoutCin**
PLY/	19	20	**PinCout**
SP+	21	22	**CS/0**
5V7	23	24	**SCLK**

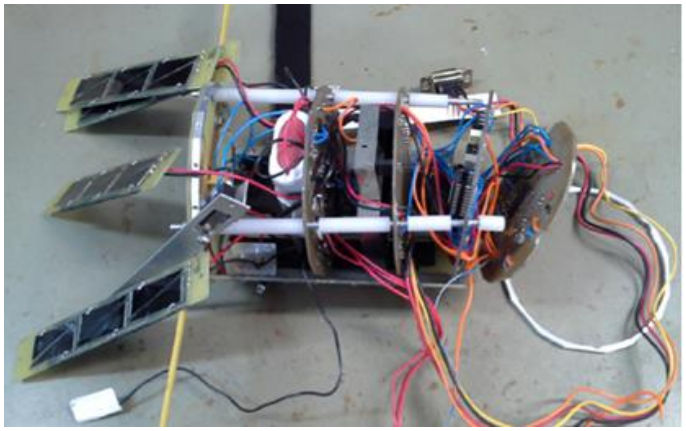
Interconnection Changes

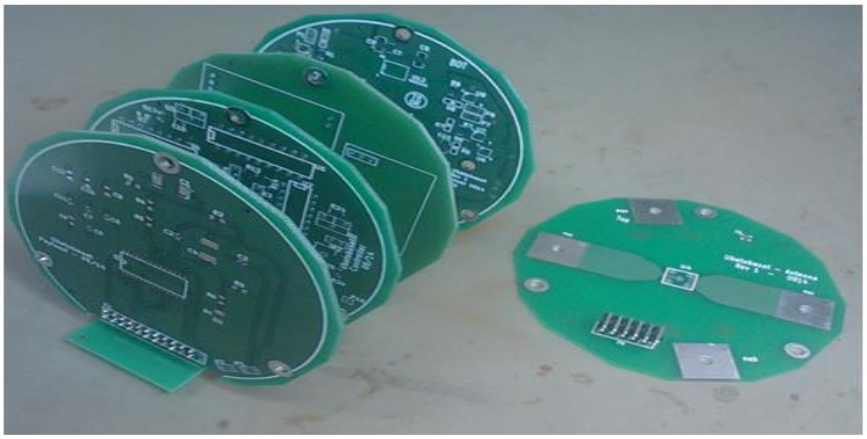
Before ...



After ...

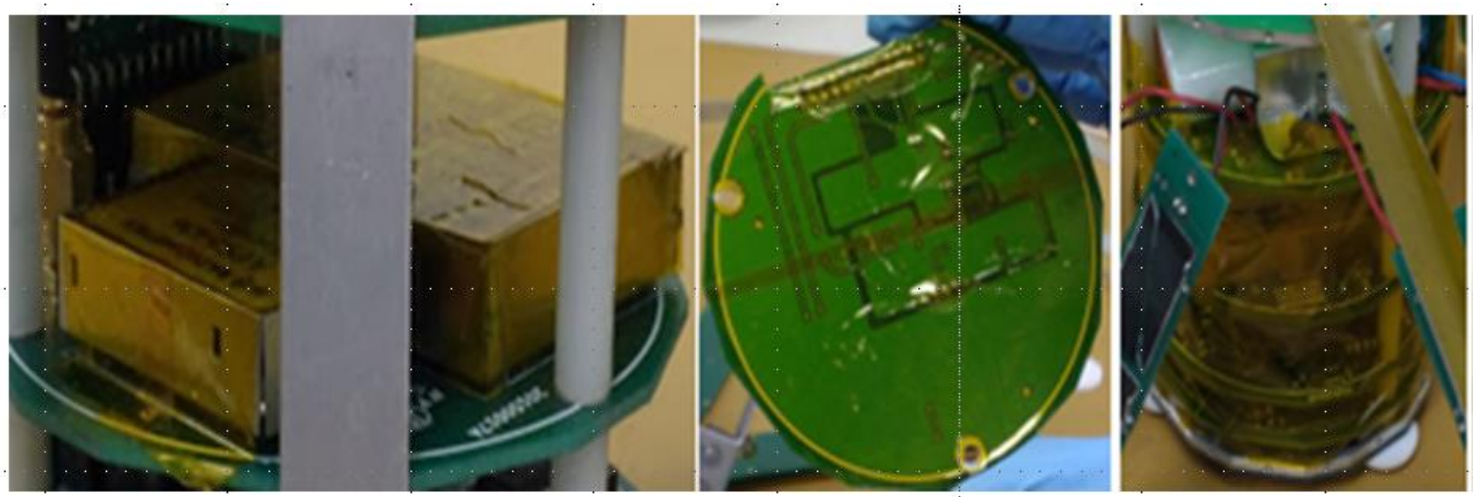






Radiation mitigation

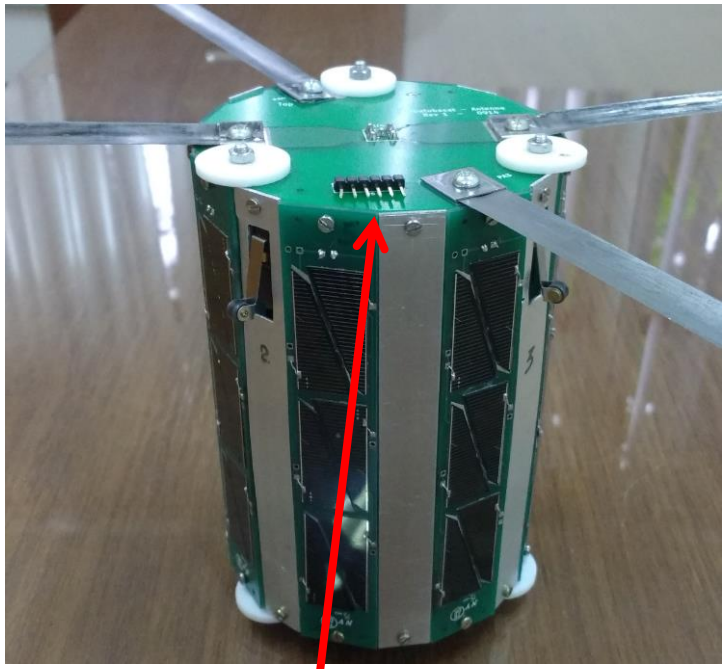
No radiation test was performed and to mitigate it the picosat was internally coated with kapton.



Other Failure Risk Mitigation techniques of the Tancredo-1 by SW: Watchdog, management of the power, temperature and operating mode.

Reengenharia

Nova versão do TubeSat

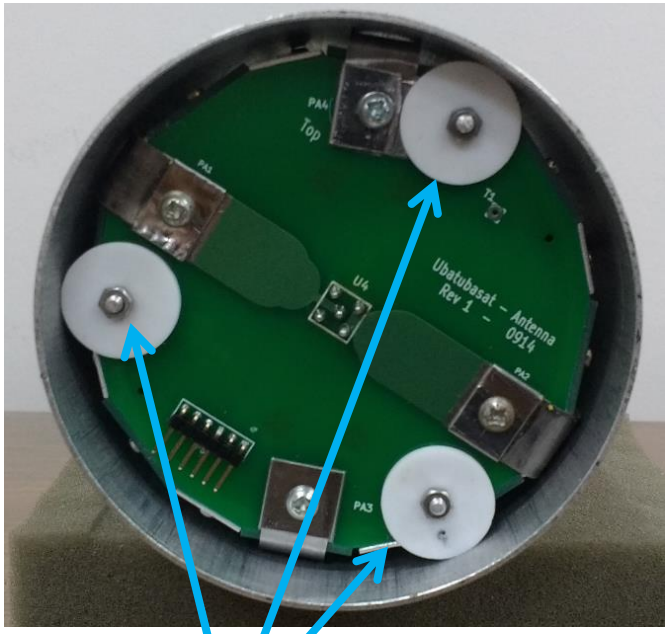


Conector do cordão umbilical: para carga da bateria e sw de bordo

RBF

Chave pressionada: SAT OFF

Compatibilidade com cilindro ejetor (TuPOD)



