Update on the International Terrestrial Reference Frame (ITRF)

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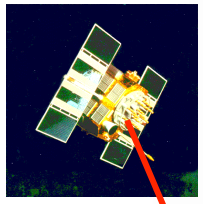
The ITRF



VLBI

SLR

GNSS

DORIS

Goal & Challenge: determine locations & deformations with an improved precision, Everywhere & Anytime on Earth, to satisfy societal and science requirements

ITRF defining parameters: Origin, Scale & Orientation

Why is a Reference Frame needed?

- **Precise Orbit Determination for:**
  - **GNSS: Global Navigation Satellite Systems**
  - **Other satellite missions: Altimetry, Oceanography, Gravity**
- **Earth Science & Societal Applications**
  - **Mean sea level variations**
  - **Hazard mitigation and tsunami warning**
  - **Plate motion and crustal deformation**
  - **Glacial Isostatic Adjustment (GIA)**
  - **…**
- **Geo-referencing applications : positioning, navigation, surveying…**

- **GNSS is today's tool for all the above and for accessing the ITRF**

==> Inter-Operability between GNSS is needed

But, GNSS Weaknesses for ITRF defining parameters:

- A GNSS Satellite does not "see" the Earth center of mass:
  - Geocenter components are absorbed by clock & other parameters
  - ==> Need more stable on-board clocks (10^{-12}), but at the satellite revolution period
  - ==> Need robust clock thermal conditions
  - ==> Add an accelerometer to each Satellite
- GNSS TRF Scale is under-determined
  - ==> Satellite antennas to be calibrated
- ITRF relies on SLR for the origin and on SLR & VLBI for the scale

