IVS: Current Status and Future Plans

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What is the IVS?

The **International VLBI Service for Geodesy and Astrometry (IVS)** is an international collaboration of organizations which operate or support Very Long Baseline Interferometry (VLBI) components:

- IVS inauguration was on **1 March 1999**.
- 83 permanent components supported by 41 institutions in 21 countries.
- ~300 Associate Members.

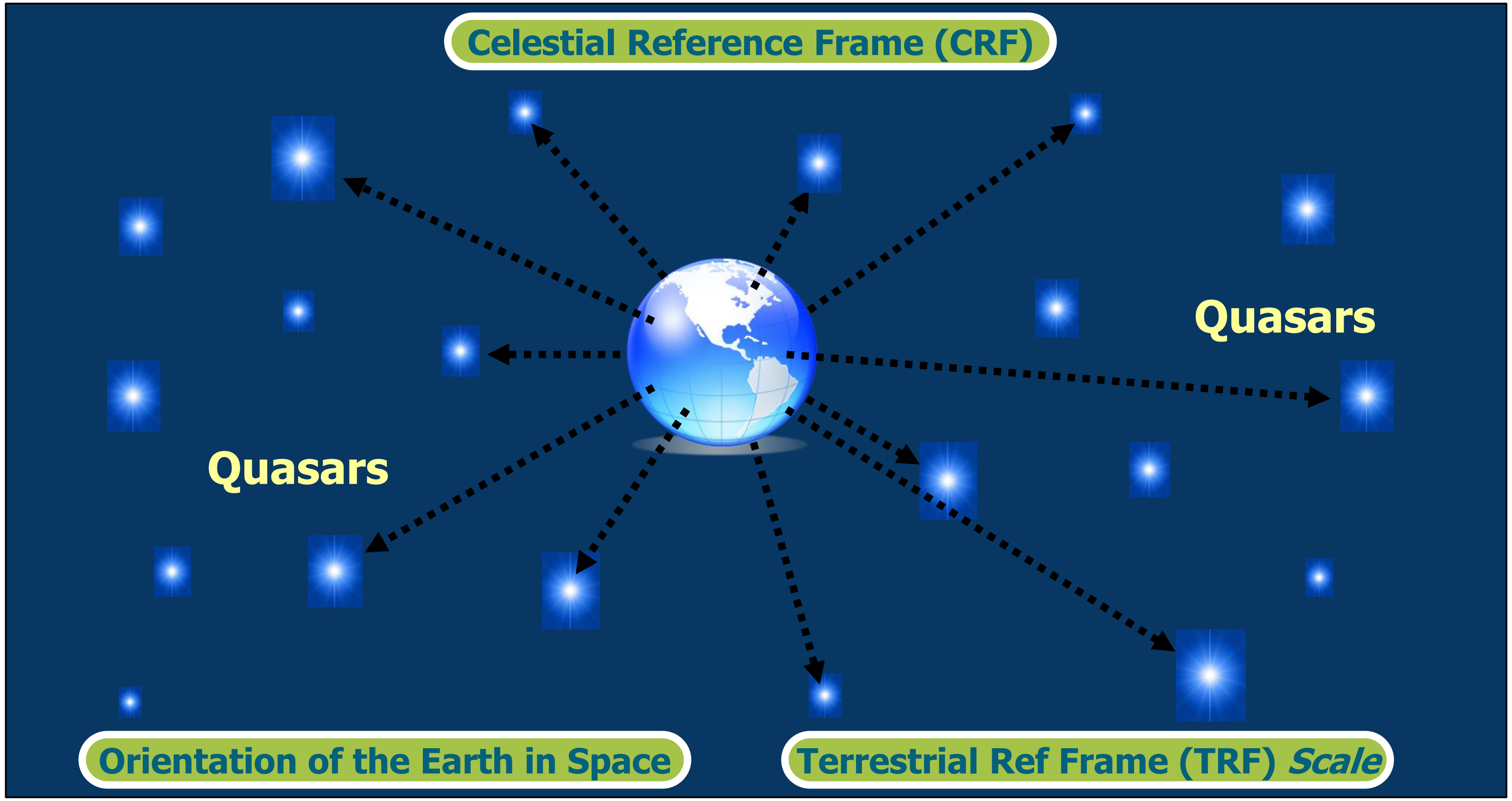
IVS is a recognized service of

- **IAG** – International Association of Geodesy
- **IAU** – International Astronomical Union
- **WDS** – ICSU World Data System

IVS Products

- Earth Orientation Parameters (EOP):
  - 24-hour sessions (all EOP)
  - 1-hour Intensives (UT1–UTC)
- Terrestrial Reference Frame (TRF)
- Celestial Reference Frame (CRF)

- Daily EOP + station coordinates (SINEX files)
- Tropospheric Parameters
- Baseline Lengths