Teflons: facilitar ejeção

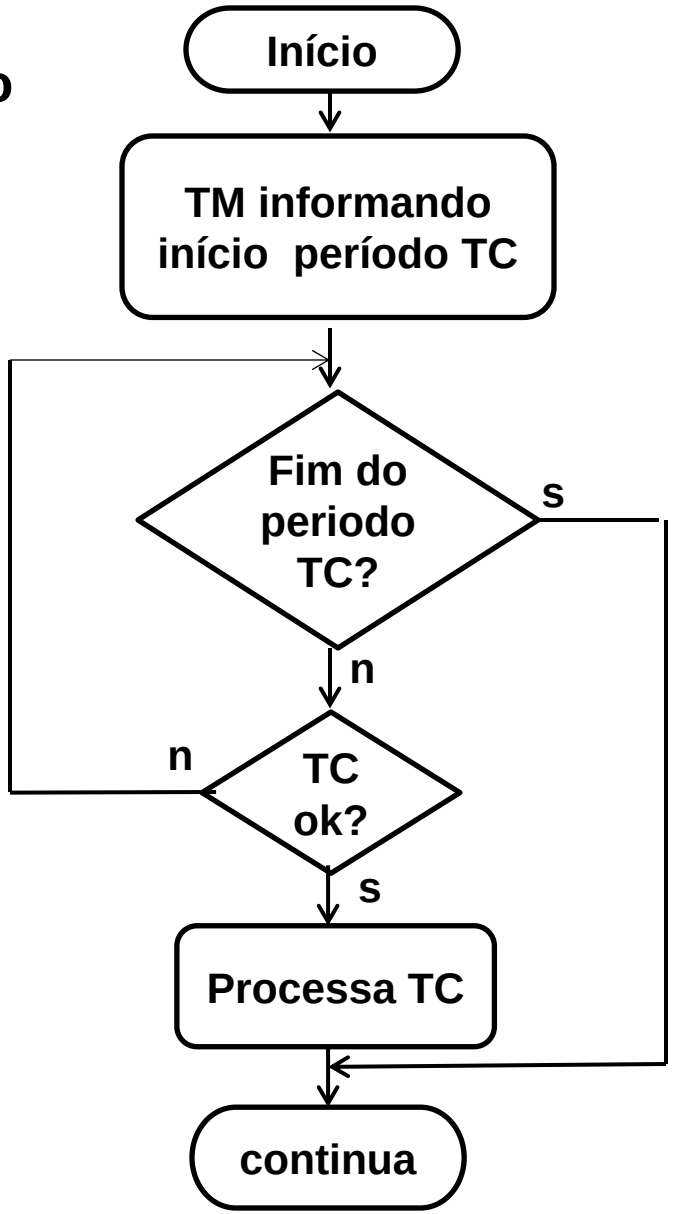
No interior do cilindro

SAT OFF

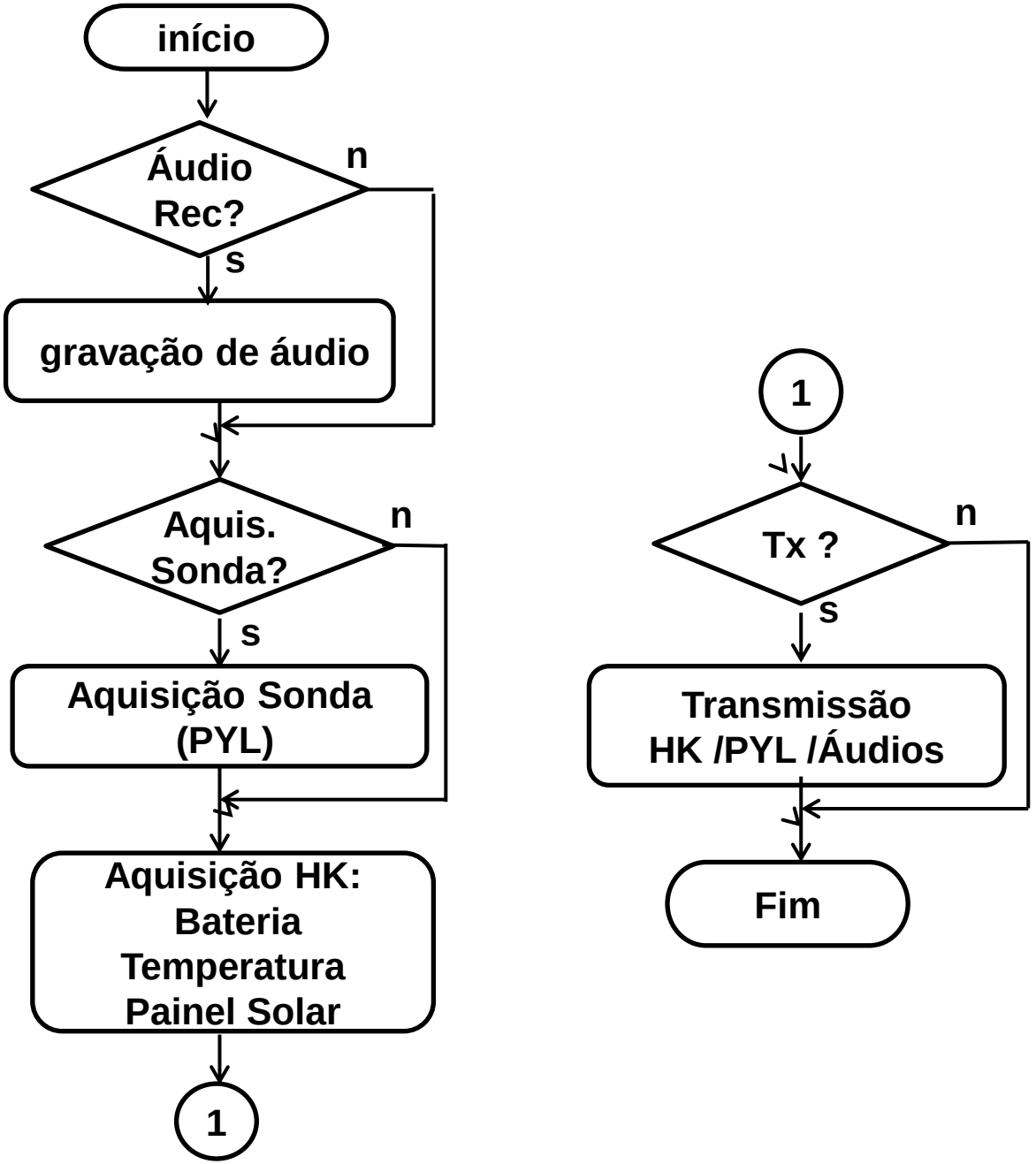
Fora do cilindro

SAT ON

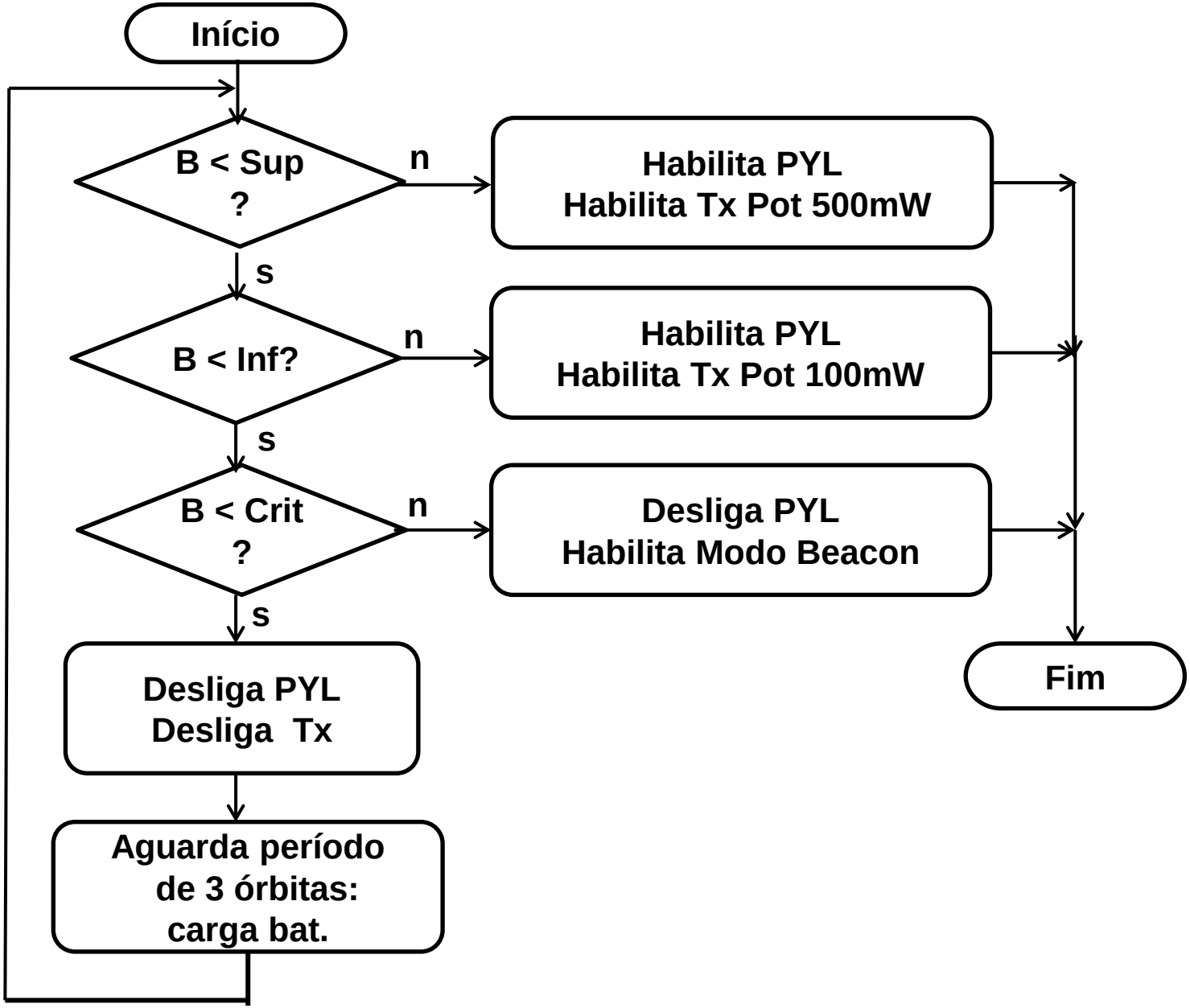
Recepção de Telecomando



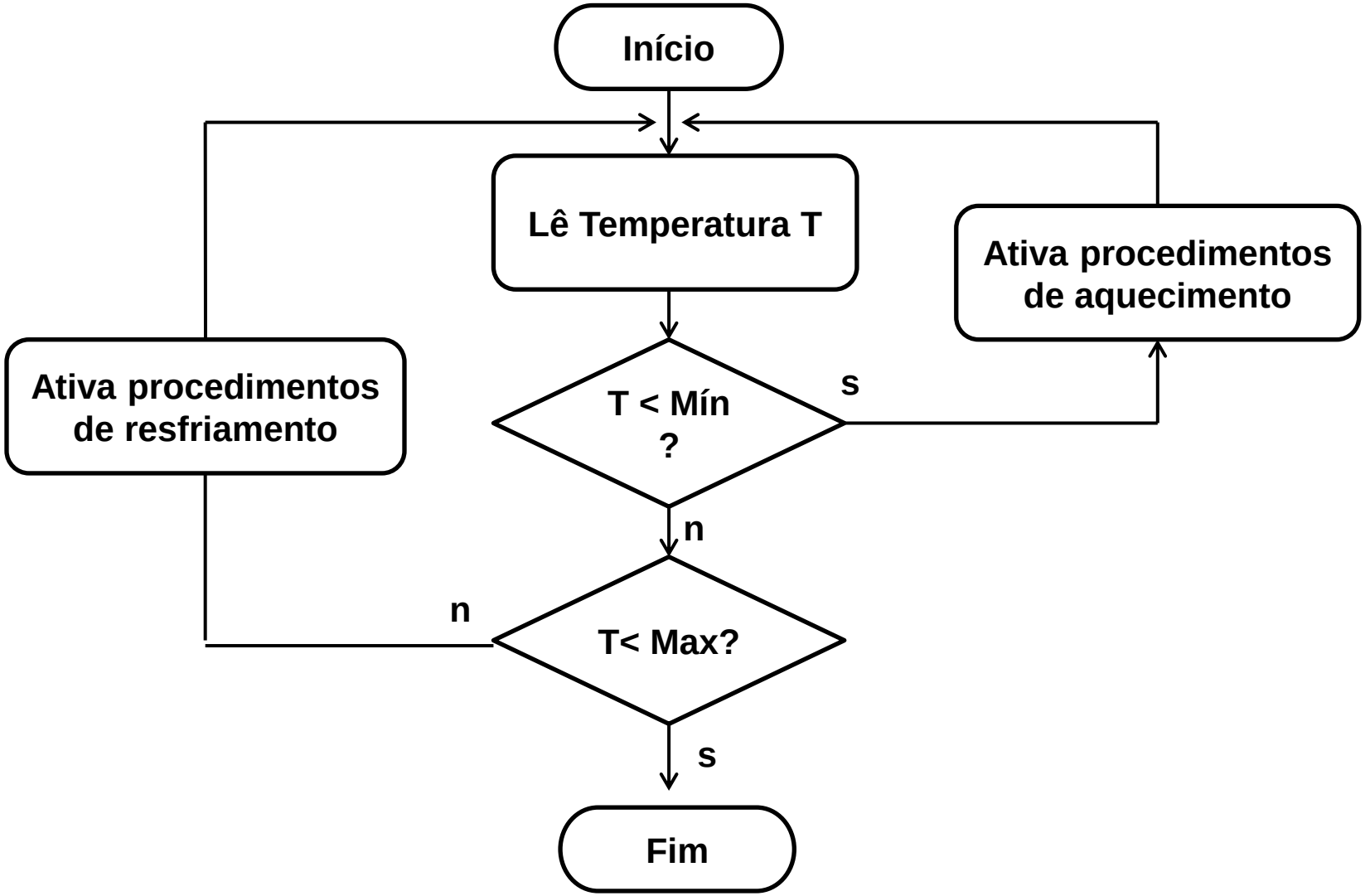
Telemetria:
HK e Payload



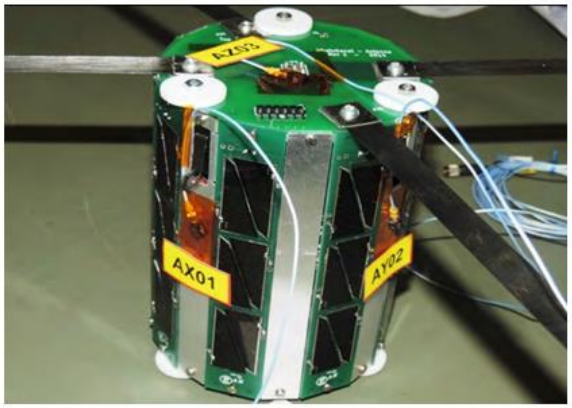
Gerenciamento de Energia



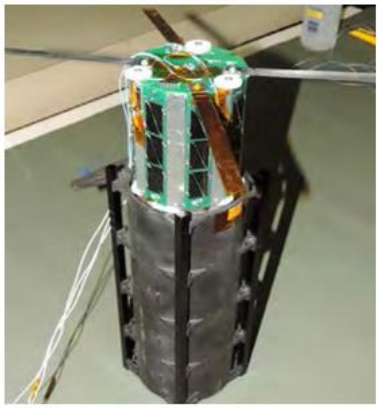
Gerenciamento Térmico



LIT/INPE: Vibration

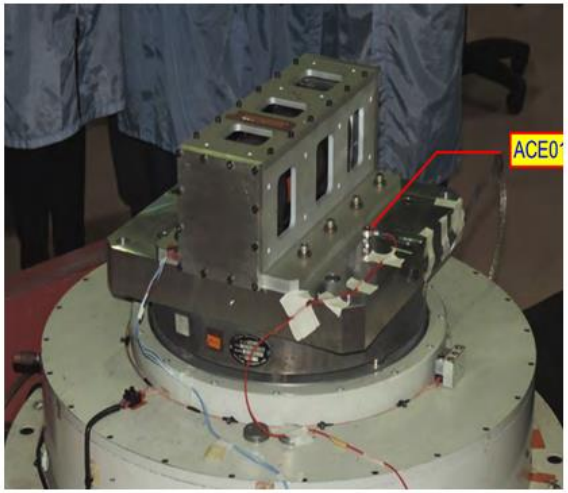


Acelerômetros

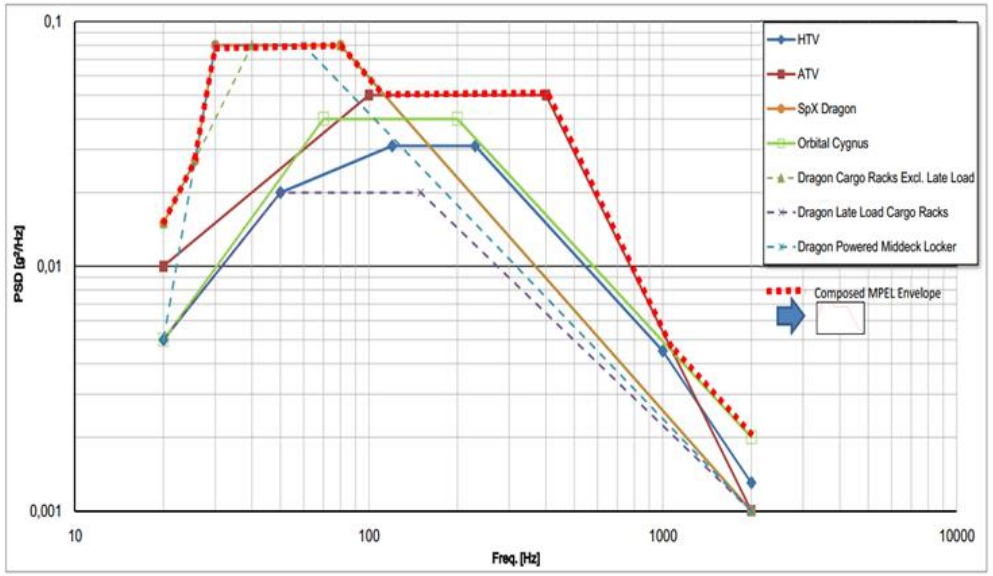


TuPOD

POD de teste

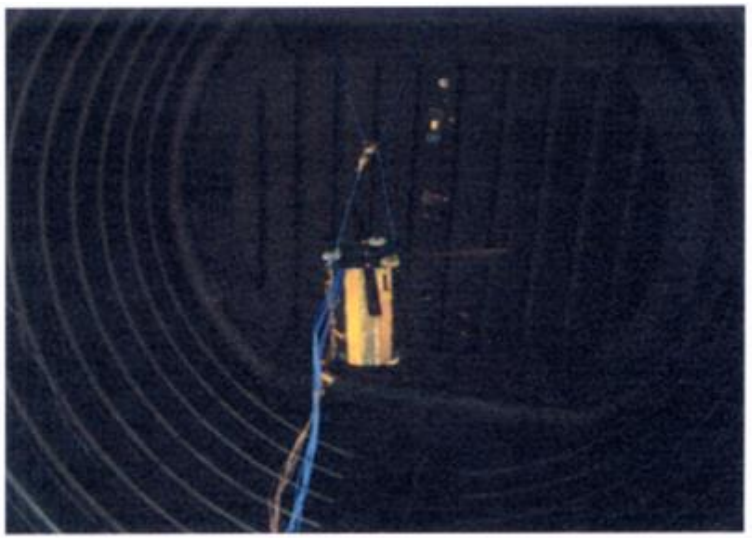


Shaker

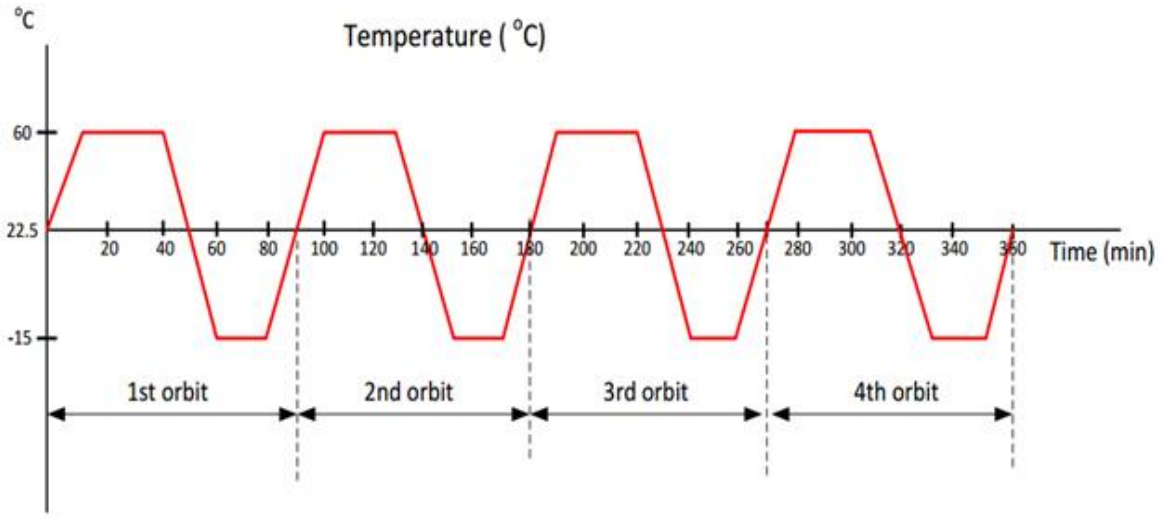


LIT/INPE: TVAC

Termopares



