“Nothing to See Here”:

Space Domain Awareness: An Amateur Detective’s View

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SpaceTech symposium, ESTEC, 23 Jul 2021

Space Domain Awareness: An Amateur Detective's View

Small group of dedicated amateurs

Observing from their back gardens, simple equipment

~15 active observers worldwide

Strong concentration in Europe

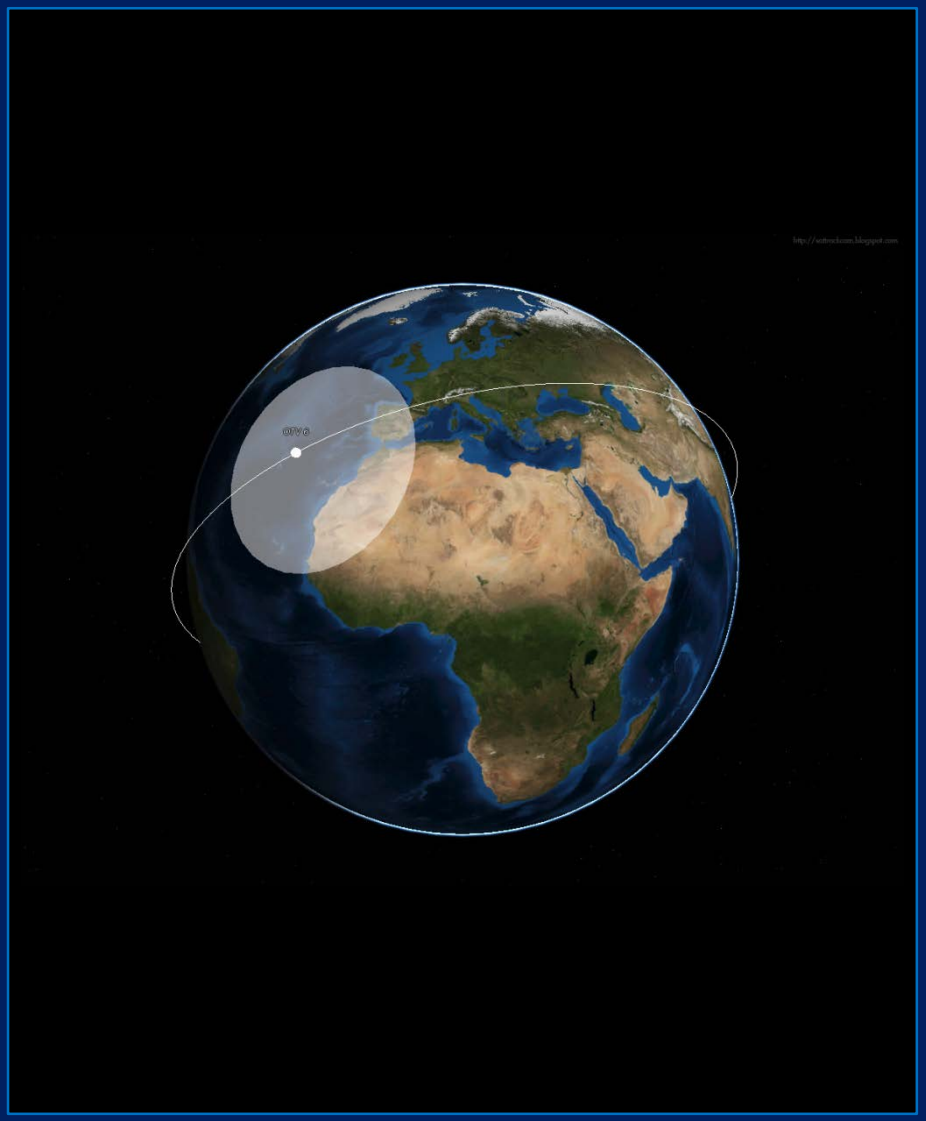
Loosely organised around a mailing list: SeeSat-L

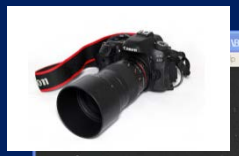
Photography and Low Light Level Video

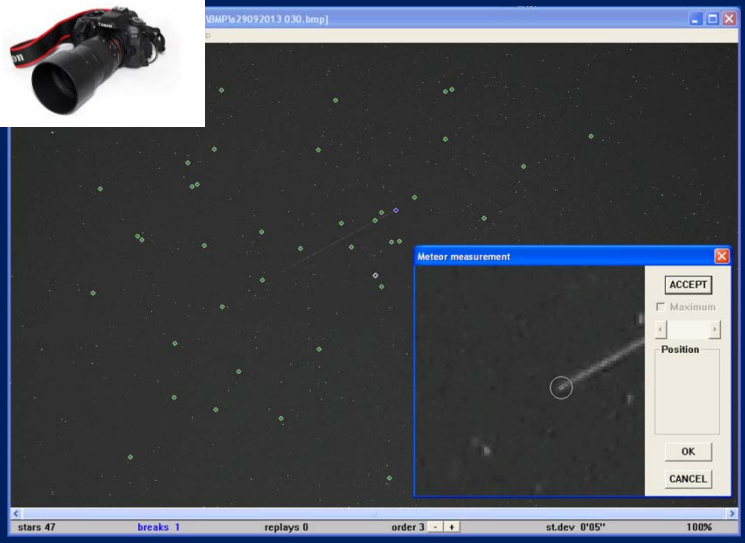
1.4/35 mm 1.8/50 mm 1.4/58 mm 1.4/85 mm 2.0/135 mm

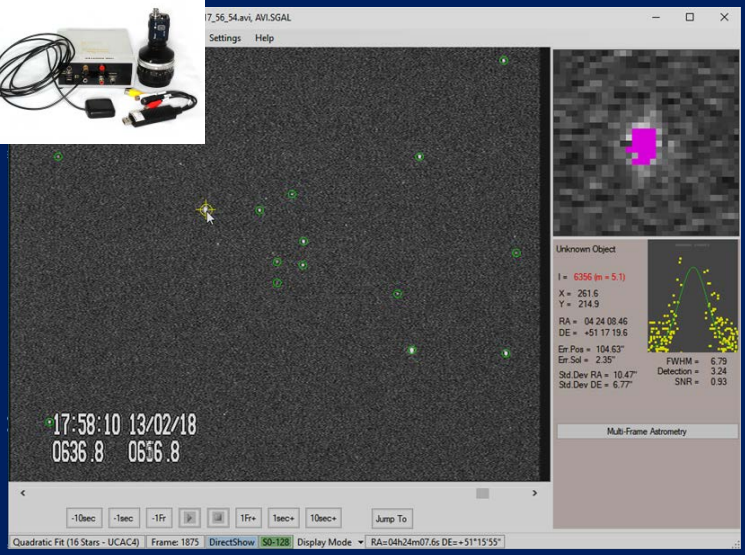
Photography and LLTV Video: Astrometry for orbit determinations

