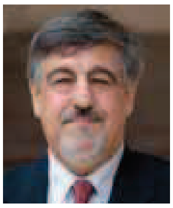
Geodesy: Out with the Old, In with the New

We should promote a new geodesy that does not instil fear into our students, but instead seeks to conveys the excitement of Modern Geodesy



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Since taking over the position of president of the International Association of Geodesy (IAG – http://www.iag-aig.org) on the 6th July 2011, I have had on occasion mused on what geodesy "is" and how to explain this arcane field to those who are not acquainted with it. For example, how do I tell the Dean of the Faculty of Engineering, at the University of New South Wales, Sydney (Australia), that I, the head of a department within his faculty which has its primary objective the education of undergraduate students in "surveying" (or more broadly in "geomatics"), now occupy an important position in the geoscience field of "Geodesy and Geophysics"? (This is not an idle exercise, as the Dean will be asked to approve my increased travel commitments over the next four years.

In order to define what geodesy "is", it is necessary to articulate what geodesy is "not". Furthermore, to explain why geodesy is important one could draw attention to its unique role in the geosciences, and to its vital services to society.

I can remember I had a disturbing "eureka" moment last year. I had given a talk to an audience of surveyors on the theme "why geodesy has a bad name". I noted that the classical topics of geodesy were no longer taught in many university surveying/geospatial/geomatics programs. I rattled off the topics, which resonated with the audience. As I listed them, many members of the audience nodded their heads… geodetic control networks, atmospheric refraction, spherical harmonic models, geodetic boundary value problem, deflections of the vertical, gravity anomalies and gravimetry, Least Squares estimation, ellipsoidal computations, map projections, reference frame transformations, positional astronomy, and so on. What I had not appreciated until that moment was that all these were "hard" topics, that few surveyors had fond memories of these subjects, and fewer would say they were better off by having studied them. Yet Modern Geodesy has progressed in the last decades in leaps and bounds, despite the shrinking number of students with a formal education in these classical geodetic topics. It struck me that we should promote a new geodesy that does not instil fear into our students, but instead seeks to conveys the excitement of Modern Geodesy.

A second revelation came to me as I participated in the centenary celebrations of the founding of the International Society of Photogrammetry & Remote Sensing (ISPRS) in Vienna by Eduard Dalezal. The IAG and the ISPRS are two of the ten "sister" organisations making up the Joint Board of Geospatial Information Societies (JBGIS). Other members of the JBGIS include the International Federation of Surveyors (FIG), the International Cartographic Association (ICA), the IEEE Geoscience & Remote Sensing Society (IGARSS), the International Geographic Union (IGU), and the Global Spatial Data Infrastructure Association (GSDI). Speakers at the ISPRS 100 year anniversary conference celebrated the history of photogrammetry and remote sensing, but also enthused about the future of satellite technologies in helping address society's environmental challenges.
I sat there and thought, "that is what Modern Geodesy also seeks to do!". The goal of Modern Geodesy is nothing less than to monitor changes in a range of physical processes in the solid earth, the atmosphere, and the oceans in order to improve our understanding of this fragile, precious and stressed planet. It was clear

to me that geodesy could be described as an Earth Observation (EO) discipline, or science. Certainly the classical definition of geodesy does not make clear that it is an EO science which has broader functions and applications, and potentially more relevance, than just as a foundation for mapping and surveying. It struck me that we must acknowledge that classical geodesy narrowly defined from this perspective of surveying and mapping needs to make way for Modern Geodesy.

So what sets geodesy (and the IAG) apart from other EO disciplines? The answer came to me some years ago. It is the fact that the IAG has fostered the establishment of "services" to provide fundamental products for many geoscientific and geospatial end-users. As president of the IAG I am especially proud to acknowledge the important work of these services. The services include the International VLBI (Very Long Baseline Interferometry) Service (IVS – http://ivscc.gsfc.nasa.gov), the International Laser Ranging Service (ILRS – http://ilrs.gsfc.nasa.gov), the International DORIS (Doppler Orbitography & Radiopositioning Integrated by Satellite) Service (IDS – http://ids.cls.fr) and the best known, the International GNSS Service (IGS – http://igs.org). Through another IAG service – the International Earth Rotation & Reference Systems Service (IERS – http://www.iers.org) – these space geodetic techniques play a critical role in defining the fundamental reference frame in relation to which changes in the location of points on (or above) the earth's surface (including satellite orbits), or the shape of the land, or level of the ocean surface, can be monitored over many years to sub-centimetre accuracy. Therefore special mention should be made of one of the IAG's "flagship" products – the International Terrestrial Reference Frame (ITRF – http://itrf.ensg.ign.fr) – which also increasingly is the basis for modern national mapping datums.

The IAG also has established the International Gravity Field Service (IGFS – http://www.igfs.net) to measure and model the earth's gravity field to high accuracy using, for example, sophisticated gravity mapping satellite missions such as CHAMP, GRACE and GOCE. Gravimetric geodesy can nowadays measure changes in gravity acceleration arising from mass transport (which changes gravity by tiny amounts) due to the global water cycle, atmospheric and ocean circulation, and solid earth processes such as volcanism and tectonics. Amazing technology!

