



Standardizing CubeSat Electrical and RF interfaces

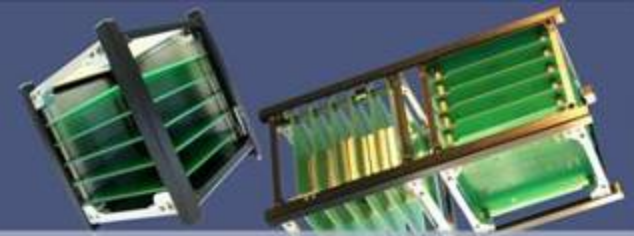
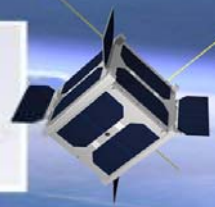
Wouter Jan Ubbels

PE4WJ

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CubeSat Structures



Nanosatellite TT&C Systems



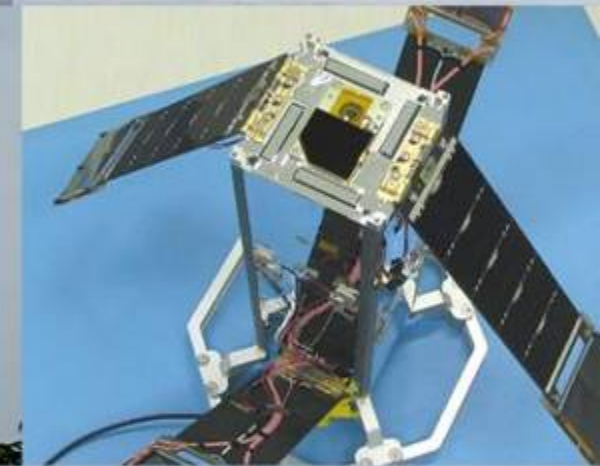
AOCS Sensors and Systems



Ground Stations



Launch Services



Missions and Platforms



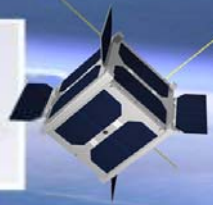
Separation Systems and PODs



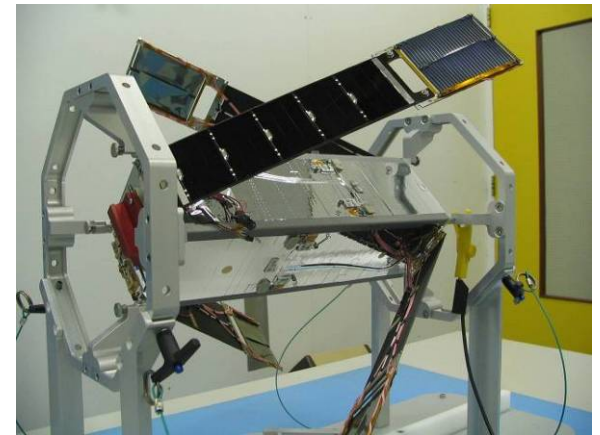
Research and Development



Education and Outreach

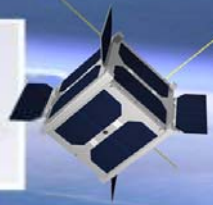


- Launched April 28th 2008 (PSLV)
- 3U CubeSat, no battery
- Nominal science mode ops
- 100mW 1200Bd BPSK VHF downlink, rx on handheld
- Over 80MB (!) of data captured so far, worldwide amateur radio network (>320 hams involved)



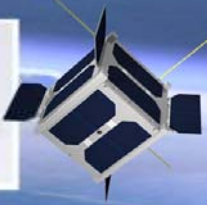


CubeSat Interfaces

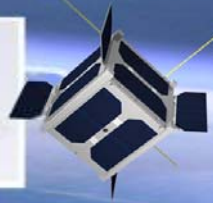


- Mechanical interfaces defined by CubeSat spec
- Electrical & RF interfaces not defined... need to do so?
- RF link to groundstation can also be regarded as an interface!