Maintain a catalogue of some 201 orbits not in the public Space-Track catalogue



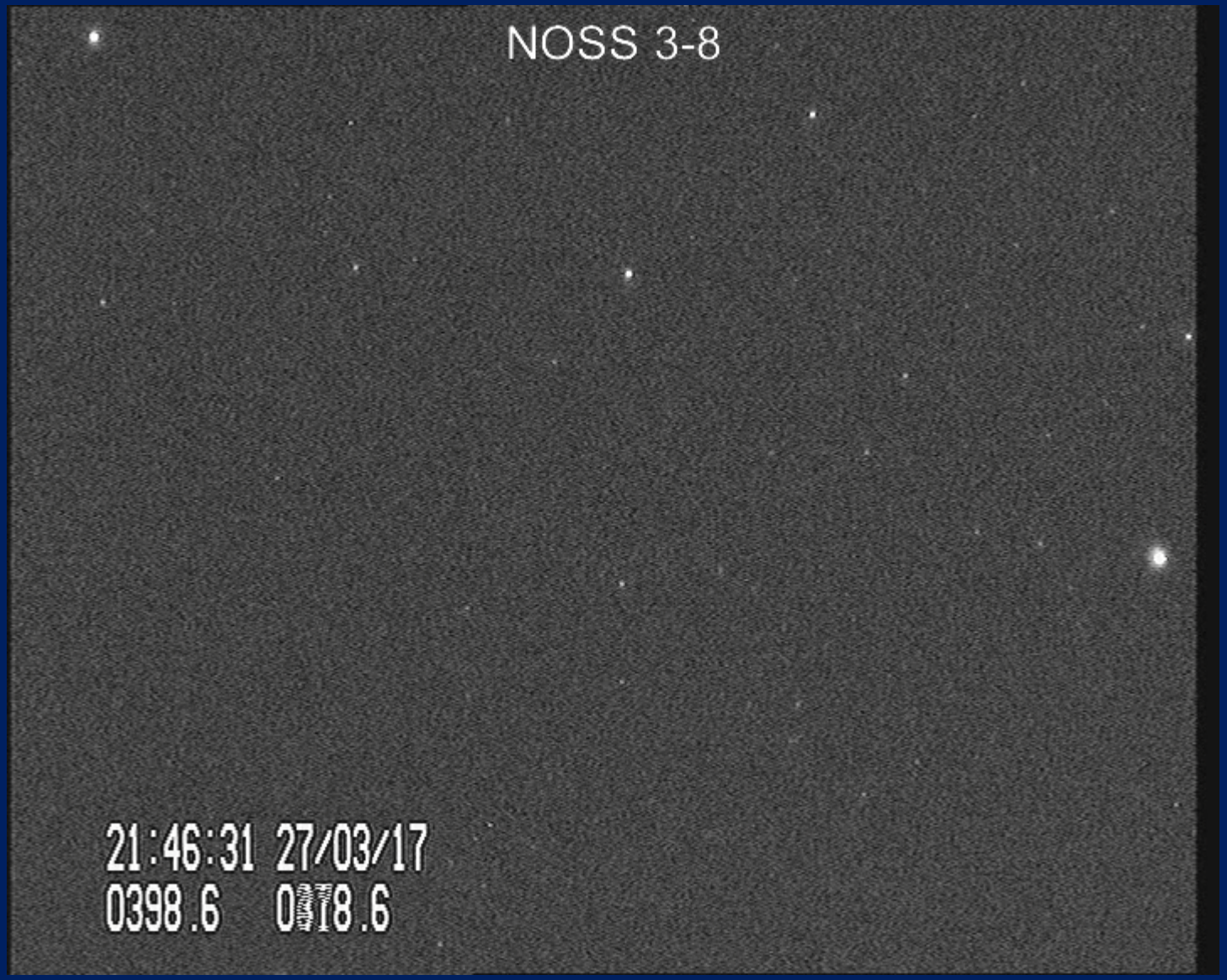






Optical Tracking and Characterization

Low Light Level video: LEO



Optical Tracking and Characterization

photographic: LEO

Optical Tracking and Characterization

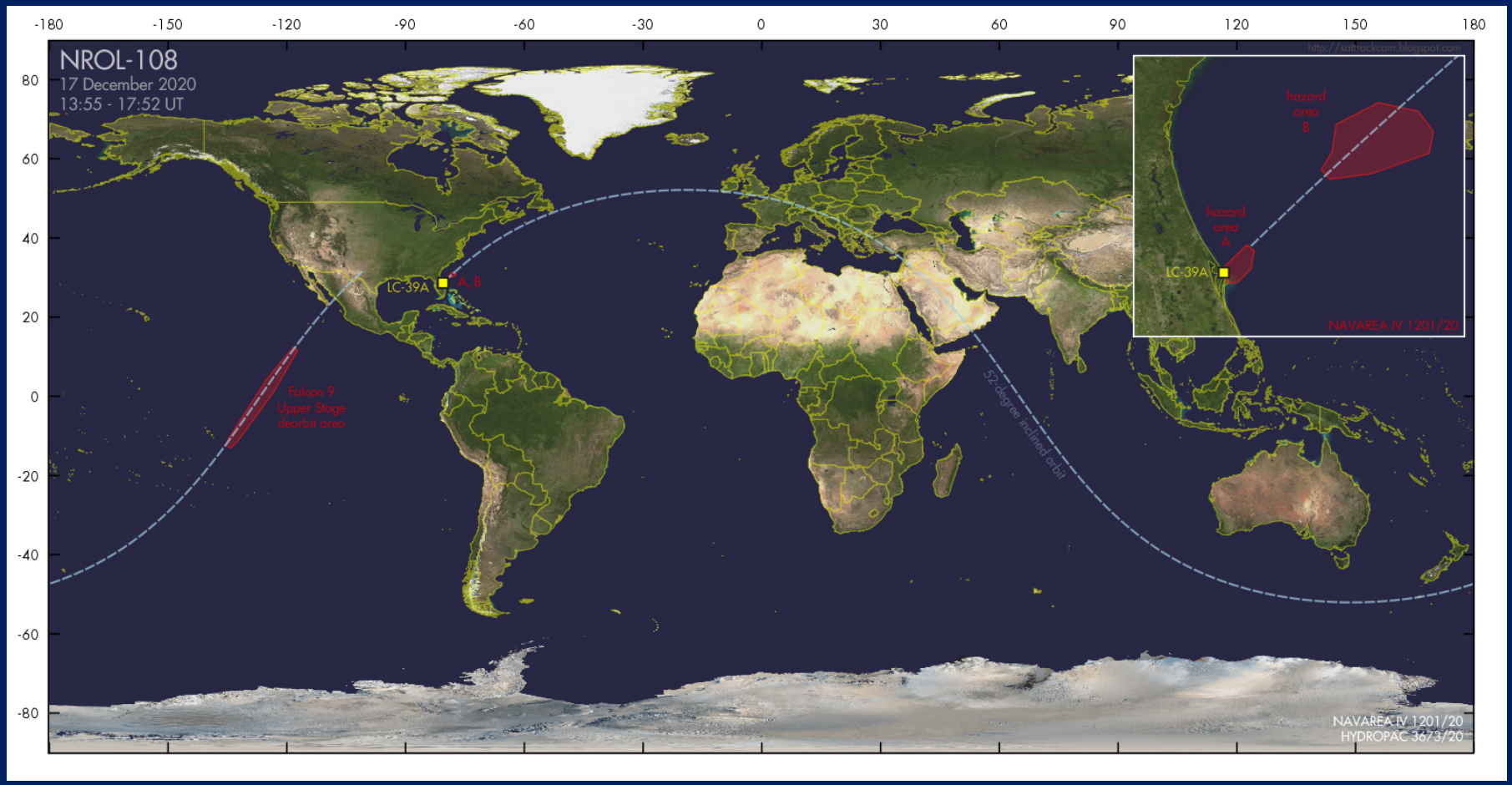
photographic: MEO, HEO

Optical Tracking and Characterization

photographic: GEO

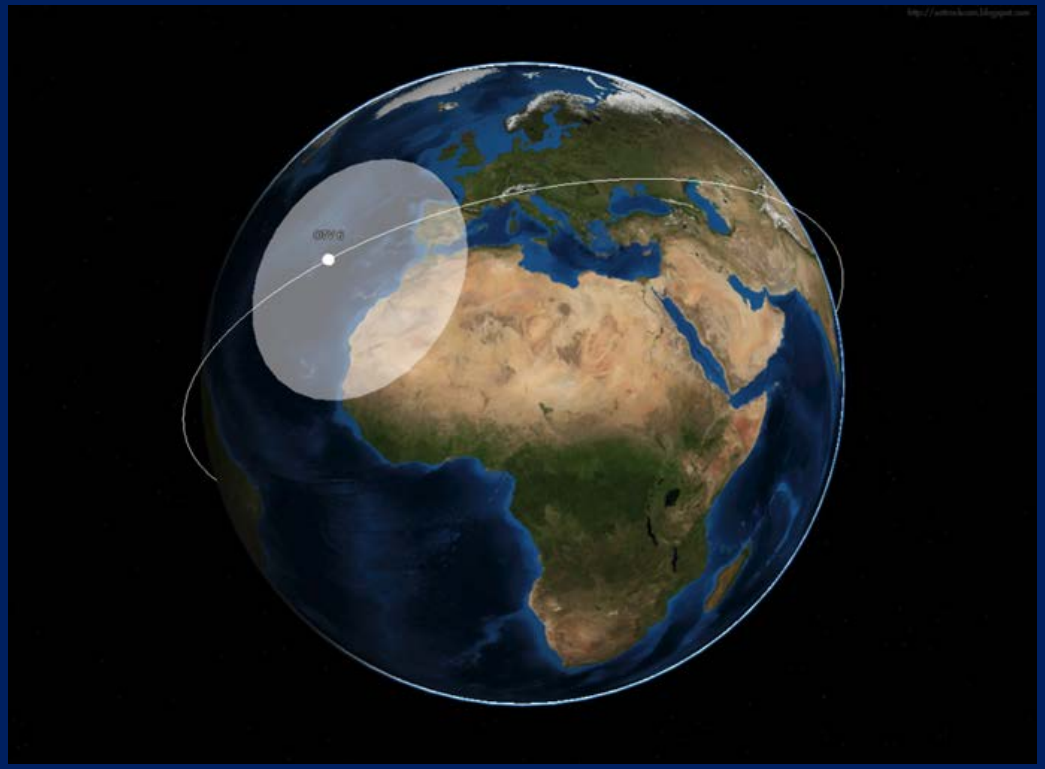
Pre-launch OSINT:

orbital plane and inclination from Navigational Warnings



Using optical data to:

