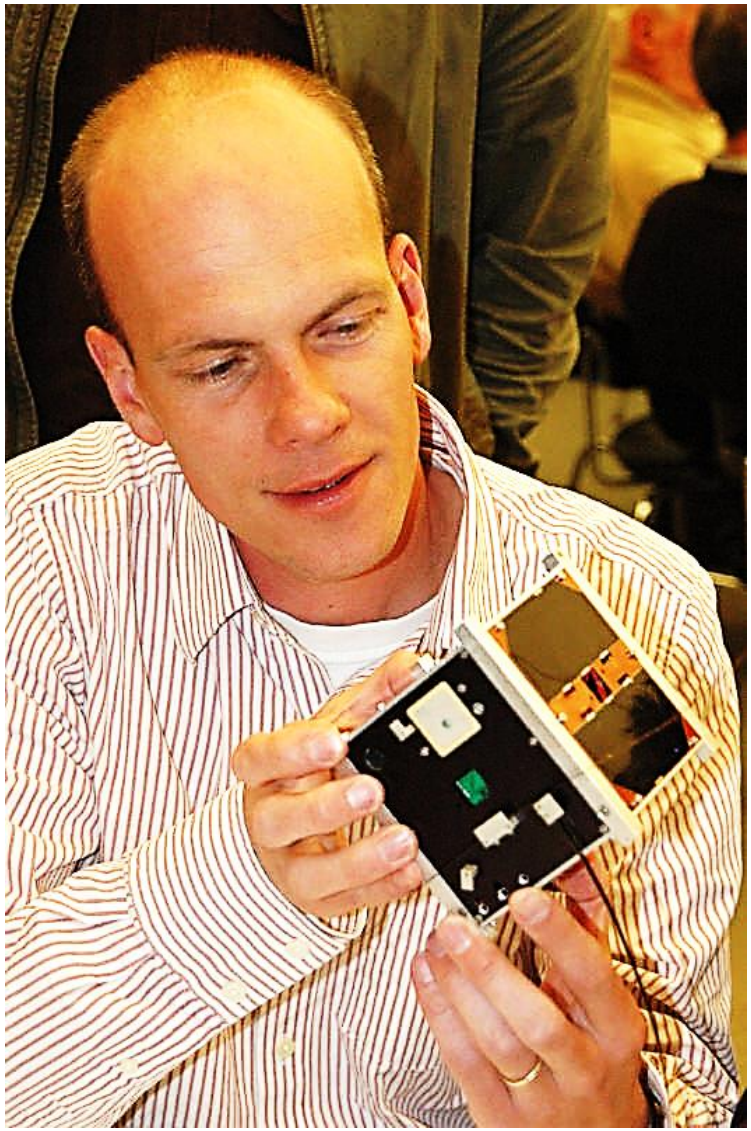


Henk Hamoen PA3GUO

Zendamateurs en Cubesat’s

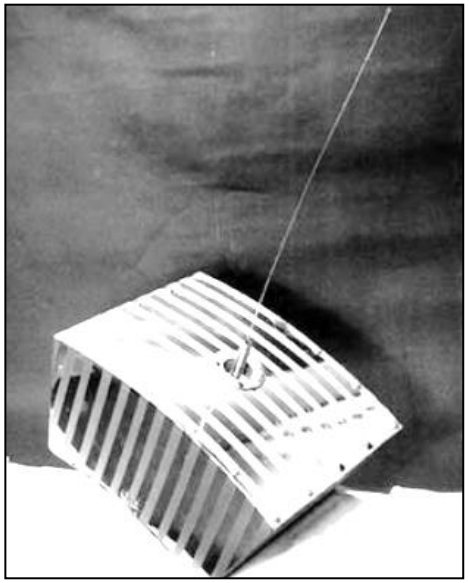
Agenda

- Amateur satellieten
- Wat is een Cubesat?
- Satellietbanen
- Doppler
- Software & Apparatuur

- Demonstratie

- Zendamateurs en cubesat’s
- Vragen

Amateur satellieten

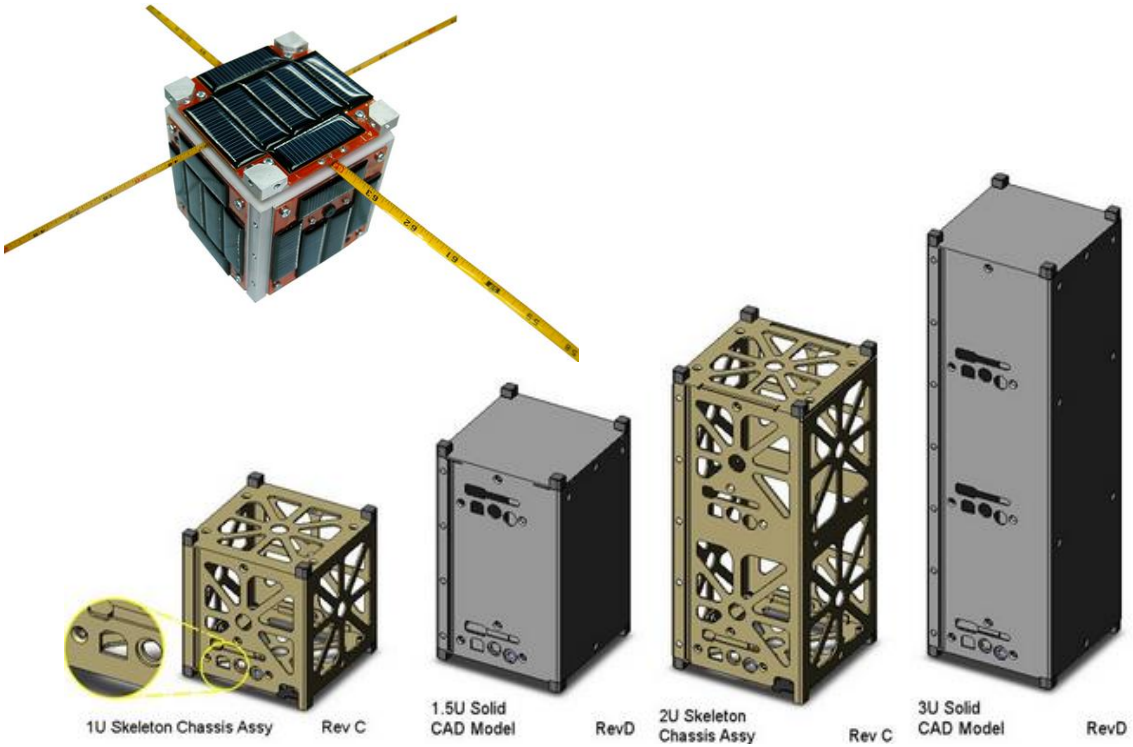


- Eerste: OSCAR-1 - 1961
- Grootste: AO-40: 450kg - HEO - Ariane 5
- Oudst werkende: AO-7 - 1974

- Duur – 2nd payload
- FunCubes: kleiner, goedkoper

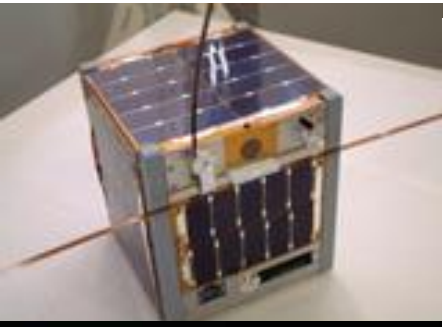
- NL: Delfi-C3, Delfin3Xt, AO-73 (FunCube-1) !

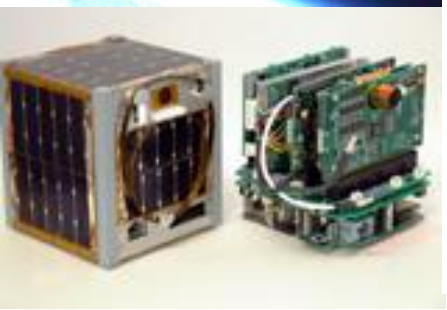
Wat is een Cubesat ?

