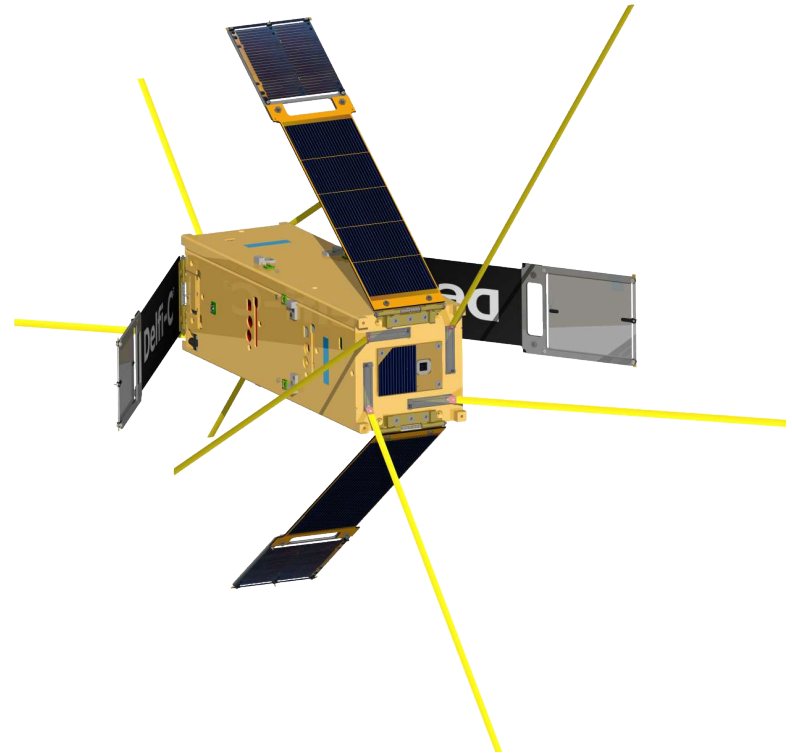
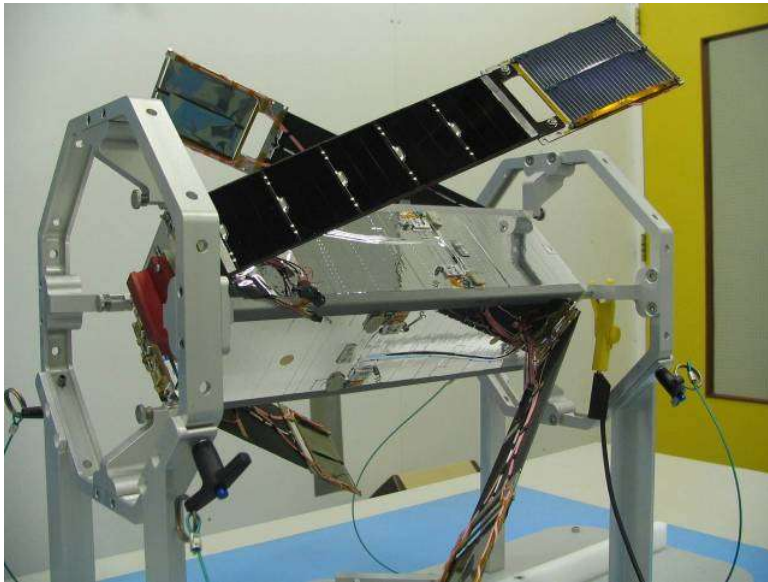


Delfi-C³

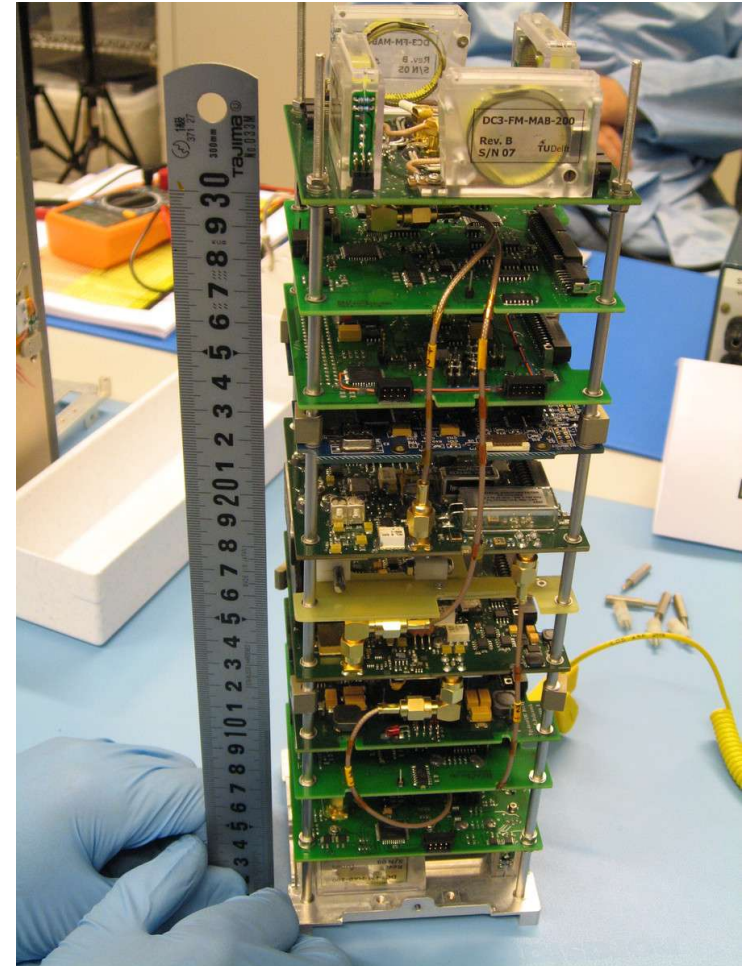


Update and Flight Results
Wouter Weggelaar PA3WEG



Delfi-C3 – quick facts

- 3U CubeSat
- NO Battery
- NO active attitude control
- 1200Bd BPSK downlink
- Linear transponder
- Payloads:
 - Thin Film Solar Cells
 - Autonomous Wireless Sun Sensor
- Start project November 2004
- Launched 28th of April 2008
- > 60 student team