This presentation is meant to foster discussion



- Main reason for the huge CubeSat success
- Standardization fosters creativity
 - Deployables, optimal use of volume
- *Somebody out there will violate it...*
- Start somewhere
- Limits choice / brings focus



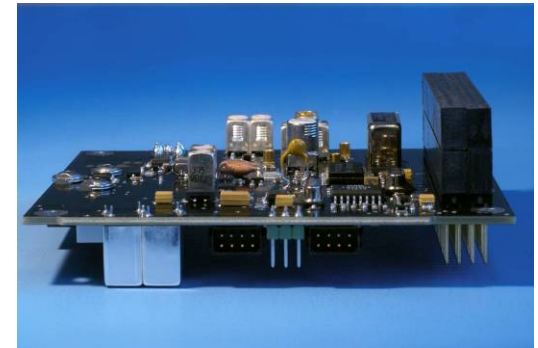
- Emerging and starting to get heritage
- Add satellite to basket (e.g. ISIS
www.cubesatshop.com, Clyde space webshop)



Pumpkin FM430, courtesy of Pumpkin inc.

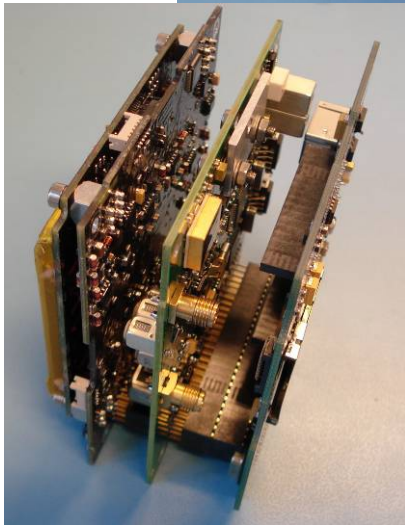
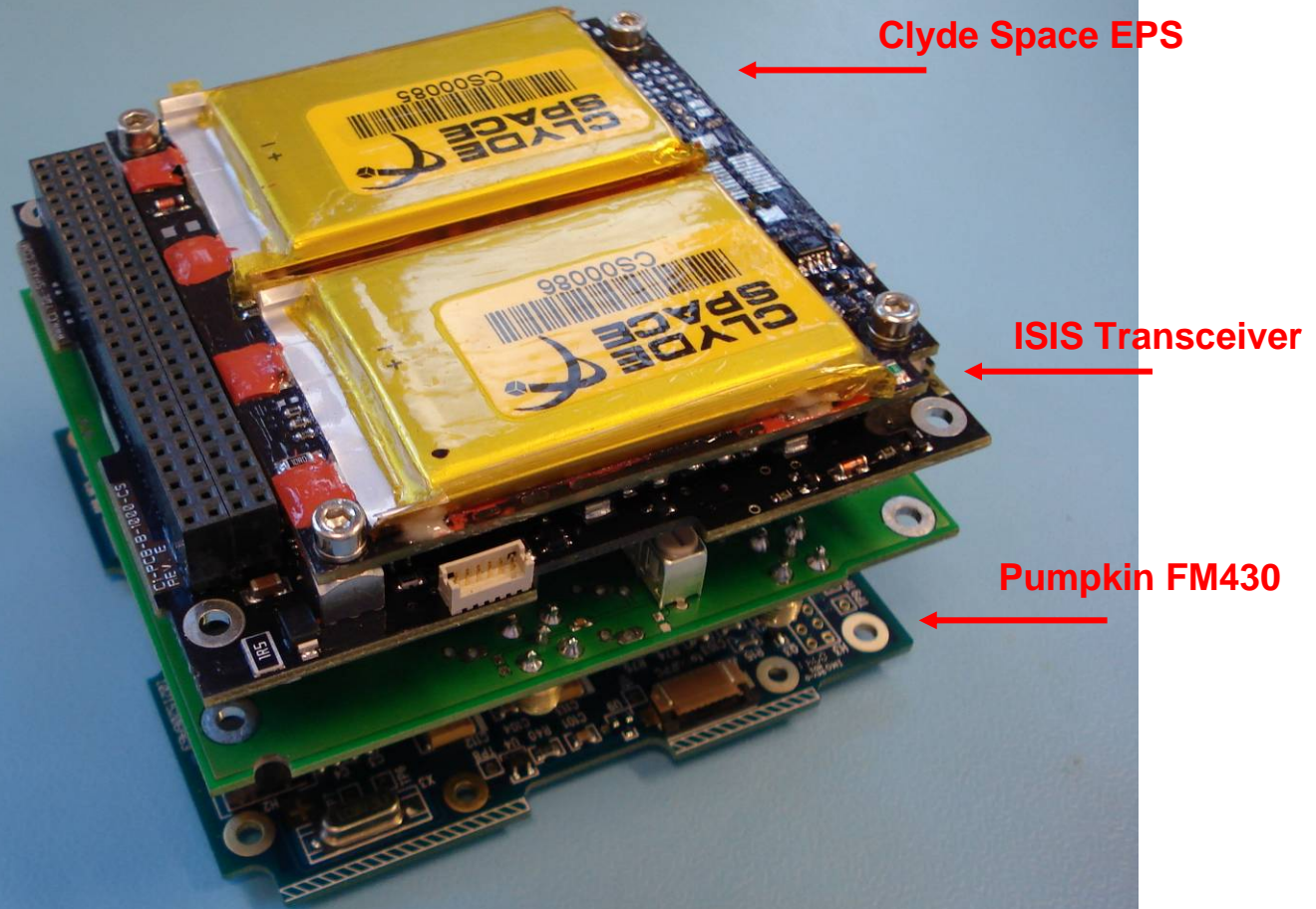
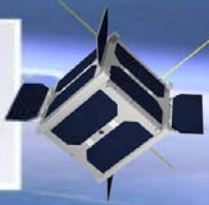