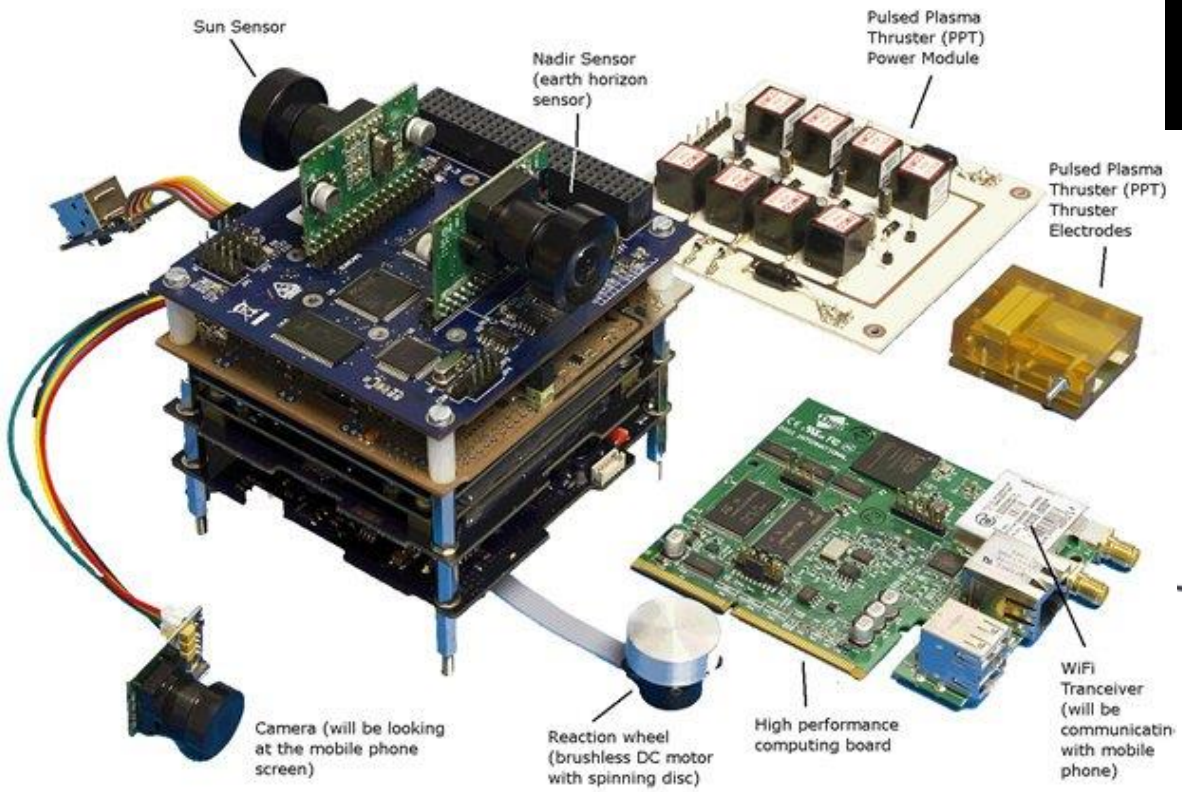


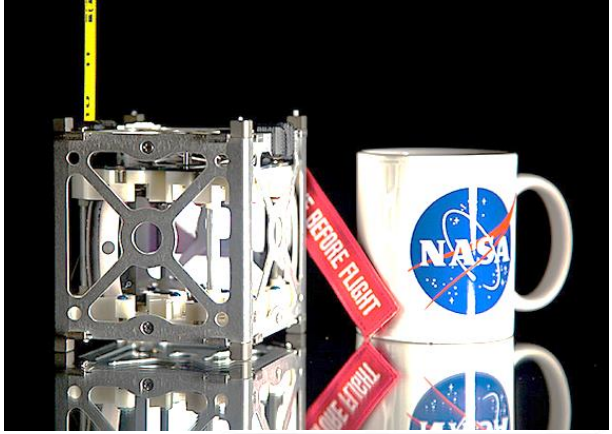
- Stanford University
- Prof. Twiggs - 1998
- <1.33 kg
- 10 x 10 x 10 cm units
- 1U, 2U, 3U, 6U, ...
- Launch Mechanism: Poly-PicoSatellite Orbital Deployer (P-POD)
- First launch: 30 Juni 2003
- Support Hands-on University-level Space Education
- 40+ launched, 300+ in development

