Astrodynamics and the First Cubesat Launcher

Drazen Svehla

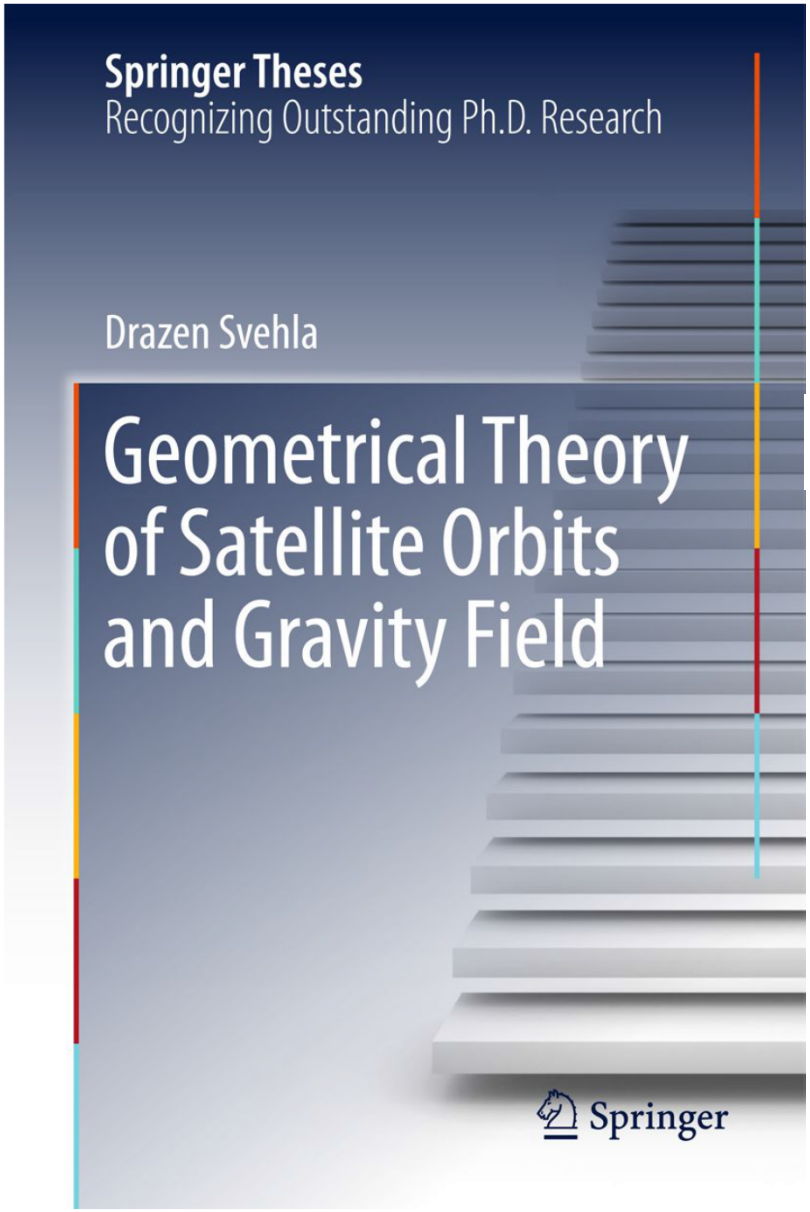
1st Adria Space Conference, October 3-4, 2019, Zagreb, Croatia

Content

- Space Geodesy
- Satellite Missions in the LEO Orbit

- Cubesat Launcher
- Engineering model
- E2E Simulation

Springer Book on Space Geodesy



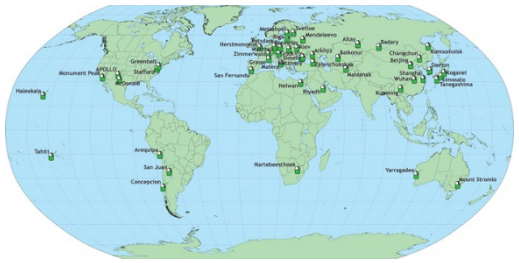
537 pages on high-precision GNSS (2018)

cm-accurate positioning in space - from LEO up to the Lunar orbit

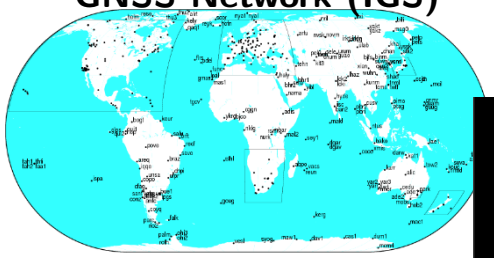
Space Geodesy

Terrestrial Reference Frame
(ITRF2014)

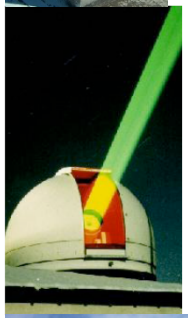
VLBI Network (IVS)

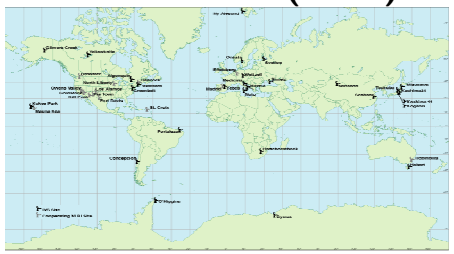


GNSS Network (IGS)



SLR Network (ILRS)

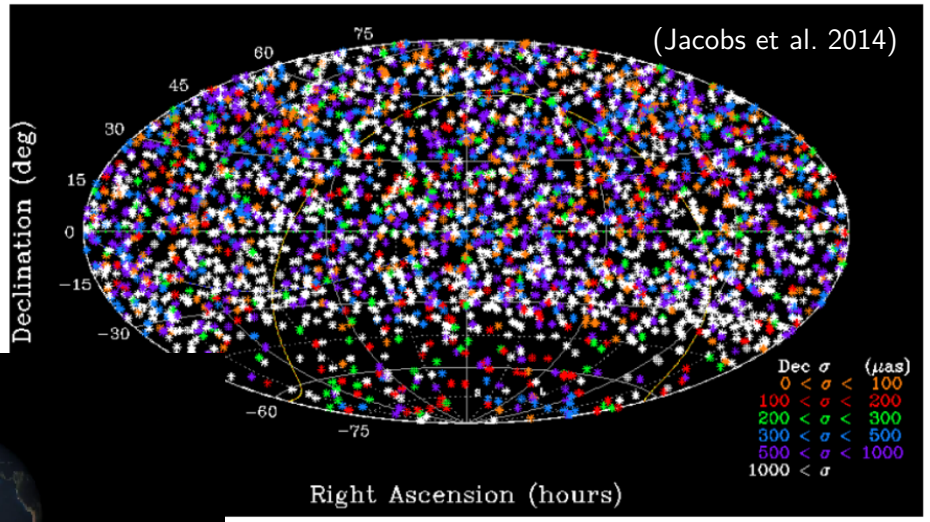


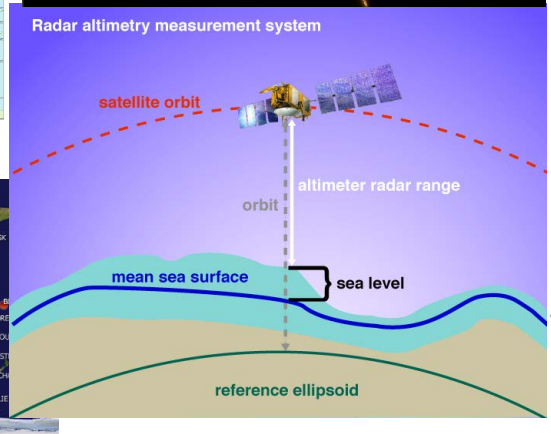


DORIS Network (IDS)