Frequencies

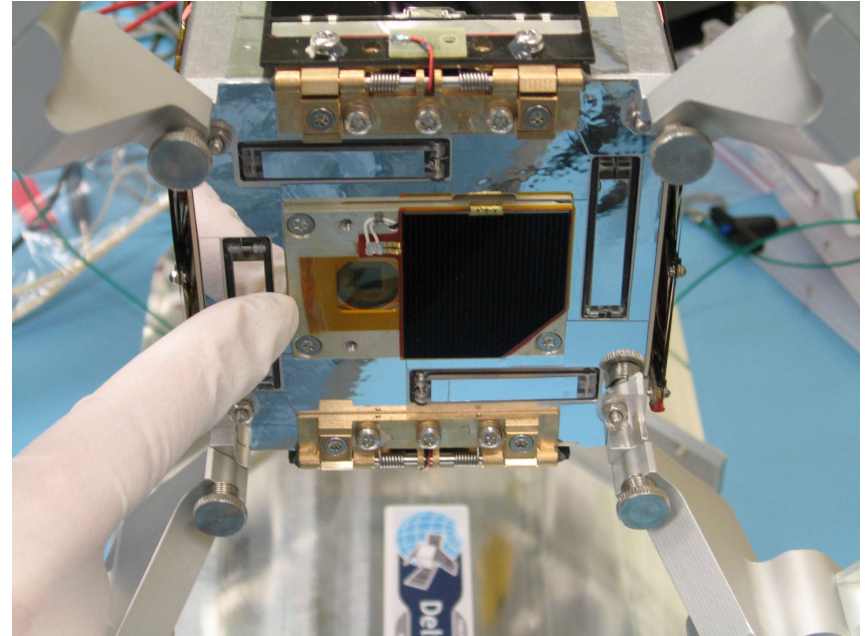
- **Primary** telemetry downlink
145.870MHz, 1200Bd BPSK AX.25 approx. 100mW
- **Backup** telemetry downlink
145.930MHz, 1200Bd BPSK AX.25 approx. 200mW
- **Transponder downlink:**
145.880-145.920MHz linear (inverting)
CW beacon 10mW at 145.870MHz (*Hi Hi de Delfi-C3 Delfi-C3*)
- **Transponder uplink:**
435.570-435.530MHz
40kHz passband, 400mW PEP
435.556MHz = 145.900MHz
- *Difference in downlink power caused by coupling capacitor having the wrong value of 10pF instead of 10nF*



TFSC



AWSS

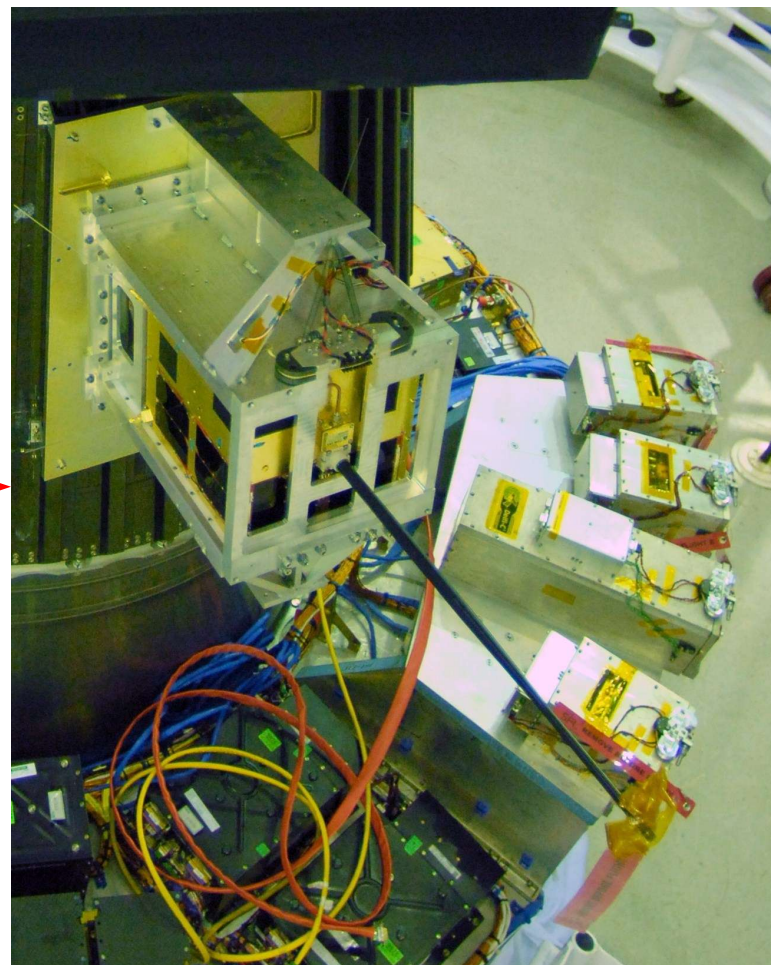


TFSC: Thin Film Solar Cell

AWSS: Autonomous Wireless Sun Sensor



PSLV-C9



- **Full Mission Success (!)**
- 454 days of operation as of today
- Radio Amateur Transponder degraded after a while, beyond normal useability
- All other subsystems fully operational
- Stability problems on I2C bus
- Problems with data analysis, hard to make conclusions on payload performance
- No critical problems or significant degradation to predict EOL



