International Federation of Surveyors
Fédération Internationale des Géomètres
International Vereinigung der Vermessungsingenieure

The Crucial Role of FIG in Promoting Professional Standards and Practices Globally

Presentation to the Fourth Plenary

Mutual Recognition of Professional Qualifications on Surveying in the ASEAN Region

(The Next Step of the International Conference for the Establishment of the ASEAN Qualification Reference Framework on Surveying).

12 August 2024 – Manila, The Philippines

Ryan Keenan, PhD, BEng (Hons) – Chair, FIG Commission 5

Member; FIG Task Force Trends & Future Ecosystem | FIG AP CDN
IAC, UN GGCE | Partner, UN-GGIM-SCoG : &Member, WG CD

1

Overview – Standards, Practices, Geodesy

- Introduction
- What is the FIG
- How the FIG is contributing
- Standards and Practices
- Ongoing Challenges in Geodesy and some Case Studies
- Closing Remarks

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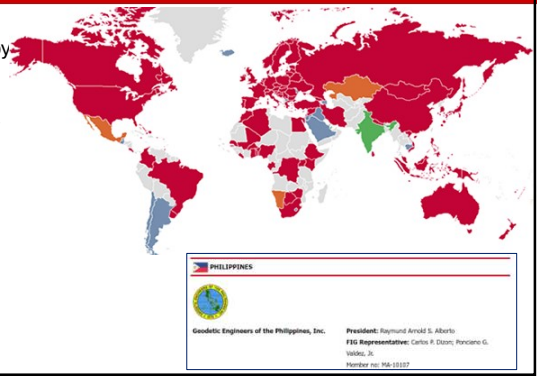
International Federation of Surveyors

- Established in 1878 in Paris by 7 member associations (BE, CH, DE, ES, FR, IT and UK)
- Federation of national survey associations (~115 member states)
- **Only** international body representing all surveying disciplines
- UN-recognised NGO



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Tackling the Global Challenges

Five Forces

- **Climate action** and the needs of a low carbon economy / also Energy and resources
- Rapid advances in **Technology and digital revolution**
- **Globalisation** and **communication**
- **(Settlements and (Rapid) urbanisation)**

Society's needs (and benefits):

- Transformational **societal** changes and expectations
- Profound changes in longevity and **demography**

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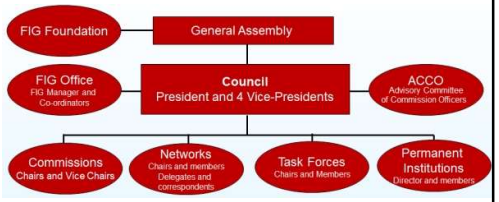
FIG Organisation

Contribution
- Knowledge generation and transfer,
- Outreach and Engagement,
- Capacity building

Professional: Standards
Institutional: Building capacity
Global Development
- Regional
- International



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Work Plans and Aims

FIG Aims:
- Planet
- People
- Partnership
- Governance and Communication

Sustainability runs throughout our work
- Task Forces are our Pillars and focussed to unpack our Relevance & Societal benefit
- FIG Commissions and FIG community working together achieves our Theme

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Commissions – the engine house of FIG

Activity and Outputs via ten **Commissions**:
1. Professional **Standards & Practice**
2. Professional **Education**
3. **Spatial Information Management**
4. **Hydrography**
5. **Positioning and Measurement**
6. Engineering Surveys
7. **Land Management & Cadastre**
8. Spatial Planning and Economic Development
9. Valuation and Real Estate
10. Construction Economics

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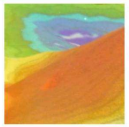
Task Forces

Task Force on FIG and the Sustainable Development Goals
2019-2022
2023-2026

FIG Climate Compass Task Force
2023-2026



Task Force on the Role of FIG in international Trends and Future Geospatial Information Ecosystem
2023-2026

Task Force on The Surveyor's Profession: Evolutionary Diversity and Inclusion
2023-2026

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People

- Sustainability is about making sure we demonstrate Diversity, Equality & Inclusion (DEI), leaving no one behind in our profession.....
- And build and maintaining our professional competence to ensure societal relevance

TF: Role in International Trends and Future Geospatial Information Ecosystems
Chair: Abbas Rajabafard

TF: Evolutionary Diversity and inclusion in the Surveying Profession

- Chair: Stephen Djaba

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Networks (incl. Capacity Development)

FIG Young Surveyors Network

FIG Standards Network

FIG Regional Capacity Development Networks

Africa (ARN)

Asia/Pacific (AP-CPD)

Americas

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Tackling the Global Challenges

2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

It is all about People!

Relevance requires a **Purposeful** and continuing intent to implement:

- Looking to societal contributions
- Looking to our people and profession

  - Can only be done in P**artnerships**.....

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Annual Working Week

~800 delegates
~ 40 Technical Sessions
~ 5 Pre-events
~ 90 Countries attended

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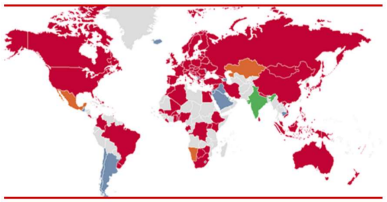
Partners – in and with sustainability



United Nations | World Bank

UN-GGIM Geospatial Societies | Professional Partners

Regional and Cultural Partners

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Partnerships

Sustainability is about making sure that both internal and external partnerships are working effectively and cultivating stronger engagement

Our relationships;

- Effective (All) member engagement
- Building and working for mutual benefit with external partners, and
- Providing Institutional capacity development

And, with UN-GGIM .....

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FIG involvement in the UN-GGIM

UN-GGIM: Geospatial Societies — United Nations Committee of Experts on Global Geospatial Information Management

UN-GGIM

- Observer status
- Geospatial Societies (GS)
- Working Groups (LAM, Geodesy, DM + input Hydro)
- Regional Networks (Africa, Asia Pacific & Americas)

and.....

- Partner of UN-GGIM Subcommittee on Geodesy

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UN-GGCE – 'Stronger. Together.'

Stronger. Together

- UN-GGCE's vision for the future is one where all countries have **strong political support** for geodesy which enables them to – together – accelerate the achievements of the SDG and derive social, environmental and economic benefits.
- The **strategic objective** is to work with Member States and geodetic organizations to strengthen our collective impact to:
  - Enhance investment in the global geodesy supply chain.
  - Improve coordination and collaboration amongst Member States and geodetic organizations.
  - Share geodetic data and improve standards, on a voluntary basis, to contribute to the global reference frame and regional densifications.
  - Provide greater technical assistance, especially for capacity development in geodesy for developing countries.
  - Make geodesy and its benefit more visible and understandable to society.

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Upcoming Activities

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Publications

- Style, format, importance
- Collaboration with partners
- Covering many aspects: reports (status), regulations (legal),
- Majority are for the international community, rather than specific member states

https://www.fig.net/resources/publications/figpub/index.asp

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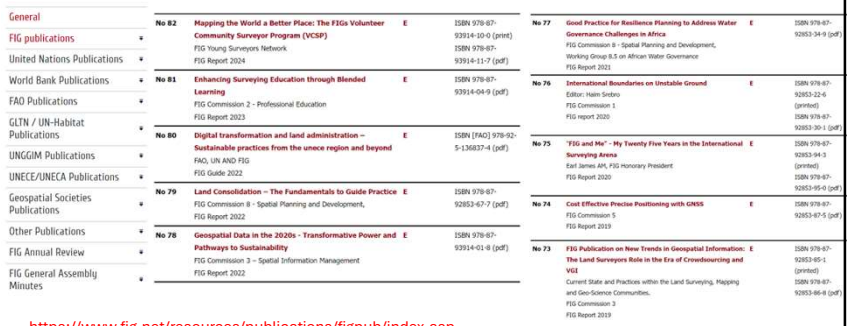
Publications > FIG Publications