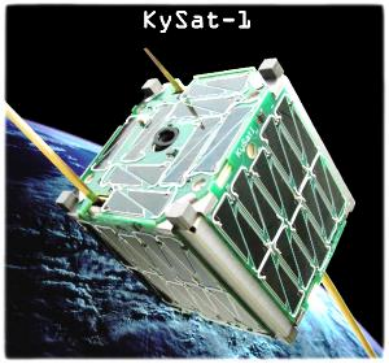
Cubesat Voorbeelden

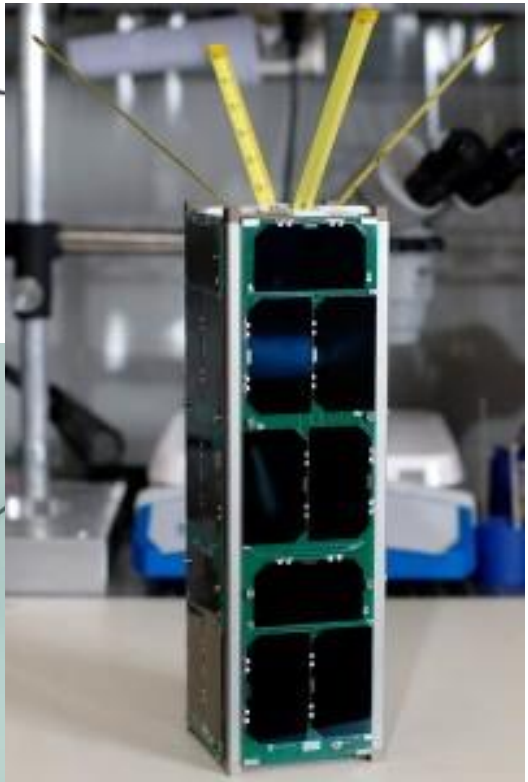


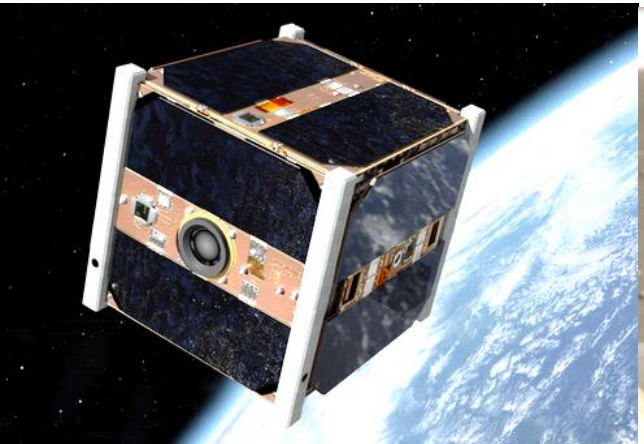


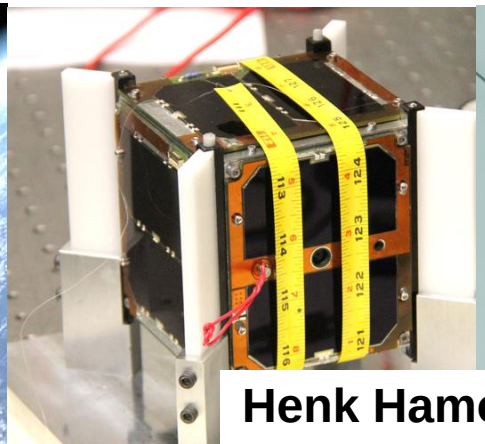












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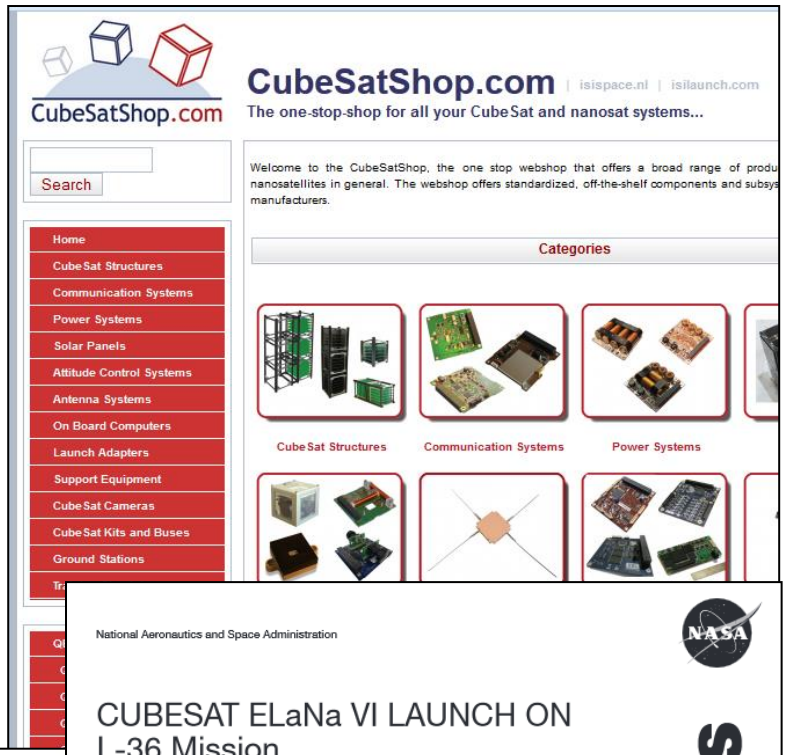
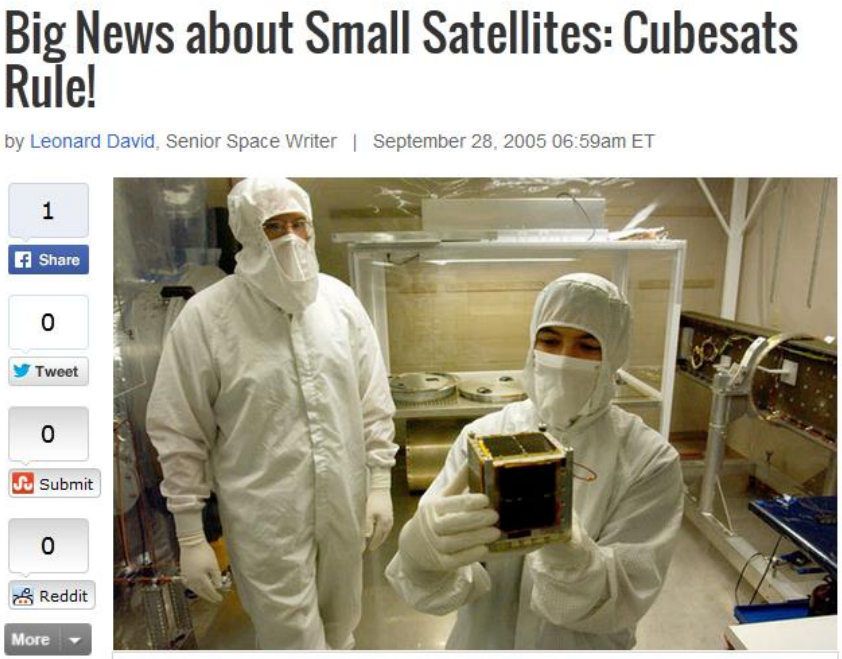
Cubesat = Business

- Magazines
- NASA
- Internet





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Satellietbanen

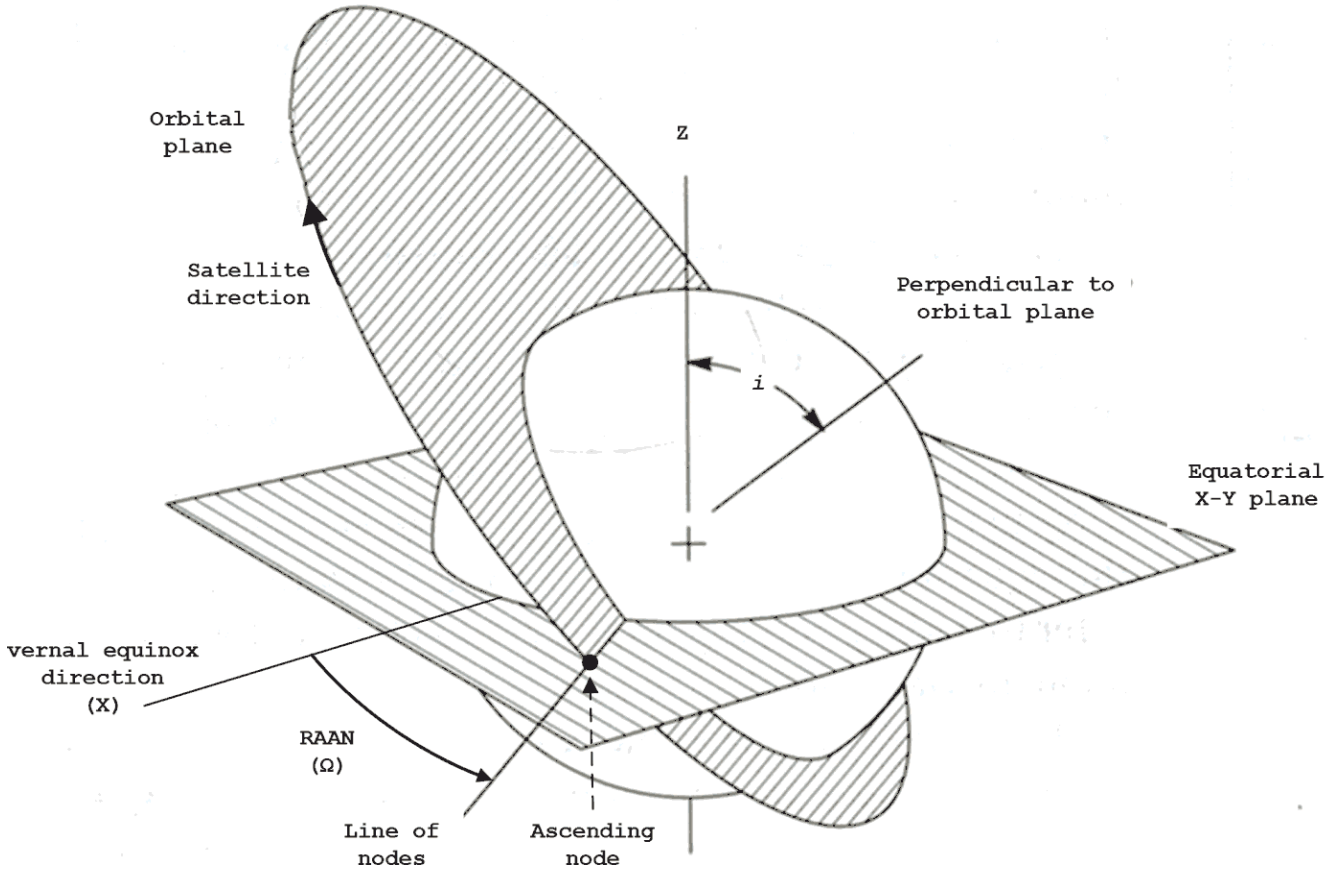
LEO = Low Earth Orbit
HEO = High Earth Orbit

