VLBI current status

Expert Consultation on Strengthening the Global Geodesy Supply Chain

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for the IVS

IVS – The International VLBI Service for Geodesy and Astrometry

- An international collaboration of organizations which operate or support Very Long Baseline Interferometry (VLBI) components.
- Founded 1999

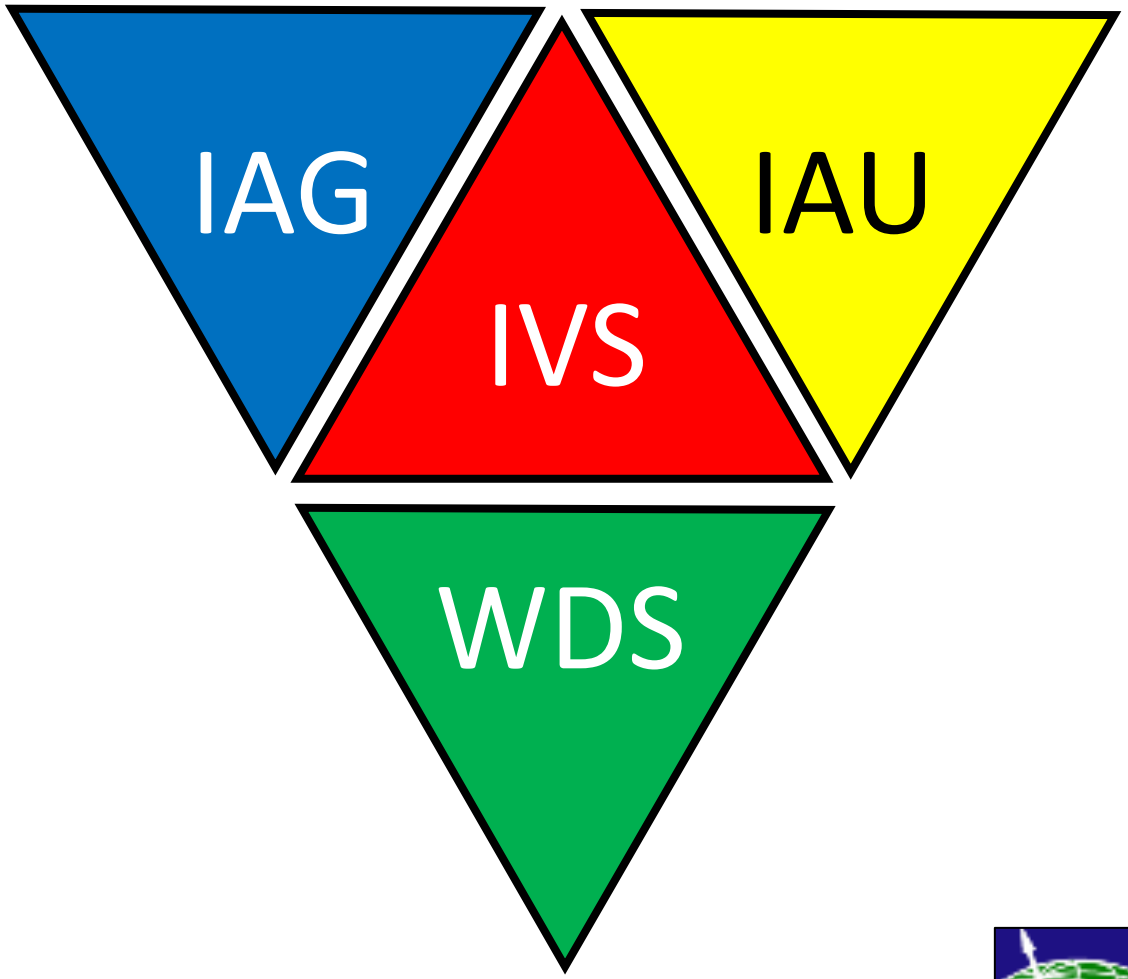
- The objectives of IVS are
  - to provide a service to support geodetic, geophysical, and astrometric research and operational activities;
  - to promote research and development activities in all aspects of the geodetic and astrometric VLBI technique; and
  - to interact with the community of users of VLBI products and to integrate VLBI into a global Earth observing system.

