



FUNcube Satellite



Wouter Weggelaar
AMSAT-NL



Dit is de presentatie zoals gehouden op de eerste
Intressedag Amateursatellieten te Paasloo op
28 September 2013 door Wouter PAS3WEG.
Gedurende de presentatie zijn video's getoond.
De links hier naar zijn toegevoegd aan het
einde van deze PDF.





Wouter Weggelaar



Afstudeerwerk Delfi-C³ – The eerste nederlandse nanosatelliet

Werkzaam bij Delfi-C3 spin-off ISIS

Radio amateur – PA3WEG

AMSAT-UK member

oprichter van AMSAT-NL

FUNcube design team member





AMSAT-UK

Inhoud



- Korte geschiedenis
- Introductie CubeSats
- Introductie FUNcube
- FUNcube in het klaslokaal: scholen
- Demonstratie van het Engineering Model
- Vraag en Antwoord



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Radio Amateur Satellites



AMSAT-UK

AMSAT-UK



- 500 individual members – not a commercial organisation – most are active radio amateurs
- One of more than 20 such groups worldwide
- In Europe, AMSAT groups exist in France, Germany, Italy, Spain, Portugal, Denmark, Sweden, The Netherlands and the UK
- Volunteer hobby!





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AMSAT-NL



- Dutch amateur radio satellite organization
- Founded to enable FUNcube-1 launch
- Still in set-up phase
- Close cooperation with AMSAT-UK



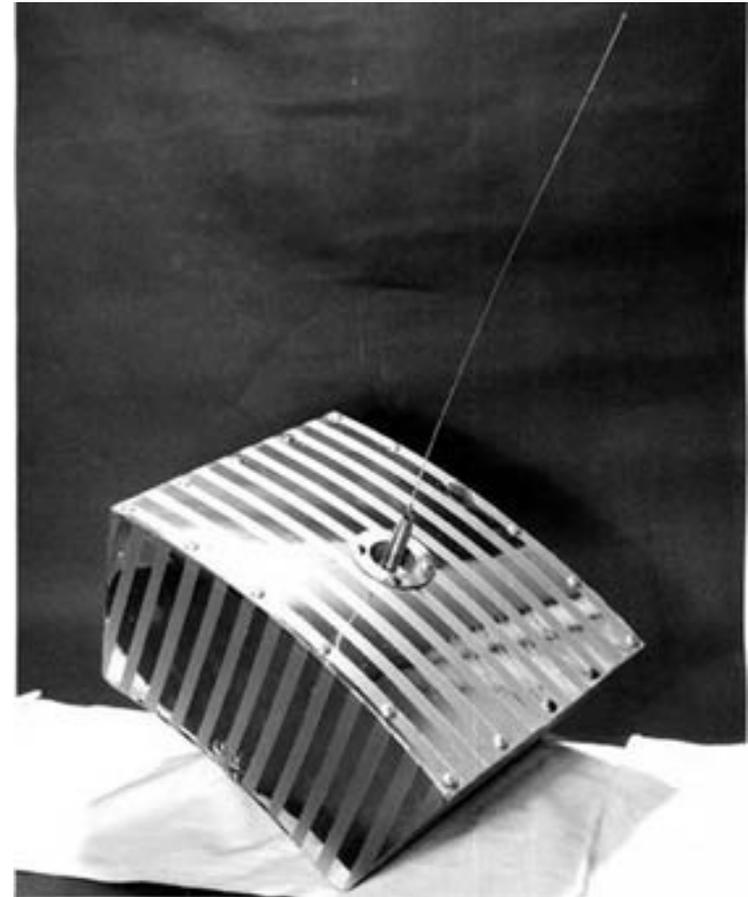


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OSCAR Satellites



- OSCAR: **O**rbiting **S**atellite **C**arrying **A**mateur **R**adio
- Oldest: Oscar 1
- launched 1961