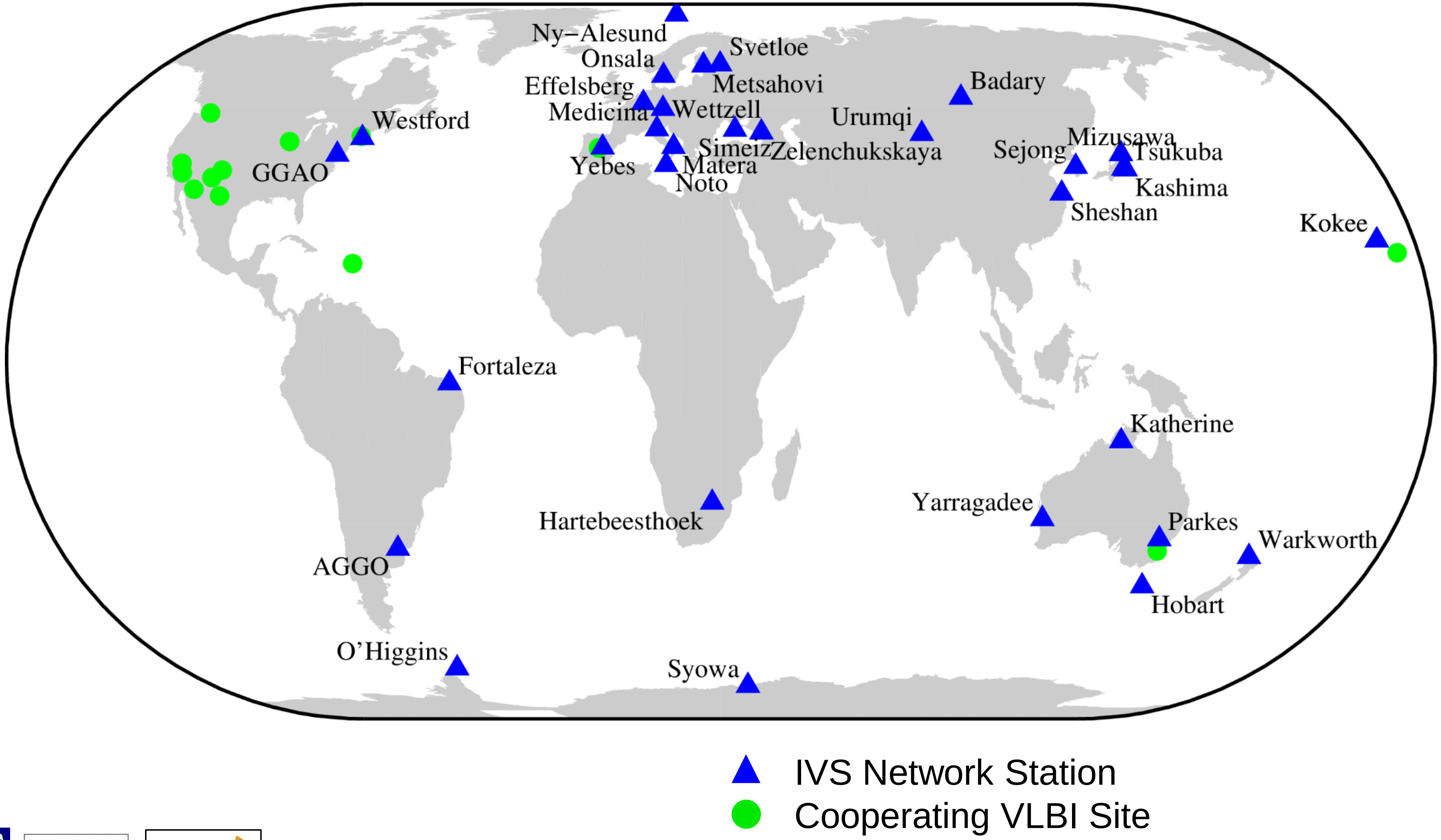
VBLI Site: E.g., Onsala Space Observatory, Sweden

Courtesy R. Haas

VGOS vs. Legacy System: Comparison of Characteristics

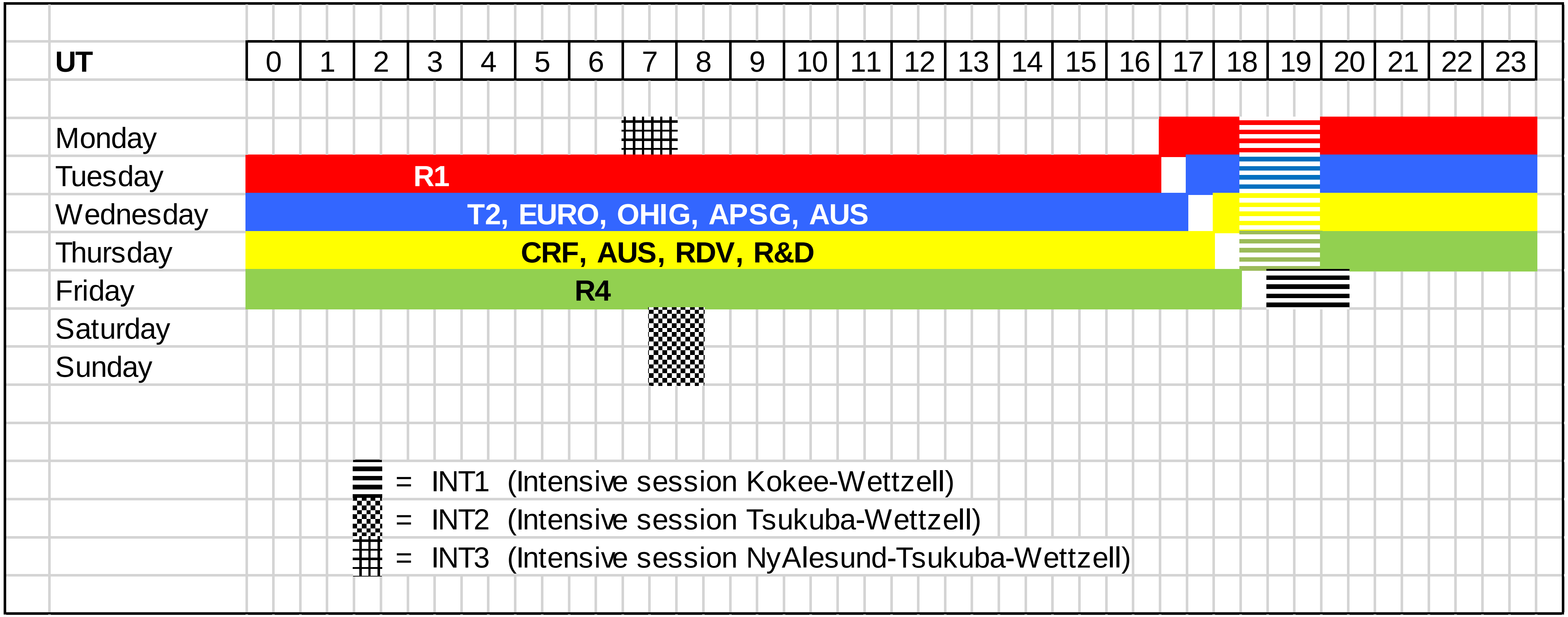
	Legacy S/X System	VGOS System	Benefit
Antenna size	5–100 m dish	12–13 m dish	reduced cost
Slew speed	~20–200 deg/min	≥ 360 deg/min	more observations for troposphere
Sensitivity	200–15,000 SEFD	≤ 2,500 SEFD	more homogeneous
Frequency range	S/X band (two bands)	~2–14 GHz (four bands)	increased sensitivity, data precision
Recording rate	128, 256, 512 Mbps	8, 16, 32 Gbps	increased sensitivity
Data transfer	usually e-transfer, some ship disks	e-transfer, ship disks when required	
Signal processing	analog/digital	digital	stable instrumentation