IVS – The International VLBI Service for Geodesy and Astrometry

- The service aspect of IVS is meant to serve both outside users and the geodetic/astrometric community itself. Both the contributors and the users of VLBI data are being served.
- IVS provides data and products for the scientific community. The main IVS products are
  - a terrestrial reference frame (TRF),
  - the international celestial reference frame (ICRF), and
  - Earth orientation parameters (EOP).

IVS – The International VLBI Service for Geodesy and Astrometry

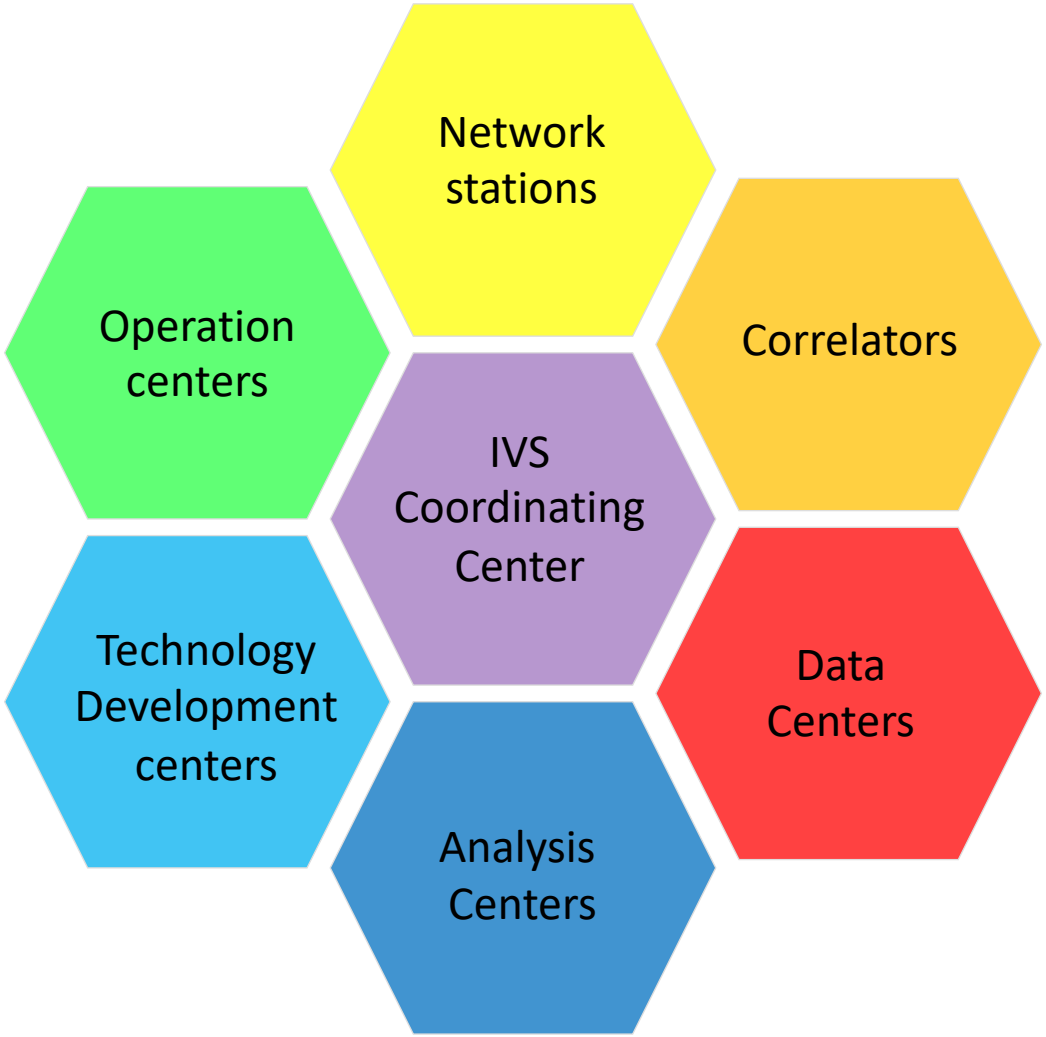
- A non-profit and best effort organisation
- 80+ permanent components
  - network stations – correlators – data centres – analysis centres – technology development centres – operation centres – coordinating centre
- 40+ institutions
  - Land survey agencies – space agencies – universities – research institutions
- 20+ countries
- In total ca. 350 associated members



IVS is a service for:

IAG – International Association of Geodesy
IAU – International Astronomical Union
WDS – World Data System of the International Science Council

