Reference Frame in Practice
Operational Aspects of GNSS CORS

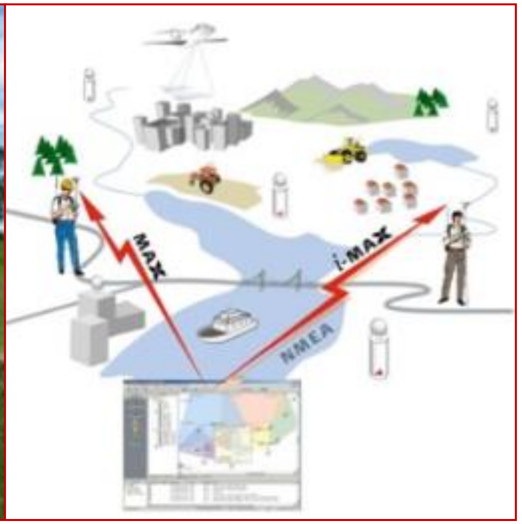
Standards and Acceptable Practices

18-20 September 2018 – Suva, Fiji

Rob Sarib – Chair FIG Asia Pacific Capacity Development Network

Presentation Content

- Overview of Standards and Acceptable Practices – what, how and why?
- Relevant Standards and Acceptable Practices for GNSS CORS and Survey Control



Standards and Acceptable Practices Overview

What are Standards?

- Standards are ***voluntary documents*** that set out specifications, procedures and guidelines that aim to ensure products, services, and systems are safe, consistent, and reliable.

- They cover a variety of subjects, including consumer products and services, the environment, construction, energy and water utilities, and more.

- To ensure they keep pace with new technologies, standards are ***regularly reviewed by technical committees***.

Smart Devices work anywhere in the WORLD !

STANDARDS Australia

Standards and Acceptable Practices Overview

What is Acceptable Practice?

- Is a technique or method that is more ***effective and efficient*** than any other
- Comprises of ***processes, checks, and testing***, to ensure a specified outcome can be delivered with ***fewer problems and unforeseen complications*** – i.e. ***optimal results***
- Could also be ***repeatable procedures*** that have proven themselves over time for large numbers of people
- Can be expected ***to evolve*** as new information, instrumentation, methodology, technology becomes available OR changes to legislative requirements
- A technique or method which has become the ***standard way of doing things*** to ensure compliance

Standards and Acceptable Practices Overview

From a FIG / geospatial and surveying technical perspective ….

Standards and Practices are a rules or requirements that is determined by a consensus opinion of specialised recognised users.

Standards and Practices describes fundamentals, specifies the terminology, the requirements, provides direction, and guidelines.

Standards and Practices are formal documents that prescribe the accepted and (theoretically) the best uniform criteria for a product, method, process, test, technique, and practices.

Standards and Practices should be for shared and repeated use; easily accessible; and reviewed regularly

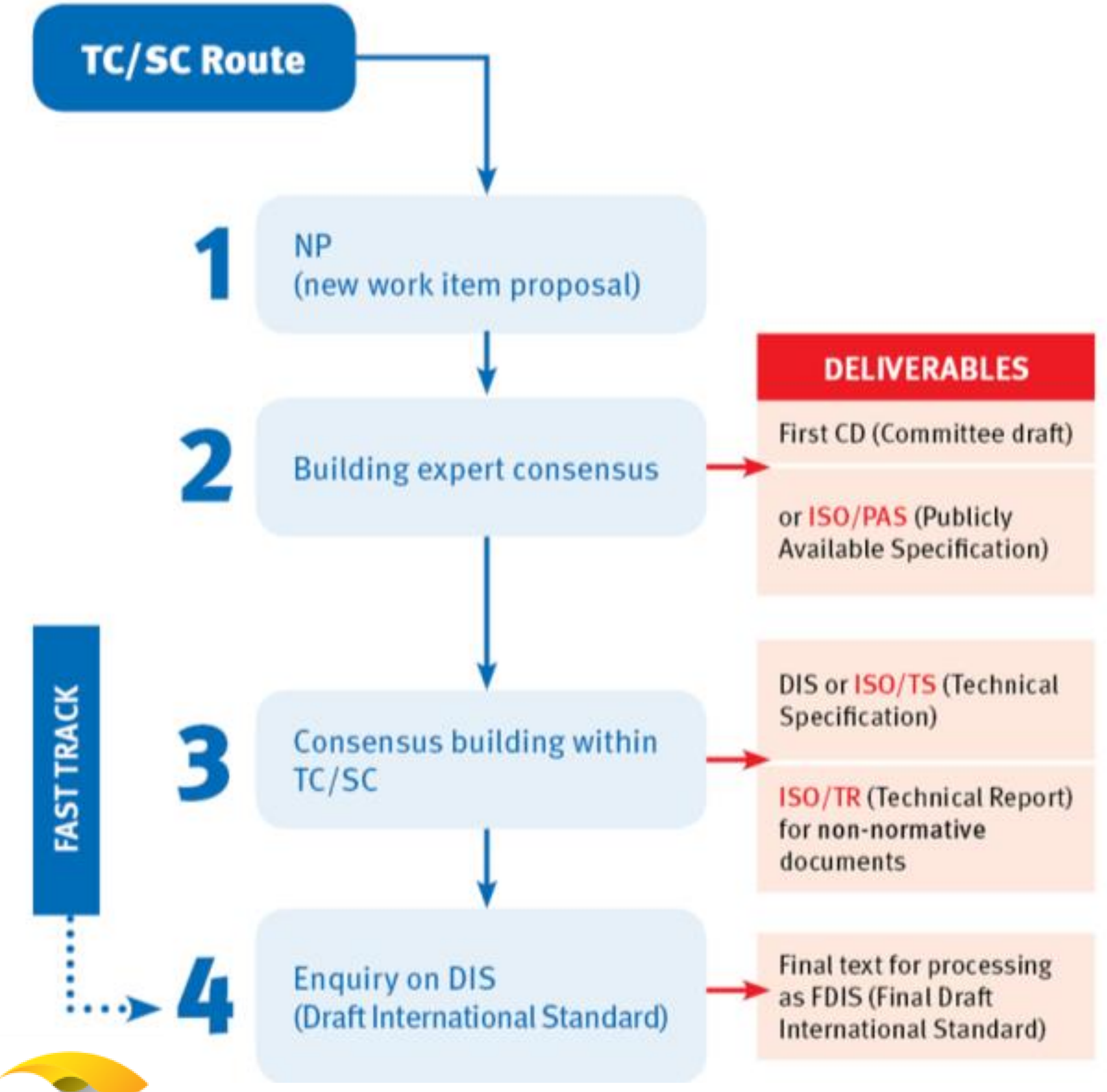
For today's presentation : Standards / Acceptable Practices = S&Ps

Standards and Acceptable Practices Overview

Types of S&Ps

- International
  - ➢These are developed by ISO, IEC, and ITU for countries to adopt for national use.
- Regional
  - ➢These are prepared by a specific region, such as the European Union's EN, or joint Australian/New Zealand.
- National
  - ➢These are developed either by a national body i.e. Standards Australia or New Zealand or other accredited bodies, recognised specialists - ANZLIC, ICSM, LINZ, Survey Boards
- S&Ps and the Law
  - ➢Generally S&Ps are voluntary and there is often no requirement for the public or an agency to comply.... BUT in some cases Governments make reference to S&Ps in legislation – when this occurs they can become mandatory

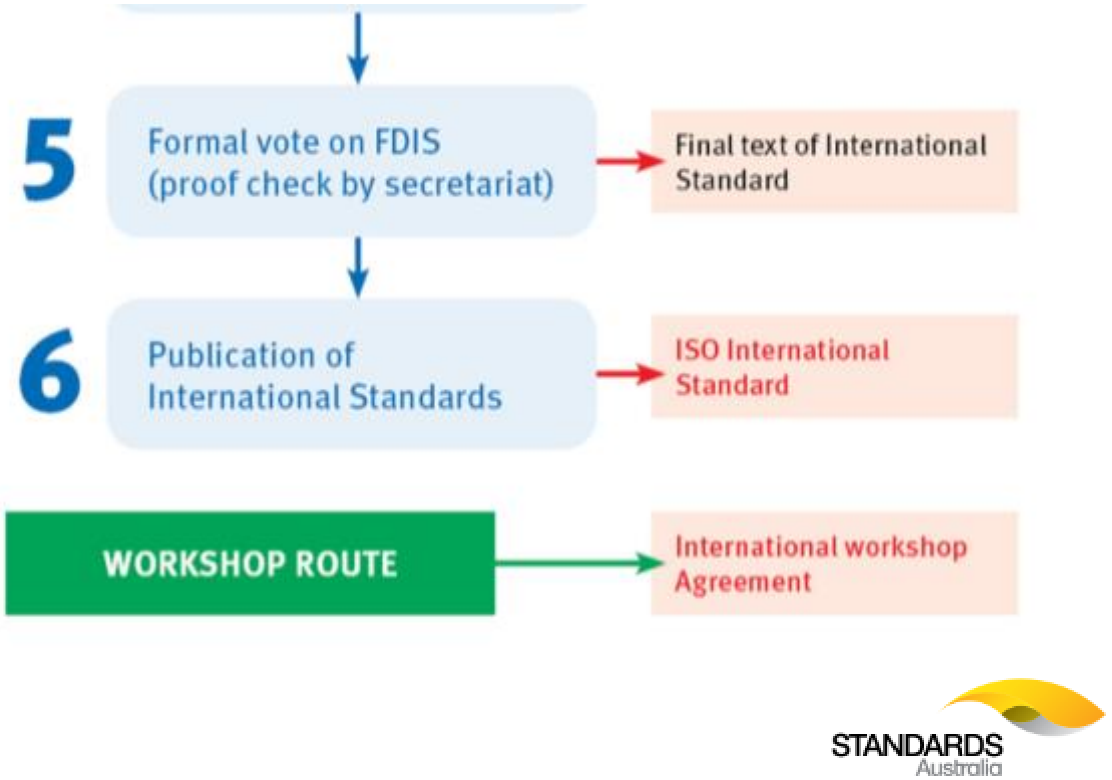
How are Standards and Acceptable Practices created?



- Requires collaboration and consultation with people to develop a S&P.
- Involves a facilitator / champion and a group independent technical experts nominated by stakeholders.
- The experts form a technical committee that is responsible for a specific subject area
- They begin the process with the development of a draft that meets a specific market need.
- This is then shared for commenting and further discussion.

STANDARDS Australia

How are Standards and Acceptable Practices created?



- The voting process is the key to consensus.
- If that's achieved then the draft is on its way to becoming a S&P.
- If agreement isn't reached then the draft will be modified further, and voted on again.
- From first proposal to final publication, developing S&Ps can take years.

Why do we have Geospatial & Surveying S&Ps?

