March 5, 2019
OFC 2019, San Diego

National Institute of Information and Communications Technology

OFC Panel: Space Photonics
Disruptive Satellite Laser Communications and Astrophotonics

The vision: Space photonics: trends, applications & societal impact

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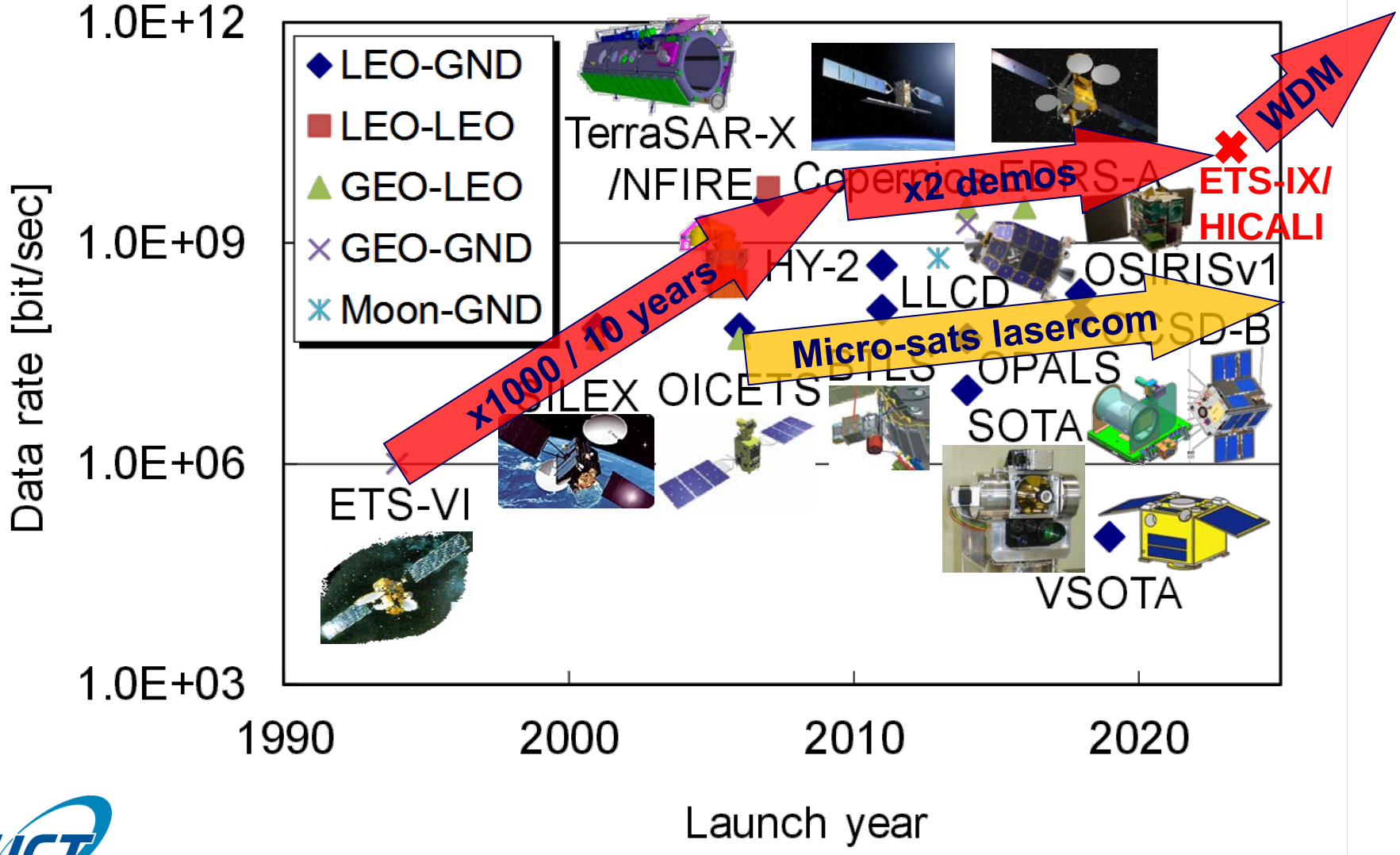
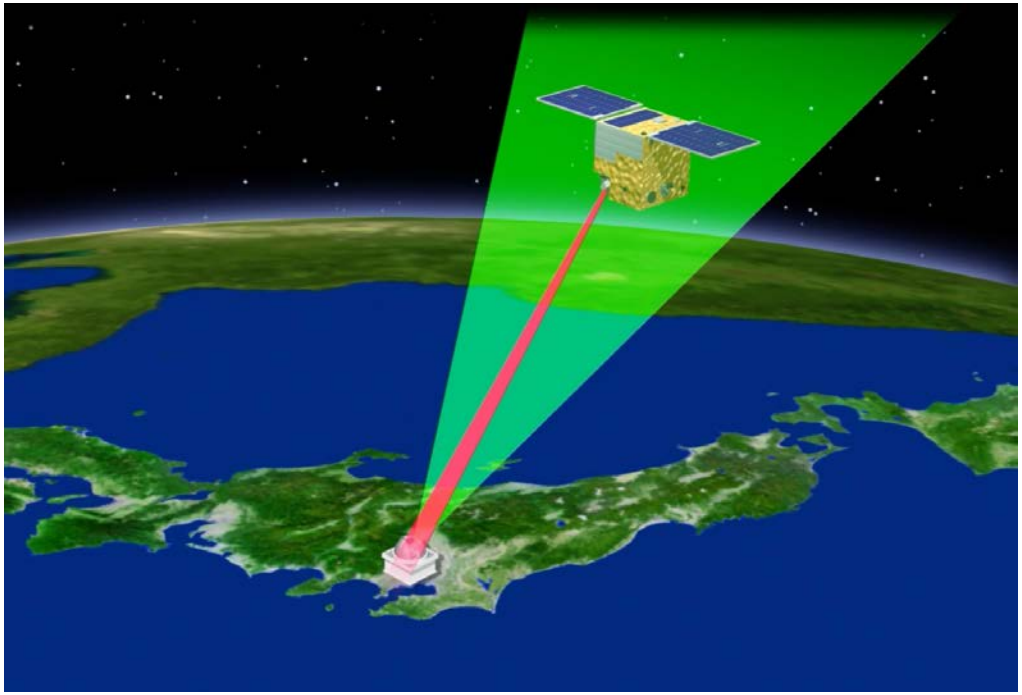
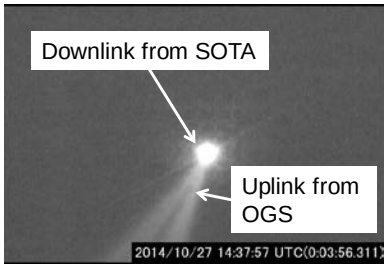
Trends of data rate for space laser comm.