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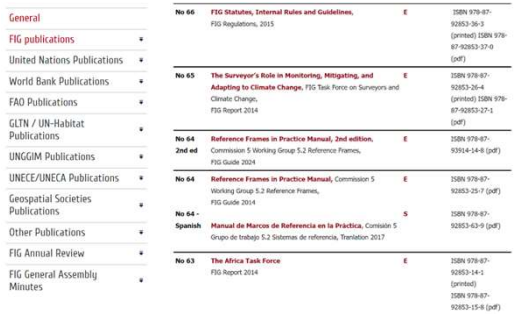
Publications



- Considerations:
  - Relevance
  - Importance
  - Awareness
  - Value
  - Neutrality

https://www.fig.net/resources/publications/figpub/index.asp

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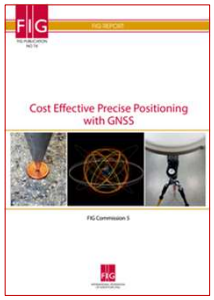
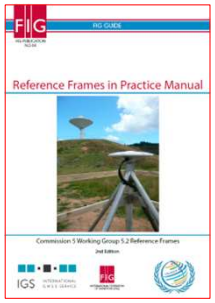
Notable Recent Publications – Comm 5





https://www.fig.net/resources/publications/figpub/index.asp

Standards & Practises – Important or not?

Interpretations

- Standards (RINEX, GeodesyML)
- SOPs
- Best (Global) Practise
- Guidelines (IGS CORS)
- Publications
- Workshops
- *Trainings*
- *Webinars et al*
- *MRA, MRPQs*

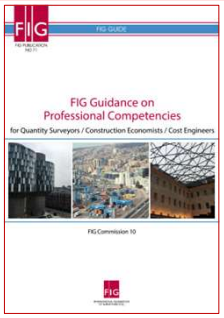
Constants

- S&P impacts everyone…. professional, informal..
- ISO and OGC are booming
- FAIR is fair….
- Most nations are experiencing similar challenges
- Geodesy is not unique
- Competence is quantifiable
- Resources are limited everywhere

FIG Guidance on Professional Competencies for Construction Engineers

FIG Publication #71 – 2018

- As construction industry is now a global industry it is important that professionals in the industry working across the globe should have a consistent standard of competencies which in turn provide confidence to their employers or clients.



- https://fig.net/resources/publications/figpub/pub71/figpub71.asp

Our Thoughts on Regional Recognition

Mutual Recognition Together

Where FIG may be able to help with Mutual Recognition Arrangements and Skills Migration

- To explore the challenges / opportunities to implement mutual recognition in the region on a broader scale and how other countries in the region can also participate.
- For example, one of the biggest challenges is to have a skills migration system that allows countries to exchange skills surveying / geospatial human resources **effectively and efficiently** for a period of time.
- It appears, government-based surveying and mapping agencies do not have a streamlined process, nor the capacity and capability to organise such activities that allow cross border (country and agency) sharing.

Regional Matrix

- To develop a regional matrix that enables countries to compare and assess their various surveying and geospatial qualifications so that organisations (and individuals) know what are the capability gaps / needs required, and whom to contact.
- Once these have been identified then tertiary education institutions, registered training organisations, professional organizations (like FIG) or other development partners can examine their own "abilities" and possibly provide the necessary training and development etc.

Assistance to ASEAN – Ideas

Advocacy & Promotion

Of a mutual recognition of the ASEAN professional qualification framework

- Provision of access to our FIG Commissions / network / sister organisations,
- Potential Capability Development activities

This initiative has been formulated over the last 15 or so years, and is worthy of significant promotion.

FIG parties

Comm 1 - Professional Standards

Comm 2 – Professional Education

Standards Network

In fact **all** of our Commissions, Networks and Task Forces, would be interested in such a program as well.

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Member Experiences

NATIONAL QUALIFICATIONS - Examples

From a regional / Australian perspective

- CRSBANZ (Council of Reciprocal Surveyors Board Australia and New Zealand)
  - have released a document about National Qualifications framework which ASEAN Flag may be interested in knowing about, as well as the body -
- "Bureau for Assessment of Oversea Qualifications"

Here are the links to these programs.

- National Competency Standards - https://crsbanz.wixsite.com/crsbanz/policies-guidelines
- Process of Assessing Qualifications (NSW) - https://www.bossi.nsw.gov.au/candidates/overseas_assessment

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Further Thoughts on MRA/MRPQ

Some key Summary points

- Most countries only need (require) formal mutual recognition for cadastral surveying.
- Other forms of surveying are less regulated.
- Are the drivers for recognition for GE linked to industry/government/all/other?

Consider to develop a framework for formal MRA in all forms of surveying, not only cadastral, but also land, engineering, geodetic, hydrographic

Initial Focus across three key categories:

- **Education** (common standards, cooperation, understanding what is available/what is recognised by professional associations),
- **Institutions** (models for establishing/operating survey boards and professional associations – arguably this should also include policies and regulations of surveying activities),
- **Profession** (possible certification and bilateral mutual recognition)

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Datum Modernisation Targets

All Member States have:

- actioned (or have concrete plans for) datum modernization
  - Geocentric reference systems
  - Alignment with ITRFxx
  - Sustainable GNSS CORS and geodetic infrastructure
  - Actively contributing to APREF
  - Succession planning around competent staffs and resources
- Used Standards & Practices to ensure F-A-I-R
  - Interoperability and Reusability being the most important (IMO)

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Recommendations

Geodetic Organisations in the Philippines

- Connection with UN-GGIM
- Involvement with SCoG
- UN-GGCE – Partner opportunity

Individuals

- Follow FIG & FIG Commission 5 – LinkedIn
- Review FIG Publications and relevance
- IGS – Associate Member status

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Closing Remarks

- Critical Needs
  - Standards, SOPs & Guidelines – technical
  - MRA across ASEAN must be delivering registrated Surveyors ASAP
  - Resources and Competencies are critical
  - Collaboration and Partnerships
- The Interface between Land and Marine Domains is now critical
- Looking forward to helping facilitate FIG assistance with this
- Wishing everyone a productive professional proactive conference

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Thank You for your Attention

- Ryan Keenan
- mailto: ryan.keenan@me.com

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FIG Commission 5
Positioning and Measurement

2023-2026

Chair: ***Ryan Keenan***, Australia

Vice-Chair of Administration: ***Kevin Ahlgren***, USA

Working Group	Chair	Co-Chair
WG 5.1: Standards, Quality Assurance and Calibration	David Martin, France	
WG 5.2: 3D Reference Frames	Nic Donnelly, New Zealand	Chris Pearson, New Zealand
WG 5.3: Vertical Reference Frames	David Avalos, Mexico	
WG 5.4: GNSS	Eldar Rubinov, Australia	Safoora Zaminpardaz, Australia
WG 5.5: Multi-Sensor Systems (Joint w/ IAG / Com. 6)	Amir Khodabandeh, Australia	
WG 5.6: Cost Effective Positioning	Li Zhang, Germany	David Mulindwa, Uganda
WG 5.7: Emerging Technologies for PNT	Allison Kealy, Australia	Jelena Gabela, Austria

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Working Group 5.1: Standards, Quality Assurance, and Calibration

David Martin, Chair, WG 5.1 & FIG Standards Network
- Head of the Survey and Alignment Group at the
- European Synchrotron Radiation Facility (ESRF)

General
- Influence the development of standards affecting positioning and measurement instruments and methods, in collaboration with the FIG Standards Network and through participation in the relevant technical committees (TCs) of the International Standards Organisation (ISO) and other appropriate bodies
- Acceptance controls, quality assurance and certification and their impact on the surveying profession
- Testing and calibration of measuring instruments.
- Assist other Commission Working Groups to implement Standards from TC 172/SC 6 and ISO TC211 as appropriate

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Working Group 5.1: Standards, Quality Assurance, and Calibration

