Enhancing the Role of Surveyors: Bridging the Gap between Demand for and Supply of Professional Education

Fahria MASUM, Germany, Liza GROENENDIJK, Netherlands, Reinfried MANSBERGER, Austria and Audrey MARTIN, Ireland

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SUMMARY

A land surveyor is often recognized as a professional primarily responsible for mapping boundaries and topographies of land parcels, locating and positioning objects and improvements on land parcels. This usually includes collecting the data used to designate land boundaries. With changes in land-person relationship, the surveyor's responsibilities have changed over a period of time. Furthermore, due to advancement in technology and new surveying equipment and techniques, the role of a surveyor is changing rapidly. In addition to emerging global challenges, the role of the surveyor is increasing more than ever before. Surveyors are involved in collecting, merging, linking, improving, visualizing, and interpreting diverse land information. Nowadays, surveyors have to work transdisciplinary with other professionals involved in land and natural resources management. This change from 'a traditional role' to 'a pragmatic role' has brought a paradigm shift in the land profession in general, and surveying in particular.

Though professional education is inevitable in response to the changing role of a surveyor, there is a big gap between demand for and supply of professional education in terms of quality and quantity. In a global context, skills and learning requirements of a surveyor vary from country to country. In most cases the approach to acquiring these skills is still very traditional thus widening the gap between demand for and supply of quality education to enhance capacities of land professional/surveyor. Similarly, limited opportunities of professional education is creating a gap in terms of quantity.

This paper suggests that fundamental objectives should include broadening the scope of professional education by focusing educational curricula on general surveying and related practical knowledge. This implies focusing on enhancing professional capacities of surveyors and other land professionals in managing and governing land instead of mere administration, mapping and measurement of land. This paper outlines a set of competencies a surveyor/land professional should attain through professional education in order to meet the challenges posed by the emerging changes in the land profession.

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1. INTRODUCTION

Surveying is one of the oldest profession in the world, dating back to 2700 BC in Egypt during the construction of the Great Pyramid at Giza. It is also one of the engineering professions which is mostly affected by technological advancement and has improved and adapted to this new phenomena. As time has gone by, not only the tools and techniques used by a surveyor have been advanced, but also the role of surveyors evolved dramatically.

In the 1978 American Congress on Surveying and Mapping (ACSM) defined surveying as

the science and art of making all essential measurements in space to determine the relative positions of points and/or physical and cultural details above, on or beneath the earth's surface and to depict them in usable form.

With a span of time new definitions of 'surveying' were introduced. The scope of surveying is seen to be broader than before. On 23rd May 2004 general assembly of International Federation of Surveyors (FIG) adopted a definition which describes a surveyor as (FIG, 2008):

a professional person with the academic qualifications and technical expertise to conduct one, or more, of the following activities;

- *to determine, measure and represent land, three-dimensional objects, point-fields and trajectories;*
- *to assemble and interpret land and geographically related information,*
- *to use that information for the planning and efficient administration of the land, the sea and any structures thereon; and,*
- *to conduct research into the above practices and to develop them.*

Previously surveying was mainly about measuring; today, surveying involves management and requires a transdisciplinary approach. Within FIG, the term 'land professional' has been introduced to refer to this broader role of a surveyor (Enemark and Williamson, 2004). Further it can be noticed that the surveying profession is often referred as geomatics or geo-informatics. As the possibilities offered by advancement in technologies involved in information processing, (tele)communication, space exploration and sensor development have dramatically changed working methods, the term land surveyor was no longer adequate to encompass more than just traditional land surveying (Lemmens 2011). However, the definition of 'surveying' or 'surveyor'

(FIG, 2008) is still being used by FIG although it is recognized it may not capture the present and future role of surveyors which continues to evolve.

As surveying as a discipline is evolving rapidly, and surveying education is facing challenges in regard to curriculum, core competencies and skills, and marketing. Surveying education needs to adopt academic study which goes beyond the technical requirements for the profession. Therefore, this paper seeks to explore the role of global challenges and nature of rapid technological advancement in the process of changing role of a surveyor. The paper presents a discussion about the professional education that can be incorporated into the new role of surveyors, and what this implies for the future of surveyors as land professionals. This paper can be considered as a background paper to facilitate discussion on how to harmonize surveying education and the way to develop a curricula and teaching methods to address the present and future needs.

