UNITED NATIONS GLOBAL GEODETIC CENTRE OF EXCELLENCE

JOINT UN-GGCE, UN-GGCE IAC AND UN-GGIM SUBCOMMITTEE ON GEODESY SESSION

Robust Global Geodesy Supply Chain (GGSC)

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Overview

1. Introduction
2. Systematic approach to GGSC
3. What is a *robust* GGCS?
4. User categories and their requirements
5. GGSC assessment framework
6. Attempts to quantify GGSC robustness. Sensitivity study
7. Outlook

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Reliance on the Global Navigation Satellite System (GNSS)

Telecommunication services

- Time synchronisation for accurate data transmission
- Without GNSS, continued operation of mobile phone networks would be impossible

Stock exchanges and financial systems

- A globally consistent timestamp of when a transaction occurs with traceability to Coordinated Universal Time (UTC) for regulatory compliance
- Without GNSS, banking systems would be severely impacted

Energy grids

- Time synchronisation in energy distribution systems
- Without GNSS, power grid operations would be more labour intensive and challenging, with further financial implications

Critical role of the Global Geodesy Supply Chain (GGSC)

18th meeting of the International Committee on Global Navigation Satellite Systems in Wellington, New Zealand, October 2024. Photo: Ryan Keenan.

"Following a week of discussions with the providers of Global Navigation Satellite Services (GNSS), it turns out my assumptions are right; unreliable geodetic products like Earth Orientation Parameters and Terrestrial Reference Frames are on the critical path for the delivery of robust PNT satellite services," says Mr. Brown.

Satellite operations may be at risk due to weaknesses in the GGSC

1. The photo and quote are taken from the following source:
United Nations Global Geodetic Centre of Excellence, "Newsletter 6" (November 2024). Available at https://ggim.un.org/UNGGCE/documents/UN-GGCE_Newsletter_6_2024.pdf (accessed on 7 March 2025).

1st Joint Development Plan & Robust GGSC

Phase 2: A robust global geodesy supply chain

Objective 2.1 – Geodetic products meet Member State accuracy, reliability and integrity standards to deliver on operational requirements

Outcomes

2.1.1 A jointly designed robust global geodesy supply chain including ground observing stations, technology, analysis, capacity, software, spectrum and cybersecurity requirements.

1. United Nations Global Geodetic Centre of Excellence (2025). "1st Joint Development Plan for Global Geodesy. Version 1.0". Available at https://ggim.un.org/UNGGCE/documents/Version_1.0_1st_Joint_Development_Plan_for_Global_Geodesy_EN.pdf (accessed on 28 February 2025).

