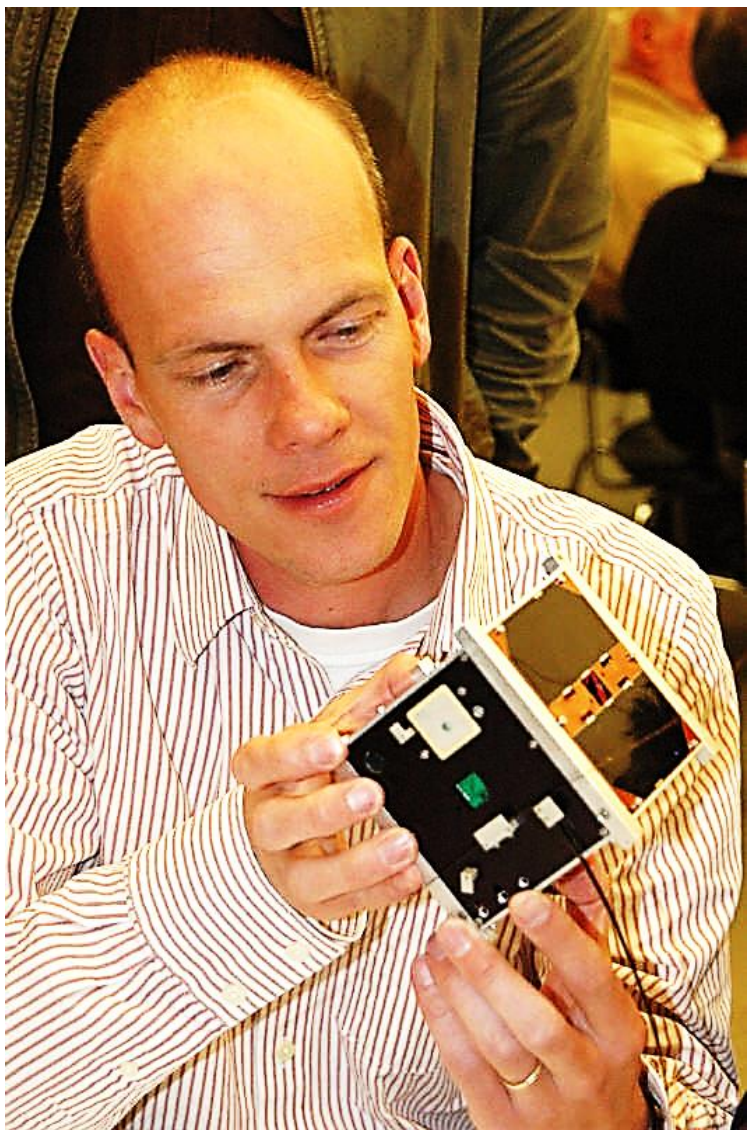




Zendamateurs en CubeSat's

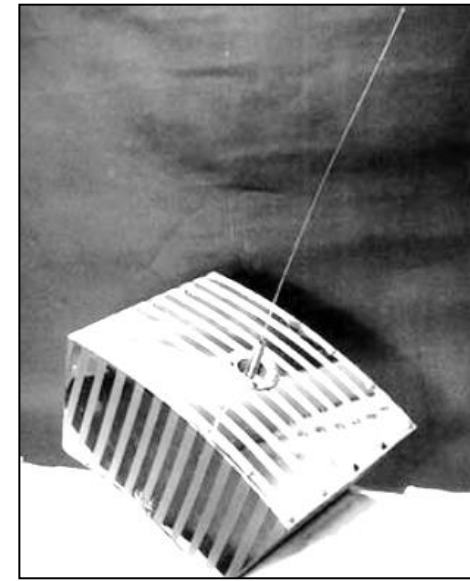
Henk Hamoen PA3GUO

Agenda

- **Amateur satellieten**
- **Wat is een Cubesat?**
- **Satellietbanen**
- **Doppler**
- **Software & Apparatuur**
- **Demonstratie**
- **Zendamateurs en cubesat's**
- **Vragen**

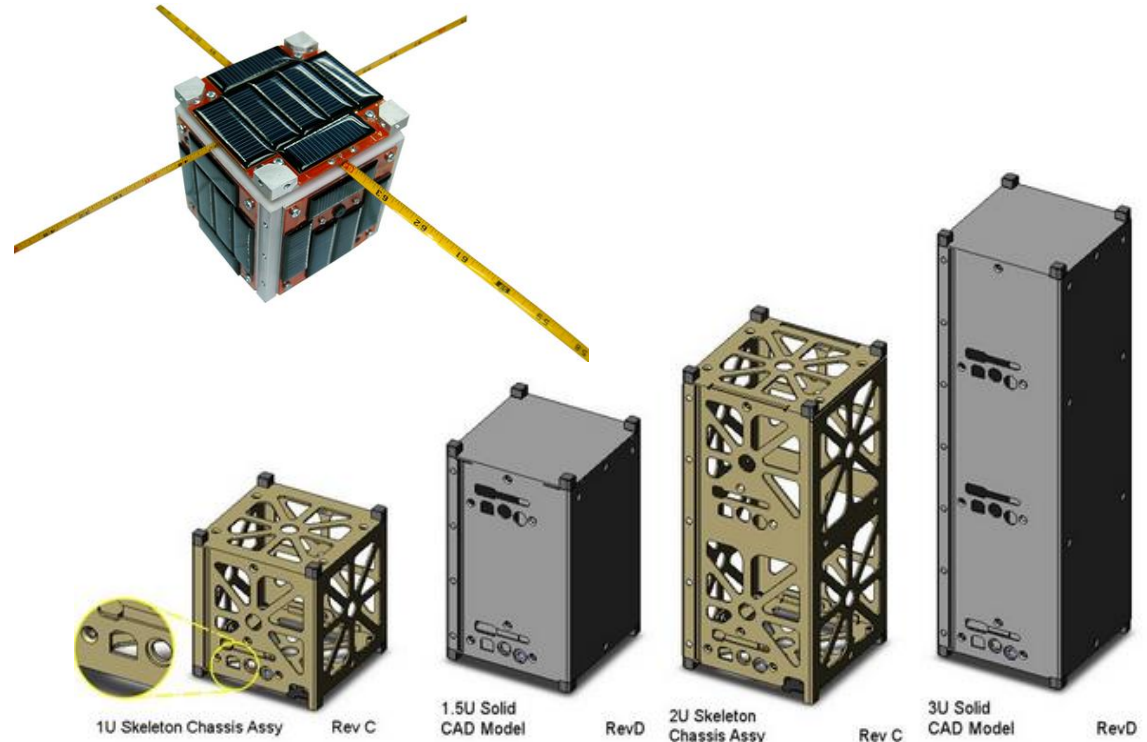
Amateur satellieten

- Eerste: OSCAR-1 - 1961
- Grootste: AO-40: 450kg - HEO - Ariane 5
- Oudst werkende: AO-7 - 1974
- Duur – 2nd payload
- FunCubes: kleiner, goedkoper
- NL: Delfi-C3, Delfin3Xt, AO-73 (FunCube-1) !

