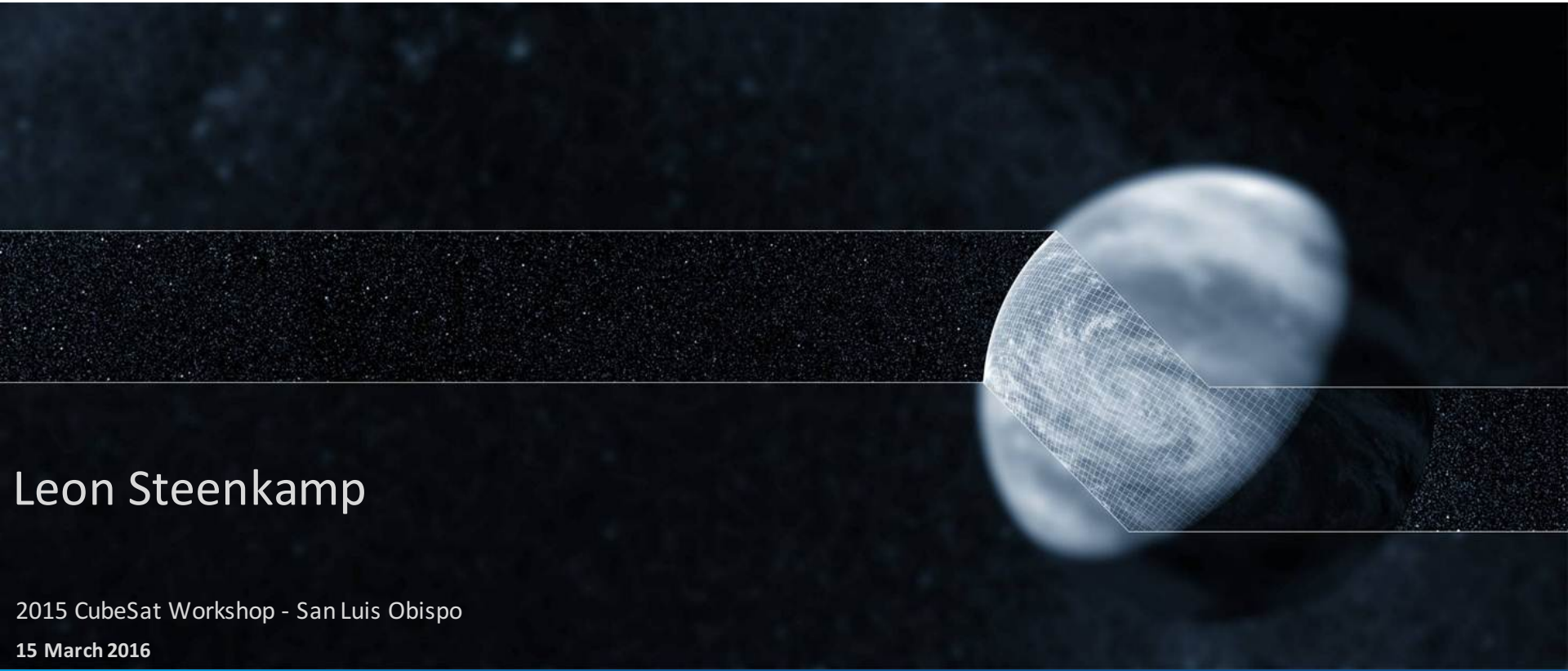


TshepisoSAT (ZACUBE-1), one year after launch



Leon Steenkamp

2015 CubeSat Workshop - San Luis Obispo

15 March 2016

+



creating
futures
2005-2015
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Hallo!

- Cape Peninsula University of Technology (**CPUT**)
- **Cape Town**, South Africa.
- **Electronic Engineering** / Satellite Systems Engineering



Outline

- Introduction
- TshepisoSAT (ZACUBE-1) Mission
- TshepisoSAT (ZACUBE-1) Spacecraft
- Launch and ground station
- Progress, telemetry and images
- Lesson Learnt

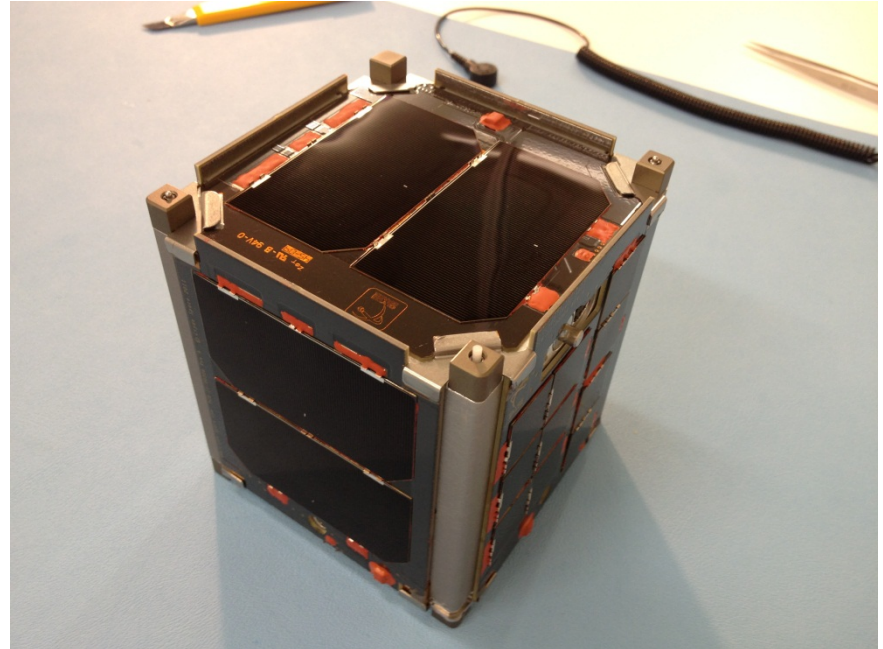


TshepisoSAT (ZACUBE-1) Mission

- Space weather mission
 - Initiate HF ionospheric propagation studies
 - Characterise beam pattern of SuperDARN array at SANAE IV in Antarctica.
- Skills development
 - Postgraduate students
 - Establish infrastructure, legacy
- Technology demonstrator
 - UHF/VHF transceiver
 - Deployable HF antenna
- Third South African satellite (ZA-003), first nano-satellite

