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Global Geodesy Needs Assessment
Expert Views and Perspectives

Version 1.0: 9 May 2024

United Nations Global Geodetic Centre of Excellence

Background report to
E/C.20/2024/10/Add.2

Committee of Experts on
Global Geospatial Information Management
Fourteenth Session
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United Nations

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About the UN-GGCE

The United Nations Global Geodetic Centre of Excellence (UN-GGCE) vision is a future where all countries have strong political support for geodesy which enables them to – together – implement the General Assembly Resolution 69/266[1] and accelerate the achievements of the Sustainable Development Goals to derive social, environmental and economic benefits.

At its tenth session in August 2020, the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), in making decision 10/104, welcomed and supported an offer by Germany to establish and host what has now become the United Nations Global Geodetic Centre of Excellence (UN-GGCE) at the UN Campus in Bonn, Germany. The UN-GGCE, established in March 2023, is envisioned to be a federated center and welcomes offers of support from Member States, including financial contributions, in person secondments, and virtual secondment.

For more information about the UN-GGCE please visit: https://ggim.un.org/UNGGCE/

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- Over 500 representatives from 110 Member State government departments and universities.
- UN-GGIM regional committees Secretariats and associated working groups from Africa, Americas, Arab States, Asia-Pacific, and Europe.
- The UN-GGIM Subcommittee on Geodesy.
- The International Association of Geodesy (IAG) and its technical Services (International DORIS Service, International Earth Rotation and Reference System Service, International Gravity Field Service, International GNSS Service, International Laser Ranging Service, International VLBI Service).
- International Federation of Surveyors (FIG).
- International Organization for Standardization Technical Committee 211 (ISO TC/211).
- International Hydrographic Organization (IHO).
- National Aeronautics and Space Administration (NASA).
- European Space Agency (ESA).

Comments

Your comments on this report are welcome.

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[1] General Assembly Resolution 69/266 (2015)

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Executive Summary

The Impending Geodesy Crisis

The global geodesy supply chain may soon be in crisis.

With the number of applications relying on satellite services still growing, the need for a robust and resilient geodesy supply chain is more crucial than ever. The global geodesy supply chain is needed to guide vehicles, automate agriculture practices, provide precise and coordinated timing to the world's financial markets, and inform pivotal policy decisions. In short, the global geodesy supply chain is not a luxury, but a critical tool that improves livelihoods and facilitates economic growth. Yet, despite its indispensable role, the current state of this vital supply chain is perilously close to collapse.

This is the conclusion drawn from information and insights provided by invited experts representing Member States, and partners from international science, surveying and standards organizations, academic institutions, private sector companies, and regional bodies. Despite the importance of the global geodesy supply chain being recognized in a United Nations General Assembly adopted resolution 69/266 in February 2015, entitled 'A Global Geodetic Reference Frame for Sustainable Development', the risk associated with weaknesses in the global geodesy supply chain remain hidden to many people.

The United Nations Global Geodetic Centre of Excellence has compiled this first Global Geodesy Needs Assessment based on information provided by Member States and partner organizations including a recent series of nine 'listening' sessions. The UN-GGCE team listened as participants provided open and forthright views on successes and challenges associated with the current supply chain, and enthusiastically expressed how the supply chain, could and should, operate in the future.

Geodesy is the science of measurement of the size, shape, orientation, and gravity field of the Earth, and how these parameters change over time. Geodesy is the science whose outputs are fundamental to the measurement of time, and measurement of any location on, above or below the Earth's surface. Land administration and land rights are not possible without the coordinate systems that geodesy provides. Furthermore, evidence is emerging that the risk of failure in the geodesy supply chain will compromise delivery of modern-day critical infrastructure operations, emergency services, safety of navigation, and the location-based services in mobile devices on which modern society depends.

The sources of risk of failure of the global geodesy supply chain are grouped into five focus areas in line with the UN-GGCE's Strategy and Operating Plan. Perspectives offered by experts provided qualitative evidence that confirmed the sources of risk, and emerging issues, in each of the five focus areas at both global and regional scales.

- **Insufficient evidence** of the importance of geodesy for governments to realize societal, environmental and economic benefits.
- **Insufficient resources** (including dedicated funds and people) to operate and stabilize the existing supply chain, let alone modernize and expand the system to meet expected future requirements.
- **Out-of-date or weak governance** mechanisms that, whilst being suitable in the pre-digital era, are no longer appropriate in a digitally connected, federated supply chain involving entities across different levels of government and across public, private, and academic sectors.
- **Fewer capacity** training opportunities being offered by academic institutions to train geodesy specialists.

- **A lack of awareness** of the reliance on geodesy of industry (geospatial as well as other sectors), the science community, and the public.

Avoiding the Impending Geodesy Crisis

Importantly, experts believe we can avoid an impending crisis.

In the listening sessions, experts offered perspectives on what the future state of a global geodesy supply chain could and should look like. Experts also offered suggestions for pathways to mitigate risks in the five focus areas, including:

- **Quantify the evidence** by sharing existing use cases, and commissioning of further business cases, that highlight the impact of geodesy on every day and commercial uses. Business cases must clearly demonstrate cost-benefit and benefit realization, be grounded on societal rather than scientific needs, and be described in words that funders will understand. Recognition of the global geodesy supply chain as 'critical infrastructure', as it is in some countries, would be welcomed by the experts.
- **Ensure enough dedicated resources are available** to continue generating accurate and reliable satellite services. Stabilization of the current global geodesy supply chain is of paramount concern. Participants called for greater visibility of the current investment and costs for future state options, and consideration of options that make better use of existing investment as well as public-private partnerships.
- **Design governance that is fit-for-purpose** to manage risks at global, regional, and national levels. Governance options suggested by participants include greater clarity on roles and responsibilities; greater accountability for the supply chain; enhanced risk identification and management; more formal arrangements between international organizations, Member States (civilian and defence), space agencies, academic institutions and the private sector; and adoption and implementation of best practices and standards.
- **Grow the opportunities to build capacity**. Participants suggested exploring options for targeting a larger, more diverse talent pool covering gender, geographical areas, and related disciplines. The success of bilateral knowledge exchange in some regions, supported by training in languages other than English, was viewed by participants as a capacity development model that could be expanded and operated globally.
- **Improve awareness** through the implementation of a clear and effective communications and stakeholder engagement strategy targeting direct industry users, the science community, and the public. Participants suggested a mix of online resources and active engagement with direct clients of geodetic services.

The findings of this Global Geodesy Needs Assessment will be used by the UN-GGCE as the major input into defining the pathways and actions of the 1st Joint Development Plan for Global Geodesy.

1. Background

1.1 Geodesy and the Global Geodesy Supply Chain

Geodesy is the science of measuring the size, shape, orientation, and gravity field of the Earth, and how these parameters change over time.

The global geodesy supply chain refers to the collection of:

- ground station observatories and observers who measure the movement of Earth and satellites. These observatories use geodetic measurement techniques such as Global Navigation Satellite Systems (GNSS), Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) and gravity.
- data centers and data center operators who collect, quality check, store, archive and distribute the data from observatories and make it available to the global analysis community; and,
- analysis centers, correlation centers and analysts who translate the data into geodetic parameters and products including Earth Orientation Parameters, Global Coordinate Reference Frames, satellite orbits and models of the Earth's gravitational field.[2]

1.2 Reliance on the global geodesy supply chain

1.2.1 Economic reliance and benefits

Global Navigation Satellite Systems (GNSS) are critically dependent on geodetic parameters and products to operate. GNSS provide highly accurate timing information, which is used as a source for timekeeping and time-synchronization.[3] In the U.S., 15 of 18 critical infrastructure and key resource sectors rely on the Global Positioning System (GPS) for timing, including communications, emergency services, banking and finance, and transportation amongst other sectors.[4]

More broadly, national economies have a growing dependence on the global geodesy supply chain. Global GNSS downstream market revenue is expected to grow at a mean annual growth rate of 9.2%, reaching a total of €492 billion by 2031.[5] Over 82% of revenue will be generated by GNSS device sales and value-added services in mass market and professional markets.[6] Across ten sectors of the US economy that utilize GNSS in day-to-day business, $US1.4 trillion of economic benefit has been

[2] United Nations Global Geodetic Centre of Excellence, 2024. *Hidden Risk: How weaknesses in the global geodesy supply chain could have catastrophic impacts on critical infrastructure and national economies*, s1.1. Supplied by UN-GGCE.
[3] *Hidden Risk*, p16.
[4] *Hidden Risk*, p16, sourced from https://www.gps.gov/multimedia/presentations/2012/10/USTTI/graham.pdf
[5] *Hidden Risk*, p16, sourced from https://www.euspa.europa.eu/sites/default/files/uploads/euspa_market_report_2022.pdf.
[6] *Hidden Risk*, p17, sourced from https://www.gsc-europa.eu/sites/default/files/sites/all/files/Report_on_User_Needs_and_Requirements_Timing_Synchronisation.pdf

realized in its private sector alone since the Global Positioning System was made available to the private sector in the 1980s.[7]

In specific sectors, evidence is emerging that:

- 43% of economic benefits to the UK from the use of GNSS (£13.6 billion per annum) are estimated to come from Emergency Services.[8]
- Modern agricultural practices are becoming increasingly reliant on reliable positioning, navigation, timing and communications for automatic machine steering, livestock monitoring, and variable rate application – practices that are shown to increase yields, reduce costs and reduce environmental impacts of food production.[9]
- Safety of navigation on water and in the air is now dependent upon access to very accurate height reference frames positioning information to avoid collisions with obstacles and other craft. This reliance on the global geodesy supply chain will extend to the autonomous vehicle sector.[10]