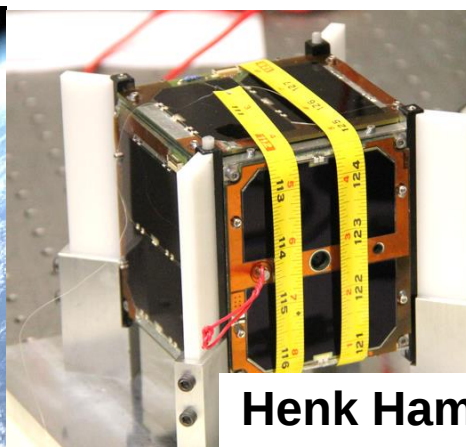
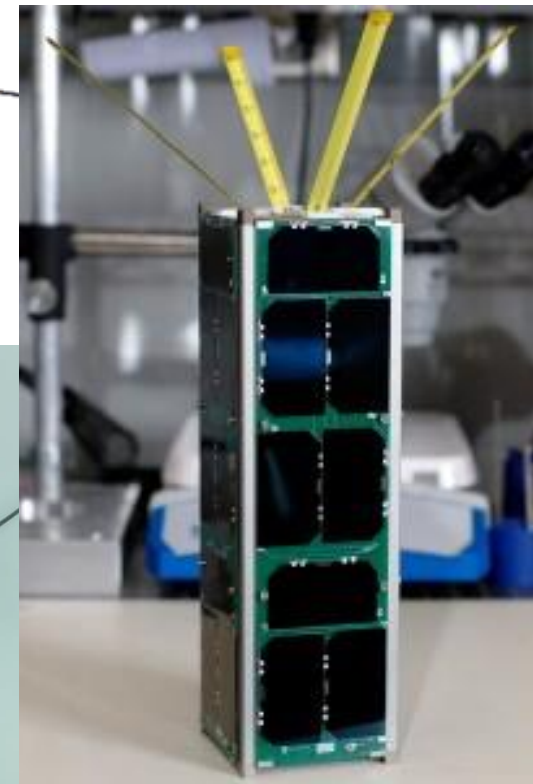
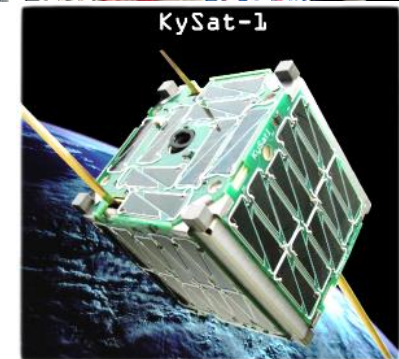
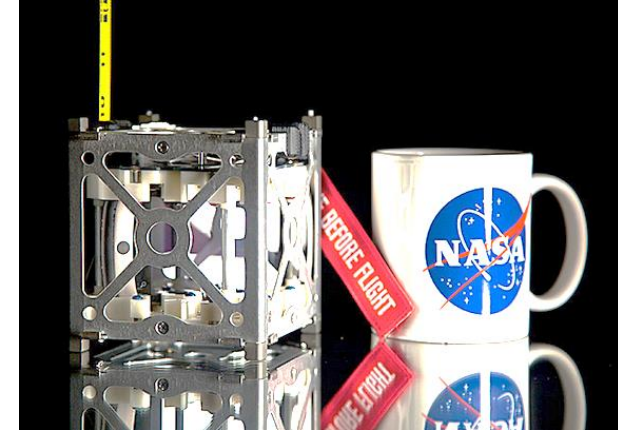
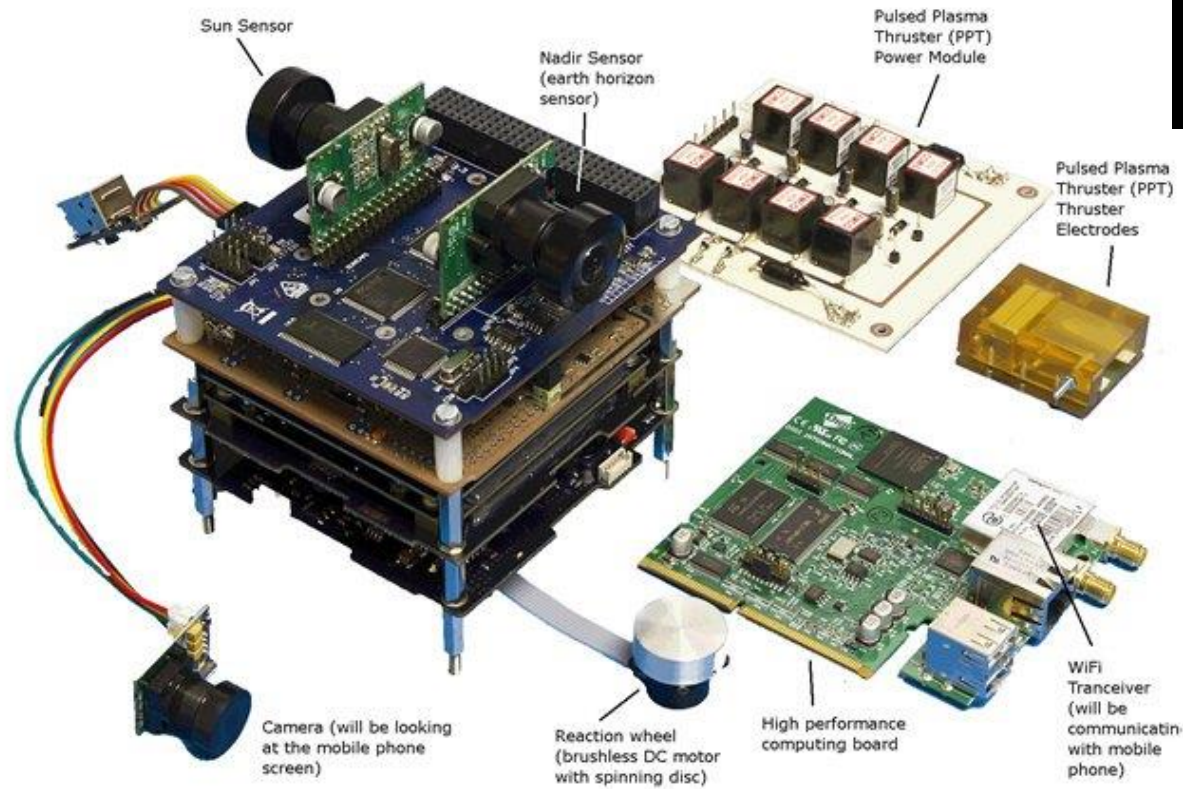


Wat is een Cubesat ?

- Stanford University
- Prof. Twiggs - 1998
- <1.33 kg
- 10 x 10 x 10 cm units
- 1U, 2U, 3U, 6U, ...
- Launch Mechanism: Poly-PicoSatellite Orbital Deployer (P-POD)
- First launch: 30 Juni 2003
- Support Hands-on University-level Space Education
- 40+ launched, 300+ in development



Cubesat Voorbeelden



Henk Hamoen PA3GUO

Cubesat = Business

- Magazines
- NASA
- Internet



Big News about Small Satellites: Cubesats Rule!

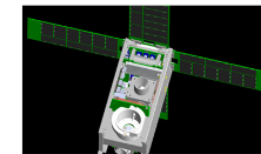
by Leonard David, Senior Space Writer | September 28, 2005 06:59am ET



home about ISIS capat



CUBESAT ELaNa VI LAUNCH ON L-36 Mission



CubeSat Deployment

Four CubeSat projects were selected for the ELaNa VI mission. The NRO funded the Naval Postgraduate School to develop IPSOL, which can attach up to eight P-PODS to a single adaptor. This allows up to 24 single-unit (1U) CubeSats to be launched at one time. The CubeSats on OUTSAT are sponsored by either the NRO Mission Support Directorate or NASA's Launch Services Program. The P-POD was designed and manufactured by the California Polytechnic State University (Cal Poly) to integrate CubeSats onto the launch vehicle. This P-POD design has flown previously on Defense Department, NASA, and commercial launches. For NASA, Cal Poly integrates the CubeSats with the P-POD and provides the entire assembly to the launch vehicle integrator.

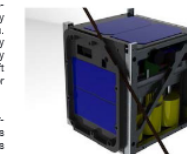
Mission Overview

NASA is partnering with the National Reconnaissance Office (NRO) to launch small research satellites, or CubeSats, for four universities on the third installment of the Educational Launch of Nanosatellite (ELaNa) mission. The Launch Services Program at NASA's Kennedy Space Center in Florida manages the ELaNa missions. The CubeSats will be flown as part of the Operationally Unique Technologies Satellite, or OUTSAT, an auxiliary payload aboard the Atlas V 401 rocket scheduled to lift off Aug. 2. Three Poly Picosatellite Orbital Deployers, or P-PODs, will carry and deploy the ELaNa VI CubeSats.

The ELaNa CubeSat Launch Initiative enables university students to obtain hands-on experience and gives private industry access to a low-cost vehicle. Since its inception in 2010, the program has selected more than 80 CubeSats from private and public institutions around the U.S., including six that were launched successfully on the ELaNa III mission. The ELaNa VI CubeSats were chosen from a prioritized list of universities that responded to two public announcements to NASA's CubeSat Launch Initiative in 2011. NASA will announce another call for proposals in mid-August. It will close in November.

Basic CubeSat Facts:

- Built to standard dimensions of 1 unit, or 1U, which is equal to 10x10x11 cm
- Can be 1U, 2U, 3U, or 6U in size
- Weigh less than 1 1/3 kg (3 lbs) per U—6U may be up to 13-14 kg
- Deployed from standard Poly-Picosatellite Orbital Deployer (P-POD)



CP6 was developed and built by the California Polytechnic State University in San Luis Obispo. Its primary purpose is to test a deployable spacecraft de-orbiting a thin-film mechanism consisting of a miniature solar sail. After the sail deploys, observations will be made from the ground to detect any altitude or velocity degradation of the spacecraft.