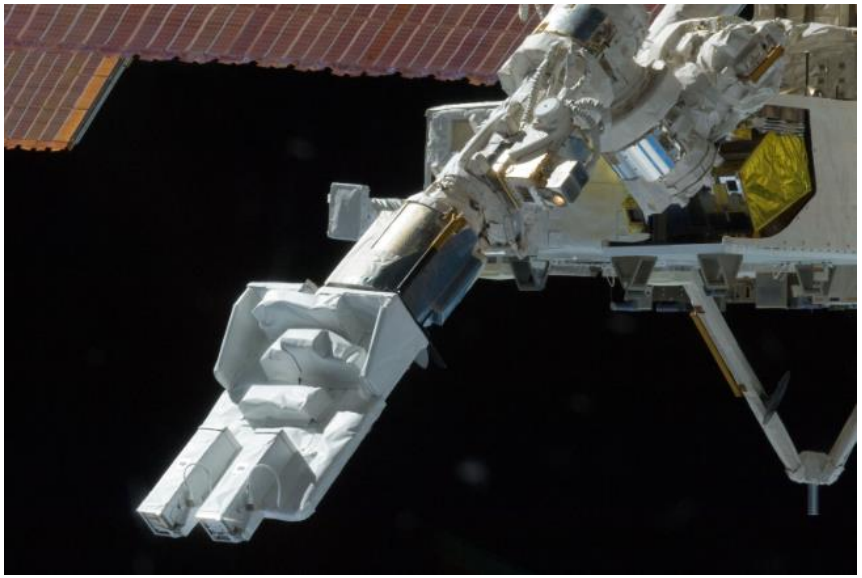
TVAC



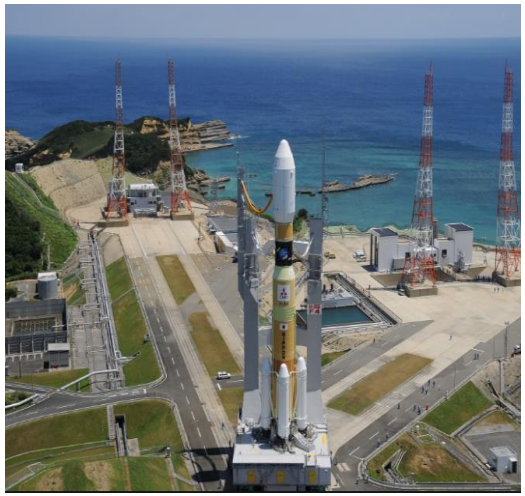
Definição de Lançamento

ISS

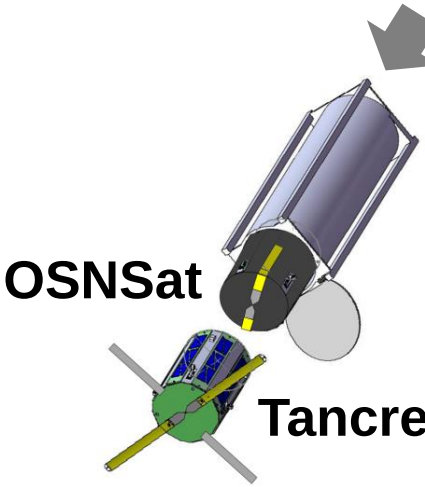
HTV-6



J-SSOD



H-IIB



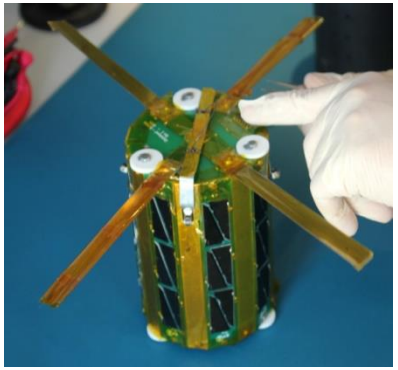
The Tancredo-1 Operation into Space

TuPOD Integration

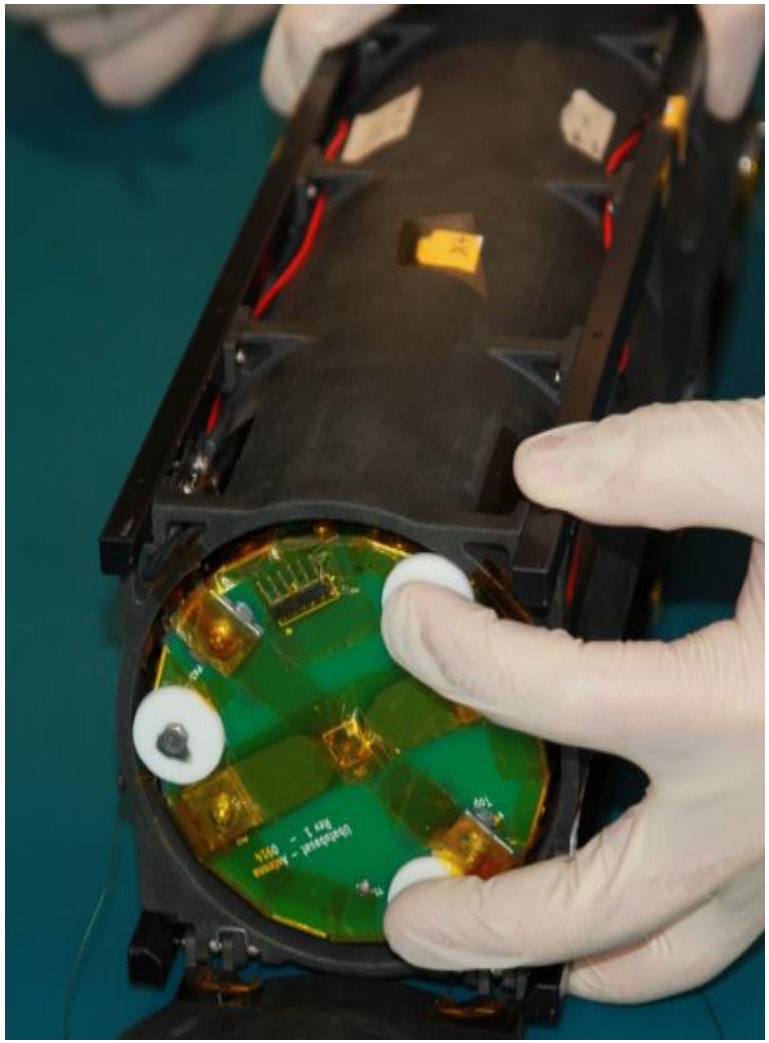
GAUSS, Italy

Jul 2016

OSNSAT



Tancredo-1



Lançamento com destino a ISS

09dez2016

- https://www.youtube.com/watch?v=CA2xO4fU_WQ

Mídia: Jornal Vanguarda

09dez2016

https://www.youtube.com/watch?v=NxTwMJJQa44&t=5s

Chegada da nave HTV-6 na ISS

13Dez2016

Source: NASA

Ejeção do TuPOD da ISS

16Jan2017

Source: JAXA

https://www.youtube.com/watch?v=R4xq_rj0QiQ

UbatubaSat: from the instant 2:56:40