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OSCAR Satellites



- Largest
- Oscar 40
- launched 2000
- 450kg to HEO on an Ariane 5





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OSCAR Satellites



- Oldest still operational - Oscar 7 - launched 1974

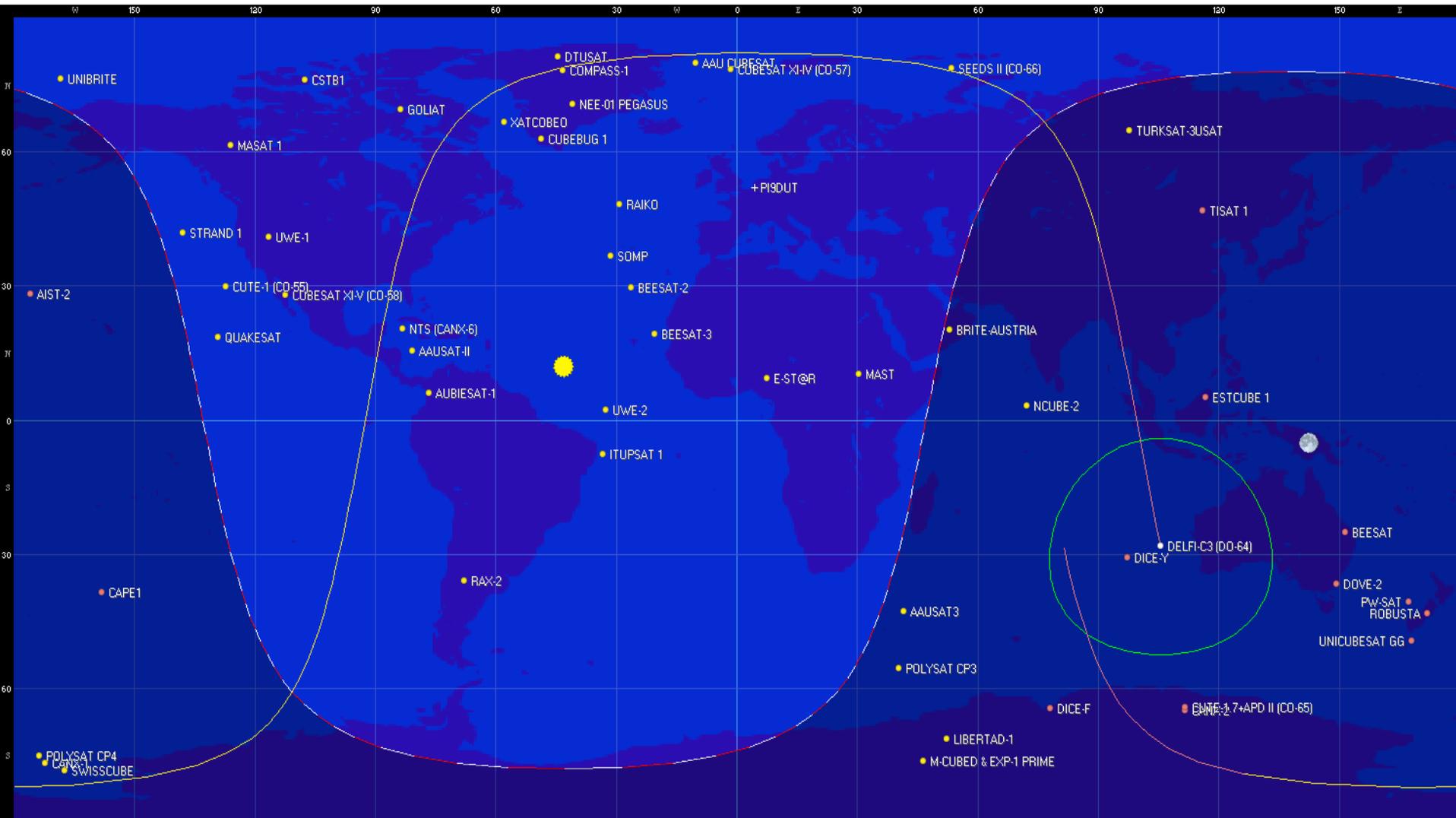


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Introduction to CubeSats





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CubeSats



- Less than 1.3 kg
- 100x100x100mm 'Units'
- 1U, 2U, 3U, 6U, 12U...
- Standard deployment mechanism: "PODS"

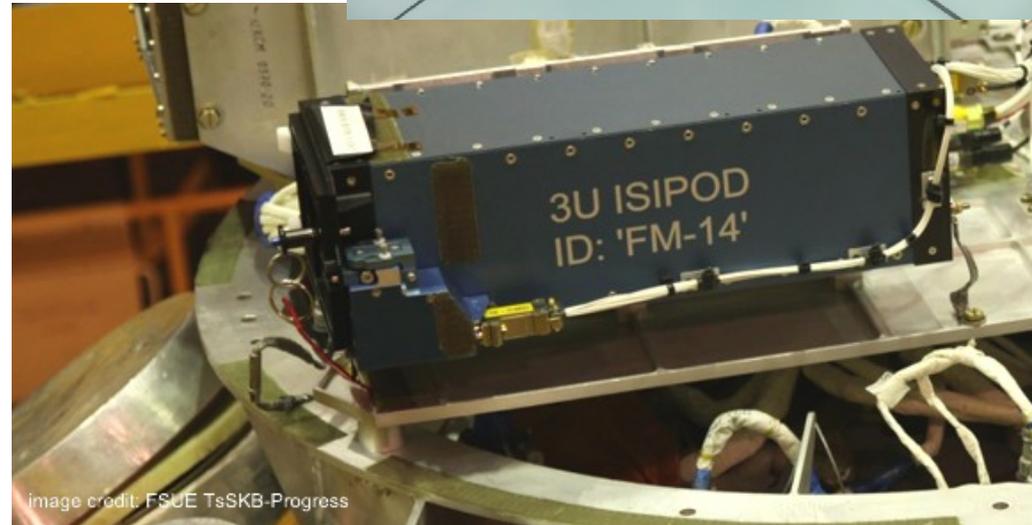
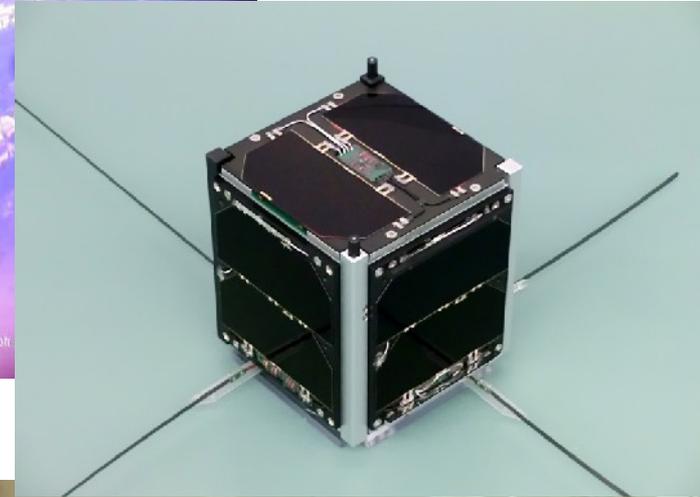
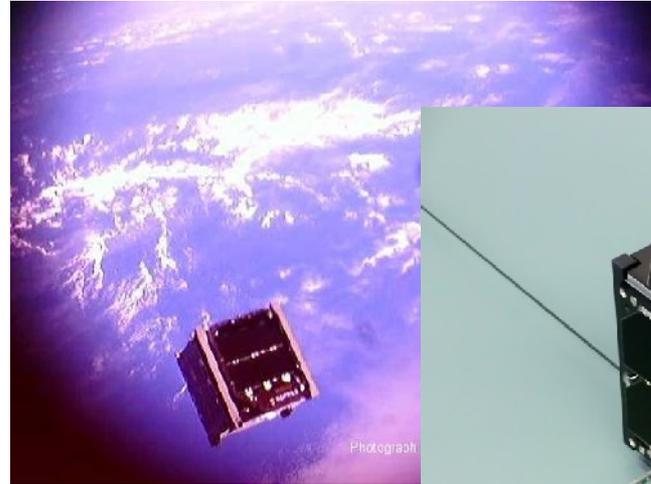