NASAfacts

Satellietbanen

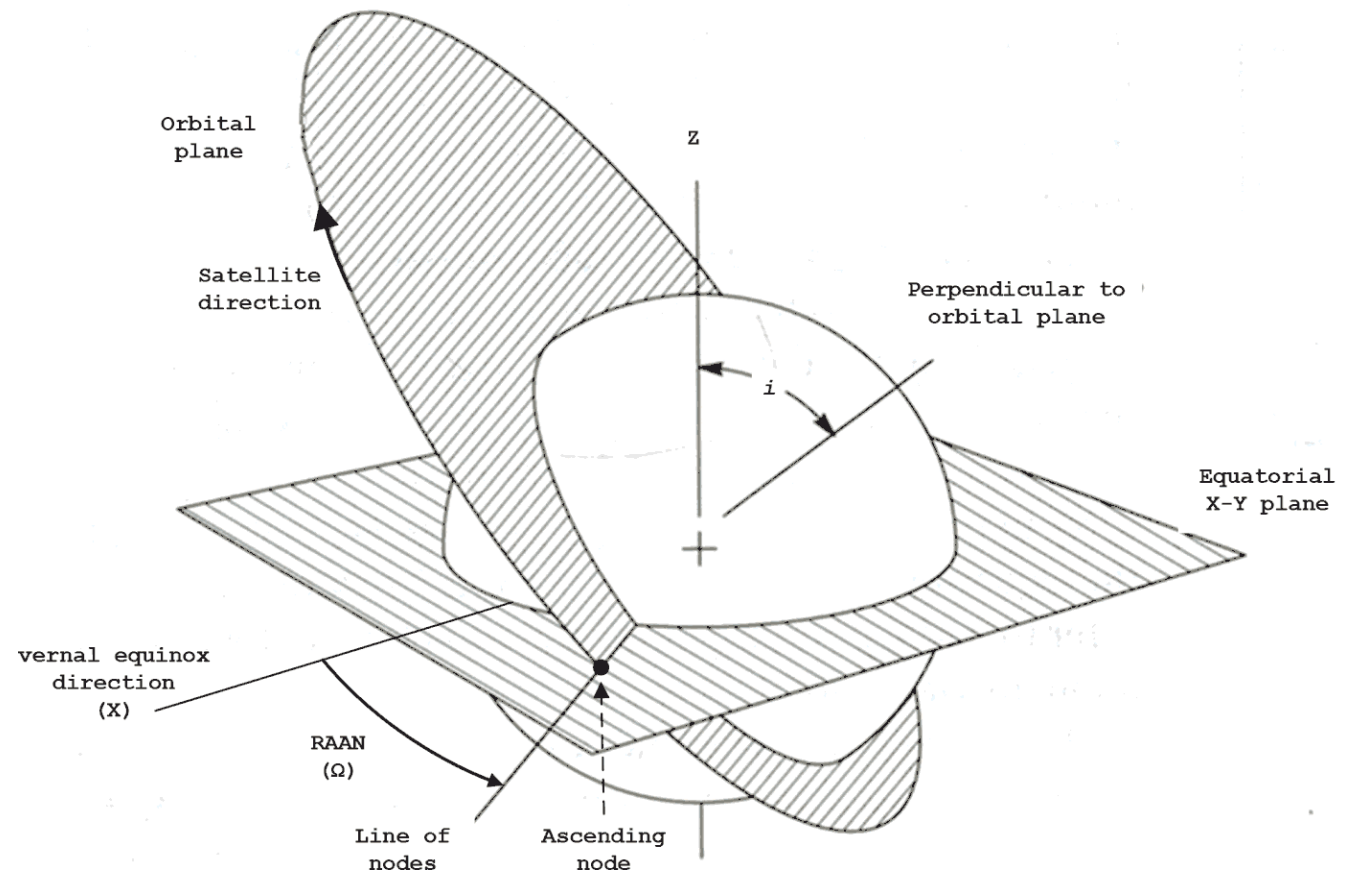
LEO = Low Earth Orbit
HEO = High Earth Orbit

Ellipse-vormig

- Voor LEO-satellieten bijna rond (Low Earth Orbit)

6 baan-parameters

- Soort baan:
 - Inclination
 - Mean Motion
 - Eccentricity
- Positie baan:
 - RAAN
 - Argument of perigee
- Positie satelliet:
 - Mean Anomaly



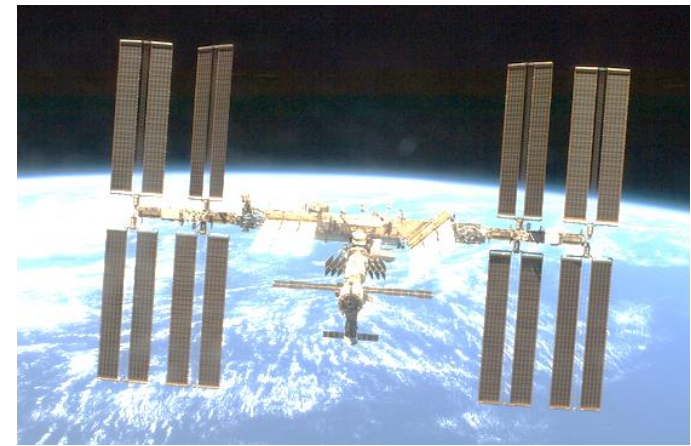
Satellietbanen

■ Low-Earth-Orbit (LEO) banen

- Satelliet komt ongeveer elke 1,5 uur over
- Passage maximaal rond 15 minuten
- Ongeveer 3 tot vier passages, dan weer tijdje 'niet-zichtbaar'
- Noord → zuid of Zuid → noord

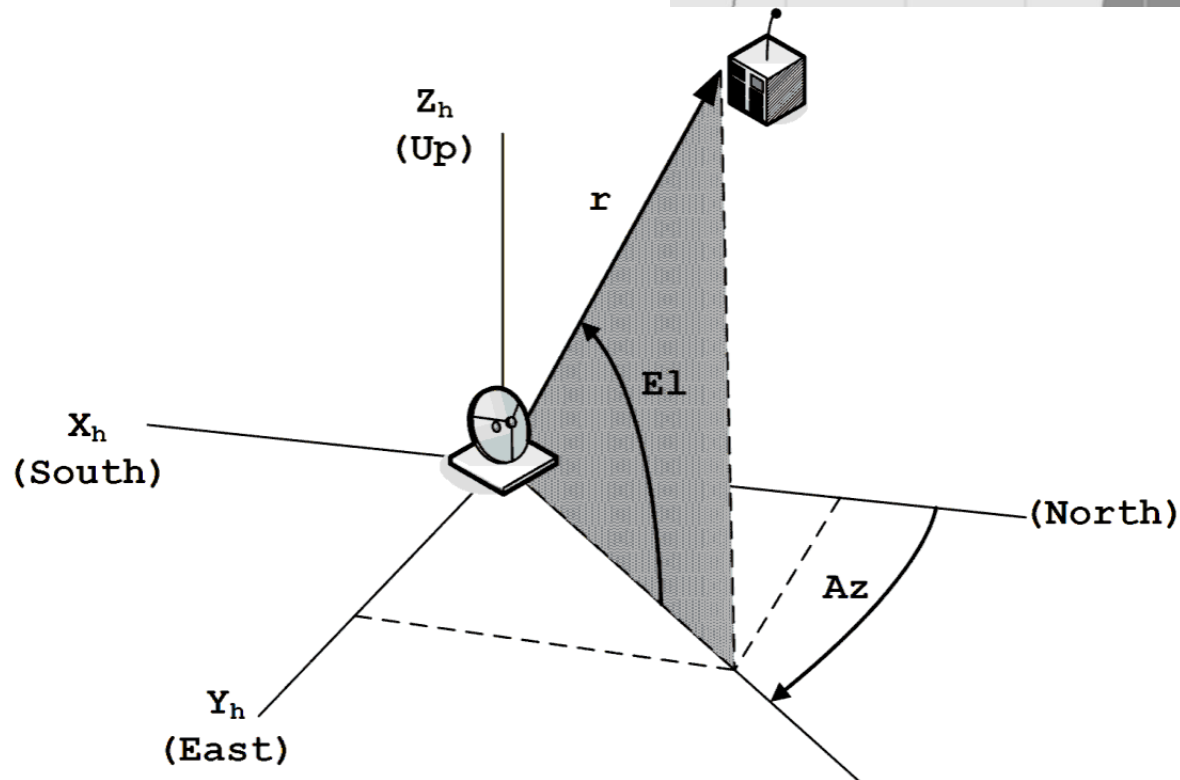
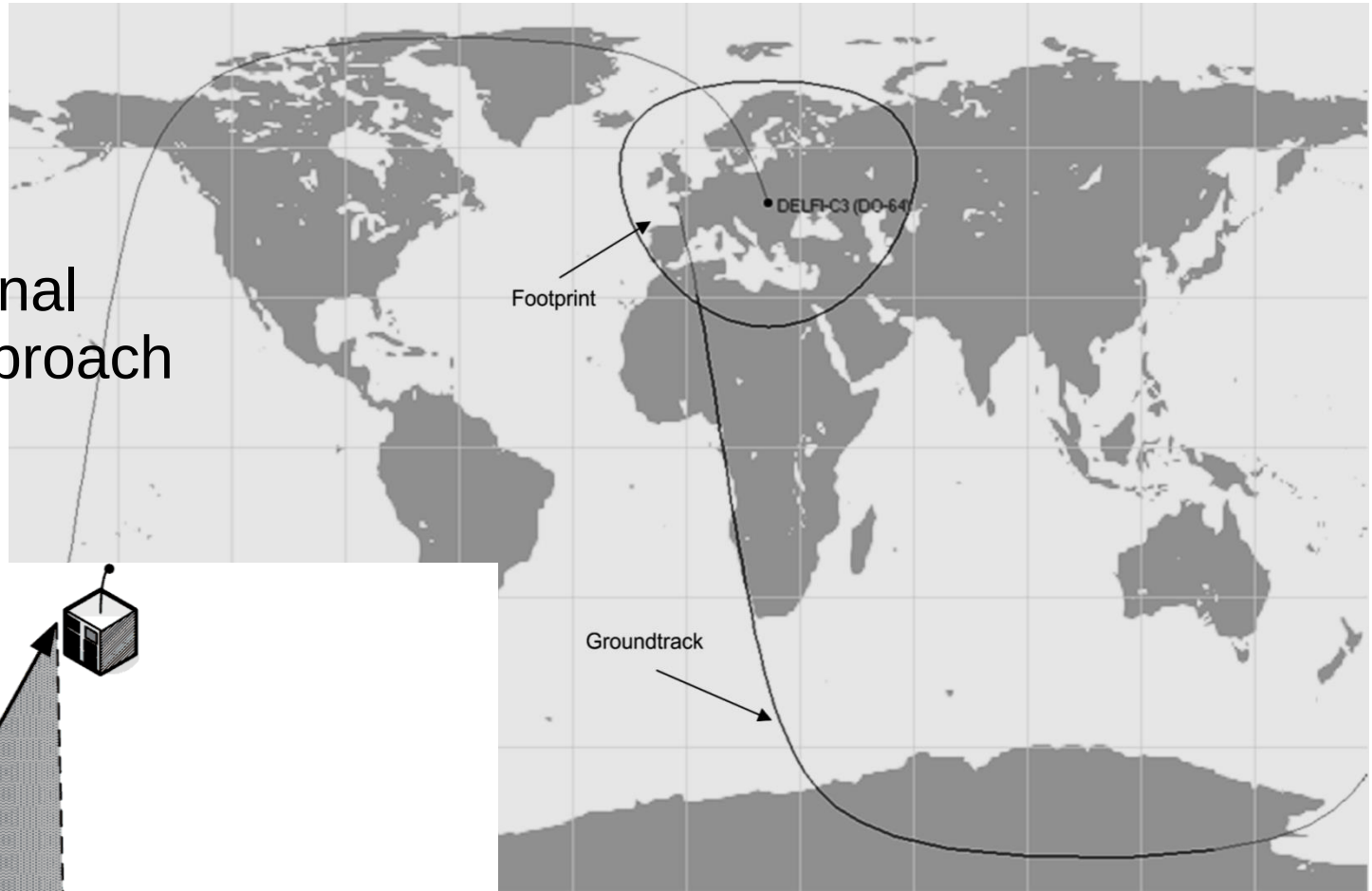
■ Footprint