- To ensure delivery of ***quality*** products and services
- To ***make judgments or prove the quality*** of other things
- To demonstrate that the ***"needs and expectations"*** (value proposition), of stakeholders / clients / consumers can and have been satisfied or met….. i.e. regulatory and / or technical specifications requirements.
- To provide confidence and assurance to government, industry and the community that the products and services rendered ***conform and are consistent*** with nationally / regionally / globally accepted standards, best practice rules or techniques or formats.

Why do we have Geospatial & Surveying Standards?

- To facilitate the ***integration of data*** and ***interoperability of systems*** that influence and transform the way we live, work and communicate.
- To **advocate or promote** an optimal cost effective way that uses the most appropriate equipment or technique or process for a project
- To provide a pathway for **knowledge sharing** and how to apply it.
- To support the ***development of capabilities*** and the basis for more ***innovate methods***.

FIG Pacific Community Communauté du Pacifique PGSC Pacific Geospatial and Surveying Council UN-GGIM-AP Leica Geosystems

Generic Geospatial Information Cycle

Capture

Delivery

Data Acquisition, Collectors, Gathers

Data processing, quality control, validation

Data Archival, Geospatial DB

Data Catalogue, Metadata

Data distribution, Access, Data discovery, Web Services

Value Added Retailers, External

Applications – Open data / layers, Visualisation, Mobile Devices

Users – General Public, Decision Makers, Research, Scientists

Applicable to GNSS and Control Surveying?

Most correct **measurement** with the best attainable **precision and / or accuracy** to produce quality **CO-ORDINATES !**

Standards and Acceptable Practices?

Source - http://www.hexagongeospatial.jp/Libraries/Why Geospatial/geospatial-information-lifecycle.jpg

What S&Ps apply to GNSS / Geodetic Surveying?

ISO International Organization for Standardization

When the world agrees

- ISO is an independent, international NGO with a membership of 162 national standards bodies / institutes.
- ISO brings together experts (45,000) to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges.
- ISO has published 22,306 International Standards and related documents, covering almost every industry, from technology, to food safety, to agriculture and healthcare.

https://www.iso.org/home.html

What standards apply to GNSS / Geodetic Surveying?

- ***ISO 17123 Series "Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments"***
  - Part 1 - Theory : general rules for evaluating and expressing uncertainty in measurement
  - Part 2 – Levels: spirit, compensator, digital
  - Part 3 - Theodolites
  - Part 4 - EDM (electro-optical distance meters and reflectors)
  - Part 5 - Total Stations
  - Part 6 - Rotating Lasers
  - Part 7 - Optical Plumbing Instruments
  - Part 8 - GNSS Field Measurements in RTK

- Evaluating and determining precision
- Technical Committee : ISO/TC 172/SC 6 Geodetic and surveying instruments

ISO 17123 Part 8 GNSS Field Measurements in RTK

- This standard specifies field procedures for evaluating the precision (repeatability) of Global Navigation Satellite System (GNSS) field measurement systems in real-time kinematic (GNSS RTK)
- These tests are primarily intended to be field verifications of the suitability of an instrument for the application at hand, and/or to satisfy the requirements of other standards.
- Determine the reference distances and height differences between the two rover points to a precision of better than 3 mm (other than RTK)
- Five sets of x, y and h coordinate measurements are made using RTK

INTERNATIONAL STANDARD

ISO 17123-8

First edition 2007-09-15

Optics and optical instruments — Field procedures for testing geodetic and surveying instruments —

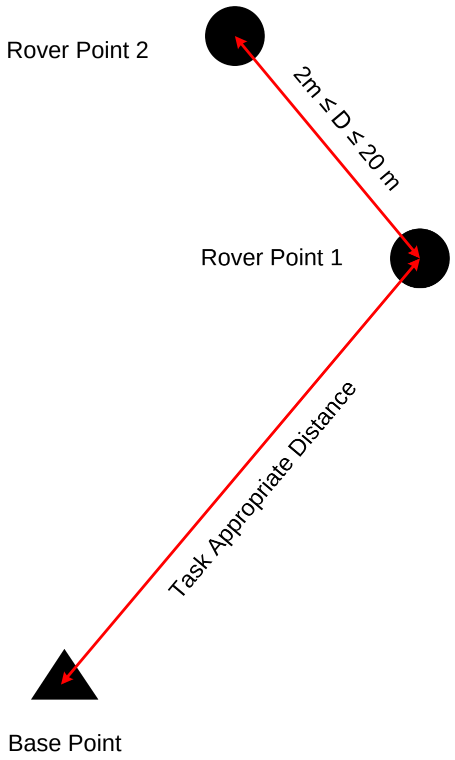
Part 8:
GNSS field measurement systems in real-time kinematic (RTK)

Optique et instruments d'optique — Méthodes d'essai sur site des instruments géodésiques et d'observation —

Partie 8: Systèmes de mesure GNSS sur site en temps réel cinématique

Reference number
ISO 17123-8:2007(E)

© ISO 2007



What standards apply to GNSS / Geodetic Surveying?

- ***ISO 12858 Series "Optics and optical instruments -- Ancillary devices for geodetic instruments"***
    - ➢ Part 1 – Invar Levelling Staffs
    - ➢ Part 2 – Tripods
    - ➢ Part 3 – Tribrachs

- Specifies the most important requirements for levels, theodolites, tacheometers, GPS equipment, EDM instruments and in combination with targets, reflectors, antennae, etc
- Technical Committee : ISO/TC 172/SC 6 Geodetic and surveying instruments

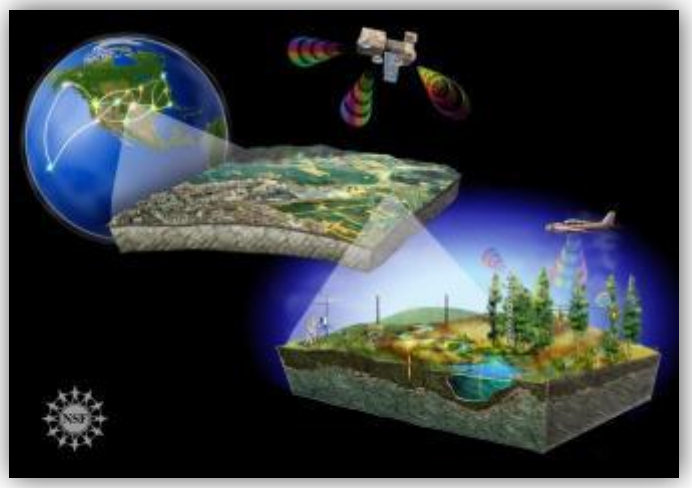
What standards apply to GNSS / Geodetic Surveying?

- ***ISO 6709 – Standard representation of geographic point location by coordinates***
  - latitude and longitude, to be used in data interchange
  - point location representation through the eXtensible Markup Language (XML)
  - decimal degrees to be used in computer data interchange
  - representation of height and depth that may be associated with horizontal coordinates

- ***ISO 191XX family of standards***
  - Concerning standardization in the field of digital geographic information.
  - They aim to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.
  - Technical Committee : ISO/TC 211 Geographic information/Geomatics

What standards apply to GNSS / Geodetic Surveying?

- ***ISO 19132, 19133, 19134*** *– Geographic information -- Location-based services*
- ***ISO 19104*** *Geographic information – Terminology*
- ***ISO 19130*** *Geographic information -- Imagery sensor models for geopositioning – optical, SAR, InSAR, LiDAR and SONAR*
- ***ISO 19159*** *Geographic information -- Calibration and validation of remote sensing imagery sensors – optical, LiDAR, SAR/InSAR and SONAR*



What S&Ps apply to GNSS / Geodetic Surveying?

- ***ISO 19111 - Geographic information -- Spatial referencing by coordinates***
  - ➢ defines the conceptual schema for the description of spatial referencing by coordinates
  - ➢ describes the minimum data required to define one-, two- and three-dimensional spatial coordinate reference systems with an extension to merged spatial-temporal reference systems
  - ➢ PART 2 - description of spatial referencing using parametric values or functions
  - ➢ Improvements –
    - ✓represent modern dynamic 3D reference frames
    - ✓represent modern geoid-based vertical datums
    - ✓represent reference frames defined as transformations from other reference frames (e.g., from ITRF)
    - ✓use modern terminology (e.g., that are used in the IERS Conventions)

What S&Ps apply to GNSS / Geodetic Surveying?

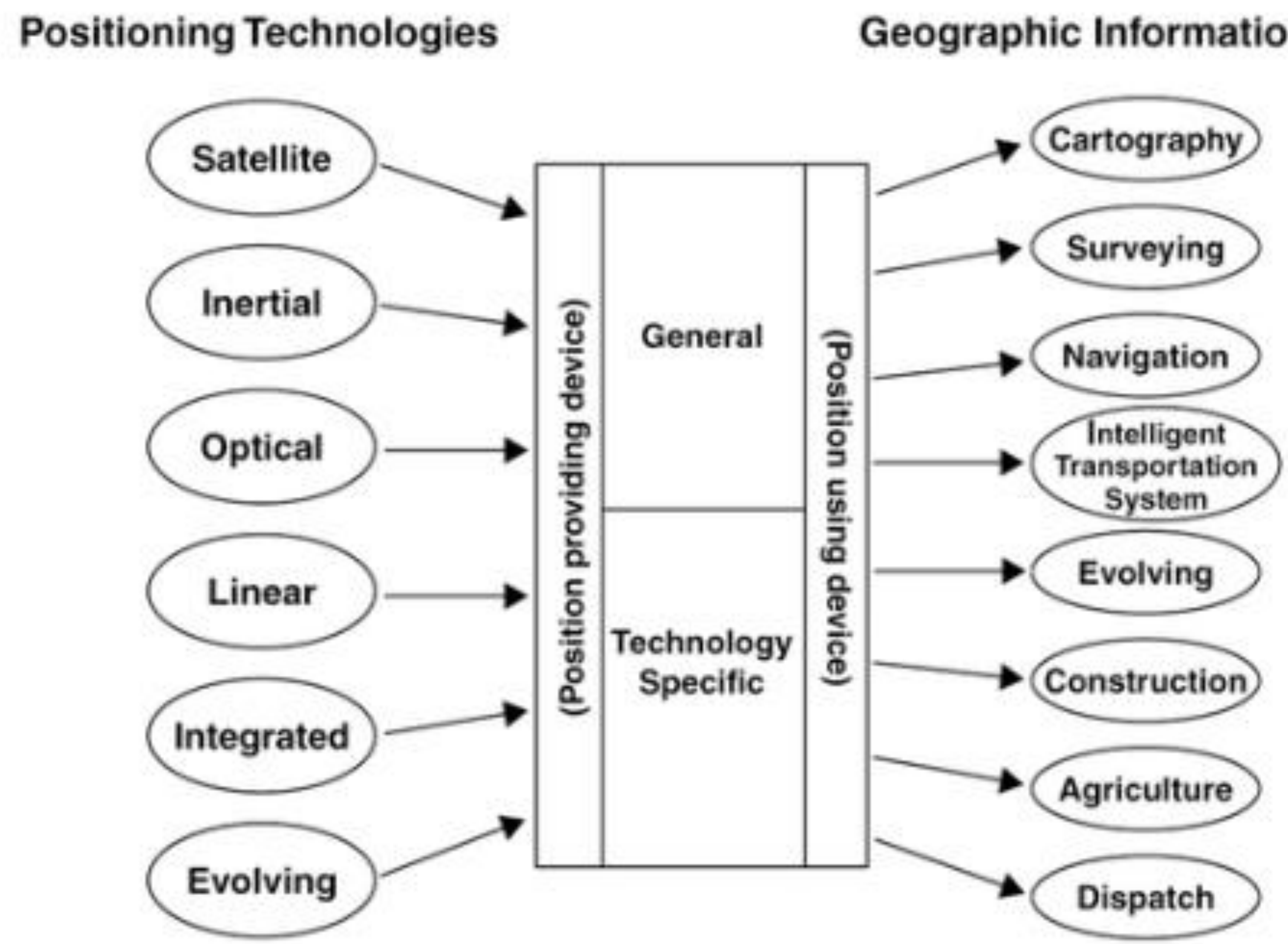
- ***ISO 19115 Geographic information – Metadata***
  - defines the schema required for describing geographic information and services by means of metadata.
  - provides information about the identification, the extent, the quality, the spatial and temporal aspects, the content, the spatial reference, the portrayal, distribution, and other properties of digital geographic data and services