image credit: FSUE TsSKB-Progress



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Radio Amateur Satellites



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Current CubeSat statistics



- 40+ launched
- 300+ being developed
- Created by groups worldwide
- US, India, Netherlands, France, Switzerland, Italy, Germany, Denmark, Norway, Austria, Spain, Portugal Poland, Estonia, Japan, Turkey, Mexico...



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Radio Amateur Satellites



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AMSAT - CubeSats



- FUNcube-1 – AMSAT-NL & UK, First AMSAT CubeSat project
- FUNcube-2 on UKube – AMSAT-UK
- FOX 1 & 2 - AMSAT-NA
- KLETSkous – Southern Africa AMSAT
- More to follow





The FUNcube Project – the background



Given that:

CubeSats are “cheap”

CubeSats can be built quickly

CubeSats should be “simple”

So in 2009 we asked ourselves:

Could we create an educational outreach mission?

Could it also have an amateur transponder?

Could we create a team of volunteers with the skills/passion?

Could we develop the actual educational outreach?

Could we fund it?





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The FUNcube Project – primary objective



Educational outreach

STEM subjects

Radio – practical understanding of communication

Electronics – how radios work

Physics – Data from 50+ telemetry channels

Orbital mechanics - Doppler

Materials science payload - Demonstrate loss of heat energy by radiation from two materials with differing surface finishes

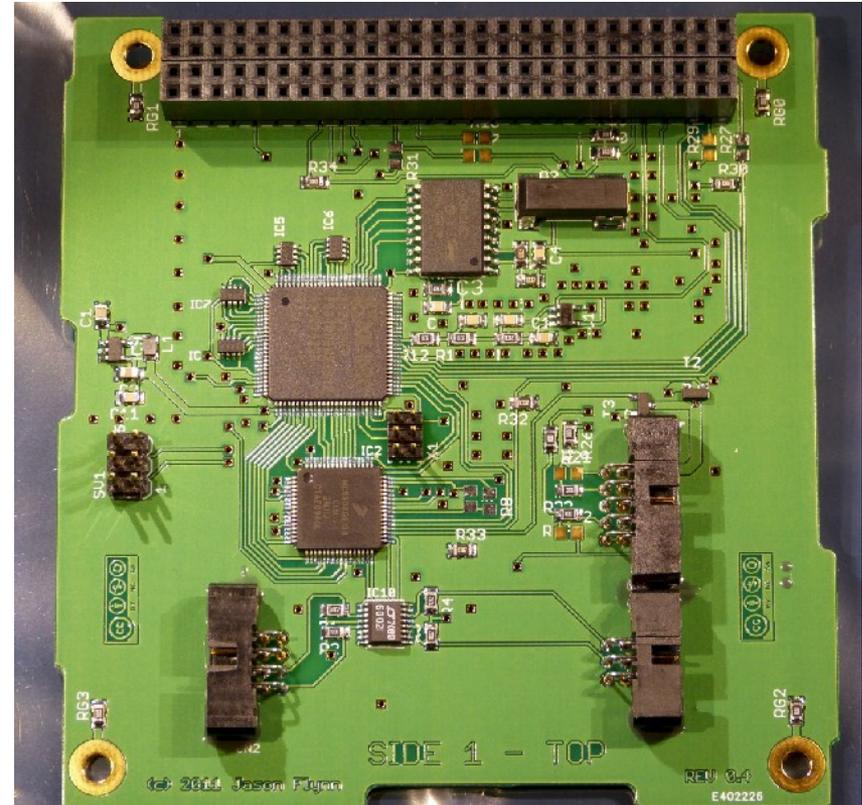
“Fitter Message” - Short greetings messages