1.2.2 Societal and environmental benefits

The global geodesy supply chain is at the core of a nation's capability to bring geospatial information together, in order to analyze and model conditions, monitor changes over time, create maps and other visualizations, and evaluate impacts across sectors and regions.[11] In particular, the global geodesy supply chain underpins the referencing and integration of geospatial information and Earth observation data describing population distribution; elevation, bathymetry and topography; land cover and use; cadastre, water and air quality; and hazard and impact monitoring.[12] These are key datasets vital to address the Sustainable Development Goals.[13]

Previously published papers have demonstrated that societal and environmental benefits may be realized using the global geodesy supply chain in the following sectors:

- Earth and climate science (for example, state of the atmosphere and oceans; measuring ice loss; measuring sea level rise;[14] flood damage caused by seal-level rise could cost the world $US14 trillion a year by 2100[15])
- Public safety and disaster management (for example, assisting with weather monitoring and forecasting);[16]

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[7] O'Connor AC et al, 2019. *Economic Benefits of the Global Positioning System (GPS).* https://www.rti.org/sites/default/files/gps_finalreport.pdf, pES-1, accessed 9 March 2024.
[8] *Hidden Risk*, p17, sourced from https://assets.publishing.service.gov.uk/media/652eb0446b6fbf000db7584e/20231018_London_Economics_Report_GNSS.pdf
[9] *Hidden Risk*, p19
[10] *Hidden Risk*, p19.
[11] Subcommittee on Geodesy to the United Nations Committee of Experts on Global Geospatial Information Management, 2021. *Position paper on sustaining the Global Geodetic Reference Frame.* *https://ggim.un.org/meetings/2021/Global_Geodesy_Forum/documents/DRAFT-Position-Paper-on-Sustaining-the-GGRF.pdf*, accessed 1 March 2024, p11
[12] Subcommittee on Geodesy, p11
[13] Subcommittee on Geodesy, p11
[14] Subcommittee on Geodesy, p10
[15] Subcommittee on Geodesy, p12
[16] Subcommittee on Geodesy, p10

- Societal benefits (for example, supporting positioning data in almost 3 billion mobile applications);[17]
- Land and water administration (for example, state of forests and ecosystems; modeling water flow).[18]

1.3 UN General Assembly Resolution 69/266 and the overall objective

Recognizing the importance of the global geodesy supply chain, the United Nations General Assembly adopted resolution 69/266 in February 2015, entitled 'A Global Geodetic Reference Frame for Sustainable Development'[19,20]. The Resolution, amongst other statements calls on Member States to:

- enhance global cooperation in providing technical assistance;
- implement open sharing of geodetic data, standards and conventions;
- commit to improving and maintaining national geodetic infrastructure;
- enhance multilateral cooperation that addresses infrastructure gaps; and
- develop outreach programmes.

Nevertheless, even with the United Nations General Assembly resolution, the risk associated with weaknesses in the global geodesy supply chain remain hidden.[21]

1.4 Motivation for the Needs Assessment and Development Plan

To sustain and enhance the global geodesy supply chain, the UN-GGCE together with Member States and partner organizations are developing a Joint Development Plan for Global Geodesy. The motivation for the Joint Development Plan is to highlight the increasing reliance we have on the global geodesy supply chain and explain the risks associated with its degradation or failure.

To guide the content, pathways, and actions of the Joint Development Plan, the UN-GGCE has undertaken a thorough Global Geodesy Needs Assessment (this report). The UN-GGCE has reviewed and summarized information gathered from reports, in-person consultation meetings and nine online, and in-person, "listening" sessions where the UN-GGCE team members listened to the needs of Member States and partner organizations around the world. This report also draws from responses and recommendations to surveys undertaken by UN-GGIM's Subcommittee on Geodesy to represent additional views from Member States, and sources material from previous reports published by the Subcommittee on Geodesy and the UN-GGCE, including the paper *Hidden Risk: How weaknesses in the global geodesy supply chain could have catastrophic impacts on critical infrastructure and national economies*.

[17] Subcommittee on Geodesy, p10
[18] Subcommittee on Geodesy, p11
[19] The terms 'Global Geodesy Supply Chain' and 'Global Geodetic Reference Frame' have the same meaning. The UN-GGCE have adopted the use of Global Geodesy Supply Chain as it is easier to explain to a lay audience.
[20] https://ggim.un.org/documents/a_res_69_266_e.pdf, accessed 6 March 2024
[21] *Hidden Risk*, p6.

1.5 Format of the Global Geodesy Needs Assessment information

The UN-GGCE has grouped the needs expressed by Member States and partner organizations into five focus areas. [22,23] Sustaining the global geodesy supply chain will require effort across all five focus areas.

FOCUS AREA	DESIRED FUTURE STATE
EVIDENCE	The importance of geodesy is understood by decision makers.
RESOURCES	The world has enough dedicated people and funding to operate and sustain the global geodesy supply chain.
GOVERNANCE	Governance of the global geodesy supply chain is fit-for-purpose to manage the risks to the supply chain at global, regional and national levels.
CAPACITY	Sufficient opportunities exist to train and grow the number of geodesists, globally.
AWARENESS	Awareness of the importance of geodesy is high within the industries that are reliant on the global geodesy supply chain and higher across the general public.

Each of the five focus areas has its own chapter with the following structure.

- **Desired Future State**
  - Summary statement which describes the experts desired future state.

- **Summary**
  - The first line of this sub-section is a summary of the current state of the focus area as viewed by the experts. The remaining paragraphs summarize the expert perspectives into high-level observations on successes, challenges, and potential future actions.

- **Narrative**
  - This sub-section groups individual expert perspectives on successes of the current state; barriers and challenges in the current state; characteristics of the future state; and potential future actions which are not currently being undertaken.
  - Specific regional needs or issues are identified under separate sub-headings.
  - Selected quotes from individuals are included to support the overall perspective of the group of experts.

[22] The five focus areas of this Needs Assessment differ slightly to the five focus areas identified by the UN-GGIM Subcommittee on Geodesy in its paper *Sustaining the Global Geodetic Reference Frame.* The Subcommittee's five focus areas were Governance, Geodetic Infrastructure; Policies, Standards and Conventions; Education, Training and Capacity Building; and Communications and Outreach. The UN-GGCE's focus areas were determined by the UN-GGCE and endorsed by the International Advisory Committee of the UN-GGCE to reflect an update in perspectives since the Subcommittee's paper as well as the specific role of the UN-GGCE. For this Needs Assessment report, Policies, Standards and Conventions are grouped with Governance; Geodetic Infrastructure is included in Resources; Evidence is now a separate focus area from Communications and Outreach; Communications and Outreach is largely covered in Awareness; and a greater focus on Communications is included in all five focus areas.

[23] *UN-GGCE Strategy and Operating Plan, public release, 11 December 2023*. Supplied.

- Statements made by individuals or organizations are referenced by footnote to the individual experts or group who made the statement.

2. EVIDENCE

2.1 Desired Future State

The importance of geodesy is understood by decision makers.

2.2 Summary

There is a lack of evidence which provides a direct link between investment in the global geodesy supply chain and societal, environmental and economic benefits.

Participants noted that some studies have been undertaken in the US, the UK, Australia and Europe that provide quantitative information on the importance of geodesy to various user segments. However, many of the societal benefits of the global geodesy supply chain are not quantified, nor is the value for money evidence of the different geodetic techniques.

Participants stated that evidence was needed to communicate the critical dependencies of telecommunications, energy, financial systems, satellite operations, logistics, transportation and emergency services on the global geodesy supply chain. Evidence is also required to demonstrate the ongoing need to continually monitor the shape and orientation of the Earth for environmental purposes including quantifying climate change and operating early-warning systems to protect against natural hazards.

Participants called for the need for evidence to be met through the development of business cases to attract investment, which include key messages promoting benefits, consideration of private sector involvement, and an evaluation of the risks that might result from a poorly maintained supply chain. Participants called for the acknowledgement of the global geodesy supply chain as critical infrastructure and for evidence to support this claim. Participants also called for evidence that demonstrates the benefits to the Member State of integrating national data into global data, particularly for global challenges such as climate change.

2.3 Narrative

2.3.1 There is a need for more, and stronger, evidence.

All Member States and the Partners are strongly aware of the need to improve the quantity and quality of evidence to describe the importance of the global geodesy supply chain which is targeted at specific audiences including the following groups.

2.3.1.1 Policy makers and government personnel outside geodetic agencies

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"We need political support for geodesy."

--Viliami Folau

- There is little evidence that **quantifies the dependency Member States have on the global geodesy supply chain for high profile / politically relevant topics like critical infrastructure systems, key resource sectors, hazards and security**[24].
- Evidence is published that shows the dependency of many critical infrastructure systems on satellites, in particular, GNSS, Earth Observation and communications. Whilst the reports model the growth in expected revenue generated by the GNSS sector in particular (for example a global revenue of €492 billion by 2031[25]), the reports do not describe any risks that may arise as a result of the challenges facing the global geodesy supply chain as expressed by experts in this Needs Assessment. **Member States described a need for evidence to clearly demonstrate this link between the global geodesy supply chain and economic benefit**[26].
- Member States need evidence that **communicates the benefits of geodesy for all citizens** and "highlight the impact of geodesy on the everyday positioning that policy holders understand".[27] This evidence must show why geodesy is needed to reduce poverty, save lives, mitigate climate change, prosper economies, contribute to natural disaster mitigation, and improve the resilience of critical infrastructure.[28]
- Specific applications include geodesy as the basis for land administration (security of land tenure and rights), maritime and aviation transportation, management of the ocean space, water and mass transport modeling and infrastructure planning; and for monitoring sea level rise and the impact of earthquakes.[29] The scientific and 'geomatic' requirements of specific users in the supply chain should also continue to be captured as part of evidence.

"[We] need business cases based on societal, not scientific needs."