- 'Dekking' van de satelliet



Satellietbanen

AOS Aquisition of Signal
TCA Time Closed Approach
LOS Loss of Signal



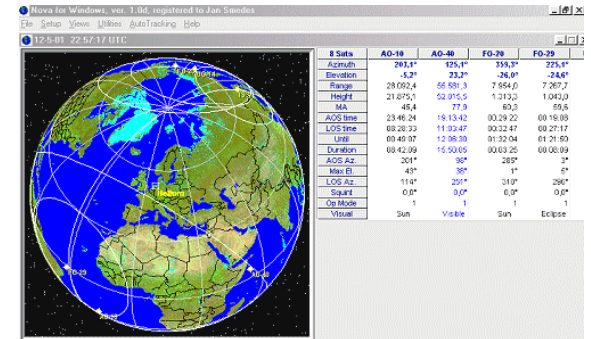
Satellietbanen

```

1 35004U 09028D 09156.84140383 .00003395 00000-0 87986-4 0 154
2 35004 40.4627 308.3133 0027431 81.4359 278.9560 15.39970114 2598

1 35004U 09028D 09156.84140383 .00003395 00000-0 87986-4 0 154
2 35004 40.4627 308.3133 0027431 81.4359 278.9560 15.39970114 2598
      incl      RAAN      e      argofper      MA      MM
  
```

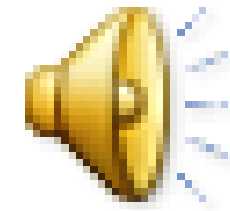
- Two-line elements
- Verkrijgbaar via internet



...

- Software begrijpt deze TLE's

Doppler (1)



- Voorbeelden
 - Formule 1
 - Politie/Ambulance
 - Trein overweg
- Frequentieverschuiving
 - Door snelheidsverschil
 - Ook voor satelliet signalen
- Typische LEO-passage:
 - 145 MHz ~ 3 kHz
 - 435 MHz ~ 10 kHz
 - 2400 MHz ~ 50 kHz (!)

$$f_w = f_b \left(\frac{v}{v - v_b} \right)$$

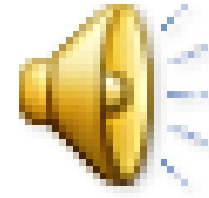
en bij verwijdering van de waarnemer:

$$f_w = f_b \left(\frac{v}{v + v_b} \right)$$

met

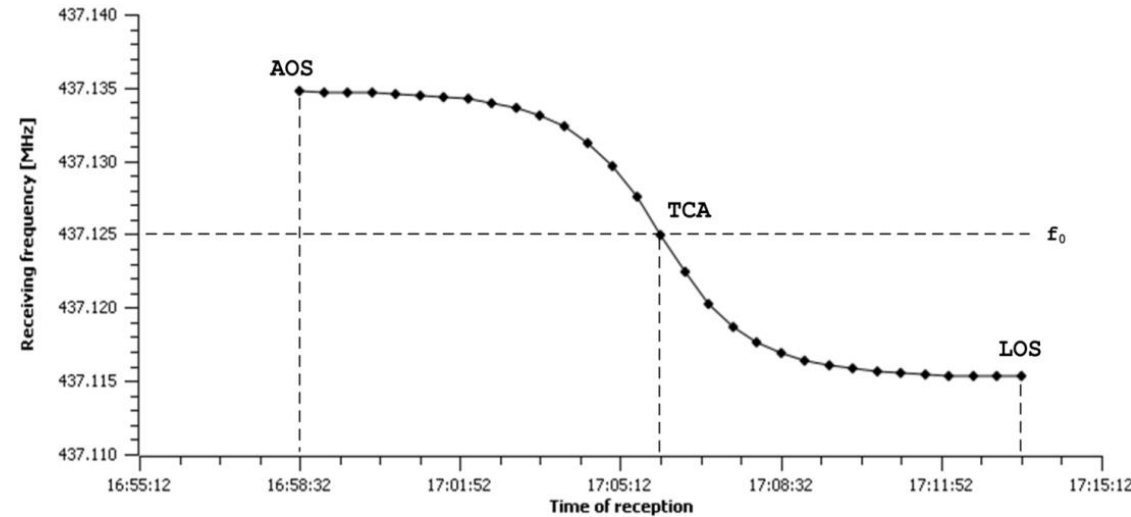
- f_b de echte frequentie van de golf die de bron uitzendt,
- v de voortplantingssnelheid van de golf in het medium en
- v_b de snelheid waarmee de golfbron beweegt in de richting van de waarnemer,

Doppler (2)