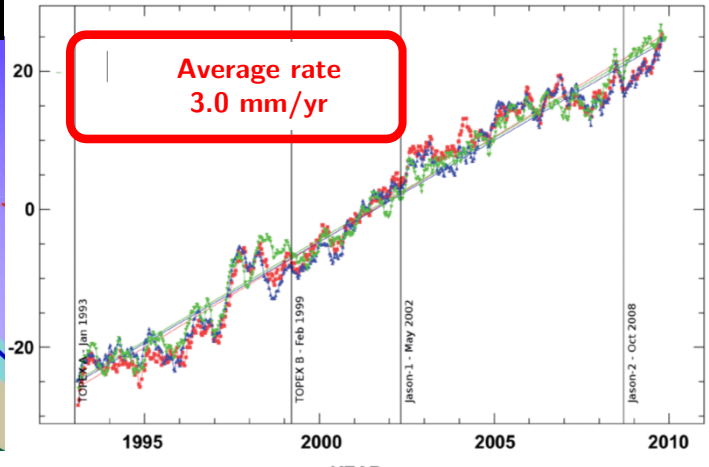
Celestial Reference Frame
(ICRF-2)

S/X-band (2/8 GHz) ICRF-2

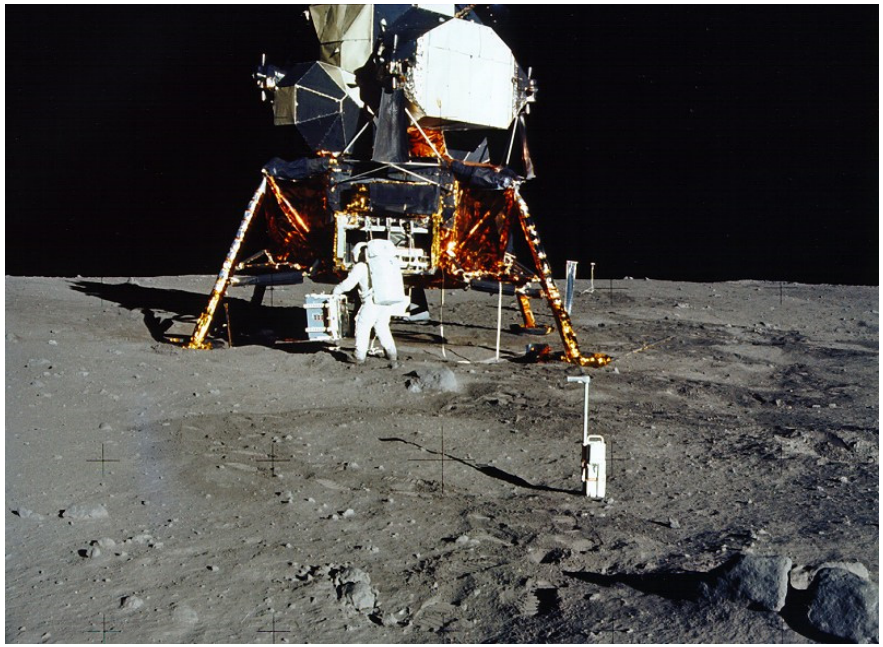


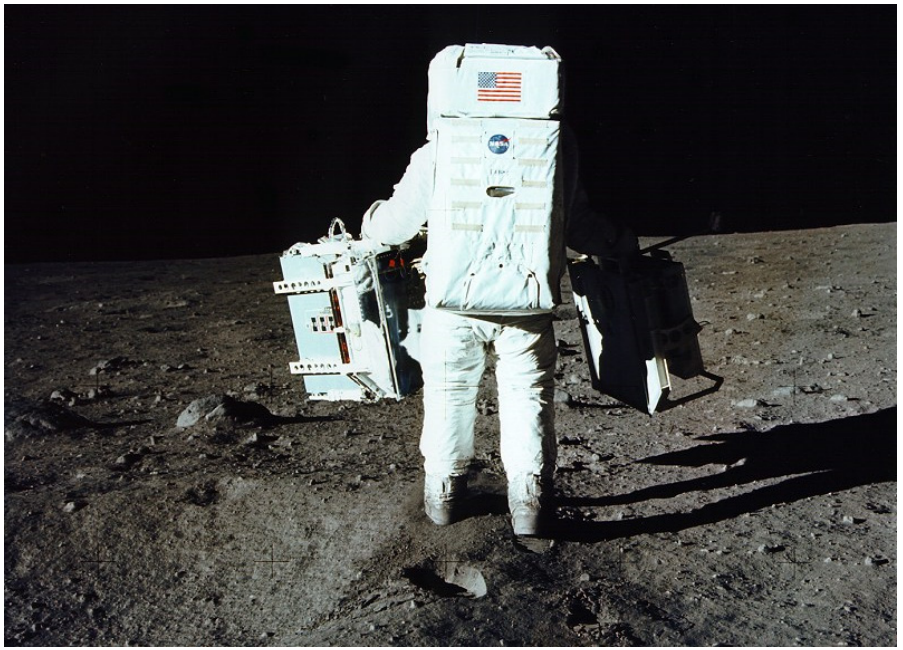


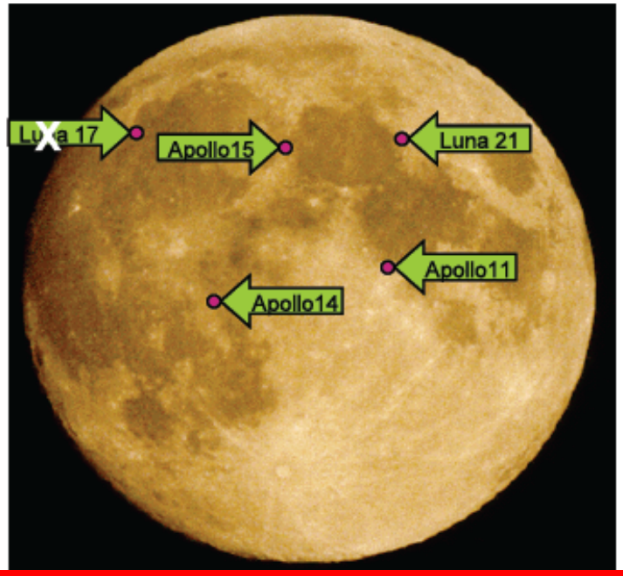
Mean Sea Level Rise