Projects
- Promote the Guide for the expression of Uncertainty in Measurements (GUM) in the surveying profession,
- Promote connection to ISO TC 172 SC6 and ISO TC211.
- FIG Standards Network Report can be found in the GA Agenda

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Working Group 5.2: 3D Reference Frames

Chair:
Nic Donnelly, New Zealand

Co Chair:
Chris Pearson, New Zealand

About WG 5.2:
- Encourage the adoption of modernized geodetic reference frames (dynamic and semi-dynamic datums) worldwide
- Encourage software providers to properly support dynamic and semi-dynamic datums
- Provide a forum for countries and other organizations involved in datum modernization to facilitate the exchange of ideas
- Contribute to the development of international standards on deformation models

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Working Group 5.2: 3D Reference Frames

Projects
- Reference Frames in Practise (RFIP) seminar series – WW24 Accra (below)
- Contributed to OGC draft 'Deformation Models and Geodetic Grids exchange standards'
- Contributed to future capacity building initiatives
- Updating the Reference Frames In Practice manual (old FIG publication 64)
- LOC Chair of 2024 Survey and Spatial New Zealand conference

RFIP in Accra – 22+ participants with support from UNOOSA-ICG and Trimble

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Working Group 5.3: Vertical Reference Frames

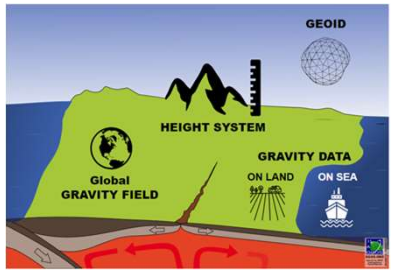
Chair:
David Avalos, Mexico

About WG 5.3:

- Inform FIG members on status of regional and global vertical reference frames, height systems and dynamics of the gravity field and geoid.
- Educate FIG members on practical aspects about the implementation of new geopotential datums (RFIP, …)

Projects:

- Develop a guideline to interpret and access the IHRF for local and national vertical control in connection with IAG, Commission 2.



Working Group 5.4: GNSS

Chair:
Eldar Rubinov, Australia

Co Chair:
Safoora Zaminpardaz, Australia

About WG 5.4:

- Supporting GNSS applications in developing regions
- Explore cutting edge new tech such as LEO PNT, 5G, etc.

Publications

- Several papers will be published covering:
  - Multi-GNSS advances including best-practice examples
  - Cost-effective high-precision positioning for mass-markets (together with WG 5.6)

Working Group 5.5 / IAG - Multi-Sensor-Systems

Chair:
Amir Khodabandeh, Australia

A joint WG between FIG and International Association of Geodesy (IAG). Focusing on the development of shared resources that extend our understanding of the theory, tools and technologies applicable to the development of multi sensor systems.

- Performance characterization of positioning sensors and technologies that can play a role in augmenting core GNSS capabilities
- Theoretical and practical evaluation of current algorithms for measurement integration within multi sensor systems.
- The development of new measurement integration algorithms based around innovative modeling techniques in other research domains such as machine learning and genetic algorithms, spatial cognition etc.
- Establishing links between the outcomes of this WG and other IAG and FIG WGs (across the whole period)
- Generating formal parameters that describe the performance of current and emerging positioning technologies that can inform FIG and IAG members.

Working Group 5.5 / IAG - Multi-Sensor-Systems

Projects:

- International field experiments and workshops on a range of multi sensor systems and technologies.
- Evaluation of UAV capabilities and the increasing role of multi-sensor systems in UAV navigation.
- Investigate the role of vision-based measurements in improving the navigation performance of multi sensor systems.
- Development of shared resources to encourage rapid research and advancements internationally.

Workshops:

- Special Sessions at Working Weeks and Supporting Special international conferences and symposia including: Mobile Mapping Symposium, ION GNSS, IGNSS Australia, IPIN, etc.

Publications:

- A number of papers will be submitted to relevant conferences & technical journals.

Working Group 5.6: Cost Effective Positioning

Chair:
Li Zhang, Germany

Co Chair:
David Mulindwa, Uganda

About WG 5.6:

- Educate FIG member associations and individual surveyors on when to use which surveying instrument or evaluation software taking into account economic reasons
- Introduction of cost-effective tools (software and hardware) to make fit-for-purpose surveying systems more accessible in developing countries for sustainable development
- Support decision makers for establishing cost-effective positioning solutions

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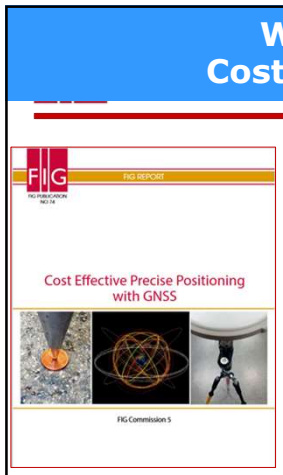

Working Group 5.6: Cost Effective Positioning

Projects:
- Developing guidelines for cost-effective use and design of survey solutions including costs for labour and investment

Workshops:
- FIG workshop with Commissions 3 and 7

Publication:
- FIG Publication and papers on Cost Effective surveying techniques

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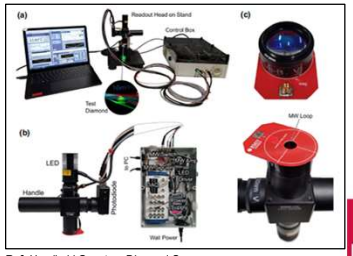
FIG Commission 5 Positioning and Measurement WG 5.7: Emerging Technologies for PNT Activity Report: 2023-2024

Co Chair:
Allison Kealy, Australia

Co Chair:
Jelena Gabela, Austria

- The primary mission of **WG5.7: Emerging Technologies for PNT*** is to identify, assess, and integrate innovative technologies that have the potential to revolutionize precision navigation and timing systems.
- By fostering collaboration and experimentation, the group aims to shape the future landscape of PNT with the infusion of emerging and disruptive technologies.

**[Joint Study Group with International Association of Geodesy (IAG)]*



Ref: Handheld Quantum Diamond Sensor
Abrahams *et al*, Phys. Rev. Applied 19, 054076 (2023)

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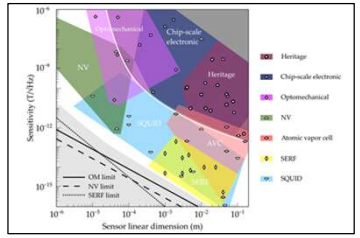
FIG Commission 5 Positioning and Measurement WG 5.7: Emerging Technologies for PNT Activity Report: 2023-2024

Activities planned in next 12 months

- White Paper on current status of quantum sensors for PNT applications.
- Conferences:
  - IGNSS (Australia) ION PNT Pacific, ION GNSS+, IAG Symposium, ISPRS, Mobile Mapping.
- Webinar on Quantum PNT and AI
- Collaborations IAG special study groups on Quantum Geodesy and Quantum PNT
- Journal publication on performance assessment of integrated GNSS and Quantum Magnetometry.
- Joint membership through FIG/IAG/ION



Ref: Magnetometer Sensitivity
From: Bennett *et al*, Sensors 21, 5568 (2021)

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FIG Commission 5 - Positioning and Measurement Contributions to UN SDGs (Sustainable Development Goals) Activity Report: 2023-2024

SDGs Task Force led by Paula Dijkstra (Comm5 representative Allison Kealy)

- Objective of the Task Force is to ensure that 'in 2026 the understanding of the 2030 Agenda and the relevance of the SDGs for our profession are embedded within FIG'.
- Pilot Project initiated to link FIG abstracts (for the last 5 years) to SDG themes - Commission 5 as Pilot
  - Pilot idea is to go over all the papers that were submitted to Comm5 during FIG 2023 Conference and see which SDGs are relevant.
- Aim: To develop a formal approach to connecting all Commissions' work to the SDGs (directly or indirectly), with results being presented at the FIG Congress 2026.