Ellipse-vormig

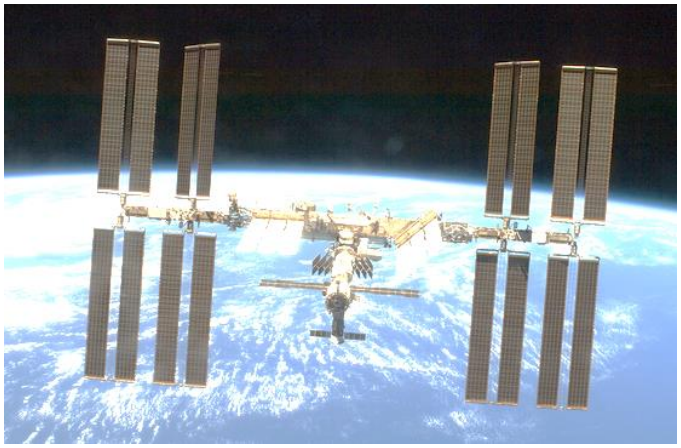
- Voor LEO-satellieten bijna rond (Low Earth Orbit)

6 baan-parameters

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



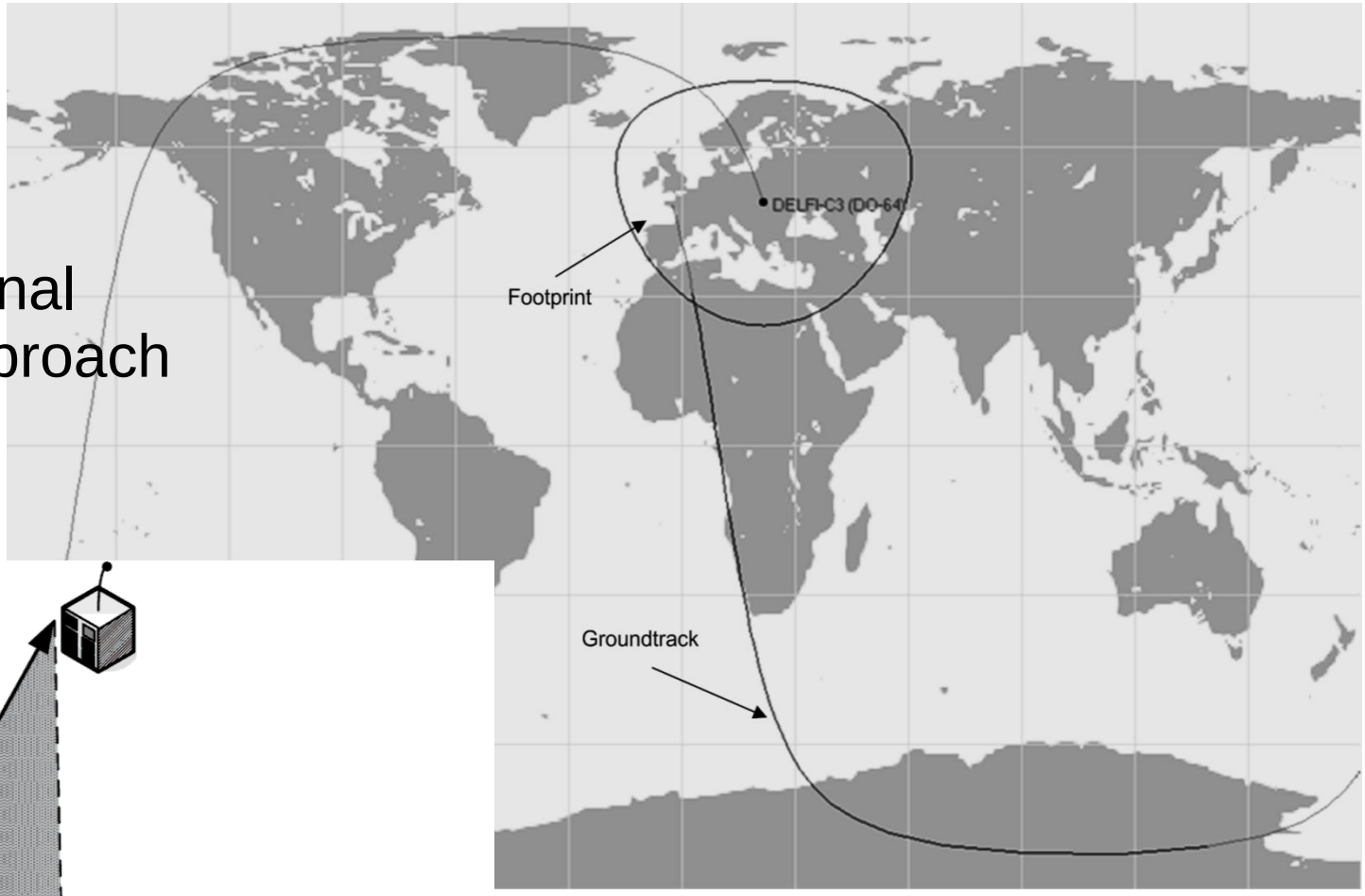
Satellietbanen

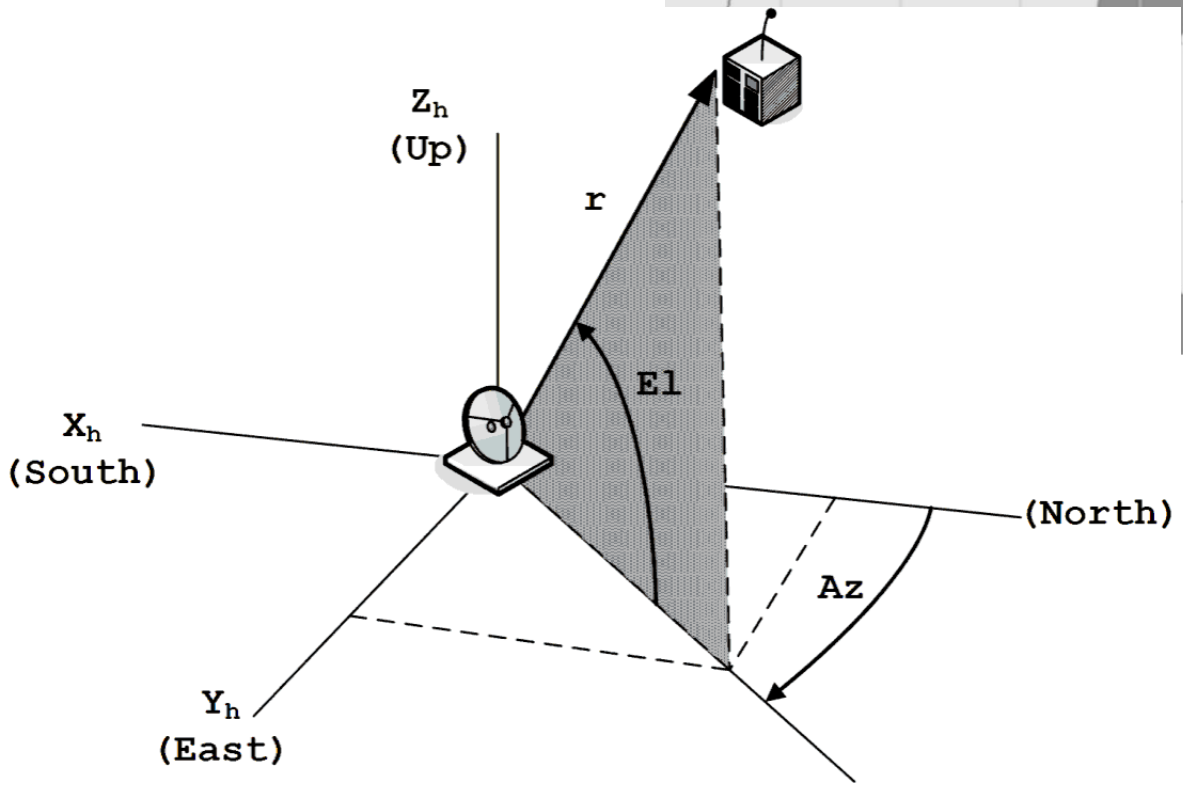


- Low-Earth-Orbit (LEO) banen
  - Satelliet komt ongeveer elke 1,5 uur over
  - Passage maximaal rond 15 minuten
  - Ongeveer 3 tot vier passages, dan weer tijdje ‘niet-zichtbaar’
  - Noord → zuid of Zuid → noord
- Footprint
  - ‘Dekking’ van de satelliet