1) Determine orbits
2) Look at type of orbit
3) Look at orbital behaviour
4) Look at photometric behaviour



Orbit type and inclination

Low Earth Orbit

Remote sensing / reconnaissance

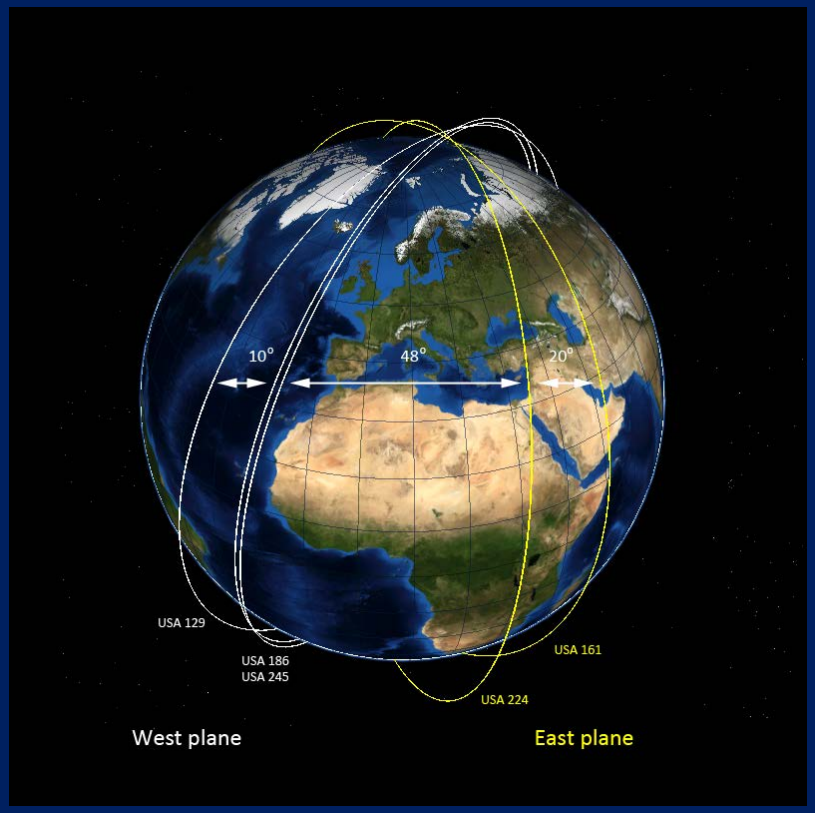
* Polar orbits
* sun-synchronous
* repeating ground track

Radar remote sensing

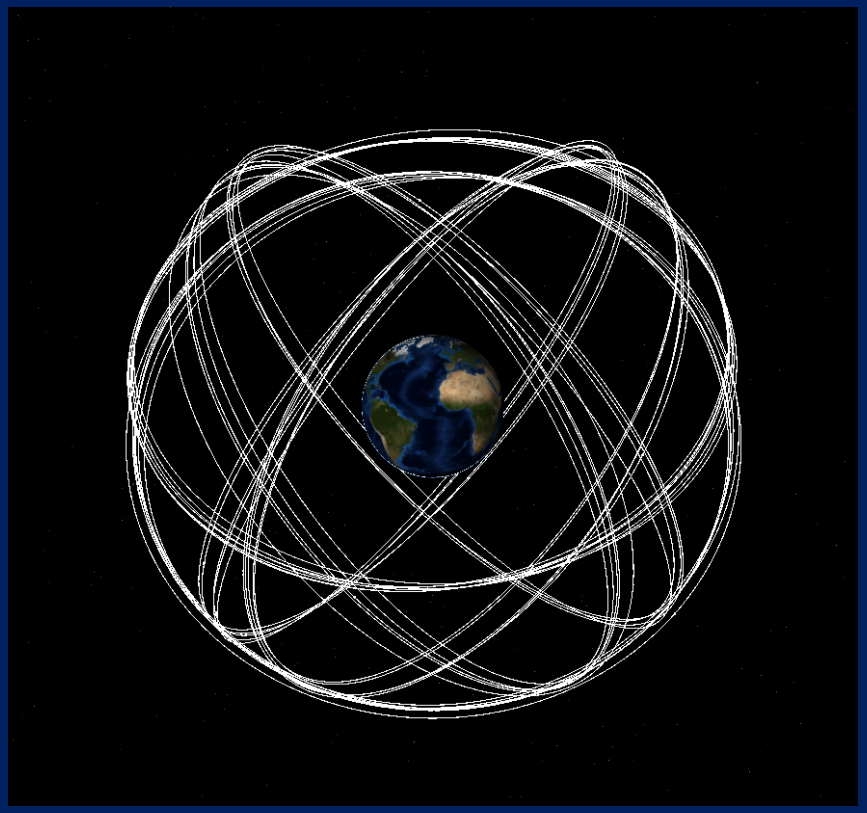
* class in retrograde orbit:
  -radar sensing (SAR)

Orbital behaviour: Constellations

* particular orbital inclinations
* particular orbital altitudes
* particular orbital plane separations



KH-11



NAVSTAR (GPS)

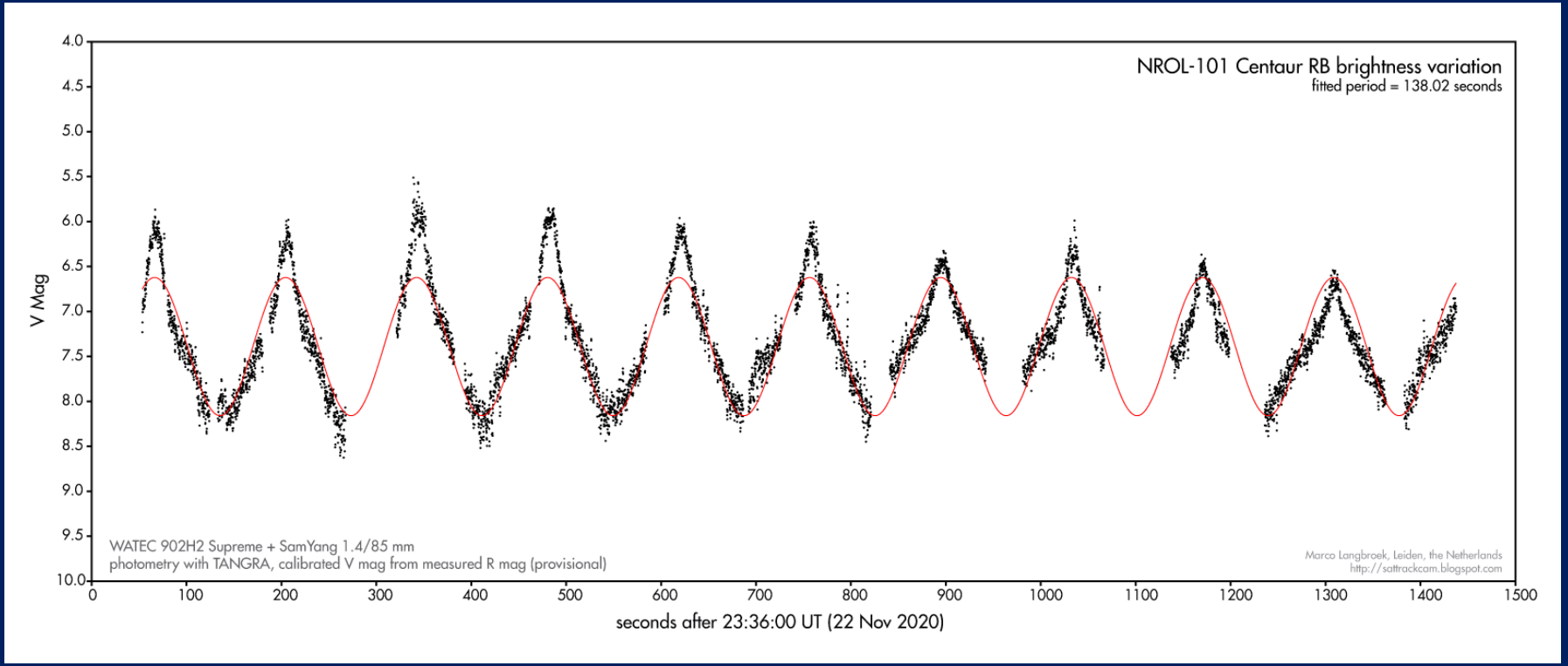
Photometric behaviour

NROL-101 (USA 310) Centaur upper stage

Iridium 33 debris (result of 2009 collison)