IVS Network: Legacy Stations



IVS Observing Program: Legacy System

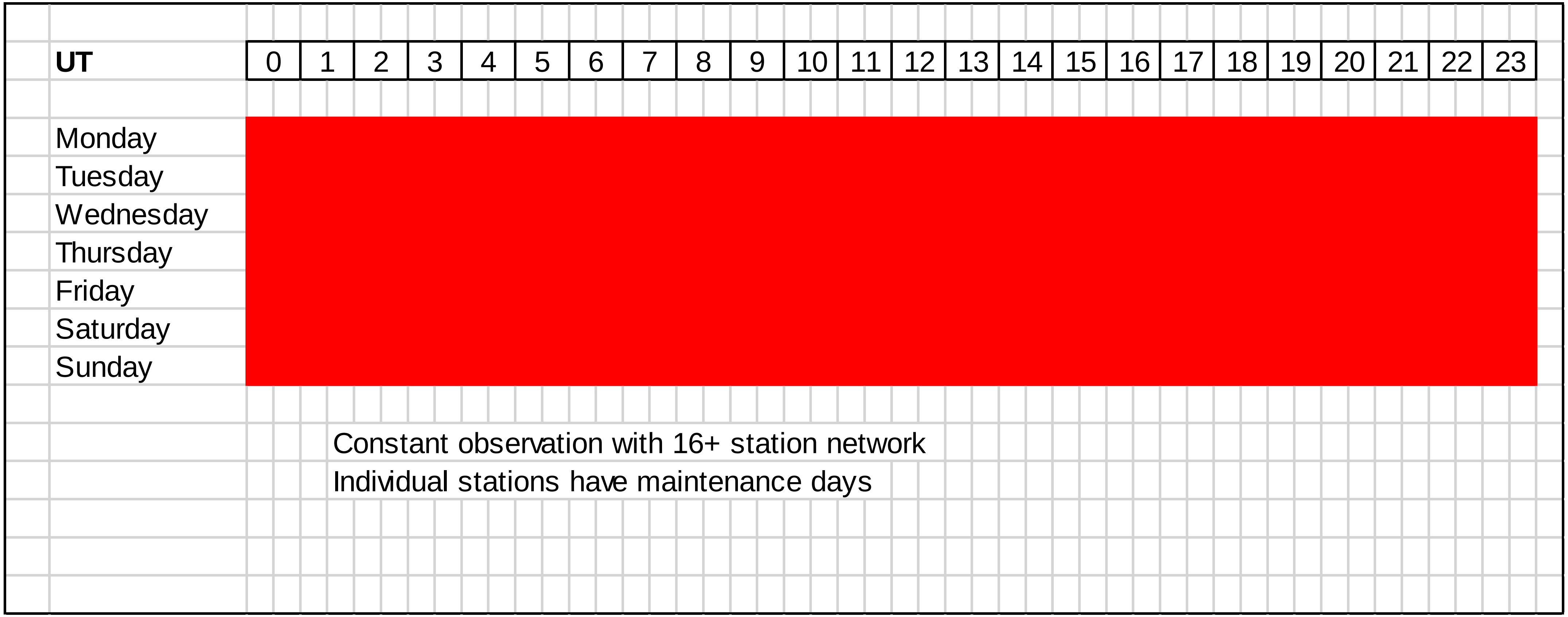
- Typical weekly layout for IVS observing sessions