Satellietbanen

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





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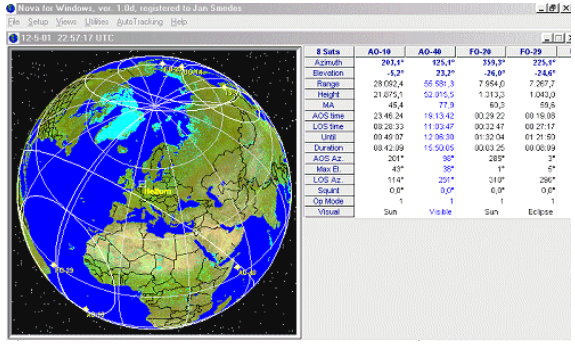
Satellietbanen

```
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
```

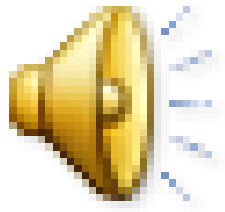


- Two-line elements
- Verkrijgbaar via internet

  http://www.celestrak.com/NORAD/elements/

  …
- Software begrijpt deze TLE’s

Doppler (1)



- Voorbeelden
  - Formule 1
  - Politie/Ambulance
  - Trein overweg
- Frequentieverschuiving
  - Door snelheidsverschil
  - Ook voor satellietsignalen
- 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:

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

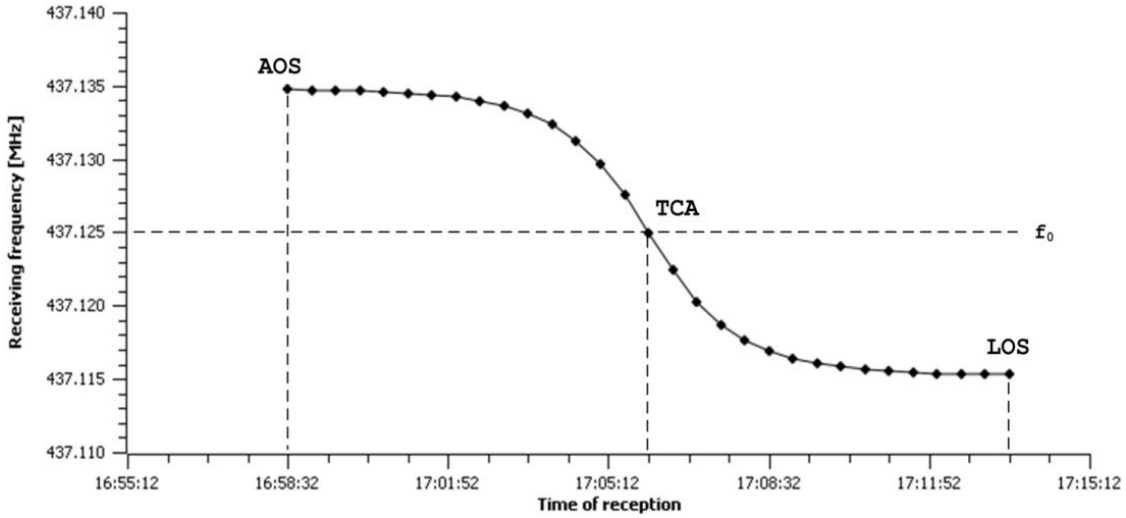
met

- 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,

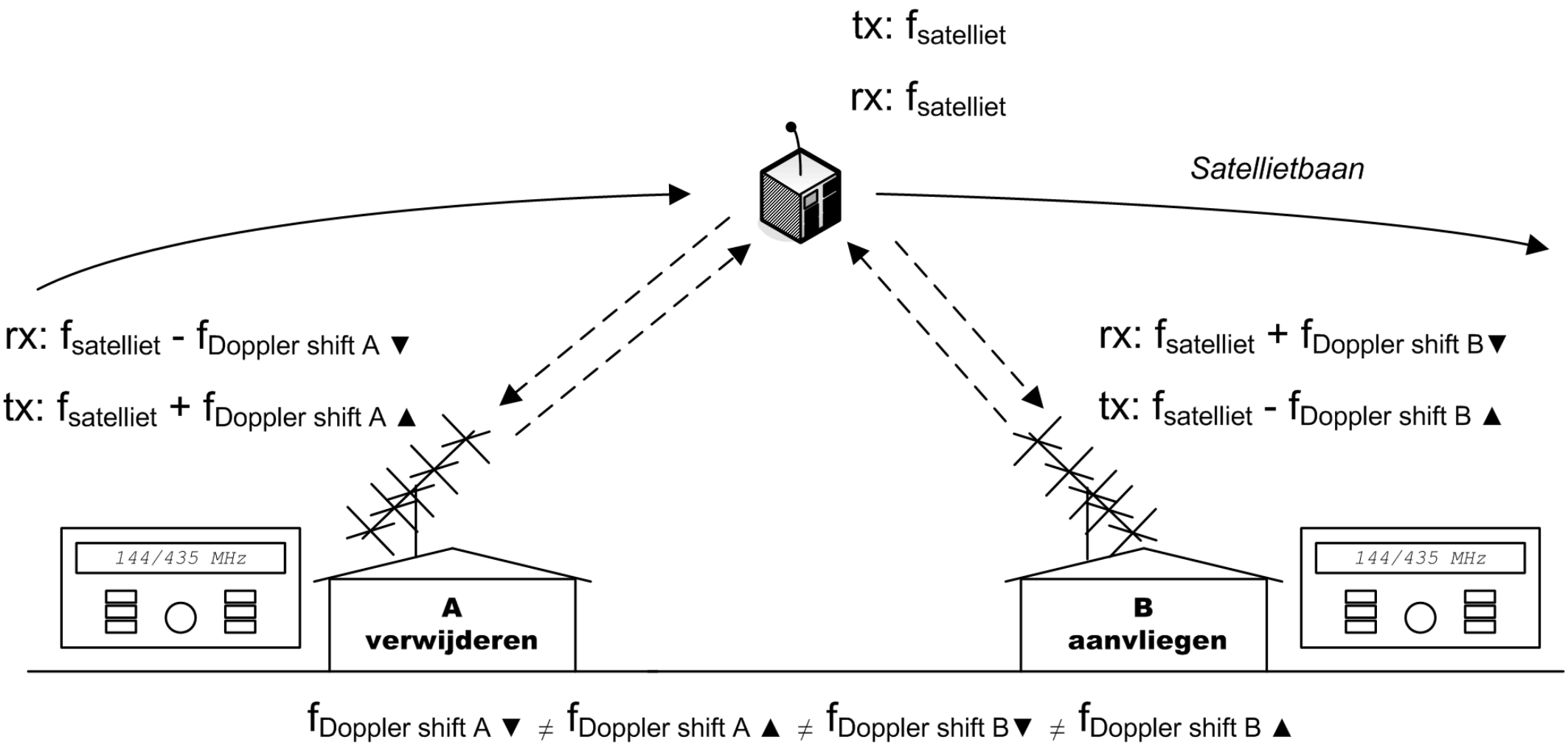
Doppler (2)

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)



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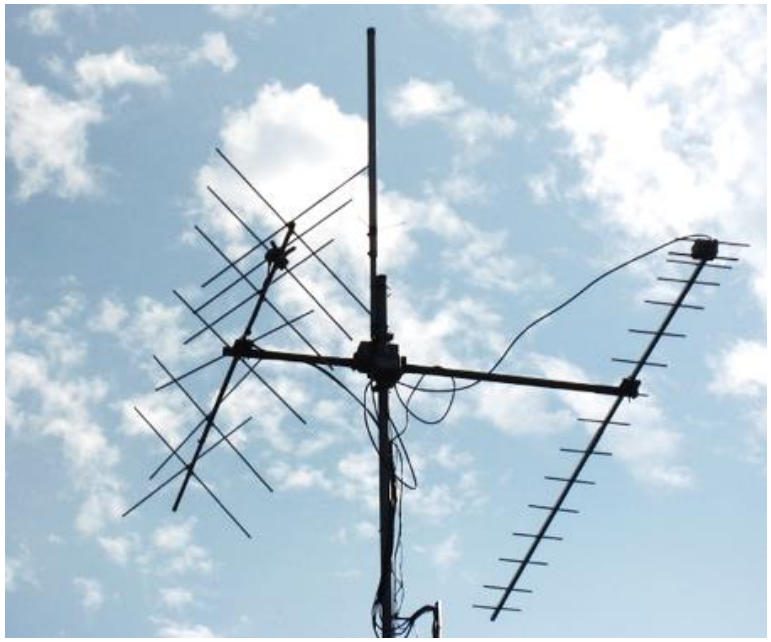
Software