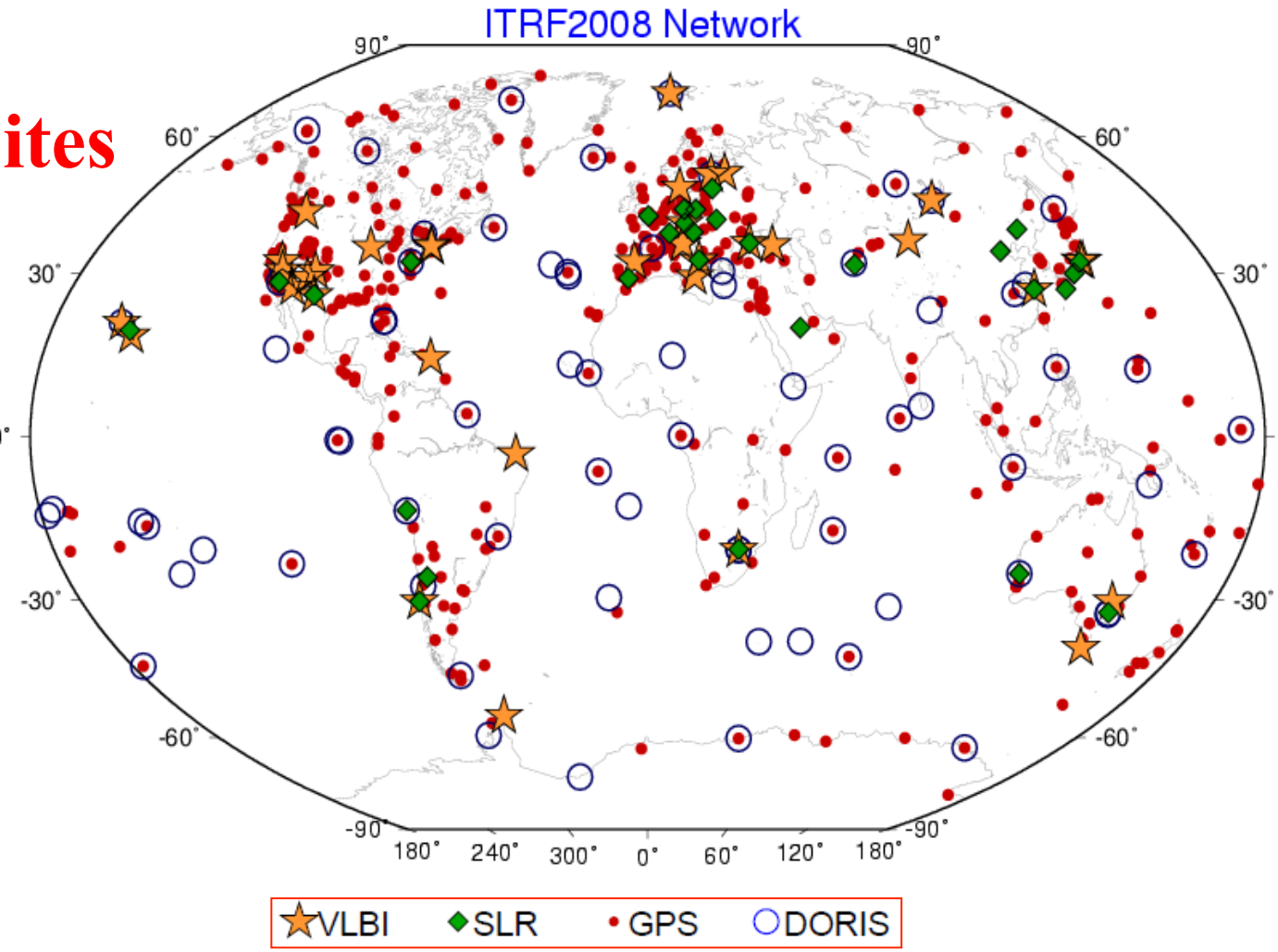
ITRF Network

~ 600 sites

~ 500 GNSS sites

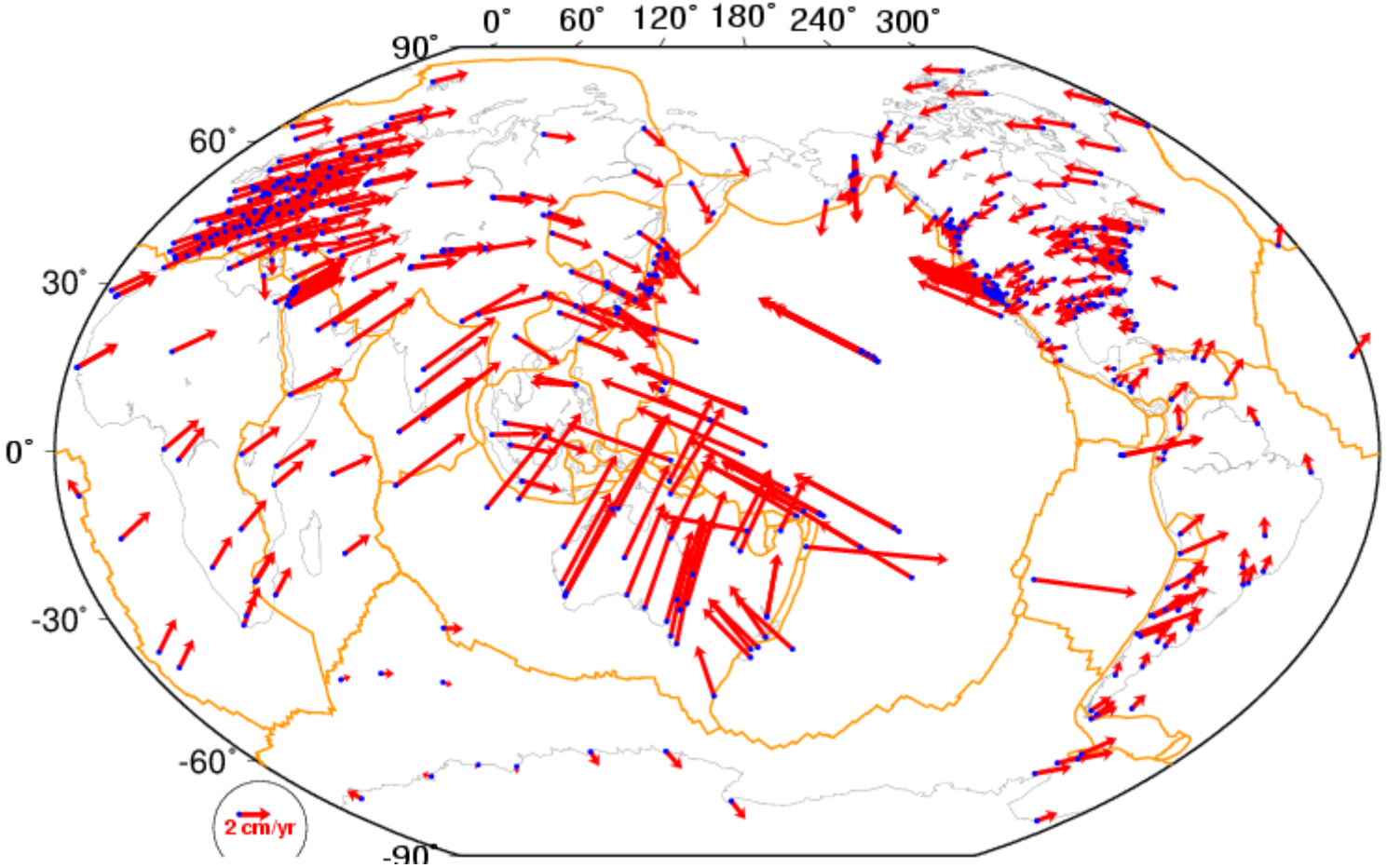
461 Sites North

118 Sites South



ITRF2008 Site Velocities:

time-span > 3 yrs, (σ ~ 0.1 – 1 mm/yr)



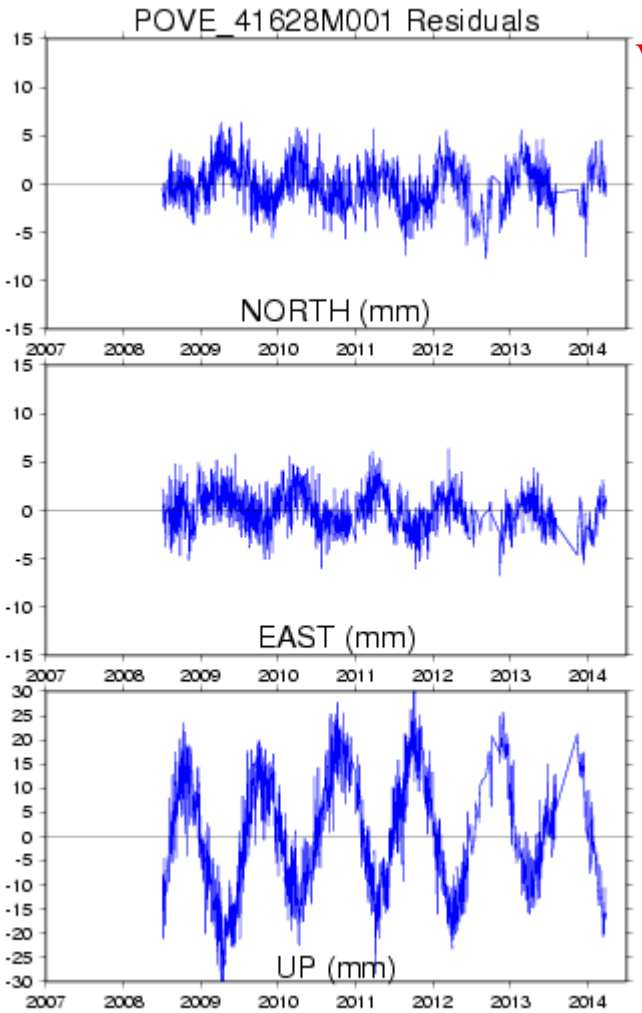
$$X(t) = X(t_0) + \dot{X}(t - t_0)$$

Next ITRF solution (ITRF2013)

- To be ready mid-2015
- Name might be changed to ITRF2014
- Expected Improvements & Developments:
  - Improved modeling of non-linear station motions
    - All kind of ruptures/discontinuities in the position time series
    - Seasonal signals
    - Modeling of post-seismic deformation