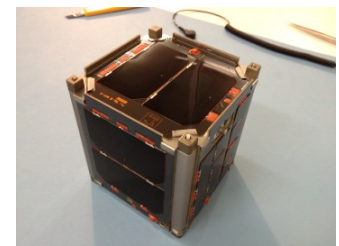
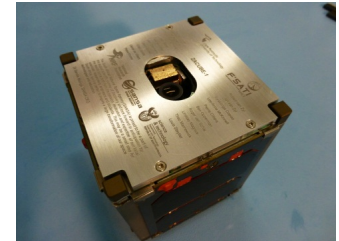


TshepisoSAT (ZACUBE-1) Spacecraft



TshepisoSAT (ZACUBE-1) Spacecraft

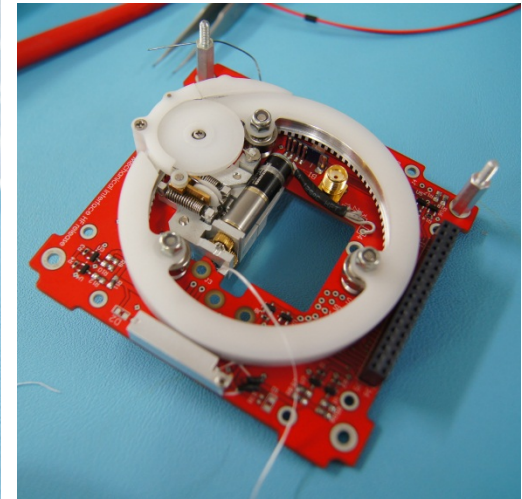
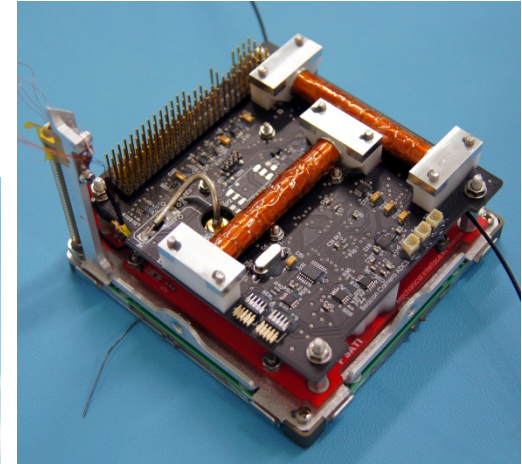
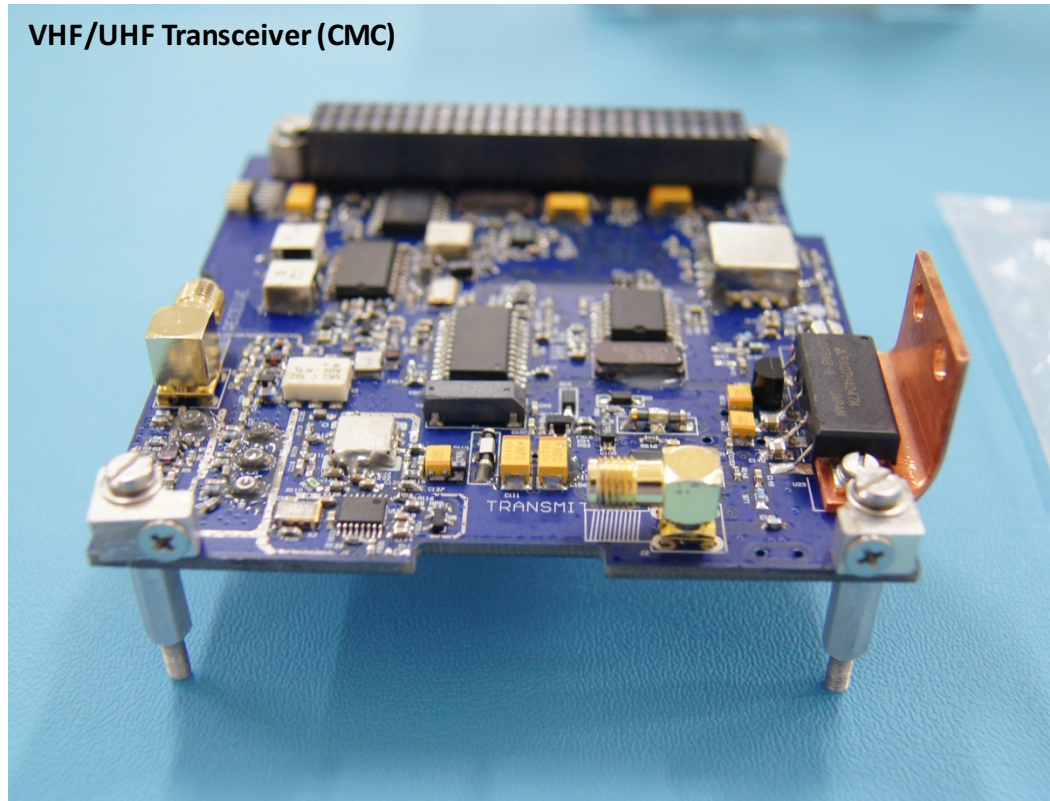
- One unit (**1U**) CubeSat – 1.18 kg
- **HF** beacon transmitter (14.099 MHz)
- Low resolution CMOS **camera**
- On orbit 1 year, 5 months and 2 days (23 April 2015)
- “Tshepiso” meaning “**promise**” in Sesotho
- Tight schedule (2 years), relatively small team
- Mix of commercial off-the-shelf and developed hardware
 - Clyde Space, ISIS, Pumpkin
 - Transceiver, ADCS, camera, HF transmitter and deployable antenna
 - Software developed in-house