- about 180 sessions per year, 3.5 sessions per week

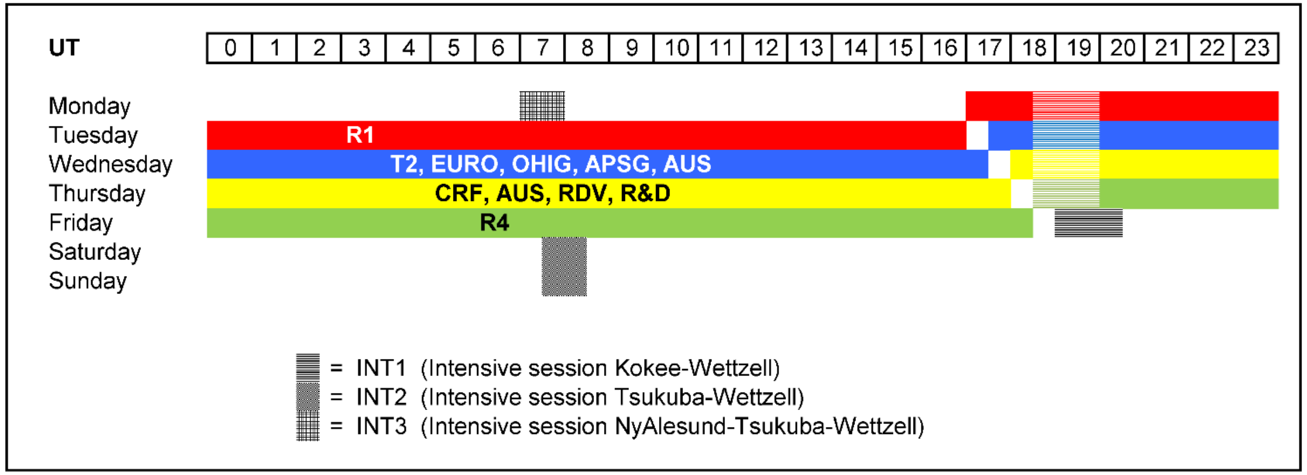
IVS Observing Program: VGOS System

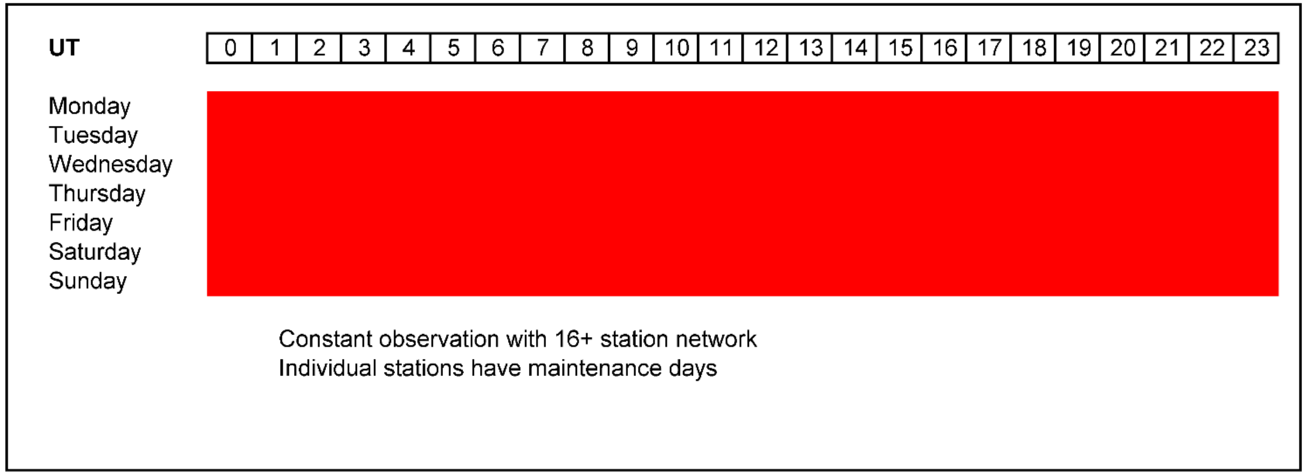
- Expected weekly observing coverage for VGOS (after 2020)



- 365 sessions per year, 7 sessions per week (24/7/365)

Transition from Legacy to VGOS System





- maintain legacy network at least until 2020
- phase in VGOS network in progressive steps
- coordinate legacy + VGOS networks in parallel for a few years
- transition the product base from legacy to VGOS around 2020
- enhance product portfolio