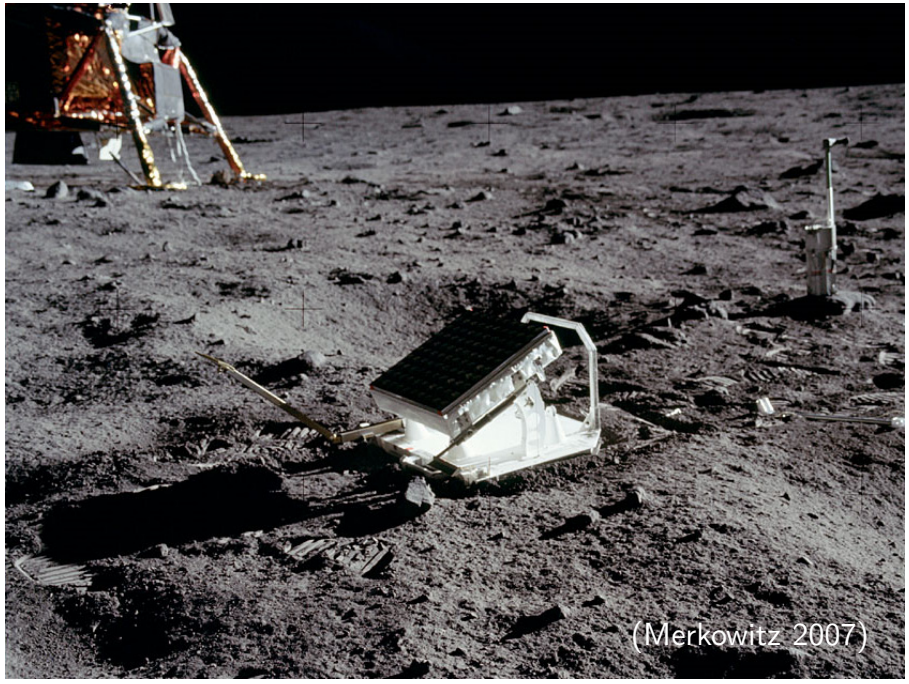
Lunar Geodesy: Lunar Laser Ranging



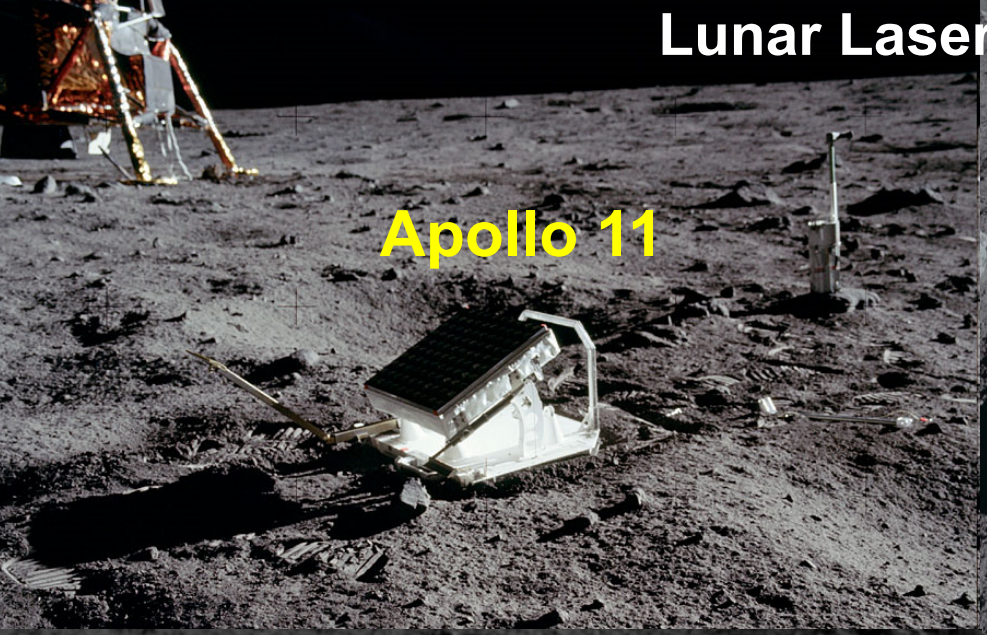


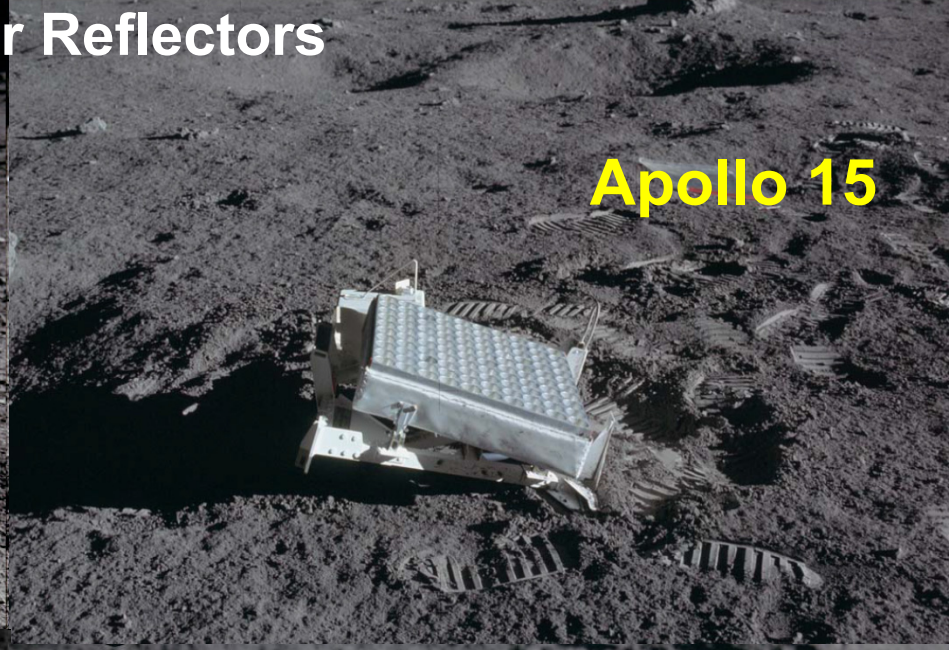


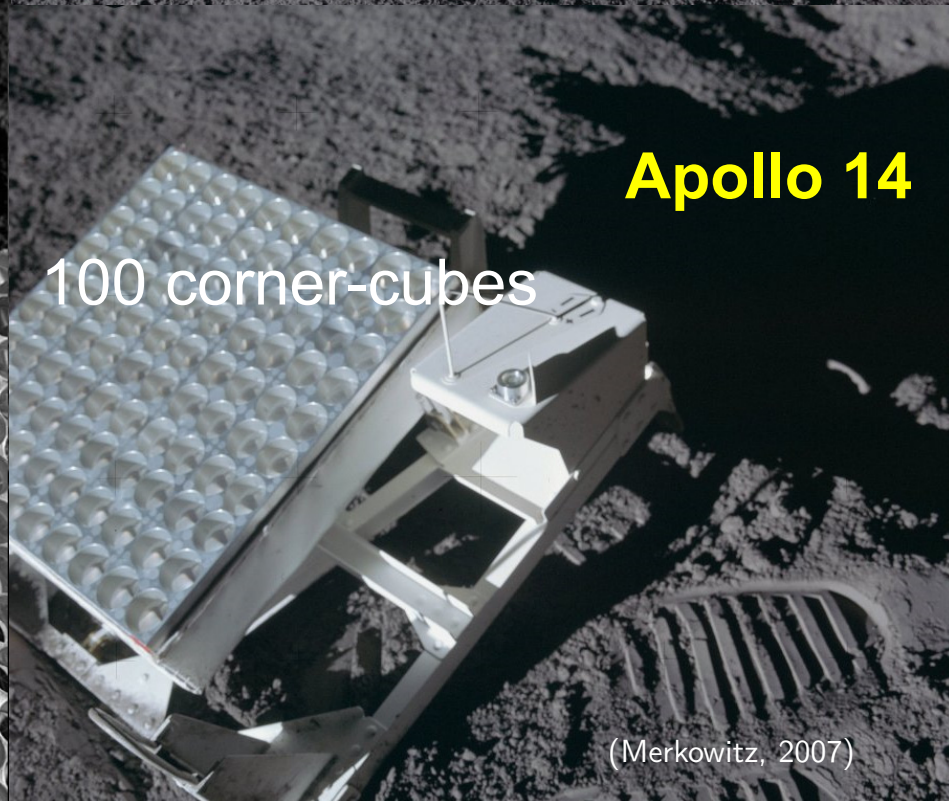
Due to the tides, Moon-Earth distance is increasing at a rate of 3.8 cm/yr



