Swedish contribution to the International Geodetic Infrastructure

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Martin Lidberg,
Head of department of Geodetic infrastructure, Lantmäteriet, Sweden
Also chairman of EUREF, www.euref.eu

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MESSAGE IN SHORT

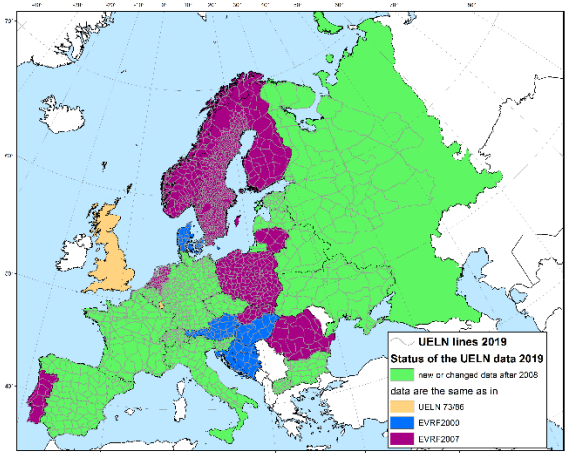
- No country can do everything
- but all countries can contribute with something
- we in Europe need a well functioning global geodetic infrastructure
- and we need to contribute
- and we probably need to support geodetic infrastructure in other parts of the world as well

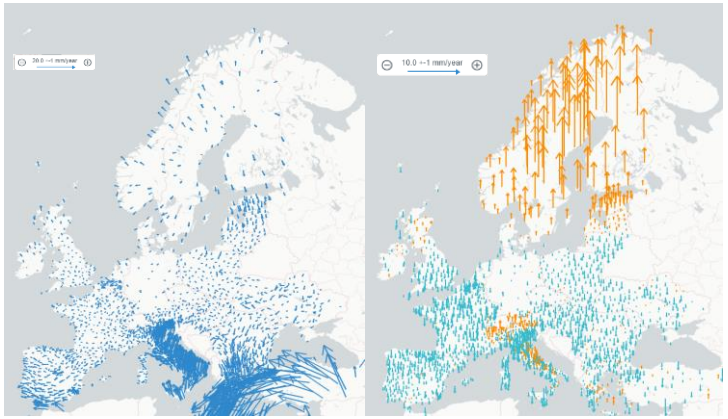
However:

- we may face severe challenges also within Europe!
- this presentation is about such an example from Sweden – and some lessons learned from that!!

But first – since I am also chairman of EUREF

- EUREF – the IAG (*International Association of Geodesy*) Reference Frame Sub-Commission for Europe
- Funded in 1987
- Yearly symposia with 100+ participants from almost all European countries
- Cooperation within Geodetic Reference Frames, GNSS infrastructure, heights, deformations, infrastructure





The story on financial challenges for the Geodetic Infrastructure at the Onsala Space Observatory - and the work to fix it!

WHAT IS THE ONSALA SPACE OBSERVATORY?

- The Swedish national facility for Radio Astronomy
- World leading research in booth Astronomy and Geodesy
- Established in the 1960s
- Owned and operated by the Chalmers Technical University, Gothenburg
- Financed by the Swedish Research Council
- "*some years ago*" the Research Council announced that they will **stop funding the Geodetic Infrastructure** (but continue with Astronomy)
- The geodetic part has developed towards an important infrastructure necessary necessary for many components in the modern society!

Explaining why Onsala should be financed trough Lantmäteriet

- Onsala is the ”anchor” connecting the National Coordinate Reference System to the Global Geodetic Reference Frame
- All countries don’t need it own ”Onsala”, but some are needed and Onsala is one of few in Europe – and it is a good one!
- Sweden, trough Lantmäteriet, is engaged in UN-GGIM. The efforts have resulted in the 2015 UN Resolution on “*Global Geodetic Reference Frame for Sustainable Development*”. *The Resolution is about contribution to the Global geodetic Infrastructure so we can live well on earth in the future!*
- The transition from a research financer (Research Council) to a national authority (Lantmäteriet) is an improvement in terms of sustainability
- Of the UN Agenda 2030 17 goals for sustainable development, 11 is dependent on a Global Geodetic Infrastructure