New VGOS Radio Telescopes

Ishioka (JP)
Inauguration, Oct 2014

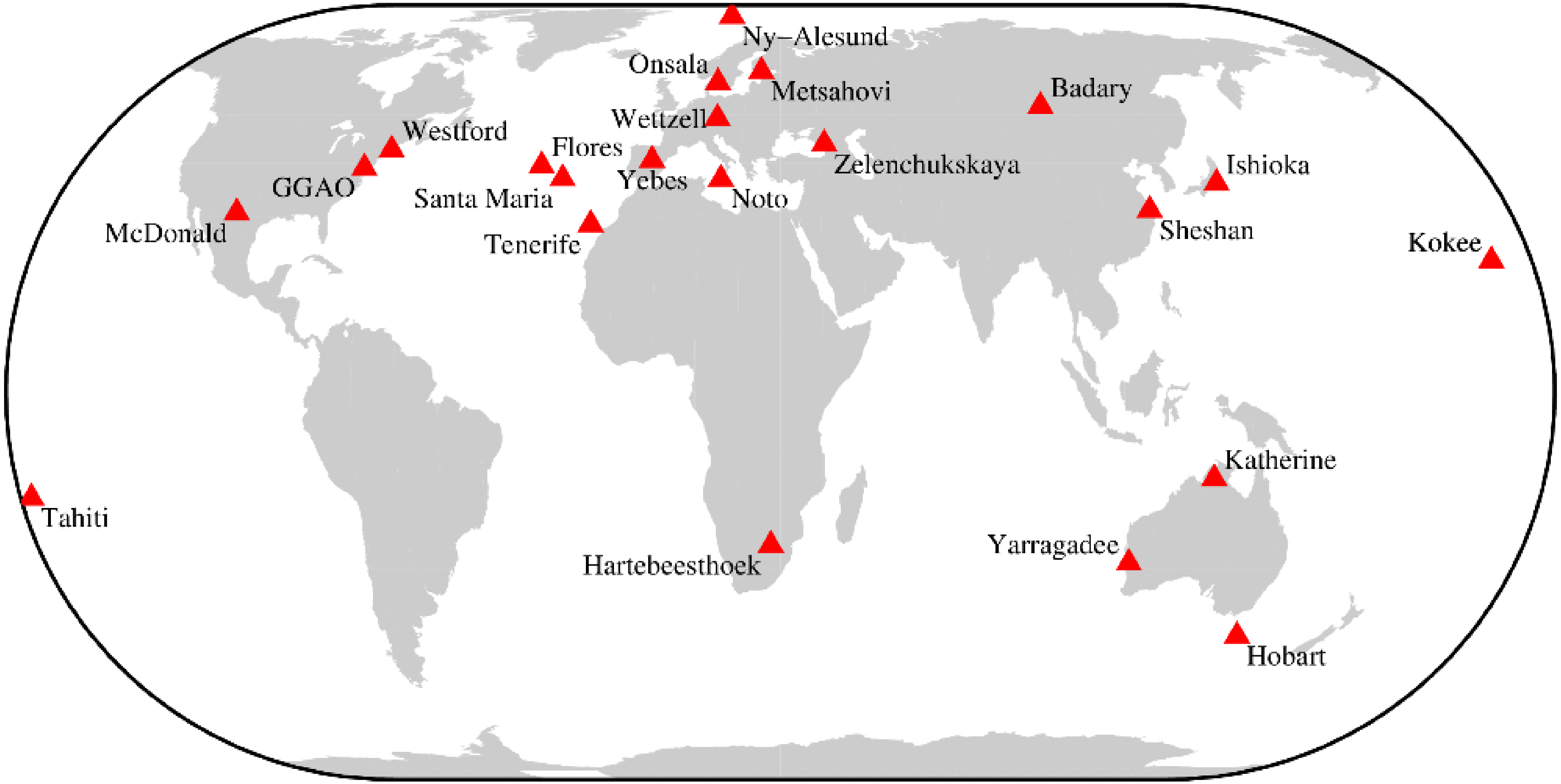
Santa Maria (PT)
Inauguration, May 2015

Courtesy G. Rajagopalan

Kokee Park (US)
First light, Feb 2016

Hartebeesthoek (ZA)
Groundbreaking, Mar 2016

Future IVS Network: VGOS Stations (est. 2020)

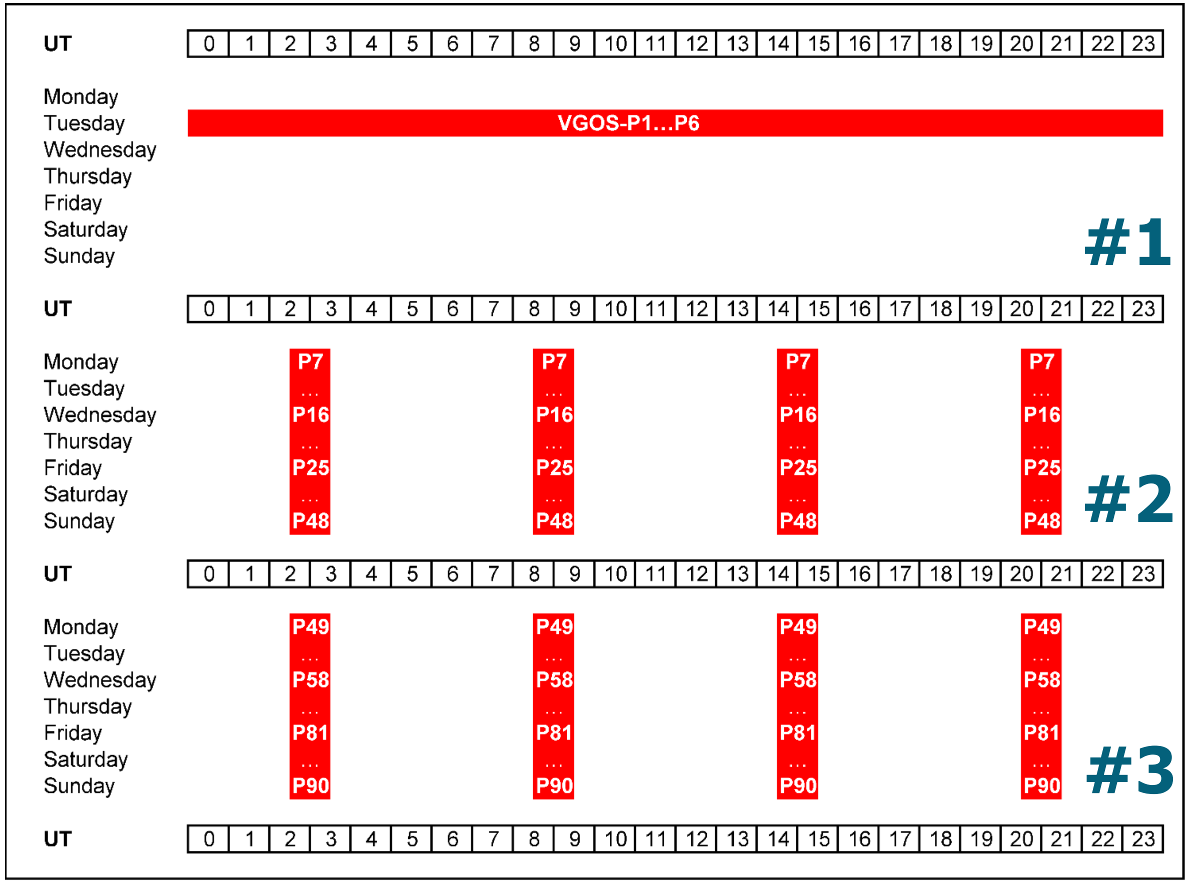


VGOS Observing Plan (= VGOS Phase-in Plan)