2. OVERVIEW OF RECENT WORK OF FIG COMMISSION 2

FIG Commission 2 is the domain of professional surveying education. The 4 (four) traditional areas for the commission are: 1) curriculum and core surveying body of knowledge, 2) teaching and learning methodology, 3) marketing and management of professional education and 4) accreditation and quality assurance. All these areas are related, but mostly driven by the first core area, the surveying curriculum. This section intends to give an overview of the discussions and directions within FIG and FIG Commission 2 in this field over the last 15 years.

Enemark and Cavero (2003) promoted an educational profile comprised of measurement science and land management, and embedded in spatial information management. They argued that the predominantly engineering focus of the surveying profession needs to change to a more managerial and interdisciplinary approach. Since then a lot of discourse has been going on to justify a paradigm shift from surveying education to educating the land professionals (Enemark & Williamson, 2004; Enemark, 2008, 2009, 2010; Magel et al. 2009; Mitchel & Enemark, 2008). At the same time it was recognized that ‘one of the main challenges of the future will be to accept that the only constant is change’. To deal with this *constant change* the educational base must be flexible. In this respect, innovative teaching and learning approaches in surveying education were promoted with particular examples (Enemark, 2004, 2007, 2009; Enemark & Gallant, 2012).

The fundamental transformation of the surveying profession took place through the introduction of the computer, internet and Information and Communication Technologies (ICT). Markus (2004, 2005) stressed the role of professional education and training in developing completely new capabilities for surveyors to act in a networked society. E-learning, open learning and knowledge management therefore received major attention in Commission 2 (Markus, 2005, 2008, and 2010). This was further reflected in a FIG publication (No. 46) titled ‘Enhancing Surveying Education through e-Learning’ (FIG, 2010).

Developing skills and qualifications of surveying professionals and technicians is a main concern for FIG Commission 2. In many countries this gains great importance also. In the United States ABET is used to allow standard recognition of educational surveying qualifications (Frank, 2007, 2009, 2010). In the United Kingdom, RICS has developed educational criteria that allow universities to assess the suitability of their curricula to the professional needs (Plimmer, 2003; Frank, 2010). With the rapidly changing surveying profession it is a continuous challenge to maintain a system of standardization. Though Frank (2008, 2012), and Greenfeld (2008, 2010, 2012) defined an understanding of core knowledge of surveying profession, the ambitions for defining a Core Curriculum in Surveying was not commonly shared within the commission. (Markus, 2010).

FIG always gives focus on the global challenges and plays significant role in terms of facilitating the understanding of the role of surveyors in addressing the global challenges. Most recently the FIG Academic Forum, as part of FIG Commission 2, has formed a working group to explore the role of the surveying and land professionals in the implementation of The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT). The aim is to contribute to strengthening land governance in professional surveying curricula and academic research (FIG, 2014a; Groenendijk & Munro-Faure, 2016).

3. GLOBAL CHALLENGES

"The supreme reality of our time is the vulnerability of our planet". This statement given in the year 1963 by the former president of the United States of Amerika, John F. Kennedy, has not lost any validity since the last 5 decades. On the contrary, the challenges to guarantee sustainability of our resources and well-being for all of us have increased.

In 2015, the United Nations defined 17 Sustainable Development Goals (SDG), which incorporate all the global challenges of today. In the following these political objectives, which should be achieved within the next 15 years, are briefly described, whereas the focus is given to objectives and measures of SDGs with a high relevance for the surveying profession and its academic education (UN 2015):

Food Security: Sustainable food production systems and resilient agricultural practices are the success factors to reduce hunger on our planet. The agricultural productivity and incomes of small-scale food producers, in particular women and indigenous peoples can be achieved by secure and equal access to land, by given knowledge and by proper financial services.

Equitable quality education and Life Long Learning opportunities for all: The number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship will increase substantially by 2030. Knowledge and skills have to meet the requirements for sustainable development. Additionally the supply of qualified teachers, including through international cooperation for teacher training in developing countries has to be guaranteed.

Gender equality: Women have to get full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life. Reforms have to be undertaken to enable women equal rights concerning economic resources, land ownership and other forms of property, financial services, inheritance and natural resources.

Resilient infrastructure and innovation: Sustainable and resilient infrastructure, including regional and trans-border infrastructure, have to be built to support economic development and human well-being. Focus has to be given to trigger research and innovation in developing countries. Significant increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.
Safe, resilient and sustainable cities and human settlements: By 2030, all people should have access to adequate, safe and affordable housing and basic services. Capacity has to be built for participatory, integrated and sustainable human settlement planning.