- PC:
  - NOVA
  - Orbitron
  - SATPC32
- Tablets:
  - App’s

Apparatuur: Antennes



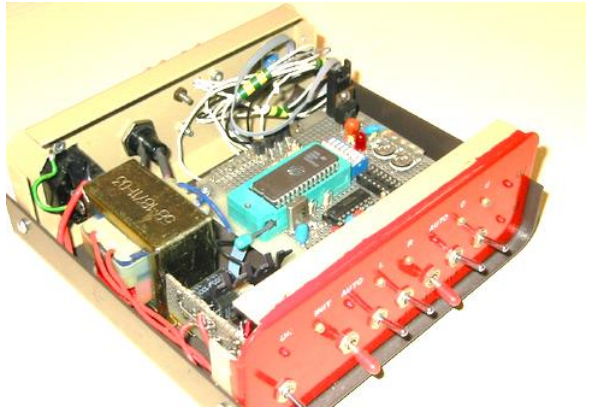
- ¼ golf rondstraler werkt aardig
  - Bijvoorbeeld voor ISS
  - Geeft niet het beste resultaat

- 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

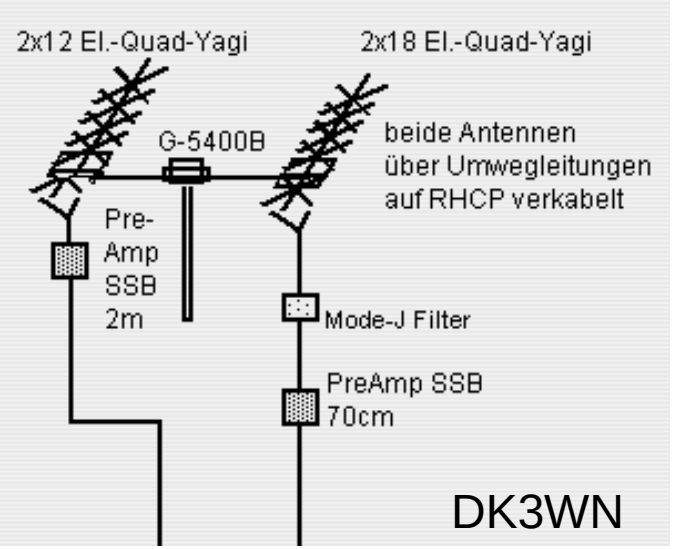
Apparatuur: Rotoren

- 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, ..



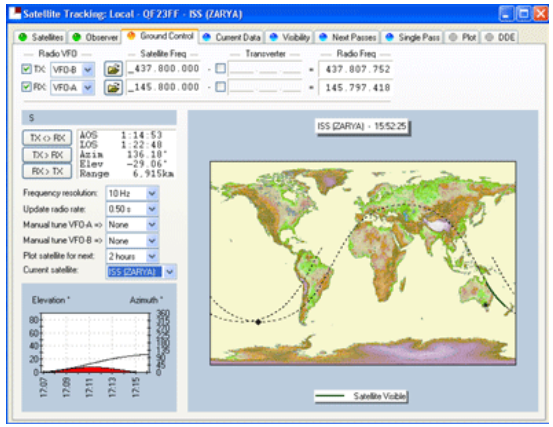
- Mode-J filter
  - Invloed TX op RX (harmonische)
  - 145 MHz uplink op 435 MHz downlink
- Antennekabel (coax)
  - Portabele (<2 meter): gewoon RG58 gebruiken
  - Bij vaste opstellingen lang (rotor lussen etc.)
    - Gebruik dan liefst een goede coax
- Voorversterkers
  - Compenseren verlies door lange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



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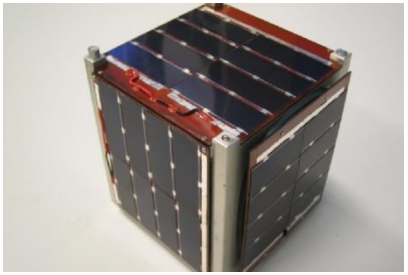
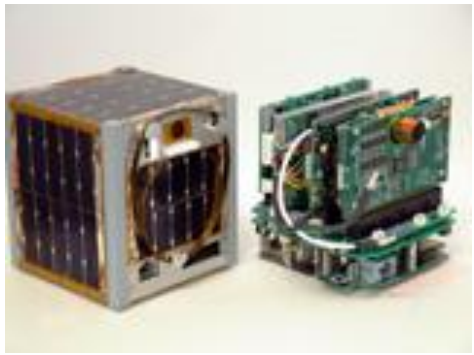
Demonstratie

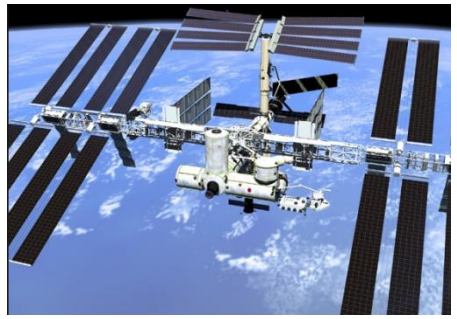
Henk Hamoen PA3GUO

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



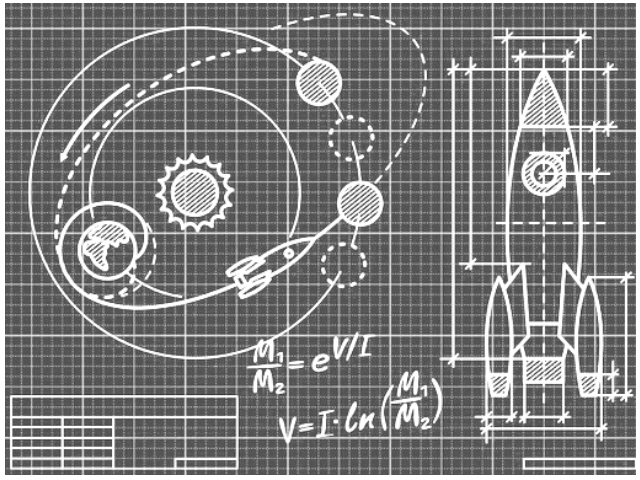




Hope-1 (HO-68)	21:16 - 21:35	72°	435.790	CW	200mW
ISS	21:25 – 21:34	13°	145.825	FM	10-25W

Zendamateurs en Cubesats

- OK... dus wat kunnen we doen BEHALVE gebruik maken van Amateur Satelieten?



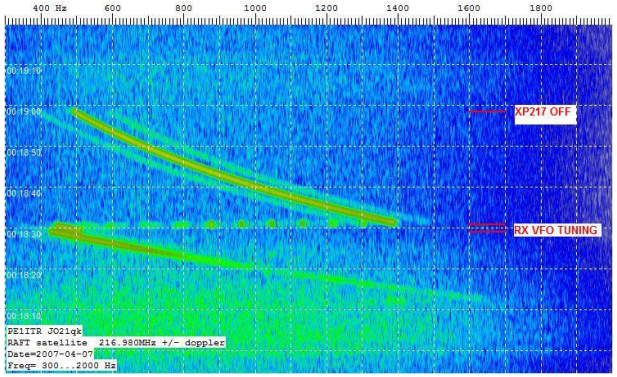
- Wetenschappelijke Experimenten!