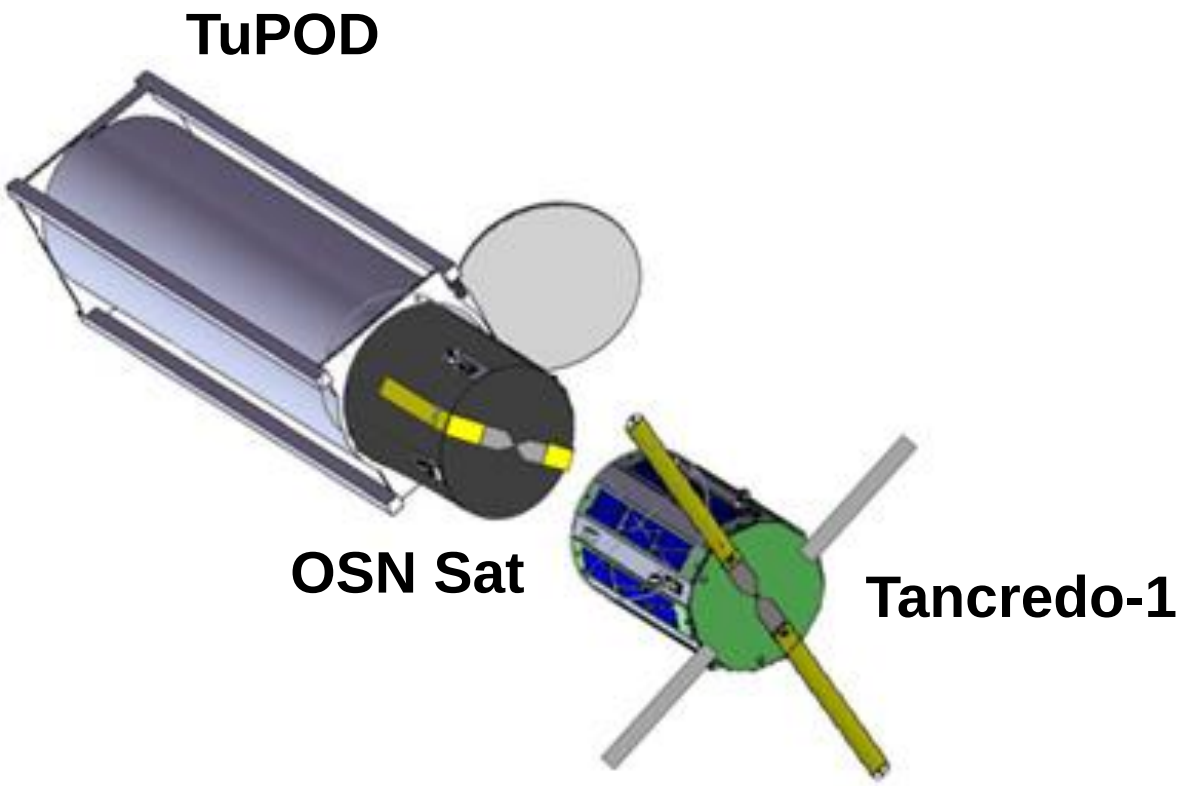
Divulgação: Jornal Hoje

16Jan2017

https://globoplay.globo.com/v/5580613/

TuPOD ejeta os TubeSats

19Jan2017



Timeline of the Tancredo-1 design

Mission and educational payload definition

Project begins with INPE-Ubatuba Agreement (2011)

Support from AEB

Neptune-30 launcher unavailability

originally planned:2015

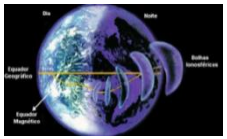
Safety requirements added

Launch obtained via ISS/Kibo/JAXA with TuPOD

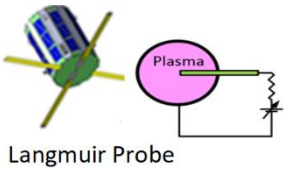
Tancredo-1

Ulises-1

Change of mission and inclusion of scientific pyld



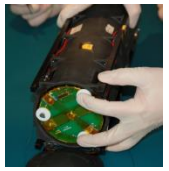
Addition of Langmuir Probe requirements



Launcher change due to new config.