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Scientific Assembly of the International Association of Geodesy
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The importance of geodetic infrastructure and its connection to the UN 2030 Ag

Martin Lidberg, Lantmäteriet, Sweden, martin.Lidberg@lm.se ; Rüdiger Haas, Chalmers University of Technology, Sweden, rudiger.haas@chalmers.se

While working on a renewed funding structure for the geodetic infrastructure at the Onsala Space Observatory, we have had the privilege to spend some time to develop motivation for the global geodetic infrastructure including the geodetic fundamental stations. As part of this work we have mapped 11 of the 17 UN Agenda 2030 goals to GGFR and Geodetic infrastructure including short motivation and explanation for each of these goals.

Here we share this description and uncomplicated motivation that may be useful also for others while working for maintaining, renewing and developing components that is part of the Global geodetic infrastructure.

The majority of the 17 UN Agenda 2030 goals are directly or indirectly related to the existence and access to a reliable and accurate global geodetic reference frame (GGRF). The GGRF has already earlier been identified by the UN as being crucial for sustainable development. Establishing and maintaining such a GGRF is only possible by making use of an international network of geodetic infrastructure, so-called geodetic core sites.

Only through a close cooperation of an international network of geodetic core sites it is possible to perform the high-precision space geodetic observations that are necessary to determine the terrestrial and celestial reference frames, as well as the earth orientation parameters. Thus, this international cooperation effort relies on worldwide network of well-established and maintained state-of-the-art geodetic infrastructure.

The United Nations 2030 Agenda for a sustainable development formulates 17 important and ambitious goals. These goals are part of an international plan for the benefit of human society and our vulnerable planet.

2: Zero hunger: Precision farming is part of this and depends on position services as well as precise geodata based on the GGRF.

6: Clean water and sanitation: Water and sewage pipes need to be established and managed. Access to geodata and a geodetic infrastructure creates the prerequisites.

7: Affordable and clean energy: Geodata based on the GGRF is a prerequisite for e.g. optimal location of wind turbines and solar panels.

8: Decent work and economic growth: The economic growth of modern society is increasingly dependent on reliable navigation and communication systems, based on a reliable geodetic infrastructure.

9: Industry, innovation and infrastructure: The infrastructure of society can only be built, managed and developed with the help of a reliable geodetic infrastructure.

11: Sustainable cities and communities: Community building and sustainable management are largely dependent on geodetic infrastructure for mapping and documentation.

12: Responsible consumption and production: Sustainable production and distribution of goods requires well-functioning logistics planning and hence depends on geodata and navigation services.

13: Climate action: Climate change, e.g. sea level changes, must be continuously monitored, and this requires an accurate and over time stable GGRF based on a reliable and sustainable global geodetic infrastructure.

14: Life below water: The GGRF is a pre-requisite for the sustainable use of the oceans and marine resources (through navigation services), and for monitoring (via satellites).

15: Life on land: Remote sensing satellites are important for global environmental monitoring and these are dependent on the GGRF.

17: Partnership for the goals: Management and development of the GGRF must be coordinated globally through international cooperation, and this promotes global partnerships between international actors.

Ref: UN General Assembly on 26 February 2015 resolution 69/266.
"A global geodetic reference frame for sustainable development"