- ***ISO 19116 – Geographic information — Positioning services***
  - specifies the data structure and content of an interface that permits communication between position-providing device(s) and position-using device(s) so that the position-using device(s) can obtain and unambiguously interpret position information and determine whether the results meet the requirements of the use

What S&Ps apply to GNSS / Geodetic Surveying?

- *ISO 19116 – Geographic information — Positioning services*

Positioning services interface allows communication of position data for a wide variety of positioning technologies and users



What standards apply to GNSS / Geodetic Surveying?

- ***ISO 19127 - Geographic information -- Geodetic codes and parameters***
  - ➢ defines rules for the population and maintenance of registers of geodetic codes and parameters and identifies the data elements required within these registers -databases
  - ➢ Linked with - ***ISO 19111, ISO 19135*** (specifies procedures for the registration of items of geographic information) and ***ISO 19162*** *(*defines the structure and content of a text string for coordinate reference systems),

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EPSG Geodetic Parameter Registry *Version: 9.5.1*

https://www.epsg-registry.org/

query by filter | retrieve by code

Name: | Search on geometry

Click to choose | North Latitude | West Longitude

Type: | BBOX | Search

Search on description | South Latitude | East Longitude

Area: | Show Map | Reset ?

EPSG Geodetic Parameter Registry *Version: 9.5.1*

Welcome guest! | (login or register) | help

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Welcome to the EPSG Geodetic Parameter Dataset

The EPSG Geodetic Parameter Dataset is a structured dataset of Coordinate Reference Systems and Coordinate Transformations, accessible through this online registry (www.epsg-registry.org) or, as a downloadable zip files, through IOGP's EPSG home page at www.epsg.org. The geographic coverage of the data is worldwide, but it is stressed that the dataset does not and cannot record all possible geodetic parameters in use around the world. The EPSG Geodetic Parameter Dataset is maintained by the Geodesy Subcommittee of IOGP's Geomatics Committee.

The EPSG Geodetic Parameter Dataset, offered through IOGP's web pages, may be used free of charge, but its use is subject to the acceptance of the Terms of Use.

Registry users may query and view the data, generate printable reports and create Well-Known Text (WKT) compliant with ISO 19162. The Registry supports anonymous (guest) access, but also permits the user to register for additional services, such as the export of the entire dataset.

Additionally the Registry provides a web service interface, permitting geospatial software to query and retrieve geodetic parameters. Information on how to access the service is available in Guidance Note 7-3: EPSG Registry Developers Guide.

If you are interested in receiving news about the EPSG Dataset, please register on IOGP's EPSG home page at www.epsg.org or contact EPSGadministrator@iogp.org.

Links

- IOGP's EPSG home page
- IOGP's Geomatics area
- IOGP's home page
- What is new to the current version
- EPSG Dataset supporting documentation
- Submit Feedback or Change Request

Report	Name	Code	Type	Status	Area Description	Remarks / Description	
☐	TGD2005 / Tonga Map Grid	EPSG::5887	ProjectedCRS	Valid	Tonga - onshore and offshore.		view
☐	Tonga Map Grid	EPSG::5883	CoordinateConversion	Valid	Tonga - onshore and offshore.		view
☐	Tonga	EPSG::1234	area	Valid	Tonga - onshore and offshore.		view
☐	Tonga Geodetic Datum 2005	EPSG::1095	GeodeticDatum	Valid	Tonga - onshore and offshore.		view
☐	Tonga - onshore	EPSG::3321	area	Valid	Tonga - onshore.		view
☐	Add Tonga data	EPSG::2012.085	Closed	Closed: 2012-11-26		Added datum 1095, proj 5883, CRSs 5884-87.	view

<<first <prev | page 1 of 1 | next> last>>

Tonga Geodetic Datum 2005[VALID]

Scope: Geodetic survey, cadastre, topographic mapping, engineering survey.

Information Source: World Bank Cyclone Emergency Recovery and Management Project, Report 7, Report of the Development of a Geodetic Datum and Map Grid for the Kingdom of Tonga, prepared for the Ministry of Lands, Survey and Natural Resources, 1st November 2004.

Data Source: IOGP

Revision Date: 2016-09-16

Change ID: EPSG::2012.085

Change ID: EPSG::2016.020

GML

International Association of Oil & Gas Producers

GeodeticDatum [Tonga Geodetic Datum 2005]

metadata

Code: *EPSG::1095*

Name: *Tonga Geodetic Datum 2005*

Aliases

Alternative name: *TGD2005*

Naming system: EPSG abbreviation

Anchor Definition: Based on ITRF2000 at epoch 2005.0

Realization Epoch: 2005-01-01

Area of Use [Tonga]

metadata

Code: *EPSG::1234*

Name: *Tonga*

Description: Tonga - onshore and offshore.

ISO A2 Country Code: TO

ISO A3 Country Code: TON

ISO Numeric Country Code: 776

Bounding Box Boundary	Value (Decimal Degrees)
South Bound Latitude	-25.68
West Bound Longitude	-179.08
North Bound Latitude	-14.14
East Bound Longitude	-171.28

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West Bound Longitude	-179.08
North Bound Latitude	-14.14
East Bound Longitude	-171.28

Note (Reference CRS): WGS 84 geographical 2D CRS

Polygon (Revision Date): 2013-11-05

Ellipsoid [GRS 1980]

metadata

Code: *EPSG::7019*

Name: *GRS 1980*

Aliases

Alternative name: *International 1979*

Naming system: EPSG alias

Remarks: Adopted by IUGG 1979 Canberra as the Geodetic Reference Spheroid of 1980 (GRS 1980).

Shape: Ellipsoid

Semi-Major Axis: 6378137 metre

Inverse Flattening: 298.257222101 unity

Prime Meridian [Greenwich]