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FUNcube-1 Hardware

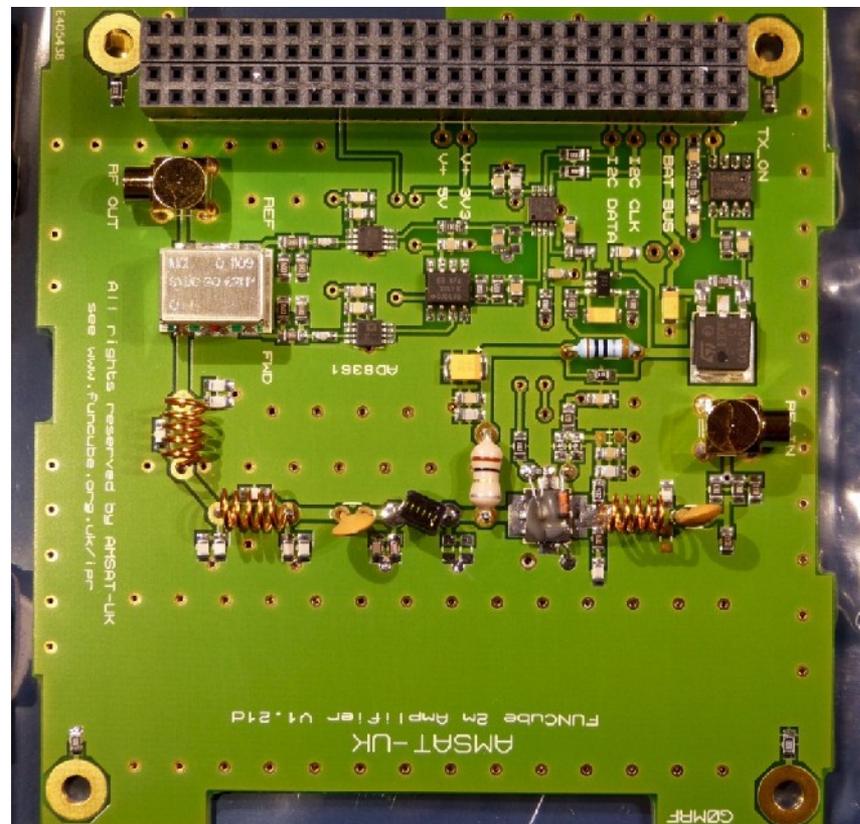
CCT board
Command, Control
and Telemetry
The brains of the
satellite
Much “dumber” than a
smartphone