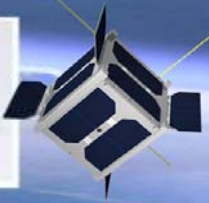
Clyde Space EPS, courtesy of Clyde Space Ltd.



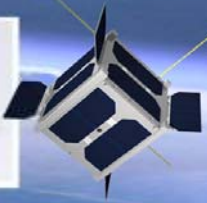
ISIS Transceiver, ISIS – Innovative Solutions In Space BV

Compatibility



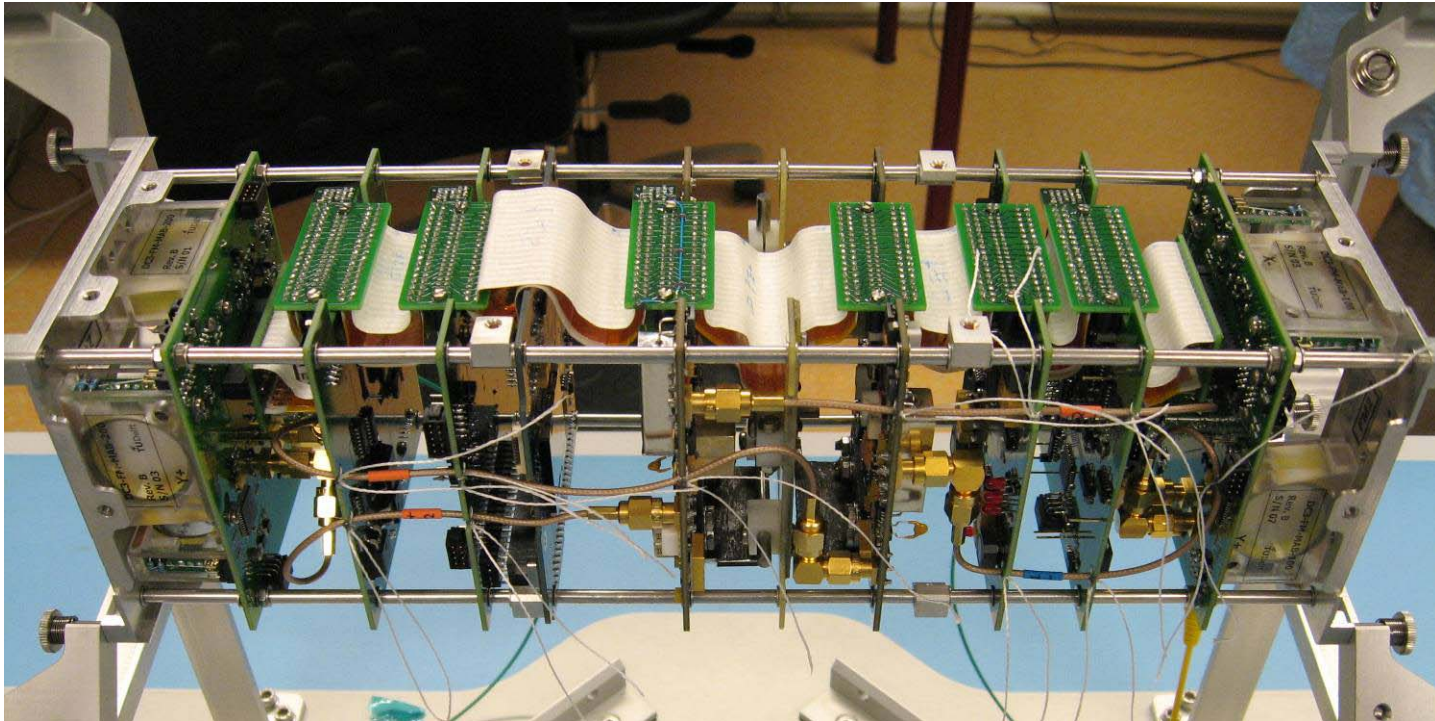
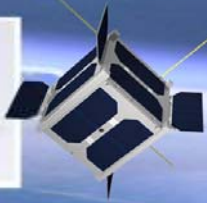