Position Residuals of Porto Velho, Brazil

Standard Solution

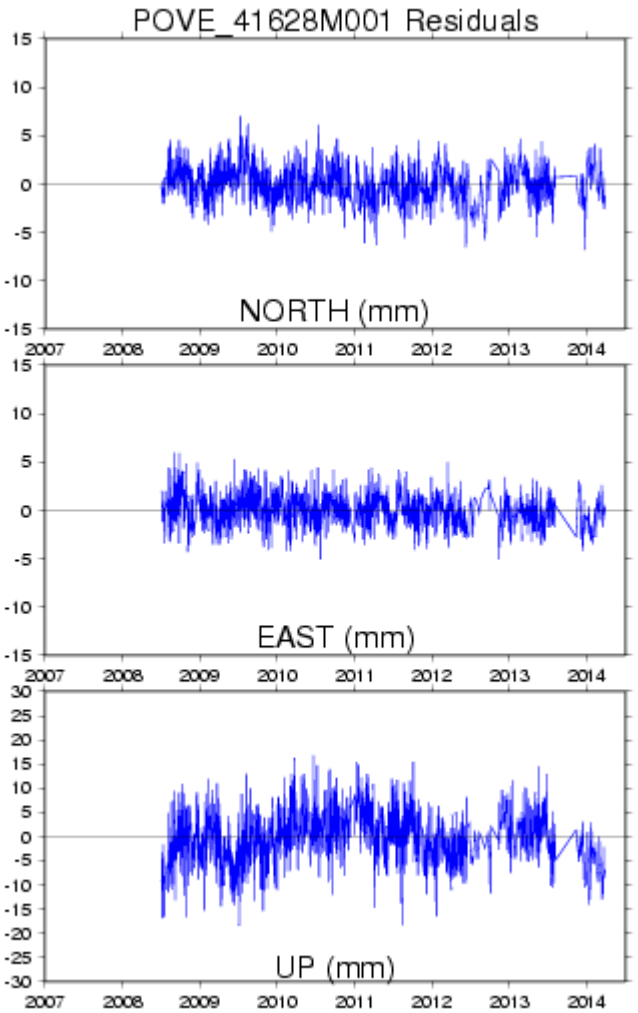


Velocity change

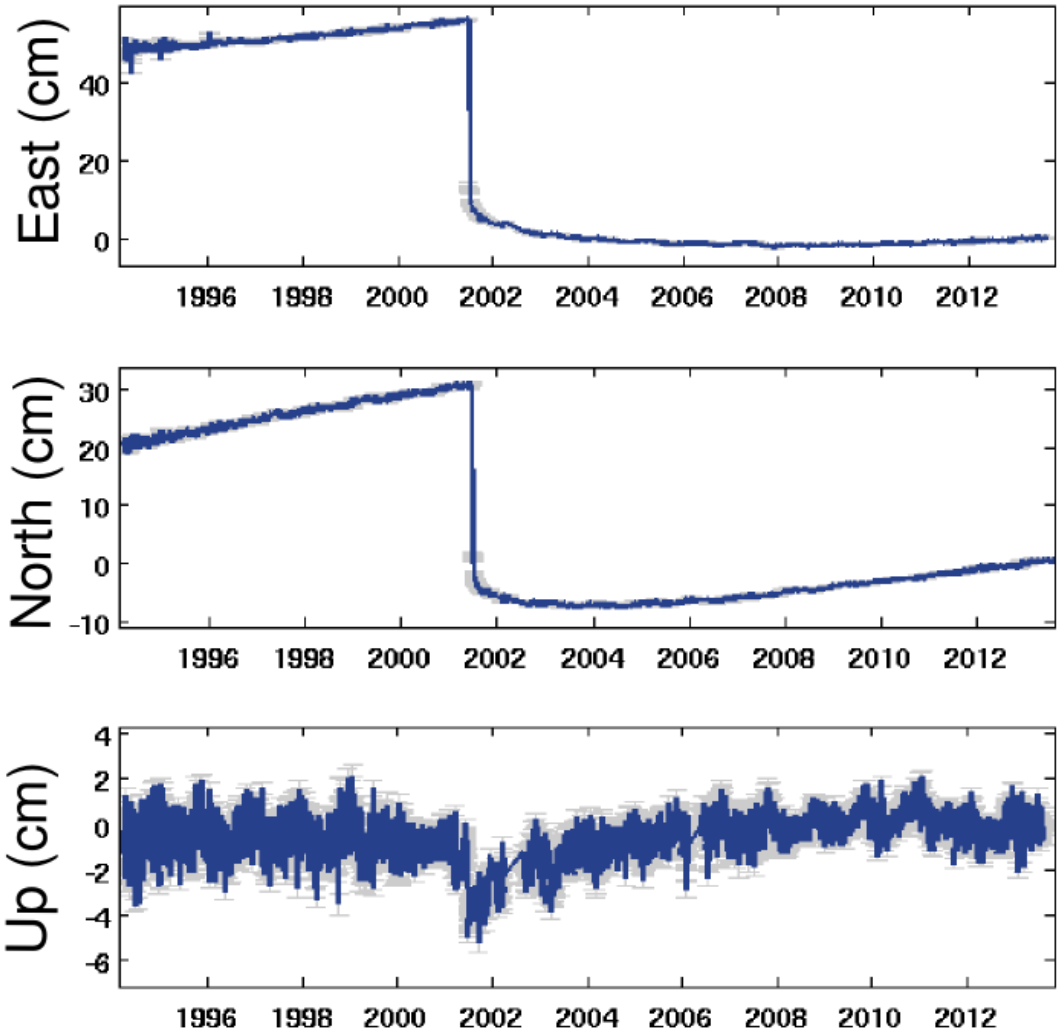
Horizontal: 0.2 mm/yr

Vertical: 1.7 (±0.15) mm/yr

Ann+semi-ann removed



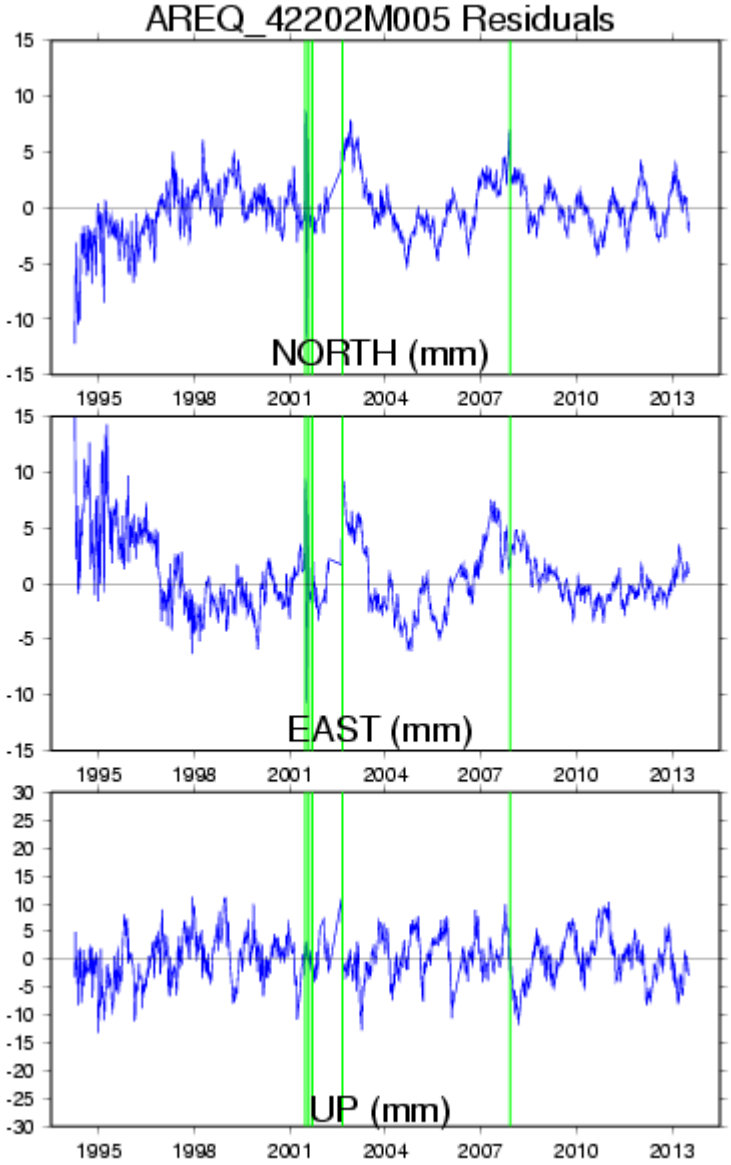
Post-Seismic Deformation



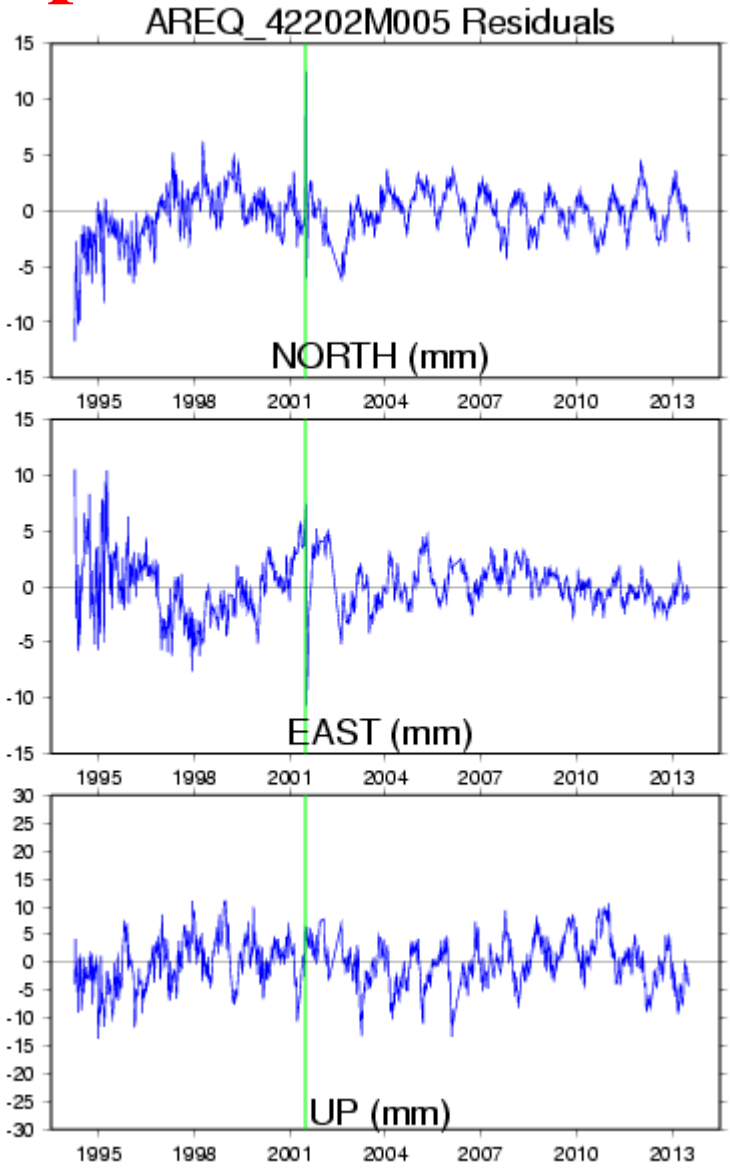
Arequipa (Peru)

Linear Function — Arequipa — Parametric Model

Multiple velocities estimated



Post-fit residuals



One velocity estimated

Lercier et al., 2014, submitted

Access to the ITRF and the IGS role

- **Any GNSS network can easily be expressed in the ITRF using IGS products (orbit, clocks, ERP: all expressed in the ITRF)**

- **Publicly available:**
  - **IGS/GNSS observations (RINEX files) & Products**
  - **Geodetic/mathematical procedure to express a GNSS network in the ITRF is**
  - **Scientific software packages**

Conclusion: Key Points

- **GNSS provides high accuracy for positioning applications**
- **IAG/IERS provides the International Terrestrial Reference Frame (ITRF), the most accurate global RF available today;**
- **All GNSS positioning services rely on the ITRF availability, through IGS products;**
- **Implementation of GNSS-based Global, Regional & National reference frames depend & rely on the availability of the ITRF;**