IVS organisation



IVS organisation

Coordinating center director

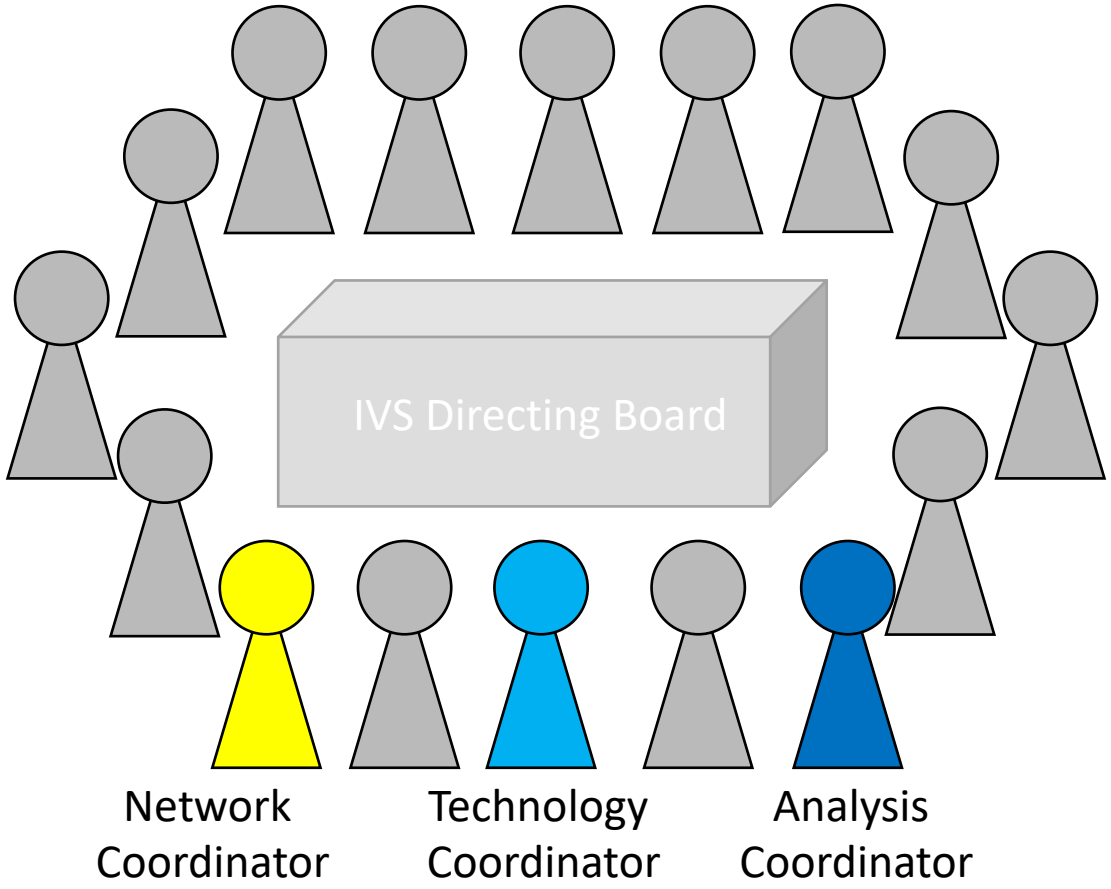
2 Network station representatives

IAG representative

IERS representative

IAU representative

1 Technology development representative



1 Correlator and operation centers representative