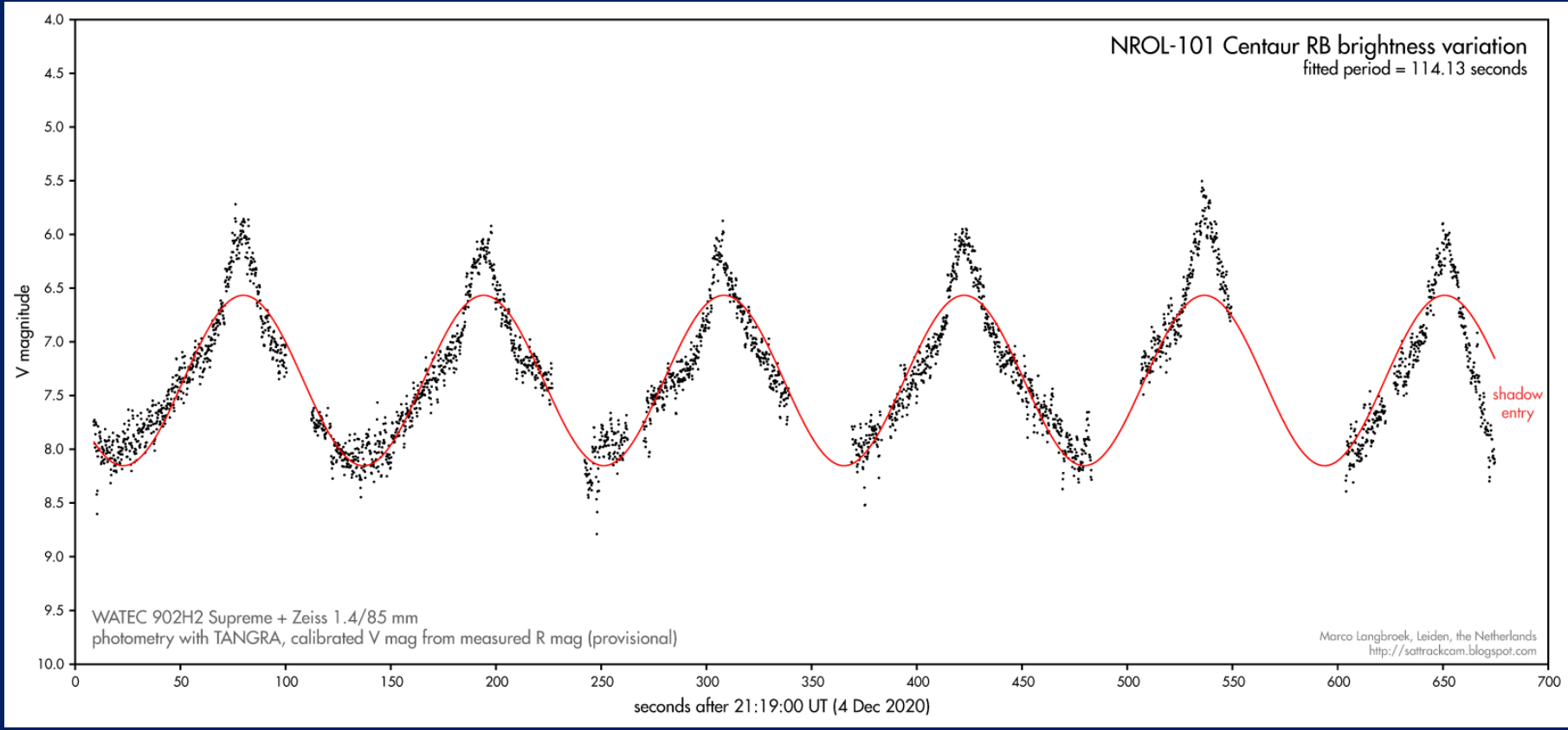
Optical Tracking and Characterization

Low Light Level video: photometric behaviour



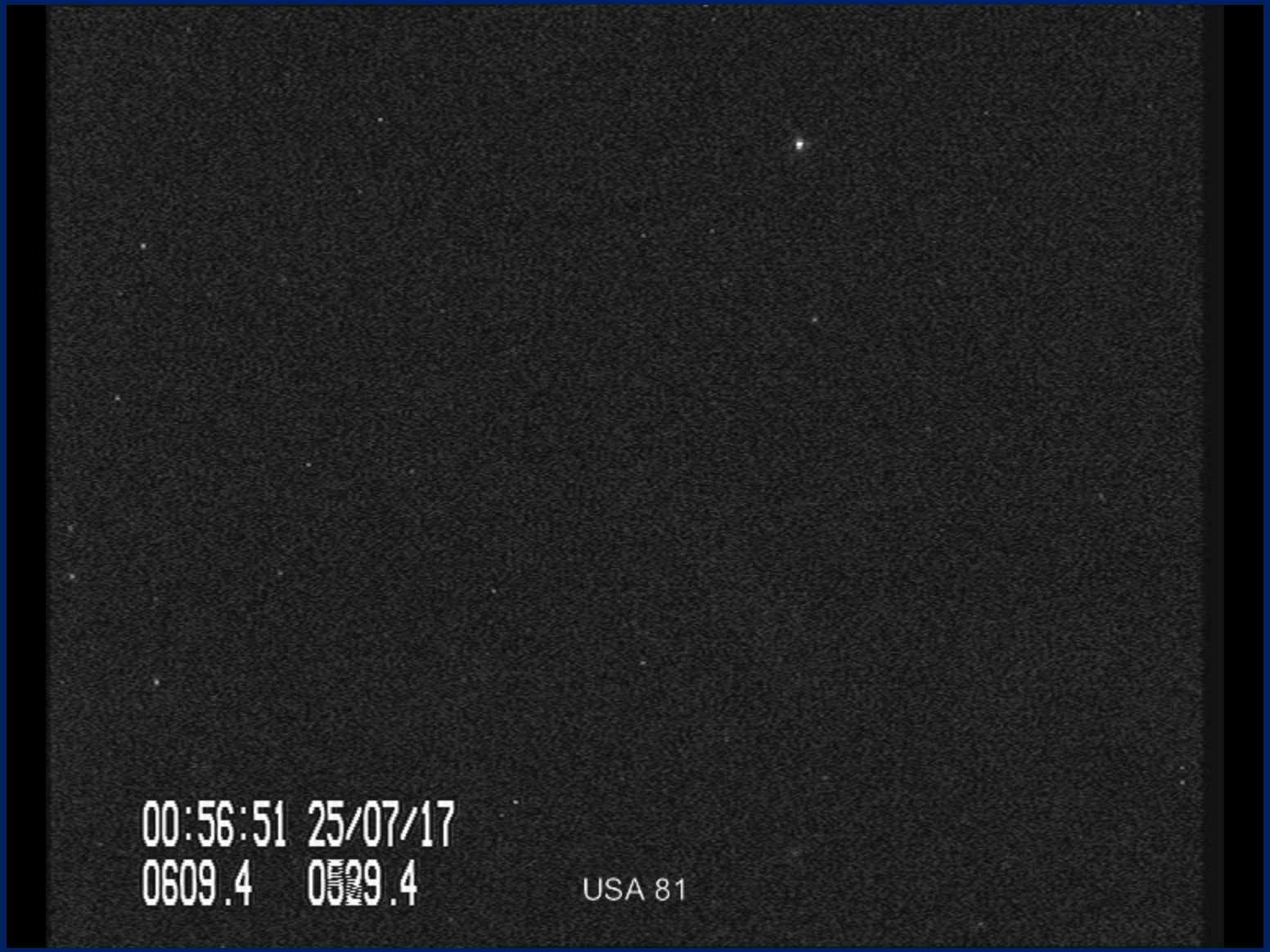
Optical Tracking and Characterization

Low Light Level video: photometric behaviour



Optical Tracking and Characterization

Low Light Level video



USA 81

Optical Tracking and Characterization

Low Light Level video: photometric behaviour

Iridium 33 debris

NROL-10 Centaur upper stage

Tumbling (rocket stages, defunct payloads, malfunctioned payloads)

Spin stabilization (operational payloads)