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FUNcube-1 Hardware



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Radio Amateur Satellites

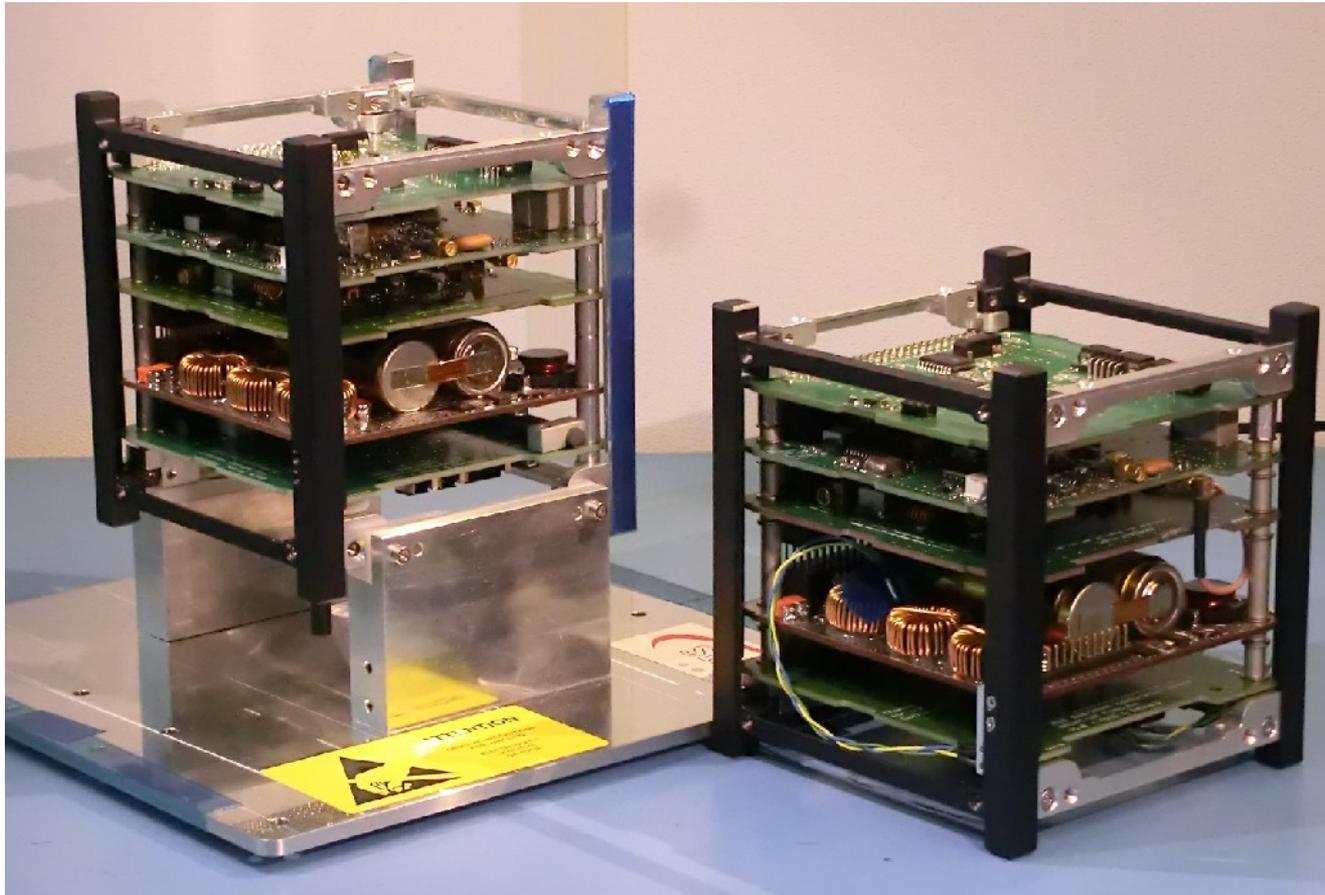


ATTENTION

OBSERVE PRECAUTIONS
FOR HANDLING
ELECTROSTATIC
SENSITIVE
DEVICES



FUNcube-1 Hardware



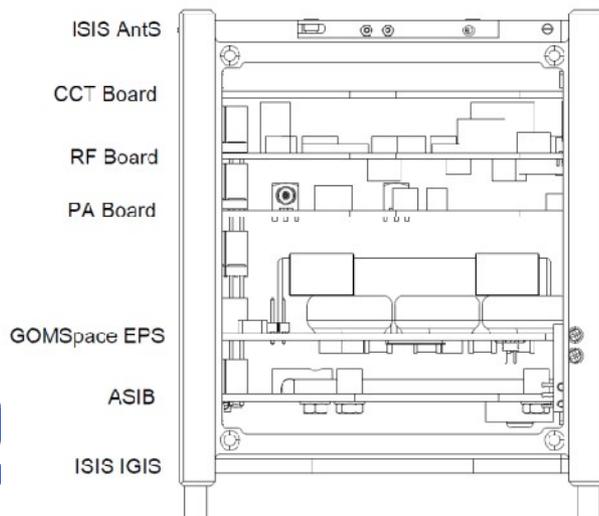
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FUNcube-1 Telemetry



- 54 Telemetry channels
- Telemetry is sent in 24 x 5 second frames over 2 minute period
- “Real time” every 5 secs, “Whole orbit” data sampled every 60 secs stored for 104 minutes and “High Res” data sampled at 1 second intervals for 60 seconds
- Text messages- 9 x 250 character greetings messages & 27 additional messages stored in memory
- Very distinctive sound to enable easy identification
- 4.3 seconds of data + 0.7 seconds of BPSK mark tone







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Amateur radio operations



- During the local night (eclipse) the sub-system switches into amateur radio mode
- The amateur radio transponder can be used to demonstrate radio communications to schoolchildren and students of all ages
- Students are able to hear amateur voice signals when the satellite passes overhead



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Radio Amateur Satellites





The “Ground Segment”- the FUNcube dongle

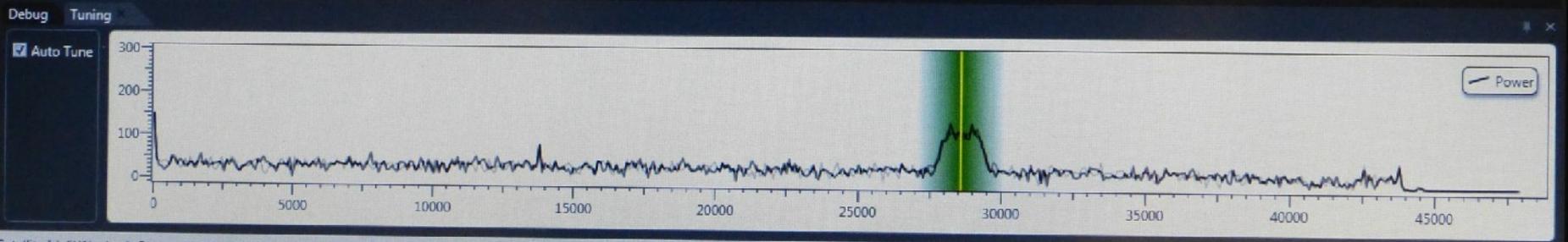
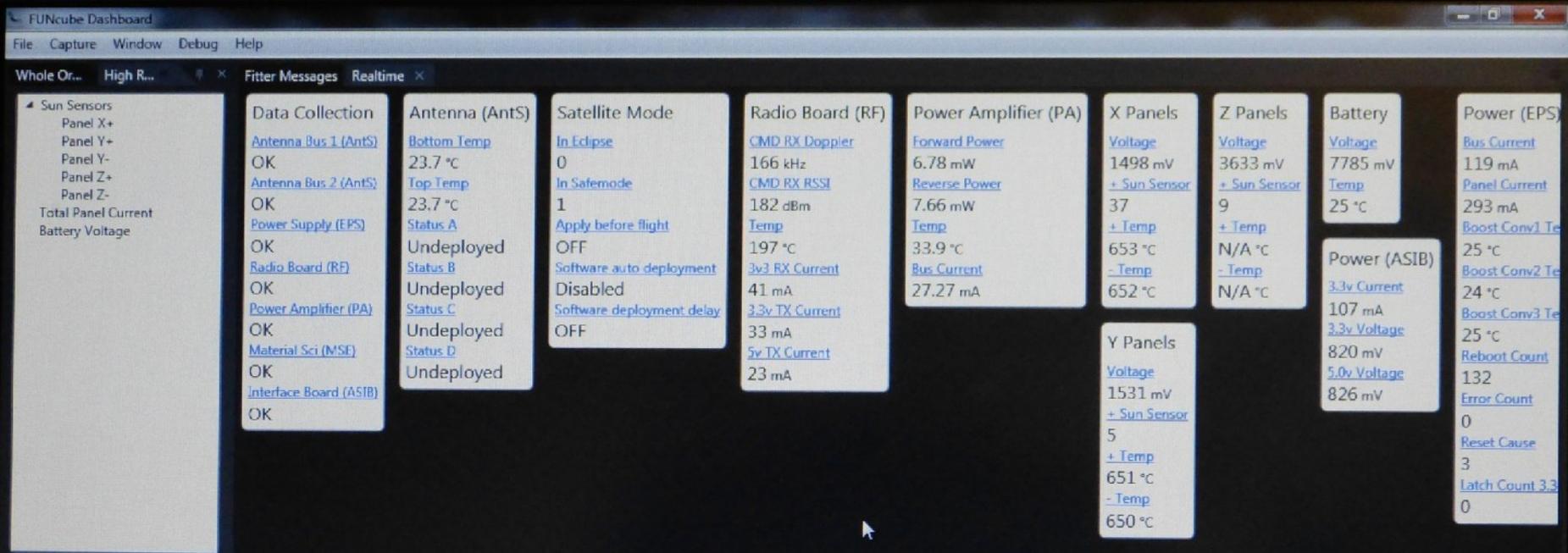