2 Analysis and data center representatives

1 Outreach and communications

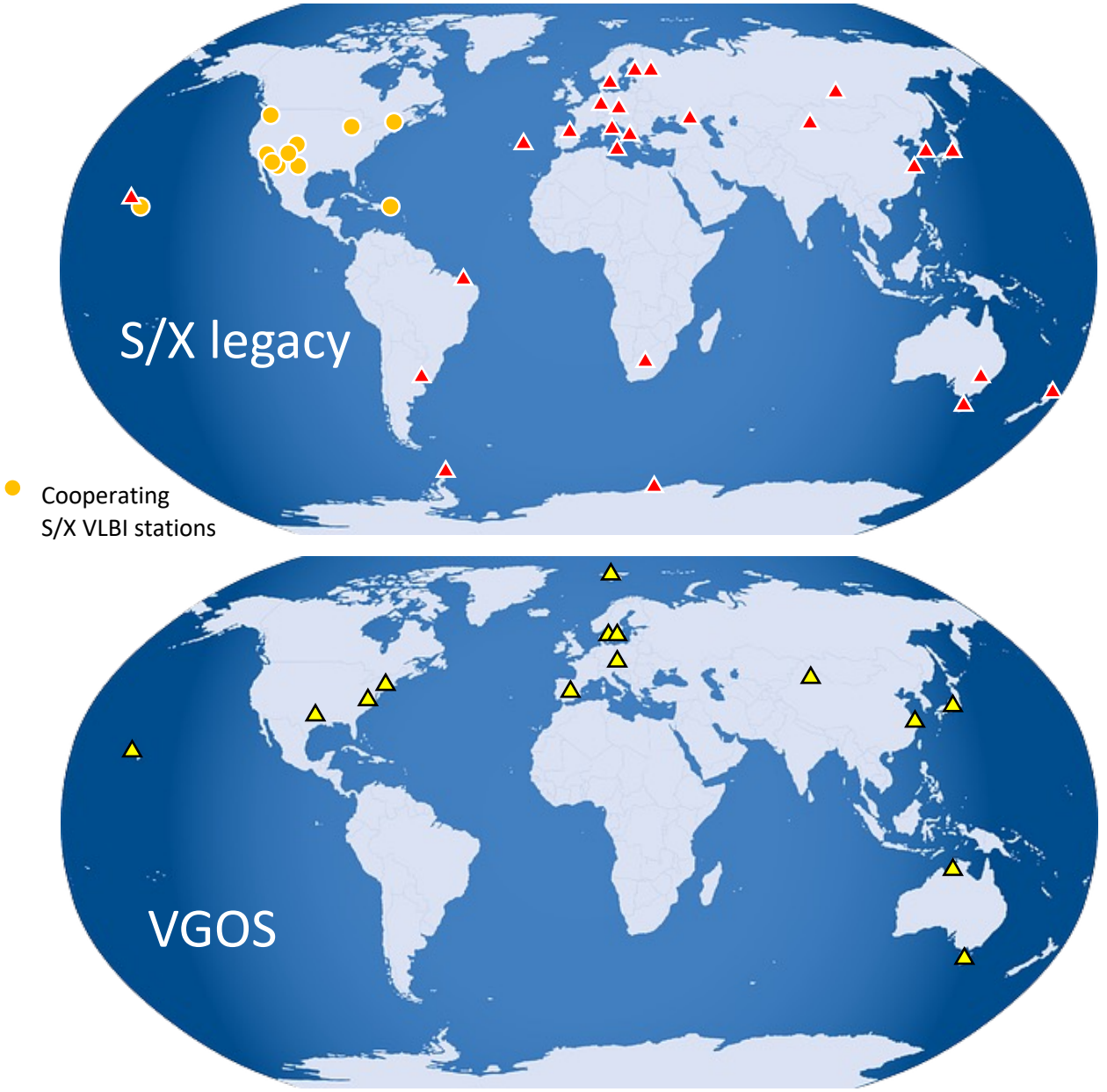
3 at large members

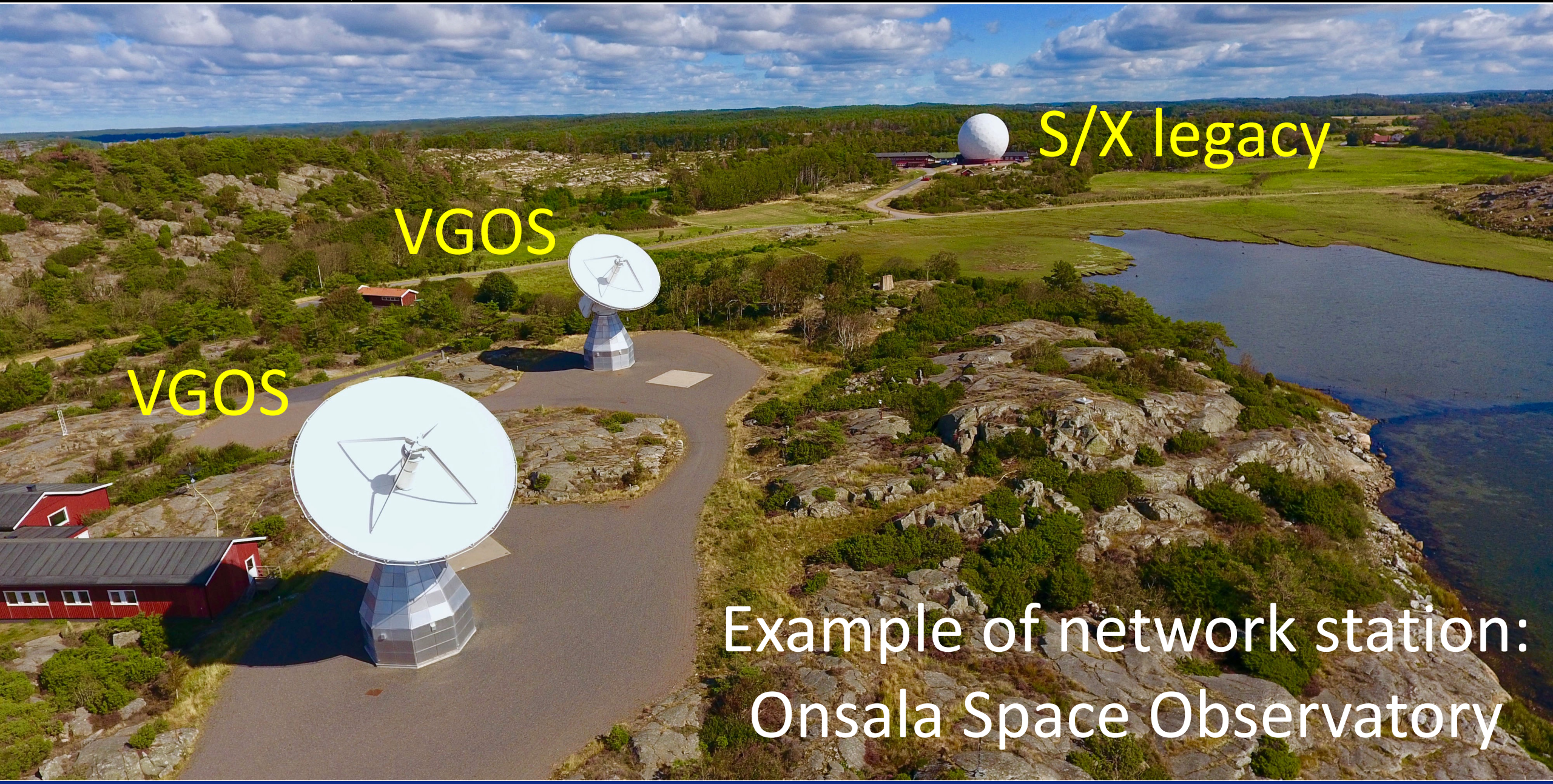
S/X legacy network

- observations going back to 1979
- today: ca. 40 stations
- large variety of radio telescopes
  - diameter 6 m – 100 m
  - slow and deforming “astro” telescopes
  - losing stations (e.g. Ny-Ålesund 20 m)
- 2/8 GHz, one circular polarization

VGOS network

- started 2017, operational since 2020
- early 2024: 15 stations
- 13 m class radio telescopes
- some twin-telescope sites
- broadband 3-14 GHz, dual polarized