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SYSTEMATIC APPROACH TO GGSC

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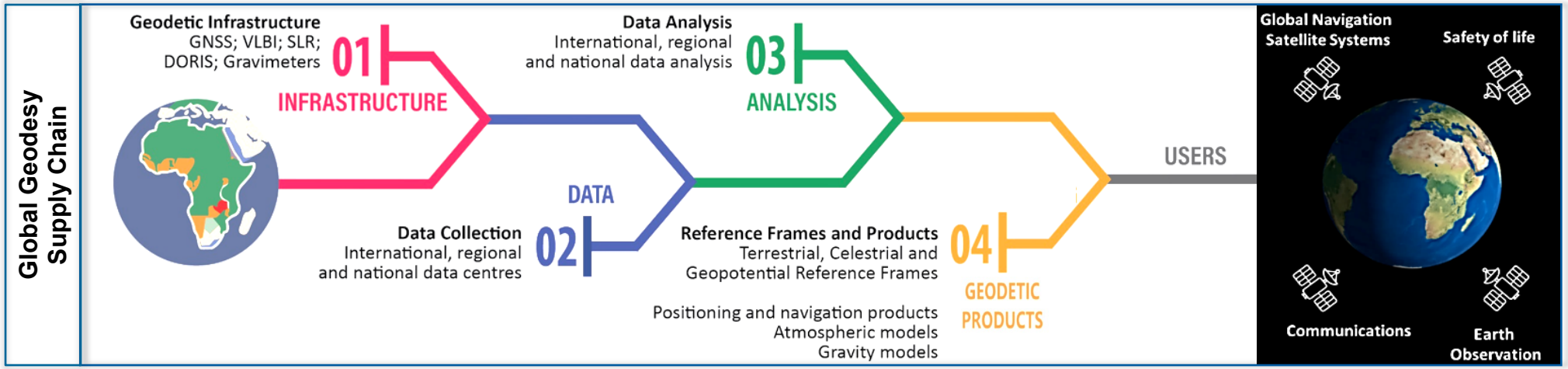
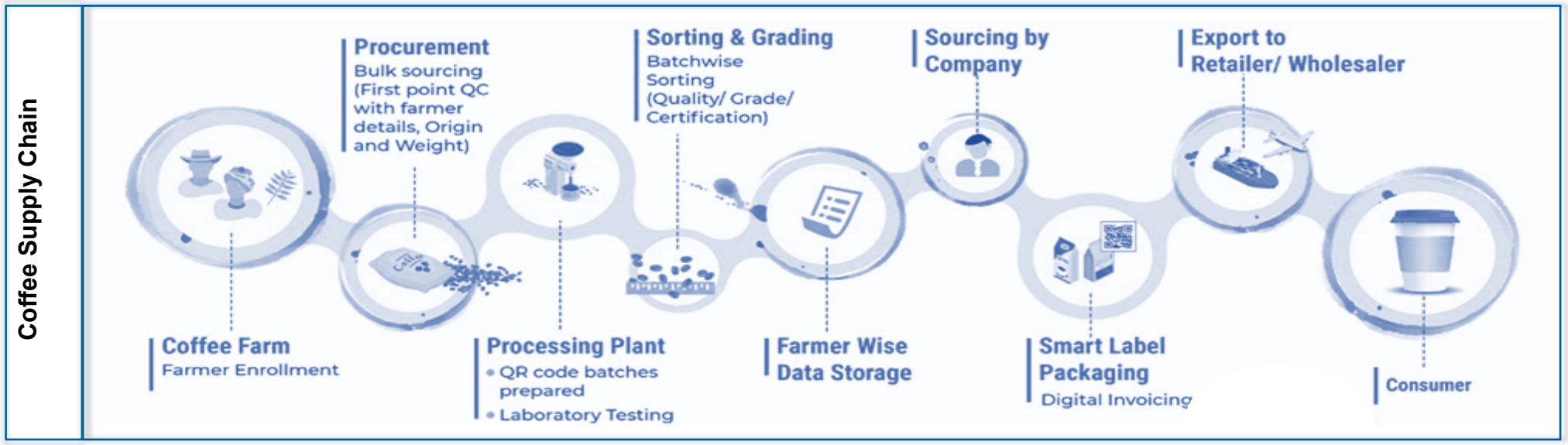
Supply chain is a complex system