TshepisoSAT (ZACUBE-1) Spacecraft

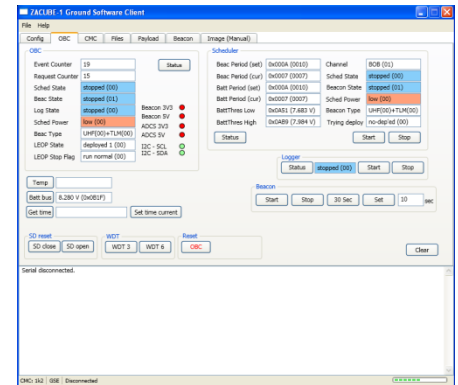
- Built systems

VHF/UHF Transceiver (CMC)



TshepisoSAT (ZACUBE-1) Software

- Flight software– C, Pumpkin Salvo RTOS
- Ground software – C, Python, C#
- Request/response model
 - Telemetry request/response
 - Tele-command and acknowledge
- Configurable on-board logger and scheduler
 - Settings and schedule files
 - Re-uses TLM and TCMD code
- File up/download – segments, block request
- Various ways of recovering – WDT, OBC, CMC, DTMF interface



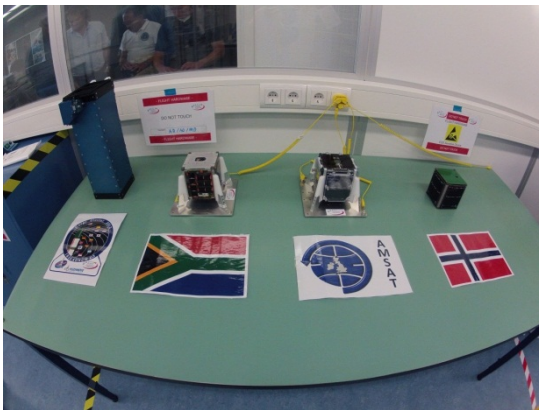
```
psload(0): 0x13
psload(1): 0x00
psload(2): 0x00

Event counter : 19
Request counter : 15
Sched state (swr) : 0x00 stopped
Log state (swr) : 0x01 stopped
Logging state : 0x00 stopped
Sched power (swr) : 0x00 low
Beacon type (cr) : 0x00 IIR beacon - msg * IIR
OBC loop state : 0x04 LEOP_STATE_RP2 - deployed - first check
LEOP stop flag : 0x01 LEOP_DEP_RUN - running as normal - should deploy
beaconsv : 00 OFF
adcs5v : 00 OFF
12c - SDA : 01 high - OK
12c - SCL : 01 high - OK
```



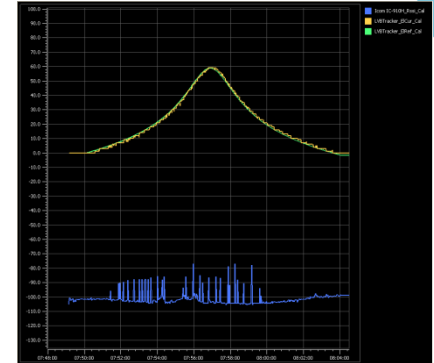
TshepisoSAT (ZACUBE-1) Launch

- Delft (ISIS) – Netherlands
- Yasny – Russia
- DNEPR (FUNcube-1, HINCube)



CPUT/F'SATI - Ground Station

- VHF/UHF (S-band in progress)
- McsLite software by Denel Spaceteq
 - Heritage from SumbandilaSat MCS
- TLM beacons on first pass



Mission Progress

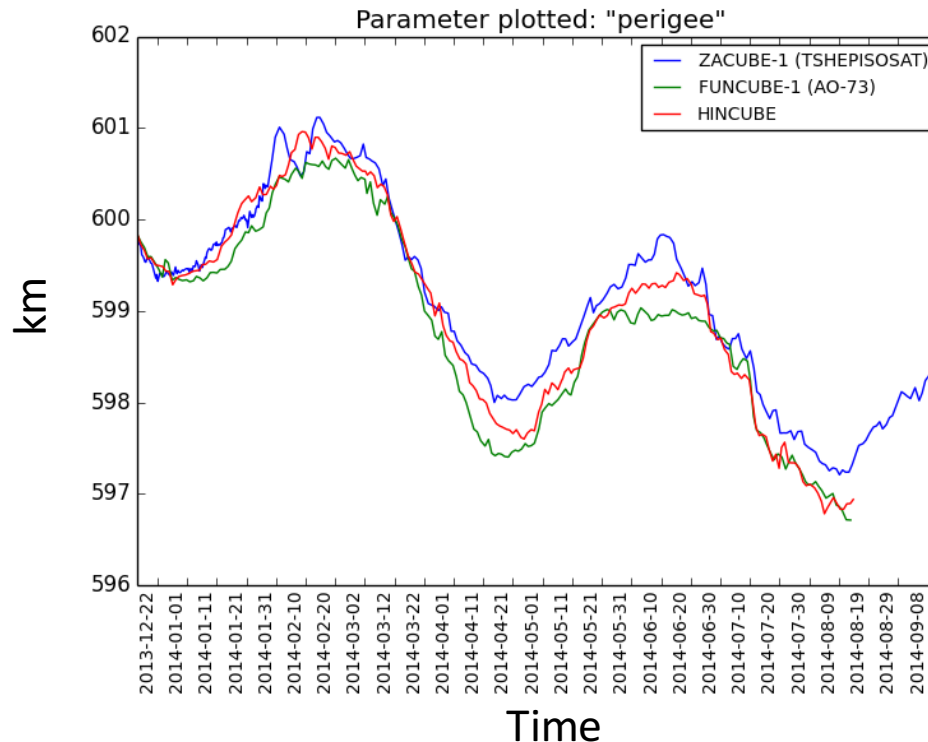
- Modest goals for initial phase
- Getting to grips with satellite and operations
- Close approaches
- Images, logging of telemetry data
- HF beacon antenna deployment
 - Problematic