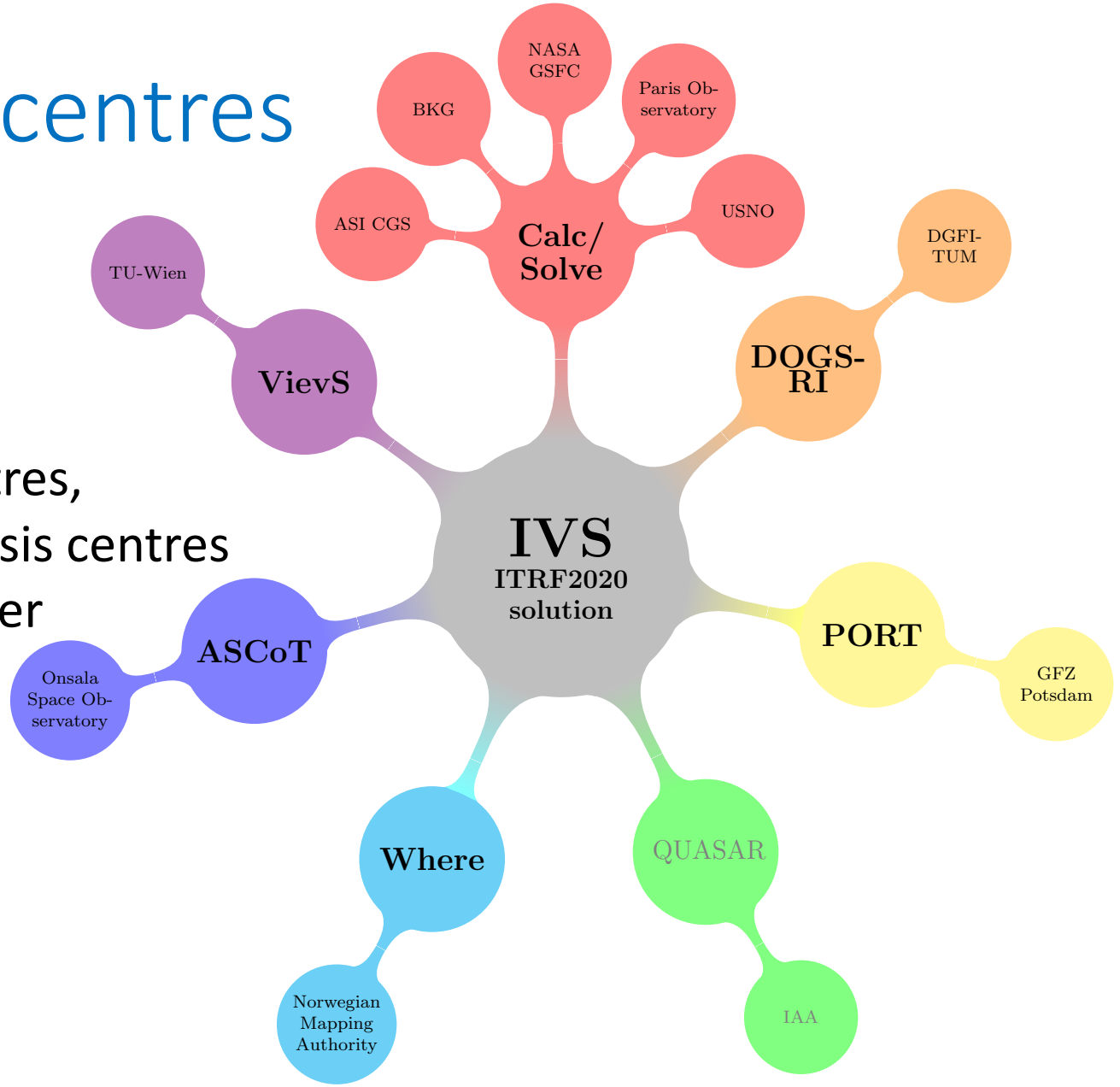


Example of network station: Onsala Space Observatory

Other IVS components

- Coordinating centre: NASA (USA)
- Main correlators:
  - Vienna (AUT), Shanghai (CHN), Bonn (GER), Wettzell (GER), Tsukuba (JAP), Haystack (USA), Washington (USA)
- Main data centres:
  - CDDIS (USA), Paris Observatory (FRA), BKG (GER)
- Main operation centres:
  - NASA (USA), USNO (USA), BKG (GER)
- Main technology development centres:
  - Haystack (USA), NASA (USA), IGN (ESP), Chalmers (SWE), NICT (JAP)