- Bus subsystem interfaces
- Payload interfaces
- Power bus
 - 3V3, 5V
- Data bus
 - I2C
 - CAN?
- External electrical interfaces (charging, RBF/ABF, checkout)



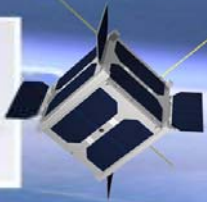
- Reliable, proven
- High current handling capability
- Flexible, spare pins
- Limits board stacking possibilities
- Mating and demating... → tools available
- Mass penalty, board space
- Not all 104 pins necessary, usually local microcontroller on every board
- Electrical interface → drives mechanical interface

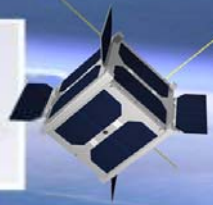
Delfi-C3 solution



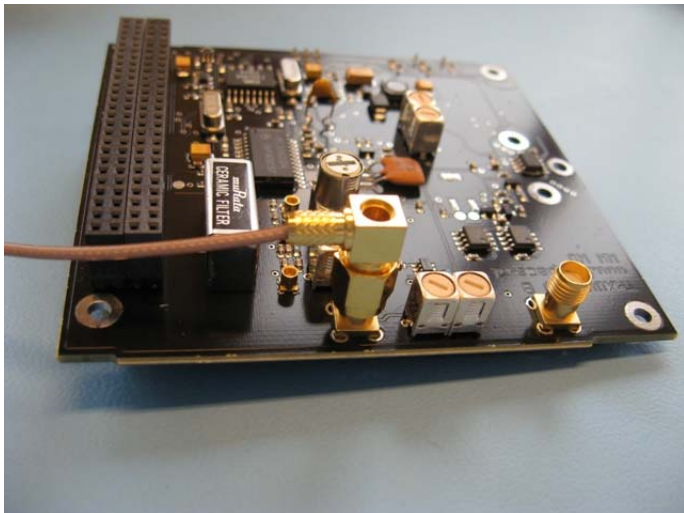


Flex-Rigid bus

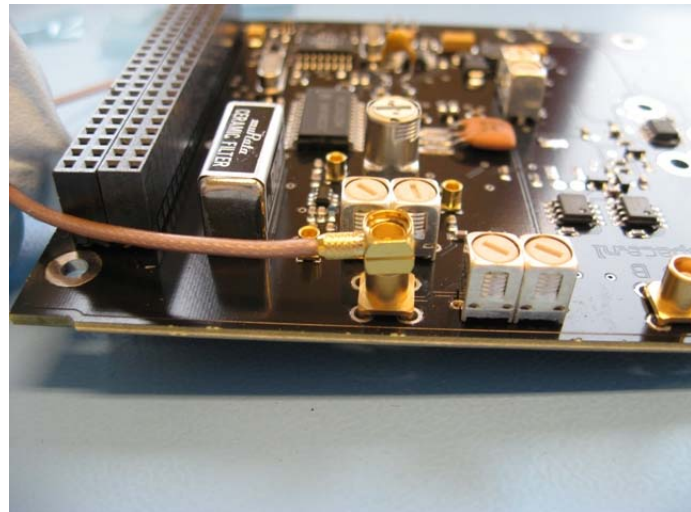




- Coaxial connectors
- Cable diameter / bend radius
- Click vs torque?
- (MCX, SMCX, SSMCX or even smaller)
- Small distances, losses no issue



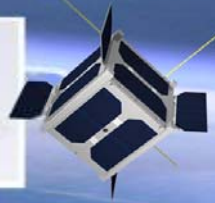
SMA



MCX



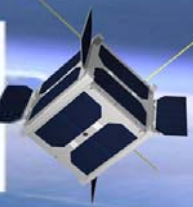
RF interfaces - external



- Modulation schemes: AFSK-over-FM far from optimal - requires about 15dB more signal/noise than BPSK (that's more than 30 times the power!)
- AX.25 generally is ok, but do **not** use frames of multiple seconds long
- GENSO compatibility
- Beacons: provide a LONG / SEMI-CONTINUOUS beacon downlink if your power budget allows you to do so, short beacons with large intervals are hard to detect
- Availability of soundcard software removes the need for "legacy" modulations / protocols → software defined radio is the way to go!



Software Defined Radio




Delfi-C3 RASCAL

File Options

Audio level: SB Audigy Audio [B400]

Frequency: 900 1100 1300 1500 1700 1900 2100 2300
1654 Hz Sync



Satellite		OBC		EPS		MeBo Z+	
Packet counter	46 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	3.16 mA	GaAs Z+ X- current	0.0 mA	MeBo Z+ current	2.765 mA
Operational mode	science	ComBo		GaAs Z- Y+ current	44.919 mA	MeBo Z-	
Last Rx Cmd RAP	RAP 1	CEP mode	OBC	GaAs Z- Y- current	246.07 mA	MEP Z- op. mode	OBC
		AWP mode	OBC			MDP Z- op. mode	OBC
		ComBo Current	5.9250 mA			MeBo Z- current	1.975 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	29.454 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	113.76 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 2
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 2
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 2
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 2
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 2
from: DLFIC3 to: TLM  a8 98 9b 40 40 40 00 88 98 8c 92 86 66 01 03 f0 0c 00 2

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Status messages

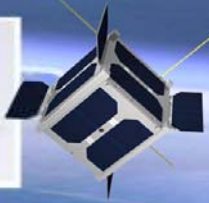
Packets received: 6 Last packet received: 01/Jan/09 15:49:37