TshepisoSAT (ZACUBE-1) Telemetry

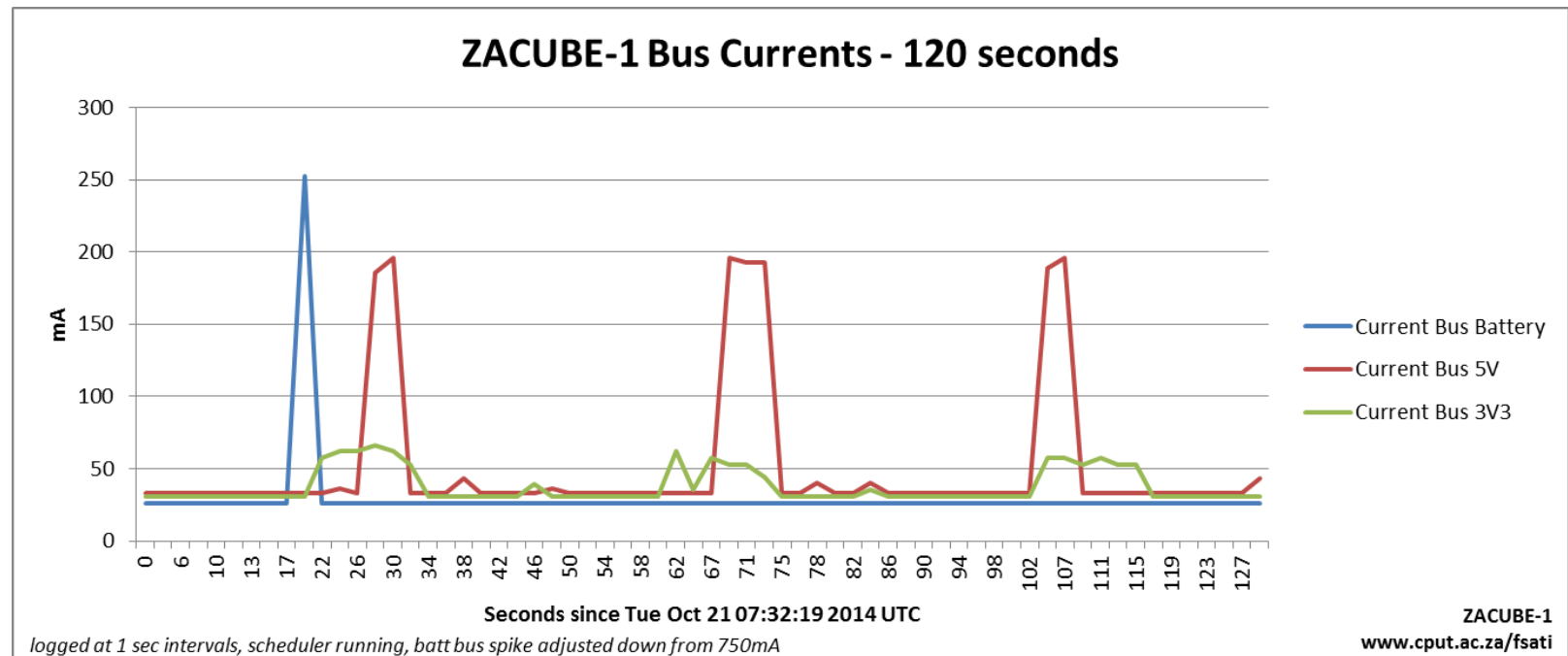


- Examined parameters from two-line element data
 - Compared ZACUBE-1, FUNCUBE-1 and HiNCube
- No significant difference after HF antenna deploy start



TshepisoSAT (ZACUBE-1) Telemetry

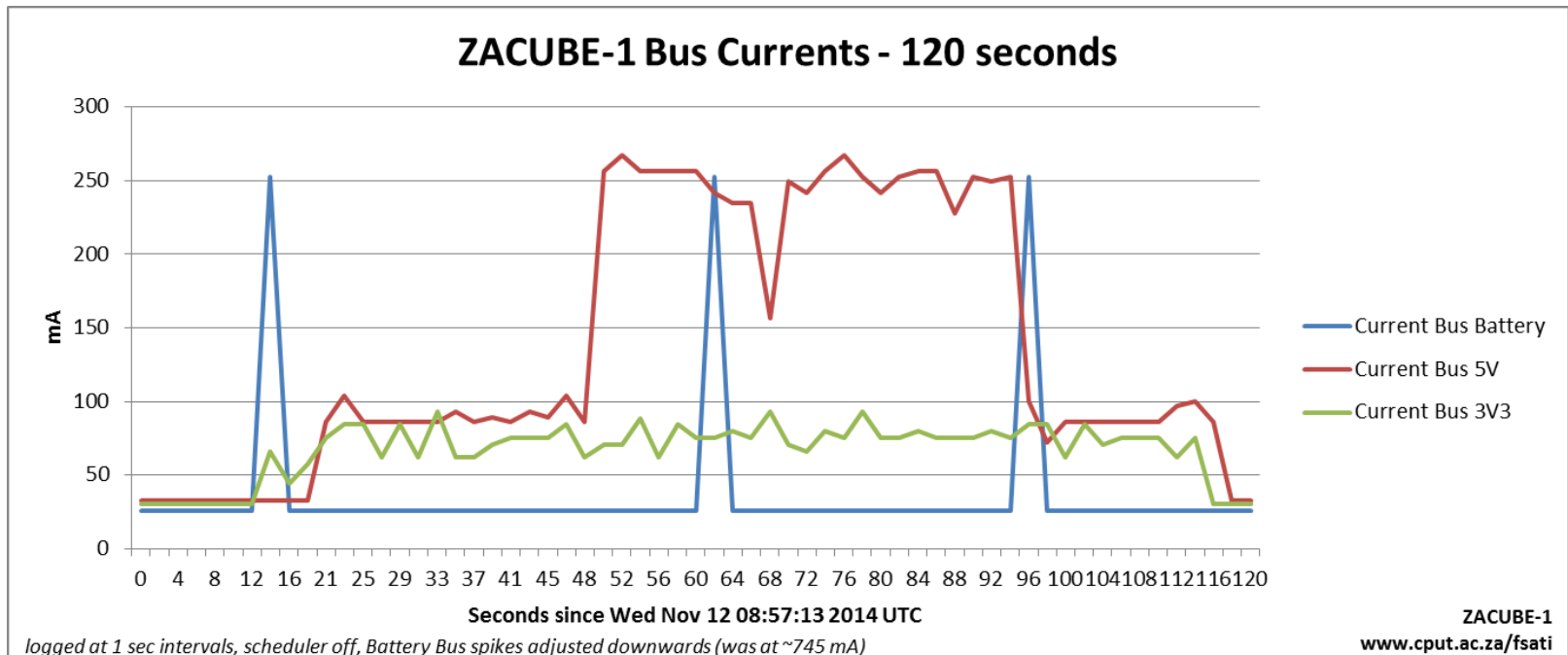
- Shows HF transmitter is switching on
 - Carrier only 5 sec, 38 sec period