USB receiver dongle

Works with all freeware SDR software & any OS

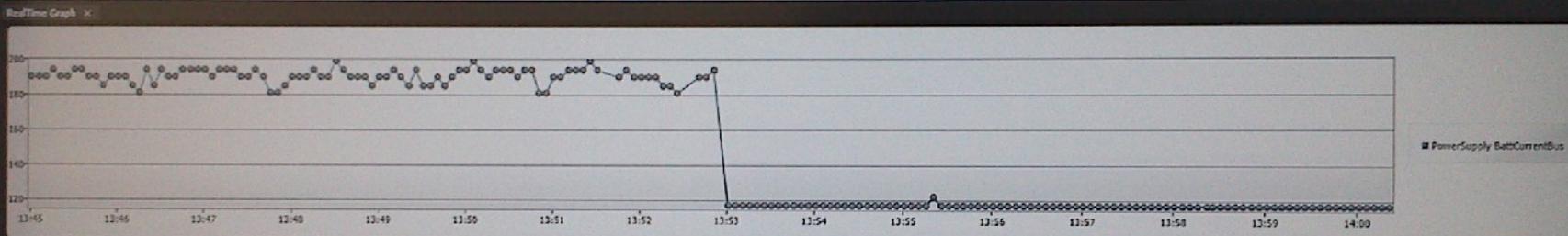
Works in combination with the FUNcube Dashboard





```

4/7/2013 11:37:17 AM 87454 FHX You can receive me using Howard G4LVB's FUNcube dongle
4/7/2013 11:37:11 AM 87454 FHX My power amplifier is designed by David, G0R9P
4/7/2013 11:37:05 AM 87454 FHX Those friendly chaps from Nardissham wrote my software, <3
4/7/2013 11:36:54 AM 87454 FHX Dave, G4DFZ is testing my data warehouse
4/7/2013 11:36:48 AM 87454 FHX I am currently testing myself in PA3WEG's Shack
  
```





FUNcube – telemetry reception



FUNcube Dashboard

File Capture Window Debug Help

Whole... High Res... Fitter Messages Realtime

- Material Science Experiment
 - Black Chassis Temp
 - Silver Chassis Temp
 - Black Panel Temp
 - Silver Panel Temp
- Panel Temperature
 - Temperature X+
 - Temperature X-
 - Temperature Y+
 - Temperature Y-
- Panel Voltages
 - Voltage 1
 - Voltage 2
 - Voltage 3
- Power Supply
 - Total Panel Current
 - Total System Current
 - Battery Voltage

Data Collection

- [Antenna Bus 1 \(AntS\)](#)
OK
- [Antenna Bus 2 \(AntS\)](#)
OK
- [Power Supply \(EPS\)](#)
OK
- [Radio Board \(RF\)](#)
OK
- [Power Amplifier \(PA\)](#)
OK
- [Material Sci \(MSE\)](#)
OK
- [Interface Board \(ASIB\)](#)
OK

Antenna (AntS)

- [Bottom Temp](#)
22.5 °C
- [Top Temp](#)
22.5 °C
- [Status A](#)
Deployed
- [Status B](#)
Deployed
- [Status C](#)
Deployed
- [Status D](#)
Deployed

Satellite Mode

- [In Eclipse](#)
0
- [In Safemode](#)
1
- [Apply before flight](#)
ON
- [Software auto deployment](#)
Disabled
- [Software deployment delay](#)
OFF

Radio Board (RF)

- [CMD RX Doppler](#)
165 kHz
- [CMD RX RSSI](#)
182 dBm
- [Temp](#)
23.99 °C
- [3v3 RX Current](#)
41 mA
- [3.3v TX Current](#)
56 mA
- [5v TX Current](#)
28 mA

Power Amplifier (PA)

- [Forward Power](#)
15.99 mW
- [Reverse Power](#)
11.71 mW
- [Temp](#)
34.1 °C
- [Bus Current](#)
34.42 mA

X Panels

- [Voltage](#)
1609 mV
- [+ Sun Sensor](#)
38
- [- Temp](#)
22.04 °C
- [- Temp](#)
22.37 °C

Y Panels

- [Voltage](#)
1894 mV
- [+ Sun Sensor](#)
5
- [- Temp](#)
22.68 °C
- [- Temp](#)
22.14 °C

Z Panels

- [Voltage](#)
1671 mV
- [+ Sun Sensor](#)
4
- [- Temp](#)
N/A °C
- [- Temp](#)
N/A °C

Battery

- [Voltage](#)
7856 mV
- [Temp](#)
22 °C

Power (ASIB)

- [3.3v Current](#)
130.00 mA
- [3.3v Voltage](#)
3280.00 mV
- [5.0v Voltage](#)
4956.00 mV

Power (EPS)

- [Bus Current](#)
146 mA
- [Panel Current](#)
0 mA
- [Boost Conv1 Temp](#)
22 °C
- [Boost Conv2 Temp](#)
22 °C
- [Boost Conv3 Temp](#)
22 °C
- [Reboot Count](#)
92
- [Error Count](#)
0
- [Reset Cause](#)
5
- [Latch Count 3.3v](#)
0
- [Latch Count 5.0v](#)
0
- [Power Tracking Mode](#)
1