metadata

Code: *EPSG::8901*

Name: *Greenwich*

Greenwich Longitude: 0°E degree

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```
<?xml version="1.0" encoding="UTF-8"?>
- <gml:GeodeticDatum gml:id="iogp-datum-1095" xmlns:gml="http://www.opengis.net/gml/3.2">
  - <gml:metaDataProperty>
    - <epsg:CommonMetaData xmlns:epsg="urn:x-ogp:spec:schema-xsd:EPSG:1.0:dataset">
        <epsg:type>geodetic</epsg:type>
        <epsg:alias alias="TGD2005" codeSpace="urn:ogc:def:naming-system:EPSG::7302" code="25588"/>
        <epsg:informationSource>World Bank Cyclone Emergency Recovery and Management Project, Report 7, Report of the Development of a Geodetic Datum and Map Grid
          for the Kingdom of Tonga, prepared for the Ministry of Lands, Survey and Natural Resources, 1st November 2004.</epsg:informationSource>
        <epsg:revisionDate>2016-09-16</epsg:revisionDate>
      - <epsg:changes>
          <epsg:changeID xlink:href="urn:ogc:def:change-request:EPSG::2012.085" xmlns:xlink="http://www.w3.org/1999/xlink"/>
          <epsg:changeID xlink:href="urn:ogc:def:change-request:EPSG::2016.020" xmlns:xlink="http://www.w3.org/1999/xlink"/>
        </epsg:changes>
        <epsg:show>true</epsg:show>
        <epsg:isDeprecated>false</epsg:isDeprecated>
      </epsg:CommonMetaData>
    </gml:metaDataProperty>
    <gml:identifier codeSpace="IOGP">urn:ogc:def:datum:EPSG::1095</gml:identifier>
    <gml:name>Tonga Geodetic Datum 2005</gml:name>
    <gml:domainOfValidity xlink:href="urn:ogc:def:area:EPSG::1234" xmlns:xlink="http://www.w3.org/1999/xlink"/>
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    <gml:anchorDefinition>Based on ITRF2000 at epoch 2005.0</gml:anchorDefinition>
    <gml:realizationEpoch>2005-01-01</gml:realizationEpoch>
    <gml:primeMeridian xlink:href="urn:ogc:def:meridian:EPSG::8901" xmlns:xlink="http://www.w3.org/1999/xlink"/>
    <gml:ellipsoid xlink:href="urn:ogc:def:ellipsoid:EPSG::7019" xmlns:xlink="http://www.w3.org/1999/xlink"/>
  </gml:GeodeticDatum>
```


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What S&Ps apply to GNSS / Geodetic Surveying?

- ***ISO/CD 19161-1 Geographic information -- Geodetic references -- Part 1: The international terrestrial reference system (ITRS)*** …under development
- *Intended purpose…..*
  - Provide the basic information and the requirements related to the International Terrestrial Reference System (ITRS), specifically its definition, realizations and access.
  - Endorse the definition(s) and terminology adopted by the International Union of Geodesy and Geophysics (IUGG), the International association of Geodesy (IAG) and the International Astronomical Union (IAU)
  - Describe the various realizations (such as ITRF, WGS-84, ETRS89, etc.)
  - Provide the required methods of realizing the ITRS.
  - Describe the various ways of getting positions expressed in a realization of the ITRS

What S&Ps apply to GNSS / Geodetic Surveying?

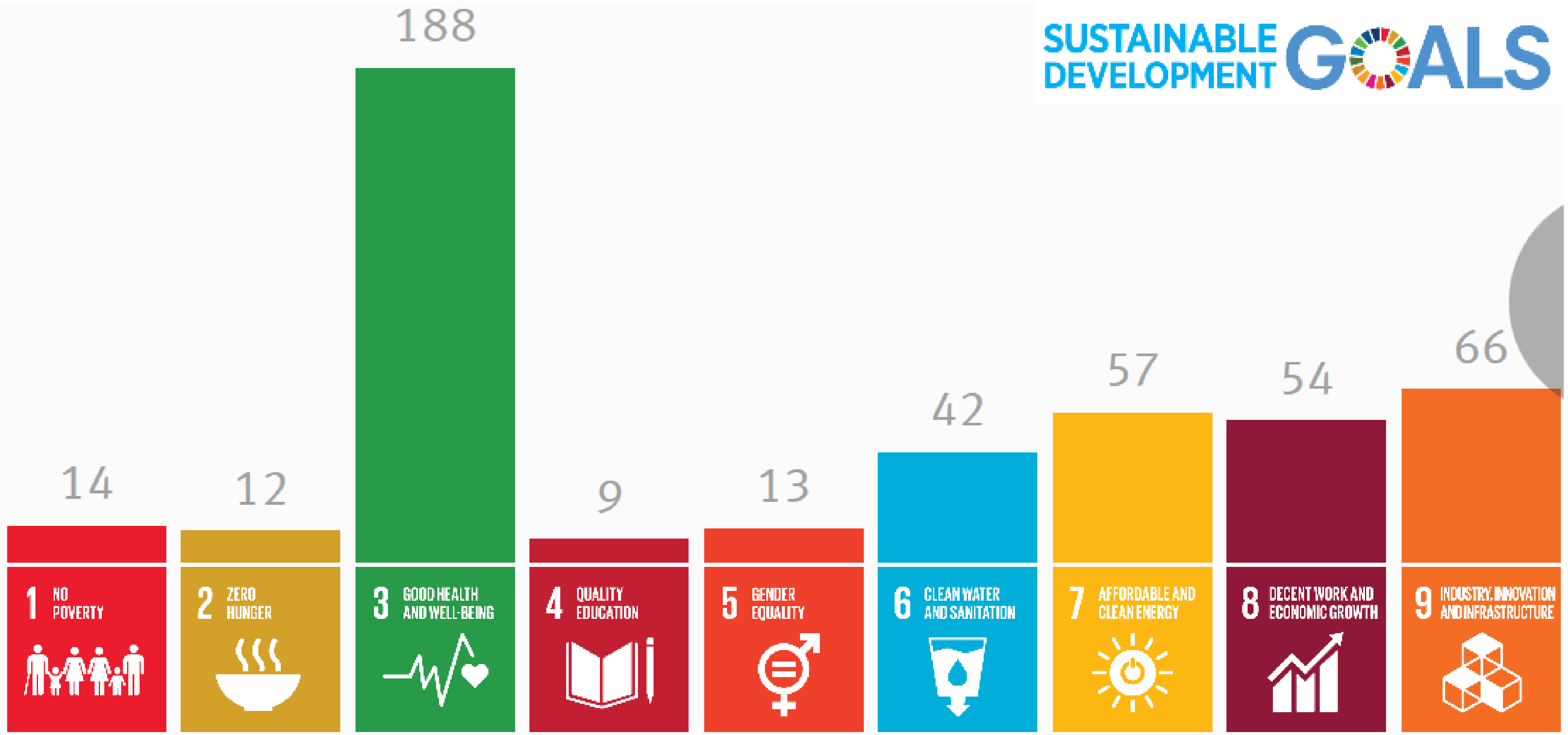
- ***ISO 9000 family of standards.***
  - The ISO 9000 standards represent an international consensus on good management practices
  - To ensure a business or organization consistently delivers products or services that meet the customer's quality and regulatory requirements
  - To enhance customer satisfaction, and continual improvement in performance.
  - These best practices have been distilled into a set of standardized requirements for a quality management system (ISO 9001:2000).
  - Are applicable regardless of what the organization does its size, or whether it's in the private, or public sector.

TQM
ISO 9001/ISO 14001

Total Quality Management
– Our commitment to total customer satisfaction.
Find out more about out TQM program from your local Leica Geosystems representative

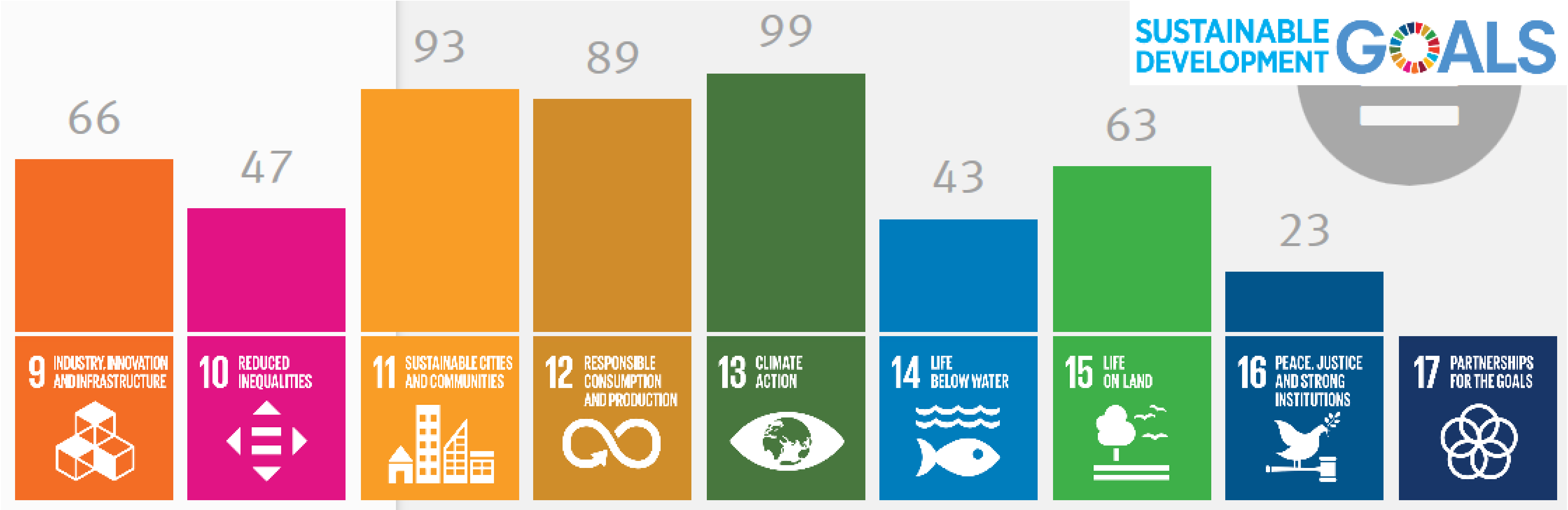
What S&Ps apply to GNSS / Geodetic Surveying?

- ***Sustainable Development Goals – SDGs and ISO***
  - *"…. represent an ambitious plan to enhance peace and prosperity, eradicate poverty and protect the planet. They are recognized globally as essential to the future sustainability of our world…."*



What S&Ps apply to GNSS / Geodetic Surveying?

- *Sustainable Development Goals - SDGs*



What S&Ps apply to GNSS / Geodetic Surveying?

- ***International GNSS Service (IGS)***
  - ➢ Operates a global network of GNSS ground stations, data centres, and data analysis centres to openly provide data and derived data products
  - ➢ IGS products include:
    - ✓ GNSS satellite ephemerides
    - ✓ Earth rotation parameters
    - ✓ Global tracking station coordinates and velocities
    - ✓ Satellite and tracking station clock information
    - ✓ Zenith tropospheric path delay estimates
    - ✓ Global ionosphere maps
  - ➢ Support the terrestrial reference frame, Earth observation and research; positioning, navigation and timing; and other applications that benefit science and society

IGS INTERNATIONAL GNSS SERVICE

What S&Ps apply to GNSS / Geodetic Surveying?

- ***International GNSS Service (IGS) Site Guidelines***
  - Universally accepted as the standard for high accuracy (geodetic quality) GNSS CORS
    - ✓ How to become an IGS station
    - ✓ Site location and security
    - ✓ Station requirements – receivers, antenna, monument, power, communications, metrological devices, radomes
    - ✓ Operations, maintenance provisions
    - ✓ Data formats, transmission, archiving
    - ✓ Metadata, Station Log File specifications
    - ✓ High-rate stations, Real-time stations, Tide Gauge stations, Timing stations
    - ✓ Co-location sites, 3-D ties / connections - VLBI, SLR, Gravity, Tide Gauges
    - ✓ IGS Data Centres : Operational, Regional, and Global

https://kb.igs.org/hc/en-us/articles/202011433-Current-IGS-Site-Guidelines

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IGS INTERNATIONAL GNSS SERVICE

Network | Products | Working Groups | Resources | About

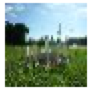
Network

Information

LAUT Station Information - Site Page

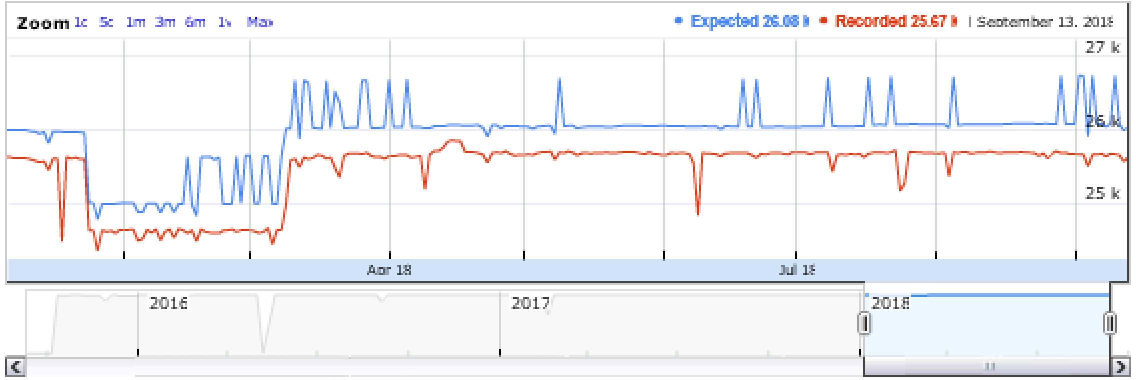
SiteID	LAUT
Country	
Station Log	laut_20180709.log
DOMES Number	
Constellation	
Data Center	

Receiver	Antenna	Calibration	Clock	Collocation
	+	N/A		None




LAUT Quality

Daily RINEX2 observations



Receiver + Firmware Antenna

IGS INTERNATIONAL GNSS SERVICE

```
     LAUT00FJI Site Information Form (site log)
     International GNSS Service
     See Instructions at:
       ftp://igs.org/pub/station/general/sitelog_instr.txt

0.   Form

     Prepared by (full name)  : bart.thomas@ga.gov.au
     Date Prepared            : 2018-07-09
     Report Type              : UPDATE
     If Update:
      Previous Site Log       : laut_20170427.log
      Modified/Added Sections : (n.n,n.n,...)