Climate change and its impacts: To be prepared against the impacts of climate-related hazards and natural disasters, education, raising awareness and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning has to be improved.

Peaceful societies, access to justice for all, and effective institutions: The rule of law has to be promoted at national and international levels and equal access to justice for all has to be guaranteed. Participatory and representative decision-making at all levels have to be established.

Global partnership for sustainable development: The international support for implementing effective and targeted capacity-building in developing countries has to be supported in national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation.

Also for other global challenges, formulated as SDGs and summarized in the following, the surveying profession is able to provide information and expertise: *Poverty reduction*; *Well-being for all*; *Sustainable management of water and sanitation for all*; *Access to sustainable energy for all*; *Sustainable economic growths and full employment*; *Inequality reduction within and among countries*; *Sustainable consumption and production patters*; *Conserve and sustainable use of oceans, seas and marine resources*; *Sustainable use of terrestrial ecosystems, sustainable forests management, and biodiversity*.

The World economic forum outlines 10 global challenges, of which *Agriculture and food security*, *Employment, skills and human capital*, *Environmental and resource security*, *Infrastructure*, *long term investigating and development* can be met only with an essential contribution of the surveying profession (WEF, 2017).

In April 2016, Hodai – a Swiss not-for-profit foundation - built a list of the top 100 crucial priorities indicating global problems. The results are updated continuously by comments provided by visitors of the homepage (Hodai 2017). Within the top 100 ranked challenges, *Unsustainable development*, *Global Conflict*, *Unsustainable agriculture*, *Urban Sprawl*, *Natural Disasters*, *Failure of critical local infrastructures*, *Flood*, and *Lost of Know-How* are outlined.

The Voluntary Guidelines on the Responsibility Governance of Tenure of Land, Fisheries and Forests in the context of National Food Security outline solutions for global challenges (FAO, 2012). Security in land tenure is seen as a key issue for fair access to land, for sustainable management of land and for eradication of hunger and poverty.

The New Urban Agenda of the UN Habitat (2016) is the outcome document of the Habitat III cities conference in Quito, Ecuador (October 2016). The 175 paragraphs cover the vision, the principles and commitments, the call for action and guidelines how to implement resilient cities.

Spatial information management is an essential pillar for good land management and with it an essential ingredient for meeting the above mentioned global challenges. The Addis Abeba Declaration Geospatial Information Management Towards Good Land Governance encourages all politicians and stakeholders to cooperate on national and international level for assessing and providing up-to-date spatial data infrastructure (UN GGIM, 2016).

4. RAPID TECHNOLOGICAL CHANGES

In recent decades surveying has undergone a number of significant developments. These developments have been made possible by developing Information Technology (IT) and the increasing speed of computer processors which can deal with large sets of spatial data, speeding up the workflow from data capture to map production.

Konecny (2002) identified the beginning of this technological revolution as the 1960s when the surveying and mapping profession was based on analogue measurements carried out by highly trained surveyors, expert in the art of precise measurement techniques. This introduction of electronic instruments significantly altered surveying practices on the land, at sea and in the air, and made conventional surveying faster and more accurate whilst also expanding the role of the traditional surveyor.

The advent of the Global Positioning System (GPS) for precise measurement in the 1990s and more recently, the addition of further global positioning systems including Glonass, BeiDou, and Galileo collectively known as Global Navigation Satellite Systems (GNSS), have enabled very precise point positioning over long distances permitting the establishment of new 3D coordinate reference frameworks. These global and regional systems are systematically replacing traditional national benchmarks and coordinate reference systems which underpin survey infrastructure. In addition real-time and near real-time GNSS positioning solutions in conjunction with smart technologies are now driving the development of location based services.

The changing landscape of surveying and mapping around the globe led to the term ‘Geomatics’ being adopted in the 1990s. However in the last decade, the Geomatics domain has further expanded. Data collection methods have transformed from surveying single data points to collecting vast data clouds using scanning technologies. Terrestrial Laser Scanners (TLS) can now quickly produce accurate 3D models from dense, feature-rich point clouds. When mounted on a vehicle and combined with GNSS and inertial measurement units (IMU) these scanners constitute mobile mapping systems (MMS) which enable rapid corridor mapping of linear features. Scan to BIM (Building Information Modelling) is now a major driving force of point cloud data survey data collection and has widened the applications of rich accurate 3D data to archaeology, architecture, quantity surveying, planning and environmental studies *inter alia*. The applications of point cloud technology extend far beyond the land and disciplines such as hydrography, which now use multi-beam echo sounders to accurately map the seabed surface, have developed in parallel. The importance of the land sea interface is of increasing significance in marine spatial planning and coastal zone management and requires homogenous geospatial datasets to promote the blue economy.