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UKube-1 variant



FUNcube Dashboard

File Capture Window Debug Help

High Resolution Filter Messages Realtime X

- Panel Voltages
 - Fixed X
 - Fixed Y
 - Fixed Z
 - Deployable +Y
 - Deployable -Y
- Batteries
 - Current 0
 - Current 1
 - Current 2

Antenna (AntS)	Radio Board (RF)	Active Magnetic Attitude Control	Panel Fix X	Panel Dep -X	Battery 0	Battery 2
Bottom Temp 255,0 °C	CMD RX Doppler 0,00 mV	Magnetometer 0 0	+ Current 1023 mA	+ Current 1023 mA	Voltage 40 mV	Voltage 39 mV
Top Temp N/A °C	CMD RX RSSI 0,00 mV	Magnetometer 1 1	- Current 1023 mA	- Current 628 mA	Cell Voltage 160 mV	Cell Voltage 160 mV
Status A 4	Temp 193,67 °C	Magnetometer 2 19275	Temp N/A °C	Temp 0 °C	Current 226 mA	Current 227 mA
Status B 4	3v3 RX Current 0,00 mA	Temp 260			Current Direction 0	Current Direction 0
Status C 4	3.3v TX Current 0,00 mA		Panel Fix Y	Panel Dep +Y	Temp 141 °C	Temp 142 °C
Status D 4	5v TX Current 0,00 mA		+ Current 1023 mA	+ Current 1023 mA		
			- Current 1023 mA	- Current 1023 mA	Battery 1	
			Temp N/A °C	Temp N/A °C	Voltage 40 mV	
Satellite Mode	Power Amplifier (PA)		Panel Fix Z	Panel Dep -Y	Cell Voltage 160 mV	
In Sunlight 1	Forward Power 0,00 mW		+ Current 1023 mA	+ Current 1023 mA	Current 227 mA	
	Reverse Power 0,00 mW		- Current 1023 mA	- Current 1023 mA	Current Direction 1	
	Temp 88,0 °C		Temp N/A °C	Temp N/A °C	Temp 141 °C	
	Bus Current 2,54 mA					

Whole Orbit High Resolution

Tuning

Auto Tune



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Tracking Software



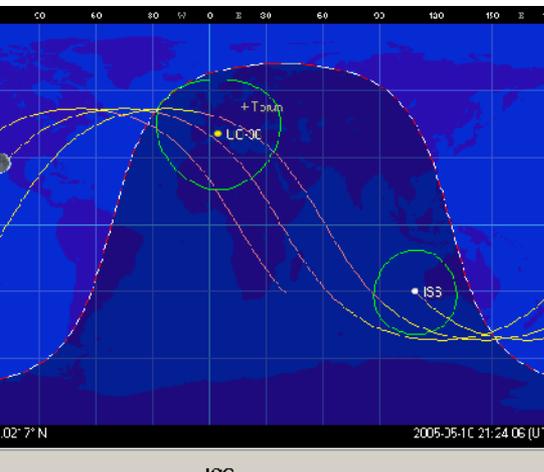
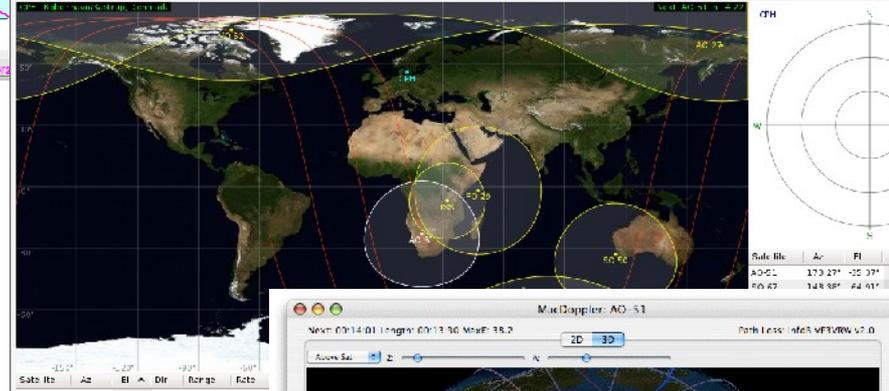
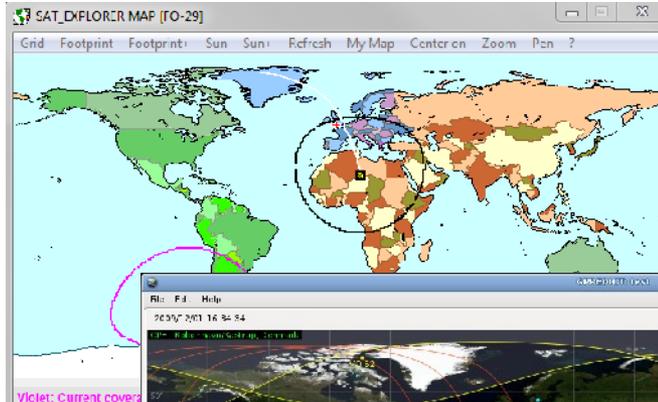
Orbitron (free, windows)

PREDICT (free, LINUX)

MacDoppler (paid, mac)

Sat Explorer (free, windows)

Gpredict (free, LINUX)