Tancredo-I

OSNSat



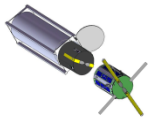
TuPOD integration July 2016

Picosat handover to Safety Review and launch via H-IIB and HTV6 in Japan at Dec, 9 2016

TuPOD ejection from ISS

Jan,16 2017

TubeSat Ejection from TuPOD

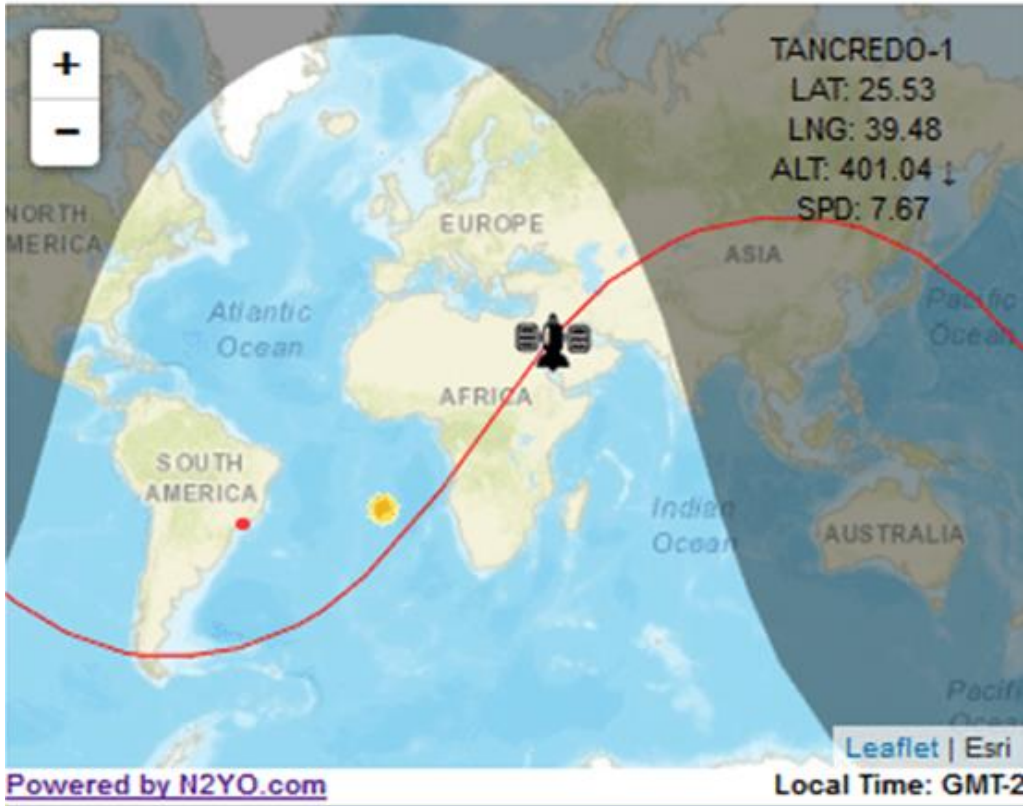


Jan, 19 2017

Source: INPE

Tancredo-1 Operation into Space

NORAD ID: 41931
Int'l Code: 1998-067KT
Perigee: 395.2 km
Apogee: 406.9 km
Inclination: 51.6 °
Period: 92.4 minutes
Semi major axis: 6772 km
Source: Japan (JPN)
Uplink (MHz):
Downlink (MHz): 437.200
Beacon (MHz): 437.200
Mode: 1200bps AFSK CW
Call sign: PY0ETA

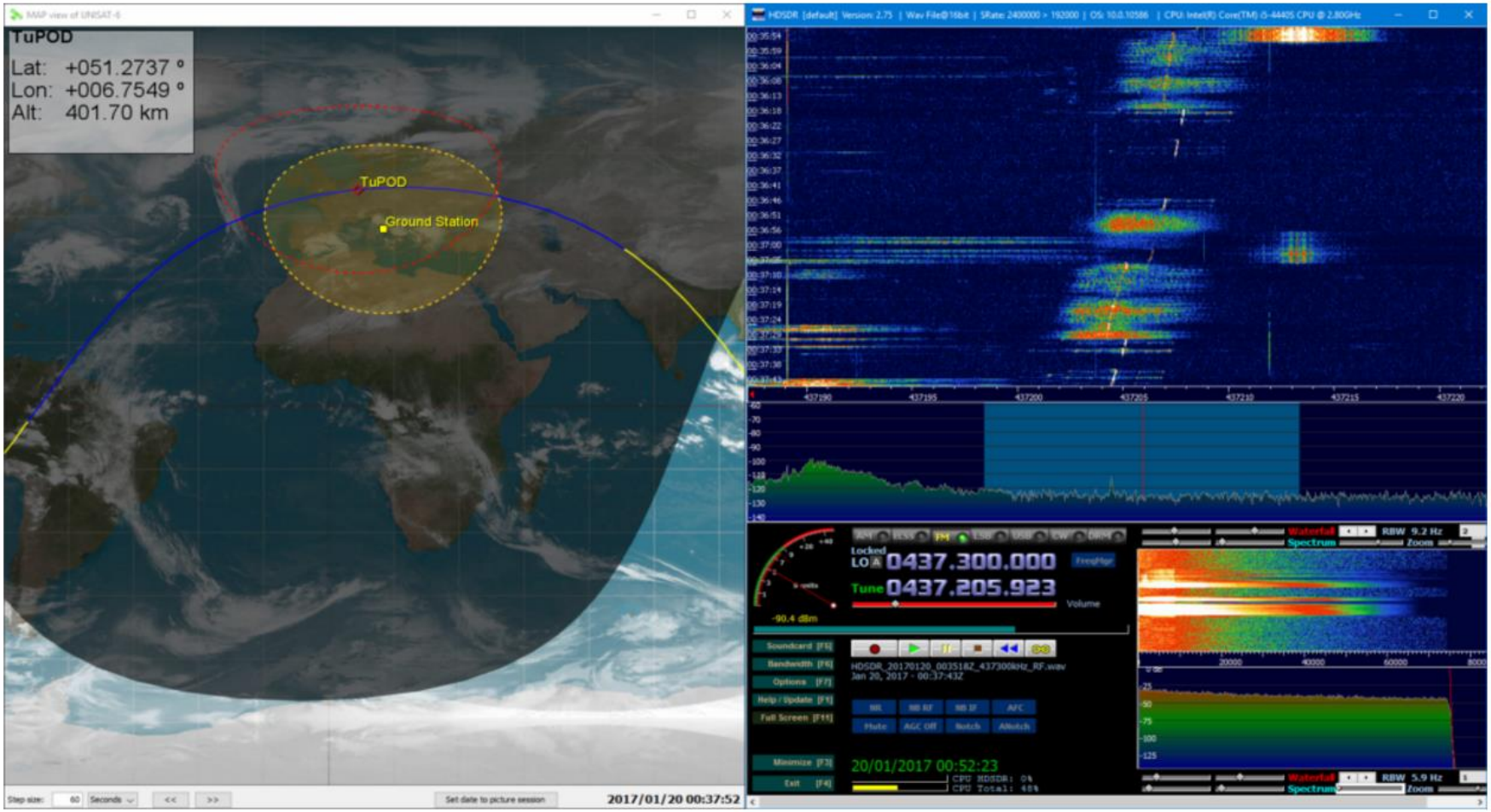


NEXT PASS OF TANCREDO-1 OVER YOUR CURRENT LOCATION

START AZIMUTH		MAX ELEVATION		END AZIMUTH		TOTAL DURATION
Feb 3 13:35	219° SW	13:41	82°	13:46	41° NE	10m 40s

Source:N2YO.com

Tancredo-1 First On-Orbit Results (received in ROME)