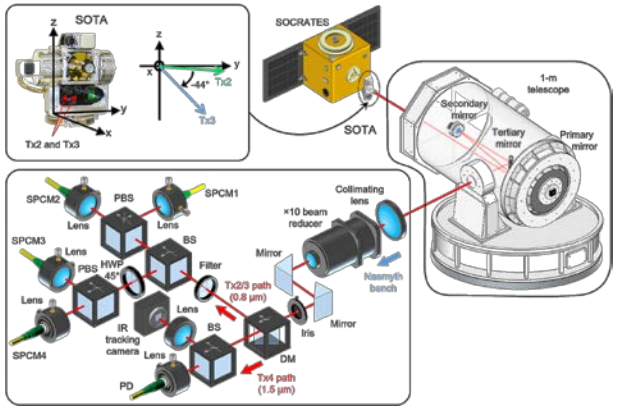


Space Optical Communications Research Advanced TEchnology Satellite (SOCRATES)/Small Optical TrAnsponder (SOTA)
(July, 2014-Nov., 2016)



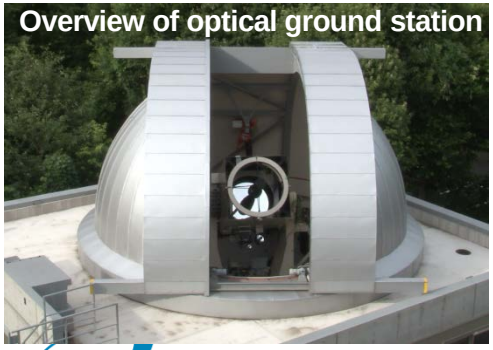


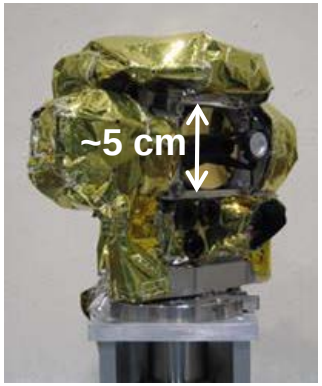
Onboard camera image via laser communication links



Successful quantum communication experiments

Nature Photonics 11, 502–508 (2017)



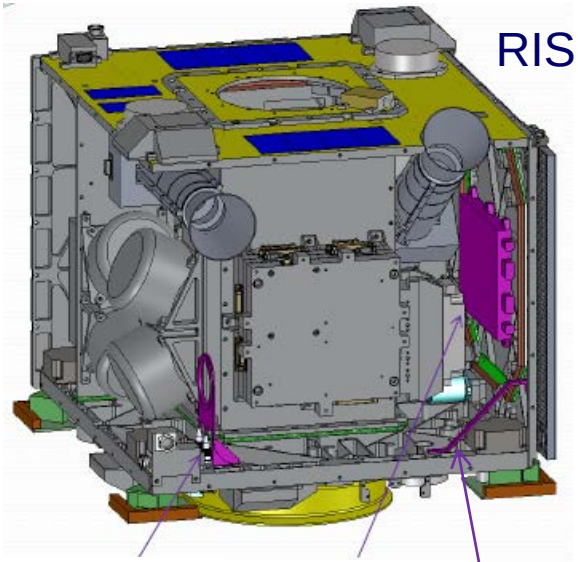


Optical part

Electrical part

- Data rate: 10 Mbps
- Wavelength: 1.55 μm
- Modulation format: IMDD
- Mass: 5.9 kg
- Power: 15.7 W

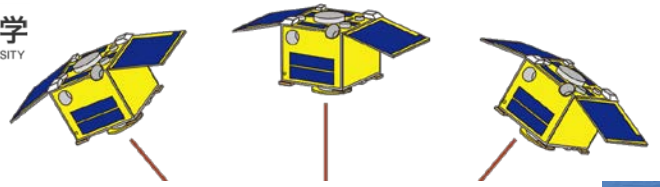
Laser communication mission onboard RISESAT, VSOTA (Very Small Optical TrAnsmitter for component validation)



RISESAT satellite

東北大学 TOHOKU UNIVERSITY

Body pointing by attitude control



Laser communication

January 18, 2019
Epsilon-4 Launched

Laser driver (Flight model)

Onboard components by NICT

Major specification

Mass:
- Satellite bus total: 55kg, VSOTA: 700g

Orbit:
- 500-900km (Nominal 700㎞), Sun synchronous (inclination 98 degree) (TBD)