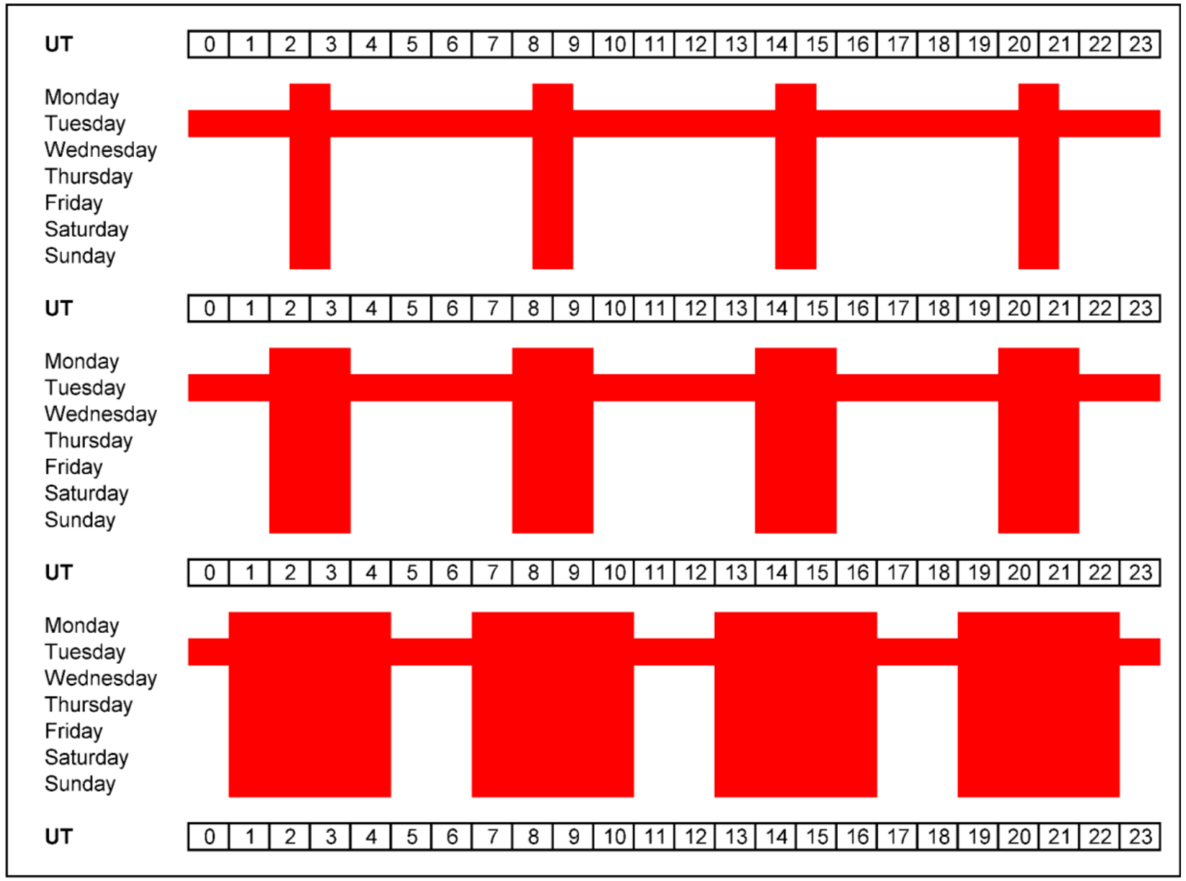
- Steps from initial VGOS broadband tests to intermediate observing scenarios to fully operational VGOS system:
  - VGOS broadband test sessions (North America, Europe)
  - VGOS Trials (three campaigns)
  - VGOS Pilot Project
  - CONT campaign(s)
  - Full VGOS 24/7/365 operations