Lunar Laser Reflectors

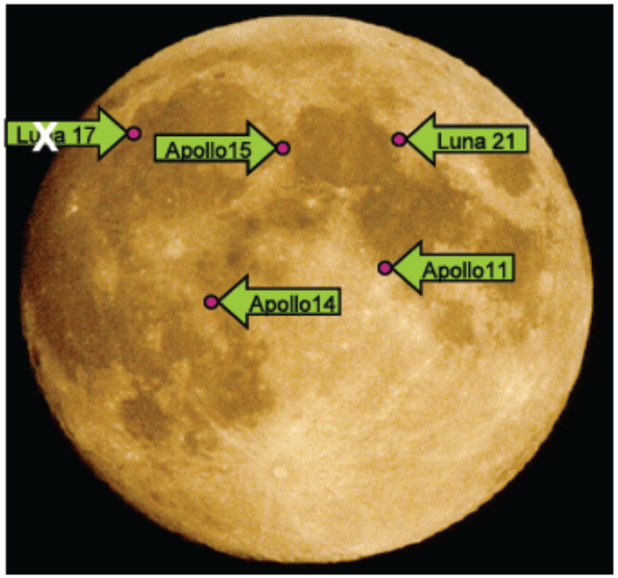


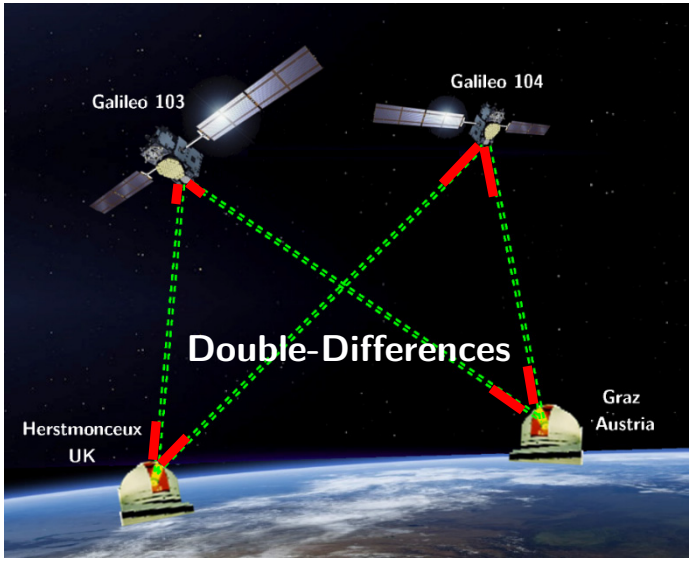


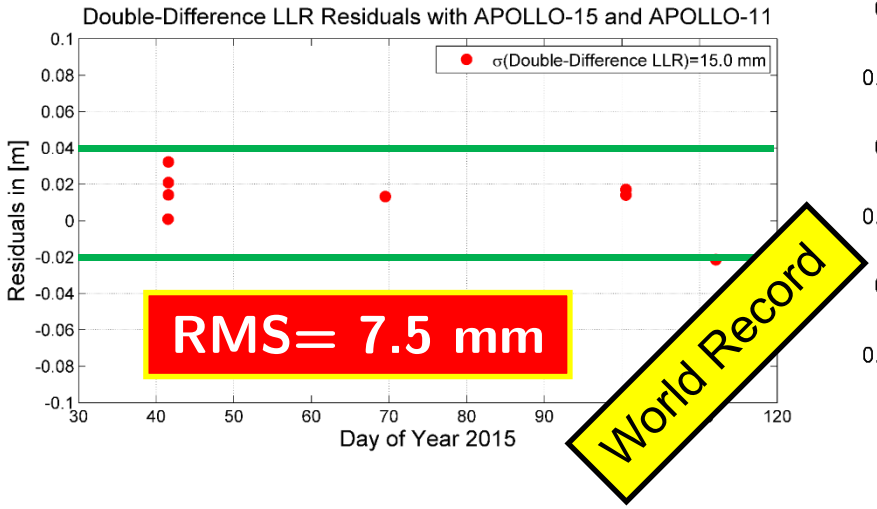


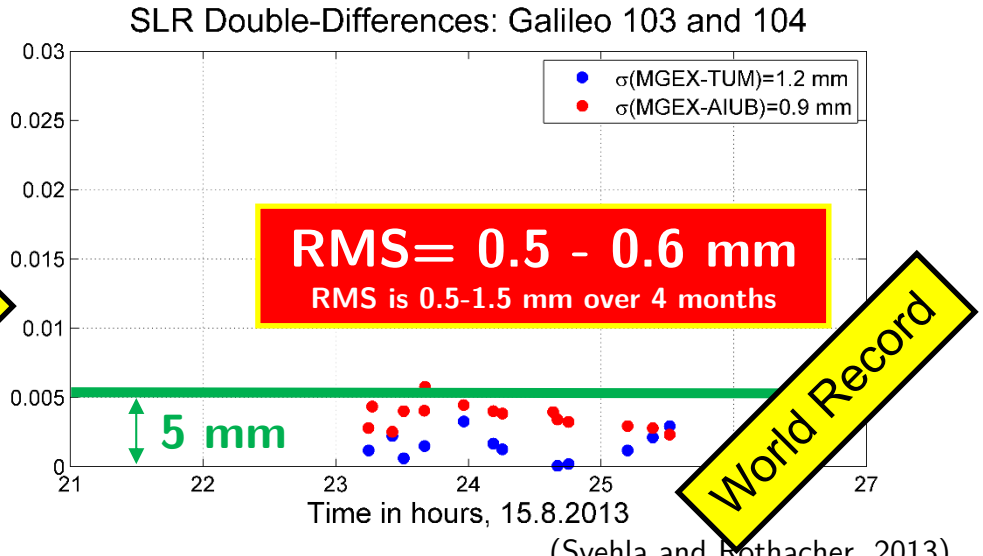
(Merkowitz, 2007)

Lunar and Satellite Laser Ranging







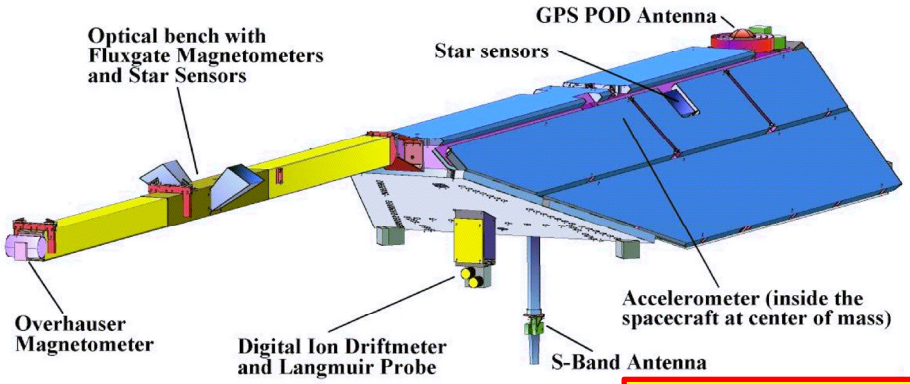


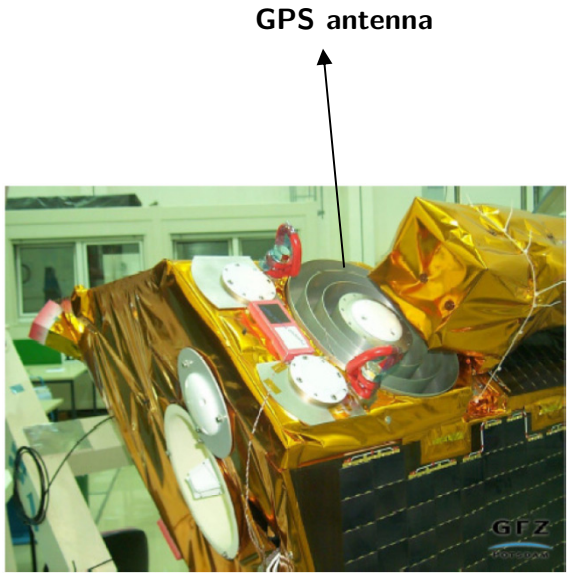
(Svehla and Rothacher, 2013)