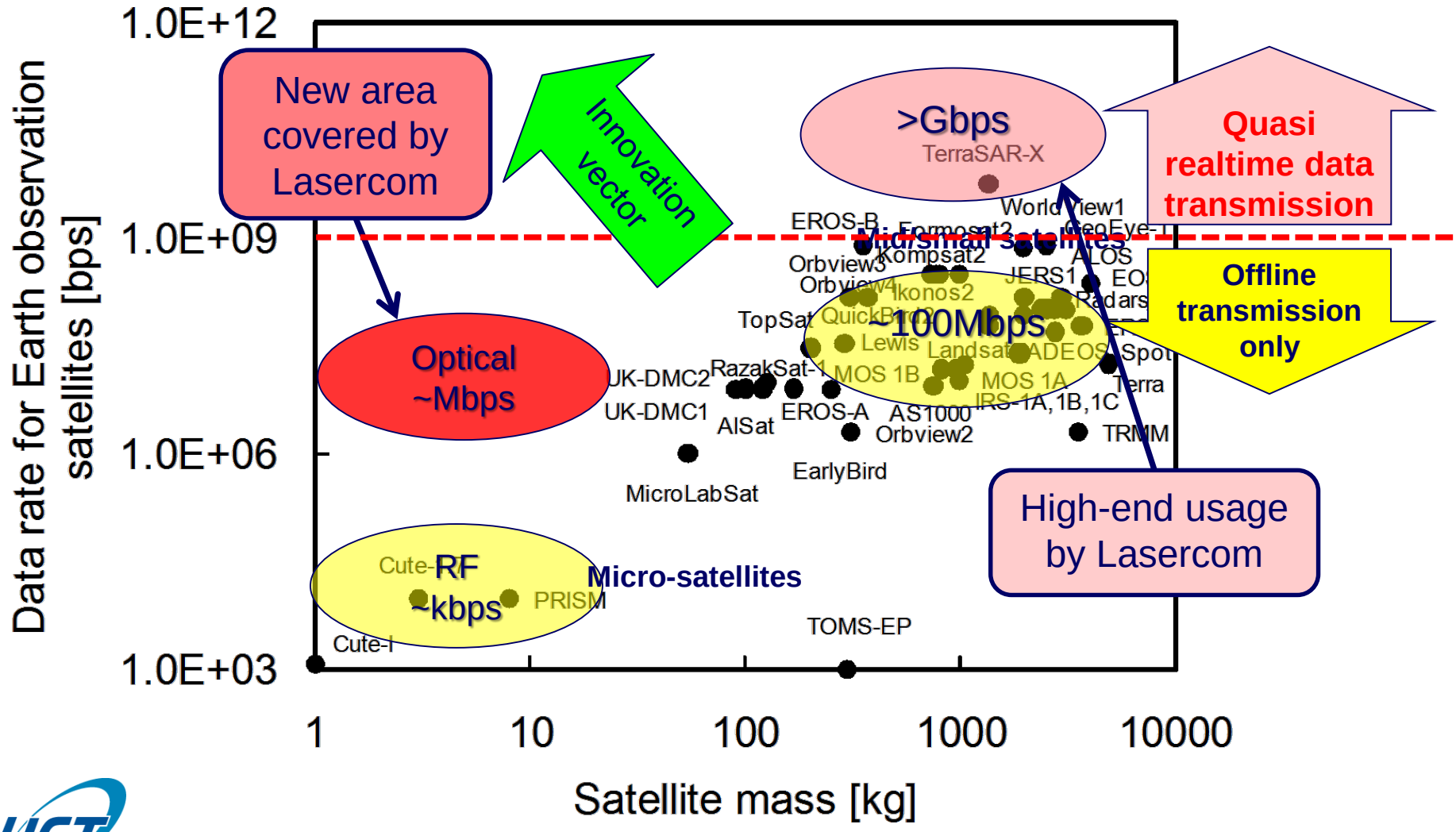
Power consumption:
- 3.5W (10 minutes)

Attitude control accuracy:
- Requirement: 0.1degree or 1.7mrad (3σ)
- Target: 0.04 degree or 0.7mrad（3σ）