THE GLOBALA GEODETIC REFERENCE FRAME

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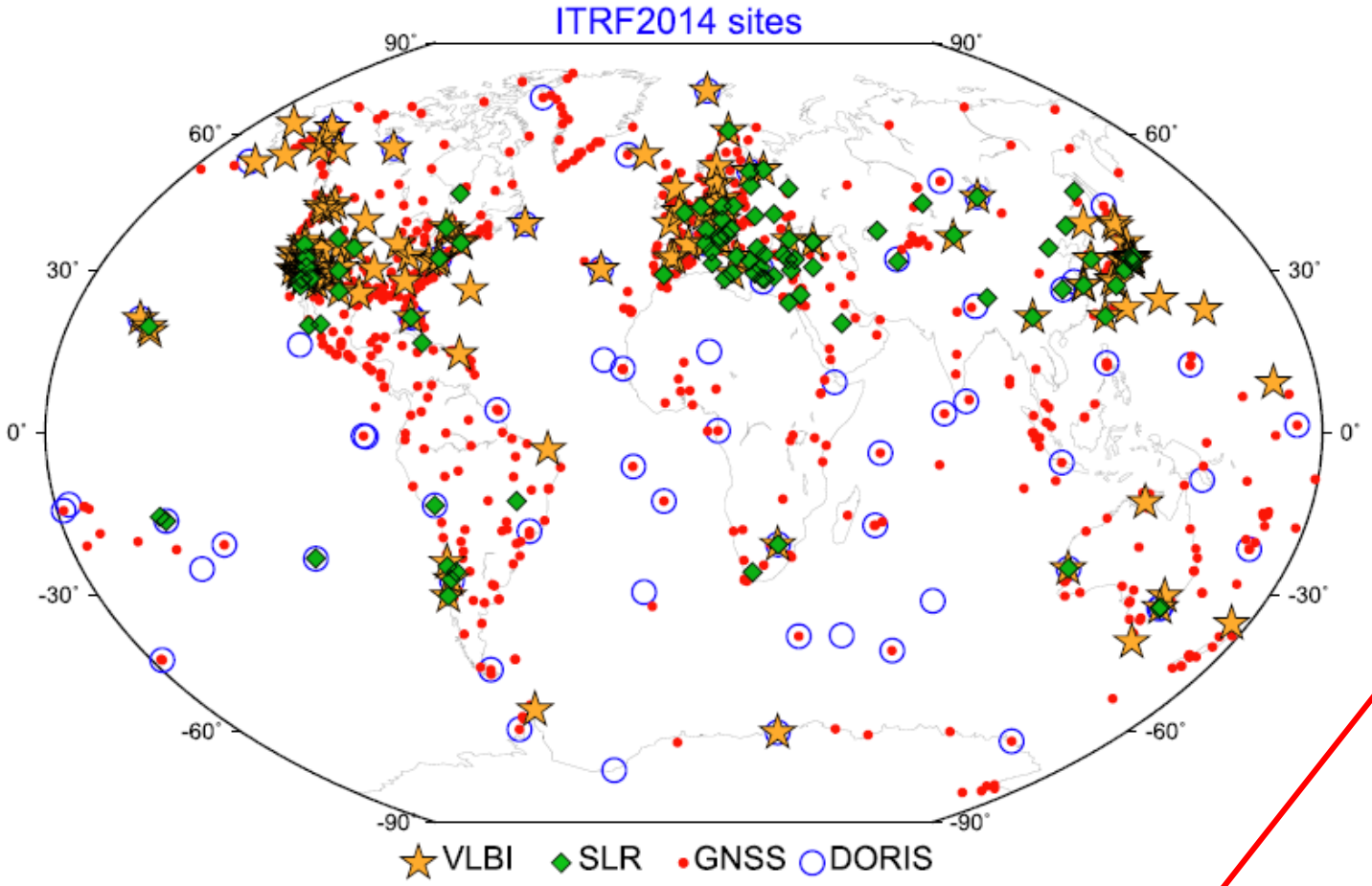
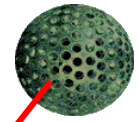
Stations in ITRF2014



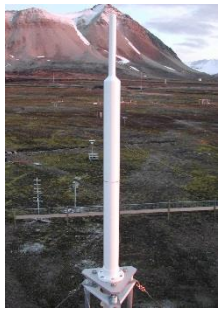


ITRF2014 map from: Altamimi, Z., P. Rebischung, L. Métivier, and C. Xavier (2016), ITRF2014: A new release of the International Terrestrial Reference Frame modeling nonlinear station motions, *J. Geophys. Res. Solid Earth*, *121*, doi:10.1002/2016JB013098