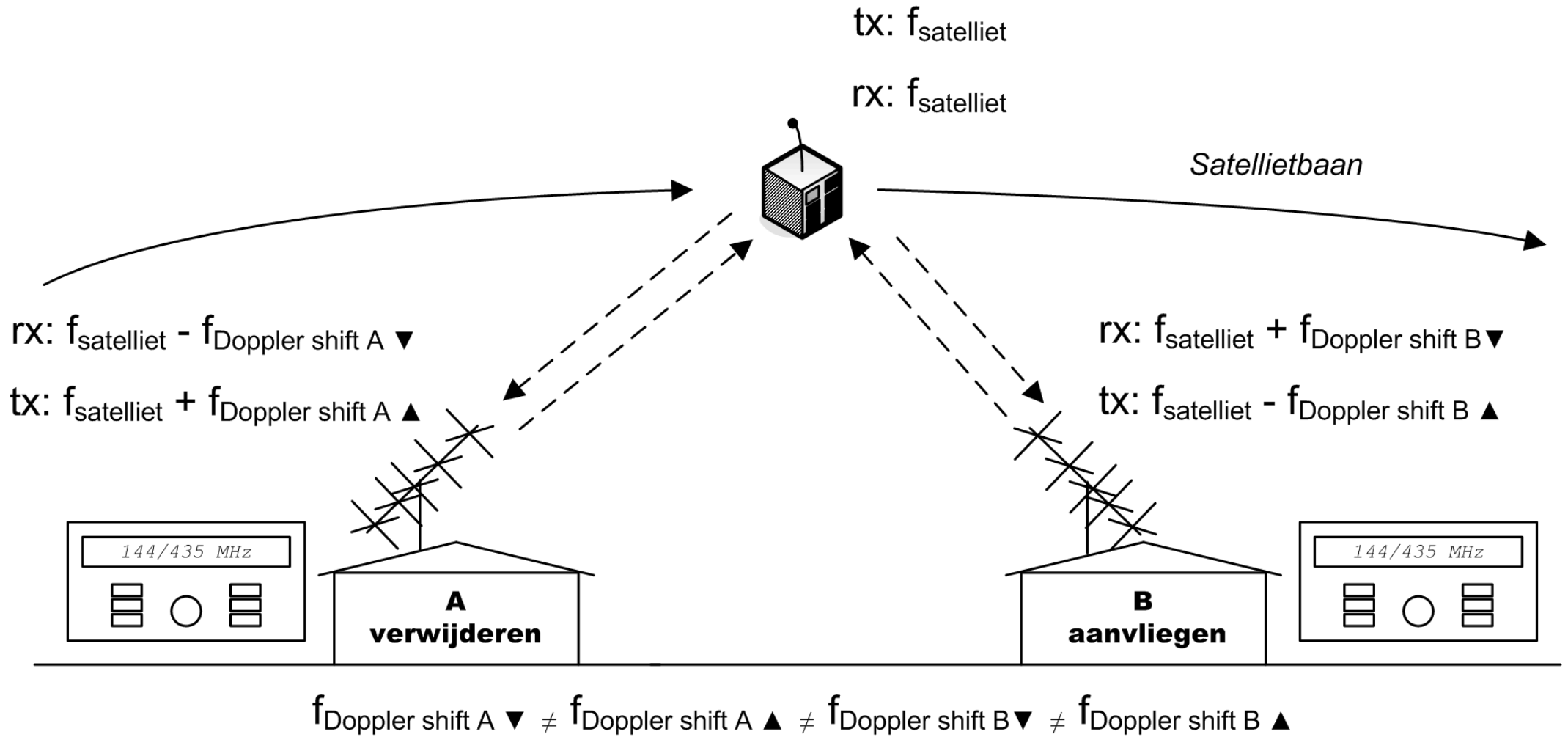


FO19 CW 437 MHz

- Goed te voorspellen als je weet:
 - Waar jij (stil) zit
 - Waar de sateliet is
 - Hoe snel de satelliet gaat
- Grootst
 - bij AOS en LOS
- Nul (heel-heel-even)
 - bij TCA
- Verandering van frequentie grootst bij TCA!



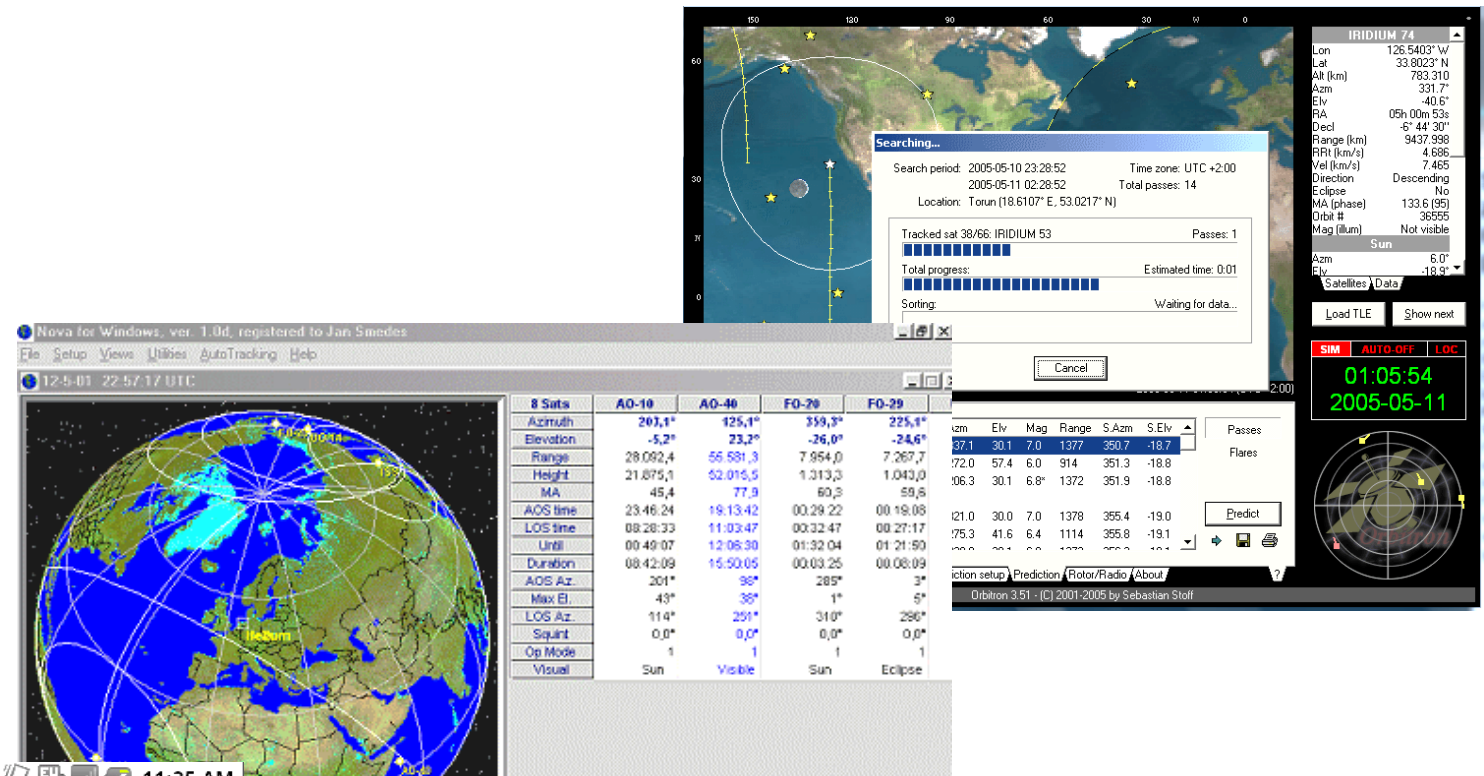
Doppler (3)



Software

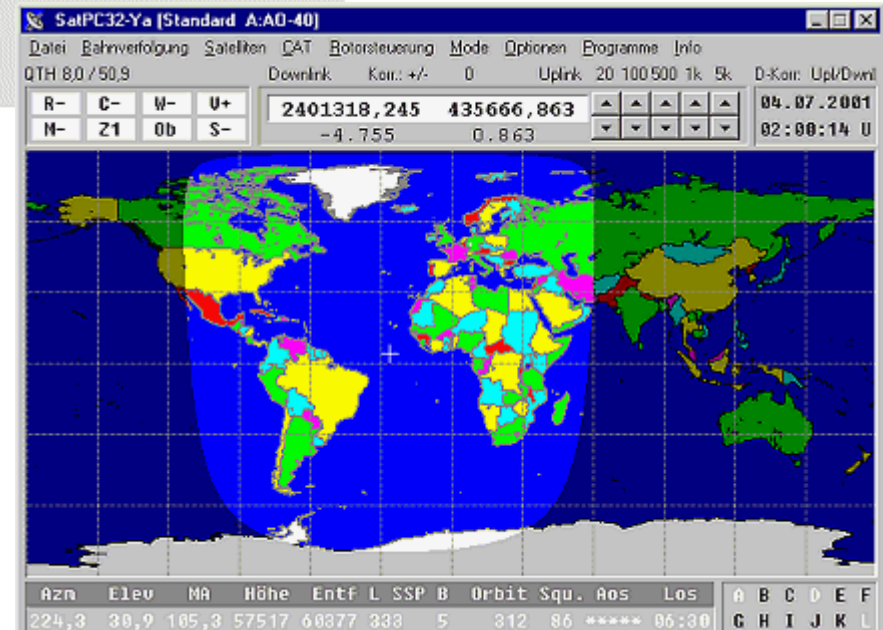
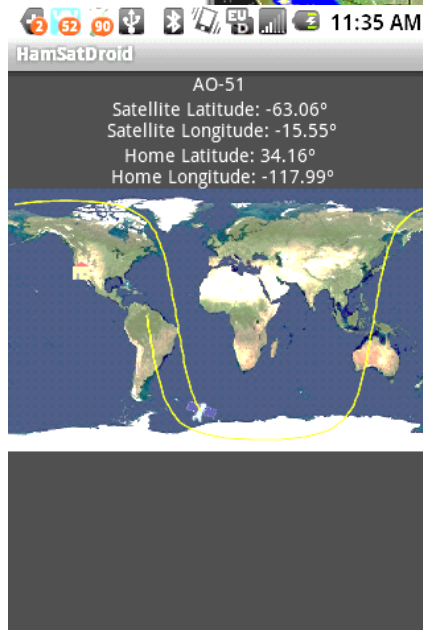
■ PC:

- NOVA
- Orbitron
- SATPC32



■ Tablets:

- App's



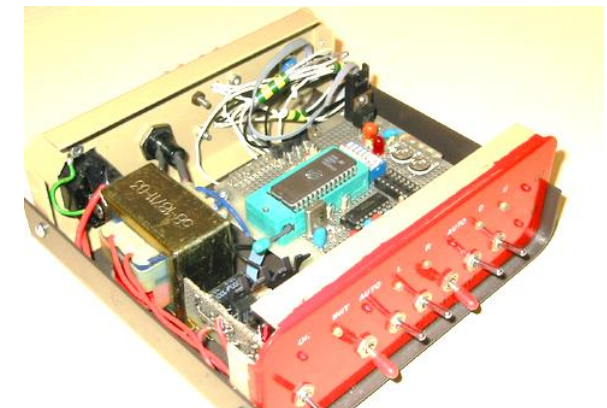
Apparatuur: Antennes

- $\frac{1}{4}$ golf rondstraler werkt aardig
 - Bijvoorbeeld voor ISS
 - Geeft niet het beste resultaat
- Richtingsgevoelige antenne is beter
 - 4 elements (145 MHz) of 7 elements (435 MHz)
 - Meer elementen → meer winst
maar: een kleinere openings hoek!
 - Voorbeelden: Arrow, DL6WU, DK7ZB