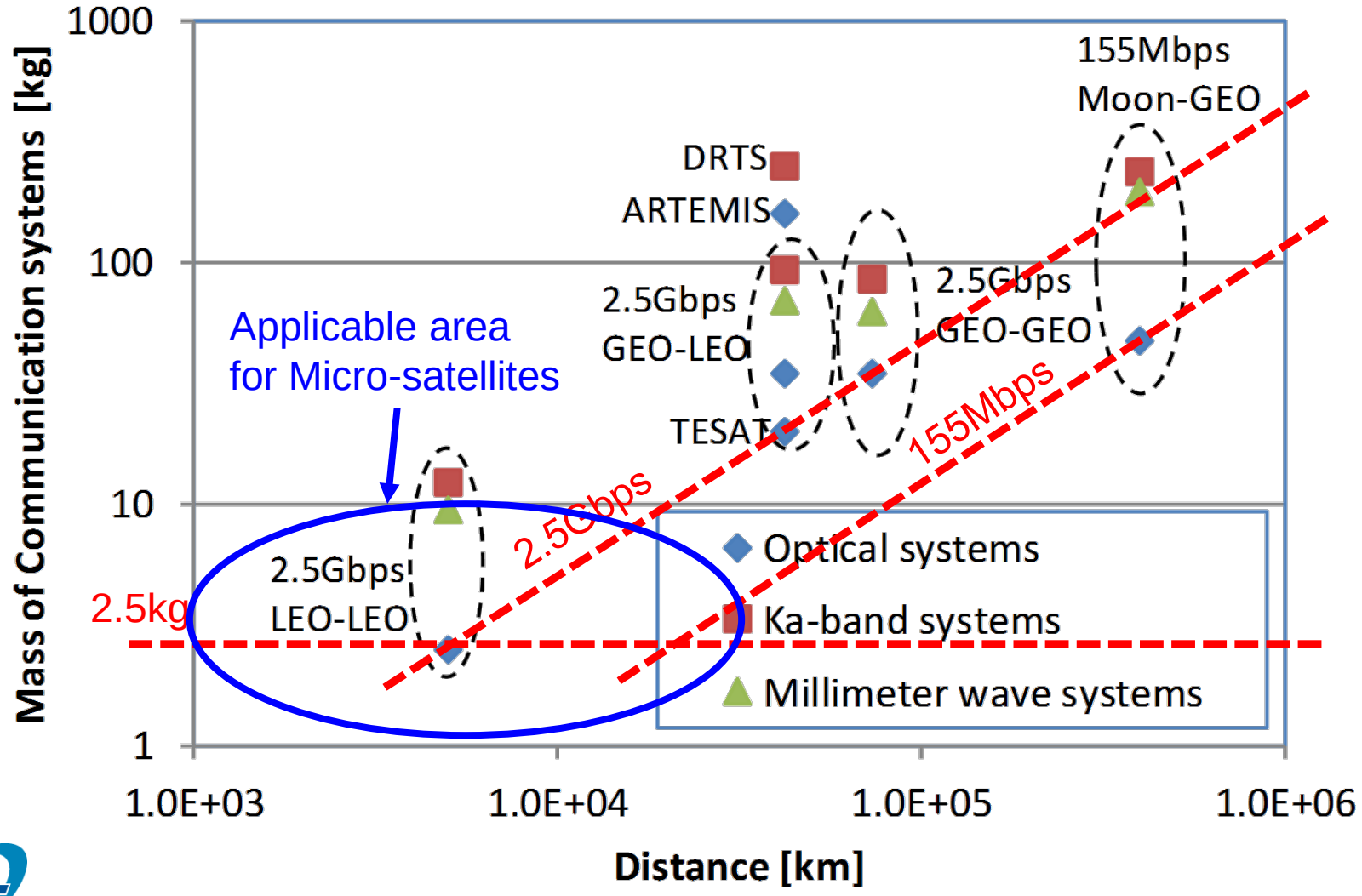
Space-based laser communication programs