- **ICG WG-D notes the progress of the alignment of GNSS associated reference frames to the ITRF**
- **ICG to acknowledge/support UN-GGIM initiative: need for UN mandate for the GGRF and its infrastructure**

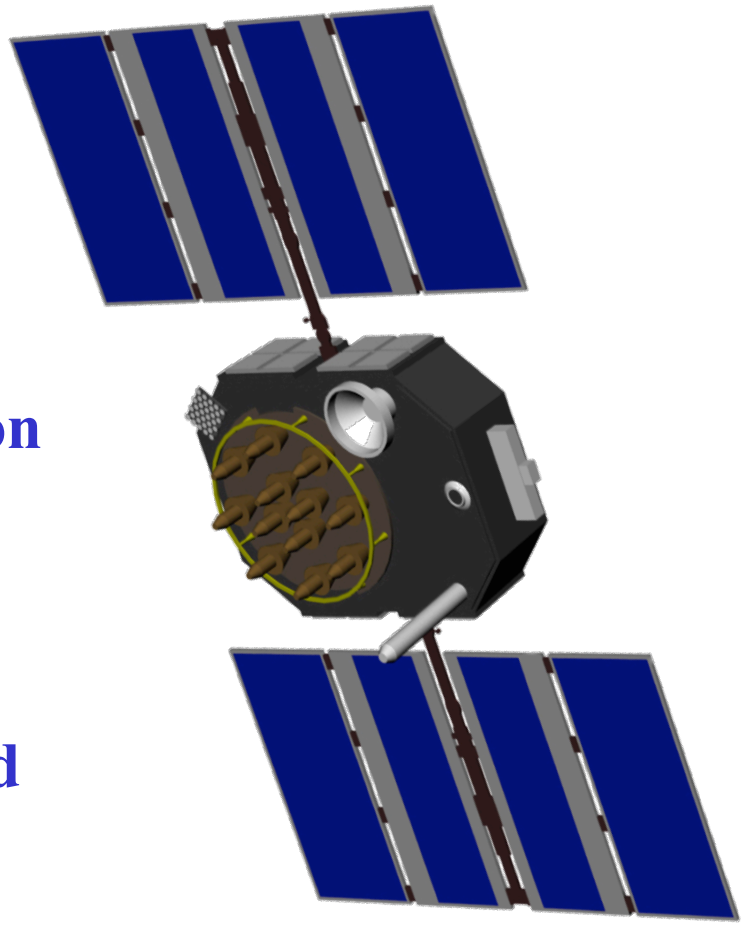
Geodetic Community Wishes Toward GNSS Providers

- **Satellite antennas to be calibrated before launch**
  ==> Ensure/improve the scale stability of the GNSS RF
- **Add an accelerometer & ultra-stable clock to each GNSS satellite**
  ==> Improve the geocenter determination by GNSS

- **Provide data of subset of GNSS control stations to IGS for inclusion in the ITRF**
  (cf. ICG-6 WG-D Recommendation)
  ==> (1) facilitate GNSS RF alignment to ITRF &
  (2) ensure interoperability between GNSS RFs

GNSS satellite data for orbit dynamics modelling

- Surface geometry and dimensions
- Surface optical properties (or material types)
- Nominal attitude model
- Transmitted power in all signals (and direction if relevant)
- Solar panel construction information (thickness, conductivity, power draw)
- Position and power output of radiators
- Thermal properties of multi-layered insulation



More detailed list

- Structural data/drawings of the satellite, with dimensions (surface only – we don't need the internals)
- Optical properties (reflectivity, specularity) of the surface materials
- Identification of what is covered in multi-layered insulation (MLI) or 'thermal blankets'
- Attitude model of the satellite
- Power of all transmitted signals (note we don't need to know anything about function of the signals, only which way they are pointed, and how much power is transmitted)
- Construction data of the solar panel (material types, thickness, conductivity, surface properties – reflectivity, specularity, emissivity, power draw from the panel)

Thank you