1.   Site Identification of the GNSS Monument

     Site Name                : Fiji CGPS
     Four Character ID        : LAUT
     Monument Inscription     :
     IERS DOMES Number        : 50804M002
     CDP Number               : NONE
     Monument Description     : PILLAR
       Height of the Monument : 1.5 m
       Monument Foundation    : STEEL RODS, CONCRETE BLOCK
       Foundation Depth       : 3.5 m
     Marker Description       : Threaded stainless steel spigot
     Date Installed           : 2001-07-10T00:00Z
     Geologic Characteristic  :
       Bedrock Type           :
       Bedrock Condition      :
       Fracture Spacing       :
       Fault zones nearby     :
         Distance/activity    :
     Additional Information   : Monument is a 400mm dia concrete pillar, 1.5
                              : metres above ground surface. A 250mm dia.
                              : stainless steel plate, (antenna mount) centred
                              : into the top of monument.
```

IGS INTERNATIONAL GNSS SERVICE

```
2.   Site Location Information

     City or Town             : Lautoka
     State or Province        :
     Country                  : Fiji
     Tectonic Plate           : PACIFIC
     Approximate Position (ITRF)
       X coordinate (m)       : -6075194.5
       Y coordinate (m)       : 270924.0
       Z coordinate (m)       : -1917189.6
       Latitude (N is +)      : -173631.70
       Longitude (E is +)     : +1772647.70
       Elevation (m,ellips.)  : 89.7
     Additional Information   : The CGPS station is located at the Fiji Sugar
                              : Cooperation (FSC), Lautoka.


3.   GNSS Receiver Information

3.1  Receiver Type            : ASHTECH UZ-12
     Satellite System         : GPS
     Serial Number            : ZR220012401
     Firmware Version         : CJ00
     Elevation Cutoff Setting : 0 deg
     Date Installed           : 2001-11-23T00:00Z
     Date Removed             : 2004-10-03T00:00Z
     Temperature Stabiliz.    : none
     Additional Information   :

3.2  Receiver Type            : ASHTECH UZ-12
     Satellite System         : GPS
     Serial Number            : ZR220012402
     Firmware Version         : ZC00
     Elevation Cutoff Setting : 0 deg
     Date Installed           : 2004-10-04T00:00Z
     Date Removed             : 2006-11-03T11:42Z
     Temperature Stabiliz.    : none
     Additional Information   :
```

IGS INTERNATIONAL GNSS SERVICE

```
4.   GNSS Antenna Information

4.1  Antenna Type             : ASH701945C_M    SCIS
     Serial Number            : 12002
     Antenna Reference Point  : BPA
     Marker->ARP Up Ecc. (m)  : 000.0000
     Marker->ARP North Ecc(m) : 000.0000
     Marker->ARP East Ecc(m)  : 000.0000
     Alignment from True N    : 0 deg
     Antenna Radome Type      : SCIS
     Radome Serial Number     : 221
     Antenna Cable Type       : RG214
     Antenna Cable Length     : 25.0 m
     Date Installed           : 2001-11-23T00:00Z
     Date Removed             : 2012-04-25T01:42Z
     Additional Information   :

4.2  Antenna Type             : TRM59800.00     NONE
     Serial Number            : 5038353984
     Antenna Reference Point  : BPA
     Marker->ARP Up Ecc. (m)  : 000.0056
     Marker->ARP North Ecc(m) : 000.0000
     Marker->ARP East Ecc(m)  : 000.0000
     Alignment from True N    : 0 deg
     Antenna Radome Type      : NONE
     Radome Serial Number     :
     Antenna Cable Type       : RG214
     Antenna Cable Length     : 25.0 m
     Date Installed           : 2012-04-25T01:42Z
     Date Removed             : 2017-03-17T00:00Z
     Additional Information   :