VGOS Trials and Pilot Project: Observing Scenario

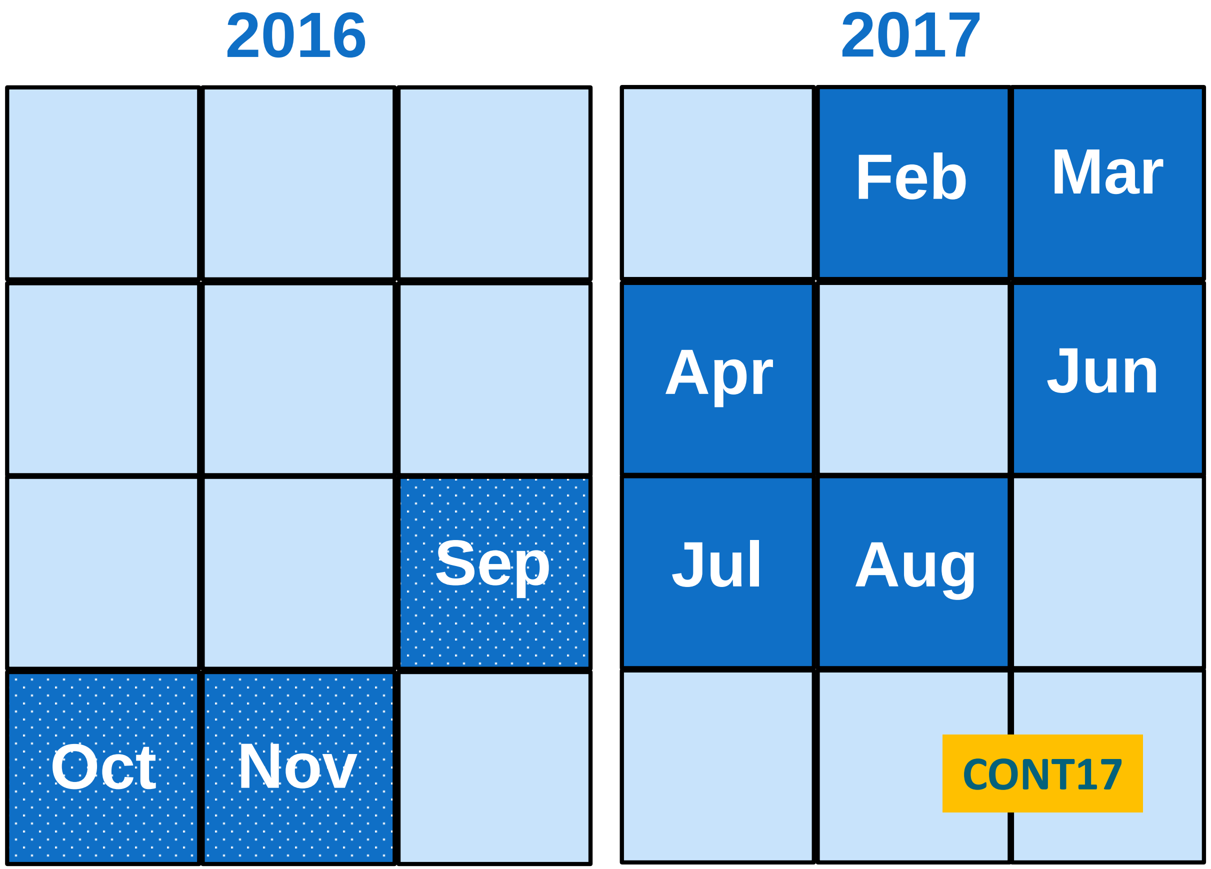
VGOS Trial Campaigns



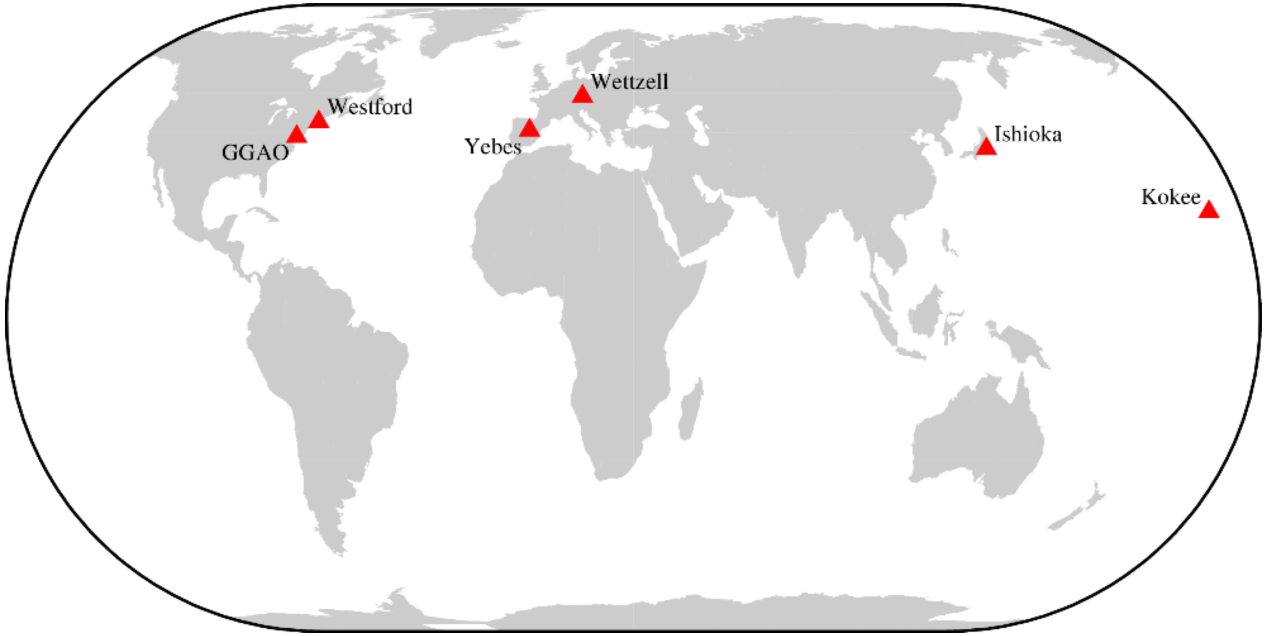
VGOS Pilot Project



VGOS Trials: Implementation



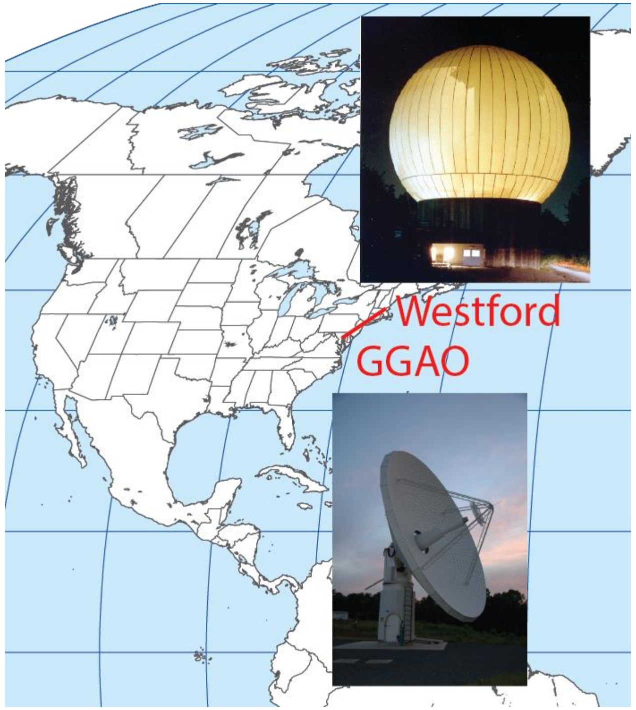
- Trial 1 of 2016 not a full end-to-end test (antenna and backend issues)