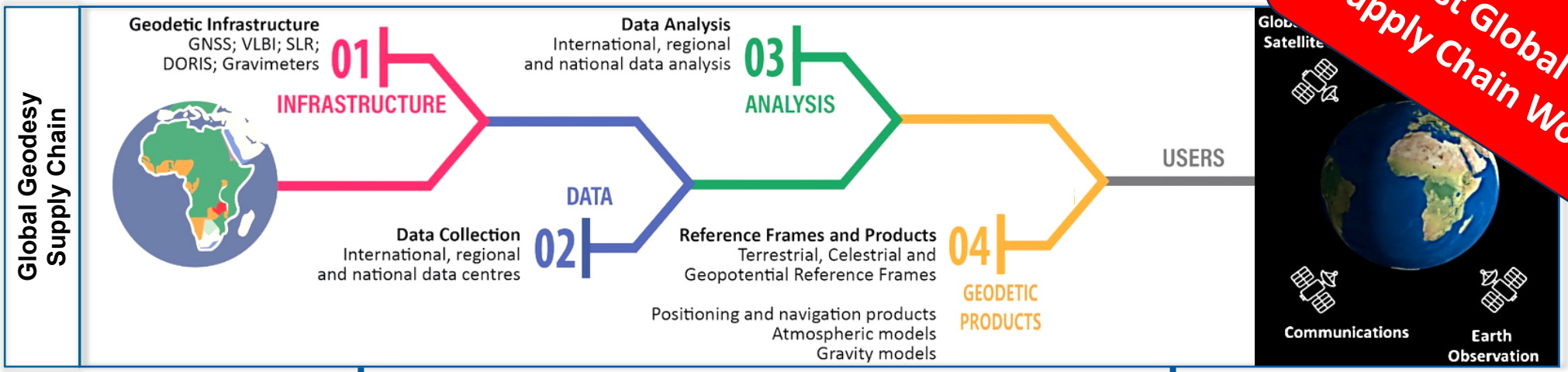




1. The GGSC schematic is adapted from https://un-ggim-europe.org/wp-content/uploads/2023/11/UN-GGCE-Strategy-and-Operating-Plan.pdf.

2. Coffee supply chain schematic is taken from https://sourcetrace.com/blog/traceable-blockchain-solutions-for-your-cuppa-coffee/.

GGSC components



Robust Global Geodesy Supply Chain Workshop

MATERIAL (STRUCTURAL)

- Sites with geodetic techniques (VLBI, SLR, DORIS, GNSS, gravimeters)
- Corelation, combination, analysis, and geodetic product development centres
- Data centres
- Data distribution networks (e.g., optic fibre)

NON-MATERIAL (OPERATIONAL)

- Strategic and operational planning
- Technical support and coordination.
- Financial management,
- Quality and compliance management
- Risk management
- Human resources

WHAT IS A *ROBUST* GGSC?

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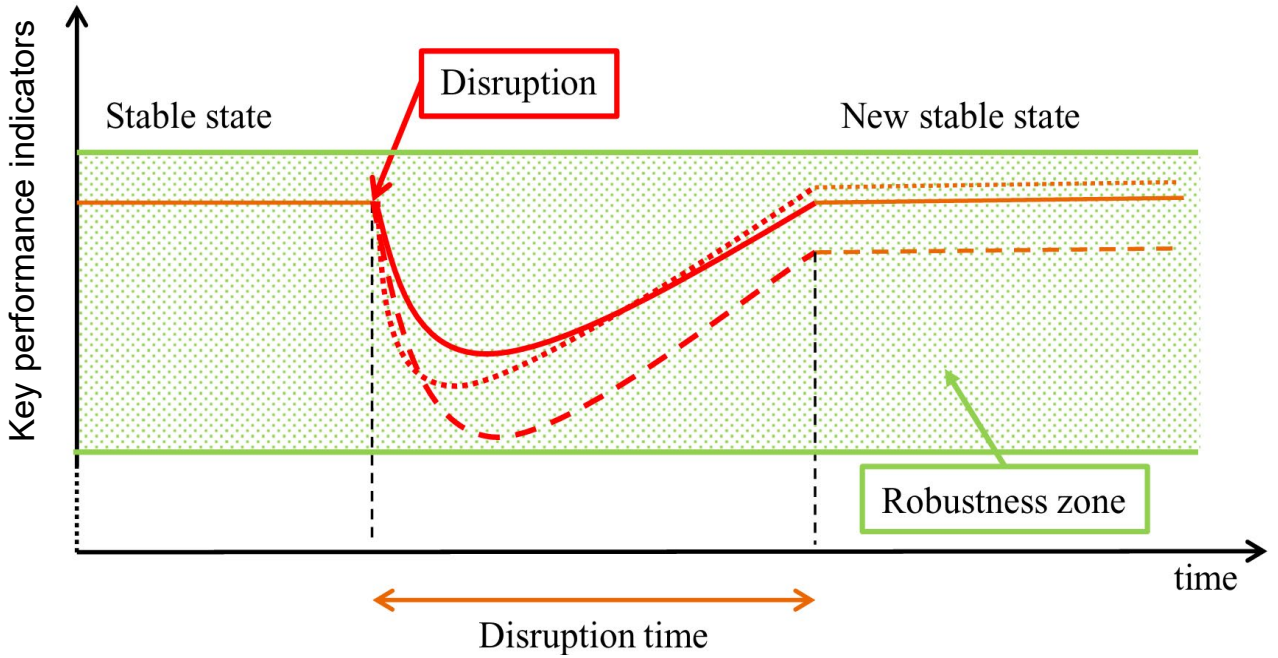
Definition of a *robust* GGSC