⇒ VLBI sites ⇐

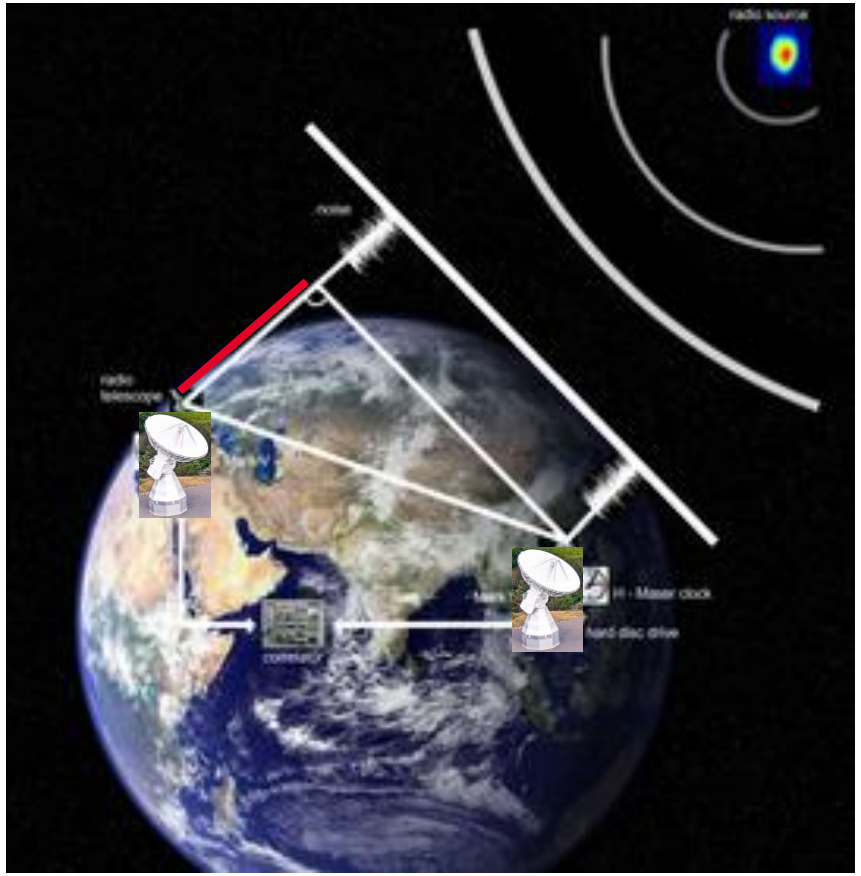
SLR/LLR laser ⇒

GPS station



DORIS ⇐

VLBI – VERY LONG BASELINE INTERFEROMETRY



- VILBI – how it works
  - Two radio telescopes "listen" to "radio noise" from a source "very far away"
  - The noise reach the two telescopes at slightly different time
  - Time difference * speed of light gives distance
- By combining many observations we get:
  - A Global Geodetic Reference Frame
  - the Earth orientation in space

ON THE NEED FOR GEODETIC OBSERVATORIES

- GPS/GNSS and precise positioning service (e.g. network RTK services) are dependent on a Global Geodetic Reference Frame
- But need also information on the satellites´ precise positions (*satellite orbits*) in the Global Geodetic Reference Frame
- This requires knowledge on the **Earth orientation in space**!
- Observations needed on daily basis!

- And it applies also for basically **all Remote Sensing satellite missions** in e.g. the Copernicus program; *(images, radar satellites for ground motion monitoring, sea level, ice melt)*

National benefits from the international contribution

- An international Geodetic Observatory gain **excellent expertise**!
- Lantmäteriet and Chalmers/Onsala have cooperated in the research and development of GPS since mid-1980s
- The first version (1993) of SWEPOS – the national GNSS infrastructure and RTK service – was established by Lantmäteriet and Onsala in cooperation
- Current design of SWEPOS is based on a series of common research projects from 2008 and onwards *(Chalmers, Lantmäteriet and RI.SE)*

- *You have probably your own stories – not identical, but maybe similar!*

Thanks!

Martin.Lidberg@lm.se