TshepisoSAT (ZACUBE-1) Telemetry



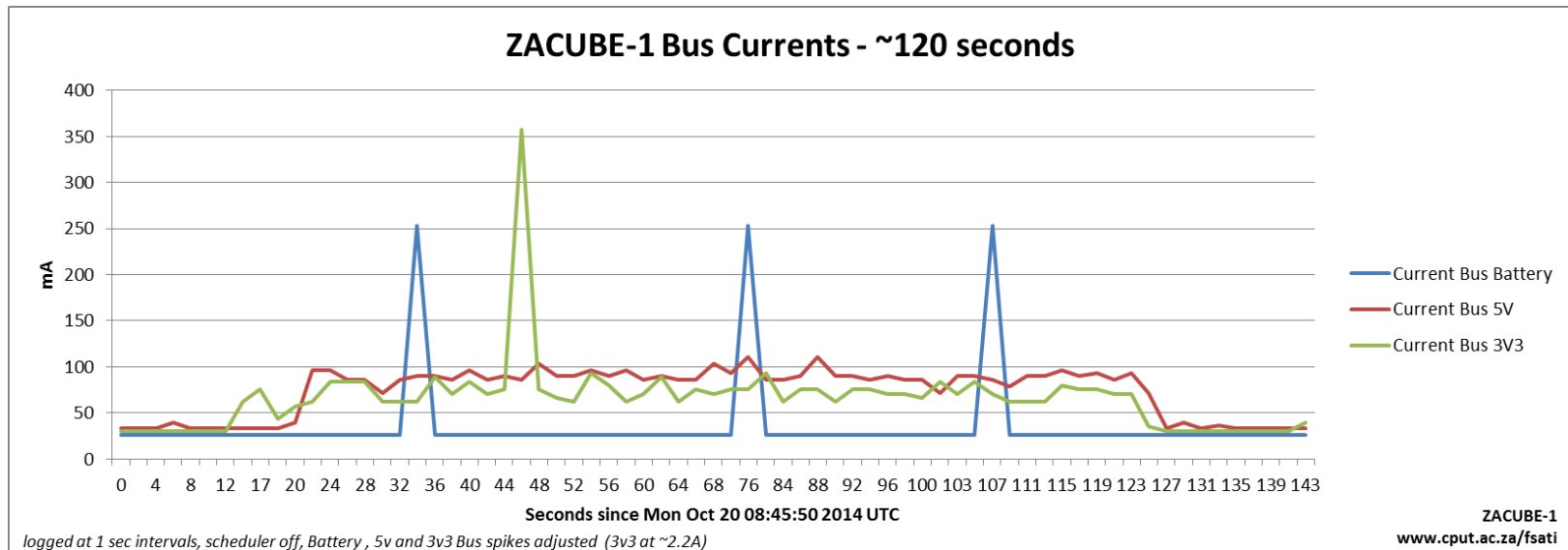
- HF antenna deployment motor running



TshepisoSAT (ZACUBE-1) Telemetry



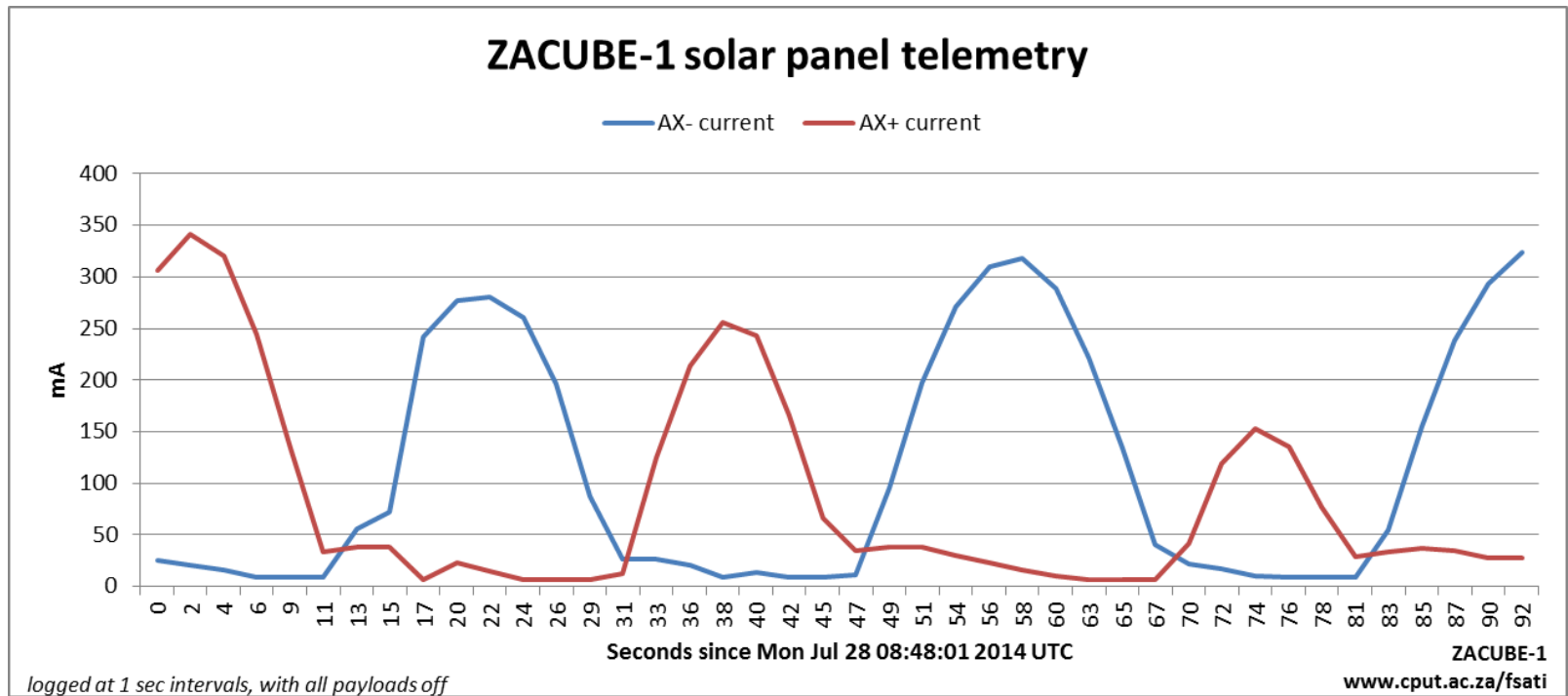
- Shows one burn event, expecting two



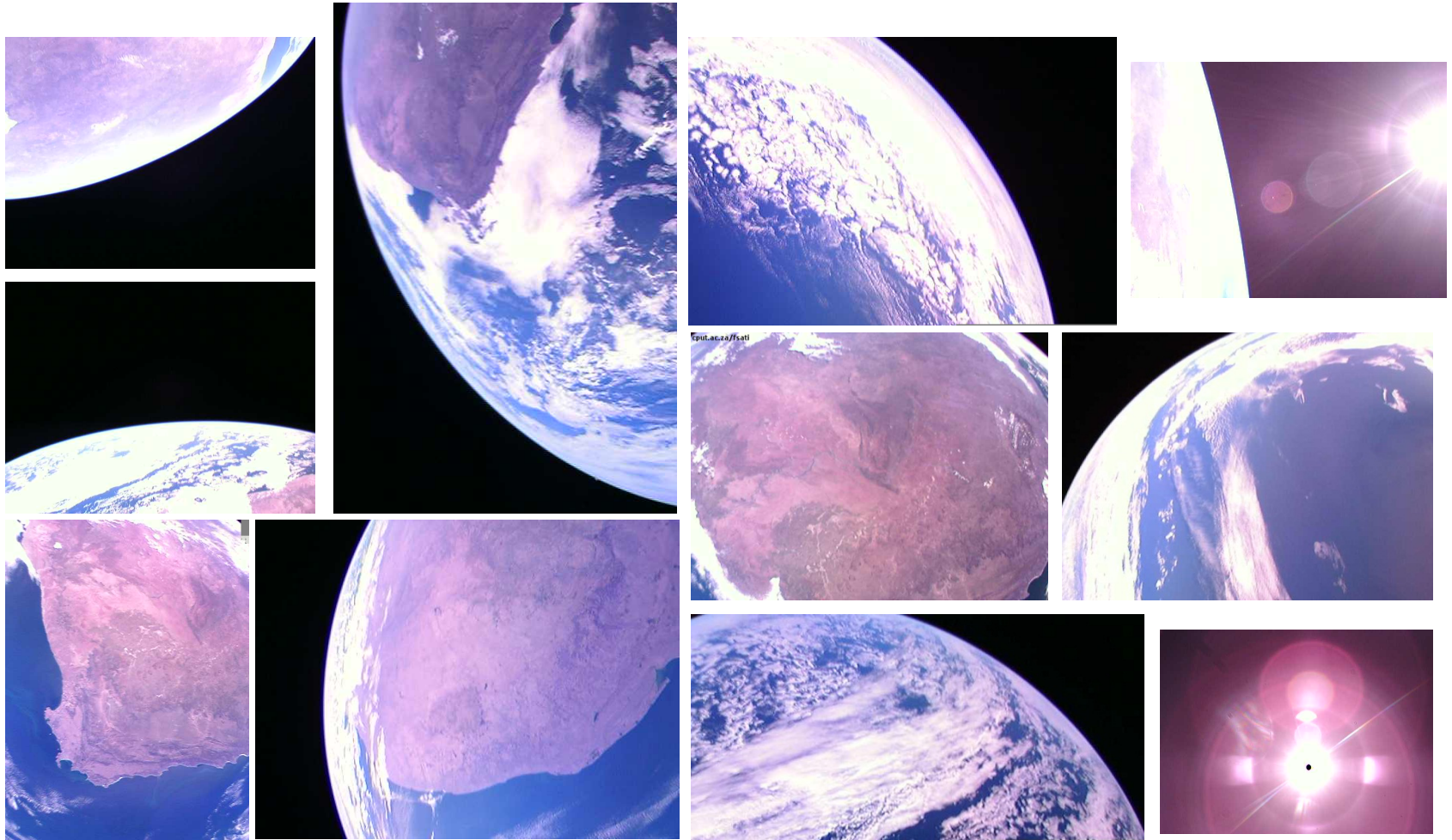
TshepisoSAT (ZACUBE-1) Telemetry



- Monitoring roll rates through solar panel currents

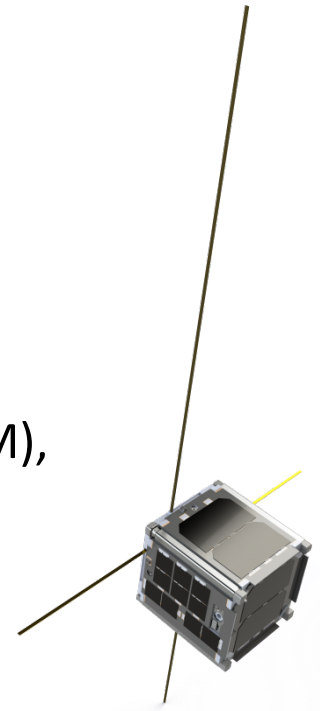


TshepisoSAT (ZACUBE-1) Images



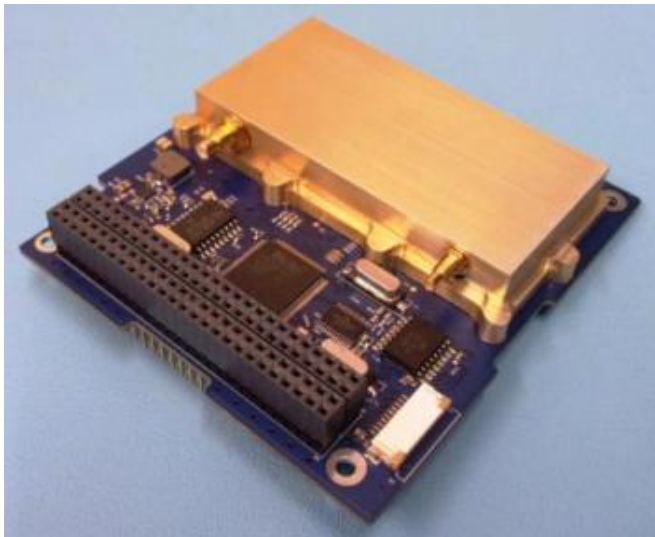