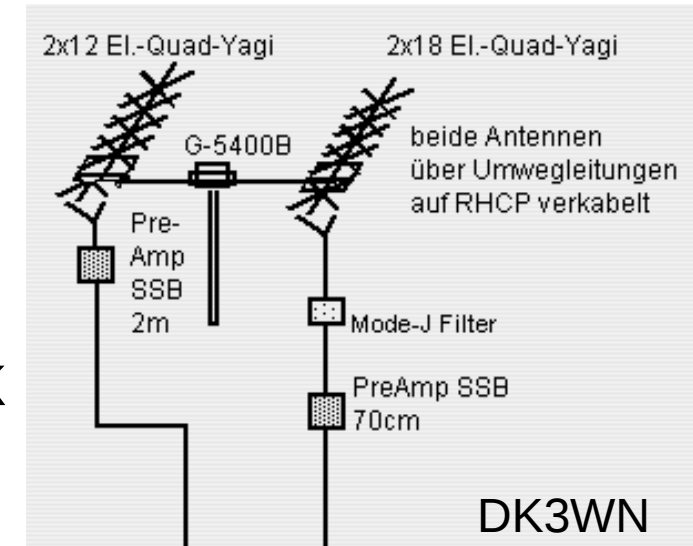
Apparatuur: Rotoren

- Antenne moet de satelliet 'volgen'
 - Horizontaal (Azimuth: 360 graden)
 - Verticaal (Elevatie: 90 graden)
 - Redelijk nauwkeurig (5 graden)
 - Openingshoek richt-antenne is klein
- Behoorlijk snel:
 - 45 .. 90 .. 45 graden elevatie in <5 minuten
 - Optie: elevatie vast op 25 graden
 - Satelliet meeste tijd <40 graden elevatie
- Computer sturing (interface)
 - Zelfbouw of bouwpakket



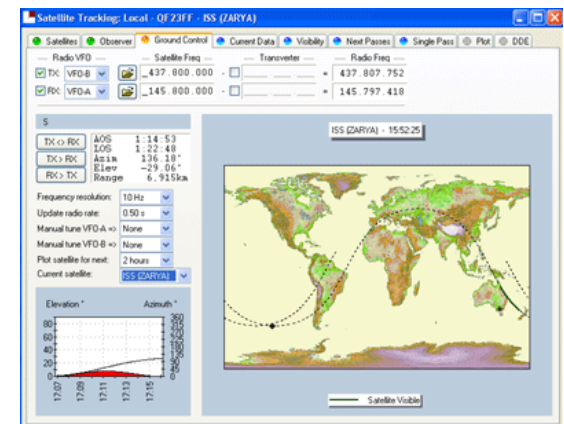
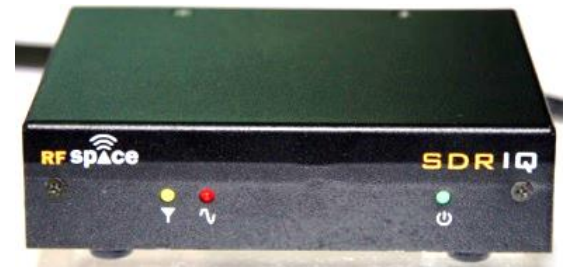
Apparatuur: Voorversterkers, Filters, Coax, ..

- Mode-J filter
 - Invloed TX op RX (harmonische)
 - 145 MHz uplink op 435 MHz downlink
- Antennekabel (coax)
 - Portabele (<2 meter): gewoon RG58 gebruiken
 - Bij vaste opstellingen lang (rotor lussen etc.)
 - Gebruik dan liefst een goede coax
- Voorversterkers
 - Compenseren verlies door lange antennekabels (coax)
 - Niet nodig voor betere SNR (ontvanger goed genoeg)



Apparatuur: Transceivers

- Full-duplex?
 - Geïntegreerde full-duplex set is fraai
 - Maar twee losse sets gaat ook prima!
 - All-mode 2m en 70cm beste eerste keus
- Wees creatief
 - Zonder de nieuwste set kan het ook!
 - Bijvoorbeeld SDR + TX
- Doppler correctie
 - Handmatig
 - Automatisch (PC)



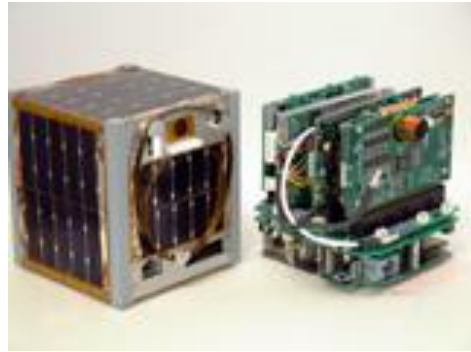
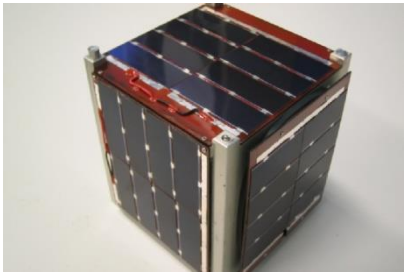
Zendamateurs en Cubesats

Demonstratie

Zendamateurs en Cubesats

SEEDS II (CO-66) 21:01 - 21:13 30° 437.485 CW 90mW

CU XI-V(CO-58) 21:12 - 21:26 83° 437.465 CW 80mW

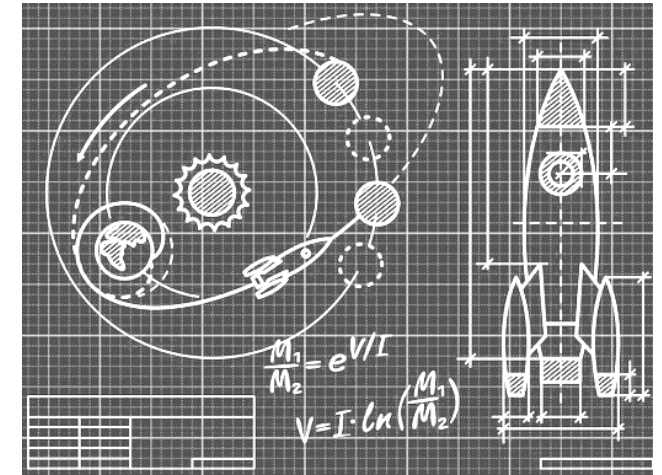


Hope-1 (HO-68) 21:16 - 21:35 72° 435.790 CW 200mW

ISS 21:25 – 21:34 13° 145.825 FM 10-25W

Zendamateurs en Cubesats

- OK... dus wat kunnen we doen BEHALVE gebruik maken van Amateur Satelieten?
- Wetenschappelijke Experimenten!
- RAFT, ANDE1, ANDE2, ..
- RAX, Aggiesat, Nanosail, O/OREOS
- + vele Japanese projecten

