



THE REFERENCE FRAME IN PRACTICE

CENTRAL TO ANY GEODETIC SYSTEM IS THE SPATIAL REFERENCE FRAME ON WHICH IT IS BASED. IN CONJUNCTION WITH PARTNER ORGANISATIONS, FIG HAS PRODUCED A BRIEF INTRODUCTION TO THE PRACTICAL USE OF REFERENCE FRAMES – AND IS WORKING ON A GEODETIC REFERENCE FRAME, TOO

A country's geodetic system comprises a network of permanent ground reference points and the associated intellectual and positional data that enables it to ensure all data concerning land, resources, and location is managed systematically and in an orderly manner. A geodetic datum underpins most national land-related information, fundamental spatial datasets, surveying and mapping infrastructure, and positioning or location-based services.

Central to any geodetic system is the spatial reference frame on which it is based. Traditionally, reference frames were locally based, but the transition to the use of satellite positioning systems has caused reference frames to become geocentric and more regional and global.

As the requirement for greater spatial accuracy increases, the effects of tectonic or crustal motions and the concept that geodetic datums need to be more dynamic in nature must be given more consideration. Consequently, a regional or global spatial reference frame should define

a location to be unambiguously represented through a set of coordinates (usually latitude and longitude or northing and easting), their positional uncertainty and site velocities.

Within FIG, the work plan of Commission 5 – Positioning and Measurement investigates fundamental spatial reference frame issues and operational geodetic topics at national, regional and global levels. This commission, made up of professional surveyors from the academic, scientific, technical, commercial and government sectors, also examines the development, application and integration of technologies for positioning and measurement, and their associated standardisation and best practices.

In conjunction with sister organisations such as the International Association of Geodesy (IAG) and United Nations Global Geospatial Information Management Asia Pacific (UN GGIM AP), the commission is also involved with delivering solutions for the geospatial aspects of important global or regional challenges such as sustainable development



FIG held three technical seminars to discuss reference frame issues at the regional or national levels and provide advice on practical technical solutions

and humanitarian needs. Since 2011, the combined activities of these organisations have been aimed at developing countries that require assistance with implementing modern geodetic reference frames and associated infrastructure, such as GNSS continuously operating reference stations (CORS) networks.

Seminars

The cooperation of these organisations during this period has seen three technical seminars on reference frames being held. The first was held in Rome as part of the May 2012 FIG Working Week; the second was convened in June following the 2013 South East Asia Survey Congress (SEASC) in Manila; and the third was arranged as part of the FIG Pacific Small Islands Developing States Symposium in 2013 in Fiji. The main purpose of these seminars was to discuss reference frame issues at the regional or national levels and provide advice on practical technical solutions.

The workshops identified the need for more geodetic-quality GNSS CORS, better management of the vertical component of reference frames, and for the region to build the overall capacity of surveyors to modernise geospatial infrastructure. Furthermore, the fulfilment of these tasks could help to understand and monitor the dynamics of the earth's continents, assist reduce persistent poverty, and create opportunities to support social and economic development. These desired outcomes and associated outputs became the focus for most emerging nations in the region.

A new manual

Another outcome of the seminars was the development of a manual on the practical or operational aspects of reference frames. FIG publication number 64, *The Reference Frame in Practice Manual*, was produced and released at the XXV FIG Congress, held in Kuala Lumpur, Malaysia in June last year. Intended for surveyors and assuming some knowledge of the topic, its objective is to provide a brief introduction to the practical use of reference frames. It addresses technical issues surrounding reference frames, presenting formulae when appropriate, and covering the following subjects:

- **Datums and projections:** An overview of the various types of projections and datums including local and geocentric datum.
- **Geodesy and global reference frames:** An overview of the science of geodesy and use of global reference frames.
- **Global terrestrial reference systems and frames:** An overview of global terrestrial reference systems and frames and transformations between them.
- **Regional and national reference frames:** Information on the different types of reference frames and datums and how crustal deformation can be accommodated in them.
- **Height systems:** A description of the various heights systems and how heights can be transformed between these systems.
- **Transforming between datums:** Information on the commonly used transformation methods and some of the more specific cases used for transforming between datums.



Attendees of the 2013 technical seminar

- **Transforming between datums in non-static reference frames:** Details on the specific case for transforming between non-static reference frames.
- **Reference frame parameter estimation via the technique of least squares:** A description of the propagation of an international or regional reference frame onto national or local stations.
- **Least squares parameter estimates:** A review of some basic concepts and techniques for the testing of geodetic measurements and least squares parameter estimates, and for estimating network reliability.
- **GNSS:** An overview of the various systems available and methods of making measurements.
- **GNSS CORS networks and linking to ITRF:** Details of how to link information from a CORS to global reference frames.
- **The International GNSS Service (IGS):** Details of the structure of the IGS and services provided by them.
- **Standards and quality of terrestrial reference frames:** An example and further reading on the subject.

The development and publication of this manual has clearly demonstrated how international organisations can collaborate to produce a tangible outcome. The IAG, UN GGIM AP and FIG will continue their cooperation by facilitating another technical seminar in Singapore in July this year, in conjunction with the next SEASC, and then again in New Zealand at the FIG Working Week in May 2016.

The memorandum of understanding between FIG and the UN Office for Outer Space Affairs has enabled delegates from emerging and developing countries to attend the reference frame in practice seminars. Participation by these delegates has assisted with the formation of the manual, and it is hoped that in the future such UN support can endure.

The United Nations Committee of Experts on Global Geospatial Information Management recognises the growing demand for more precise positioning services, the economic importance of the global geodetic reference frame, and the need to improve global cooperation within geodesy. In July 2013, it agreed to formulate and facilitate a draft resolution for a Global Geodetic Reference Frame. This resolution is to be presented to the UN General Assembly this year.

THE DEVELOPMENT AND PUBLICATION OF THIS MANUAL HAS CLEARLY DEMONSTRATED HOW INTERNATIONAL ORGANISATIONS CAN COLLABORATE TO PRODUCE A TANGIBLE OUTCOME

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