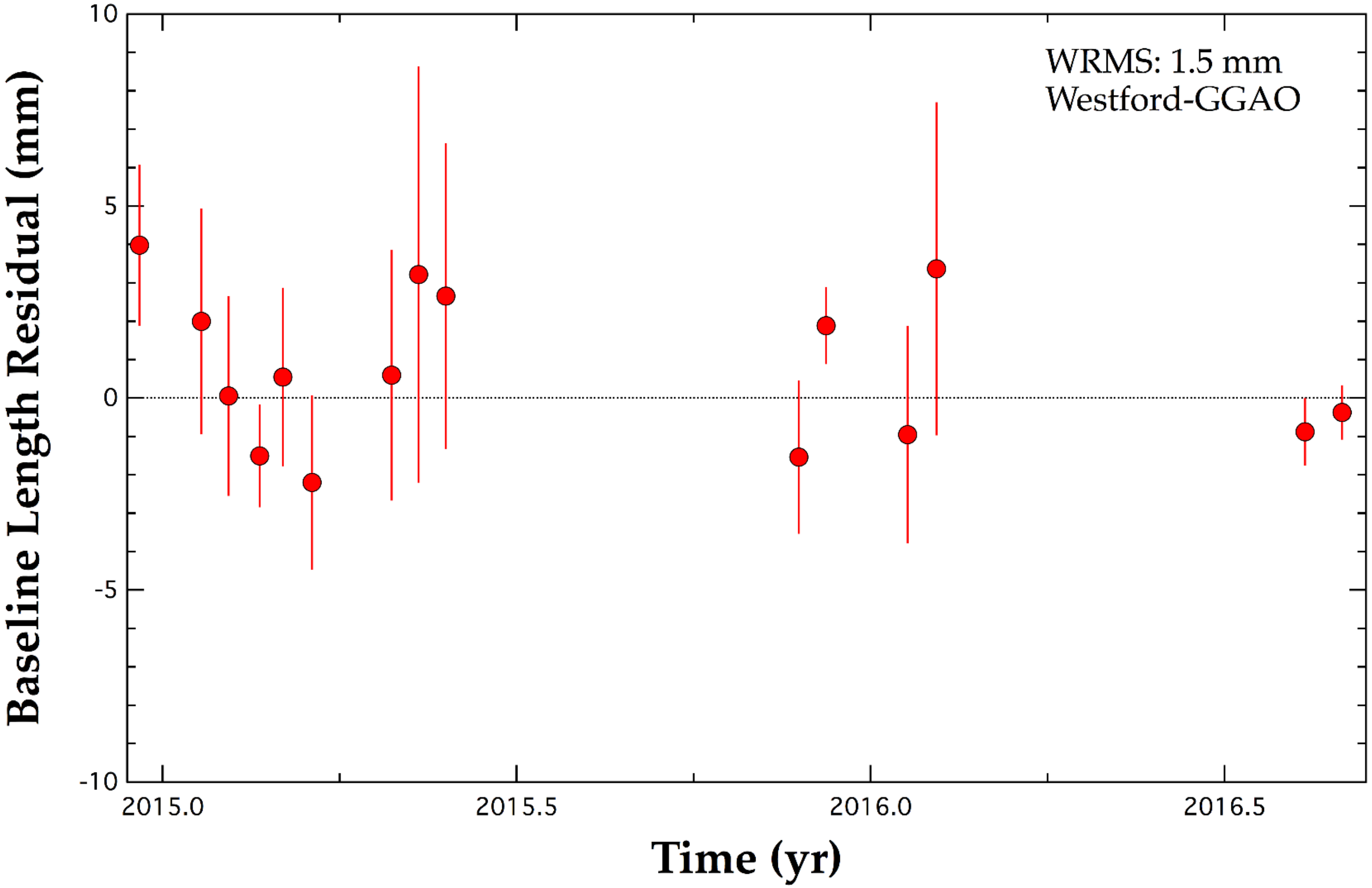


- Repeat of Trial 1 in 2017 (Feb–Apr)
- Trial 2 (Jun–Aug)
- CONT17 is planned to have a VGOS portion (Nov 28 – Dec 13)

VGOS Tests: Precision Assessment

from Poster **G41B-1016**: Pedro Elósegui et al. – Accuracy evaluation of the next-generation VLBI systems from first observations





VGOS: Data Transport, Correlation, Analysis

Data transport (raw data) in 2020:

- Legacy S/X network: ~2000 TB/year
- VGOS: ~1000 TB/day (~40 TB/day/site)
- Required network data rates at...
  - each site: 5.6 Gbps (now ~1 Gbps)
  - correlator: 134 Gbps (now 1–20 Gbps)
- Challenge: transport bandwidth

Correlation:

- Software correlator on PC cluster with off-the-shelf components (scalable)
- Challenge: power consumption (for processors and cooling)

Analysis:

- Tremendeous increase in observables
- High degree of automatization required
- Different levels of latency (next slide)
- Dependency on rapid availabilty of auxiliary data, e.g.,
  - Meteorological data
  - Mapping functions from numerical weather models

VGOS: Possible Product Portfolio

Product	Granule	Update every	Expected Accuracy (WRMS)	
Ultra-rapid	0.5 hours	0.5 hours	UT1−UTC:	7 μs
Rapid w/ continuous near-real time correlation	3 hours	3 hours	UT1−UTC: Polar motion: Nutation offsets:	5 μs 75 μas 75 μas
Rapid w/ batch correlation of 3-hr or 24-hr blocks		3–24 hours		
Intermediate w/ continuous near-real time correlation	3 hours	24 hours	UT1−UTC: Polar motion: Nutation offsets:	3 μs 45 μas 45 μas
Intermediate w/ batch correla-tion of 3-hr or 24-hr blocks		24 hours		
Final	3 hours	7 days	UT1−UTC: Polar motion: Nutation offsets: Telescope coordinates: Source positions:	1 μs 15 μas 15 μas 3 mm 15 μas

Has a kangaroo pressed the emergency stop button?

Serious design flaw:

- It happened at Yarragadee in Western Australia.
- You cannot think of everything.
- pedestal emergency stop button at head-height for a kangaroo
- kangaroo pressed e-button
- extension of experiment checklist

Antenna: pad clear of obstructions	☑
Antenna: has a kangaroo pressed the pedestal e-stop button?	☐
Antenna: Time OK (i.e. SNTP server OK)	☑

Ny Ålesund Twin Telescope

Courtesy Veidekke Arctic