TubeSat TANCREDO-I signal

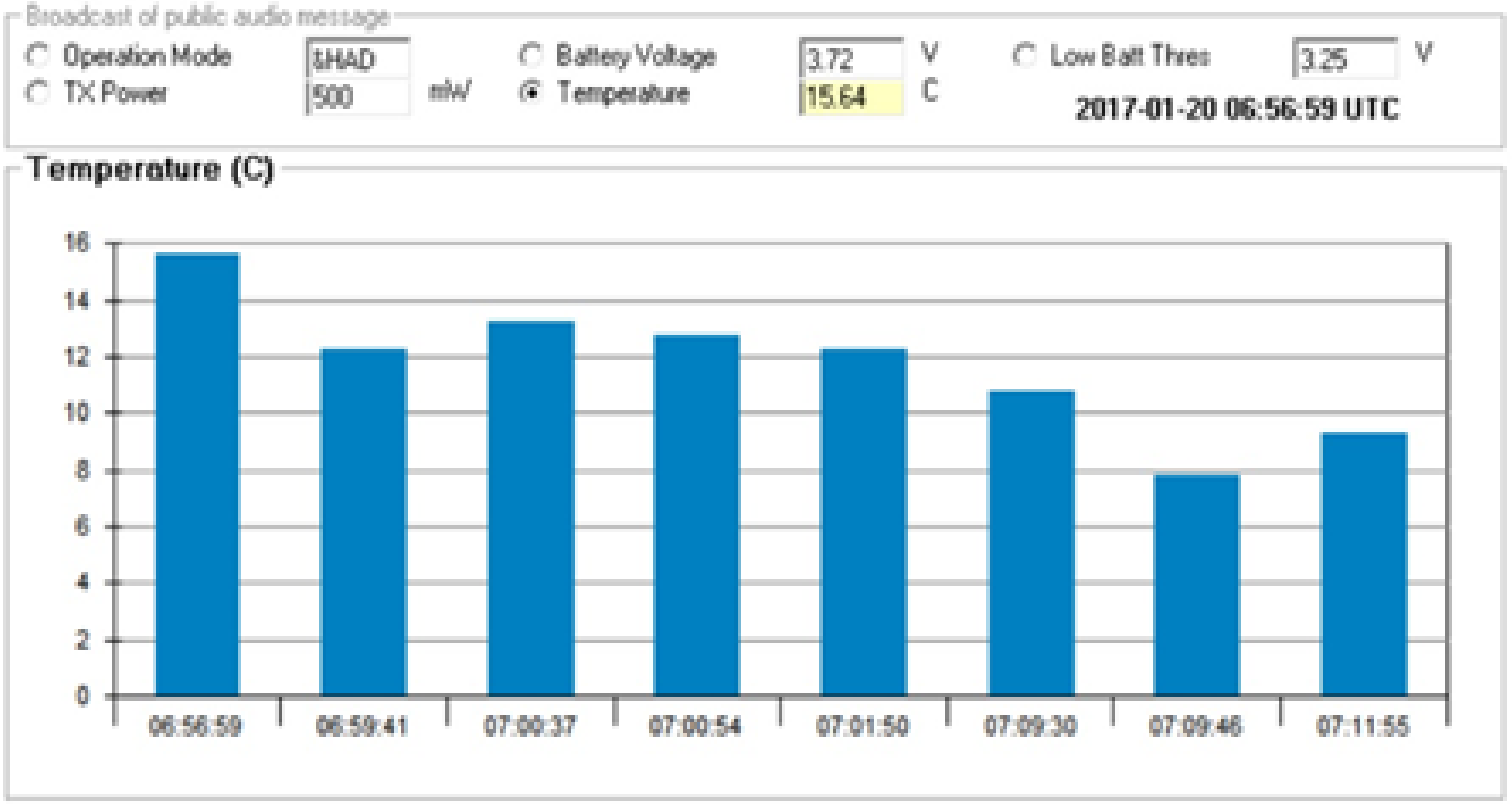
Source: Gauss Srl

Tancredo-1 (PY0ETA) signal received in Florida

https://www.youtube.com/watch?v=mhC9f92ayDI

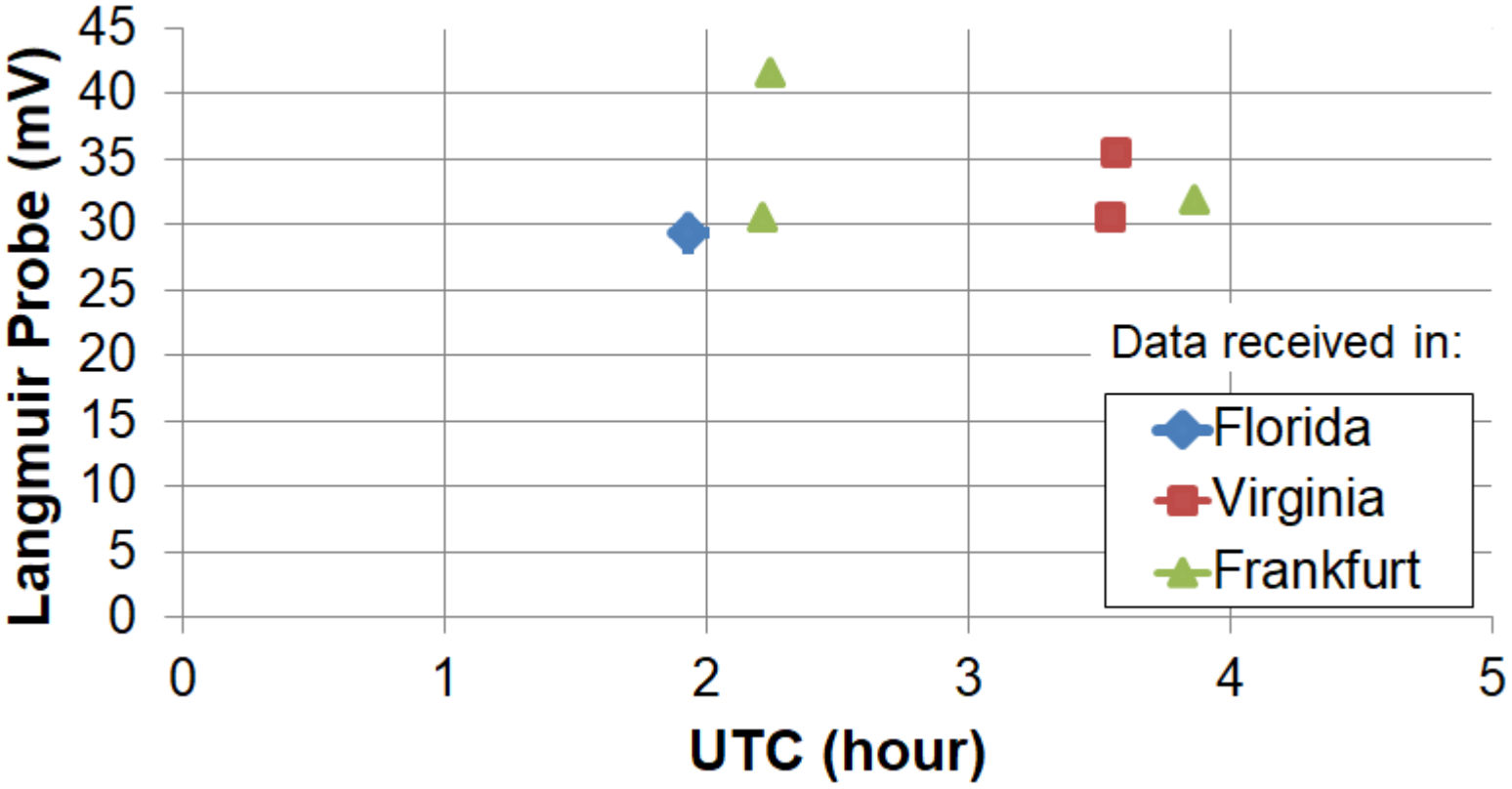
Source: Drew Glasbrenner (KO4MA)

Tancredo-1 (PY0ETA) signal received in Germany



Source: MikeRupprecht (DK3WN)

Langmuir Probe data (01/20/2017)



Source: Source: Data from Drew (FL,USA), Mike (DE), Scott (VA, USA).

Results: Standard operation

Frame: 0x63 TC_Window

Seq	Hex	Description		
1	eb	header		
2	90	header		
3	0b	frame lenght		
4	63	TC_Window		
5	2	battery lsb	Battery:	3.76 V
6	3	battery msb		
7	**ff**	**ARF_CFG**	**Operation:**	**Standard**
8	**2**	**REC_CFG**		
9	1	cycle_dly	1 s	
10	38	temperature	27.4 °C	
11	d8	check sum		
Sum	0		Frame validated	

Standard Operation: tx power switching

Frame: 0x4a Langmuir Probe

Seq	Hex	Description		
1	eb	header		
2	90	header		
3	14	frame length		
4	4a	LP24	LP data	
5	17	hour	**OBC Time**	**23:49:56**
6	31	min		
7	38	sec		
8	f2	bat lsb	Bat	3.68 V
9	2	bat msb		
10	37	temperature	Temp	26.9 °C
11	0e	LP1 lsb	LP1	68.4 mV
12	0	LP1 msb		
13	4	LP2 lsb	LP2	19.5 mV
14	0	LP2 msb		
15	2	LP3 lsb	LP3	9.8 mV
16	0	LP3 msb		
17	5	LP4 lsb	LP4	24.4 mV
18	0	LP4 msb		
19	32	power	**Power**	**500 mW**
20	31	check sum		
Sum	0			Frame validated

seq	hex	Description		
1	eb	header		
2	90	header		
3	14	frame length		
4	4a	LP24	LP data	
5	17	hour	**OBC Time**	**23:51:09**
6	33	min		
7	9	sec		
8	f2	bat lsb	Bat	3.68 V
9	2	bat msb		
10	34	temperature	Temp	25.4 °C
11	0f	LP1 lsb	LP1	73.3 mV
12	0	LP1 msb		
13	7	LP2 lsb	LP2	34.2 mV
14	0	LP2 msb		
15	2	LP3 lsb	LP3	9.8 mV
16	0	LP3 msb		
17	5	LP4 lsb	LP4	24.4 mV
18	0	LP4 msb		
19	a	power	**Power**	**100 mW**
20	85	check sum		
Sum	0			Frame validated

Results: Upper Reference voltage

Frame: 0xb5 No TC

Seq	Hex	Description	
1	eb	header	
2	90	header	
3	0a	frame lenght	
4	b5	NoTC	without TC
5	d6	**bat high thr lsb**	**3.55 V**
6	2	**bat high thr msb**	
7	3d	temperature	29.8 °C
8	1	cycle dly	
9	32	power	500 mW
10	7e	ckeck sum	
Sum	0		Frame validated

Results: Lower Reference voltage

Frame: 0xAD Audio St

Seq	Hex	Description	
1	eb	header	
2	90	header	
3	0b	frame length	
4	AD	Aud St	Play recorded audio
5	f9	battery lsb	Battery: 3.72 V
6	2	battery msb	
7	99	**bat low thr lsb**	**3.25 V**
8	2	**bat low thr msb**	
9	32	power	500 mW
10	1d	temperature	14.1 °C
11	e8	check sum	
Sum	0	frame validated	