--Richard Gross

- Member States explained that there is **a need to show how the global geodesy supply chain underpins government priorities, for example, digital transformation / digital twin programs** which are being implemented in many countries. Geodesists understand that the supply chain is a fundamental component of the success of the program, however, Member States would like to have evidence to show how important geodesy is and highlight the risks of not including geodesy in this process.
- **Policy makers in government also have limited evidence highlighting the risks associated with a lack of geodesy capacity.** Whilst some participants felt that the links and dependencies were clear between the global geodetic science community and the operations of geodetic

[24] For further detail, refer to the *Economic Reliance and Benefits* sub-section of the Background chapter of this report.
[25] European Union Agency for the Space Programme, 2022. *EUSPA EO and GNSS: Market Report.* https://www.euspa.europa.eu/sites/default/files/uploads/euspa_market_report_2022.pdf. Accessed 3 March 2024.
[26] Wernher Hoffmann, IAG & UN-GGCE Listening World Tour, 28 November 2023
[27] Mark Greaves, IAG & UN-GGCE Listening World Tour, 28 November 2023
[28] Fernand Eanes Bale, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[29] Andrick Lal, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024

infrastructure [30], others believed there was not.[31] The American Association for Geodetic Surveying, in its *Geodesy Crisis* paper, provides qualitative information and useful facts on the dependencies of industry and systems on geodesy, as well as highlighting the risks of a declining pool of trained professionals.[32]

- Participants noted the **need to personalize evidence to fit the priorities of the funder.** Translating evidence of benefits from global case studies into the local context maximizes the likelihood of a decision maker in a Member State or a non-government organization (NGO) donor understanding how geodesy can support their own priorities. Some of the specific applications of geodesy will be more important to some Member States than others, for example sea level rise is a critical issue particularly for coastal and small island states,[33] and cadastral assistance is important in eastern Europe.[34]
- Participants noted there is often resistance, and therefore the challenges associated with, asking for infrastructure and capacity development to be made available to another Member State, and explaining how it would benefit your Member State. [35]
- Although participants noted the circulation of highly-influential reports such as those produced by the International Panel on the Climate Change (IPCC), participants called for **further evidence of the dependencies of the applications on the global geodesy supply chain**, citing examples including post-earthquake management, the launch of the GENESIS satellite mission and other space missions, IPCC requirements for monitoring the rates of change in sea level, quantifying mass and water transport (e.g. glacial melting), and augmentation services.[36]

2.3.1.2 Industry Sector

- **Industry sectors rely heavily on the global geodesy supply chain** for example, for planning, transport, defence, finance, communication and power supply. A representative from Tunisia described the importance of having strong geodetic foundations for offshore mining and resources projects while other Member States and partners organizations highlighted the dependency of defence industries, the Intelligent Transport Sector, and multinational companies who require efficient logistical supply chain management such as Walmart and Amazon.[37]
- **It is unknown by Member States how much industry is contributing to the global geodesy supply chain** and Member States questioned how they could better engage with the private sector to have discussions on co-funding / co-operating the global geodesy supply chain.

[30] Richard Gross, 2nd Consultative Meeting on Needs Assessment, 21 November 2023.
[31] Kevin M. Kelly, IAG & UN-GGCE Listening World Tour, 28 November 2023; José Carlos Rodríguez-Pérez, IAG & UN-GGCE Listening World Tour, 28 November 2023
[32] American Association of Geodesists, 2022. *The Geodesy Crisis.* https://aagsmo.org/wp-content/uploads/2022/02/TheGeodesyCrisis_Final.pdf,, accessed 8 March 2024.
[33] Viliami Folau, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[34] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[35] Daniel Roman, IAG & UN-GGCE Listening World Tour, 28 November 2023
[36] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[37] UN-GGIM Arab States meeting February 2024

- There was a call to understand whether IAG Services or global geodesy data / analysis centers had evidence of the requirements of people who use their products and services. [38]

2.3.1.3 Science community outside of geodesy

- **Large parts of the science community are either unaware, or fail to acknowledge, their reliance on the global geodesy supply chain.** Examples include: 1) the lack of acknowledgement in reports from the Intergovernmental Panel on Climate Change on the dependency of sea level monitoring, mass and water transport, and disaster risk reduction, and 2) modeling of risk management in coastal areas.[39]
- The ability to quantify slowly changing Earth processes, like climate change, are often taken for granted. It is seldom realised that they rely on a stable reference frame over long time. That can only be achieved by a continuous observation with a stable observatory network.[40]

2.3.2 The barriers to the creation of evidence

2.3.2.1 Expertise

- Some participants noted that the challenge appears to stem from the **difficulty of explaining the impact and results of a highly specialized infrastructure** in everyday terms.

"Explaining the need for non-GNSS geodetic data in non-expert terms is difficult."

-- Tom Herring

"Es muy dificil hacer entender al poder político, sobre la importancia de la geodesia. Dar recursos economicos a una ciencia que no muestra resultados, es dificil. Los politicos quieren mostrar obras, no pueden mostrar numeros escondidos

[It is very difficult to make political power understand the importance of geodesy. Giving economic resources to a science that does not show results is difficult. Politicians want to show works, they cannot show hidden numbers]"

-- Gustavo Caubarrere

- Participants suggested that **the quality of the evidence varies for the different techniques**.[41] Evidence to show the critical nature of GNSS is strong, but weaker for the other techniques particularly as the other techniques are 'further back in the value chain'.[42] There were further calls to publish evidence of the impact of a global geodesy supply chain collapse on the space

[38] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023; UN-GGIM Arab States meeting February 2024
[39] IAG Service Listening Session
[40] IAG Service Listening Session
[41] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[42] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023

sector and satellite orbits' determination, and the products derived from satellites, including navigation, positioning, and time synchronization.[43]

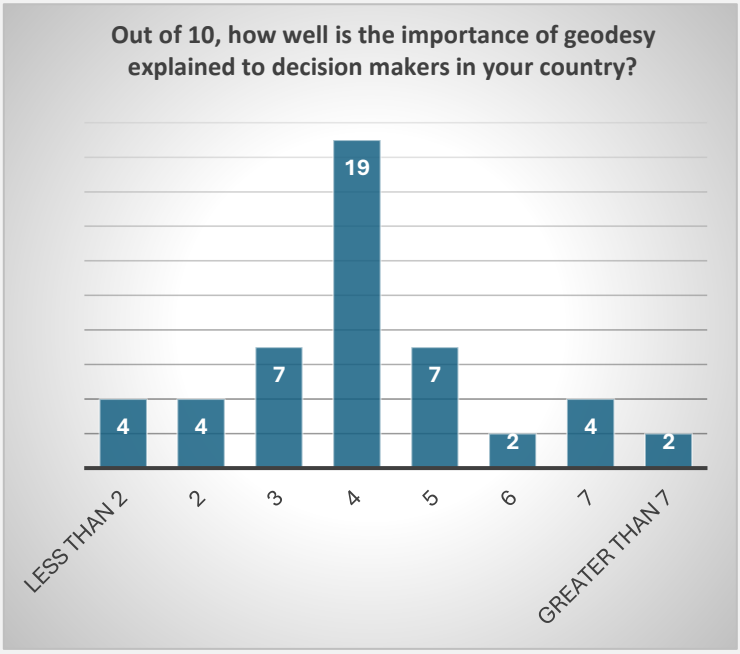
2.3.2.2 Dedicated and specialist resources

- **Participants agreed that the curation of impactful evidence requires dedicated communication specialist resources.** There was strong recognition of the need to engage professional communication personnel to assist in translating the story of geodesy into a story people can more easily understand. [44] **Member States and partners organizations agreed that the UN-GGCE will be a welcome and much-needed resource to assist with the curation of the evidence they need.**[45] The UN-GGCE was encouraged to work with communication specialists, media and policy makers.

[43] Fernand Eanes Bale, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[44] IAG Service Listening Session
[45] IAG Service Listening Session

Survey: How well is the importance of geodesy explained?

In selected Listening World Tour sessions, participants were asked to respond subjectively to the above question. Participants who responded gave an answer out of 10. When analyzed globally, participants from different Member States reported varying degrees of success in reporting the importance of geodesy to decision makers. Many participants rated their success around 3-4 out of 10, with only a very small number reporting high degrees of success (7/10 or greater).



Number of respondents	49
Average score	4.0
Median score	4.0
Standard Deviation	1.8
Lowest score	0
Highest score	8

Recognizing this is a small sample size, it is difficult to understand regional interpretations of the data, however, it is worth noting that the responses suggest that participants in the Asia-Pacific subjectively felt greater success in explaining the importance of geodesy to decision makers, followed by the Americas. This response could reflect the success of obtaining funding for geodesy programs in the region; a high awareness of the importance of geodesy to high priority regional issues such as industry needs, disaster management and improved land administration.

2.3.3 Suggested actions from experts to improve the global evidence base

Current State: The importance of geodesy is poorly understood by decision makers.
Desired Future State: The importance of geodesy is better understood by decision makers.

- Curate evidence, with the assistance of communications experts, which shows the importance of the global geodesy supply chain in a way policy / decision makers can understand, on topics which will attract their attention (e.g. national security, critical infrastructure, key resource sectors, economic benefits)
- Develop use cases to: 1) show how geodesy is used every day to improve people's lives and, 2) show you the impact of not having access to geodetic products and services (e.g. impacts in capability to forecast weather).[46]
- A comprehensive report showing how geodesy supports national priorities across Member States and how it can be used by other Member States to select and customize the topics that may hold national significance.[47] For example, participants called for the sharing of success stories such as the Australia's *Positioning for the Future* program and proposals for funding the Wettzell and Metsähovi stations in Germany and Finland respectively.[48]

"Governments are attracted to using space. Geodesy has been doing it for decades. Linking space to the big ticket items like climate change, sea level rise, disaster recovery and resilience is a way to attract investment… We need to talk to politicians about the ability to monitor our environment, respond to disasters… sectors such as transport, aviation and maritime are totally reliant on space platforms and geodesy."