GPS and Earth Observation

CHAMP satellite

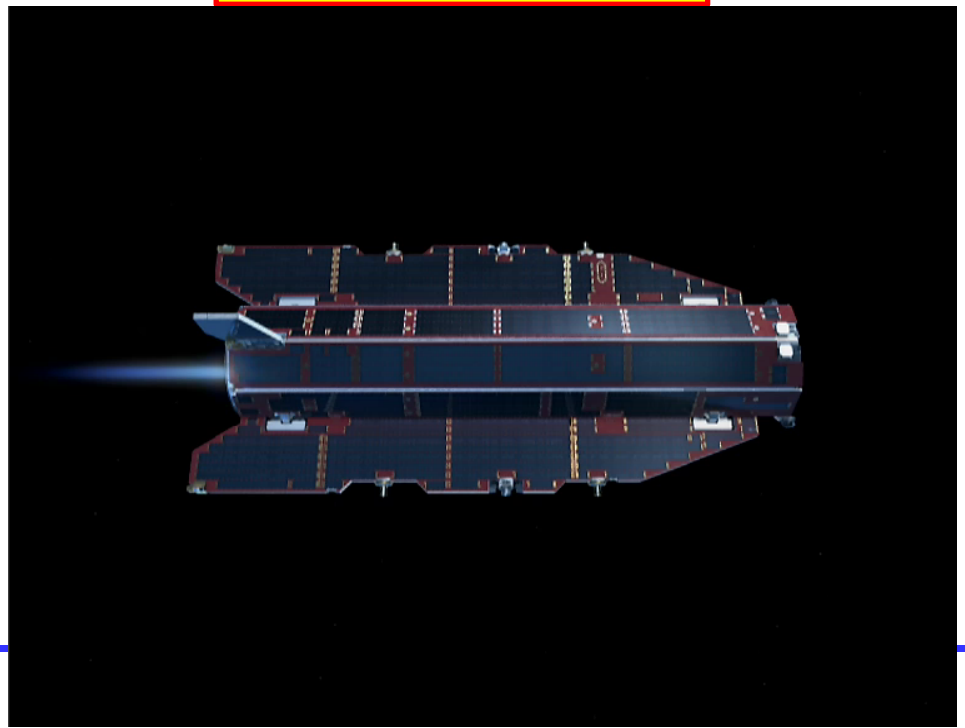
Altitude 400 km



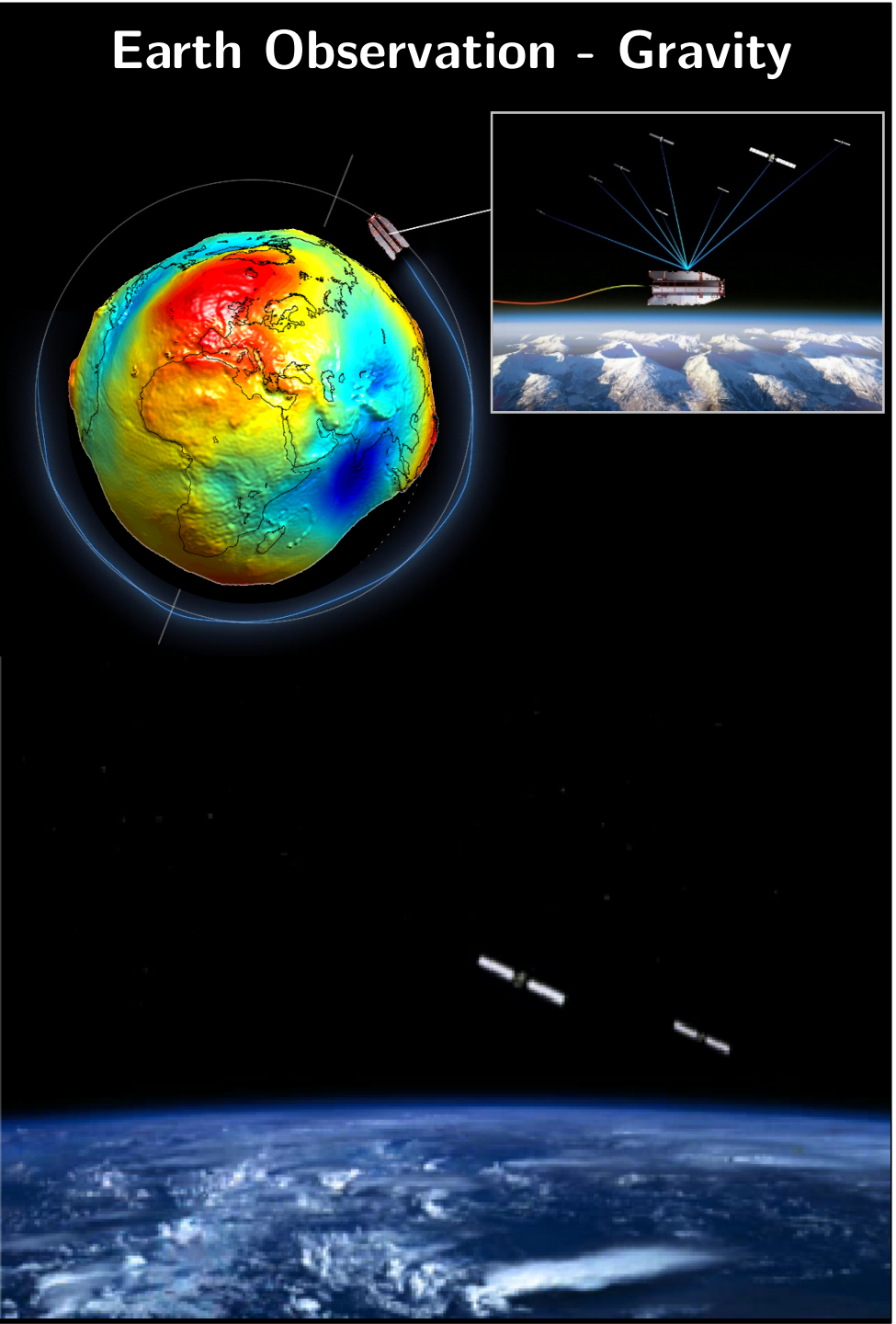


GOCE satellite

Altitude 220 km

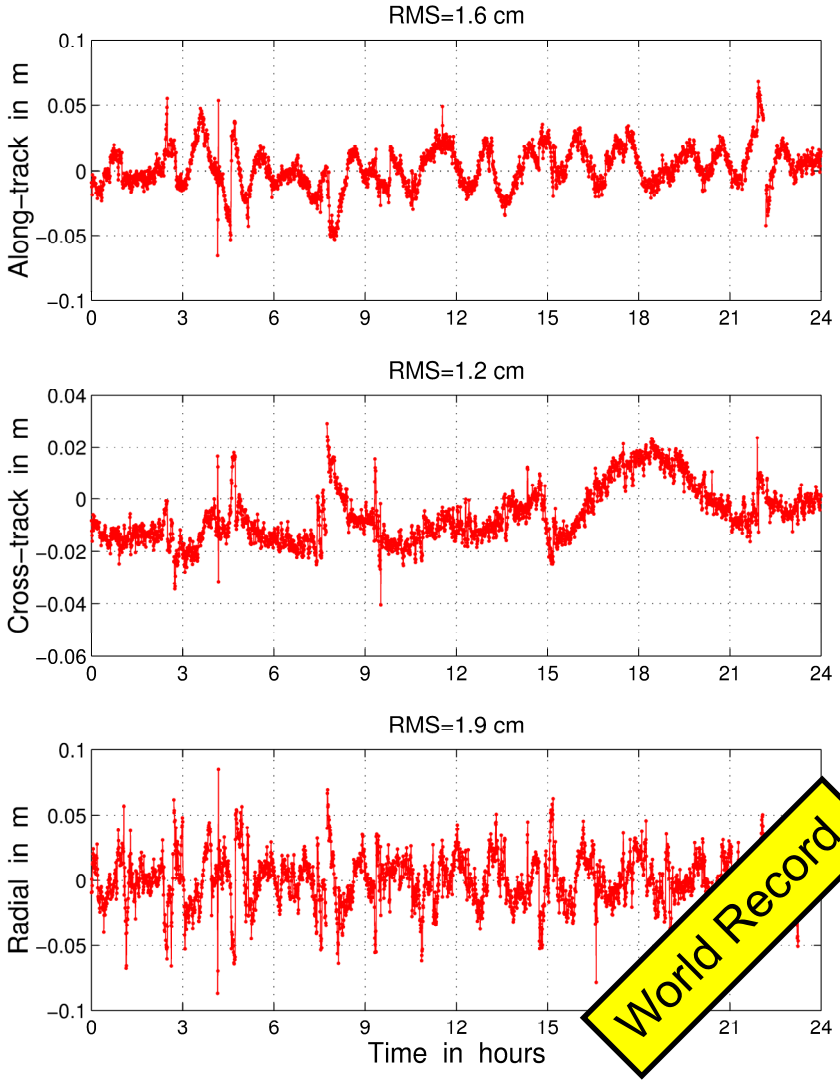


Earth Observation - Gravity

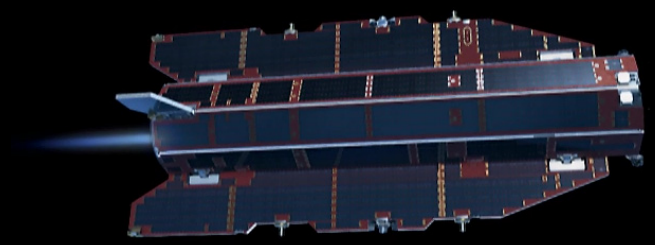


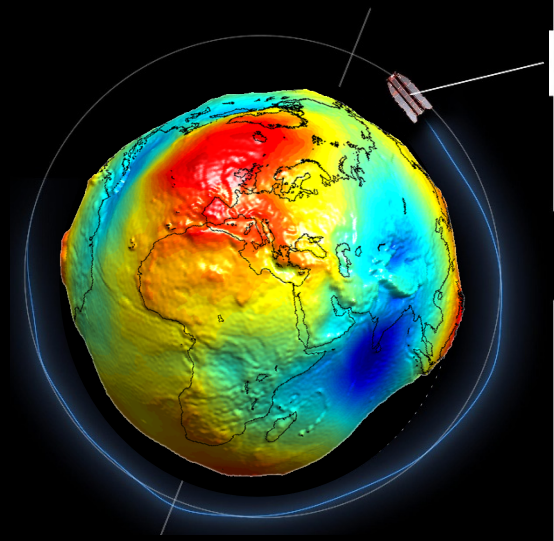