TshepisoSAT (ZACUBE-1) Lessons

- What would we do differently (or again)?
 - Flight software and transceiver performing well
 - Have a camera if possible
 - Add forward error correction
 - Automate as much as possible on the ground
- Thorough, representative testing (testing!)
- Operations plan, full run through on ground
- Data path
 - Know what you want to do with your data (payload and TLM),
 - Easy access to data – enables sharing,
 - You will think of new things to do with it
- If possible, have a plan B



VHF/UHF Transceiver (CMC)

- Updated ZACUBE-1 transceiver and S-Band transmitter to be used for upcoming ZACUBE-2 mission



CMC – VHF/UHF Transceiver
(Communications Major Component)



STX – S-Band Transmitter



Thank you

TshepisoSAT (ZACUBE-1), one year after launch

Leon Steenkamp

<http://www.cput.ac.za/fsati>

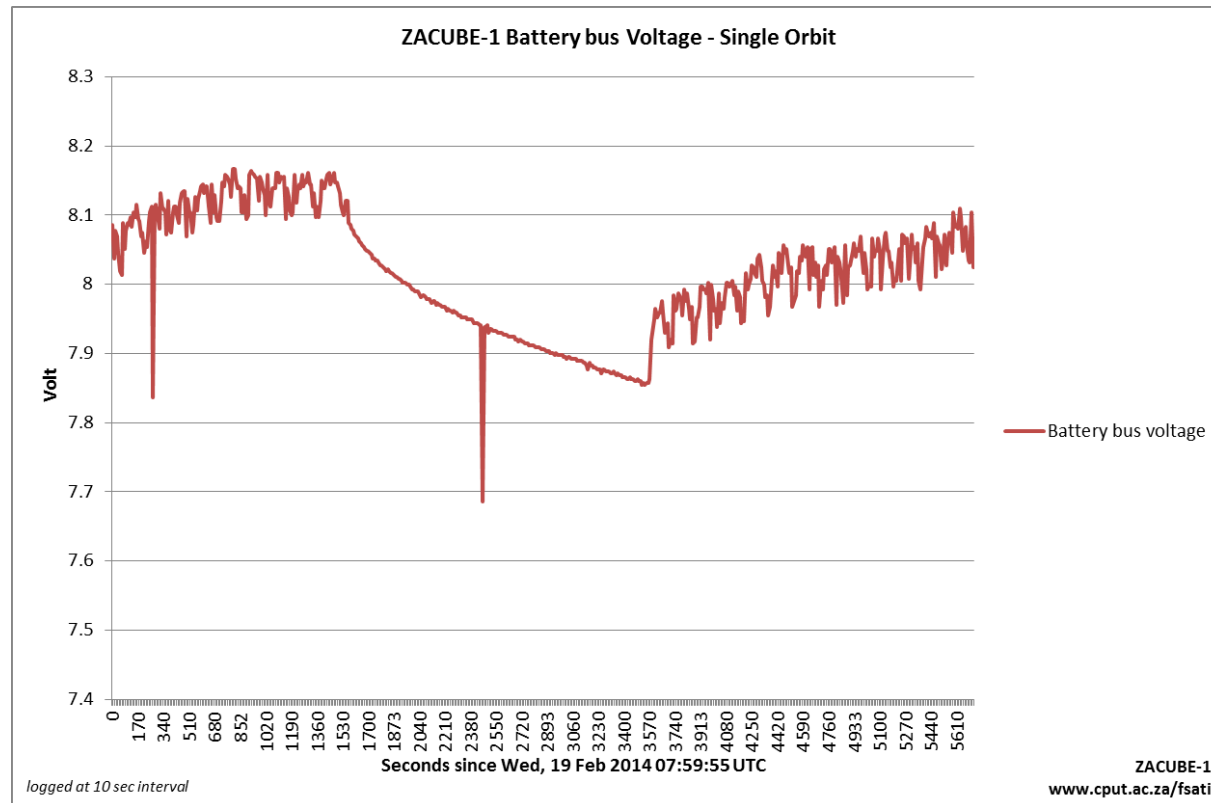
 fsatispace

Funding:

- Department of Science and Technology (DST)
- National Research Foundation (NRF)