--Craig Sandy

- Undertake a cost-benefit analysis and benefits realization study, including a risk assessment of what happens if products delivered by the IAG stop[49] or are used incorrectly.[50] An example suggested was to demonstrate how geodesy contributes to natural disaster mitigation.[51] Stronger engagement with the private sector could assist with crafting the evidence in terms of costs versus benefits[52].

"With almost everyone here from public sector, I think we should reach out to the private sector. They can talk real $ business"

--Jeffrey Verbeurgt

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[46] International Advisory Committee, Meeting 18th March 2024
[47] Daniel Roman, IAG & UN-GGCE Listening World Tour, 28 November 2023
[48] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[49] Salim Masoumi, IAG & UN-GGCE Listening World Tour, 28 November 2023
[50] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[51] Kevin M. Kelly, IAG & UN-GGCE Listening World Tour, 28 November 2023
[52] Jeffrey Verbeurgt, 2nd Consultative Meeting on Needs Assessment, 21 November 2023

- Develop a priority list for investment. This could be used to attract donors and maximize the efficiency of the available resources for investment.[53]
- Develop a 'pyramid' of key messages outlining benefits of and critical dependencies on the global geodesy supply chain, where messages at the top of the pyramid are applicable to all, and subsequent messages are tailored depending upon the user segment.[54] The messages must provide:
  - a compelling overview of why geodesy is important, and what is needed to make the global geodetic supply chain so fundamental[55];
  - the importance of the dependencies between the different geodetic networks (global, regional and national), and the specific or unique advantages some services have that make them critical to fundamental operations of society such as time measurement[56]; and
  - evidence to show that commercial services (including Google) also depend on the global geodesy supply chain[57].
- Map out and better understand all current contributions to sustaining the Global Geodesy Supply Chain, including infrastructure, analysis, capability, and in-kind contributions from international organizations and Member States.[58]
- Map out and communicate who is using geodetic products to make it easier to show the value proposition[59].
- Define the Essential Geodetic Variables (EGV), for example, sea level, ice melt and terrestrial water storage. The Essential Geodetic Variables are fundamental for other observing systems (e.g. climate) and could be used to promote key geodetic products such as reference frames, Earth Orientation Parameters and gravity models.[60,61]

[53] IAG Services Listening Session
[54] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[55] Elisabetta D'Anastasio, IAG & UN-GGCE Listening World Tour, 28 November 2023
[56] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023; IAG Service Listening Session
[57] Rolf Dach, IAG & UN-GGCE Listening World Tour, 28 November 2023
[58] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[59] UN-GGIM Arab States, via UN-GGCE
[60] International Advisory Committee, Meeting 18th March 2024
[61] Draft White Paper „Definition of Essential Geodetic Earth Observation Variables" by Thomas Gruber, Detlef Angermann and Laura Sanchez" (under review within GGOS).

3. RESOURCES

3.1 Desired Future State

The world has enough dedicated people and funding to operate and sustain the global geodesy supply chain.

3.2 Summary

The current global geodesy supply chain needs to be stabilized. Member States and partner organizations described a need to stabilize the funding and the amount of people currently dedicated to ground observatories, data centers, analysis centers, and standards development we have now. Member States and partner organizations also called on the need for additional resources to modernize the global geodesy supply chain to ensure stations, techniques, processes, software and products can meet the expanding (and more critical) user demands. More than 50% of global geodetic observing stations in the supply chain are aging and outdated systems or degrading in terms of accuracy and reliability. This can result in growing maintenance costs, longer observing station outages and poor reliability of the observing stations. In turn, this can lead to degradation in the quality of essential geodetic parameters and products.

All Member States and partners organizations acknowledge the crucial importance of the International Association of Geodesy and its Services. In particular, the coordination they provide to observe the Earth and develop critical products which are used every day by people for positioning, navigation and timing services. All Member States and partner organizations expressed their concern for the over-reliance the world has on the in-kind support provided by Member State institutions voluntarily participating in IAG and its Services and the risks this poses to satellite services and national economies.

When discussing resource needs, participants noted the dependency on improved evidence to justify an increase in resourcing. In particular, there is a need for the science community to provide a clear and specific description of the ground observatories and analysis capabilities required to improve the accuracy and stability of geodetic products. This evidence, in addition to the evidence discussed in Chapter 2 is needed to rationalize the need for further resources, and to ensure that observatories, techniques, and processes can meet expected user demands.

At the regional and national scale, some participants were open to business models that included the private sector noting that public private partnerships may be the only way to access the funding required to enhance the supply chain in their region. Participants called for an improved description of the importance of regional reference frames, to encourage 'buy in' from countries to work together and contribute to regional reference frame development and sustainment as geodesy depends on continuity across the political borders.

3.3 Narrative

3.3.1 The global geodesy supply chain is severely under-resourced.

- **Member States and partner organizations agree that all elements of the global geodesy supply chain – ground observatories, data centers, analysis centers and the product development chain – are not resourced with enough money and people to sustain it.** For example, the number, distribution, age and current operational capability of ground

observation stations were identified as problem areas by all IAG Service networks (SLR, VLBI, GNSS, DORIS and Gravity)[62], with some examples quoted as 'too many single sources of failure'[63], 'only a handful of stations [are] providing the data we need'[64] and 'half of our stations are non-productive' [65]. Participants volunteered views that more than 50% of ground observation stations in the supply chain are old generation systems or degrading in terms of accuracy and reliability.[66] The impact of these lower accuracy and lower reliability of observing stations leads to a poorer global coordinate reference frame, which in turn leads to lower accuracy and reliability of the satellite services.[67] Some network infrastructure, in particular laser ranging, has not been able to keep up with the growth in demand for some services over the past 25-30 years[68], and remain relatively expensive to operate.

- **The number of Member States contributing to the global geodesy supply chain is far less than the number of Member States using it. This is unsustainable.**[69]
- In 2020, the UN-GGIM Subcommittee on Geodesy coordinated a survey of the resources used by the IAG Services in the global geodesy supply chain. This was used to capture a snapshot of the operational costs, number of data and analysis centers, the technology being used, the roles of people and number of people working in the IAG Services. The information gathered in this survey provided a useful starting point to identify weaknesses and needs for each Service.
- In 2024, the UN-GGCE undertook a follow-up survey of the IAG Services to estimate the operational funding required to provide their products. This included the cost of operating and maintaining the ground observatories, data centers, analysis centers, as well as costs associated with the management and coordination of the Services.
- Preliminary analysis suggests that the total costs are in the order of USD60 million per year[70] for the four space geodesy techniques (IGS, IVS, ILRS, IDS) employed in the realization of the global geodetic reference frame and development of Earth Orientation Parameters. **As of 2021, this equates to less than 0.05% of GNSS- and EO- revenue generated from these satellite services.** This estimate is for the **cost of the current status** of the global supply chain, which provides products at an accuracy and stability that is not sufficient for the most demanding applications.

- **Inadequate funding of the IAG and IAG Services for its activities, and inadequate funding of many of the Member State geodesy institutions that contribute to the IAG at different levels was a serious concern of participants**. [71,72] Dependencies on single sources of funding (particularly from within Member State governments) was identified as a source of risk, as

[62] IAG Service Listening Sessions
[63] Richard Gross, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[64] José Carlos Rodríguez-Pérez, IAG & UN-GGCE Listening World Tour, 28 November 2023
[65] Mike Pearlman IAG & UN-GGCE Listening World Tour, 28 November 2023
[66] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[67] Nicholas Brown, pers comm.
[68] Mike Pearlman IAG & UN-GGCE Listening World Tour, 28 November 2023
[69] International Advisory Committee, Meeting 18th March 2024
[70] This estimation is not complete at the moment, as it lacks information from the gravity related IAG Services and further refinements in the individual estimations for the other techniques are pending.
[71] Florian Seitz, IAG & UN-GGCE Listening World Tour, 28 November 2023
[72] IAG Service Listening Sessions

participants noted it is getting harder to get operational resources into geodesy,[73] and any reductions in funding have an immediate flow-on effect to services people rely on every day.[74] International organizations such as the IAG have little or no resources to contribute. [75] Participants reported some stations are reducing time spent on core geodetic functions in order to perform funded work such as space debris tracking. [76] Also noted were the difficulties of carrying out operational work within research institutions, and vice versa, requiring traditional scientific outputs from operational teams.[77]

"If [I had a] magic wand – [I would ask for] increased funding. IAG services operate on shoestring budget. Partly due to funding, our staff are all only part-time in their roles and unable to devote the whole of their working day to support IAG service issues – this makes innovation and other "nice to have" things like communications difficult to sponsor in a long-term sense."

--Allison Craddock

- **Member States highlighted a need to identify pathways for developed countries to help improve the number and quality of ground station observatories (particularly in the southern hemisphere) outside their own countries** in order to fill gaps in the network and enhance the accuracy and stability of geodetic products such as the global coordinate reference frame and Earth Orientation Parameters.
- Participants acknowledged that the **specialized nature of the hardware and software used in the observatories and analysis centers and noted that there are few suppliers of technology**. These suppliers may be research institutes, universities or small companies with limited support, and development may depend on a single person. [78]
- Addressing the needs of the most demanding scientific (and accuracy) applications, e.g. sea level rise, require **increased resources to enhance coordination and collaboration across the complementary geodetic techniques and ultimately enhance the combined analysis of the data**. [79]

3.3.2 How to invest? Stabilize or expand?

Participants noted the **demand from some user groups for higher accuracy geodetic products and questioned the current supply chain's ability to achieve these accuracies**. Emerging accuracies, particularly from the space industry, were quoted at an accuracy of 1 mm and stability of +/- 0.1 mm/yr.[80,81] Sea level rise, storm surge and flood modeling, many geophysical applications, and real-time PNT services are believed by participants to require a

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[73] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[74] Rolf Dach, IAG & UN-GGCE Listening World Tour, 28 November 2023
[75] Johannes Bouman, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[76] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[77] IAG Services Listening Sessions
[78] Johannes Bouman, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[79] IAG Services Listening Sessions
[80] Plag and Pearlman, Global Geodetic Observing System, 2009
[81] IAG Services Listening Sessions

more accurate reference frame[82] than the currently available 5mm +/- 0.5mm/year.[83] This accuracy requirement raised questions amongst many participants on whether or not the number, location and quality of stations is sufficient to achieve the stated accuracies.