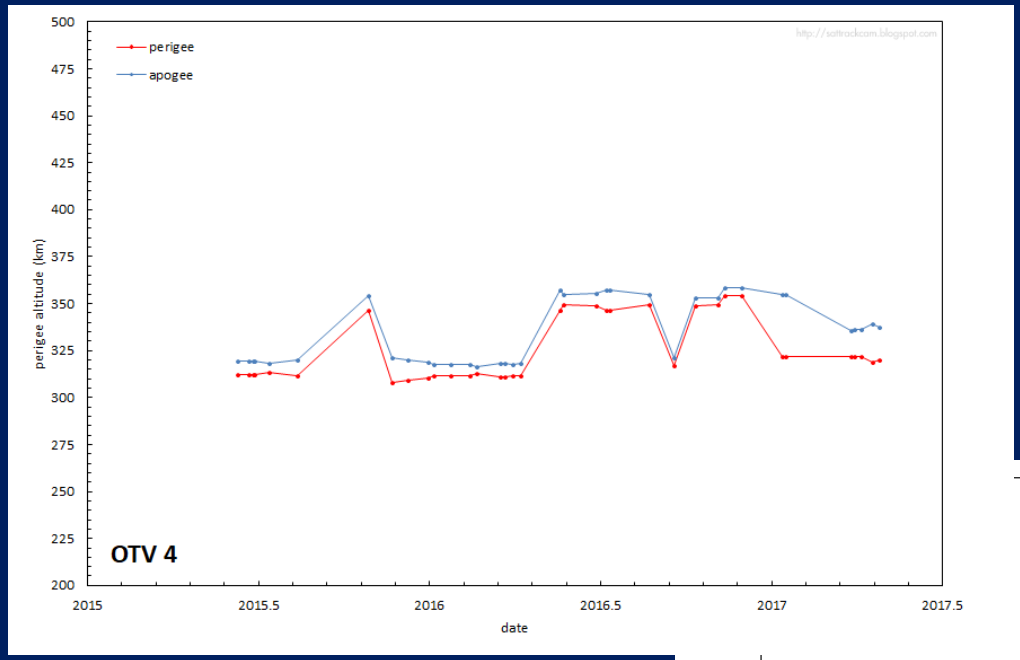
Shape (operational payloads): flares due to reflective surfaces, e.g. solar- or antenna panels

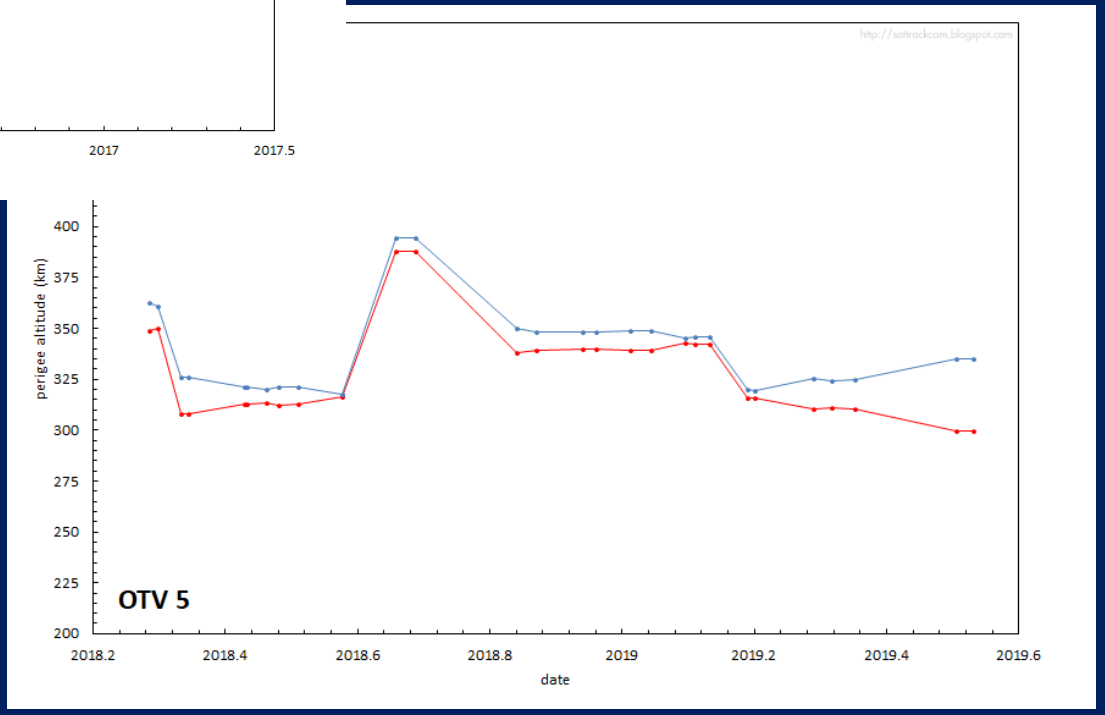
Optical Tracking and Characterization

Orbital behaviour

Optical Tracking and Characterization

orbital behaviour

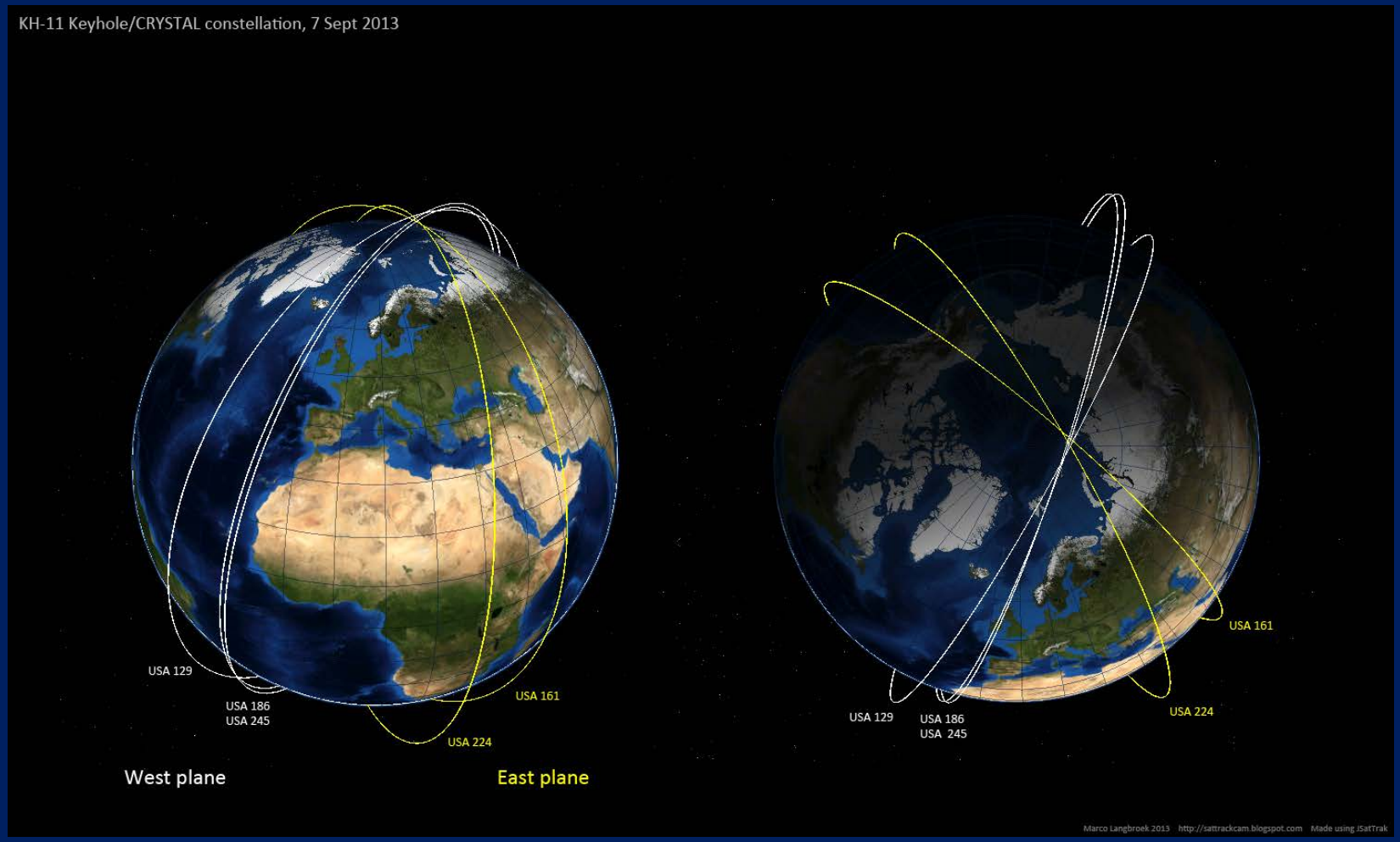




Optical Tracking and Characterization

orbit type and orbital behaviour

KH-11 ‘IMPROVED ENHANCED CRYSTAL’