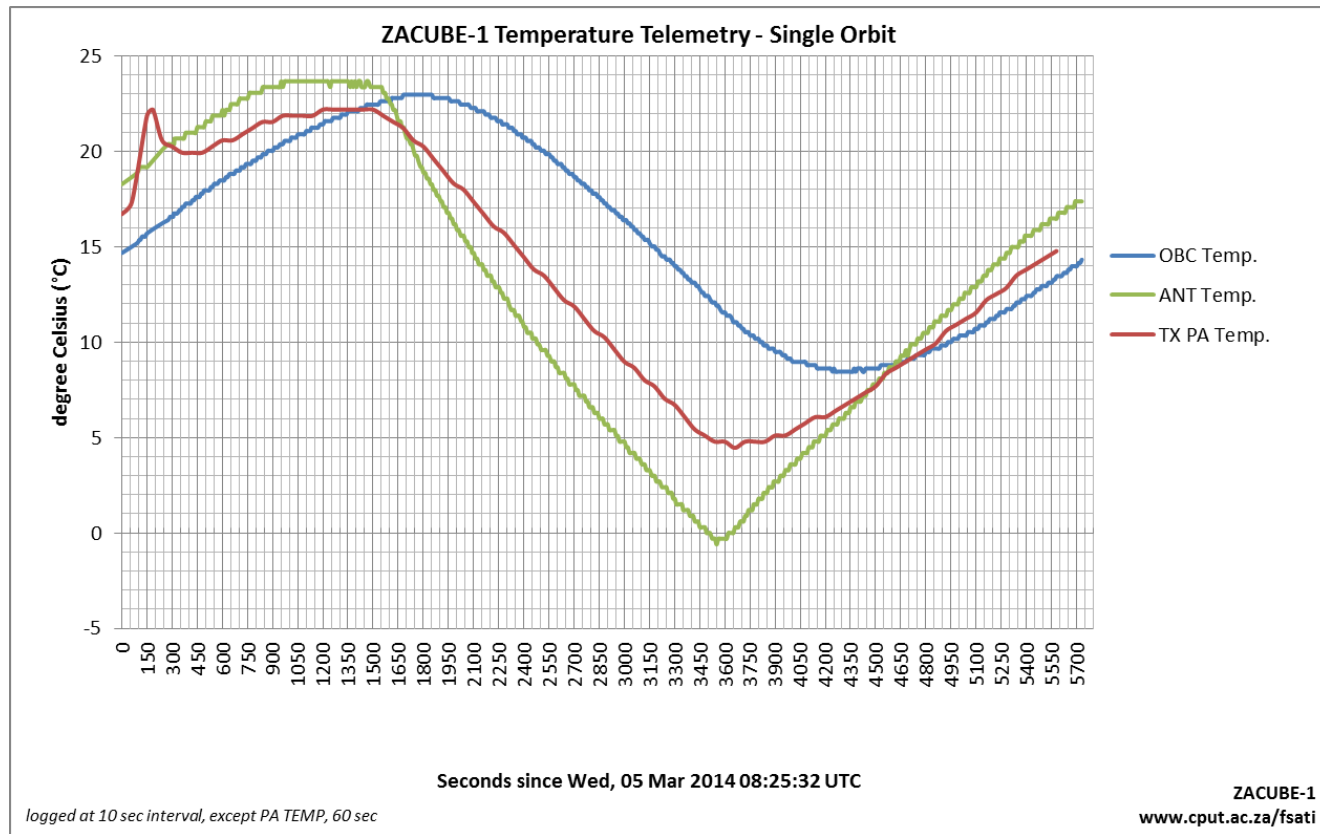


TshepisoSAT (ZACUBE-1) Telemetry

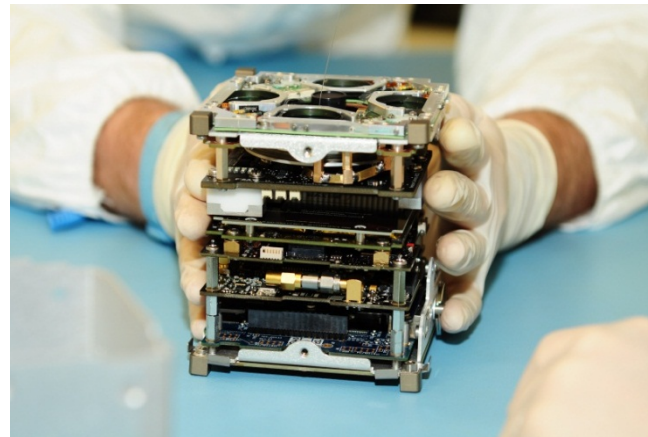
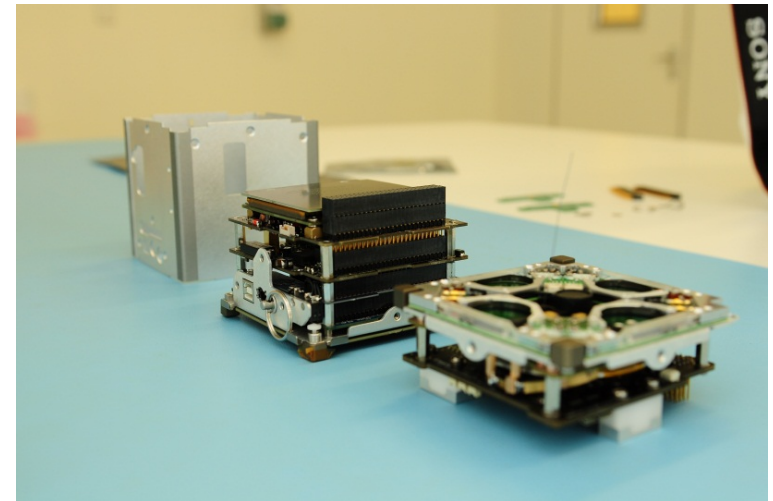
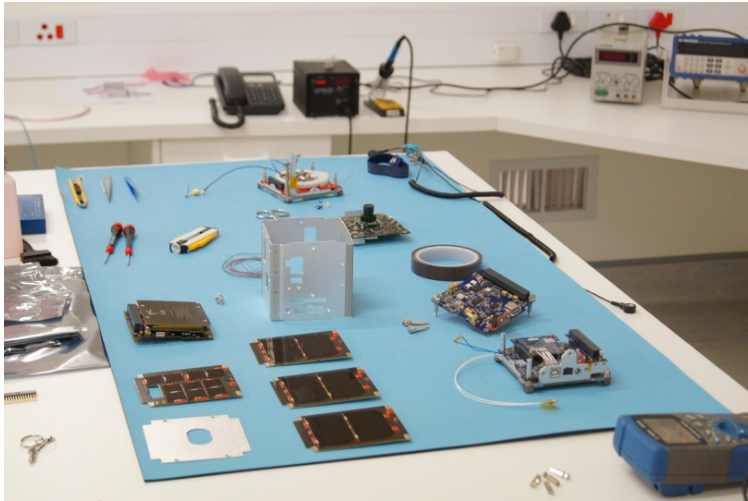


TshepisoSAT (ZACUBE-1) Telemetry

- On-board temperatures



TshepisoSAT (ZACUBE-1) Spacecraft



TshepisoSAT (ZACUBE-1) Layout