PREDICT: Tracking OSCAR-27

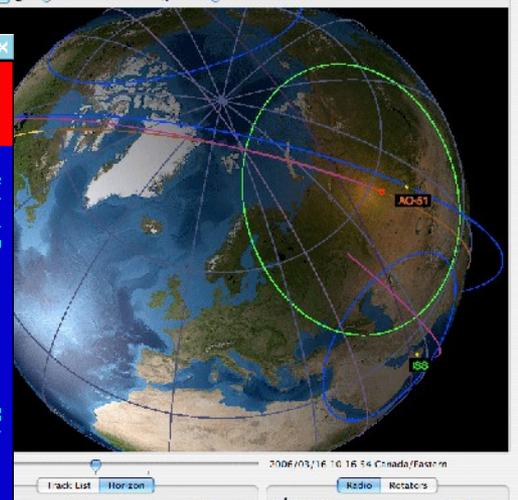
PREDICT Real-Time Satellite Tracking
Tracking: OSCAR-27 On Mon 15May06 19:50:41

Satellite	Direction	Velocity	Footprint	Altitude	Slant Range
24.87 N.	129.32 Hz	16694 mi	3760 mi	492 mi	1664 mi
55.67 W.	+5.96 El	26867 km	6051 km	792 km	2678 km

Mode: J I W Transponder

Uplink :	145.85000 MHz	TX :	145.84713 MHz	Path loss :	144.235 dB
Downlink :	436.79500 MHz	RX :	436.80360 MHz	Path loss :	153.763 dB
Delay :	8.931 ms		Approaching	Echo :	17.868 ms

Eclipse Depth	Orbital Phase	Orbital Model	Squint Angle	AutoTracking
-59.20°	14.6	SGP4	N/A	Active





Data Warehouse – Online Resource



The screenshot shows the 'Real Time Data' page for the FUNcube satellite. It includes a navigation menu on the left with links like 'Home', 'Real Time Data', 'High Resolution Data', 'Who's On Air', 'Enter Messages', 'Amateur Radio Info', 'Download Map', and 'Upload Tracking'. Below the navigation is a 'Data Providers' section listing 'RASWEG'. The main content area displays 'Real Time Data' for the satellite, with a sub-section for 'Electrical Power Subsystem'. A table shows various parameters such as Photo Voltage, Total System Current, Battery Voltage, and Temperature, along with their current values, minimums, and maximums.

Name	Value	Min.	Max.
Photo Voltage 1	0 mV	0.00	10.00
Photo Voltage 2	0 mV	0.00	11.00
Photo Voltage 3	0 mV	0.00	9.90
Total Photo Current	0 mA	-9	11
Battery Voltage	7484 mV	-10	10
Total System Current	140 mA	-9	11
Reboot Count	1072	N/A	N/A
EPS Software errors	0	N/A	N/A
Boost Converter Temp 1	22 °C	-10	10
Boost Converter Temp 2	22 °C	-9	11
Boost Converter Temp 3	22 °C	-9	11
Battery temp	22 °C	-9	11
Watch Up Count 5v	0	N/A	N/A
Watch Up Count 3.3v	0	N/A	N/A
Reset Cause	5	N/A	N/A
PowerPoint Tracking Mode	0	N/A	N/A

Allows schools to look at data trends from all around the globe
Does not rely on reception success





Launch status



FUNcube-1:

DNEPR launch from Yasny, Russia

November 2013

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FUNcube-2 on UKube-1:

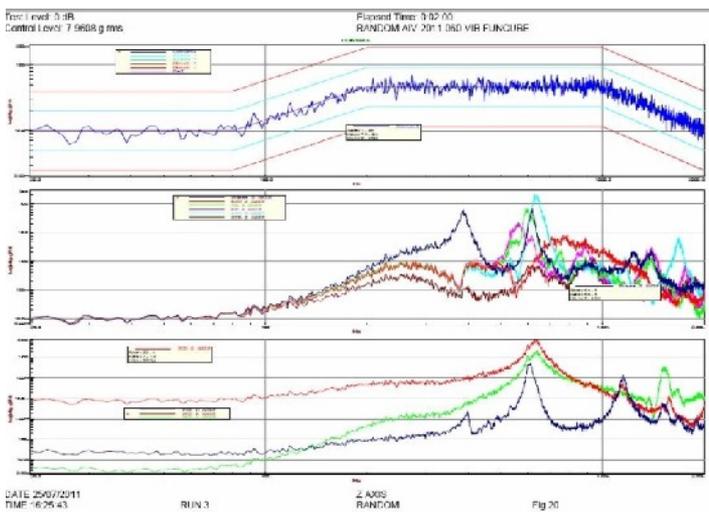
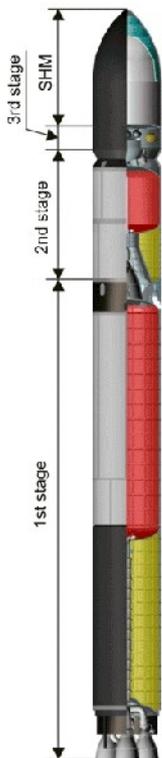
**Soyuz launch from Baikonur, Khazakstan,
Early 2014**





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DNEPR: converted SS-18 Intercontinental ballistic missile



Primary payload:
DubaiSat-2

19 secondary micro
and nanosat
payloads

Launches from an
underground silo

Approx altitude
600x685 km



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The FUNcube Project



- FUNcube-1 Engineering Model
“hands on” demo





Links



Time-lapse video van de assemblage in de cleanroom: <http://youtu.be/sEMoLOcGOOw>
Antenne Deployment test: <http://youtu.be/ddR-IIZHNbw>
Het laden van de ISIPOD met de drie CubeSats: <http://youtu.be/3xT3SDIFUOg>





Thank you for your attention



Any Questions?

Wouter Weggelaar: pa3weg@amsat.org

FUNcube websites: www.funcube.org.uk
and www.funcubedongle.com

AMSAT-UK website: www.uk.amsat.org

AMSAT-NL website: www.amsat-nl.nl