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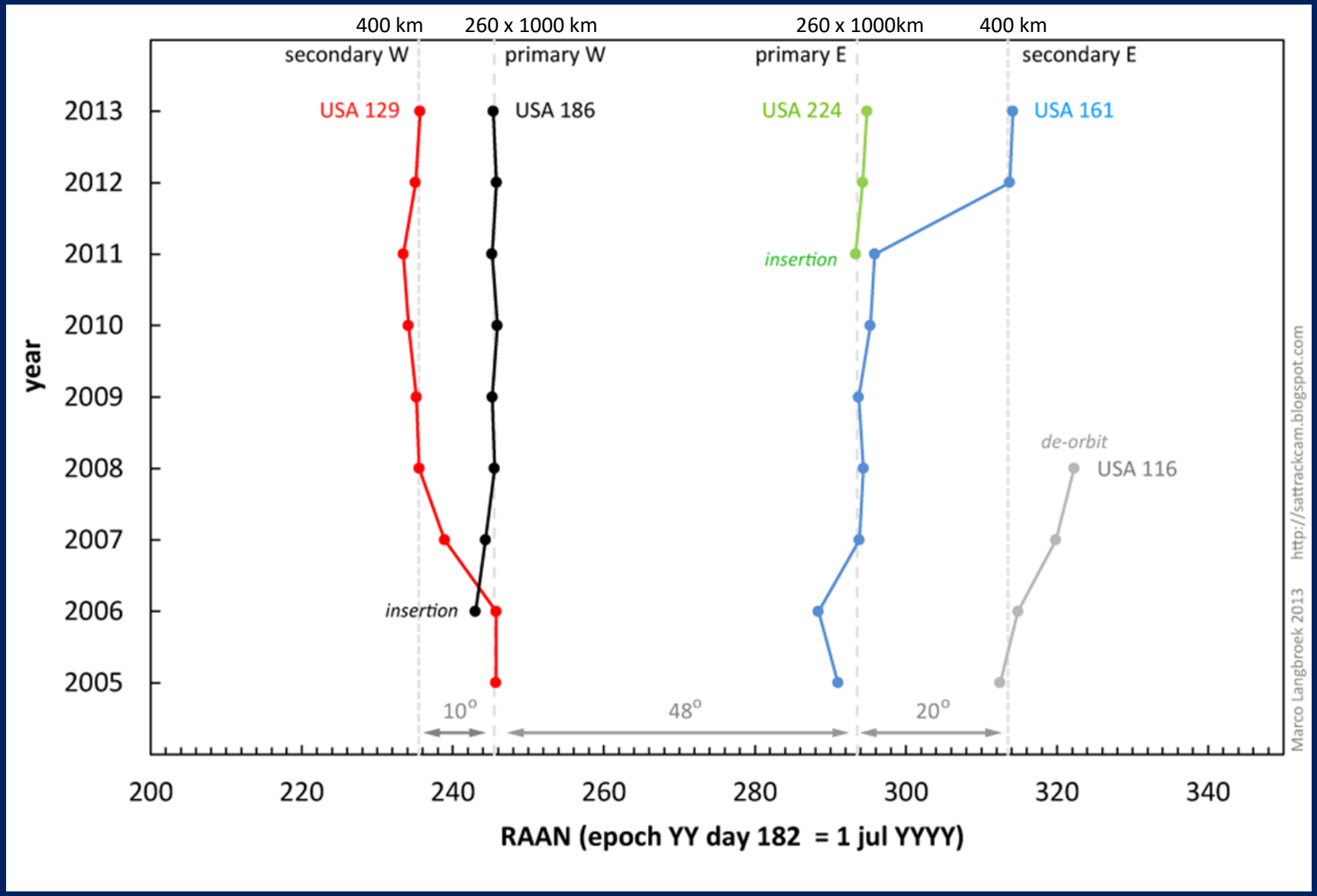
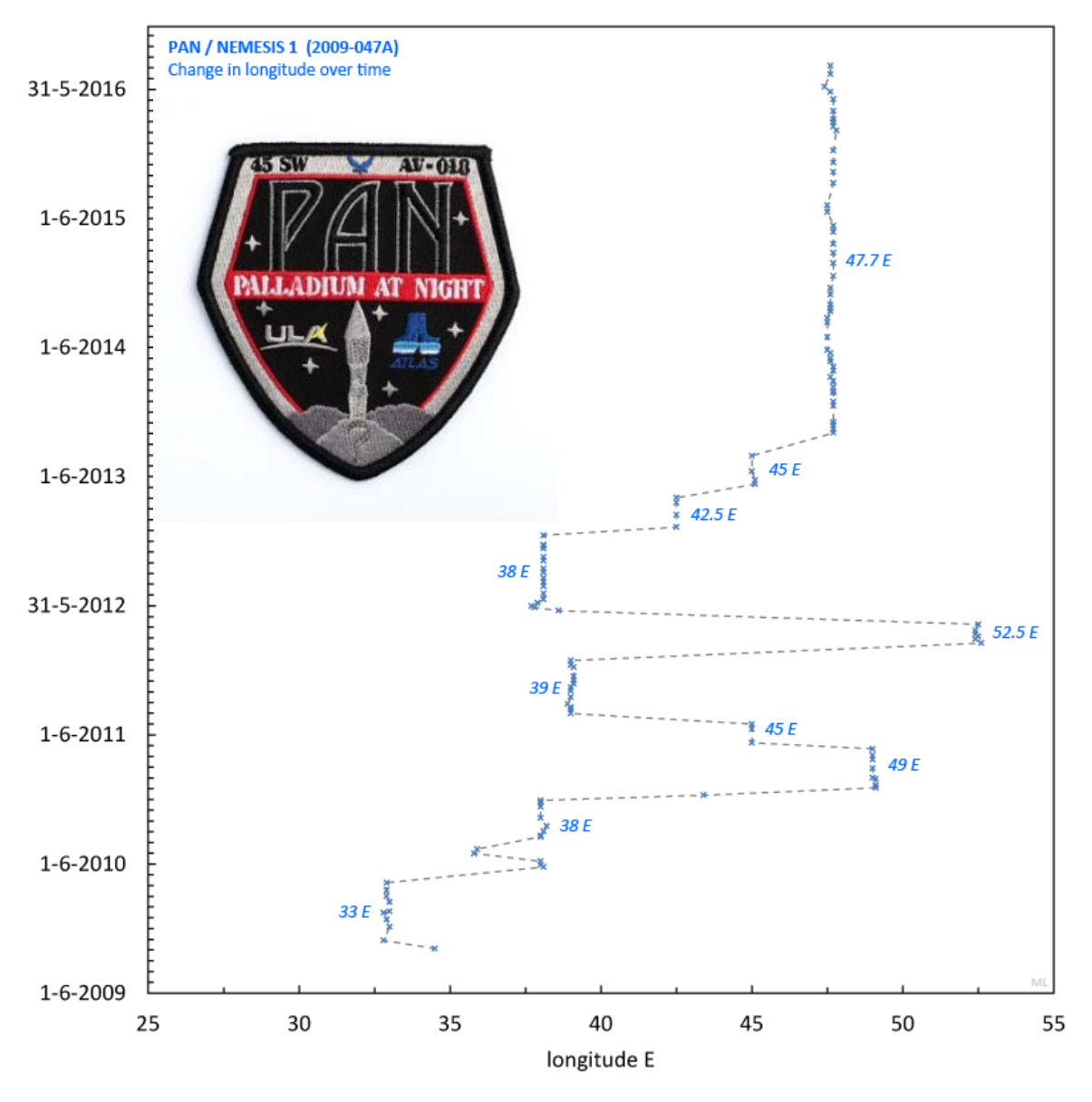
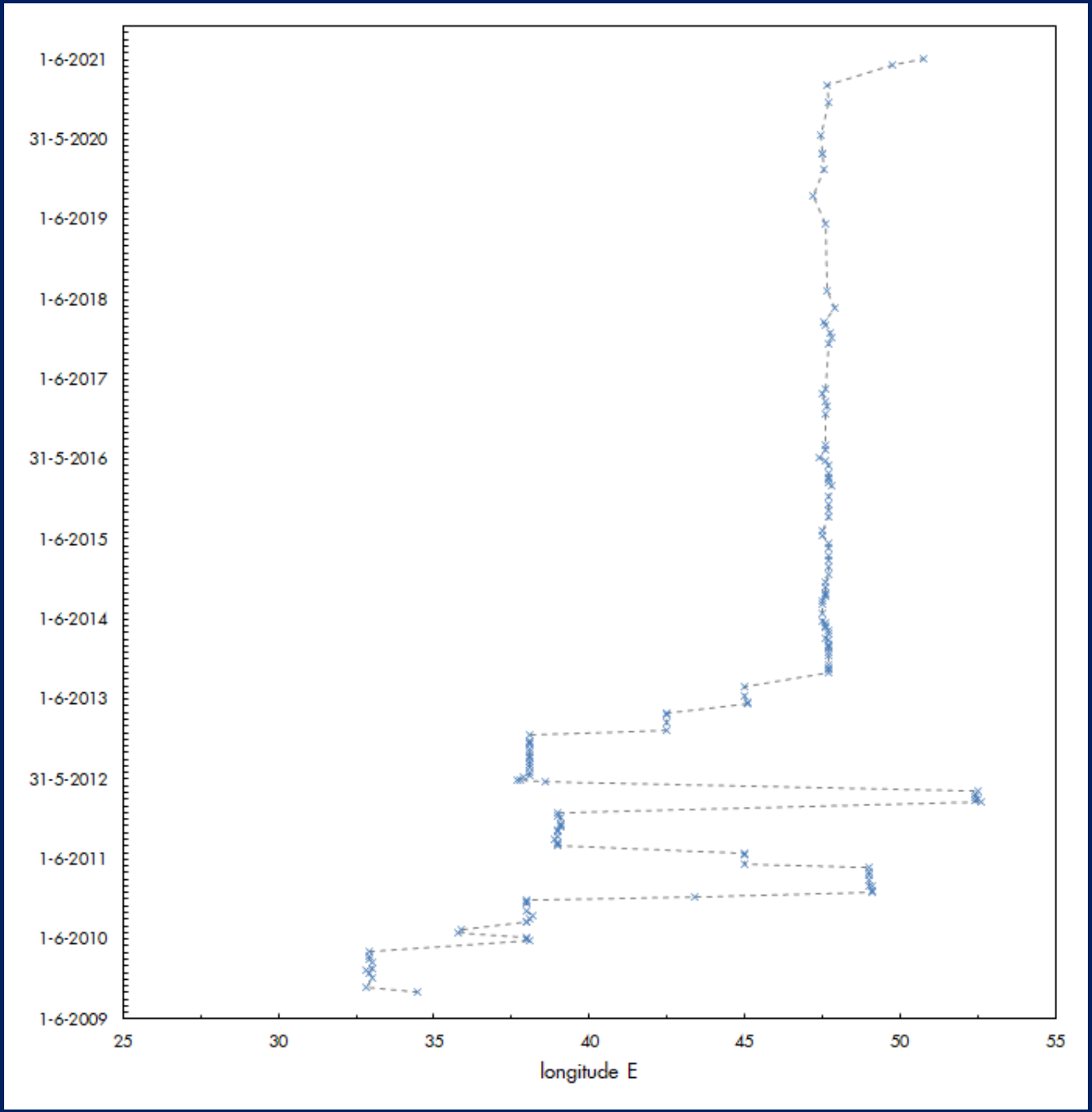