All the IAG services generate products on a continuous basis. These products may be the primary outputs of geodetic analysis, such as precise coordinates of GNSS monitor stations, or global meteorological values of humidity, temperature and pressure, or maps of ionospheric disturbances, rate of rotation of the earth, orientation of its rotation axis, and many others. Such products can be used directly by many scientists. In addition, indirect products such as the reference frame, precise orbits of EO satellites, precise timing scales and high-accuracy GNSSenabled navigation capability, support many other scientific and professional users. The challenge for the surveying, and the geomatics disciplines in general, is to embrace Modern Geodesy, and to cheer its achievements. My role now is to "sell" geodesy because it is more accessible (through the increased use of GPS/GNSS) and more relevant (through its unique EO capabilities) than any time in the past.

There are a number of reasons for this transformation from esoteric geoscience to an integral part of today's geospatial industry. Firstly, Modern Geodesy relies on space technology, and enormous strides have been made in accuracy, resolution and coverage due to advances in satellite sensors and an expanding portfolio of satellite missions. Secondly, geodesy can measure earth parameters that no other remote sensing technique can, such as the position and velocity of points on the surface of the earth, changes of sea level and the shape of the earth's ocean, ice and land surfaces, and map the spatial and temporal features of the gravity field. These geodetic parameters are in effect the "fingerprints" of many dynamic earth phenomena, including those that we now associate with global change (due to anthropogenic or natural causes) as well as responsible for devastating events such as earthquakes, tsunamis and volcanoes. The challenge is to invert the outward expressions of these dynamic earth processes in order to measure and monitor over time the underlying physical causes. Finally what relentlessly drives geodesy into the future is the innovative use of signals transmitted by Global Navigation Satellite Systems (GNSS) such as the U.S.'s GPS and Russia's Glonass, E.U.'s Galileo, and China's BeiDou – the latter two constellations are incomplete, but will be deployed in the coming decade.

However, GNSS is more than just another space geodetic technology. GPS in particular is today used for an enormous range of applications, from consumer uses such as for car navigation and in mobile phones to access location-based services, to professional applications such as machine automation (guidance of farm, mining and construction vehicles), emergency services, military operations, rapid mapping, surveying, transport management, and many more. However it is the special ultra-high accuracy form that is of geodetic interest. The IGS therefore deserves special mention, and is an organisation close to my heart – having served on the IGS Governing Board for the last 7 years. The IGS was established in 1994 as the first of the IAG's geometric services, primarily by computing high accuracy GPS and Glonass satellite orbit and clock "products" as well as open (and free) access to measurements made by a global ground network of continuously operating GNSS tracking stations. These hundreds of GNSS receivers on stable pillars or solid monuments operate continuously around the world also function as precise monitoring systems for ground movement due to global effects such as continental drift, local subsidence due to fluid extraction or underground mining, uplift due to volcanism or post-glacial rebound (the land rising since the last Ice Age released the pressure of many kilometres of overbearing ice), and more.

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The IGS is not resting on its laurels, and has just launched a "multi-GNSS experiment" (M-GEX), seeking to augment its tracking network with next generation multi-GNSS receivers able to track the new satellite signals. In 2013 the IGS is on track to launch a new "real-time" service. It must be pointed out however, that the representation of countries from South America, Asia and Africa, as hosts of GNSS tracking stations, as homes to product analysis centres, and on its governance body is disappointing. Nevertheless, some progress is being made with the Asia-Pacific Reference Frame Project (APREF – http://www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html), which aims to encourage cross-border cooperation in GNSS geodesy; and the demonstration campaigns being promoted under the auspices of the Multi-GNSS Asia Organisation (MGA – http://www.multignss.asia) to encourage regional experimentation with next generation GNSSs such as the new Japanese QZSS and Chinese BeiDou satellite signals.

What about the other services? Geodesy has set itself an ambitious agenda – striving to increase the level of accuracy in the determination of many of the geodetic parameters by a factor of ten over the coming decade. The IAG's Global Geodetic Observing System (GGOS – http://www.ggos.org) will integrate all geodetic measurements from all services in order to monitor the phenomena and processes within the earth system at far higher fidelity than at present. This integration implies the inclusion of all relevant information for parameter estimation, the combination of geometric and gravimetric data, and the common estimation of all the necessary parameters representing the solid earth, the hydrosphere (including oceans, ice-caps, continental water), and the atmosphere. GGOS is geodesy's contribution to the Global Earth Observing System of Systems (GEOSS – http://www.earthobservations.org) initiative.

Again, South America, Africa and Asia can, and should play a greater role in the IAG services, and in GGOS. The geodetic infrastructure that underpins today's IAG services needs to be upgraded and extended. Nowhere is this need greater than in the countries outside North America, Europe and Australia. My IAG presidency will treat this expansion of IAG engagement with the highest priority.

In summary, geodesy is facing an increasing demand from science, engineering applications, the earth observation community, and society at large for improved accuracy, reliability and access to geodetic services, measurements and products. All countries, and all geospatial professionals can contribute. Our slogan should be "geodesy matters, now more than ever", but it must be Modern Geodesy… out with the old, in with the new.

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