- RAFT, ANDE1, ANDE2, ..
- RAX, Aggiesat, Nanosail, O/OREOS
- + vele Japanese projecten

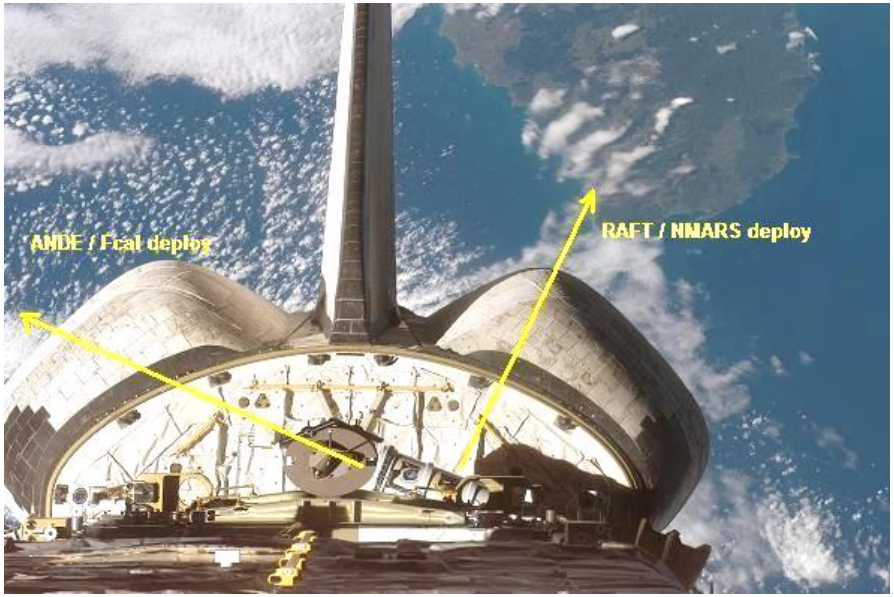
Daarom zijn Radio Amateur belangrijk!

- 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’)



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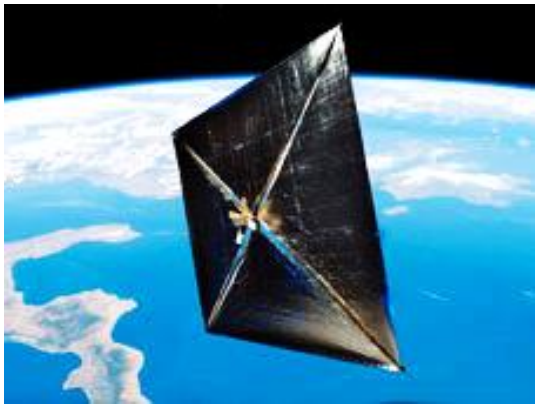
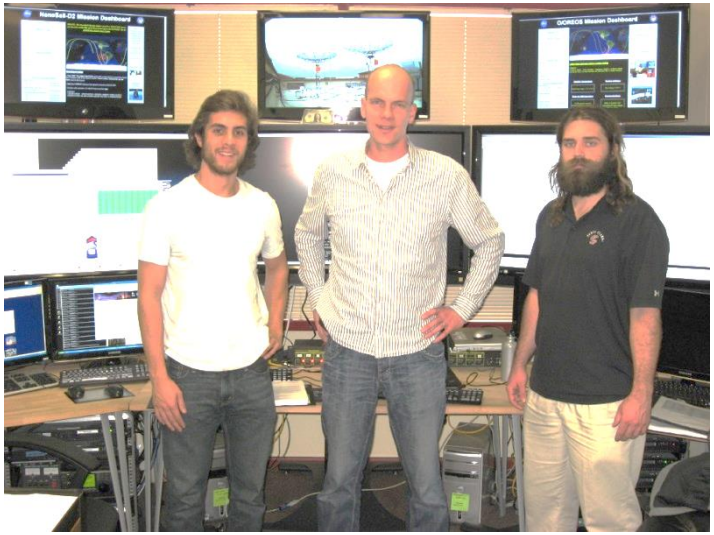
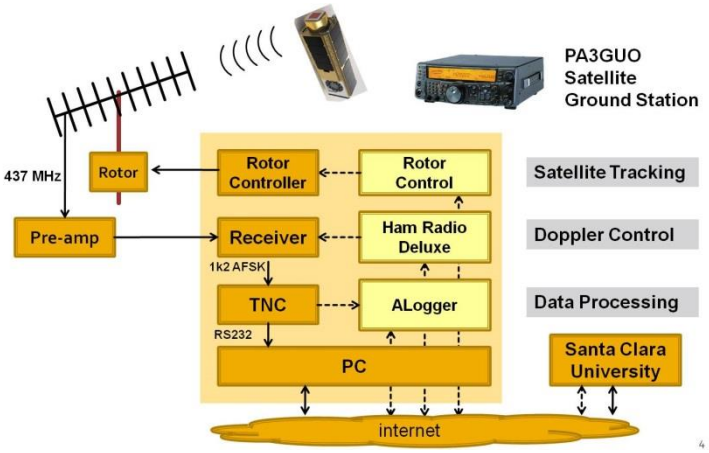
Nanosail & O/OREOS



- NASA projects
- Ondersteund door SCU (San Jose)





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

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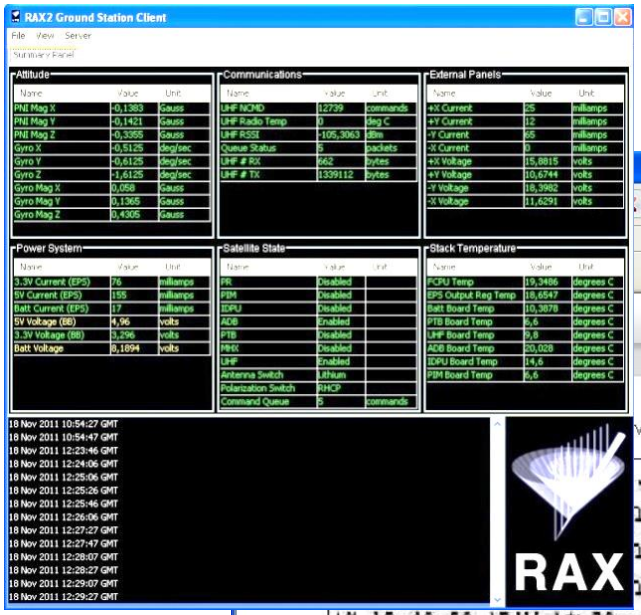
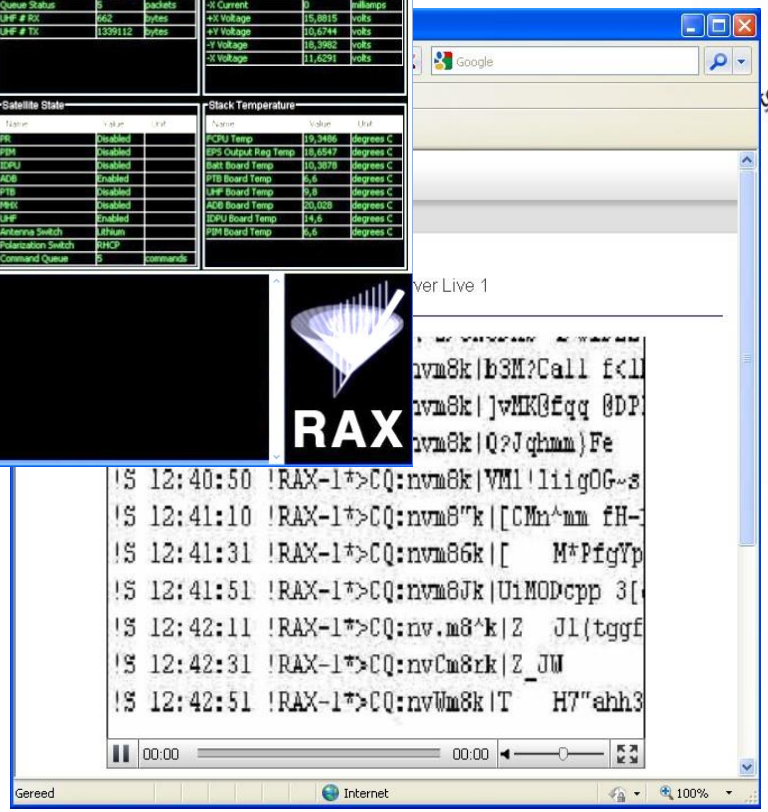
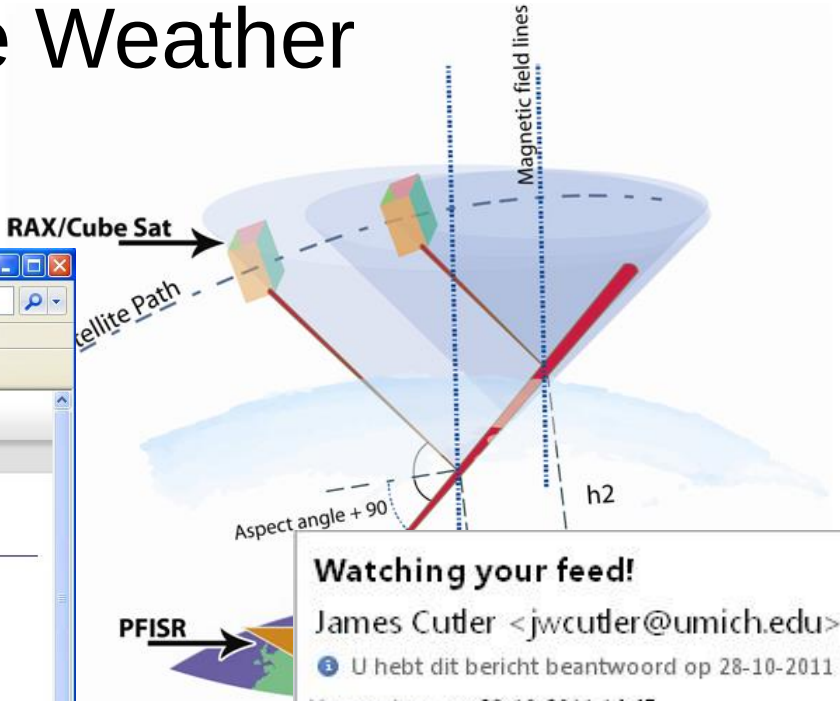
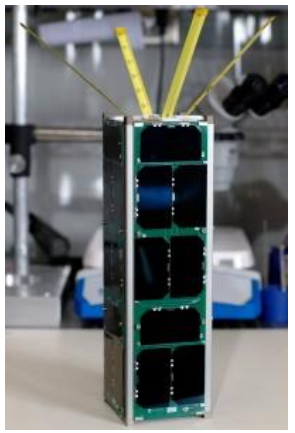
RAX