CASE STUDY: Orbital Behaviour




1-6-2021
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longitude E

Optical Tracking and Characterization

Orbital behaviour

Optical Tracking and Characterization

Orbital behaviour

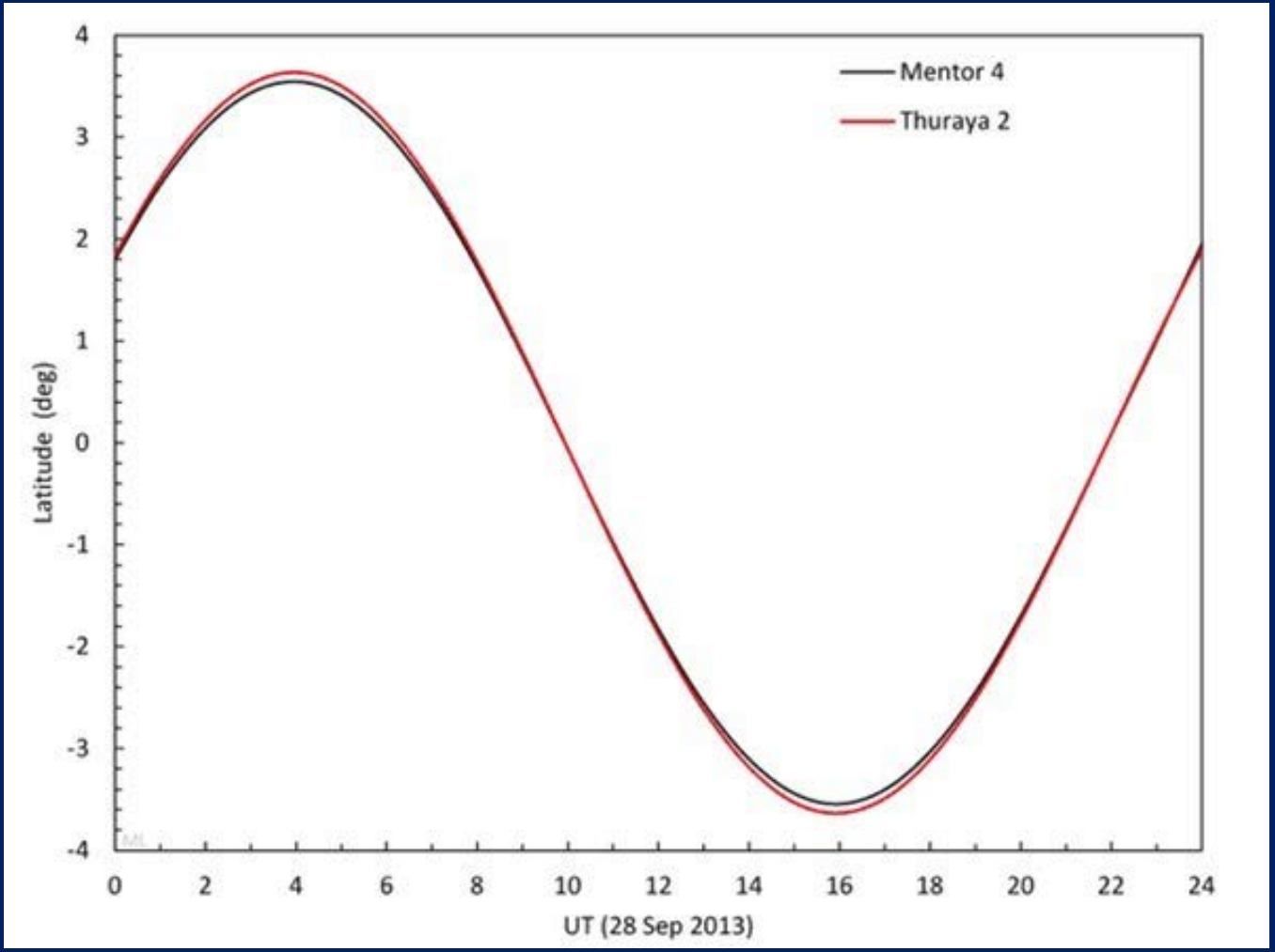
PAN (NEMESIS I)

Mentor 4 (ADVANCED ORION 4)

Launched in the same year (2009)

Optical Tracking and Characterization

Orbital behaviour



Optical Tracking and Characterization

Orbital behaviour

TOP SECRET//COMINT/TALENT KEYHOLE//REL TO USA, AUS, GBR

SID today

January 2009

(S//SI//REL TO USA, FVEY) Two New Collection Assets to Greatly Expand MHS Target Coverage

By: (U//FOUO) [redacted], Menwith Hill Station (F77)

(TS//SI/TK//REL) Menwith Hill Station will accept two new satellites in 2009 – an ORION spacecraft [redacted] and a NEMESIS spacecraft [redacted]. The arrival of these new vehicles will give MHS greater flexibility in missions, surveys, and signals development efforts and provide opportunities for collection, discovery, and sharing. [redacted] will also provide the Intelligence Community with an opportunity to use Overhead in a non-traditional way for a FORNSAT SIGDEV mission.

(S//TK//REL) [redacted]
(TS//SI/TK//REL) [redacted] currently has a launch date of 13 January 2009. After launch, Alice Springs Mission Ground Station will control [redacted] as it deploys and drifts westward, with MHS gaining control 59 days later.