- **Robust** GGSC is a system that can maintain its performance (i.e., produce geodetic products with the required quality) despite a wide range of internal failures or external disturbances.



- The system is called robust **Global** Geodesy Supply Chain because no single country alone can produce in a robust manner geodetic products with the required accuracy for non-scientific and scientific purposes.

1. The Figure is adopted from the following source: Monostori J. (2016). Robustness- and complexity-oriented characterization of supply networks' structures. Procedia CIRP, Vol. 57, 67-72 pp, https://doi.org/10.1016/j.procir.2016.11.013.

Benefits of GGSC robustification

Robust GGSC

- Ensures timely adaptation to instabilities and a changing environment
- Prevents propagation of failures (i.e., cascade of failures)
- Prevents performance degradation and potential system collapse (i.e., approaching the so-called breakdown point)
- Ensures control of geodetic product uncertainties

WHAT DOES A ROBUST GGSC LOOK LIKE?

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GGSC USER CATEGORIES AND THEIR REQUIREMENTS

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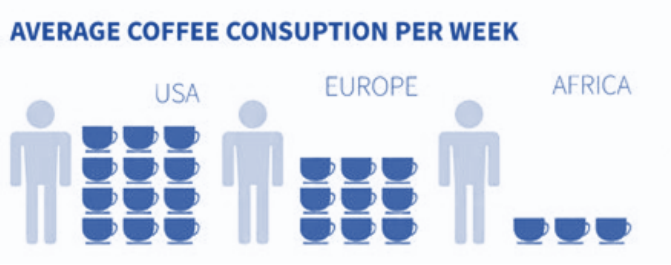
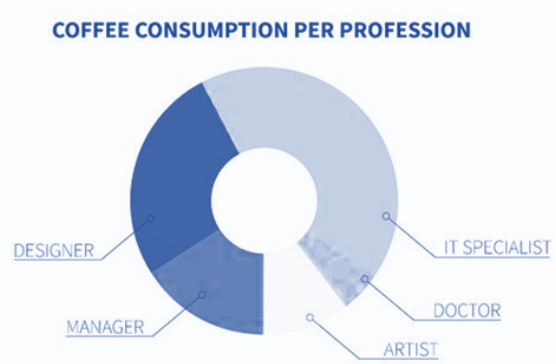
What do users expect?

Market segmentation and consumer preference analysis





Robust Global Geodesy Supply Chain Workshop

SOCIO-ECONOMIC DEVELOPMENT

- operational (non-scientific) needs
- used by industries, civil sector, national authorities, etc.
- positional accuracy between 5 mm and 10 cm
- minimal latency

SCIENTIFIC ADVANCEMENT

- scientific needs
- used by researchers, academic institutions, etc.
- positional accuracy 1-5 mm
- considerable latency

1. Note that the schematic about coffee supply chain analysis has no scientific meaning and is shown here only for illustration purpose. The schematic is adapted from https://in.pinterest.com/pin/perfect-detailed-coffee-infographic-elements-with-sample-data-made-in-coffee-consumption-around-the-wo--318137161177122663/.
2. The groups and requirements of GGSC users are adapted from: Plag, H.-P., & Pearlman, M. (2009). Global Geodetic Observing System. Meeting the Requirements of a Global Society on a Changing Planet in 2020. Berlin Heidelberg: Springer-Verlag. doi:10.1007/978-3-642-02687-4.