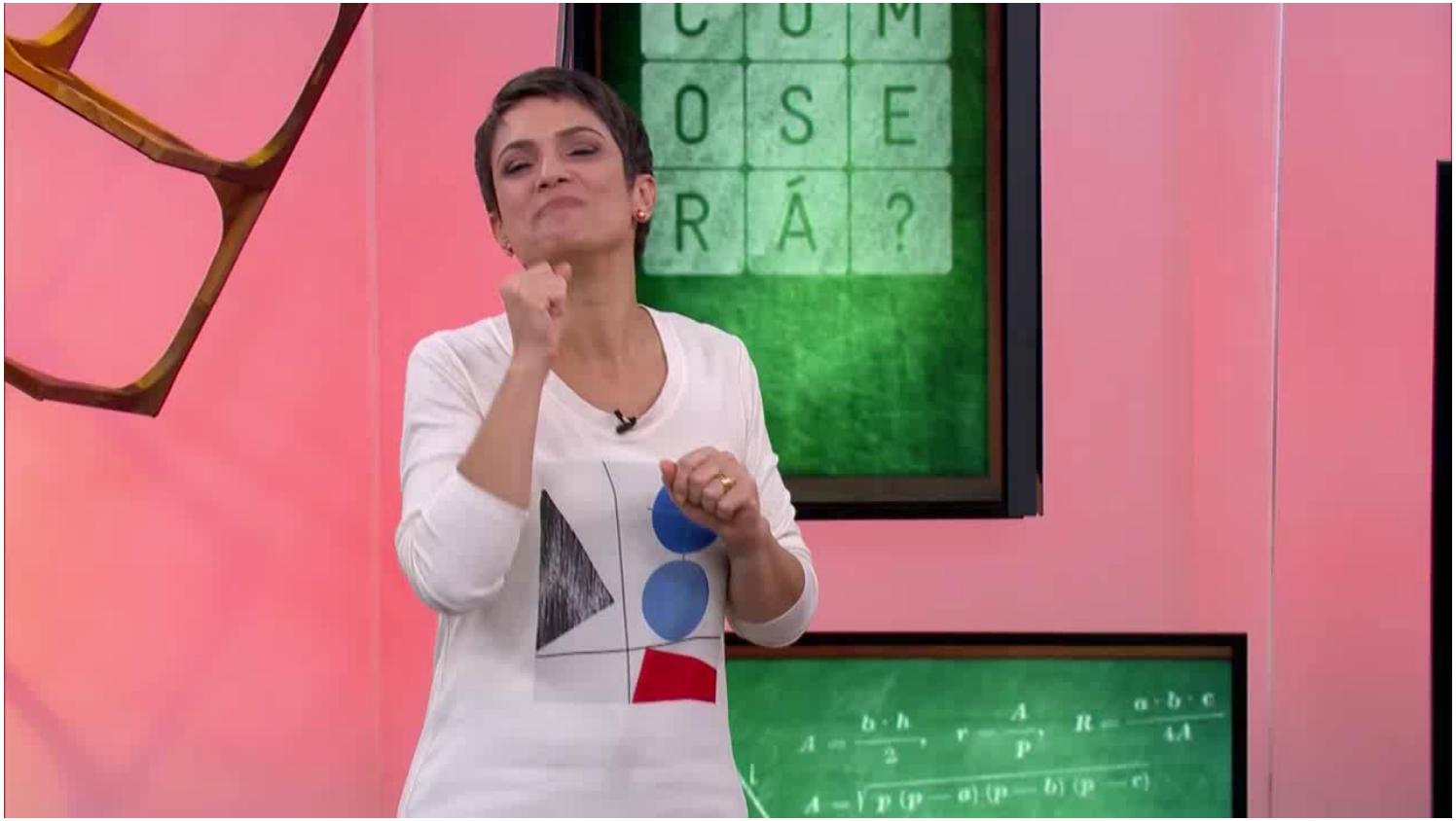
Results

Frame: 0x45 Langmuir Probe

Seq	Hex	Description		
1	eb	header		
2	90	header		
3	10	frame length		
4	45	LP12	UTC	01:52:00
5	16	hour	OBC	22:09:59
6	9	min		
7	3b	sec		
8	ff	bat lsb	Bat	3.75 V
9	2	bat msb		
10	3e	temperature	Temp	30.3 °C
11	11	lp1 lsb	LP1	83.1 mV
12	0	lp1 msb		
13	3	lp2 lsb	LP2	14.6 mV
14	0	lp2 msb		
15	32	power	P	500 mW
16	51	check sum		
Sum	0			Frame validated

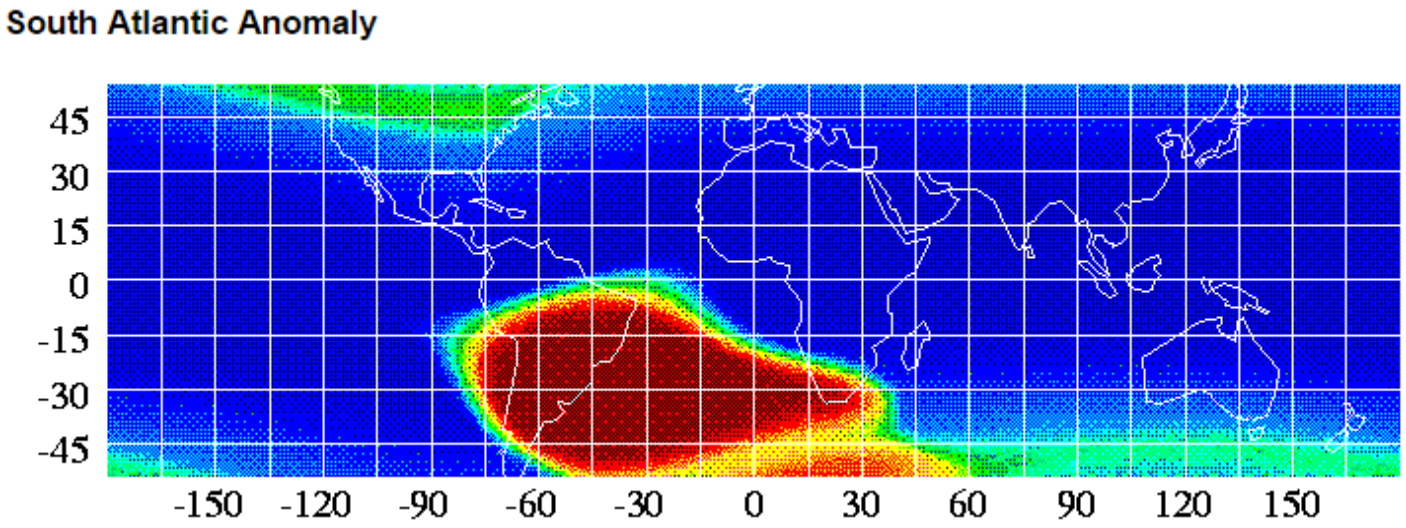
COMO SERÁ?

Exibição em 18mar2017
https://globoplay.globo.com/v/5730667/programa/



Tancredo-1 Preliminary Failure Analysis

After several passes mainly over SAA region, Tancredo-1 has become inactive and possible root causes are investigated. Its life time was expected to last few weeks up to 2 months according to solar activities.

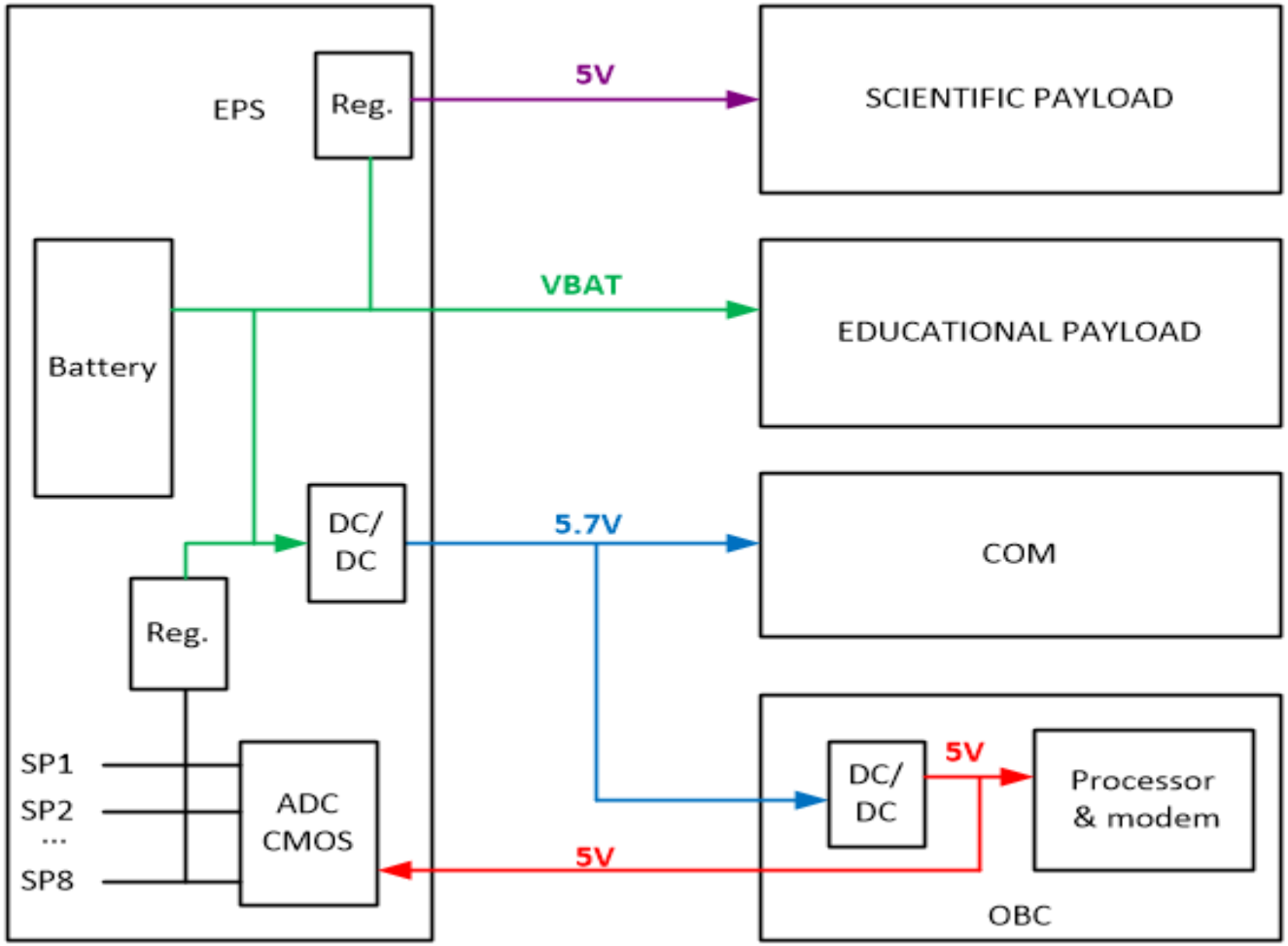


Tancredo-1 failure analysis

As **all** Tancredo-1 **telemetry** and payload signals received show **normal** operation without details, possible hypotheses for its inactivity shall be investigated.