- **Resourcing of the current ground observatories in the supply chain needs to be stabilized.** When asked if resources should be put towards stabilizing the funding for the operation of existing ground station observatories[84], or adding new observatories, participants overwhelmingly responded for the former.[85] IAG participants considered it important to understand future accuracy requirements of users, and then consider how to grow the ground observatory network to ensure that the products and services meet emerging user requirements.[86]

"Stabilize. We're hemorrhaging on the existing infrastructure and staff"

-- Dan Roman

"We need to repair the foundation before we can build another floor on the house."

-- Allison Craddock

- Increasing accuracy is often mentioned as a criterion for the improvement. Without wanting to deny this important argument, the robustness and reliability of the global geodetic supply chain is a much more complex task, that cannot be reduced just to one simple parameter.[87]

"The global geodesy supply chain needs to be made more robust, not just more accurate."

-- Richard Gross

3.3.3 The need for more training and capacity development resources

- In a number of Listening World Tour sessions and in person consultation sessions, **Member States identified a need for access to more "practical resources"**[88] to assist them with sharing technical guidance, advice etc., including contacts to discuss ground observatory

[82] 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[83] Zuheir Altamimi, 2nd Consultative Session, 21 November 2023
[84] Stabilizing includes upgrading the components of existing ground station observatories.
[85] Dan Roman, Riccardo Barzaghi, Allison, Peter Teunissen, and others.
[86] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[87] IAG Services Listening Sessions
[88] Abdullah Alqahtani, UN-GGIM Arabs States meeting, February 2023.

specifications and costing, online technical manuals or guidance on how to modernize a geospatial reference system.[89]

3.3.4 The need for dedicated resources for standards

- The International Organization for Standardization Technical Committee 211 (ISO TC/211)[90] along with a number of Member States identified **significant capability and capacity weaknesses in Member States relating to standards**. There are currently very few dedicated resources working on geodetic standards. In most cases, the maintenance of standards is dependent on in-kind contributions from geodetic staff working in government agencies and scientific institutions. Given that standards are critical in the use of geodetic data and are the way the majority of users access PNT products, this puts the accuracy and reliability of geodetic products at risk. Furthermore, the application of standards increases the effectiveness and facilitates the usage of geodetic products.

3.3.5 Regional analysis: resources in the regions

- **Regional reference frames in Europe, the Asia-Pacific and the Americas are well established, functional and supporting Member States in the development of national geospatial reference system development and maintenance**. In these regions, many Member States also have national reference frames which are aligned to the regional and/or the global reference frame. Regional reference frames are the link between the global frame, which is the frame in which GNSS operates, and national reference frames. Regional reference frames ensure that a national reference frame is more closely aligned to GNSS and improves the modeling of regional-scale movements in the Earth's crust due to plate motion, deformation and other causes.
- **Participants identified the lack of stations in some regions as being problematic, as local datums are not aligned to the ITRF**. IAG Services operators are aware of gaps in the station locations.[91]
- **UN-GGIM Africa and UN-GGIM Arab States reported that they have not yet developed nor implemented their regional reference frames**.[92] In Africa, this is due to a mix of a lack of financial resources, limited access to geodesists, and a lack of formal geodesy training programs.[93]

"In many African countries, there are lack of geodetic infrastructure such as GPS stations, satellite tracking station and geodetic survey networks."

-- Ibikunle Raphael

3.3.6 Suggested actions from experts

[89] IAG Services Listening Session.
[90] UN-GGCE and FIG, ISO, IHO Listening World Tour session, 20 February 2024.
[91] Subcommittee on Geodesy Geodetic Infrastructure Working Group Questionnaire, March 2020
[92] UN-GGIM Arabs States meeting, February 2023; UN-GGCE and UN-GGIM Africa Listening World Tour session, 27 February 2024.
[93] UN-GGCE and UN-GGIM Africa Listening World Tour session, 27 February 2024.

Current State: The world does not have enough dedicated people and funding to operate and sustain the global geodesy supply chain.
Desired Future State: The world has enough dedicated people and funding to operate and sustain the global geodesy supply chain.

- Provide options for funding to stabilize the current supply chain, and further options to improve accuracy and capacity gaps, should be developed. Participants called for an improved understanding of the current investment in the global geodesy supply chain, estimated cost for future state options, and pathways for investment to reach those future state options.
- Develop a prioritized list of resource requirements (e.g. geodetic ground station), along with the expected impact / enhancement this resource would provide in terms that decision makers can understand. [94]
- Identify pathways for developed countries to help improve the number and quality of ground station observatories (particularly in the southern hemisphere) outside their own countries
- Formalize in-kind contribution to make them more sustainable and not dependent from a specific person.[95]
- Encourage exploration of a greater array of funding sources, including but not limited to Member States, multilateral banks such as the World Bank, The African Development Bank or the Islamic Development Bank, public-private partnerships, and philanthropists.[96]
- Demonstrate the return on investment must be shown to funders. Regardless of the funding source, participants recognized that donors and funders will need to be continuously shown the value of, and return on, investment in the global geodesy supply chain.[97]
- Investigate the option of a Trust operated under the auspices of the UN-GGCE to assist with urgent or intermediate funding.[98] Investigate how this Trust could be used to allocate fit-for-purpose resources to sustain the global geodesy supply chain.
- Consideration should be given to establishing public-private partnerships, particularly in countries where finances do not exist to install infrastructure, and to explore some of the products where commercial returns are possible.[99] A research-based report on what hardware is needed where, and which non-material resources are needed to operationalize this, was also suggested.[100]
- The Asia-Pacific particularly called for support for dedicated resources for small island developing states,[101] and requested examples of evidence of how geodesy can quantify and understand the impact of long-term sea level change in local areas[102] and on islands such as Tonga which is sinking at a rate of 7mm per year. [103]

[94] International Advisory Committee, Meeting 18th March 2024
[95] International Advisory Committee, Meeting 18th March 2024
[96] Fernand Eanes Bale, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[97] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[98] Ryan Keenan, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[99] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[100] Jeffrey Verbeurgt, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[101] Andrick Lal, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[102] Nic Donnelly, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[103] Viliami Folau, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024

- Encourage greater sharing of information, particular with respect to ground observatory hardware and software to minimize duplication of effort, make geodetic observatory manufacturing less bespoke and optimize operations between Member States and partners organizations.[104] Develop a research-based report on what hardware is needed where, and which non-material resources are needed to operationalize this.
- Establish an online 'UN-GGCE Academy' with access to freely available resources, contact information, technical manuals, guidance material and webinars.
- Provide access to a pool of geodetic equipment which Member States can apply to use.
- The UN-GGCE to support the ISO Geodetic Register (ISOGR) through 1) promotion of the ISOGR, and 2) potentially becoming (or assisting in the funding of) the Registration Authority to ensure the long-term sustainability of ISOGR.

[104] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023

4. GOVERNANCE

4.1 Desired Future State

Governance of the global geodesy supply chain is fit-for-purpose to manage the risks to the supply chain at global, regional and national levels.

Note: in the context of the global geodesy supply chain, governance refers to the process of making decisions, managing risk, allocating funding, ensuring commitment and coordinating activities.

4.2 Summary

Member States noted that the governance of the global geodesy supply chain at both a global and regional level (in all regions) is not commensurate with the risk of degradation or failure and the impacts this could cause. Member States used the analogy of "building a beautiful building on foundations of sand".

Participants acknowledged the existence of, and current collaboration between, a number of regional and global bodies which act as governance bodies for different components of the global geodesy supply chain. Participants noted that much of this collaboration is unfunded or in-kind, or undertaken without formal agreements following its initial development on pure scientific basis. Participants stated the lack of legislation, policies or other rulings to incorporate recommendations, mandate the operations of infrastructure, and adopt standards into national policies as being a major barrier to future success.

Participants called for stronger institutional arrangements within Member States, between Member States, with the private sector, and between Member States and international bodies. Sharing of best practices and standards was suggested as a short-term path for improvement.