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









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

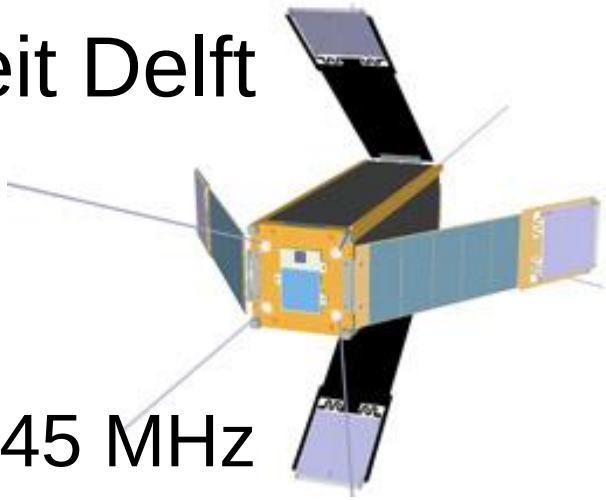
Aan: Henk Hamoen

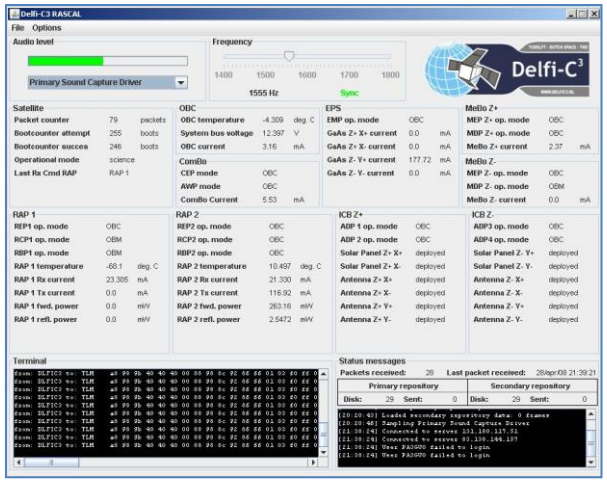
Thanks, looks great!

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

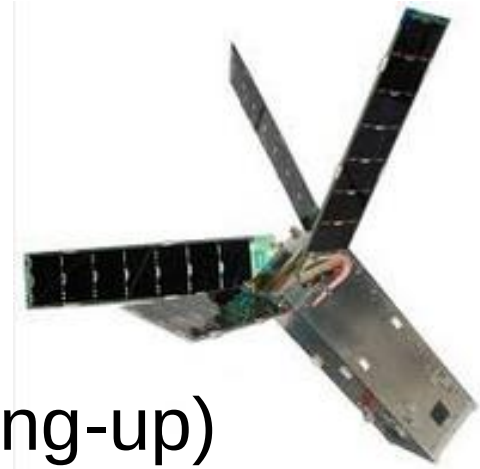
Henk Hamoen PA3GUO

Delfi-C3, Delfi-n3Xt



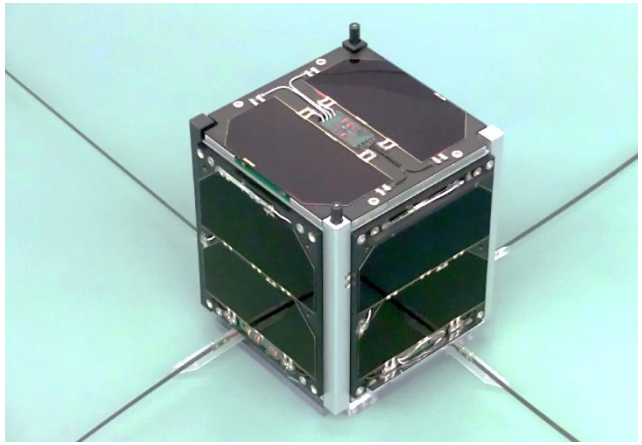


- Technische Universiteit Delft
- Delfi-C3
  - Lancering: 2008
  - Telemetry downlink: 145 MHz
  - Transponder: niet meer functioneel (435 → 145 MHz)
- Delfi-n3Xt (2013)
  - Lancering: 2013
  - Telemetry downlink: 145 MHz
  - Transponder: status onduidelijk (system hang-up)



FUNcube-1 / AO-73

- Funcube: Educational Outreach
  - Scholen, ... FunCubeDongle (FCD)
- AMSAT-UK, AMSAT-NL
  - ‘Nederlandse’ Cubesat
- Telemtry
  - 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

Henk Hamoen PA3GUO

Zendamateurs en Cubesats

Vragen ?

Henk Hamoen PA3GUO

YouTube

FunCubeDongle vs. Kenwood TS-2000:

http://www.youtube.com/watch?v=xFZGlqKPPQo&feature=share&list=UUAQ_8JiNQqo-Kukfu9G0d0w&index=3

NanoSail Telemetry Decoding (SDR)

http://www.youtube.com/watch?v=s1vZfm500hE&feature=share&list=UUAQ_8JiNQqo-Kukfu9G0d0w&index=2

Radio Amateurs supporting a mission in space:

http://www.youtube.com/watch?v=WGvRnqII0j8&list=UUAQ_8JiNQqo-Kukfu9G0d0w&feature=share&index=11