Radio amateur network

- Overwhelming response from the amateur radio community
- 328 amateurs (others on guest account)
- >3000 downloads of RASCAL
- Top submitters
 - JA0CAW
 - ZL2BX
 - PA0DLO
 - OH8MBN
 - PE1ITR

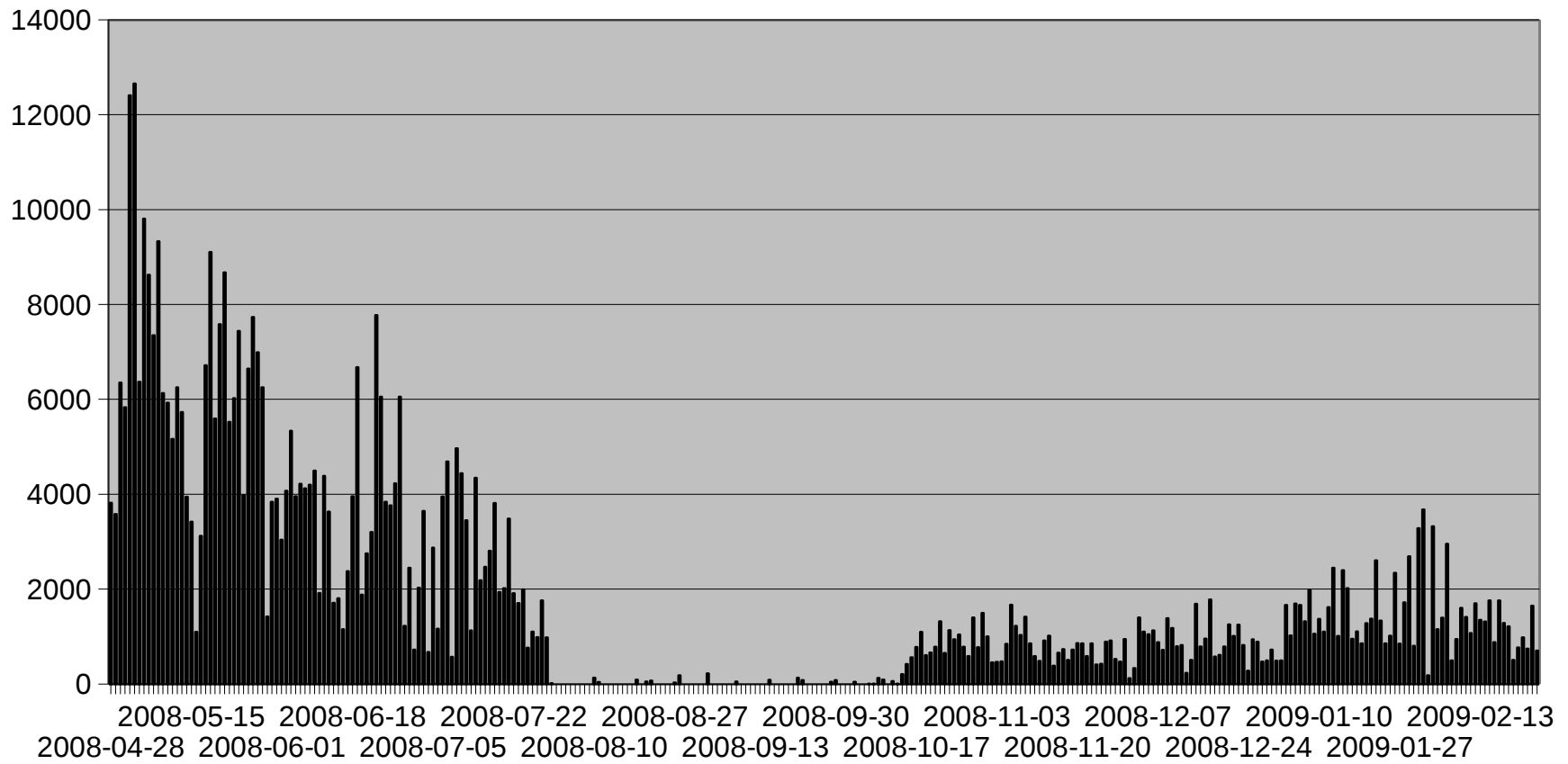


Ground segment



Total number of packets: 699777
(approx. 100.1 MB)

Packets per day



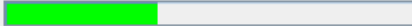
Improvements on RASCAL


- 1.1.0
 - Increased bandwidth of tracking loop
 - Minor bugfixes
- 1.1.1 (soon to be released)
 - Added AWSS presence indicators
 - Cleaned up the code
 - Reference diode information added




Delfi-C3 RASCAL

File Options

Audio level  SigmaTel Audio

Frequency  1664 Hz Sync

 TUDelft - DUTCH SPACE - TNO
Delfi-C³
WWW.DELFIC3.NL

Satellite			OBC		EPS		MeBo Z+	
Packet counter	36	packets	OBC temperature	27.885 deg. C	EMP op. mode	OBC	MEP Z+ op. mode	OBC
Bootcounter attempt	12	boots	System bus voltage	0.0 V	GaAs Z+ X+ current	0.0 mA	MDP Z+ op. mode	OBC
Bootcounter succes	12	boots	OBC current	2.765 mA	GaAs Z+ X- current	0.0 mA	MeBo Z+ current	2.765 mA
Operational mode	science		ComBo		GaAs Z- Y+ current	48.825 mA	MeBo Z-	
Last Rx Cmd RAP	RAP 1		CEP mode	OBC	GaAs Z- Y- current	273.42 mA	MEP Z- op. mode	OBC
			AWP mode	OBC			MDP Z- op. mode	OBC
			ComBo Current	5.9250 mA			MeBo Z- current	2.37 mA