4.3  Antenna Type             : JAVRINGANT_DM   NONE
     Serial Number            : 00682
     Antenna Reference Point  : BPA
     Marker->ARP Up Ecc. (m)  : 000.0015
     Marker->ARP North Ecc(m) : 000.0000
     Marker->ARP East Ecc(m)  : 000.0000
     Alignment from True N    : 0 deg
```

What S&Ps apply to GNSS / Geodetic Surveying?

- ***RTCM - Radio Technical Commission for Maritime Services***
  - International non-profit scientific, professional and educational organization
  - Members are organizations that are both non-government and government
  - Is an independent organization supported by its members from all over the world.
  - The current technical standards include:
    - ✓ RINEX: The Receiver INdependent EXchange Format ; Developed by International GNSS Service/RTCM Special Committee 104 Working Group on RINEX (data ***interchange format for raw satellite navigation system data***)
    - ✓ RTCM 10402.3 Differential GNSS (Global Navigation Satellite Systems) Service, Version 2.3; is used around the world for differential satellite navigation systems, both maritime and terrestrial.
    - ✓ RTCM 10403.3, Differential GNSS (Global Navigation Satellite Systems) Services - Version 3 - A more efficient alternative to RTCM 10402.3

What S&Ps apply to GNSS / Geodetic Surveying?

- ***RTCM - Radio Technical Commission for Maritime Services***
  - ➢ The current technical standards include:
    - ✓ RTCM 10410.1, Standard for Networked Transport of RTCM via Internet Protocol (Ntrip) - An application-level protocol that supports ***streaming Global Navigation Satellite System (GNSS) data over the Internet.***
    - ✓ RTCM 10401.2, Standard for Differential Navstar GPS Reference Stations and Integrity Monitors (RSIM) - A companion to RTCM 10402.3; addresses the performance requirements for the equipment which broadcasts DGNSS corrections.


RTCM 10410.1
RTCM Paper 111-2009-SC104-STD
with Amendment 1
RTCM Paper 139-2011-SC104-STD/1

RTCM STANDARD 10410.1

NETWORKED TRANSPORT OF RTCM via INTERNET PROTOCOL (Ntrip) - Version 2.0

DEVELOPED BY
RTCM SPECIAL COMMITTEE NO. 104

JUNE 28, 2011

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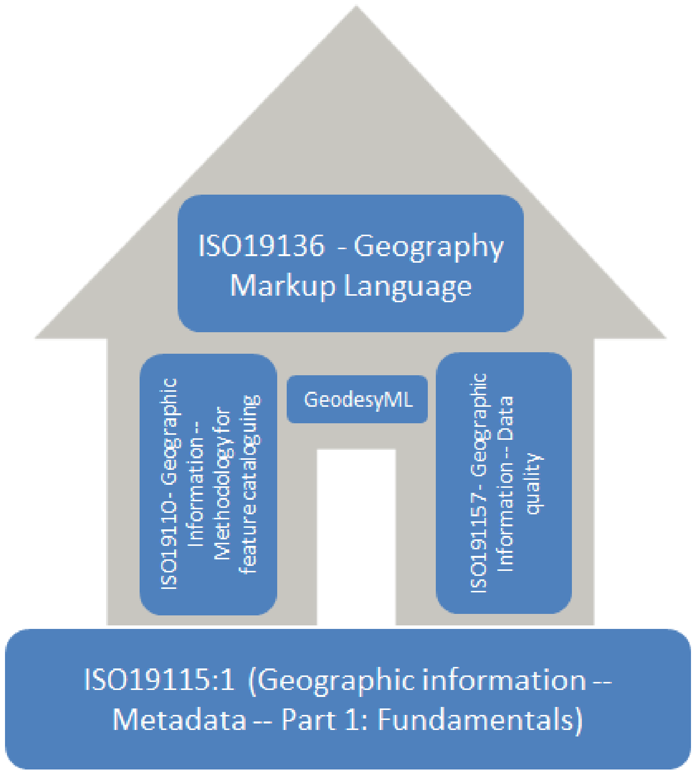
Radio Technical Commission for Maritime Services
1800 N. Kent St., Suite 1060
Arlington, Virginia 22209-2109, U.S.A.
E-Mail: info@rtcm.org
Web Site: http://www.rtcm.org

http://www.rtcm.org/differential-global-navigation-satellite--dgnss--standards.html

What S&Ps apply to GNSS / Geodetic Surveying?

- ***GeodesyML***
  - An XML-based standard that describes (encodes) the ***sharing and exchanging of geodetic data and metadata***
  - GNSS data relating to equipment, site logs, measurement, adjustment, quality, monuments, reference frames and data lineage
  - Machine readable / supports interoperability
  - Alignment with ISO



http://geodesyml.org/

What S&Ps apply to GNSS / Geodetic Surveying?

- ***OGC – Open Geospatial Consortium***
  - An international consortium of more than 521 companies, government agencies, research organizations, and universities participating in a ***consensus process*** to develop publicly available ***geospatial, and interface standards***
  - Supports ***interoperable*** solutions that "geo-enable" the Web, wireless and location based services, and mainstream IT
  - ISO aligned

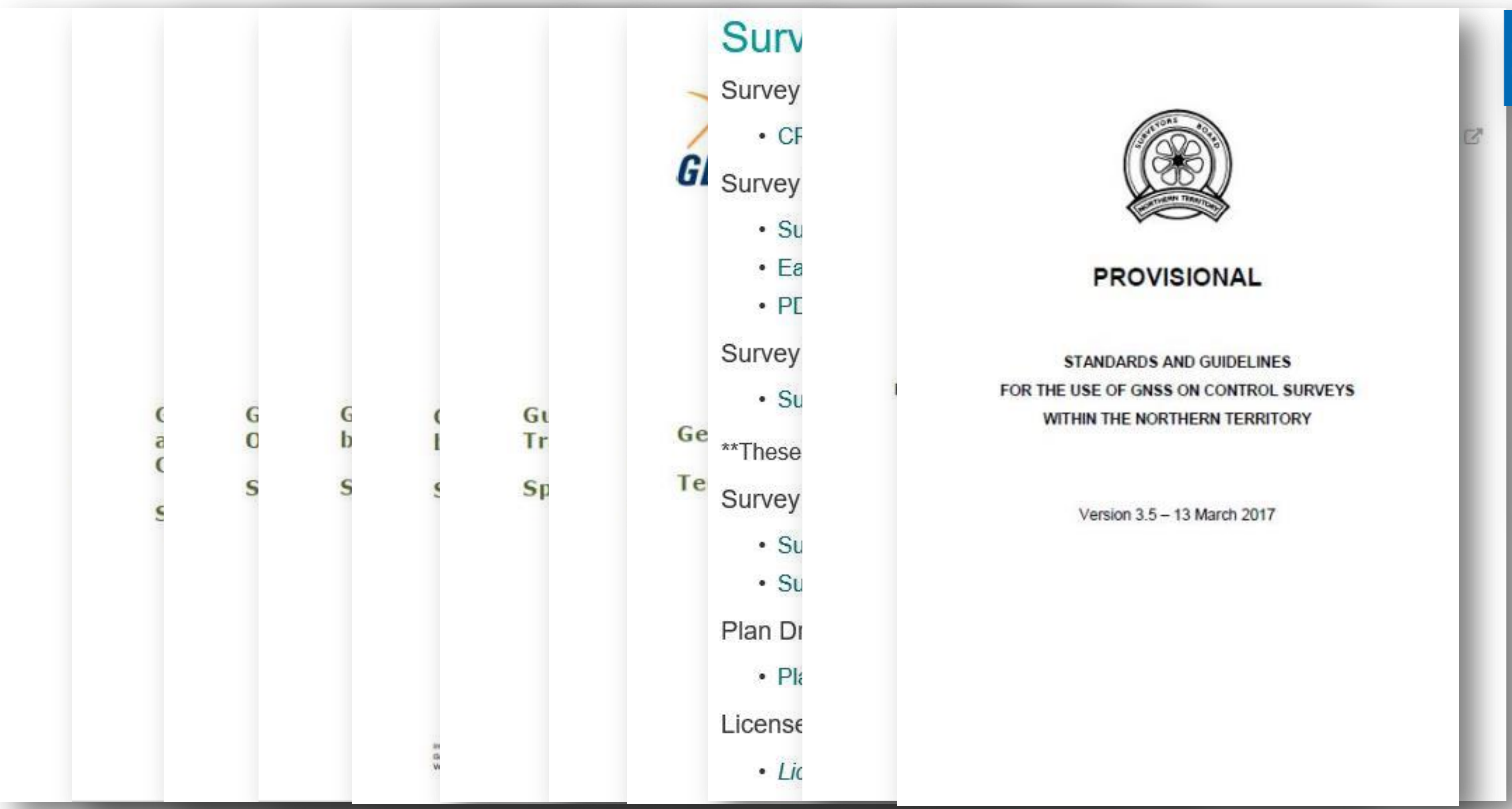
Topic 2 - Spatial referencing by coordinates	4.0	08-015r2	Roger Lott	2010-04-27
This document is consistent with the second edition (2007) of ISO 19111, Geographic Information - Spatial referencing by coordinates [ISO 19111:2007]				
Topic 2.1: Spatial Referencing by Coordinates - Extension for Parametric Values Topic 2.1	1.0	10-020	Paul Cooper	2014-04-16

Version	Document Title (click to download)	Document #	Type
1.0	OpenGIS Coordinate Transformation Service Implementation Specification	01-009	IS
	Coordinate Transformation Services - OLE/COM (1.0)	01-009	SAP

OGC®
Making location count.

http://www.opengeospatial.org/

What S&Ps apply to GNSS / Geodetic Surveying?



http://www.icsm.gov.au/publications/standard-australian-survey-control-network-special-publication-1-sp1

Standard for the Australian Survey Control Network (SP1), Version 2.1, October 2014

PDF versions:

Standard for Australian Survey Control Network v2.1.pdf

- Guideline for Adjustment and Evaluation of Survey Control v2.1.pdf
- Guideline for Continuously Operating Reference Stations v2.1.pdf
- Guideline for Control Surveys by GNSS v2.1.pdf
- Guideline for Control Surveys by Differential Levelling v2.1.pdf
- Guideline for Conventional Traverse Surveys v2.1.pdf
- Guideline for Installation and Documentation of Survey Control Marks v2.1.pdf

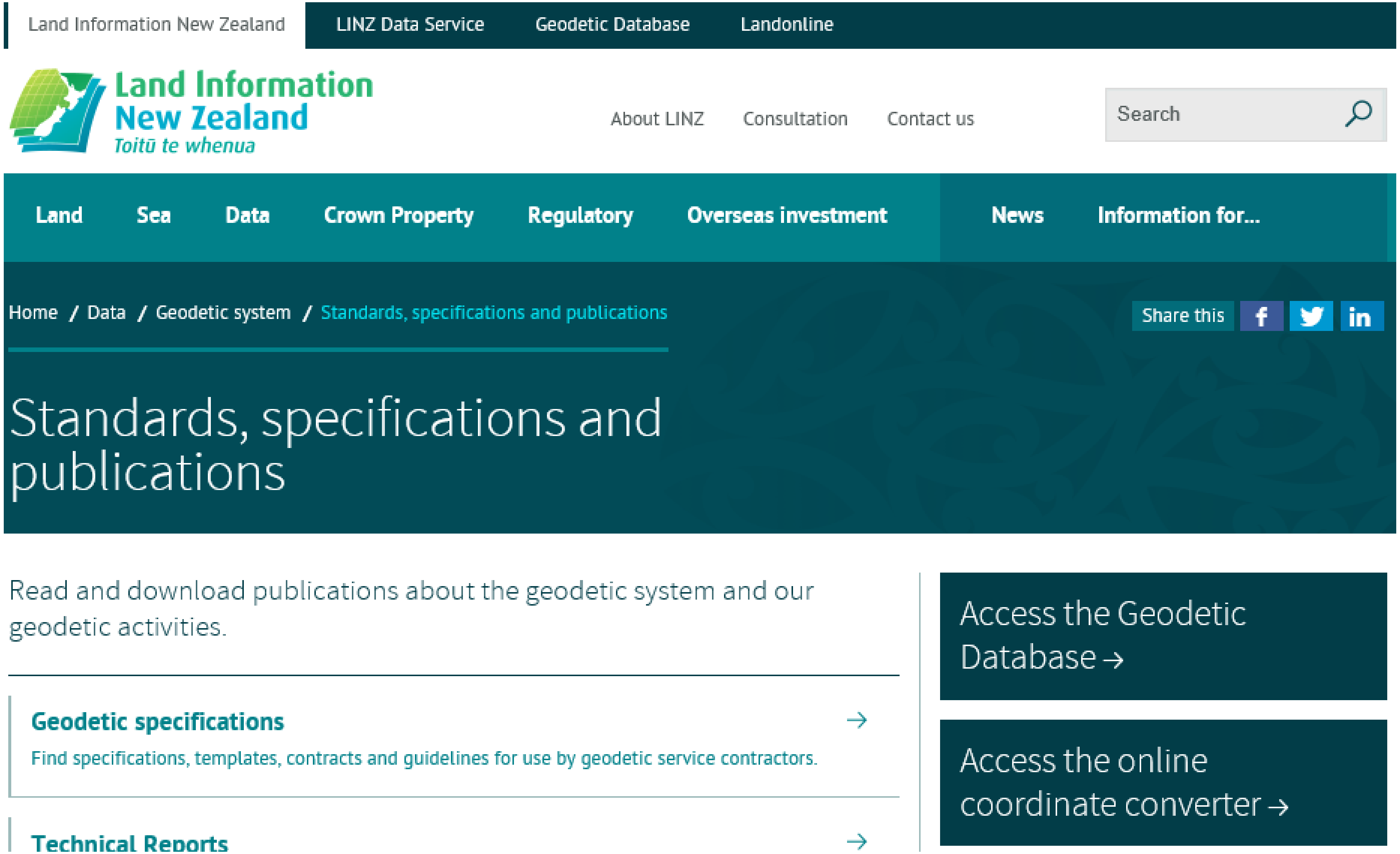
Word versions:

Standard for Australian Survey Control Network v2.1.docx

- Guideline for Adjustment and Evaluation of Survey Control v2.1.docx
- Guideline for Continuously Operating Reference Stations v2.1.docx
- Guideline for Control Surveys by Differential Levelling v2.1.docx
- Guideline for Control Surveys by GNSS v2.1.docx
- Guideline for Conventional Traverse Surveys v2.1.docx
- Guideline for Installation and Documentation of Survey Control Marks v2.1.docx

The previous version of SP1, v1.7, September 2007 has now been archived.

http://www.icsm.gov.au/publications/standard-australian-survey-control-network-special-publication-1-sp1



https://www.linz.govt.nz/data/geodetic-system/standards-specifications-and-publications

Standards

Standards describe criteria that must be followed to achieve compliance.

- Standard for New Zealand Vertical Datum 2016 - LINZS25009

  This standard defines the national vertical reference system: New Zealand Vertical Datum 2016 (NZVD2016)

- Standard for Ross Sea Region Geodetic Datum 2000 Projections - LINZS25008

  This standard replaces the version published on 17 March 2011.

- Standard for tiers, classes, and orders of LINZ data - LINZS25006

  The purpose of this standard is to ensure that the geospatial accuracy framework (LINZS25005) is consistently applied across LINZ cadastral survey and control system datasets

- Standard for the geospatial accuracy framework - LINZS25005

  This standard defines frameworks for specifying and classifying the accuracy of coordinates and the spatial relationships between them.