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Commission 5 Sessions 2024
Pre-event: RFIP Workshop 18/19 May 2024

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Commission 5 Sessions 2024
Pre-event: RFIP Workshop 18/19 May 2024

- 32 attendees, 15 countries, 5 continents
- Presentations from UNOOSA, IAG, IGS, AFREF, ARABREF and many African countries.
- Many thanks to sponsors:
  - Trimble
  - UN-OOSA ICG
  - sponsoring 3 attendees from Nigeria, Kenya, and Uganda

L->R: Ms. Izuegbu OGOCHUCKWU (Nigeria)
Ms. Rachael Umazi GEDION (Kenya)
Dr. Augustus ATURINDE (Uganda)

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Working Week 2024 in Ghana

- **RFIP Workshop** – 18/19 May 2024 – with UNOOSA-ICG sponsorship and presentations by ICG, IAG, UN-GGCE and AFREF representatives
- **Tech Sessions**
  - 5.1 GNSS CORS REFERENCE STATIONS AND NETWORKS – Session 1 for Senior Policy Makers
  - 5.2 GNSS CORS REFERENCE STATIONS AND NETWORKS – Session 2 for Technical Experts
  - 5.3 NOVEL COST-EFFECTIVE POSITIONING & ENGINEERING SYSTEMS AND THEIR APPLICATIONS IN AFRICA
  - 5.4 THE GROWING ROLES & RESPONSIBILITIES OF SURVEYORS AS DATA ENGINEERS AND RESOURCE MANAGERS
  - 5.5 ADVANCING SURVEYING THROUGH TECHNOLOGY AND UNCREWED SYSTEMS
  - 5.6 ANNUAL COMMISSION 5 MEETING

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Commission 5 Sessions Technical Program

Session	Title	Date / Time	Location
TS01F	Novel Cost-Effective Positioning & Engineering Systems and their Applications for Africa **Joint with Com6*	Monday, 08:00	Kundum, La Palm
TS05F	The Growing Roles & Responsibilities of Surveyors as Data Engineers and Resource Managers	Tuesday, 08:00	Kundum, La Palm
TS07F	Accelerating Land Administration Success with GNSS CORS Networks: Insights for Senior Decision Makers	Tuesday, 14:30	Kundum, La Palm
TS08F	GNSS CORS Reference Stations and Networks – Session 2 for Technical Experts	Tuesday, 16:30	Kundum, La Palm
TS09F	Advancing Surveying through Technology including Uncrewed Systems	Wednesday, 8:00	Kundum, La Palm

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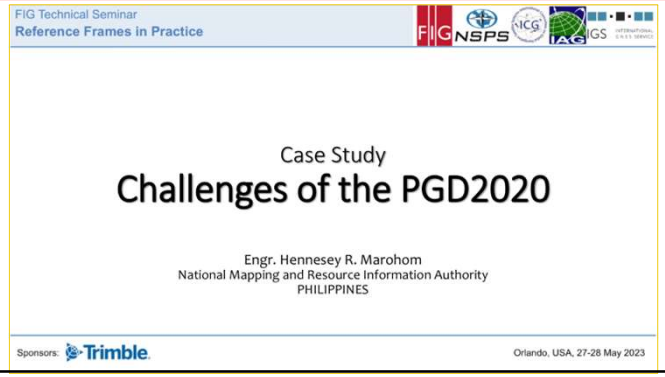
Reference Frames in Practise 2023



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Upcoming Events

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Publications – Commission 5

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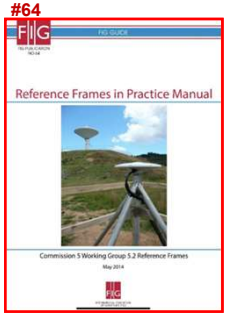

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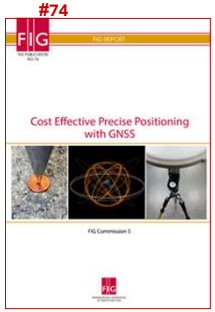

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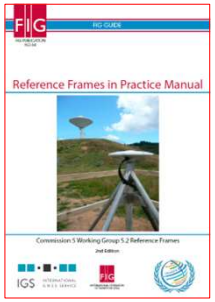
FIG Publication – RFIP Manual Update



- The First Update (2024) to the 2014 edition (Publication #64) is done!
  https://fig.net/resources/publications/figpub/pub64/Figpub64.pdf
- Includes contributions from IGS and UN-GGCE
- Released at WW24 in Accra during the RFIP Workshop
  - Languages (EN initially)
  - Softcopy being considered

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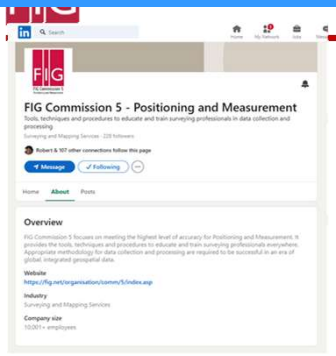
Commission 5 New LinkedIn Group Page!!



https://www.linkedin.com/showcase/fig-commission-5-positioning-and-measurement

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Commission 5 Open Meeting

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TS07F - Land Administration and GNSS CORS

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Geodesy – Use Cases

- GRS – geocentric reference systems, for regions
- Vertical Reference Systems
- Deformation Models using NTv2

- Thanks to our partners from IAG, Universitat Beira (Portugal), Land Information New Zealand (LINZ) – and others who help the FIG RFIP Workshops remain

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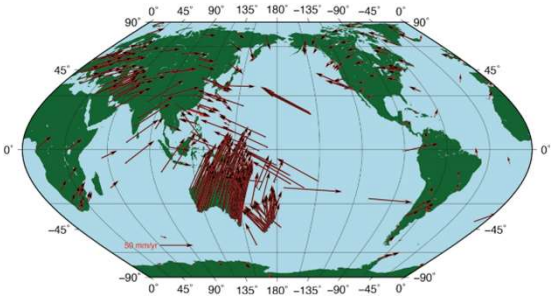
Asia Pacific Reference Frame (APREF)



Status: 22-May-2024
https://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/asia-pacific-reference-frame

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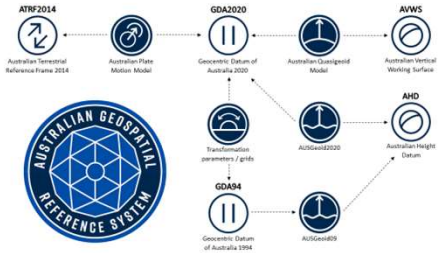
Australian Geospatial Reference System (ARGS)

The AGRS is a collection of:

- **datums** (e.g. Geocentric Datum of Australia 2020, Australian Height Datum),
- **reference frames**(e.g. Australian Terrestrial Reference Frame) and
- **working surfaces** (e.g. Australian Vertical Working Surface) used to define latitude, longitude, height, orientation and gravity throughout Australia;
- **infrastructure**, including a national network of GNSS CORS and survey marks to provide an authoritative and accurate network in support of positioning applications;
- **models** describing dynamic, geophysical processes that affect spatial measurements; and
- **standards** to ensure positioning information is Findable, Accessible, Interoperable and Reusable (e.g. ISO / OGC / GeodesyML



The AGRS is managed by the Intergovernmental Committee on Surveying and Mapping Geodesy Working Group (AU-NZ) iscm.gov

https://www.ga.gov.au/scientific-topics/positioning-navigation/australian-geospatial-reference-system

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Joining Land and Sea using Geodesy

Forum on the Integration of Terrestrial, Maritime and Cadastral Domains at UN-GGIM-#14

SOLUTION

- use the geoid as the primary height reference surface and link all other surfaces
- (ellipsoid, MSL (mean sea level), HAT, LAT (highest/lowest astronomical tide), MDT …) to the geoid.