RAP 1		RAP 2		ICB Z+		ICB Z-	
REP1 op. mode	OBC	REP2 op. mode	OBC	ADP 1 op. mode	OBM	ADP3 op. mode	OBC
RCP1 op. mode	OBC	RCP2 op. mode	OBM	ADP 2 op. mode	OBM	ADP4 op. mode	OBC
RBP1 op. mode	OBC	RBP2 op. mode	OBM	Solar Panel Z+ X+	undeployed	Solar Panel Z- Y+	deployed
RAP 1 temperature	30.945 deg. C	RAP 2 temperature	-68.1 deg. C	Solar Panel Z+ X-	undeployed	Solar Panel Z- Y-	deployed
RAP 1 Rx current	24.885 mA	RAP 2 Rx current	22.91 mA	Antenna Z+ X+	undeployed	Antenna Z- X+	deployed
RAP 1 Tx current	114.94 mA	RAP 2 Tx current	0.0 mA	Antenna Z+ X-	undeployed	Antenna Z- X-	undeployed
RAP 1 fwd. power	123.35 mW	RAP 2 fwd. power	0.0 mW	Antenna Z+ Y+	undeployed	Antenna Z- Y+	undeployed
RAP 1 refl. power	0.6194 mW	RAP 2 refl. power	0.0 mW	Antenna Z+ Y-	undeployed	Antenna Z- Y-	undeployed

Terminal

```

from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 01
from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 01
from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 01
from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 02
from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 02
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from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 02
from: DLFIC3 to: TLM a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 02

```

Status messages

Packets received: 7 Last packet received: 17/Apr/08 14:32:44

Primary repository			Secondary repository		
Disk:	7	Sent: 0	Disk:	7	Sent: 0

```

[14:32:11] Starting RASCAL
[14:32:12] Loaded primary repository data: 0 frames
[14:32:12] Loaded secondary repository data: 0 frames
[14:32:13] Sampling Primary Sound Capture Driver
[14:32:31] Sampling SigmaTel Audio
[14:32:44] Unable to connect to server 83.138.144.157

```


Delfi-C3 RASCAL



File Options

Audio level



Primary Sound Capture Driver

Frequency



Satellite

Packet counter	36	packets
Bootcounter attempt	12	boots
Bootcounter succes	12	boots
Operational mode	science	
Last Rx Cmd RAP	RAP 1	

OBC

OBC temperature	27.885	deg. C
System bus voltage	0.0	V
OBC current	2.765	mA

ComBo

CEP mode	OBC
AWP mode	OBC
ComBo Current	5.9250 mA

EPS

EMP op. mode	OBC	
GaAs Z+ X+ current	0.0	mA
GaAs Z+ X- current	0.0	mA
GaAs Z- Y+ current	48.825	mA
GaAs Z- Y- current	273.42	mA

MeBo Z+

MEP Z+ op. mode	OBC	
MDP Z+ op. mode	OBC	
MeBo Z+ current	2.765	mA

MeBo Z-

MEP Z- op. mode	OBC	
MDP Z- op. mode	OBC	
MeBo Z- current	2.37	mA

RAP 1

REP1 op. mode	OBC	
RCP1 op. mode	OBC	
RBP1 op. mode	OBC	
RAP 1 temperature	30.945	deg. C
RAP 1 Rx current	24.885	mA
RAP 1 Tx current	114.94	mA
RAP 1 fwd. power	123.35	mW
RAP 1 refl. power	0.6194	mW

RAP 2

REP2 op. mode	OBC	
RCP2 op. mode	OBC	
RBP2 op. mode	OBC	
RAP 2 temperature	-68.1	deg. C
RAP 2 Rx current	22.91	mA
RAP 2 Tx current	0.0	mA
RAP 2 fwd. power	0.0	mW
RAP 2 refl. power	0.0	mW

ICB Z+

ADP 1 op. mode	OBC
ADP 2 op. mode	OBC
Solar Panel Z+ X+	undeployed
Solar Panel Z+ X-	undeployed
Antenna Z+ X+	undeployed
Antenna Z+ X-	undeployed
Antenna Z+ Y+	undeployed
Antenna Z+ Y-	undeployed

ICB Z-

ADP3 op. mode	OBC
ADP4 op. mode	OBC
Solar Panel Z- Y+	deployed
Solar Panel Z- Y-	deployed
Antenna Z- X+	deployed
Antenna Z- X-	undeployed
Antenna Z- Y+	undeployed
Antenna Z- Y-	undeployed

Terminal

```

from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 01
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 01
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 01
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 02
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```

Status messages

Packets received: 7 Last packet received: 17/Apr/08 14:32:44

Primary repository			Secondary repository		
Disk:	7	Sent: 0	Disk:	7	Sent: 0