	Asia	USA	Europe
Past	- 1994: **ETS-VI** (NICT), GEO-GND, 0.8μm/0.5μm, IMDD, 1Mbps - 2006: **OICETS** (JAXA/NICT), LEO-GEO,LEO-GND, 0.8μm, IMDD, 50Mbps - 2011: **HY-2** (China), LEO-GND, 1.5μm, IMDD, 504 Mbps - 2014: **SOCRATES/ SOTA** (NICT), LEO-GND, 0.98/1.5μm, IMDD, 10Mbps - 2016: **Micius** (China), BB84, 0.85/0.532/0.671μm - 2019: **RISESAT/ VSOTA** (NICT), LEO-GND, 0.98/1.5μm, IMDD, ~1kbps	- 1995: **GOLD** (NASA JPL), GEO-GND, 0.8/0.5μm, IMDD, 1Mbps - 2000: **STRV-2** (BMDO), LEO-GND, Failure, 0.8μm, IMDD, 1.2Gbps - 2001: **GeoLITE** (NRO), GEO-GND - 2008: **NFIRE** (MDA), LEO-LEO, 1.06μm, BPSK, 5.6Gbps - 2013: **LLCD** (NASA GSFC), Lunar-GND, 1.5μm, PPM, 622Mbps - 2014: **OPALS** (NASA JPL), ISS-GND, 1.5μm, IMDD, 30~50Mbps - 2015: **OCSD-A** (Aero. Corp.), LEO(1.5U)-GND, Failure, 1.5μm, IMDD, 5-50Mbps - 2018: **OCSD-B/ AeroCube-7B** (Aero. Corp.), LEO-GND, 1.5μm, IMDD, 50/100Mbps	- 2001: **SILEX** (ESA), GEO-LEO, GEO-GND, GEO-Air, 0.8μm, IMDD, 50Mbps - 2008: **TerraSAR-X** (DLR), LEO-LEO/GND, 1.06μm, BPSK, 5.6Gbps - 2011: **BTLS** (Russia), ISS-GND, 1.55μm/0.85μm, IMDD, 125Mbps - 2013-2016: **EDRS/ Copernics** (ESA), GEO-LEO, GEO-GND, 1.06μm, BPSK, ~1.8Gbps, Including **AlphaSat, Sentinel-1A, EDRS-A, Sentinal-1B** - 2016-2017: **OSIRISv1-2** (DLR), LEO-GND, 1.5μm, IMDD, 20M-100Mbps
Future plan	- 2019: **ISS/ SOL** (SONY), IMDD - 2020: **CANON**, IMDD - 2019: **JDRS** (JAXA), GEO-GND, 1.5μm, DPSK, 1.8Gbps - 2020: **ALOS-3** (JAXA), LEO-GEO, 1.5μm, DPSK, 1.8Gbps - 2021: **ETS-IX/HICALI** (NICT) , 1.5μm, DPSK, 10Gbps	- 2019: **LCRD** (NASA GSFC), GEO-LEO, GEO-GND, 1.5μm, DPSK/PPM, 2.8G/622Mbps - 2021: **DSOC** (NASA JPL), Deep space-GND, PPM, 264Mbps(max) - 2022年: **LEMNOS** (NASA GSFC), Moon-Earth, PPM, 311Mbps - 2025年: **LOP-G** (NASA), Moon-Earth	- 2019: **OPS-SAT** (TU Graz), LEO-GND, PPM, 2kbps (uplink) - 2019: **OSIRISv3,v4** (DLR), LEO-GND, 1.5μm, IMDD, 10Gbps - 2019: **EDRS-C** (ESA), GEO-LEO, 1.06μm, BPSK, ~1.8Gbps - 2021: **ScyLight #1**（ESA） - 2022: **Moon Village**（ESA）, Moon-Earth, PPM, 7Mbps - 2024: **DOCS** (ESA), Deep space-GND, 16-PPM, 10Mbps