- Standard for New Zealand Geodetic Datum 2000 - LINZS25000

  A national geodetic system and its associated national survey control system are fundamental components of a nation's infrastructure.

https://www.linz.govt.nz/data/geodetic-system/standards-specifications-publications/standards-guidelines

Guidelines & fact sheets

Guidelines and fact sheets provide explanation of how standards can be applied and describe different services or products that are offered by LINZ.

- Coordinate Accuracy - LINZG25706

  This fact sheet describes how LINZ describes the accuracy of coordinate data. It explains the terms network and local accuracy and shows how they have been implemented in LINZ to give coordinate accuracy classifications called orders.

- New Zealand Vertical Datum 2009 - LINZG25705

  This factsheet describes the New Zealand Vertical Datum 2009 (NZVD2009) that is based on the New Zealand Quasigeoid 2009 (NZGeoid2009). It also describes how heights in terms of other vertical datums can be transformed in terms of NZVD2009.

- New Zealand Geodetic Datum 2000 Projections - LINZG25702

  This fact sheet supersedes LINZG25702 Fact sheet - New Zealand Geodetic Datum 2000 Projections which was published in November 2007.

- New Zealand Geodetic Datum 2000 - LINZG25700

  This fact sheet supersedes the LINZG25700 Fact sheet - LINZS25000 Standard for New Zealand Geodetic Datum 2000 which was published in November 2007.

- Ross Sea Region Geodetic Datum 2000 - LINZG25701

August 2017

→ LINZ Data Service Update June 2017 | 15 June 2017

» **View all News**

You might be interested in

↗ Geodetic Database

↗ Geodata.govt.nz

→ Our location strategy

→ Licensing and using data

Connect with...

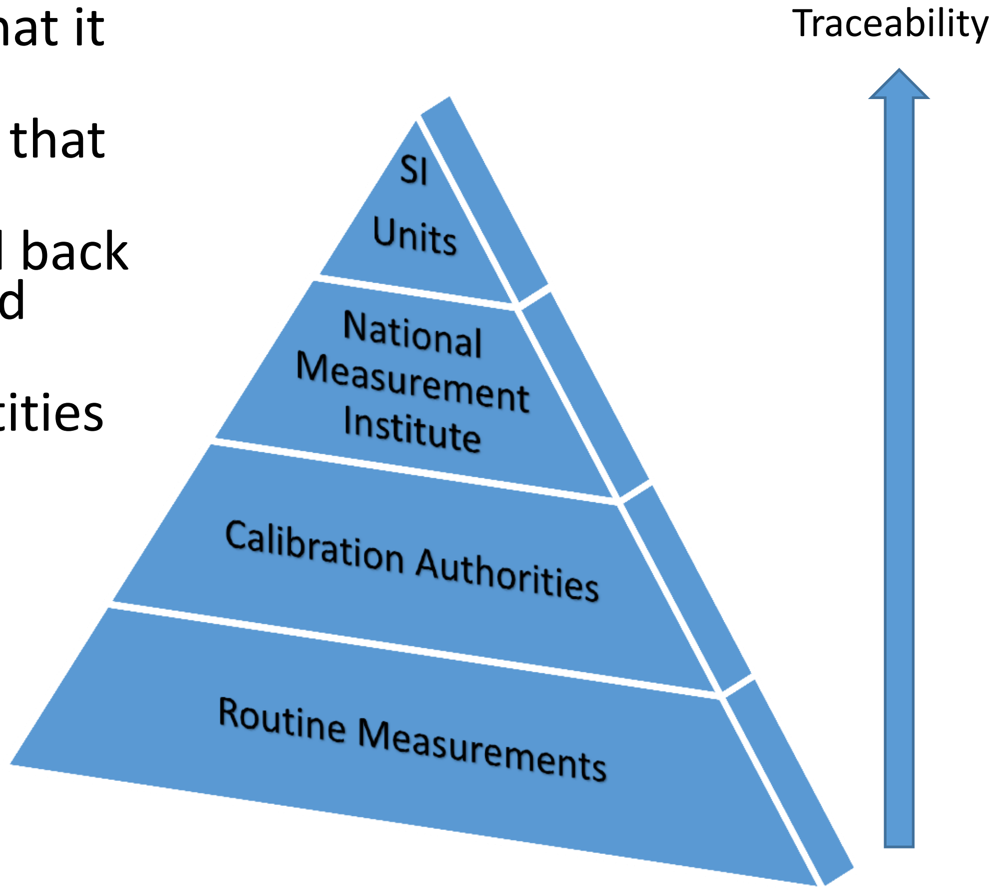
→ **National Geodetic Office**
customersupport@linz.govt.nz
Phone 0800 665 463

https://www.linz.govt.nz/data/geodetic-system/standards-specifications-publications/standards-guidelines

What S&Ps apply to GNSS / Geodetic Surveying?

- **Measurement Quality - Traceability to a Reference Standard**
  - Traceability is a method of ensuring that a measurement (with uncertainties) is an accurate representation of what it is trying to measure
  - Traceability ensures an unbroken chain of comparisons that ends at a National Metrology Institute (NMI)
  - In other words, a resultant measurement can be traced back to a reference standard through a series of accurate and documented calibrations
  - Reference standards of measurement or physical quantities such as
    - ✓length (metre)
    - ✓mass (kilogram)
    - ✓time (second
    - ✓electric current (ampere)
    - ✓thermodynamic temperature (kelvin)
    - ✓amount of substance (mole)
    - ✓luminous intensity (candela)

    (**International System (SI) of Units**)



Source David Martin FIG

What S&Ps apply to GNSS / Geodetic Surveying?

- **Measurement Quality - Traceability to a Reference Standard**
  - ➢Documentation for procedures / processes / specifications in relation to-
    - ✓Establishment / densification of the reference standard network
    - ✓Connection to the reference standard
    - ✓Performing a GNSS or control survey
    - ✓Propagation of uncertainty
    - ✓Minimisation of errors in GNSS measurement
    - ✓Recording and documenting the above
    - ✓Examples

"Ensuring that GNSS Surveying measurements are what they claim to be is as much about best practice as it is about traceability. This is a key to our approach in Australia" – Matt Higgins.

➢In Australia "position" is ***physical quantity*** and thus a ***recognised reference standard***. Most of Australia's GNSS CORS are reference standards therefore allowing users to obtain traceability.

Source David Martin FIG

Australian Government
Geoscience Australia

Certificate of Verification of a Reference Standard of a Position-Measurement in Accordance with Regulation 13 of the National Measurement Regulations 1999 and the National Measurement Act 1960

Name of Verifying Authority:

Name: Geodesy Section
Organisation: Geoscience Australia
Address: Corner Jerrabomberra Ave and Hindmarsh Drive, Symonston ACT 2609 Australia
Telephone: (02) 6249 9111
Email: geodesy@ga.gov.au

Client detail:

Name: Ryan Ruddick
Organisation: Geodesy Section, Geoscience Australia
Address: Symonston ACT 2609 Australia
Telephone: (02) 6249 9426
Email: Ryan.Ruddick@ga.gov.au
Date of request: 24 October 2017

Description and denomination of standard of measurement:

The measurement was undertaken using an antenna `JAVRINGANT_DM NONE` (International GNSS Service antenna naming convention) with the serial number 00687 and refers to a point located 0.0000 m below the antenna reference point. This antenna is attached to a stainless steel plate on a concrete pillar via a 5/8 inch spigot thread. The station (4 character ID: DARW) is located at Darwin in Northern Territory, and has the inscription National Geodetic Fiducial Network AU014. The certificate was determined using data from 03 September 2017 to 09 September 2017 inclusive. Analysis was undertaken following the procedures detailed in Geoscience Australia's GPS Analysis Manual for the Verification of Position Issue 2.1. The reference number of this certificate is DARW11122017.

Permanent distinguishing marks:

Exempt under Regulation 16 (4)

Date of verification: 11 December 2017

Date of expiry of certificate: 11 December 2022

NATA

Accredited for compliance with ISO/IEC 17025. Accreditation No. 15002.

Value of standard of measurement:

Station (4 character ID): `DARW`

South Latitude and its uncertainty of value:

$$12° \ 50' \ 37.30846'' \pm 0.00023'' \ (0.007 \text{ m})$$

East Longitude and its uncertainty of value:

$$131° \ 7' \ 57.87925'' \pm 0.00026'' \ (0.008 \text{ m})$$

Elevation above Ellipsoid and its uncertainty of value:

$$125.107 \pm 0.017 \text{ m}$$

Geocentric Datum of Australia (GDA2020) coordinates referred to the GRS80 ellipsoid being in the ITRF2014 reference frame at the epoch 2020. The uncertainties are calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, k, of 2.

Details of any relevant environmental or other influence factor(s) at the time of verification:

Uncertainty of the coordinates of the recognized-value standard of measurement of position (i.e. GDA2020); and Uncertainty due to instability of the GPS antenna mounting and modelling of the antenna phase centre variations.