GGSC ASSESSMENT FRAMEWORK

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Supply Chain Operations Reference (SCOR) framework

- **Performance**
  metrics to describe the GGSC performance
- **Processes**
  descriptions of processes executed within the GGSC and their relationships
- **Practices**
  unique ways that lead to better GGSC performance (e.g., process automation, innovative technologies and methods)
- **People**
  description of skills (e.g., experience, training, competency level) required to perform tasks and manage processes within the GGCS

1. APICS (2017). "Supply Chain Operations Reference Model. SCOR. Version 12.0". Available at https://www.apics.org/docs/default-source/scor-training/scor-v12-0-framework-introduction.pdf?sfvrsn=2 (accessed on 6 March 2025).

Metrics to describe the GGSC performance

We define performance attributes with respect to:

- **Geodetic products** (i.e., fit for purpose to meet user requirements)
  - Uncertainty
  - Stability
  - Timeliness
- **Structural GGSC components** (i.e., ability to deliver geodetic products in a robust manner)
  - Spatial coverage and density of geodetic observations
  - Infrastructure (i.e., hardware and software) reliability

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GGOS Global Geodetic Observing System
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ATTEMPTS TO QUANTIFY GGSC ROBUSTNESS. SENSITIVITY STUDY

(publication in preparation) José C. Rodríguez, Liubov Poshyvailo-Strube, Nicholas Brown

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Study specifications

Objective of the study

- to determine how close GGSC is to a scenario where geodetic products would experience significant deterioration;
- to learn how fragile the current GGSC is.

What did we investigate?

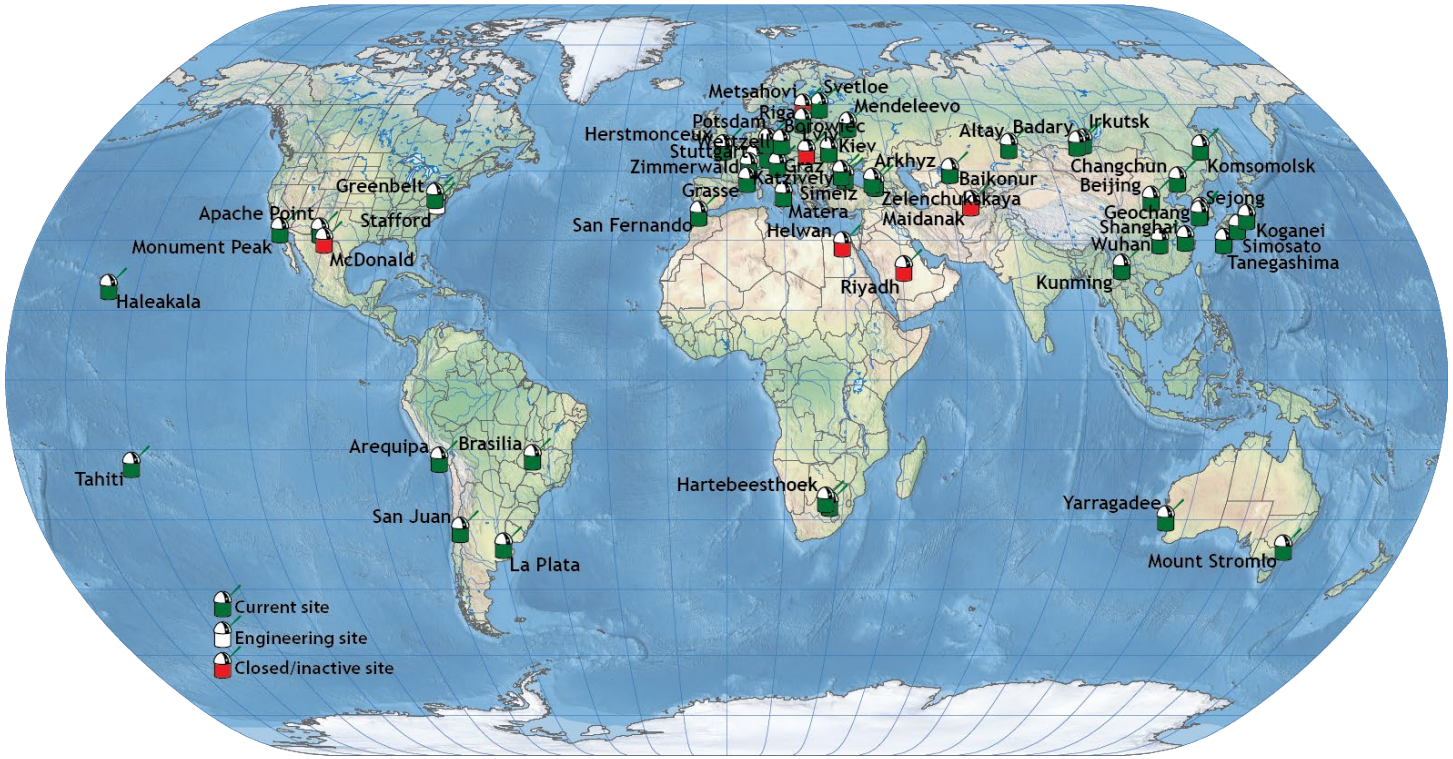
- global Satellite Laser Ranging (SLR) network though sensitivity studies with the Australian stations Yarragadee (7090) and Mount Stromlo (7825)
- 10 years of data, from 2014 to 2024