POSITIVES

- Physical height reference surface - water always flows downhill
- Exists onshore and offshore
- *(No other surfaces meet these two criteria)*

CHALLENGES

- Global geoid model has absolute accurate of ~20 cm (relative accuracy is better than this)
- Local / Regional geoid models require airborne and terrestrial gravity data which can be expensive
- Development of hydroid models to convert between MSL, LAT etc. and the geoid are challenging (but necessary for every primary reference surface)
- UN-GGCE is willing and able to assist Member States with these challenges (and others).

UN-GGCE will be hosting a Workshop on the Land/Sea Interface in Indonesia – Dec 2024

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International Association of Geodesy

presented by
Richard S. Gross

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109–8099, USA

FIG Reference Frames in Practice

May 18-19, 2024
Accra, Ghana

Jet Propulsion Laboratory
California Institute of Technology

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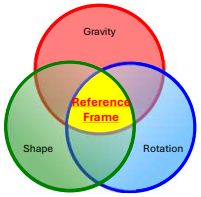
Geodesy

Geodesy is the science of accurately measuring and understanding three fundamental properties of the Earth and their changes in time

- Geometric shape
- Rotation and orientation in space
- Gravity field



Establishing and disseminating the Terrestrial Reference Frame (TRF) is central to Geodesy

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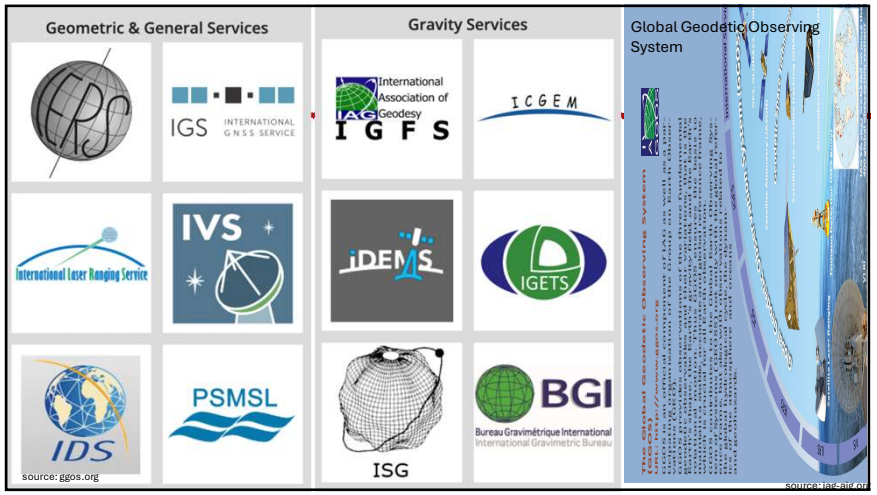

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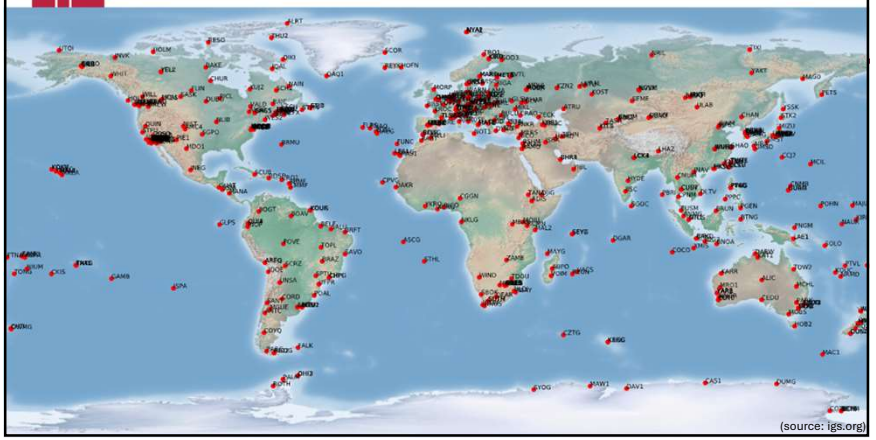
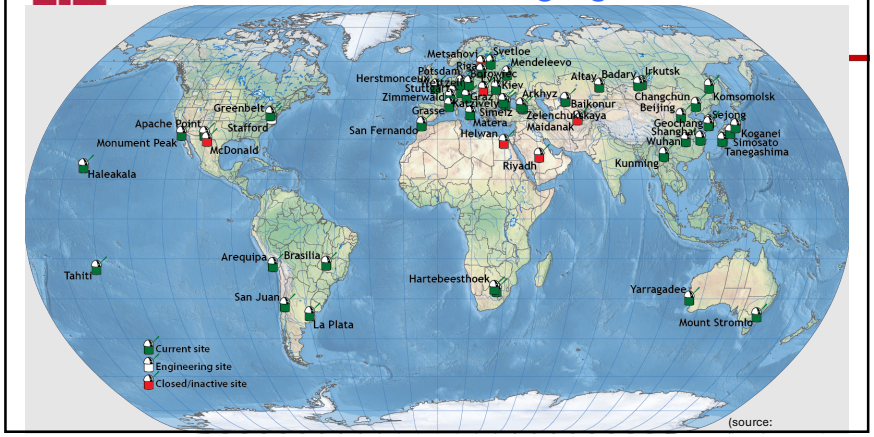
International GNSS Service



64

International Laser Ranging Service



65

International DORIS Service

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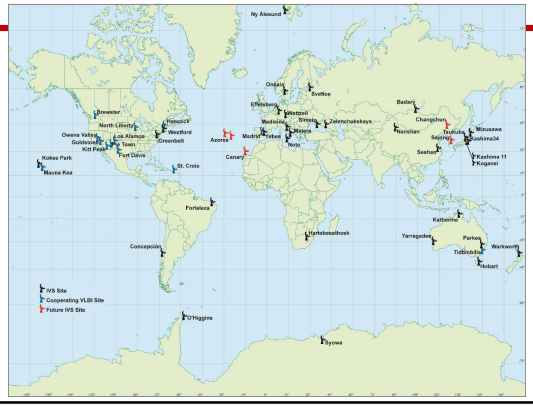
International VLBI Service
for Geodesy and Astrometry



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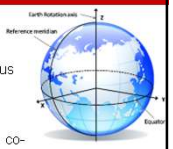
Terrestrial Reference Frame (TRF)

- **Definition of the TRF**
  - An accurate, stable set of positions and velocities of reference points on Earth's surface
  - Provides the stable coordinate system to link measurements over space and time for numerous scientific and societal applications including critical climate and sea level change studies
- **Determination**
  - The GNSS, VLBI, SLR, & DORIS geodetic networks, along with ground surveys of stations at co-located sites to tie the networks together, provide the data for determining the TRF as well as for direct science investigations
- **Improvement**
  - An improved TRF is needed for numerous scientific and societal applications including critical climate and sea level change studies

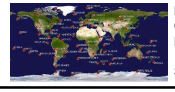


Terrestrial Reference Frame

GGOS Goal: TRF accurate to better than 1 mm, stable to better than 0.1 mm/yr over 10yrs


GNSS

SLR

VLBI

DORIS

68

Using NTv2 Files for Datum Transformations in Deforming Regions: The Cases of Bhutan and Chile

Rui FERNANDES, Portugal
José Antonio TARRIO, Chile
Chokila CHOKILA, Bhutan
Gonçalo HENRIQUES, Portugal
Pedro ALMEIDA, Portugal
Marcelo CAVERLOTTI, Chile

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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Introduction

- Geocentric Datums based on modern space-geodetic techniques (mainly GNSS) have been adopted worldwide as National Reference Frames.
- Such Datums are nowadays mainly permanently materialized through networks of CORS (Continuously Operating Reference Stations) GNSS stations instead of passive reference control points.
- GNSS CORS based Datums has many advantages compared with Classical Datums based on passive control points:

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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Introduction

- GNSS CORS based Datums has many advantages compared with Classical Datums based on passive control points:
  - Permanent materialization of the reference network since the CORS stations are continuously acquiring the data.
  - Permanent monitoring of the stability of the network – any change in the positions is noticed – the same is not true for passive control points.
  - The internal accuracy of the fiducial network is few millimeter level.
  - No need for passive control points when carrying out surveying in the vicinity of the CORS station (up to 25-30Km).
  - Direct connection to the international reference frames, namely ITRFxxx, which facilitates the integration of international projects (e.g., definition of borders).
  - Use of the most modern geodetic techniques which will contribute to modernize and transfer of knowledge to the Surveyors community.
  - Possibility to monetize the access to RTK corrections generating income to governmental authorities.