Picosat Failure Analysis

Tancredo-1´s power distribution



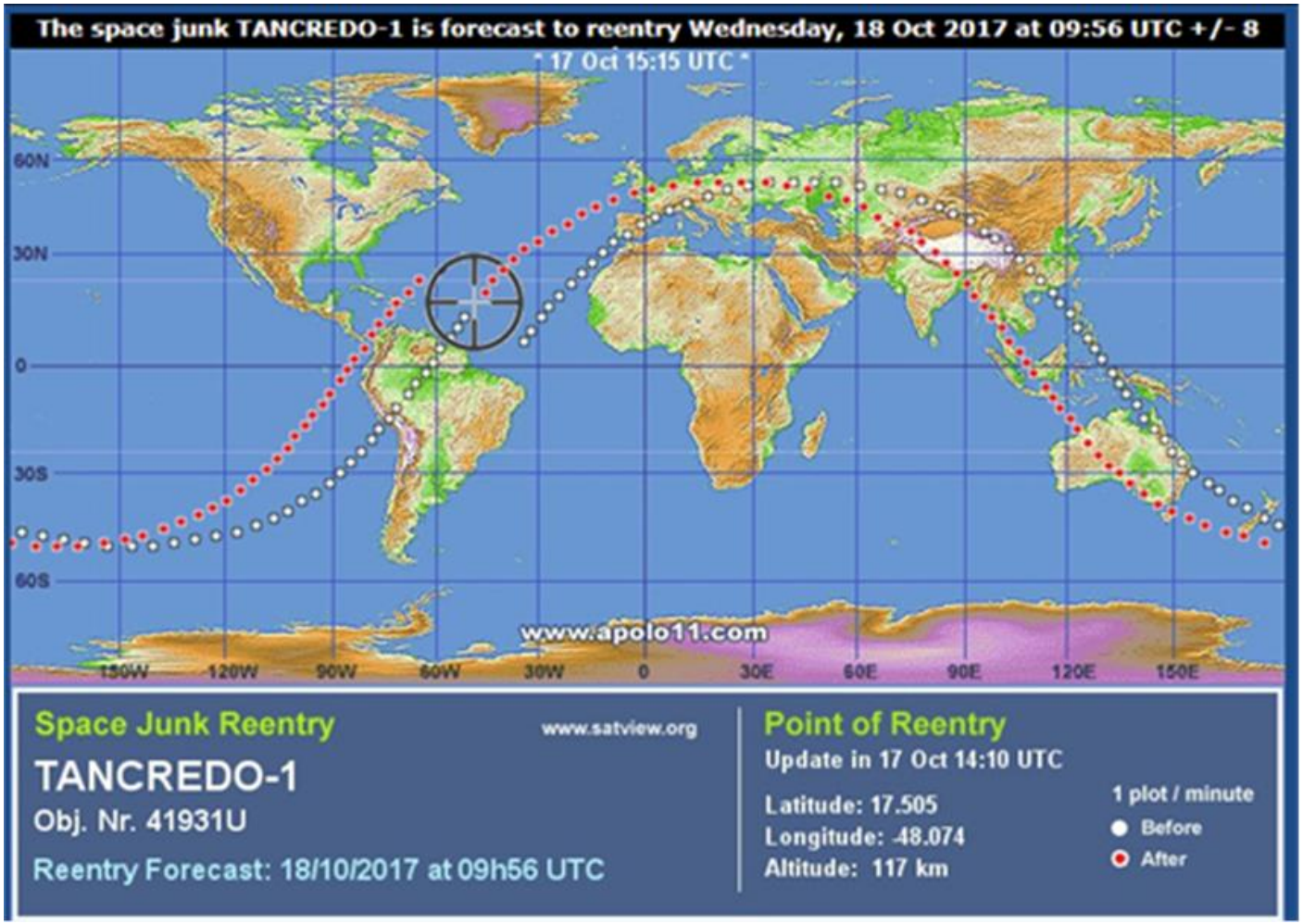
Picosat Failure Analysis

- Considering that **EPS is more exposed to the environment** there is a high failure probability for the picosat **silence by radiation** by SEE.
- Other assumption is the **DC-DC converter** may have been damaged **or data acquisition CMOS** integrated circuit may have **short circuited** and thus **cutting off** the OBC processor´s **power**.
- It's also possible that only Communication subsystem may have been damaged despite of kapton shielding mitigation.
- The **atomic oxygen** exists in the upper regions of the atmosphere and can **damage the kapton** shielding.

Conclusions

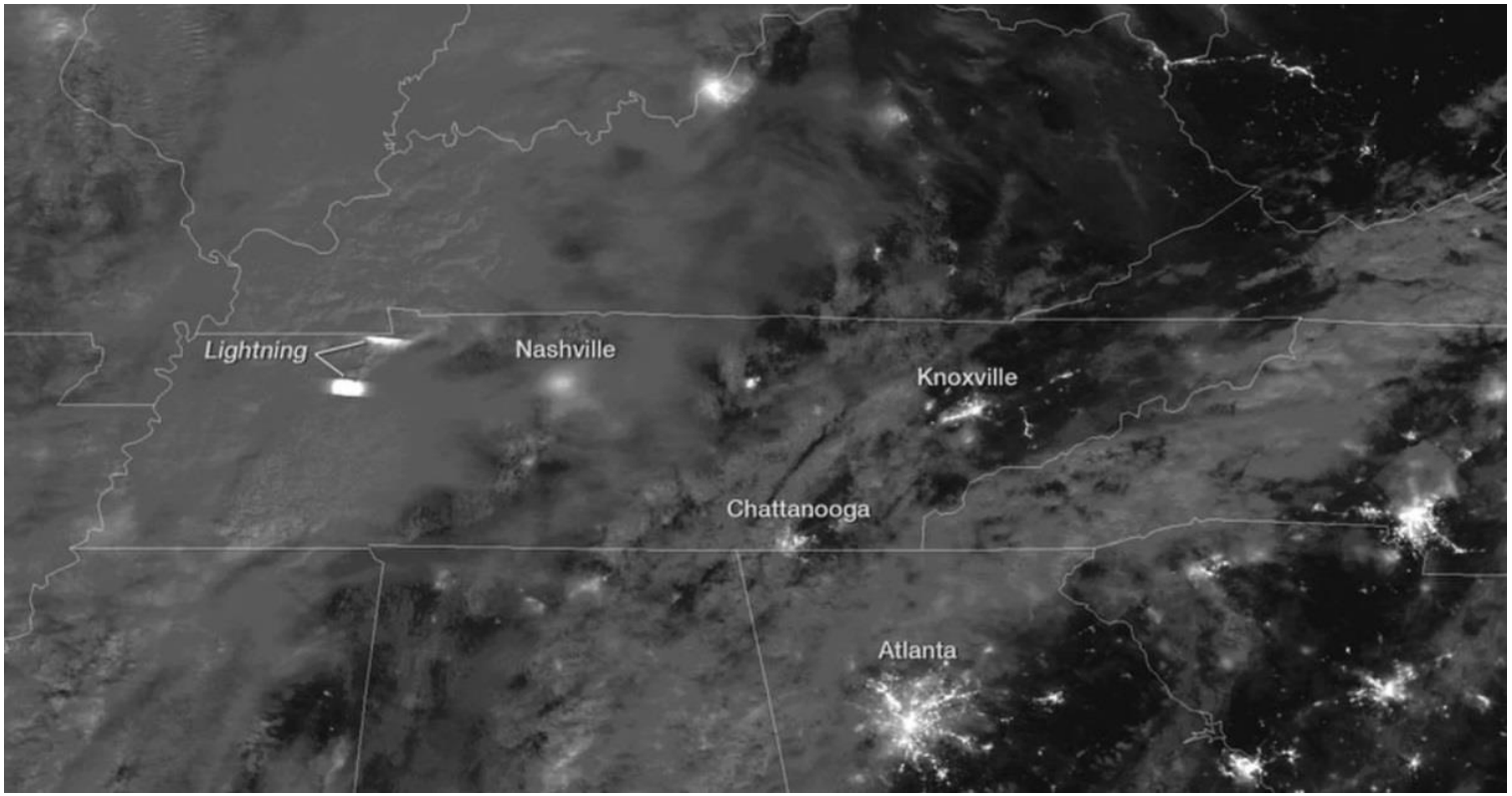
- This work **reported** the development and the first **on-orbit results** from the first UbatubaSat satellite named Tancredo-1.
- A group of **youngsters** took part in the complete picosatellite **project life span** (assembly, integration, testing, coding, launch and, tracking).
- The project also got **support** from various **organizations** such as UNESCO, GAUSS, AEB,JAXA and AMSAT.
- The **picosat worked successfully in orbit** but went silent after 4 days and its formal monitoring ceased 3 weeks after launch.
- The authors believe in this project the most **import asset** is what it **left on Earth** and not so much the picosat that reenters in 60 days or so.

Reentrada na atmosfera: 18Out2017



Tancredo-2

- RaioSat (CCST-INPE)
- Plataforma: CubeSat 3U



RaioSat

References

[1] Tikami, Auro. *Uma metodologia para re-engenharia de sistemas espaciais aplicada a um picossatélite,* INPE, 2016.

[2] Tikami, Auro; et al. *First On-Orbit Results from the Tancredo-1 Picosat Mission,* 1st IAA Latin American Symposium on Small Satellites, Buenos Aires, March 7 – 10, 2017.

[3] Tikami, A. ; Dos Santos, W. A. . *Systems Re-Engineering a TubeSat Platform for Picosatellites.* In: Quinto Congreso Internacional en Ciencia y Tecnología Aeroespacial, Bogotá, 2014.

Obrigado!

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