Analysis centres



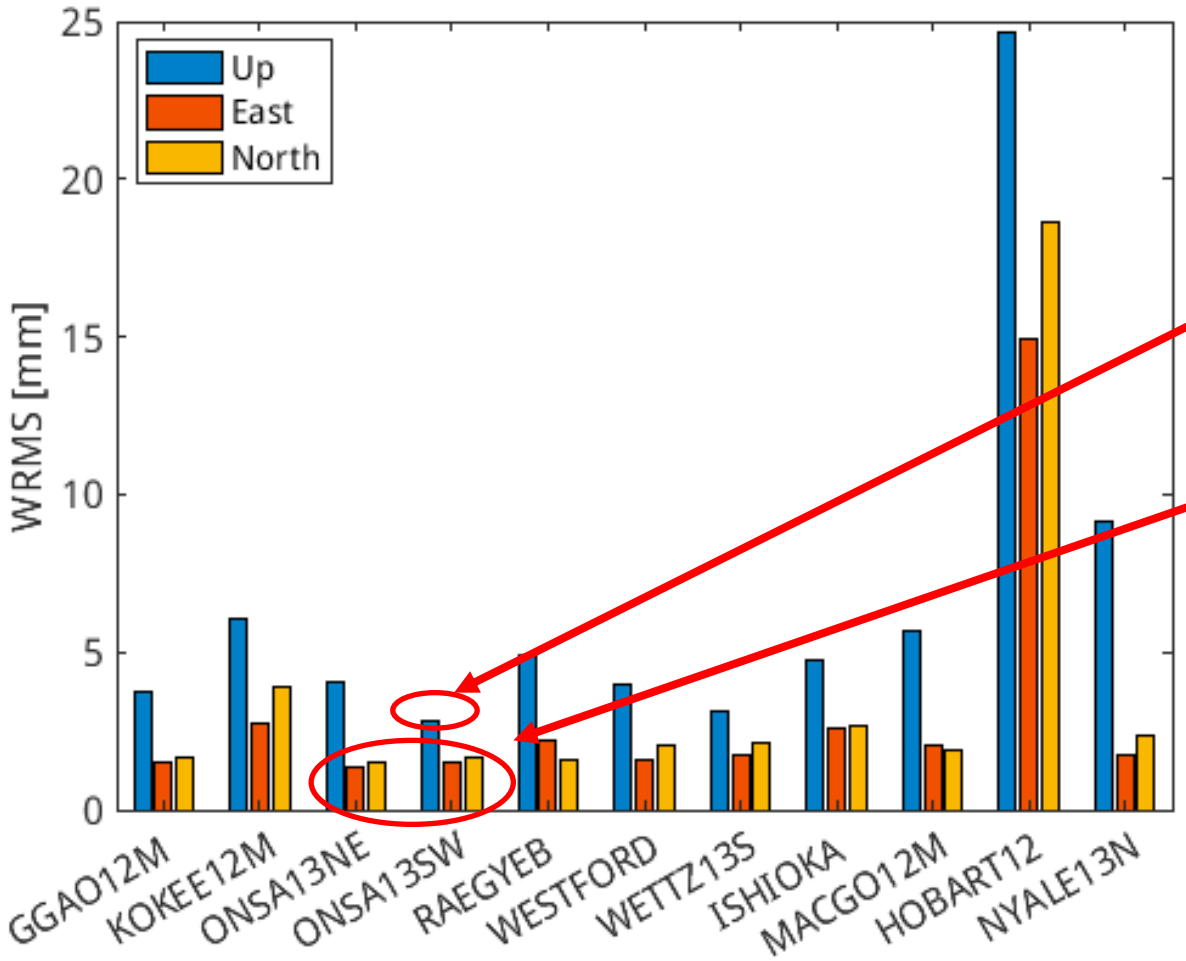
- 10 full analysis centres,
- 20+ associate analysis centres
- 1 combination center

Using 7 different software packages.

Current VGOS performance: station positions

Station position WRMS from analysis of VGOS 2019–2023 data.

(Ref. Nilsson, Haas, Le Bail, IVS GM 2024)



Station position repeatability, VGOS 2019–2023.