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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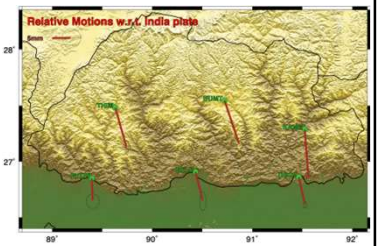
Introduction

- Not only Classical Datums need to be updated to Geocentric Datums!
- In Deforming Regions, modern Geocentric Datums also need to be regularly updated.
- Bhutan example:



Since 2003, when DrukRef03 (the 1st geocentric datum of Bhutan) was defined, the total shortening of the baselines between stations in the southern part of the country and stations in the central part is already about 8-10cm.

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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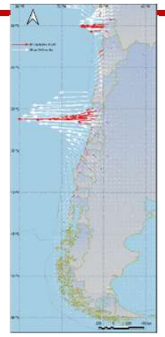
Introduction

- Not only Classical Datums need to be updated to Geocentric Datums!
- In Deforming Regions, modern Geocentric Datums also need to be regularly updated.
- Chile example:



Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

73

Introduction

- The adoption of a new geocentric datum requires the estimation of transformation parameters between the old datum and the new datum.
  - This is essential to convert all existing geo-referenced information (cadastral, maps, engineering projects) acquired in the old datum into the new datum.
  - Cadastral information, in particular, has strict accuracy requirements (few centimeters) since areas should not change significantly when new coordinates are assigned to the plot's boundaries.

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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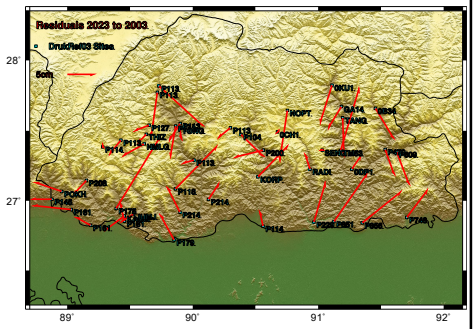
7-Parameter (Helmert) Transformations

- Helmert is a Conformal Transformation: it does not change shapes.
- A unique national-wide 7-parameter (Helmert) transformation is unable to minimize errors due to:
  - past measurements using classical techniques (significantly less accurate than the modern space-geodetic techniques)
  - active deformations due to plate tectonics.



Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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7-Parameter (Helmert) Transformations

- Chile:
  - The geodetic measurements of Classical Datums (PSAD56 and SAD69) were made in the 50s to 70s.
  - The transformation parameters between the classic and modern (SIRGAS) are made available only for cartography, scale 1:25000. The accuracy is ± 17 m (according to EPSG).

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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NTv2 Transformations

- NTv2 (National Transformation Version 2) is a grid-based format widely used for datum transformations. It offers several advantages over 7-Parameter Transformations:
  - Higher Accuracy: NTv2 transformations account for variations due to internal deformations and/or observational errors.
  - Local Adaptation: can be customized for specific regions, capturing local geodetic anomalies and irregularities.
  - Efficiency: once the grid is established, NTv2 transformations can be applied quickly and efficiently to large datasets.
  - Versatility: NTv2 can be used for both horizontal and vertical transformations.
  - Broad Software Support: Many geospatial software packages support NTv2 transformations.
  - Maintenance: They can be regularly updated to reflect the latest geodetic measurements and models.

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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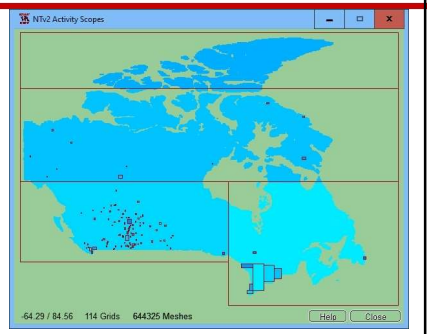
NTv2 Transformations

- NTv2 (National Transformation Version 2) was initially developed by the Geodetic Division of Natural Resources of Canada being nowadays officially in use in many countries worldwide.
  - It is formed by 114 grids of different sizes containing 644,325 meshes.
  - The magnitude and direction of the correction is given at each corner of the mesh so the correction for each point of interest can be computed by interpolation



Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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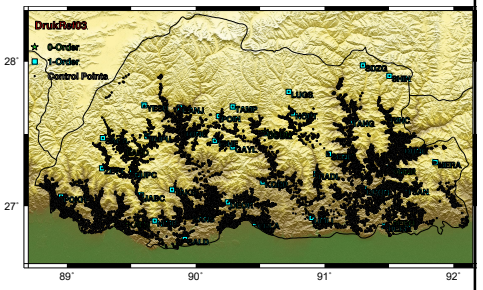
Bhutan Example
- Transformation from DrukRef03 into new DrukRef23

- There are approximately 27200 passive control points distributed in the country mainly established for acquiring cadastral information w.r.t. DrukRef03.
- They are heterogenous spatially distributed and the quality also greatly varies since they were computed using different methodologies (RTK, Classical Observations) at many different epochs.



Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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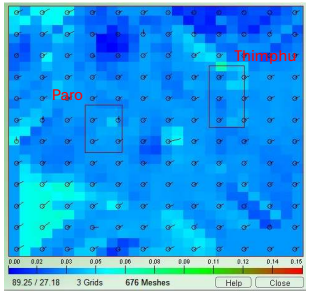
Bhutan Example
- Transformation from DrukRef03 into new DrukRef23

- Three Grids were computed:
  - One covering the entire observed area
  - Two covering the urban areas of Thimphu and Paro
- The main grid will be recomputed when the remaining districts will be observed during Phase 2 of the project (planned to start in July).



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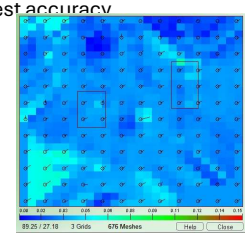
Bhutan Example
- Transformation from DrukRef03 into new DrukRef23

- The width (and consequently the number) of each mesh is an important factor to achieve the best accuracy



Entire Area			
X (km)	Y (km)	Meshes	Mean Error (mm)
0.567	0.482	12753	136.3
1.133	0.965	3245	90.1
1.700	1.447	1369	82.3
2.267	**1.930**	**729**	**72.4**
2.494	2.123	625	83.0
3.400	2.895	361	83.0
Thimphu Grid			
X (km)	Y (km)	Meshes	Mean Error (mm)
0.293	0.513	552	163.1
0.439	0.770	256	153.2
0.586	1.026	144	69.4
0.850	1.488	90	44.9
0.879	**1.539**	**81**	**34.2**
0.908	1.591	90	66.9
0.937	1.642	64	74.6
Paro Grid			
X (km)	Y (km)	Meshes	Mean Error (mm)
0.370	0.393	462	105.8
0.555	0.590	240	78.6
0.739	0.787	121	76.8
1.109	**1.180**	**72**	**66.1**
1.294	1.377	56	74.0
1.405	1.495	49	103.5
1.849	1.967	30	109.7

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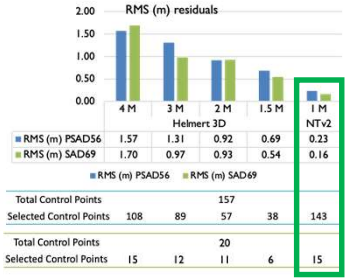
Chile Example
- Transformation from Classical into Geocentric Datum

- Two **separate** comparisons between Helmert and NTv2 transformations have been done between the Classical (PSAD56 and SAD69) and the new Geocentric Datum (SIRGAS).