Primary repository		Secondary repository	
Disk: 69	Sent: 0	Disk: 69	Sent: 0

```

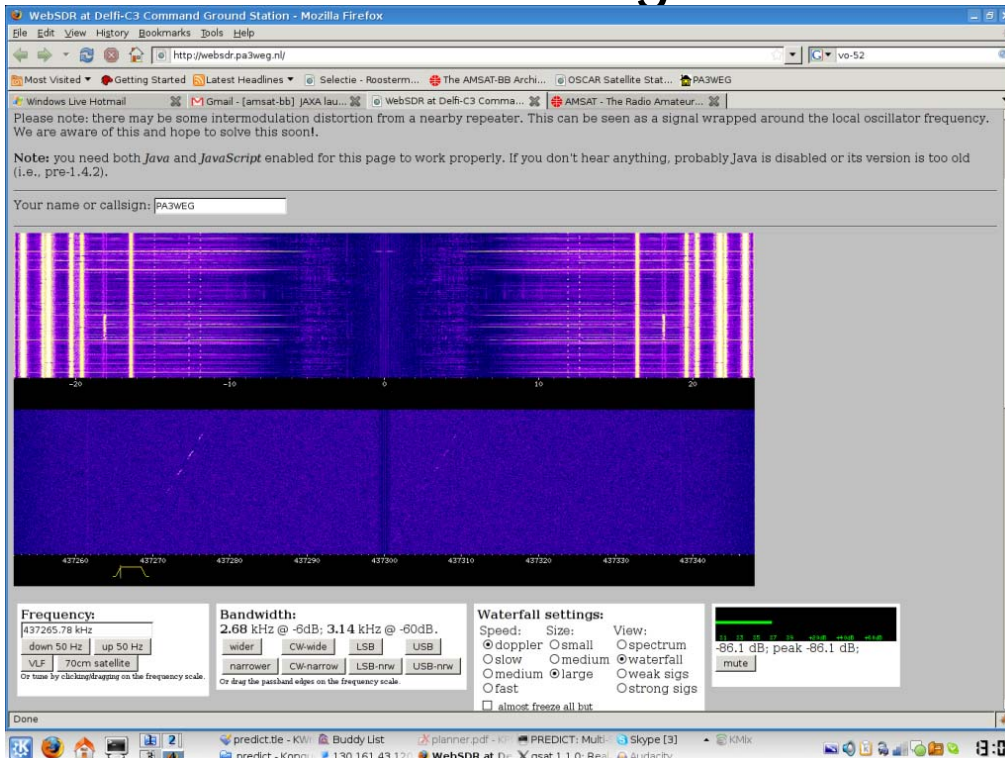
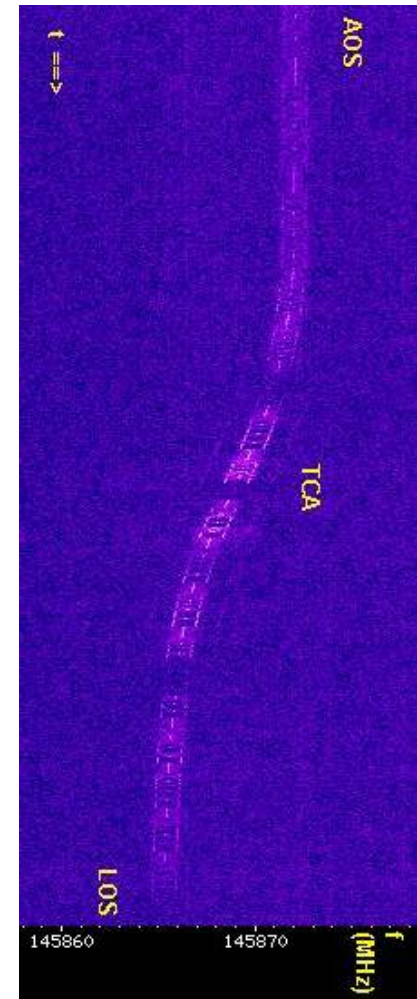
[15:49:26] Loaded program settings
[15:49:27] Loaded primary repository data: 64 frames
[15:49:27] Loaded secondary repository data: 64 frames
[15:49:28] Sampling Primair stuurprogramma voor opnemen van ge
luid
[15:49:29] Sampling SB Audigy Audio [B400]

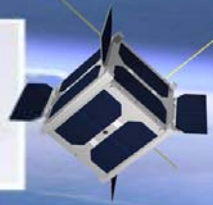
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WebSDR

- Software defined groundstation
- “Crosstaggering”
- www.websdr.org

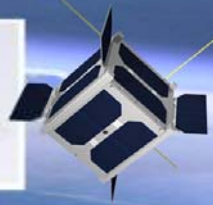





- Requirements on CubeSats will become more strict
 - Emerging commercial / scientific missions
 - Launch service providers
- Larger CubeSats or derivatives (4U, 5U, 6-pack)
- GENSO



Contact information



ISIS - Innovative Solutions In Space BV



Rotterdamseweg 380

2629 HG, Delft

The Netherlands

+31 15 256 9018

info@isispace.nl

www.cubesatshop.com

www.isispace.nl