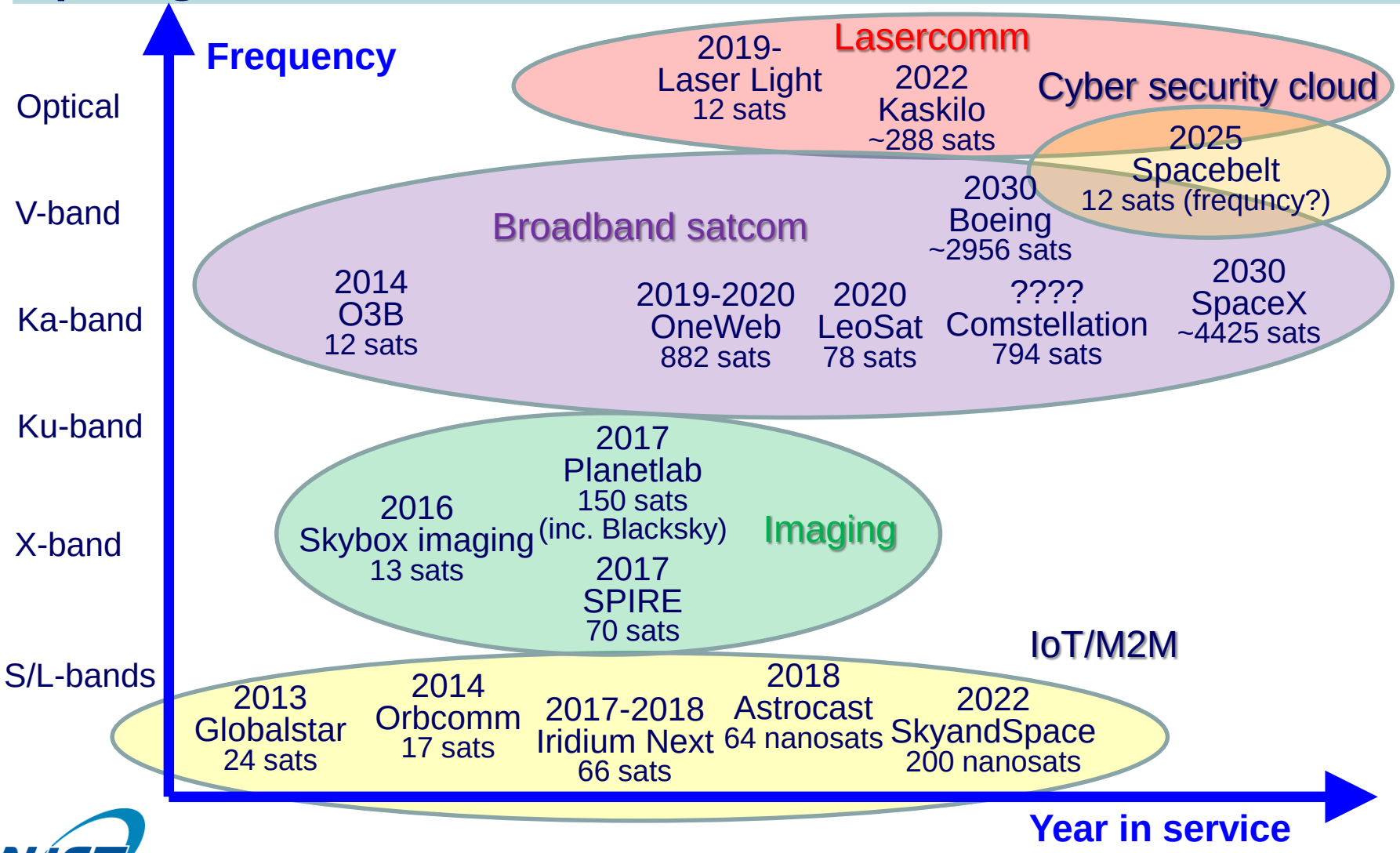
Laser communication infrastructure for Micro-satellites