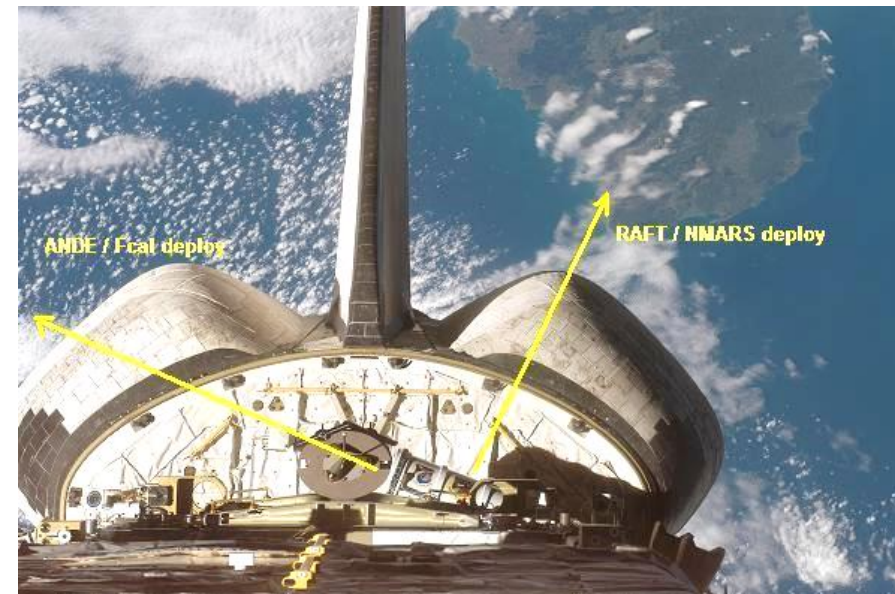
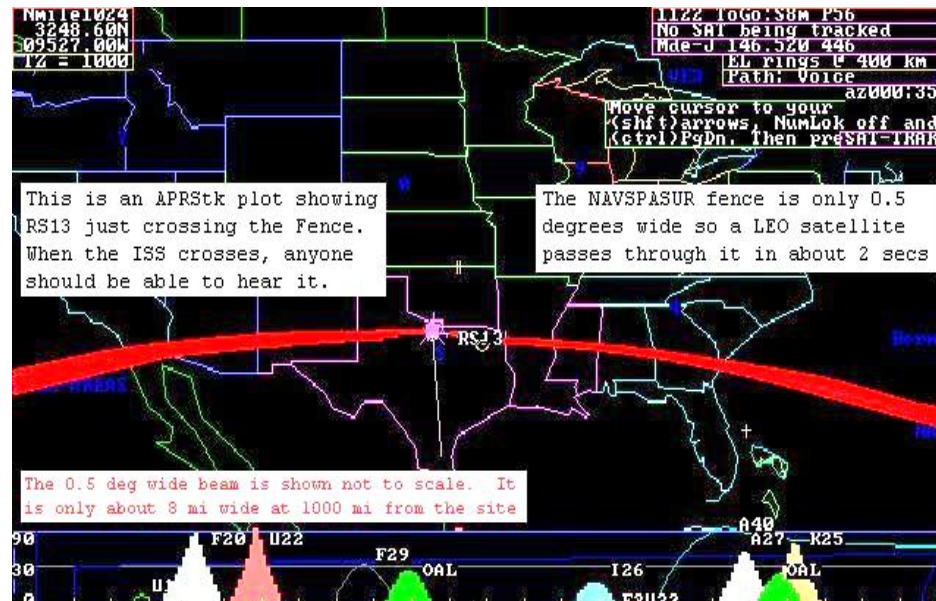
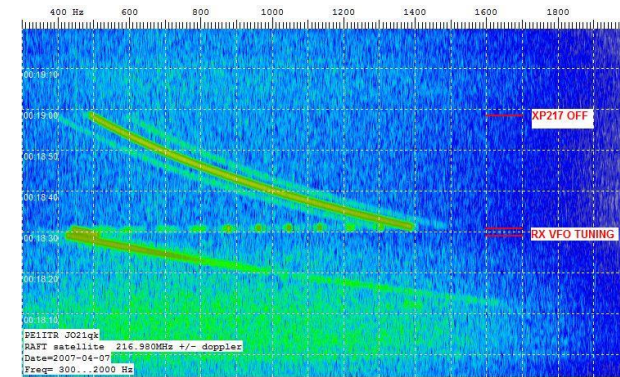


Daarom zijn Radio Amateur belangrijk!

- Radiocommunicatie
 - Niet onderzoeks-hoofddoel van de universiteiten
- Footprint / access
 - Spannende momenten: direct na lancering
 - Meer contacttijd: meer data
- Ervaring is beschikbaar
 - Bewezen radio-installatie & operators staan klaar
 - Ook tijdens weekenden
 - Bepalen van de juiste kepler set's na lancering

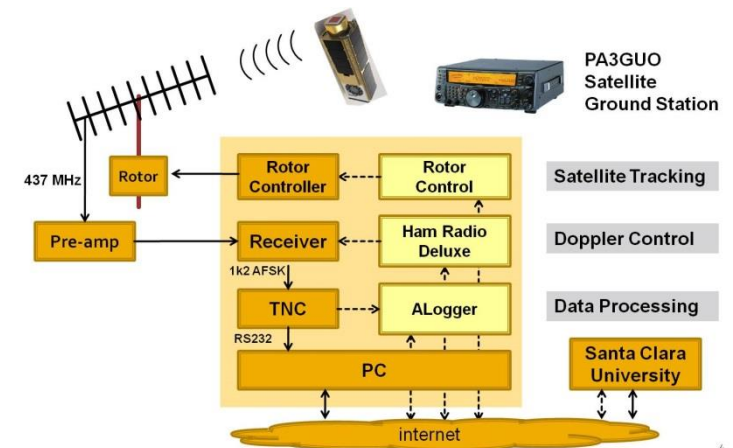
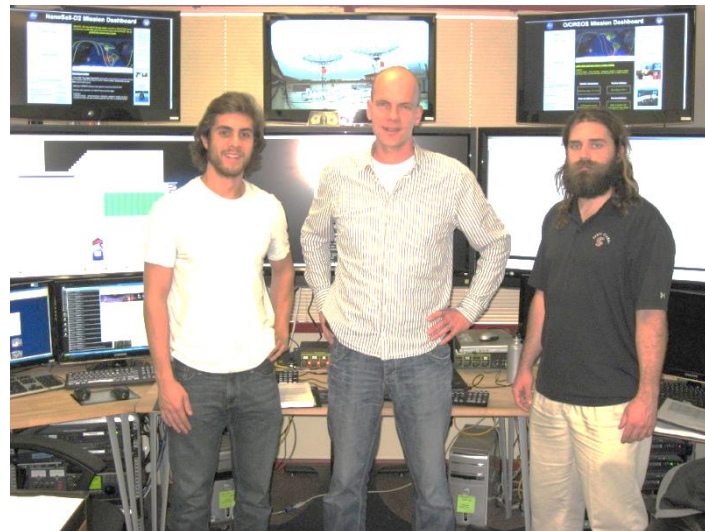
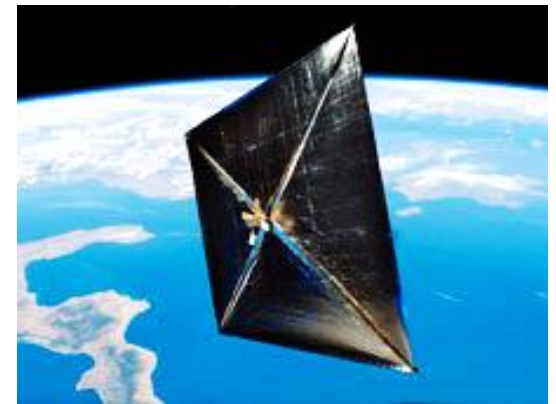
RAFT, ANDE, MARS, FCAL

- USNA Satellite, Bob Bruninga
- PE1ITR/Rob, DK3WN/Mike, PA3GUO/Henk
- RAFT moest bewezen worden boven US (vliegend door de 'radar fence')



Nanosail & O/OREOS

- NASA projects
- Ondersteund door SCU (San Jose)



- FASTSAT Lancering, geen 'deploy', en 'her-ontdekt'
- Sail Deployment over Spain

RAX

- University of Michigan, James Cutler
- Onderzoek van Space Weather



RAX2 Ground Station Client

File View Server

Summary Panel

Attitude			Communications			External Panels		
Name	Value	Unit	Name	Value	Unit	Name	Value	Unit
PNI Mag Z	-0.1303	Gauss	UHF RCHD	12759	Commands	A12 Current	25	milliamps
PNI Mag Y	-0.1421	Gauss	UHF Radio Temp	0	deg C	A17 Current	12	milliamps
PNI Mag X	-0.3355	Gauss	UHF RSSI	-105,3063	dBm	A7 Current	89	milliamps
Gyro X	-0.5125	deg/sec	Queue Status	0	packets	A3 Current	0	milliamps
Gyro Y	-0.6125	deg/sec	UHF # RX	662	bytes	V1 Voltage	15.8815	volts
Gyro Z	-7.6125	deg/sec	UHF # TX	1,359112	bytes	V2 Voltage	10.6744	volts
Gyro Mag X	0.558	Gauss				V3 Voltage	18.3965	volts
Gyro Mag Y	0.1365	Gauss				V4 Voltage	11.6291	volts
Gyro Mag Z	0.4305	Gauss						

Power System			Satellite State			Black Temperature		
Name	Value	Unit	Name	Value	Unit	Name	Value	Unit
3.3V Current (EPS)	76	milliamps	PS	Disabled		ECPU Temp	19.3486	degrees C
Batt Current (EPS)	155	milliamps	PSM	Disabled		EPS Output Reg Temp	18.6547	degrees C
Batt Current (EPS)	17	milliamps	EDPU	Disabled		Batt Board Temp	10.3078	degrees C
5V Voltage (BB)	4.96	volts	ACB	Enabled		PTB Board Temp	8.5	degrees C
3.3V Voltage (BB)	3.295	volts	PTB	Disabled		UHF Board Temp	8.5	degrees C
Batt Voltage	3.1694	volts	W02	Enabled		AGB Board Temp	13.030	degrees C
			UAP	Enabled		EDPU Board Temp	14.5	degrees C
			Antenna Switch	Uthum		PSM Board Temp	8.5	degrees C
			Polarization Switch	RHCP				
			Command Queue	0	commands			

18 Nov 2011 10:54:27 GMT
 18 Nov 2011 10:54:47 GMT
 18 Nov 2011 12:23:46 GMT
 18 Nov 2011 12:24:06 GMT
 18 Nov 2011 12:25:06 GMT
 18 Nov 2011 12:25:26 GMT
 18 Nov 2011 12:25:46 GMT
 18 Nov 2011 12:26:06 GMT
 18 Nov 2011 12:27:27 GMT
 18 Nov 2011 12:27:47 GMT
 18 Nov 2011 12:28:07 GMT
 18 Nov 2011 12:28:27 GMT
 18 Nov 2011 12:29:07 GMT
 18 Nov 2011 12:29:27 GMT