Orbit of CHAMP Satellite Based on GPS

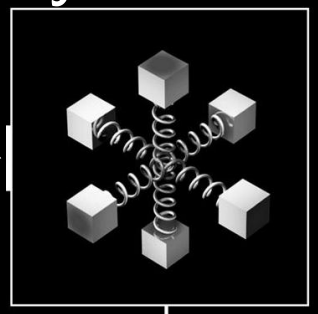
(Svehla and Rothacher, 2003)



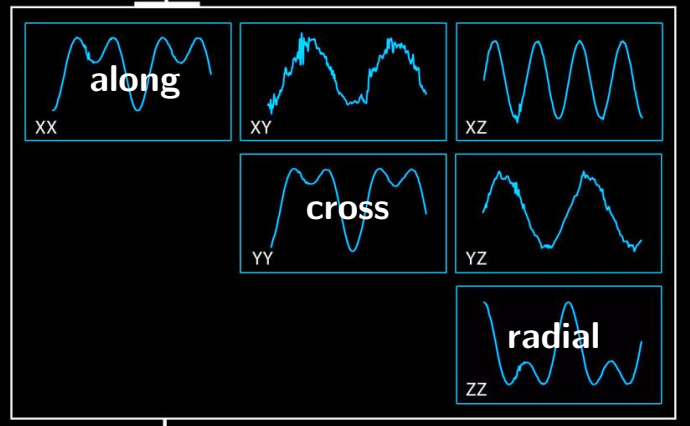
Gravitational Gradiometry

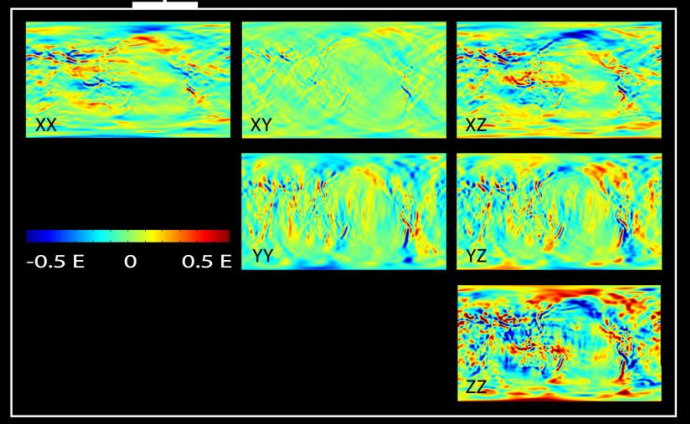


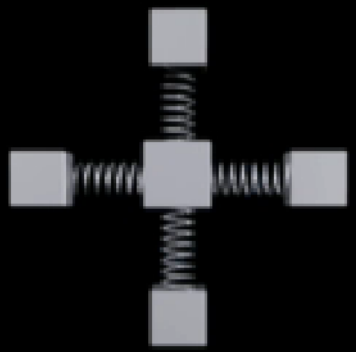




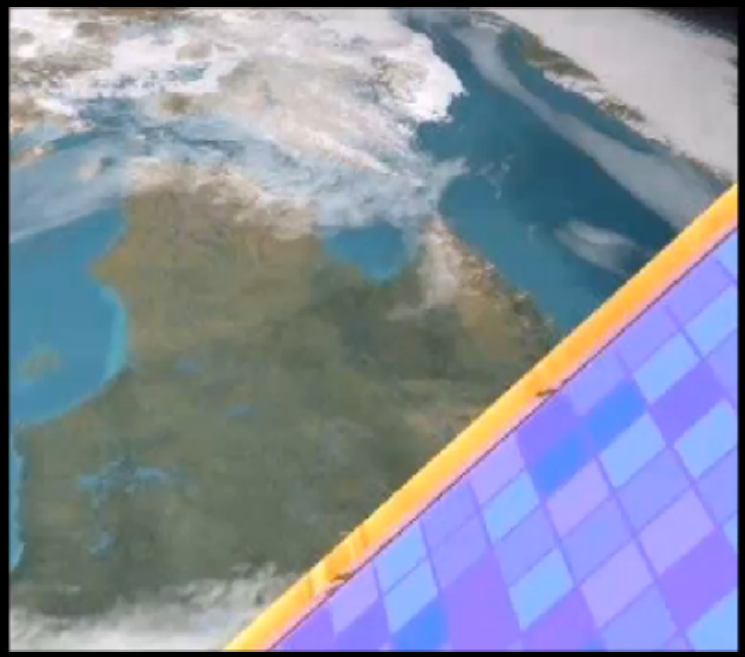
5×10^{-12} m/s^2 over 1 m
$=5\times10^{-3}$ E/Hz$^{1/2}$