Applicable area with mass and distance



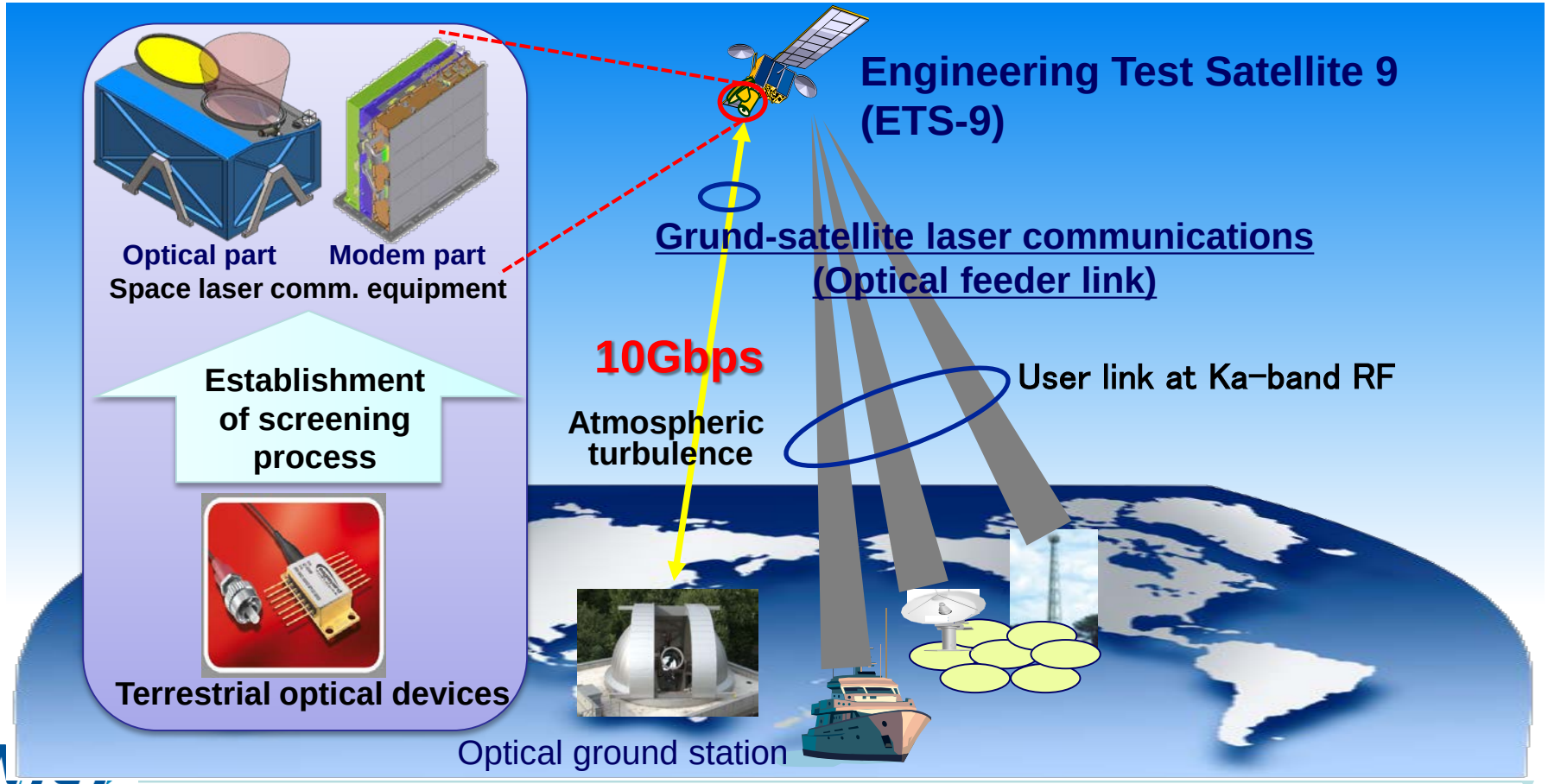
Frequency map for Mega-constellations programs



Research and development for optical feeder links
~10-Gbps laser communication terminal (HICALI)~

HICALI: HIgh speed Communication with Advanced Laser Instrument

NICT conducts the R&D for 10-Gbps ground-to-GEO laser communication technology and aims for the in-orbit verification of the basic optical feeder link technology onboard the Engineering Test Satellite 9 (ETS-9). Advanced major optical communication devices are evaluated through the screening process to ensure the space environmental tolerance and reliability.




ETS-IX/HICALI
Any questions?