(S//TK//REL) MHS will perform testing and verification before putting the spacecraft into full operations. If the current launch date stands, [redacted] will be fully operational sometime around mid May 2009. (Click HERE for larger image.)

(TS//SI/TK//REL) [redacted]'s initial mission is a survey of the People's Republic of China (PRC) line-of-sight microwave towers and emitters. [redacted] will survey the area drifting from [redacted] east for approximately 30-45 days. At [redacted] east, [redacted] will pick up its new primary mission from [redacted]: Thuraya collection and Afghanistan/Pakistan exfiltration.

(TS//SI/TK//REL) After spacecraft [redacted] transfers the Thuraya mission to [redacted], [redacted] will drift 0.1 degree a day west, continuing the PRC survey for approximately 200 more days. After completion of the PRC survey, [redacted] will take on a new mission targeting Latin America, Middle East and North Africa, greatly expanding MHS's target and coverage area.

TOP SECRET//COMINT/TALENT KEYHOLE//REL TO USA, AUS, GBR

Optical Tracking and Characterization

Orbital behaviour

(S//TK//REL) [redacted]

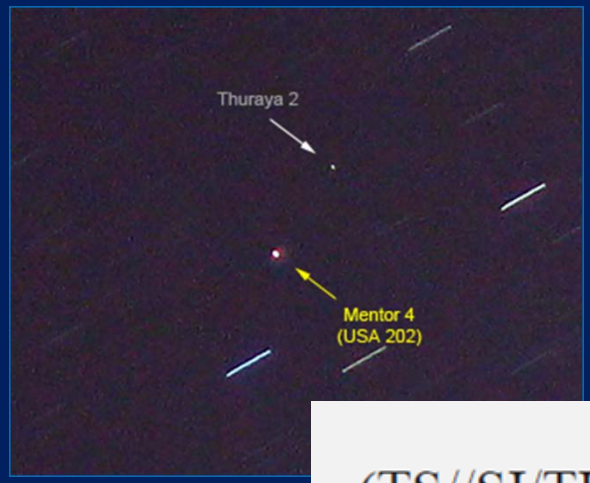
(TS//SI/TK//REL) Currently, [redacted] has a launch date of 11 April 2009. [redacted]'s mission will be Foreign Satellite (FORNSAT) collection from space – targeting commercial satellite uplinks not normally accessible via conventional means. [redacted] will provide the Office of FORNSAT a "site in the sky" when denied a site on the ground for collection. Ground processing equipment is being put in place at MHS that can cover both drift/dwell and sustained collection.

(S//TK//REL) MHS expects to have full operations on [redacted] 85 days after launch. (Click HERE for larger image.)

(TS//SI/TK//REL) The arrival of [redacted] and [redacted] at MHS will open up new opportunities for discovery and will enhance collection efforts for the intelligence community into areas not previously explored.

Optical Tracking and Characterization

Orbital behaviour



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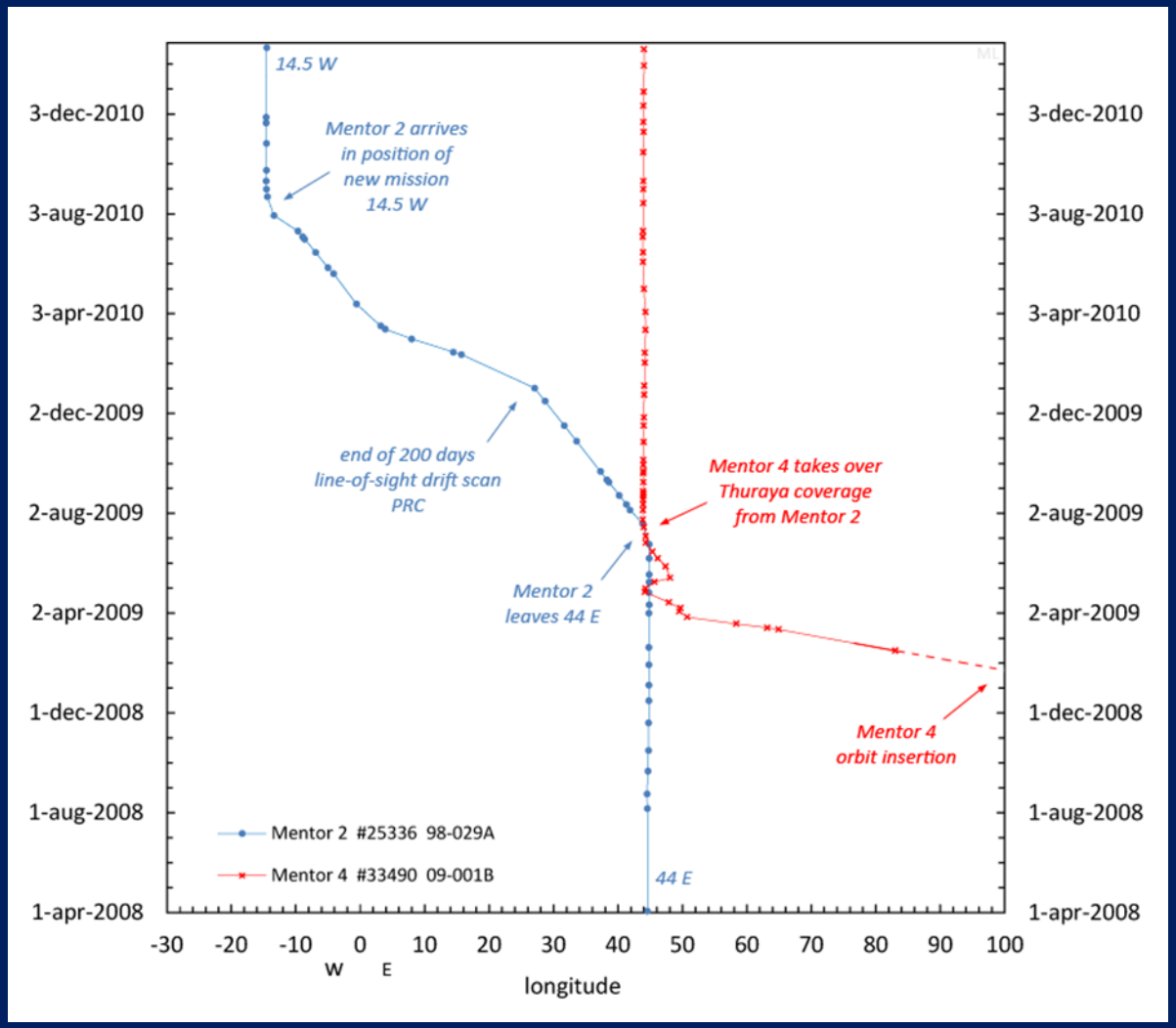
Optical Tracking and Characterization

Orbital behaviour

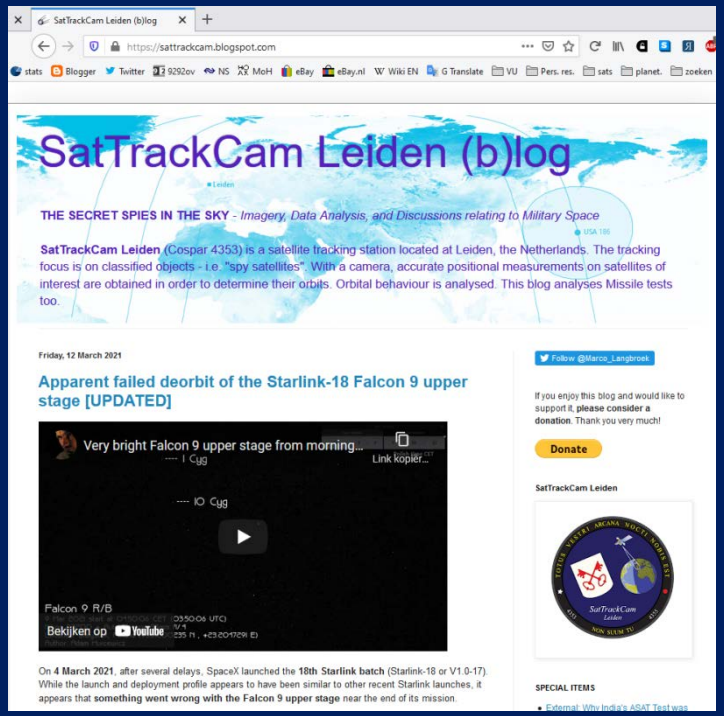


M. Langbroek:

A NEMESIS in the Sky. PAN, Mentor 4, and Close Encounters of the SIGINT kind

The Space Review, 31 Oktober 2016

http://www.thespacereview.com/article/3095/1



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