4.3 Narrative

4.3.1 Current barriers to good global governance

- ***Much of*** **the supply chain is held together by goodwill and best effort.** Ground observing stations, data centers and analysis centers producing geodetic products are installed and operated by a mix of government agencies at different levels, academic institutions, and the private sector.[105] Participants noted a heavy reliance on in-kind or unfunded contributions, and "best effort basis" by government agencies, universities, or research societies to operate the services and participate in governing groups[106] and the need for enhanced technical coordination.[107] Some institutions and agencies do have bilateral or multilateral agreements in place to operate infrastructure or provide services. Some of these agreements have funding; many are voluntary.[108]
- **There is no governance model which oversees the whole global geodesy supply chain and the governance models in place for some elements of the global geodesy supply chain are**

[105] Combined responses from all Listening World Tours.
[106] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[107] IAG Services Listening Session
[108] Zuheir Altamimi, 2nd Consultative Session, 21 November 2023

not appropriate. There are various governance bodies involved in this global geodesy supply chain, including Member States and the IAG. Some of these bodies have good governance and terms of reference.[109,110] Nonetheless, these governance bodies are disconnected which means information cannot be shared, there is no escalation point for major issues, root causes to problems cannot be resolved and risk management is inadequate. Ultimately, this means **no group is responsible for the operation of the global geodetic supply chain and the generation of accurate and reliable geodetic products which are critical to people's lives**. For example, the members of Executive / Governing boards of the IAG Services (who are responsible for the development of geodetic products) are not the owners / managers / funders of the ground observatories, data centers or analysis centers. [111,112]

- **The participants perceive that the global geodesy supply chain is very dependent on 'in-kind' contribution**. Most of the IAG scientists are paid by their institutions or through research grants, or are involved on a voluntary basis for the interest of science.[113] It is unclear from participants' responses as to how many of these arrangements are formalized.
- Participants noted **the reliance 'in-kind' contribution and short-term funding / contracts is likely a cause for the lack of standardization of infrastructure and data delivery**,[114] although progress was noted in the IAG/GGOS Bureaus on the improvement of the consistency of geodetic key products and the global station coverage.[115]

"[The] sustainment of critical infrastructure and functions relies on in-kind support and is not always guaranteed year to year."

-- Ryan Ruddick, IAG & UN-GGCE Listening World Tour, 28 November 2024

"IAG activities are heavily supported by in-kind contribution of government agencies, academia and scientific organizations."

-- Elisabetta D'Anastasio, IAG & UN-GGCE Listening World Tour, 28 November 2024

- **Due to a lack of appropriate governance, there is a lack of authority in Member States to enforce operations of the supply chain and apply standards.** IAG participants noted a lack of ability to have government authorities incorporate the recommendations, infrastructure and standards into national policies and laws.[116] Outside of the IAG, participants noted potential weaknesses in the governance model. Participants noted the IAG's strengths as a science body, but observed that the IAG had limited political influence and a limited appreciation of

[109] Zuheir Altamimi, 2nd Consultative Session, 21 November 2023
[110] Richard Gross, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[111] Zuheir Altamimi, IAG & UN-GGCE Listening World Tour, 28 November 2023
[112] Richard Gross, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[113] Zuheir Altamimi, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[114] Daniela Carrion, Randall Carman, Rebekka Steffen, IAG & UN-GGCE Listening World Tour, 28 November 2023
[115] Mathis Bloßfeld, IAG & UN-GGCE Listening World Tour, 28 November 2023
[116] Daniel Roman, IAG & UN-GGCE Listening World Tour, 28 November 2023

the challenges of operating stations.[117] Some Member States such as Germany and Mexico have successfully overcome this barrier by identifying geodetic observatories as critical infrastructure or in law as 'information of national interest'.[118]

> *The national geodetic reference frame is included in a law, [and] recently the national geodetic network was declared officially [as] information of national interest.*
>
> -- *Guido Alejandro González Franco*

- Participants acknowledged previous strong collaborative efforts from Member States and the UN-GGIM Subcommittee on Geodesy which led to the adoption of the UN General Assembly Resolution on 'A Global Geodetic Reference Frame for Sustainable Development' and the establishment of the UN-GGCE. The UN 'brand' and the existence of the UN General Assembly Resolution is very powerful for some Member States such as Argentina.[119]

4.3.2 Regional successes

- **Some regional bodies, such as SIRGAS in the Americas, have strong communication and working relationships** between international bodies, Member States, and academic institutions.[120] Participants stated that working through regional partnerships for explicit ties between the International Terrestrial Reference System, and national reference systems and infrastructure, has aided a global solution.[121]

4.3.3 Global requirements for fit-for-purpose governance

- **Participants wished to see greater clarity on the role and responsibilities of geodetic organizations**,[122] stronger alliances to oversee the supply chain (made up of willing Member States)[123], identification of and support to 'national champions',[124] and separate governance bodies that can undertake risk analyses and drive processes that can achieve fast results.[125] Member States in particular require stronger governance for the entire supply chain to ensure accountability, Memoranda of Understanding [126][127][128]

> *"There is a need for global geodesy guidelines including deliverables accuracies order, interoperability, certification every 3 years, single global reference frame,*

[117] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023, Johannes Bouman, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[118] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[119] Sergio Cimbaro, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[120] Sergio Cimbaro, UN-GGIM Americas and UN-GGCE Listening World Tour, 29 November 2023
[121] Daniel Roman, IAG & UN-GGCE Listening World Tour, 28 November 2023
[122] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[123] Johannes Bouman, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[124] Johannes Bouman, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[125] Laila Løvhøiden, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[126] UN-GGCE, from UN-GGCE initial analysis of IAG opinions

[128] UN-GGCE, from UN-GGCE initial analysis of IAG opinions

ellipsoid, geoid adoption. Also implement a single vertical datum for all worldwide tide gauges."

-- Alexander Holsteinson, UN-GGIM Americas & UN-GGCE Listening World Tour, 29 November 2023

I would have an instruction manual on how to build a standard piece of geodetic infrastructure – what bits to buy – how to put them together – how to operate them. Of course, at the back of the book would be a blank cheque to take down to the observatory shop!"

-- Randall Carman, IAG & UN-GGCE Listening World Tour, 28 November 2024

- **Participants called for authoritative data governance frameworks**,[129] guidance on establishing and maintaining geodetic infrastructure, and documentation on best practices for data collection, processing, and management.[130] A stronger competent body could be responsible for these functions as well as a stronger 'top-down' approach[131] to consistent product development and quality control of global services[132]. A different governance arrangement might oversee greater implementation of standards and protocols for data sharing and data quality.[133]
- **The global geodesy supply chain should be recognized as critical infrastructure.** Participants called for greater recognition of the components of the global geodesy supply chain as 'critical infrastructure' in Member States[134], particularly where the supply chain supports other legislated functions such as definition of Member State jurisdiction.[135] Participants noted that such a recognition comes with a responsibility for upkeep and renewal.[136] Whilst legislation may not be needed in all cases, the geodetic infrastructure should be formally recognized as critical infrastructure in an appropriate way.[137] Recognition should imbed with Member State obligations to UN resolutions and any regional agreements or regulations.[138] Participants noted that development and implementation of legislation or other institutional arrangements is the responsibility of the Member State.[139]

"Legislating with unified geospatial criteria as critical infrastructure all geodetic observatories and their data/metadata/deliverables is a must ASAP."

[129] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[130] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[131] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[132] Florian Seitz, IAG & UN-GGCE Listening World Tour, 28 November 2023
[133] Johannes Bouman, 2nd Consultative Meeting on Needs Assessment, 21 November 2023 and Guorong Hu, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[134] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[135] Andrick Lal, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[136] Joel Haasdyk, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[137] Nic Donnelly, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[138] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[139] UN-GGCE, from UN-GGCE initial analysis of expert opinions

-- Alexander Holsteinson, UN-GGIM Americas & UN-GGCE Listening World Tour, 29 November 2023

"If we are defining our EEZs [Exclusive Economic Zone] and they are legislated and deposited to UN DOALOS, we should legislate the geodetic observatories, since EEZ are defined using this infrastructure."

-- Andrick Lal, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024

4.3.4 Suggested actions to improve governance

Current State: Governance of the global geodesy supply chain is not commensurate with the risk of degradation or failure and the impacts this could cause.
Desired Future State: Governance of the global geodesy supply chain is fit-for-purpose, to manage the risks to the supply chain at global, regional and national levels.

- Member States, the International Association of Geodesy and other partners design a governance model for the global geodesy supply chain which is commensurate with the risk. Member States suggested amending the governance arrangements to ensure Member States, who provide the vast majority of the funding for the global geodesy supply chain have more influence than they currently have.
- A revised governance model should include clear role descriptions and responsibilities of all parties. Consider governance models from other international organizations such as the World Meteorological Organization (WMO) and International Hydrographic Organization (IHO). Invite representatives from WMO and IHO to assist in the design process.

"It would be great to identify the critical roles within the IAG services, that should ideally not be done on a best-efforts basis (i.e. like the IERS)."

-- Anna Riddell, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024

- Critical roles, key outputs and service levels of the global geodesy supply chain should be clearly defined by Member States, the IAG and other partners. Governance should be established to ensure critical roles, key outputs and service levels are funded and risks are managed. [140,141]
- Consider the long-term goal of a UN Technical Commission to govern the supply chain, similar to the operations of the World Meteorological Organization,[142] and with oversight of mechanisms to attract donors to invest in global geodesy.[143]
- Regional entities, scientific services and international bodies should be included in an amended governance model. Realignment of regional entities and scientific services into a

[140] Anna Riddell, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[141] Ryan Ruddick, IAG & UN-GGCE Listening World Tour, 28 November 2023
[142] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[143] Zuheir Altamimi, IAG & UN-GGCE Listening World Tour, 28 November 2023

revised governance model was also suggested,[144] as was building communities of practice for effective capability, good capacity, and better training.[145]

- If considering public-private partnerships, participants suggested consideration be given to business models that do not threaten the 'neutral' status of IAG services, nor violate government sponsorship parameters.[146]
- Member States who provide in-kind support for the global geodesy supply chain should attempt to strengthen funding, support and awareness of these arrangements to formalize the commitment.
- The global geodesy supply chain or at least the ground station observatories should be recognized, governed and resourced as critical infrastructure.
- Development of authoritative data governance frameworks, guidance on establishing and maintaining geodetic infrastructure, and documentation on best practices for data collection, processing, and management.

[144] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[145] Andrick Lal, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[146] Allison Craddock, IAG & UN-GGCE Listening World Tour, 28 November 2023

5. CAPACITY

5.1 Desired Future States:

Sufficient opportunities exist to train and grow the number of geodesists, globally.

5.2 Summary

The number of geodesists being trained is declining, for reasons not completely clear.