- **It is clear that NTv2 provides a much better adjustment in both cases.**



Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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Conclusions

- NTv2 (National Transformation Version 2) transformations, being able to accommodate and minimize internal deformations and/or observational errors, provide better adjustments when it is necessary to transform existing geo-information from Classical to Geocentric Datums (or even new Geocentric Datums are computed).
- The two studied areas (Bhutan and Chile) clearly show the advantages of the NTv2 approach in high deforming areas.
- Bhutan also show the additional advantage of using grids with different mesh sizes (particularly useful when high accuracy is required like in urban areas).

Credit: Rui et al, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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Toitū Te Whenua
Land Information
New Zealand

New Zealand's 3D and Vertical Datums

New Zealand Case Study, Reference Frames in Practice Technical Seminar
FIG Working Week 2024, Accra, Ghana

Nic Donnelly
Mātanga Tātai Wāhi Mātāmua/Principal Geospatial Specialist – Geodesy
Chair, FIG Commission 5 Working Group 5.2 – 3D Reference Frames

19 May 2024

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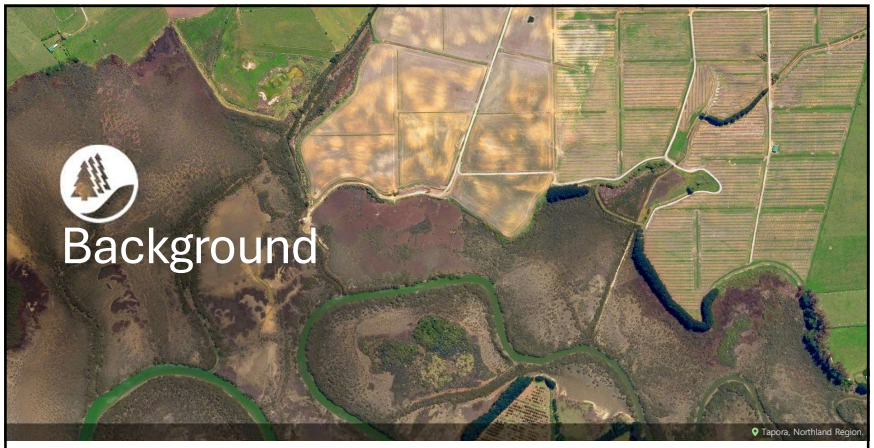

Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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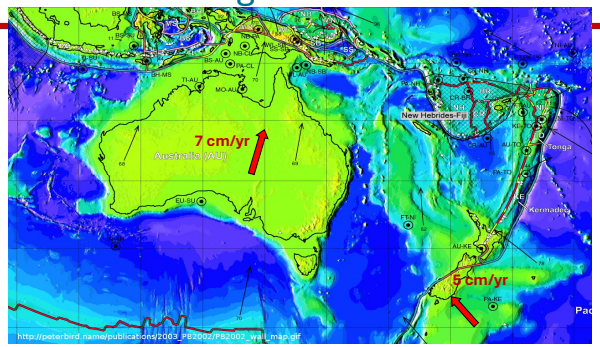
Tectonic Setting of New Zealand



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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Significant Earthquakes

Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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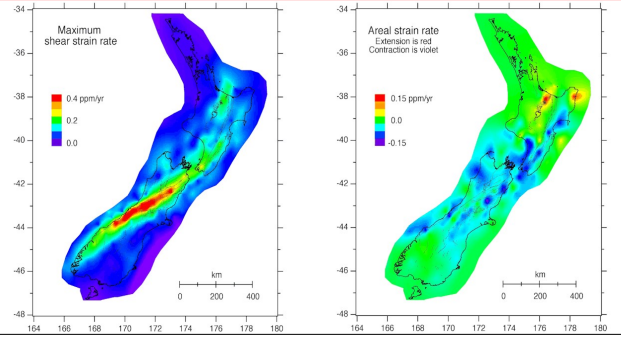
Complex Deformation Environment



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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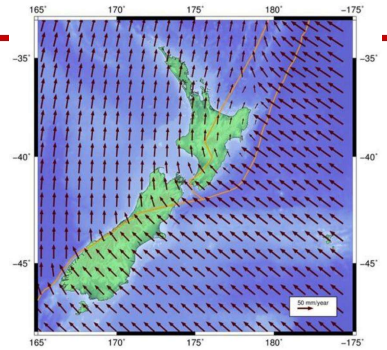
Introduction to New Zealand Geodetic Datum 2000

- Semi-dynamic datum
  - Aligned to ITRF96 at epoch 2000.0
- Incorporates a deformation model
  - Secular component (horizontal only)
  - Earthquake "patches" (horizontal and vertical; forward, reverse and hybrid)
- Enables propagation of coordinates and observations between observation epoch and reference epoch
- For most applications, has the characteristics of a static datum, so easy to use



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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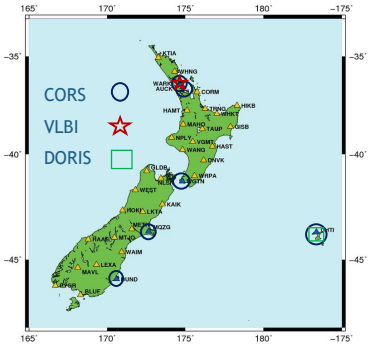
Alignment to ITRF



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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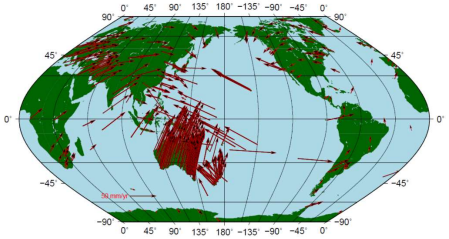
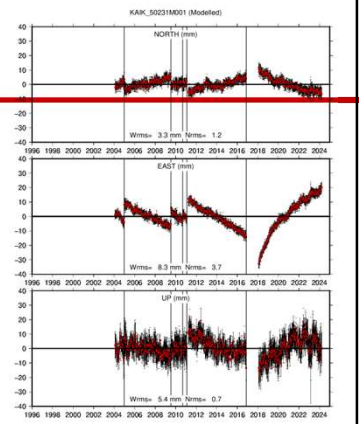
Alignment to APREF





Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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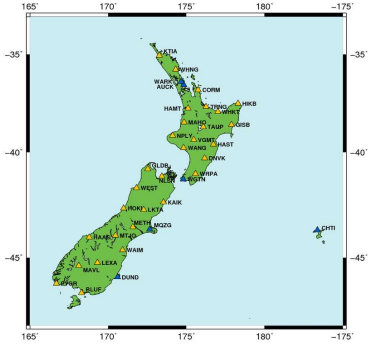
Monitoring the Datum

- PositioNZ continuous GNSS network
  - 35 stations on mainland NZ
  - 1 on Chatham Islands
  - 4 in Antarctica
- Several hundred other continuous GNSS operated by science and commercial sectors



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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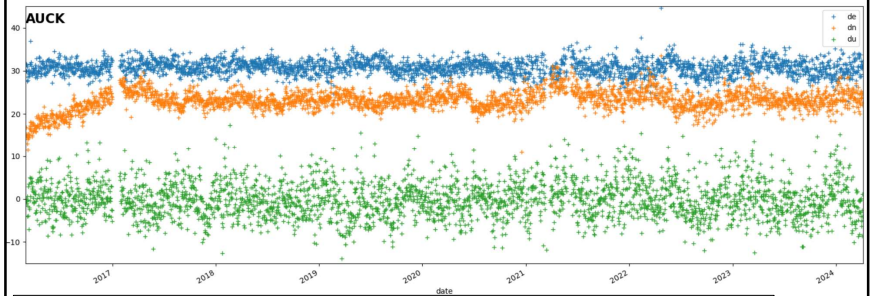
Continuous GNSS measurements