Signature:	Signature:
11 December 2017	11 December 2017
Dr John Dawson NATA approved signatory	Mr Gary Johnston Geoscience Australia approved signatory
Section Leader Geodesy and Seismic Monitoring Branch Geoscience Australia	Branch Head Geodesy and Seismic Monitoring Branch Geoscience Australia

Being a person, or a person representing a body, appointed as a verifying authority under Regulations 71 and 73 of the National Measurement Regulations 1999 in accordance with the National Measurement Act 1960, I hereby certify that the above standard is verified as a reference standard of measurement in accordance with the Regulations, by the above-named authority.

AUSTRA

National
Standar
Determi

I, Dr R. Bruce
following deter

Dated 11 Octo

R. BRUCE WAI

Dr R. Bruce Wa
Chief Metrologi

4 Definitions

Schedule 1—Recognized-value standards of measurement in the Australian Fiducial Network

Note: See sections 6 and 7.

	Coordinates (m) at 2020.0			Coordinate Uncertainty (m)			Velocity (m / year)			Velocity Uncertainty (m / year)		
Site	*X*	*Y*	*Z*	*u(X)*	*u(Y)*	*u(Z)*	*Vx*	*Vy*	*Vz*	*u(Vx)*	*u(Vy)*	*u(Vz)*
Ceduna (SA)	-3753473.1960	3912741.0310	-3347959.6998	0.0244	0.0249	0.0229	-0.0421	0.0024	0.0501	0.0002	0.0002	0.0002
Manton Dam (NT)	-4091359.6096	4684606.4258	-1408579.1371	0.0098	0.0105	0.0072	-0.0355	-0.0137	0.0576	0.0002	0.0001	0.0002
Mt Stromlo (ACT)	-4467103.2062	2683039.4818	-3666948.7613	0.0100	0.0080	0.0090	-0.0367	0.0006	0.0452	0.0002	0.0002	0.0002
Sydney (NSW)	-4648240.8666	2560636.4510	-3526317.7982	0.0107	0.0082	0.0093	-0.0352	-0.0015	0.0453	0.0002	0.0002	0.0002
Tidbinbilla (ACT)	-4460996.9609	2682557.0875	-3674442.6411	0.0104	0.0082	0.0093	-0.0368	0.0007	0.0452	0.0002	0.0002	0.0002
Hobart (TAS)	-3950072.2586	2522415.3710	-4311637.4095	0.0094	0.0079	0.0098	-0.0395	0.0083	0.0411	0.0002	0.0002	0.0002
Melbourne (VIC)	-4130636.7623	2894953.1442	-3890530.2534	0.0098	0.0083	0.0094	-0.0393	0.0042	0.0448	0.0002	0.0002	0.0002
Parkes (NSW)	-4554255.2088	2816652.4429	-3454059.6981	0.0107	0.0085	0.0093	-0.0363	-0.0015	0.0467	0.0002	0.0002	0.0002
Hillarys (WA)	-2355572.1203	4886093.2099	-3343993.6599	0.0081	0.0112	0.0091	-0.0478	0.0106	0.0491	0.0002	0.0001	0.0002
Bundaberg (QLD)	-5125977.5335	2688801.2479	-2669890.2146	0.0113	0.0082	0.0082	-0.0311	-0.0105	0.0490	0.0002	0.0002	0.0002

What S&Ps apply to GNSS / Geodetic Surveying?

- **Measurement Quality – Testing vs Calibration of Equipment**

  - **Testing** is intended to
    - ✓ Verify the suitability of a particular instrument for the required application
    - ✓ Satisfy the requirements of best practice standards
    - ✓ Generally the instrument uses its own measurements to qualify and quantify its performance

  where as…

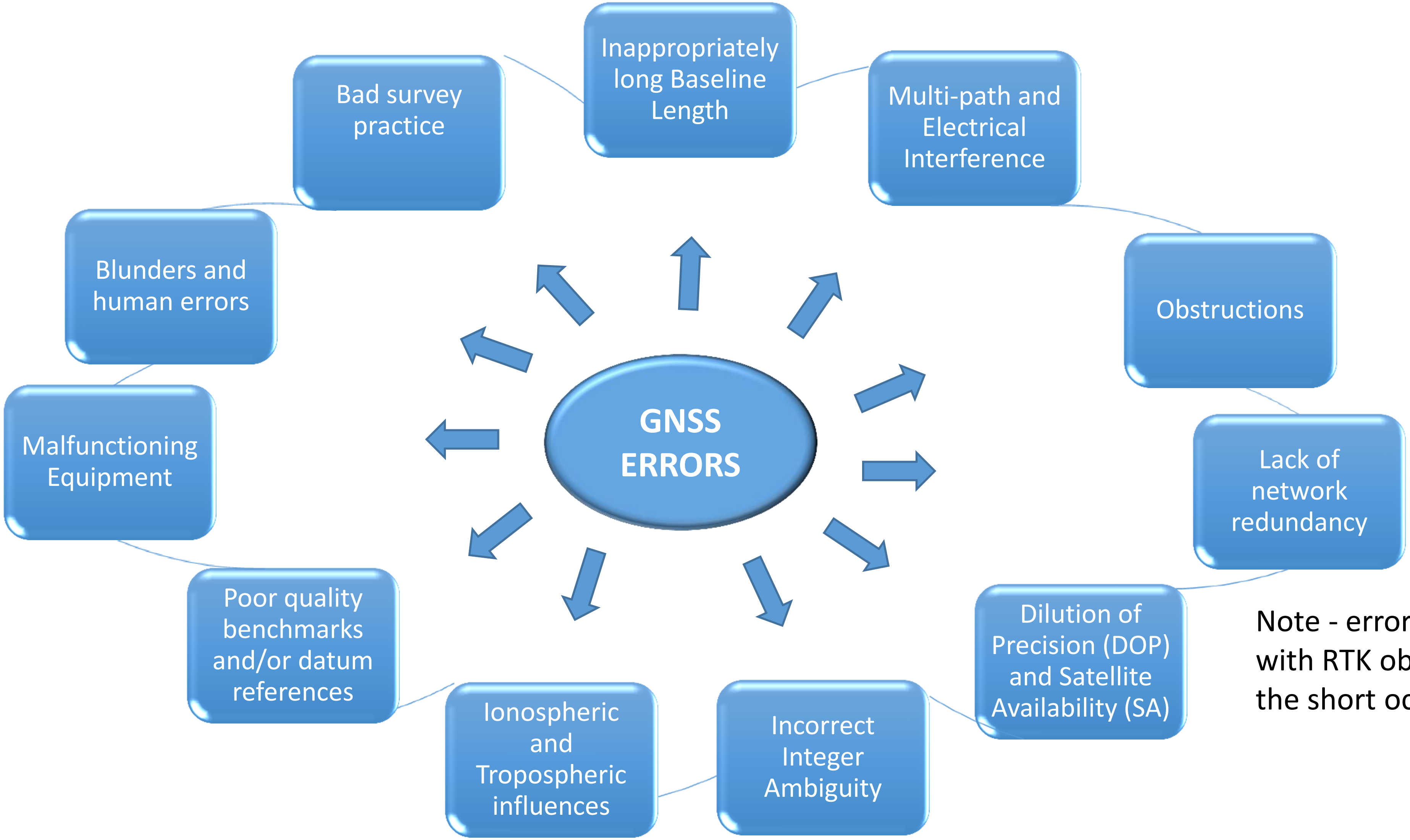
  - **Calibration** links the instrument by comparison directly to reference standard so as to ensure traceability

"Traceability and standards make the difference between quality products and services" – David Martin

Source David Martin FIG

What S&Ps apply to GNSS / Geodetic Surveying?

- ***Measurement Quality***
  - Minimisation of Errors – CRITCAL to articulate standards, practices, knowledge

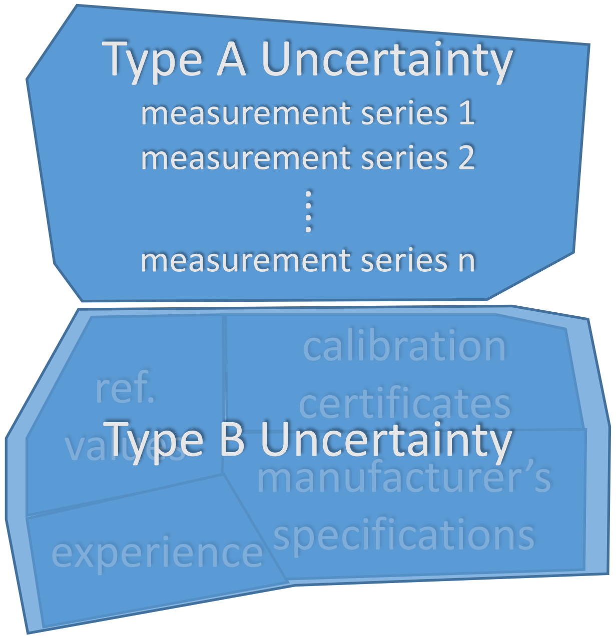


Note - errors can be amplified with RTK observations due to the short occupation times

Source David Martin FIG

What S&Ps apply to GNSS / Geodetic Surveying?

- ***Measurement Quality***
  - Representation and determination of quality – “uncertainty”
  - Control surveys undertaken to derive the horizontal and vertical position of survey control marks should be adjusted in a rigorous least squares adjustment process
  - ***Evaluation of Measurement Data – Guide to the Expression of Uncertainty in Measurement, Joint Committee for Guides in Metrology*** – Bureau International des Poids et Mesures, Paris, France.

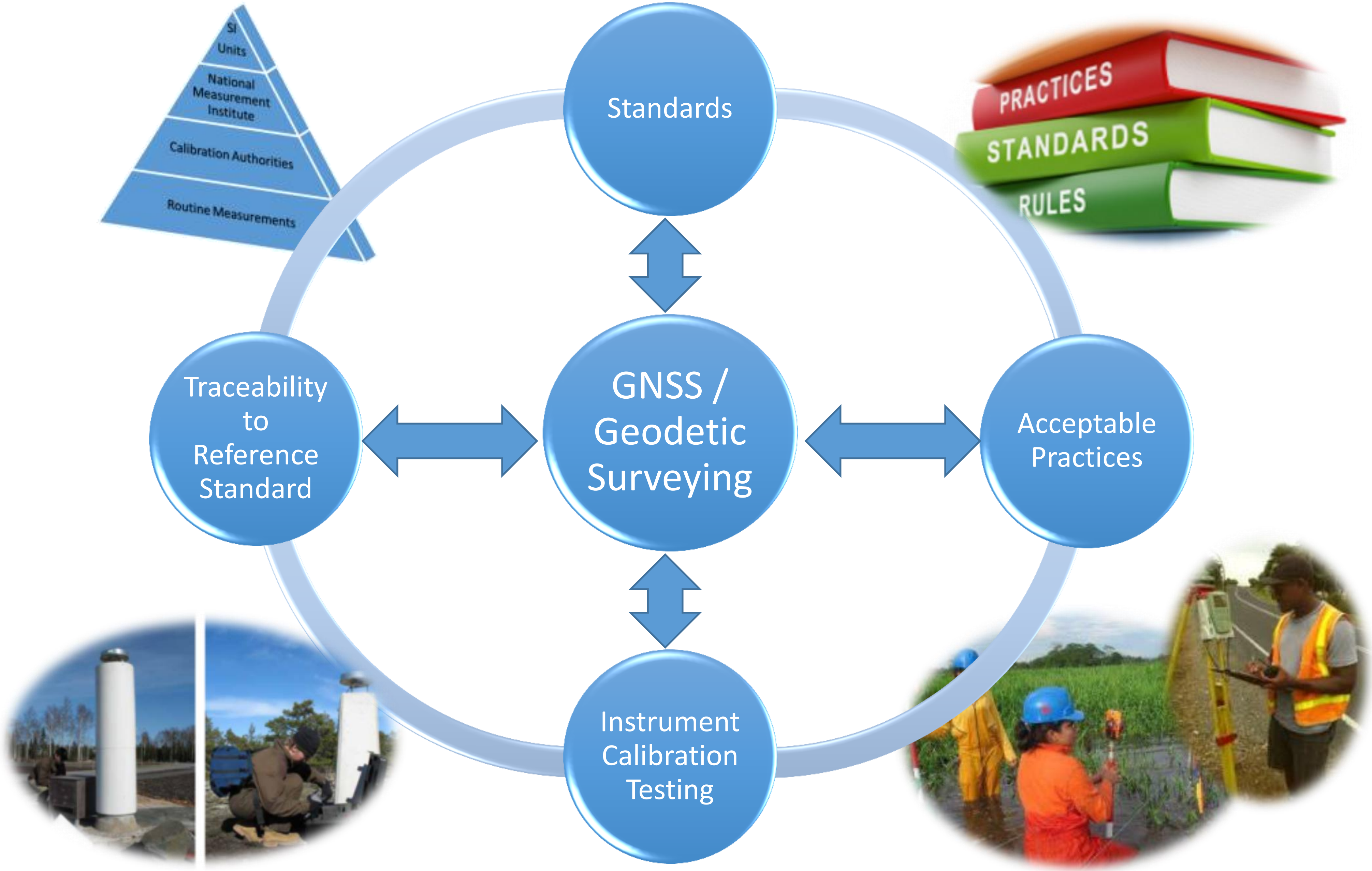


measurement uncertainty *non-negative parameter characterizing the dispersion of the* ***quantity values*** *being attributed to a* ***measurand****, based on the information used*

$$U = \sqrt{(\text{Type A})^2 + (\text{Type B})^2}$$

Source David Martin FIG

S&Ps Framework wrt GNSS / Geodetic Surveying



Standards and Acceptable Practices for PICTs GNSS CORS and Survey Control ?

- Scan the environment to discover what exists, what is relevant and what are the benefits
- Understand what Government policy is applicable and if it can be leveraged - “Climate Change and Sea Level Rise”
- Get actively involved in “Geospatial and Surveying” standards and practices community – internationally, regionally, nationally and locally
- Ensure you have traceability / connections to international / regional (and national / local if they exist) standards and practices AND its impact or role in achieving the SDGs
- Need to establish and agree on what is important for the region and what you want to achieve – fit for purpose
- Consult and collaborate to reach consensus
- Ensure there is flexibility and agility so that quick change is possible - outcome focus standards and practices

Standards and Acceptable Practices for PICTs GNSS CORS and Survey Control ?

Exist?

PICTs - STANDARDS Network

Other Committees

Committee of Geodetic Experts

Pacific Community Communauté du Pacifique

PGSC Pacific Geospatial and Surveying Council

Standard

BEST PRACTICES

Guidelines

ISO International Organization for Standardization

IGS INTERNATIONAL GNSS SERVICE

OGC

STANDARDS NEW ZEALAND

STANDARDS Australia

Leica Geosystems

FIG

UN-GGIM-AP

Australian Government Geoscience Australia

Land Information New Zealand Toitū te whenua

ANZLIC the Spatial Information Council

ICSM INTERGOVERNMENTAL COMMITTEE ON SURVEYING & MAPPING

Development Partners

The Future – Asia Pacific Region Capacity Development Plan

Collaboration is the KEY !
Our geospatial future is in our hands

Consolidate our network to consider

TO WHAT END do we need to develop our capacity? What will be its purpose? Drivers – social, economic, political?

WHOSE capacities need to be developed? Which groups or individuals need to be empowered? Local / Regional?

WHAT KINDS of capacities need to be developed to achieve the broader development objectives? Technical & Non-technical?