Participants noted several regional and national initiatives, and achievements, to boost capacity. In general, however, the number of university courses and other formal geodesy training programs are reducing. The reasons for this drop were unclear to participants, as to whether this is due to a lack of demand because of the specialized nature of geodesy, or a lack of awareness of geodesy being a potential career choice.

Participants were keen to grow the number of potential geodesists through re-engagement with the academic sector, online courses or 'geodesy schools' offered by specialists outside of universities, more multi-lingual training, and multilateral partnerships between Member States. Options to increase diversity were also suggested.

5.3 Narrative

5.3.1 Global capacity challenges

- Participants noted that **the number of geodetic professionals is shrinking**, because of the current group of professionals retiring,[147] the challenge of maintaining personnel when better incomes are available in other businesses and sectors,[148] lack of career paths,[149] less students being interested in geodesy as a career[150], and fewer courses being offered in many countries.[151]

> *"Two aspects are identified that may affect our current state, the support of senior management to maintain current activities and the challenge of maintaining the personnel involved because if they obtain a better position or income, they even move to an area not necessarily related to the geodetic reference frame."*
>
> *-- Guido Alejandro González Franco, UN-GGIM Americas & UN-GGCE Listening World Tour, 22 November 2023*

> *"The interest for studying Geodesy is going down in my country …"*

[147] Tom Herring, IAG & UN-GGCE Listening World Tour, 28 November 2023
[148] Guido Alejandro González Franco, UN-GGIM Americas & UN-GGCE Listening World Tour, 22 November 2023, and Nic Donnelly, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[149] Nic Donnelly, UN-GGIM Asia-Pacific & UN-GGCE Listening World Tour, 31 January 2024
[150] IAG Services Listening Session
[151] UN-GGCE, from UN-GGCE initial analysis of opinions from UN-GGIM Europe and UN-GGIM Asia Pacific

-- Сасхо Димески

- **Completely qualified staff are hard to find.** Where professionals are recruited, participants and survey respondents noted that the majority of professionals require further training 'on the job'.[152] International associations have offered 'geodesy schools' as an intensive workshop experience to train up future geodesists, although these may be met with mixed success. [153]

"We rarely find completely qualified staff. When we do, we often end up hiring the geodesy professors from universities, which means that we will have fewer trained geodesists in the future. We are eating our seed corn."

-- International Association of Geodesy

[Africa has a] shortage of experts in physical, geometric and space geodesy; shortage of in university and in government offices.

-- Bruno Kyamulesir, UN-GGIM: Africa Listening World Tour, 27 February 2024

- Participants noted that the **capacity problem is not limited to technical expertise, but that there is also a lack of professionals willing / able to step into coordination, governance, or standards roles** such as Working Group chairs or Central Bureau staff.[154] This also extends to a noted lack of coordination across various initiatives and actions undertaken by associations, space agencies, the private sector, and national mapping authorities.
- This global lack of capacity in Member States and universities mean the **people that are working in geodesy have increasingly demanding workloads and therefore have less and less time available to volunteer time to (international) organizations**.[155]
- The impact of the **lack of capacity (especially from volunteers) puts developing countries who, generally speaking, have less geodetic capability and capacity, at greater risk of falling behind** as they have a need for more training and capacity development opportunities, particularly personalized training which is focused on their specific country needs.[156]

5.3.2 Regional capacity challenges

- **Participants are keenly aware of the shrinking pool of geodesy professionals at a regional level**. Competency surveys have been undertaken to assess what levels are available now and for the future.[157] In some regions, funding is made available to developing countries for training or bilateral agreements are in place for knowledge sharing;[158] in others, strong mentoring and knowledge sharing programs run by professional associations are in place.[159]

[152] Summary of responses to Question 8 at the IAG & UN-GGCE Listening World Tour, 28 November 2023
[153] Bruno Kyamulesir, IAG & UN-GGCE Listening World Tour, 28 November 2023
[154] Allison Craddock, IAG & UN-GGCE Listening World Tour, 28 November 2023
[155] Ryan Keenan, FIG,ISO and IHO Listening World Tour, 20 February 2024
[156] IAG Service Listening Session.
[157] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[158] UN-GGCE, from UN-GGCE initial analysis of opinions from UN-GGIM Americas
[159] UN-GGCE, from UN-GGCE initial analysis of opinions from UN-GGIM Asia Pacific and UN-GGIM Africa

Many European and Asia-Pacific Member States reported reductions in university courses, whilst others such as China and Saudi Arabia are experiencing growth in geospatial courses based on demands from industry.[160]

The first challenge that I see is the lack of experts to mentor young people in geodesy in developing nations like Uganda. Secondly, the people who have some geodesy interest don't have funds to further their studies.

-- Bruno Kyamulesir, IAG & UN-GGCE Listening World Tour, 28 November 2023

5.3.3 Suggestions from experts for global courses of action

Current State: Insufficient opportunities exist to train and grow the number of geodesists, globally.
Desired Future State: Sufficient opportunities exist to train and grow the number of geodesists, globally.

- Increase efforts to make geodesy more visible in high school to encourage pupils to further study.[161]
- More creative initiatives for recruitment may halt the shrinking pool of specialists. The shortage of skilled people is being dealt with in various ways, including looking at related disciplines such as data scientists or mathematicians with transferable skills,[162] vacation employment or traineeships,[163] and offering scholarships or workplace training directly with academic institutions.[164]

In Victoria [Australia], we are working with our Skilled Migration program to get Surveying added to the program. It means we can get a few more surveying skilled people given visas.

-- Craig Sandy, UN-GGIM Asia-Pacific and UN-GGCE Listening World Tour, 31 January 2024

- Participants called for wider and more creative initiatives to grow the pool of potential geodesists, with many calling for widening the potential pool of candidates through increasing diversity[165] or consideration of recruiting from related disciplines.

"Increase diversity (gender, generation, geographical background). Having role models in all areas of the world will increase the number of students and then also the visibility of geodesy."

-- Rebekka Steffen, IAG & UN-GGCE Listening World Tour, 28 November 2023

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[160] UN-GGCE, from UN-GGCE initial analysis of opinions from UN-GGIM Asia Pacific and UN-GGIM Arab States
[161] International Advisory Committee, Meeting 18th March 2024
[162] Jack McCubbine, UN-GGIM Asia-Pacific and UN-GGCE Listening World Tour, 31 January 2024
[163] Craig Sandy, UN-GGIM Asia-Pacific and UN-GGCE Listening World Tour, 31 January 2024
[164] Gordon Jones, UN-GGIM Asia-Pacific and UN-GGCE Listening World Tour, 19 January 2024
[165] Rebekka Steffen, IAG & UN-GGCE Listening World Tour, 28 November 2023

- Capacity development and practical experience could be accelerated through multilateral partnerships among Member States. Practical experience was viewed by participants as required for the operation of geodetic stations and analysis centers.[166] Participants welcomed options that brought together the regional groups and helped lesser advanced Member States, particularly as participants noted that the distribution of geodetic knowledge is unequal.[167]
- Participants also called for an increase in geodesy training and development opportunities, particularly in the technical development of modern geodetic and geospatial technology.[168] One suggestion was Member States working in partnerships to fill gaps that cannot be filled by formal education and training.[169]
- For the longer term, participants suggested that the success of bilateral knowledge exchanges and workshops occurring in some regions could be extended globally, with workshops or specialist courses being developed as a series for participants to implement learning in their organization.[170] Such courses could continue to be offered by professional bodies.[171]
- Look to neighboring fields of science. An initiative some Member States and academic institutions are trying is to train people up from fields of science which are similar to geodesy.

We train people that are similarly skilled (a physicist is just a geodesist waiting to bloom). We also engage with the local university as well and help educate a new generation of geodesist. We try to do projects together and help with courses and exams. We need to be engaged to ensure a new generation is educated.

-- Kristian Evers

- Capacity development could be overseen by a relevant competent body. Participants called for an assessment of the gaps in capabilities by country, relative to the needs of the country.[172] Participants suggested several actions to be considered by a relevant competent body. A 'Competence Register' could be built and maintained by a relevant competent body, where other Member States can call upon assistance to help design, install, train, and maintain specialized infrastructure, particularly where Member States may struggle to resource and sustain a specific infrastructure department.[173]
- Dedicated people focused on capacity development was also suggested,[174] as was the publication of a list of informal education material on websites[175] covering topics such as

[166] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[167] Jeffrey Verbeurgt, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[168] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[169] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[170] Jeffrey Verbeurgt, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[171] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[172] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023.
[173] Ryan Keenan, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[174] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[175] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023

Geodesy Fundamentals, Advanced Space Geodesy, and making Successful Bids for Development Funding.[176]

- Focus effort on train the trainers. Organizations such as AFRIGIST in Africa recognize there is a lack of geodesy expertise in Africa and want to help fix the problem by offering to be trained and then train others. Regional bodies like AFRIGIST want to take ownership of Africa's problems. They do not want other people to solve them.

"The problems are ours. We need to solve them ourselves."

-- Abdoulaye, UN-GGIM Africa Listening World Tour

- Some regions suggested some innovative ways to encourage knowledge sharing and building capacity:[177]

"Can the retirees come to the Pacific on a volunteer scheme to train the surveyors?"