```

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[14:32:13] Sampling Primary Sound Capture Driver
[14:32:31] Sampling SigmaTel Audio
[14:32:44] Unable to connect to server 83.138.144.157

```

Issues

- TX dropouts due to databus issues
- Resets due to databus issues
- EPS issues in beginning of mission
- All non critical
- Transponder issues



Timeline

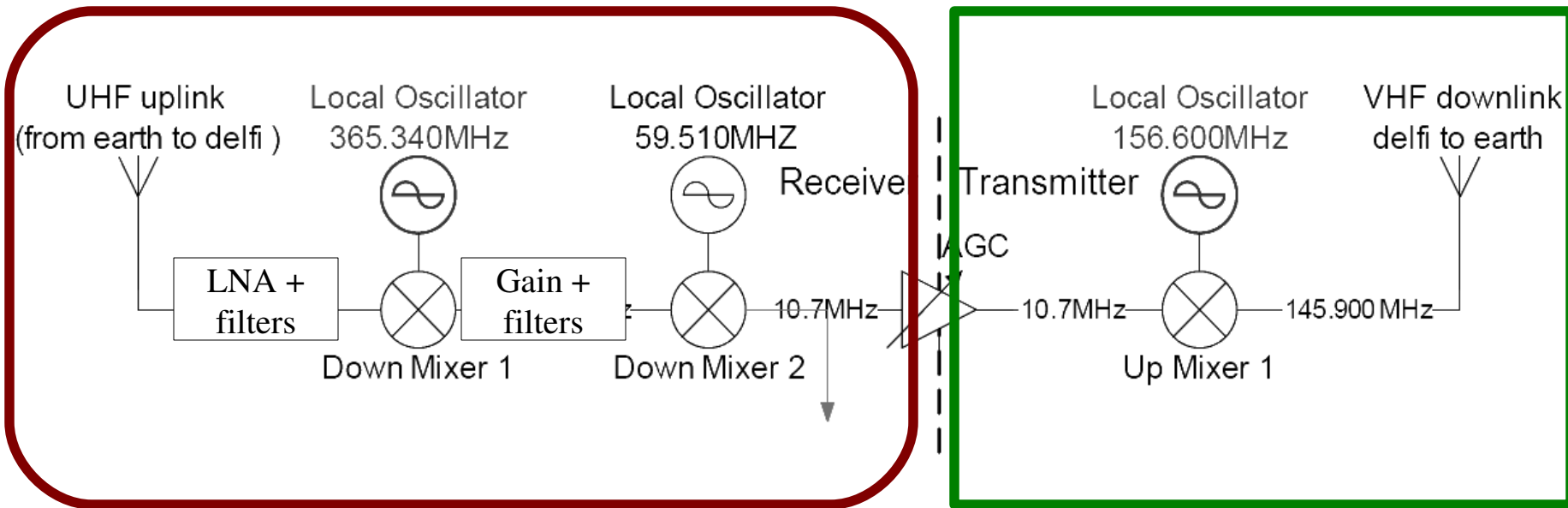
- 28 April 2008, 03:53 UTC Launch
 - 06:39:08 UTC First received by Rick Mann (US)
 - 11:49:51 UTC First reception in Delft
- 30 April 2008, 10:50:42 UTC Delfi-C³ CDHS set to Read-Only mode
- 15 May 2008 Designated DO-64