Applied tools

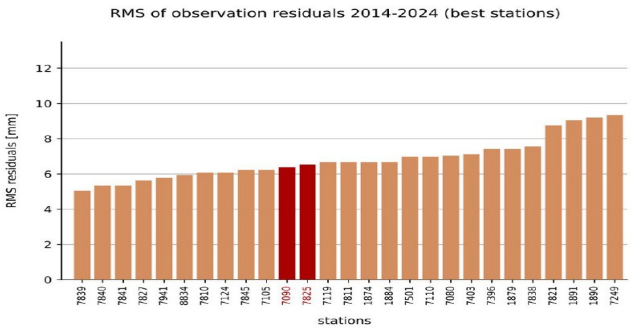
- Modified SATAN software package
  - SATellite ANalysis (SATAN)[1] developed at the Royal Greenwich Observatory, UK
  - Modifications co-developed by ILRS Analysis Centre NSGF, UK and IGN-Yebes Associate Analysis Centre, Spain [2]

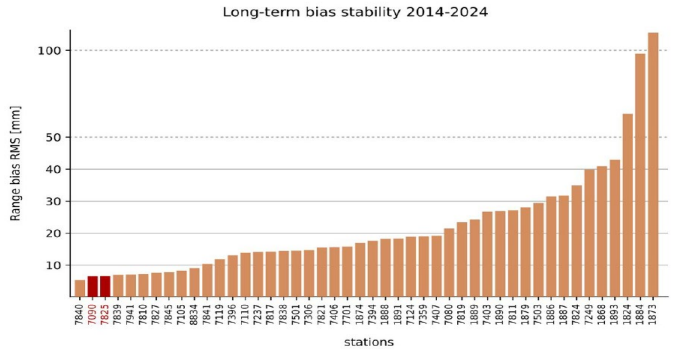
1. Sinclair AT, Appleby GM (1988) SATAN: programs for determination and analysis of satellite orbits from SLR data. SLR Technical Note 8. Greenwich Observatory, Cambridge.
2. Rodríguez, J.C. *et al.* (2022). Geodetic Analyses at the National Geographic Institute of Spain. In: Freymueller, J.T., Sánchez, L. (eds) Geodesy for a Sustainable Earth. International Association of Geodesy Symposia, vol 154. Springer, Cham. https://doi.org/10.1007/1345_2022_182.