- Stable



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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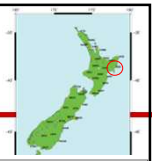
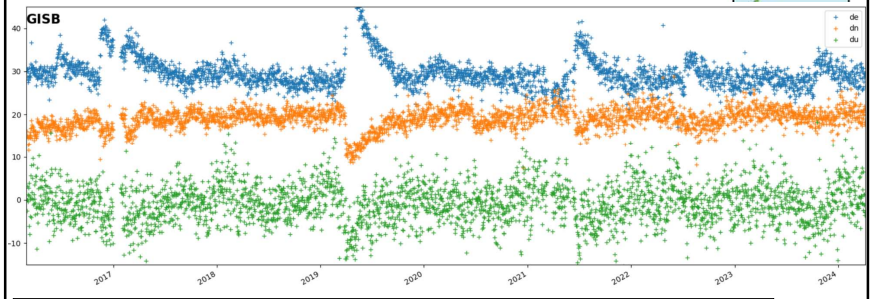
Continuous GNSS measurements

- Slow-slip events





Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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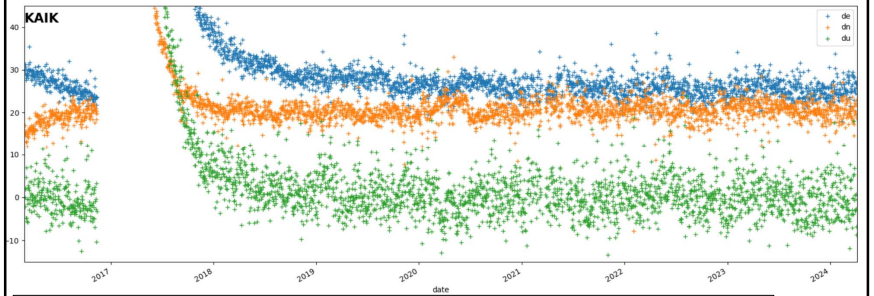
Continuous GNSS measurements

- Earthquake



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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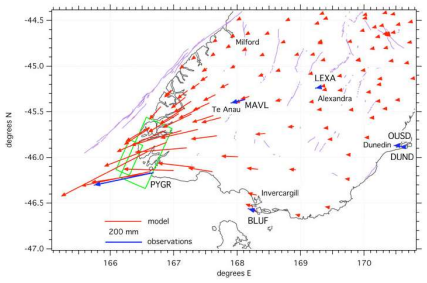
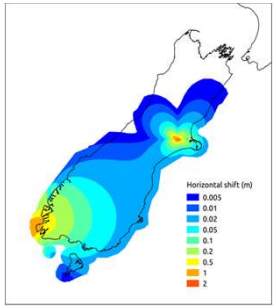
Earthquakes – Deformation model patching





Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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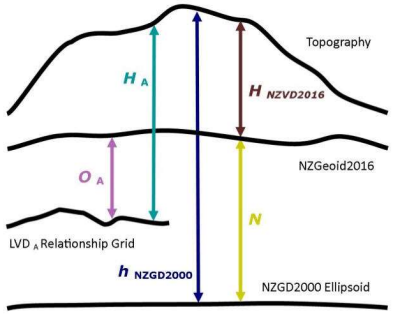
Introduction to NZ Vertical Datum 2016

- Quasigeoid reference surface (NZGeoid2016)
- Normal-orthometric heights
- Accessible using GNSS ellipsoidal heights
- Enables levelling over long distances by combining precise levelling and static GNSS



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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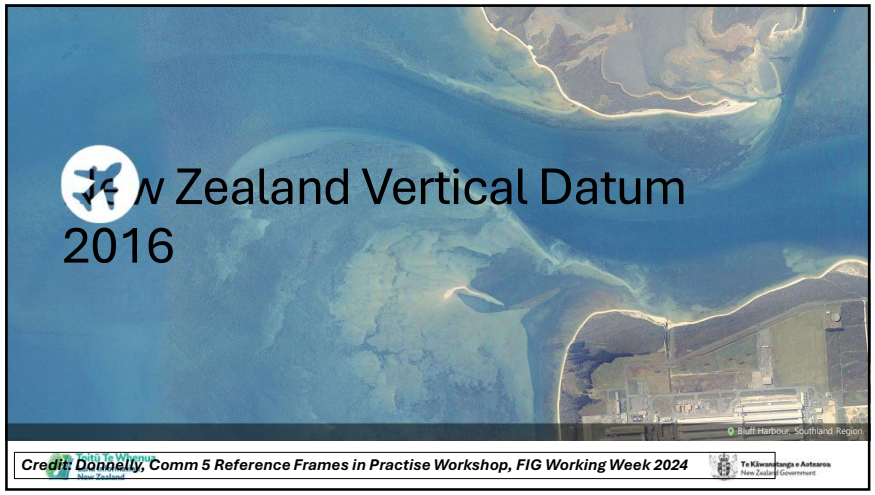

Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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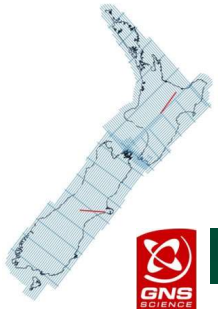
NZGeoid2016 local input data



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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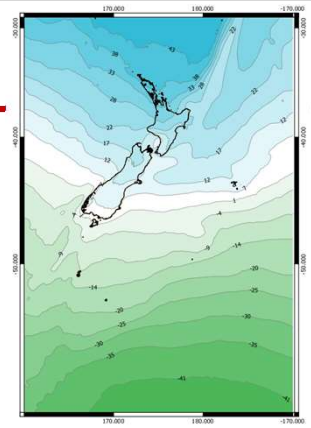
NZGeoid2016

- Eigen-6C4 global model
- Local gravity data and digital elevation model
- Modified Stokes kernel
  - $\psi_0 = 2.5°$, L = 160
- Published on 1' grid (1.8 km)
  - 160° E to 170° W
  - 25° S to 60° S



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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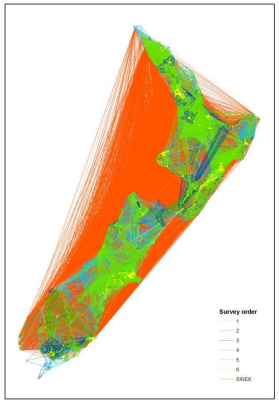
Coordinate Computation

- ITRF2020 coordinates computed each day for all continuous GNSS
- All geodetic data combined in a least squares adjustment to produce NZGD2000/NZVD2016 coordinates
  - ~700,000 observations
  - ~83000 marks
  - GPS/GNSS, triangulation, precise traverse and precise levelling data collected over many decades
  - PositioNZ continuous GNSS stations held fixed (average of daily coordinates over a year)
  - Utilises deformation model and quasigeoid model to ensure computations are carried out in a consistent reference frame and at a consistent epoch



Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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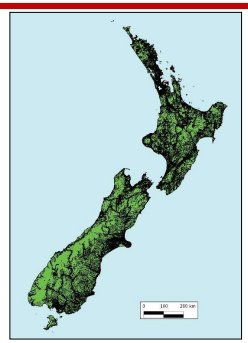
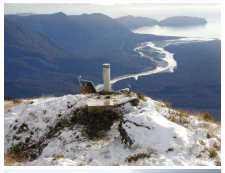
Connecting to the datums

- Public and private real-time GNSS streams (as well as RINEX data for post-processing
- Nearly 100,000 passive geodetic marks (with accurate coordinates/heights)





Credit: Donnelly, Comm 5 Reference Frames in Practise Workshop, FIG Working Week 2024

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