GRACE Mission
Satellite-to-Satellite Tracking
K/Ka-band (10 um)

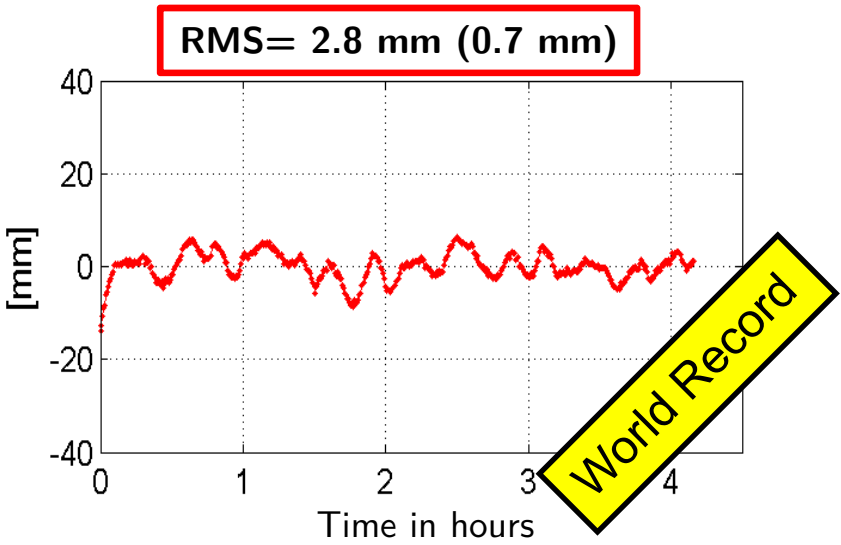


Orbit Separation 200 km

Altitude=500 km
Inclination=89°

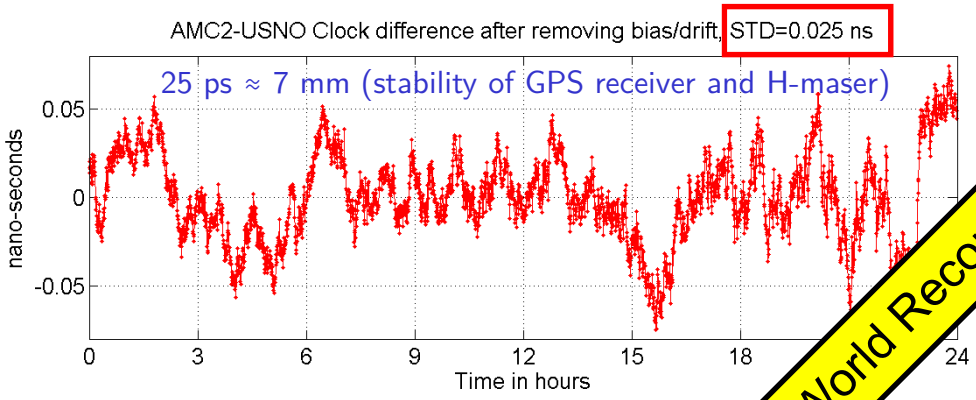
NASA/DLR GRACE Mission

GPS vector between the two satellites separated by 200 km



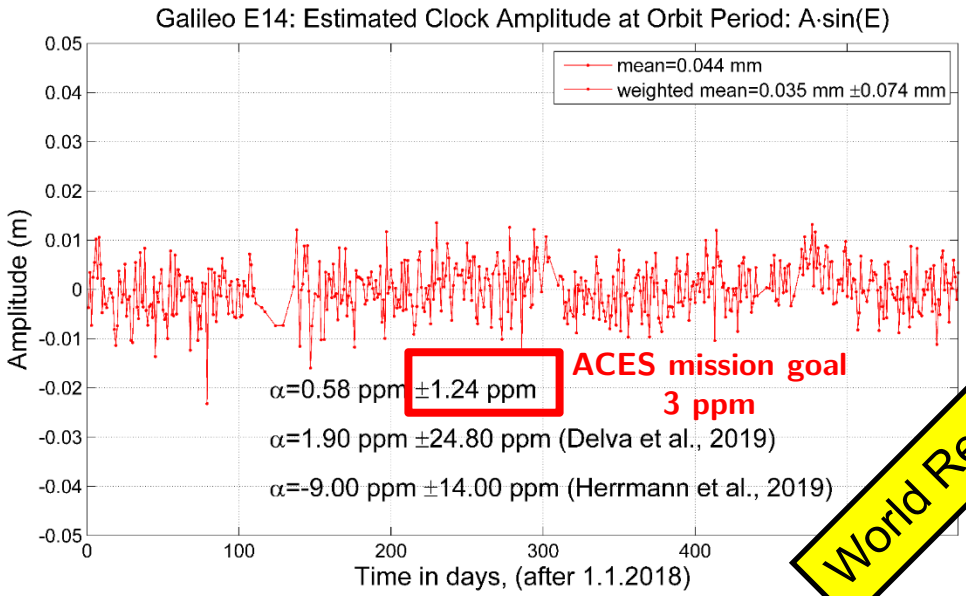
Time/Frequency Transfer with GPS

Time Between Colorado Springs and USNO



World Record

New Test of the Gravitational Redshift (ACES mission goal 3 ppm)



World Record

esa Topical Team on Geodesy
Applications of the ACES Mission

ACES and FUTURE GNSS–BASED EARTH OBSERVATION and NAVIGATION

26 – 27 May 2008, Munich, Germany

Institute of Astronomical and Physical Geodesy
Technische Universität München, Germany

PROCEEDINGS

Drazen Svehla, Christophe Salomon, Luigi Cacciapuoti
Editors

ESA Topical Team on Geodesy 2005-2009

Cubesat Launcher – Concept and Funding

February 3, 2018: JAXA launched the smallest rocket to ever insert an object in orbit around Earth with the TRICOM 1R satellite (4 kg)

9.5 m tall and 52 cm in diameter

Goals:

1) The 4-m Rocket to Launch 1 kg into Space

2) The First Single Stage to Orbit

Motivation:

We need to pioneer a new rocket specific impulse: above the limit of I_{sp}=400 s