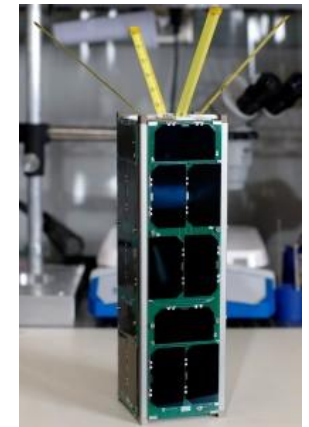
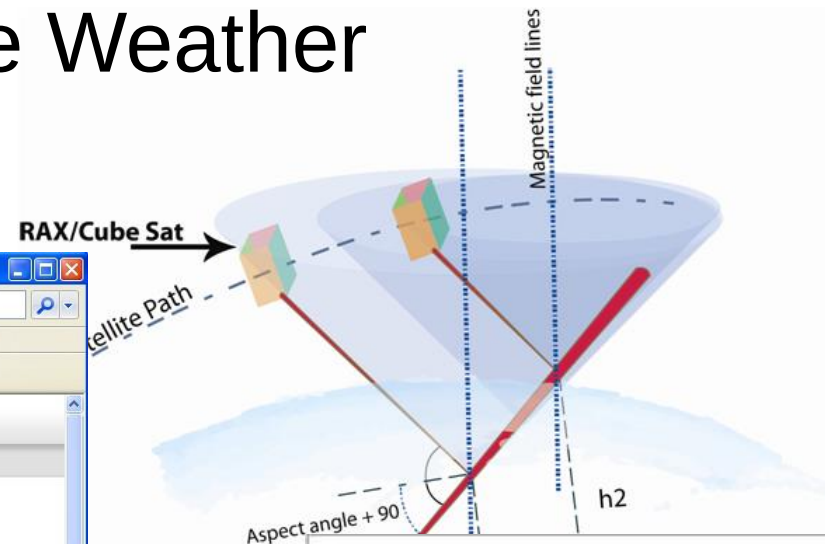
RAX

```

!S 12:40:50 !RAX-1*>CQ:nvm8k|VM1!1iigOG~s
!S 12:41:10 !RAX-1*>CQ:nvm8k|CMn^nm fH-
!S 12:41:31 !RAX-1*>CQ:nvm86k| M*PfgYp
!S 12:41:51 !RAX-1*>CQ:nvm8Jk|UiMODcpp 3[
!S 12:42:11 !RAX-1*>CQ:nv.m8^k|Z J1(tggf
!S 12:42:31 !RAX-1*>CQ:nvCm8rk|Z_JW
!S 12:42:51 !RAX-1*>CQ:nvUm8k|T H7"ahh3
  
```

00:00 00:00

Gereed Internet 100%



Watching your feed!

James Cutler <jwcutler@umich.edu>

U hebt dit bericht beantwoord op 28-10-2011 14:48.

Verzonden: vr 28-10-2011 14:45

Aan: Henk Hamoen

Thanks, looks great!

--

James Cutler, Assistant Professor
 University of Michigan
 Department of Aerospace Engineering

Henk Hamoen PA3GUO

Delfi-C3, Delfi-n3Xt

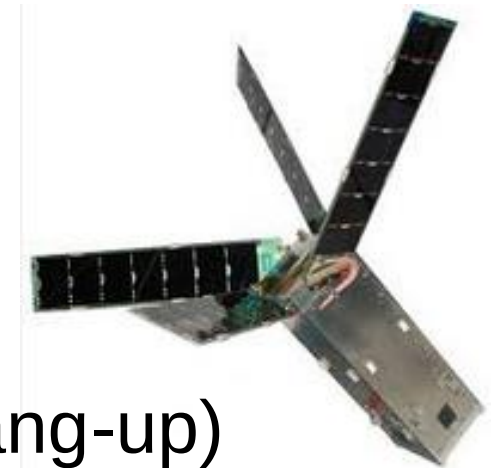
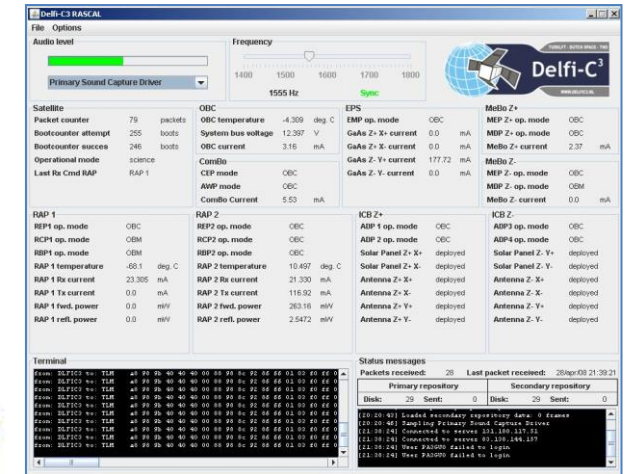
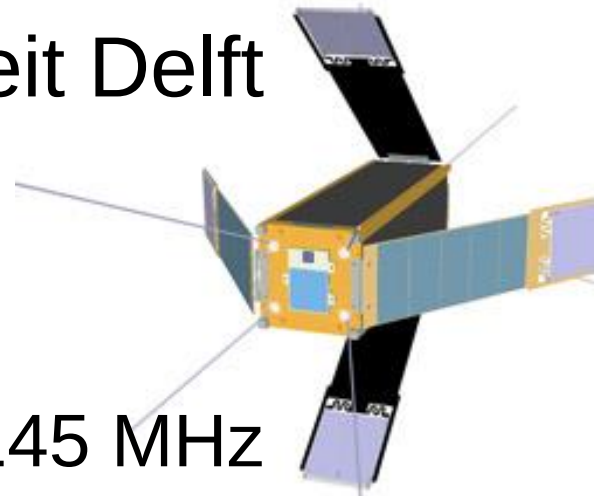


- Technische Universiteit Delft
- Delfi-C3

- Lancing: 2008
- Telemetry downlink: 145 MHz
- Transponder: niet meer functioneel (435 → 145 MHz)

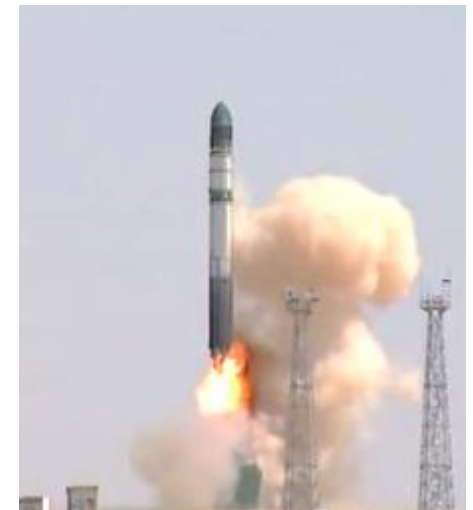
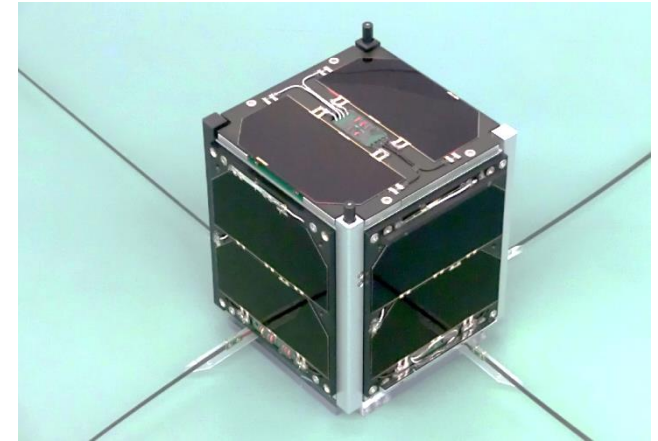
- Delfi-n3Xt (2013)

- Lancing: 2013
- Telemetry downlink: 145 MHz
- Transponder: status onduidelijk (system hang-up)



FUNcube-1 / AO-73

- Funcube: Educational Outreach
 - Scholen, ... FunCubeDongle (FCD)
- AMSAT-UK, AMSAT-NL
 - 'Nederlandse' Cubesat
- Telemetry
 - Downlink 145 MHz BPSK
- Transponder:
 - Uplink 435.150 - 435.130 MHz LSB
 - Downlink 145.950 - 145.970 MHz USB



Meer informatie



www.AMSAT.org

www.pa3guo.com

www.dk3wn.info

Zendamateurs en Cubesats

Vragen ?

YouTube

FunCubeDongle vs. Kenwood TS-2000:

http://www.youtube.com/watch?v=xFZGIqKPPQo&feature=share&list=UUAQ_8JiNQgo-Kukfu9G0d0w&index=3

NanoSail Telemetry Decoding (SDR)

http://www.youtube.com/watch?v=s1vZfm500hE&feature=share&list=UUAQ_8JiNQgo-Kukfu9G0d0w&index=2

Radio Amateurs supporting a mission in space:

http://www.youtube.com/watch?v=WGvRnqll0j8&list=UUAQ_8JiNQgo-Kukfu9G0d0w&feature=share&index=11