Best vertical
ca. 2.5 mm WRMS

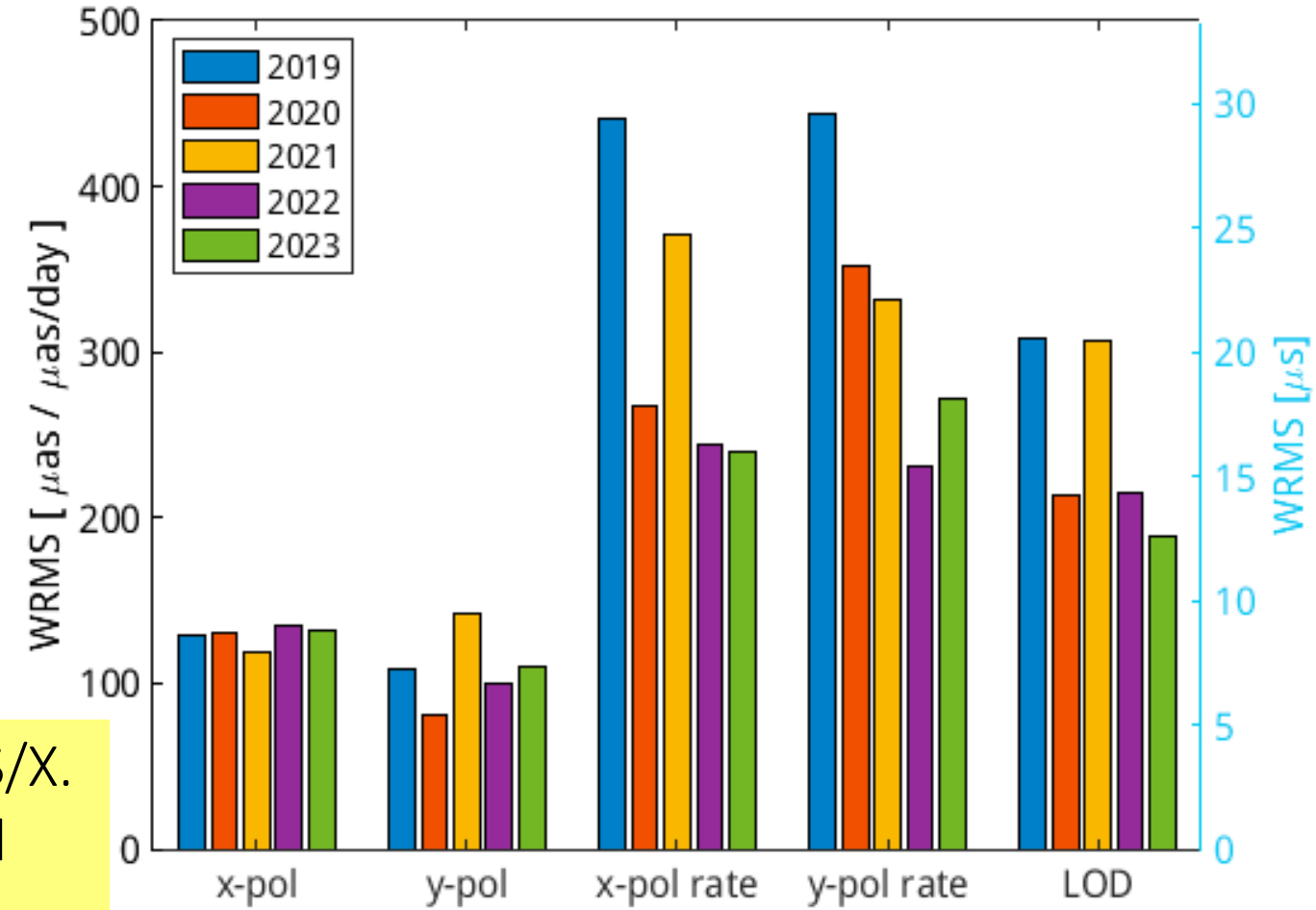
Best horizontal
< 1.5 mm WRMS

=> Today's VGOS is about a factor of > 2 better than legacy S/X.

Current VGOS performance: EOP

WRMS differences between VGOS and GNSS EOP 2019–2023.

(Ref. Nilsson, Haas, Le Bail, IVS GM 2024)



=> Today's VGOS is on same level as legacy S/X.

- Improvements with more stations and improving network geometry

Challenges for the IVS?

- best effort, non-profit organisation, no formal professional obligation
  - relies solely on the IVS member institutions, no common money
- establishing new VGOS stations is expensive and takes time
  - VGOS roll-out is slower than expected, but more stations to come in the next 2–5 years
  - several stations have not yet reached ”full-VGOS” specifications
- increased disturbances due to active users of the RF spectrum, both ground-based and space-borne, e.g. 5G, Starlink, both S/X and VGOS
  - initiatives on IAU and IUGG level for regulation of VGOS bands
- data transport requires access to high-speed optical fibre network
  - still a bottleneck primarily at correlator side
- still too few correlators to reach 24/7 operations

IVS plan for the next 10 years

- VGOS shall become “the work horse of the IVS”
  - Using VGOS for all IVS products, i.e. CRF, EOP, TRF
  - Multi-frequency CRF: Continue S/X CRF and build up VGOS CRF

- Future IVS observation plan
  - Twice daily VGOS UT1-UTC determination with low latency
  - Several 24-h VGOS sessions (12+ stations) per week for EOP/TRF (=> goal 24/7)
  - Several 24-h VGOS and S/X CRF sessions per year
  - Additional R&D sessions

Outlook: IVS VGOS network in a few years

▲ New VGOS stations