-- Andrick Lal, UN-GGIM Asia-Pacific Listening World Tour

- Member States and partner organizations, in particular, the International Federation of Surveyors (FIG) highlighted the need for improved collaboration and coordination for the delivery of capacity development programs. It was recognized that many groups are well meaning, but are unaware of other capacity development which is in place. Each group has limited resources, however, with stronger alignment, with assistance from the UN-GGCE, it is possible to capitalize on this effort and limit duplication.[178]
- Governments / National Mapping Agencies could recognize geodesy as a critical resource requirements for the future and implement policies and strategies to ensure that the capacity can be fulfilled.[179]
- Government could pay university for students that commit to serve for the Government afterwards.[180]
- A further need the community has to capitalize on efforts being made is to ensure training material and workshops are made available in many languages to ensure wider use.[181]

[176] Ryan Keenan, 2nd Consultative Meeting on Needs Assessment, 21 November 2023
[177] Andrick Lal
[178] Ryan Keenan, FIG, ISO, IHO Listening World Tour, 20 February 2024
[179] International Advisory Committee, Meeting 18th March 2024
[180] International Advisory Committee, Meeting 18th March 2024
[181] UN-GGIM Africa, UN-GGCE

6. AWARENESS

6.1 Desired Future State

Awareness of the importance of geodesy is high within the industries that are reliant on the global geodesy supply chain and higher across the general public.

6.2 Summary

The awareness of 'modern' geodesy is low in critical industries, in science communities, and the public.

Participants noted some awareness of the importance of geodesy in selected case studies in some regions. Participants also acknowledged the challenges of raising awareness of 'modern' geodesy even within organizations and the geospatial discipline more broadly. Critically, participants noted resistance to the idea that benefits to a Member State can arise from infrastructure and capacity development outside of a Member State.

Participants called for a clear, effective communications and stakeholder engagement strategy and plan. The strategy and plan must enhance awareness of the importance of geodesy to other industries (including the space sector), and other sciences that rely on geodesy without being aware of geodesy's importance. Such a campaign should raise the awareness of geodetic infrastructure being 'critical infrastructure'. Participants also sought increases in public awareness using consistent, clear, and simple messaging. Such messaging could raise the profile of geodesy amongst students (to increase capacity), decision makers, and the public (to increase influence on politicians).

6.3 Narrative

6.3.1 Global awareness challenges

- **There is a lack of awareness of the geodesy discipline, and the value it provides, within the senior management of geodetic institutions, decision makers, policy makers, the wider scientific community and general public.** Of greatest concern to participants who were from government geodetic agencies was the lack of awareness, particularly amongst their senior management.[182]
- Another concern raised by a number of Member States and partner organizations was the **lack of awareness of the importance of geodesy in defence agencies**. Participants highlighted the range of dependencies that defence programs have on geodesy, including the use of GNSS, Earth Observation and satellite communications, and spoke of the lack of collaboration / engagement between government science and defencec organizations responsible for geodesy. Many Member States representatives were unaware whether their government have staff who know about geodesy, work on geodesy, or are considering the risk of degradation of the global geodesy supply chain.[183]

[182] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[183] UN-GGCE, from UN-GGCE initial analysis of IAG opinions

- Many participants spoke of a **lack of awareness of what modern geodesy provides even in the closely related / adjacent industries**.[184] Increasingly industries are reliant on satellite services for position, navigation and timing services such as mining, agriculture, construction, maritime, intelligent transport etc. Nonetheless, the scientists and engineers (let alone the owners) of these industry bodies are unaware of the global geodesy supply chain, its risk of degradation and the risk to their stakeholders.

> *"[There is a] lack of understanding and/or awareness in the wider scientific community, even if from relatively close fields, about the importance of geodesy."*
>
> *-- José Carlos Rodríguez-Pérez, IAG & UN-GGCE Listening World Tour, 28 November 2023*

- Participants noted the **lack of active, coordinated outreach and awareness initiatives**, to promote the awareness of geodesy outside of the discipline and to the public.[185]
- Participants also observed a **lack of awareness by influential groups** on their dependency on the global geodesy supply chain. Such groups publish reports which are widely distributed and noticed within Member State governments (such as reports from the Intergovernmental Panel on Climate Change) where the global geodesy supply chain plays a critical function in their deliverables.[186]
- **With the exception of GPS, most geodetic techniques (including other GNSS) are unknown to the general public** as their products are not directly used by the broad society. Nevertheless, all geodetic techniques are necessary for a reliable and robust global geodesy supply chain.[187] In most cases, people access the products generated by geodetic techniques in an aggregated form as a user of GNSS.[188]
- It is difficult to identify who uses geodetic products as they are provided for free to download without any registration and their usage is not referenced through the provider of the end products.[189]

6.3.2 Suggested actions from experts to raise awareness of geodesy, globally

- **A stakeholder engagement strategy should be developed by a competent body.** Member States and partner organizations need a clear and effective communications and stakeholder engagement strategy and plan. Some messaging will be consistent for all stakeholders.
- **Clear, simple messaging should be developed to raise awareness amongst the public and other industries** on the importance of geodesy[190] with talking points for different stakeholders.[191] Engagement with UN-GGIM regional committees, industry partners who earn

[184] Kevin M Kelly, IAG & UN-GGCE Listening World Tour, 28 November 2023
[185] Zuheir Altamimi and Richard Gross, 2nd Consultative Session, 21 November 2023
[186] UN-GGCE, from UN-GGCE initial analysis of expert opinions
[187] IAG Services Listening Session
[188] IAG Services Listening Session
[189] IAG Services Listening Session
[190] Group Session, 2nd Consultative Meeting on Needs Assessment, 20 November 2023
[191] UN-GGCE, from UN-GGCE initial analysis of IAG opinions

money using the global geodesy supply chain, and bodies who oversight the activities of geodesy's direct clients, was also recommended.[192]

"Geodesy becomes an everyday word, where it is recognised for its contributions on creating a connected, sustainable and stronger world."

-- Anna Riddell, UN-GGIM Listening World Tour session with IAG

- For the public, participants suggested a range of tactical tools such as fact sheets,[193] videos, school tours,[194] field trips to observatories or universities[195], a 'Day of Geodesy',[196] sessions and lectures given to students in other disciplines,[197] and further training.[198] Expansion of such tools into other languages was seen as an important step.[199] The evidence used in awareness activities should include references to the importance of geodesy actions that occur every day, such as the criticality of reference frames to navigation using mobile phones.[200]
- Some participants encouraged raising awareness by describing **what the world would look like if the global geodesy supply chain was not working**.
- Participants noted the need to explain the interconnection of the different pieces of the geodetic infrastructure, and why they are needed to provide and enable services that are normally taken for granted.[201]

I would find it useful to have clear and concise explanation of what happens when geodesists stops doing their work. Geodesy is a bit like a refrigerator - it works for a while even after you turn it off. That's very hard for decision makes to handle, as it is doesn't cause immediate problems when funding is cut. Explain the importance is difficult and we welcome all the help we can get.

--Kristian Evers

- **Translate, translate, translate!** Member States and partner organizations provided resounding support to translation as much information, especially technical material and evidence for decision makers, from English into other languages.[202] Member States also advocated for the **use of the UN logo**[203] on the material which is very influential in many Member States[204].

[192] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[193] Kevin M Kelly, IAG & UN-GGCE Listening World Tour, 28 November 2023
[194] Randall Carman, IAG & UN-GGCE Listening World Tour, 28 November 2023
[195] International Advisory Committee, Meeting 18th March 2024
[196] Jürgen Müller, IAG & UN-GGCE Listening World Tour, 28 November 2023
[197] Mathis Bloßfeld, IAG & UN-GGCE Listening World Tour, 28 November 2023
[198] Ilya Oshchepkov, Hayo Hase, IAG & UN-GGCE Listening World Tour, 28 November 2023
[199] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[200] UN-GGCE, from UN-GGCE initial analysis of IAG opinions
[201] IAG Service Listening Session.
[202] UN-GGCE, from UN-GGCE initial analysis of opinions from UN-GGIM Americas
[203] Hannu Koivula UN-GGIM: Europe Listening World Tour, 16 February 2024
[204] Sergio Cimbaro, UN-GGIM: Americas Listening World Tour, 29 November 2023

Sources Used

- Nine UN-GGCE Listening World Tour sessions, including over 500 registered participants from 110 Member States.
    - Two sessions with IAG (28 November 2023)
    - UN-GGIM Americas (29 November 2023)
    - UN-GGIM Asia-Pacific (31 January 2024)
    - UN-GGIM Arab States (4-8 February 2024)
    - UN-GGIM Europe (16 February 2024)
    - Two sessions with FIG, IHO, ISO TC/211 (20 February 2024)
    - UN-GGIM Africa (27 February 2024)
- IAG Services Listening Sessions, held in 2024
    - International Laser Ranging Service - ILRS (9 February 2024)
    - International Gravity Field Service - IGFS (28 February 2024)
    - International VLBI Service for Geodesy and Astrometry - IVS (8 March 2024)
    - International Earth Rotation and Reference Systems Service - IERS (13 March 2024)
    - International GNSS Service - IGS (13 March 2024)
    - International DORIS Service - IDS (2024)
- UN-GGCE in person Expert Consultation Sessions, held in November and December 2023 (including representatives from all five UN-GGIM regions and partners).
- *Hidden Risk: How weaknesses in the global geodesy supply chain could have catastrophic impacts on critical infrastructure and national economies. Background report for decision-makers.* DRAFT report provided by UN-GGCE, February 2024.
- UN-GGIM Subcommittee on Geodesy: Global Surveys on Geodetic Reference Frame Competency Surveys (2018 and 2021)
- UN-GGIM Subcommittee on Geodesy: Geodetic Infrastructure Working Group Questionnaire (March 2020)
- UN-GGIM Subcommittee on Geodesy Position Paper on Sustaining the Global Geodetic Reference Frame, tabled at the 11th session of UN-GGIM Committee of Experts (2021)[205]
- A Position Paper of the UN-GGIM Subcommittee on Geodesy Working Group on Governance (2019) [206]

[205] https://ggim.un.org/meetings/GGIM-committee/11th-Session/documents/E-C.20-2021-7-Add-2_Position_Paper_on_Sustaining_the_GGRF_29Jul2021.pdf
[206] https://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/GGRF_Position_Paper2019_24July_web.pdf