- 29 July 2008, 10:00 UTC Switch from Science Mode to Transponder
- End of September 2008 First signs of transponder degradation
- 14 October 2008, 11:00 UTC Switch to Basic Mode to investigate
- 29 January 2009, 09:33:17 UTC Switch to Science Mode



Transponder issues

- Diagnostic test results:
 - Local oscillator and uplink frequency OK for both RHCP and LHCP polarization
 - Over 400 W uplink power required to get a marginal downlink
 - Not useful for radio amateurs
 - Transponder IF at full gain
 - Corresponding command receiver also not working
- Conclusion:
 - Somewhere in the chain between antennae and power splitter there is a short or an open connection
 - Can be anything: Bad cable or solder joint, failed component, tin whisker, etc.
 - No further actions possible from ground
 - Unfortunately no AO-16 alike loopback due to time constraints





Telemetry and command RX paths not shown



Performance of passive attitude control

Modelled performance of design:

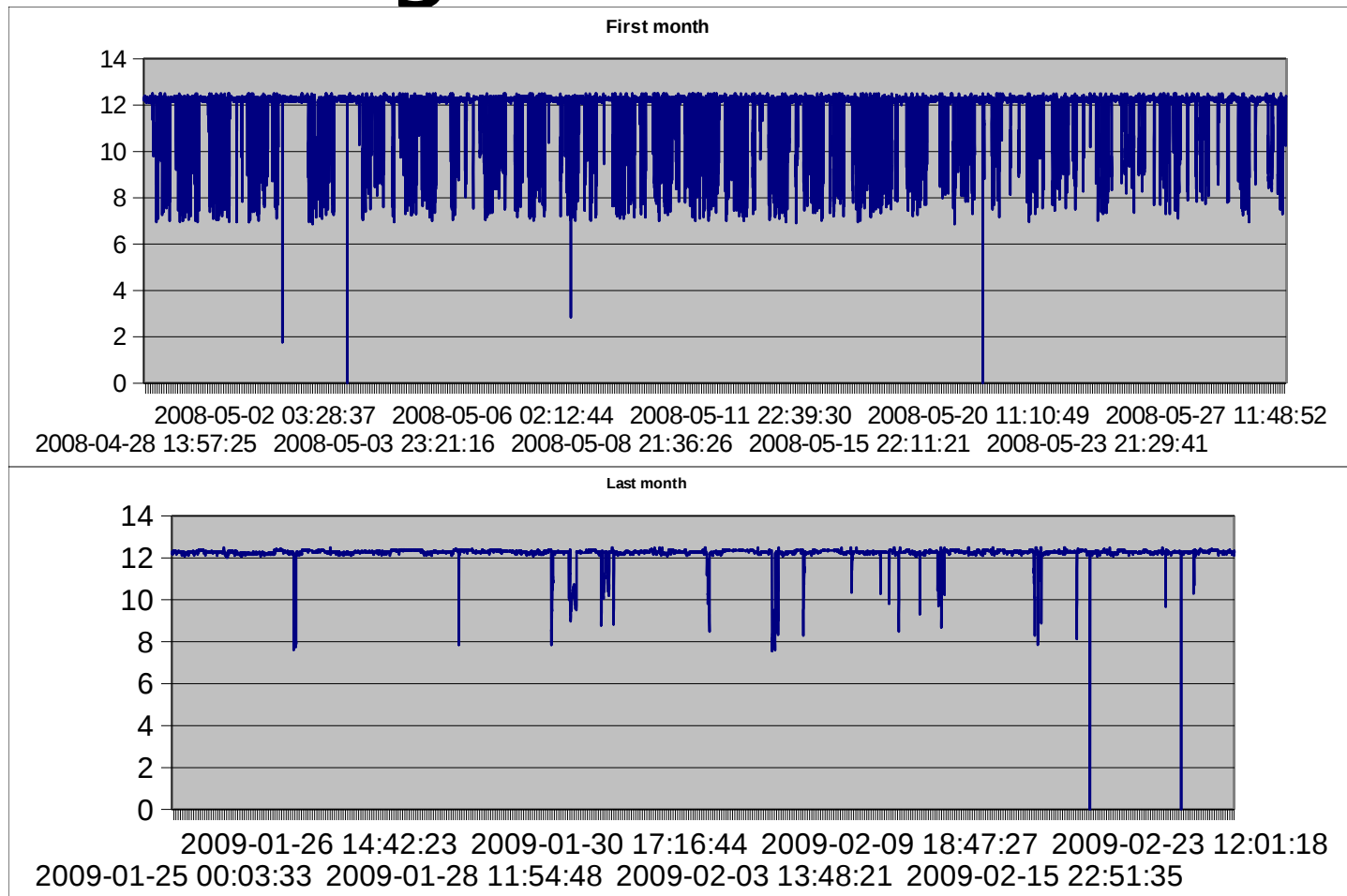
Rotation with passive magnetic (hysteresis) material within a few orbits to 0.2 - 2 °/s from a max. of 10 °/s after ejection from X-POD

Actual:

In the order of weeks before attitude gets from 9°/s to about 1°/s