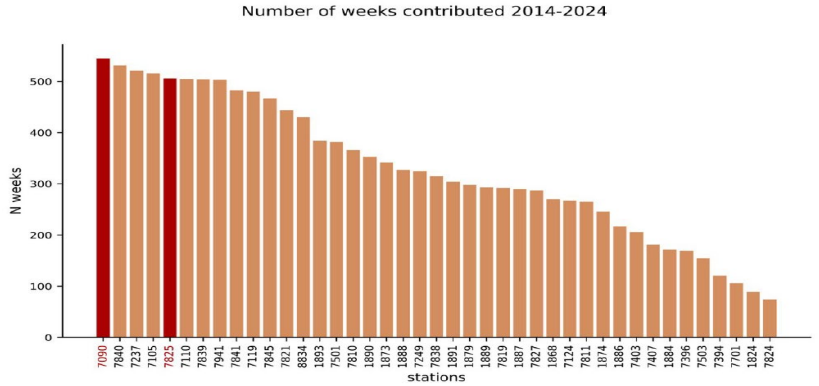
Sensitivity studies with Australian SLR stations

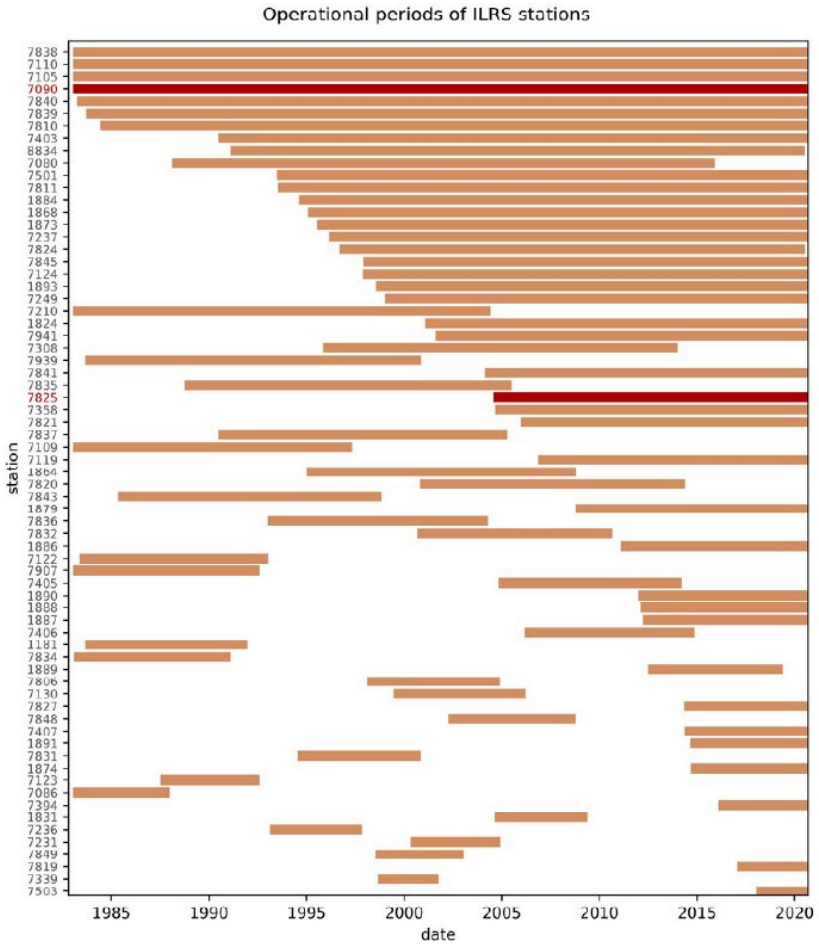


Source: https://ilrs.dgfi.tum.de/images/slrmap_web_dec_2019.png



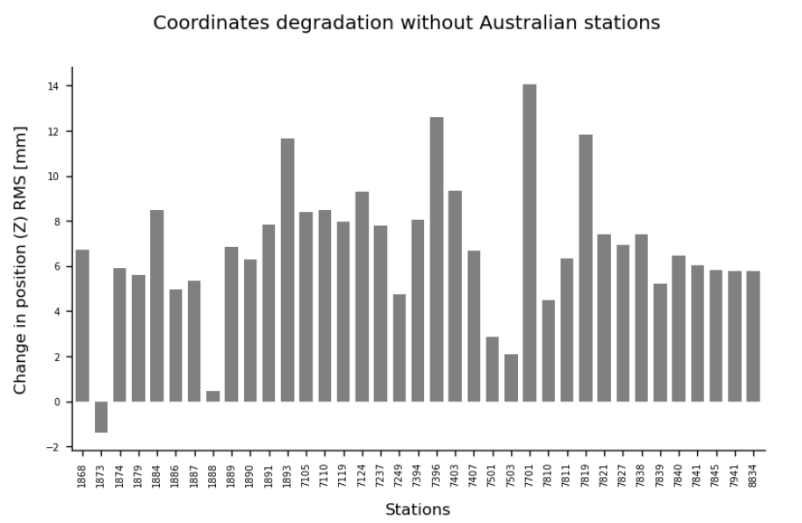


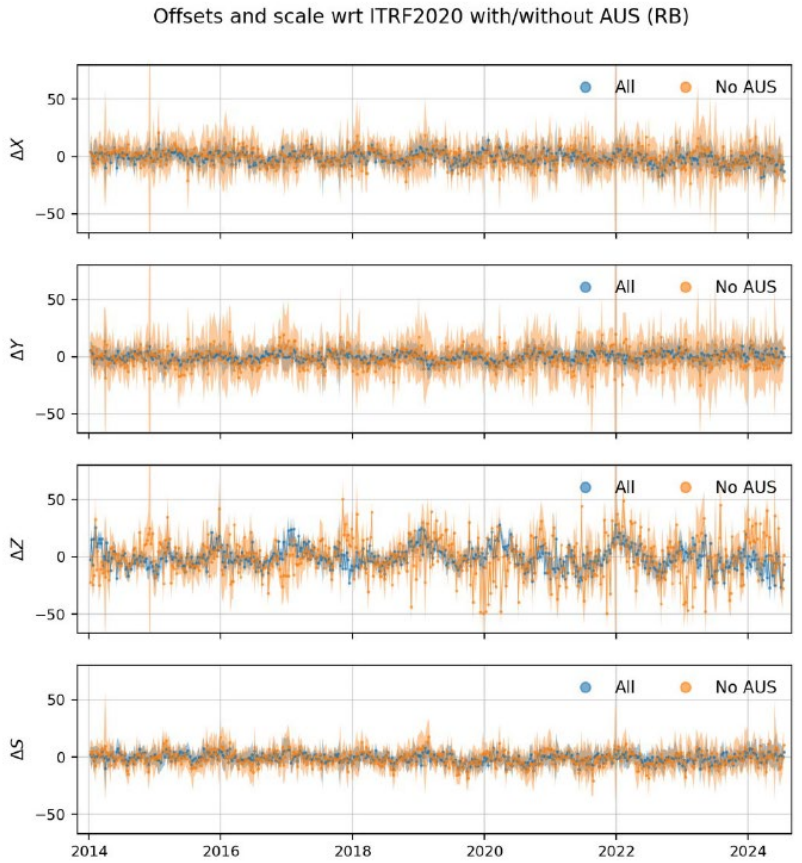




First results. Impact of the Australian stations

- Significant impact of the SLR station from Australia on geodetic products **highlights the fragility of GGSC**
- **Degradation of SLR station coordinates**
  - Significant degradation of the Z component of the station position
- **ITRF degradation**
  - Degradation of the Helmert parameter precision
- **Less precise Earth Rotation Parameters**
- It is unclear what the minimum level of regional redundancy is needed for a robust global SLR network
- Further studies are required to further analyse GGSC fragility





OUTLOOK

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Plans and ideas

1. Analyses on GGSC **user categories and their requirements**
2. Definition of the **current GGSC state**
3. Description of the **desired robust GGSC state**
4. **GGSC gap analysis** with the focus on non-scientific needs. Note that this is a prerequisite for Phase 3, where scientific needs will be included
5. Analyses **internal and external GGSC disturbances**
6. Establishment of a framework and **pathways to strengthen the GGSC towards long-term robustness**

Source: https://clipart-library.com/clip-art/coffee-png-transparent-25.htm


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