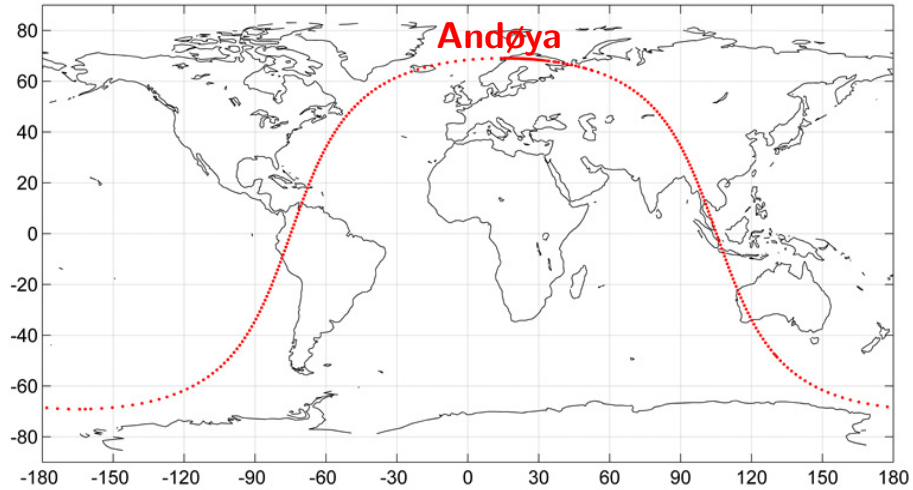
SpaceX: I_{sp}=321 s RocketLab: I_{sp}=303 s

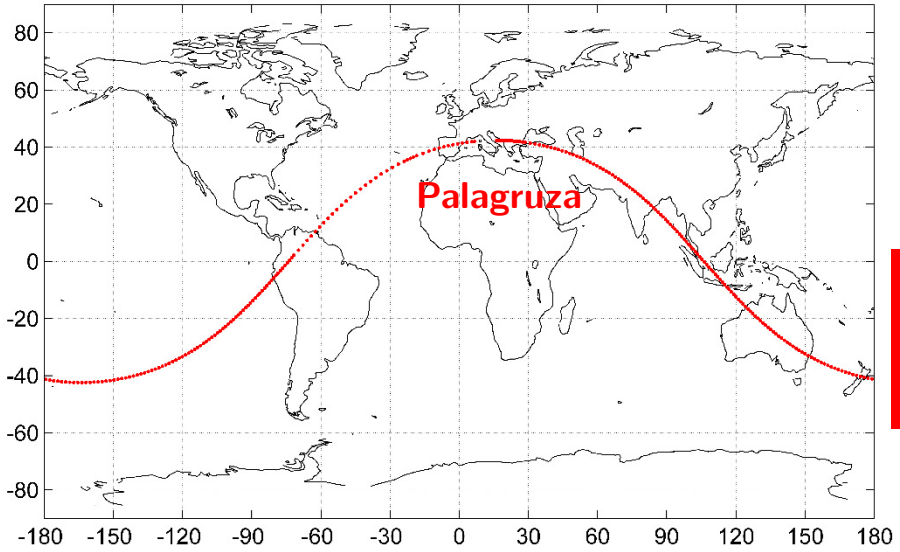
Funding Interests:

ESA, DLR, Swiss Space Office

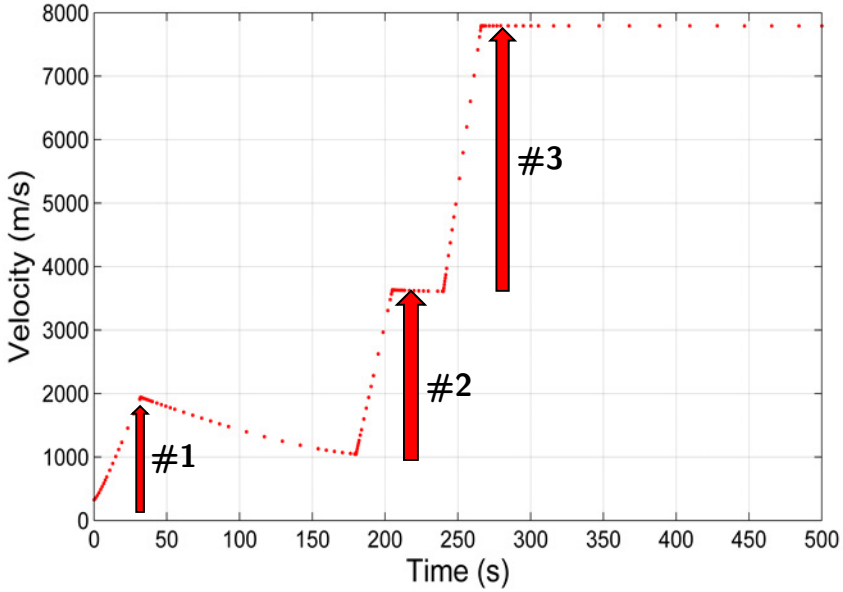
End-to-End Simulation of the JAXA Launch

Ground Track





Velocity Profile



Goals:
1) The 4-m Rocket to Launch 1 kg into Space
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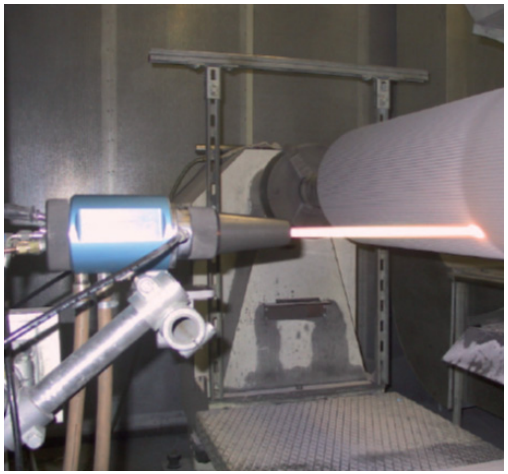
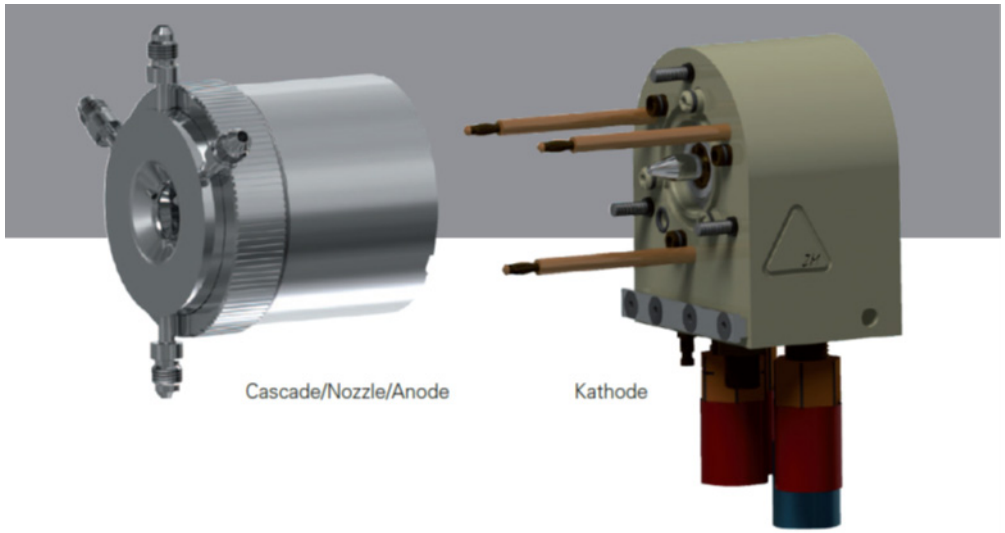
Cubesat Launcher - Engineering Model

H2+O2 propulsion



Plasma Technology



UniBW in Munich (Prof. Schein)

Developments at DLR

(See talk by O. Bozic)

Thank You