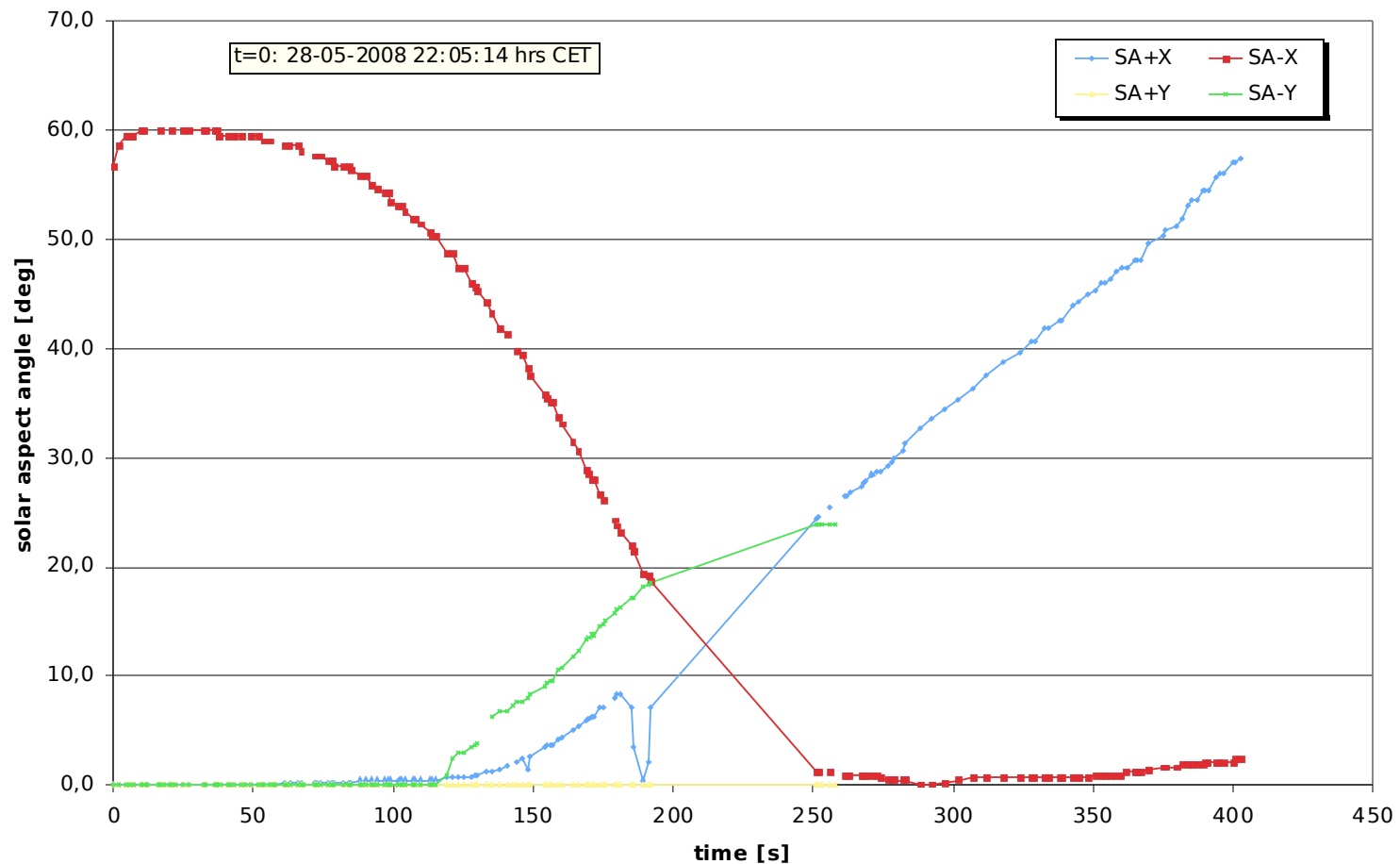


Bus voltage



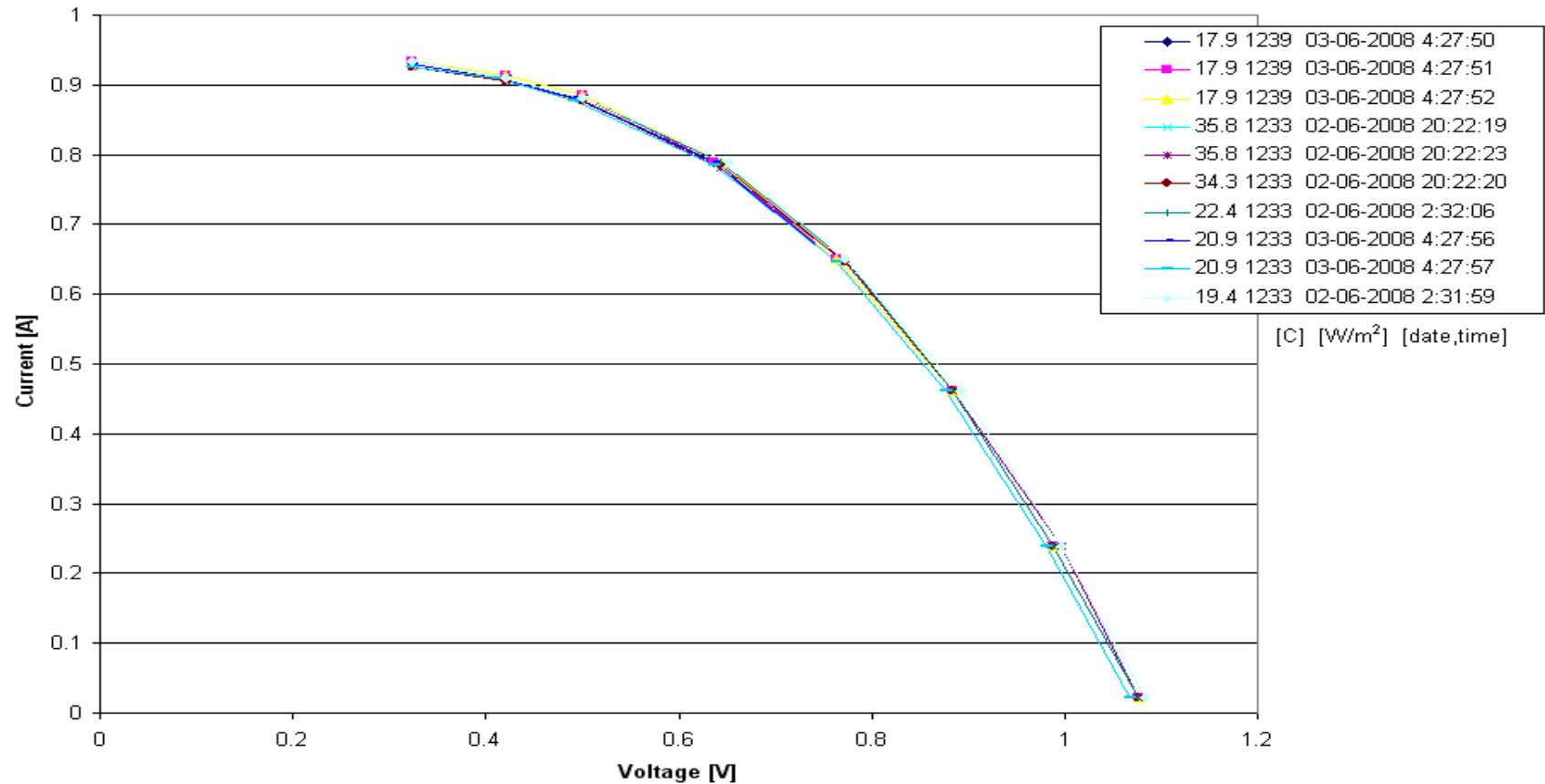
Antenna shading

reference diode output



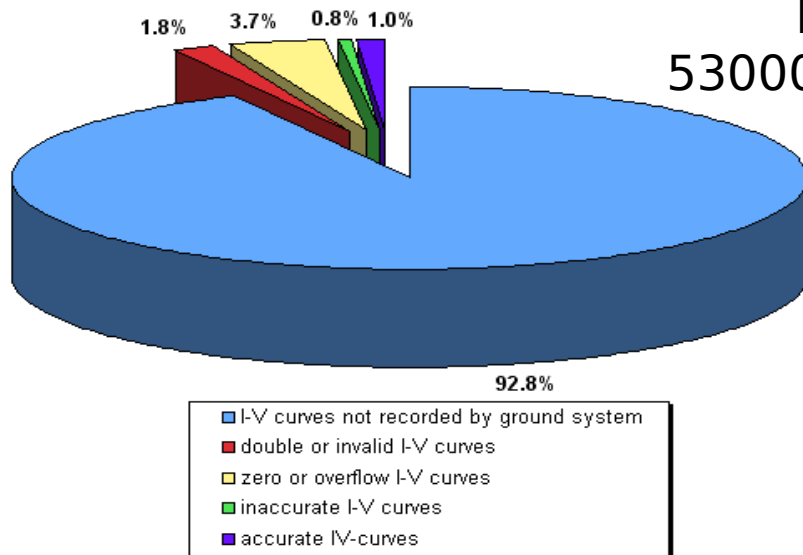
TFSC payload data

I-V Curve Panel -X



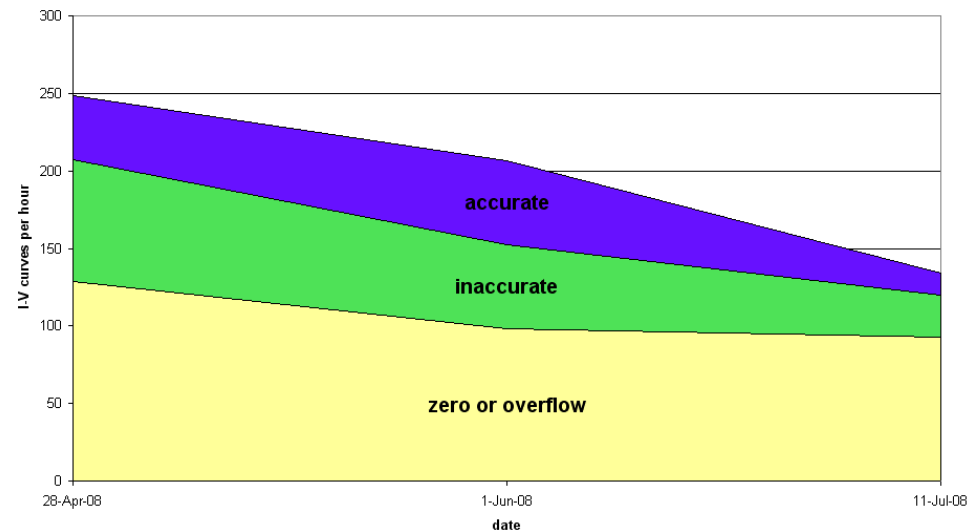
TFSC curves harvested

TFSC I-V curves harvested



In 3 months Science Mode more than 53000 accurate I-V curves have been harvested

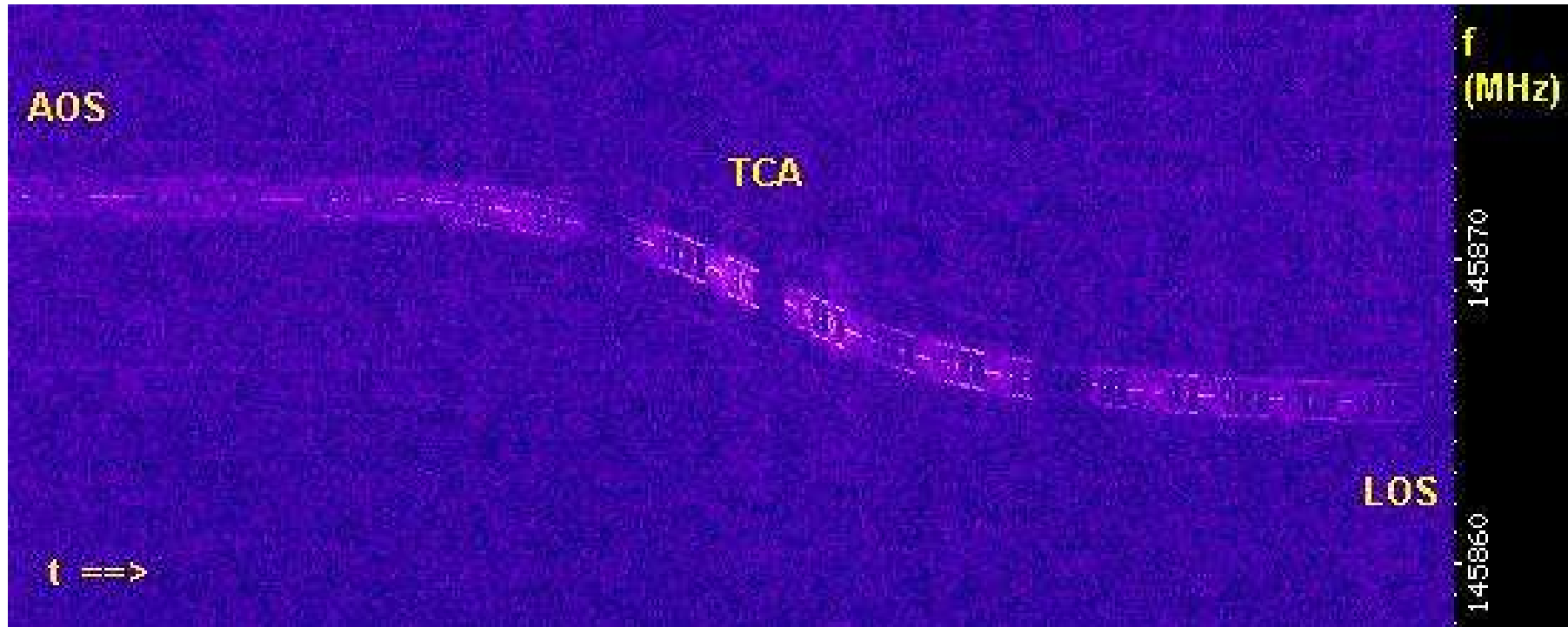
I-V curves harvested in time



WebSDR reception(1)

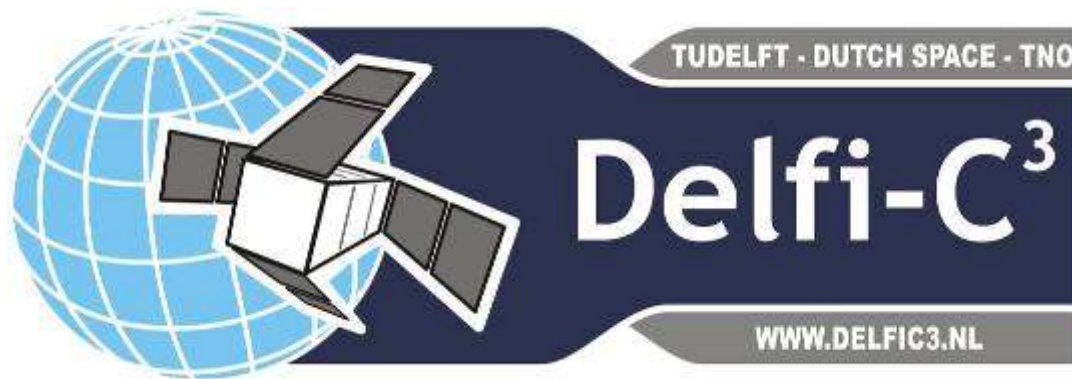


WebSDR reception(2)



<http://websdr.pa3weg.nl>





www.delfic3.nl
pa3weg@amsat.org