In the air photogrammetric data capture has also significantly advanced in recent years with the development of Aerial Laser Scanning (ALS) techniques and high-resolution digital aerial cameras. These advanced methods when married with structure from motion (SfM) and new image matching techniques have enabled National Mapping Agencies (NMAs) to effectively use aerial photogrammetry as a standard method for large scale mapping. Most recently, the development light weight drone platforms housing multiple geo-coded measurement sensors has resulted in an explosion of aerial 3D data captured and processed in near real-time. Geomatics competencies also encompass the study of dynamic changes in the Earth under the title of Earth Observation (EO) or Satellite Remote Sensing (SRS) and developments in space-borne sensors have enabled remote sensing techniques to provide coverage of the Earth's surface at high resolutions. This data is invaluable when used to monitor changes in both the natural and built environment.

Local and global applications of data necessitate the need for spatial data structures and interoperability which allow multiple digital deliverables from authoritative data sources. Spatial data is generally held in Geographic information Systems (GIS) which are widely used and have become an indispensable tools for governance, commerce, and environmental and social science. Specifically, for the management of legal boundaries and cadastral systems Land Information Systems (LIS) have become a standard tool. They comprise of authoritative spatial data which contain an accurate, current and reliable land record and associated attributes and thus provide a vital base layer for governance. Traditional 2D cadastres based on geographic location have in recent years, modernized to become 3D databases which can enable 4D modelling where the geographic location is simply one attribute of the data. The attribute information within these databases is increasingly originating from a wider and non-technical or professional population as the ubiquitous use of the internet enables crowd sourcing to become a significant data collection tool. These technological advancements have given rise to data quality issues whereby the quality of data must be based on purpose or usage, currency, relevance and also its accuracy and precision; thus it must be 'Fit for Purpose'. In addition the development of faster simplified measurement procedures have enabled non-surveying professionals to become data collectors and changed the surveyors' role to workflow and data managers and evidence based decision makers.

5. NEW ROLE FOR SURVEYORS

In facing a number of fundamental challenges the role of surveyors has been changed over time. The current role of surveyors is twofold – mainstream role (as a traditional surveyor in particular) and pragmatic role (as a land professional in general). On the one hand, the mainstream role of the traditional surveyor includes collecting, merging, linking, improving, visualizing, and interpreting diverse land information with up-to-date and high-resolution geo-information and on the other hand, the pragmatic role of land professionals includes managing, controlling and developing land. In both cases, surveyors have to work transdisciplinary with other professionals, who are involved in land and natural resources management. Undoubtedly, this twofold role of surveyors has huge potential to make a big contribution for achieving the SDGs.

Surveyors are the custodians of enabling technologies and systems that are critically important to the future of the human race (FIG 2014, p.10). Therefore, it is one of the major roles of surveyor to offer professional expertise, advices and services on gathering of land information in different scales (i.e. national, regional, local) with various measures (e.g. land surveying, GNSS, photogrammetry, Remote sensing and GIS). In the contemporary era, surveyors are also widely involved in different branches of land management and are playing key roles in the domains of land management and land administration. Their present and future role as land professionals in land administration and management imbue them with new meaning and definition. In this respect "FIG-Definition of Surveyors" (www.fig.net, 2006 and Magel, 2006) outlines the potential role of surveyors, as

- Stabilisers of public order and the work of surveyors as a precondition of a flourishing economy.
- Guardians of rights of property and user as well as Guardians for a safe system of records in land administration systems.
- Producers, Administrators and Distributors of local, national and global spatial data infrastructure.
- Managers of land, water and other natural resources.
- Enablers, Mediators and Advisors for urban and rural planning and development, including conflict resolution.
- Hinges (Interfaces) in global, national and local early warning systems for disaster prevention and risk management.
- Active partners in the development and use of e.g. global navigation satellite systems (GNSS) and high resolution imaging systems.

It is an indisputable fact that professionally surveyors' work covers all facets of interdependence between land, people and institutions to bring about socio-economic development. These important professional connections occur both at local and international levels. It is evident that the scope of surveying profession will stretch further across the three pillars of sustainable development – social, economic and environmental. Undoubtedly, this relationship provides surveyors with an important role of agents of societal change in future.

6. CHANGING COMPETENCES

The changing role of the surveying profession has impact on the required competences and with it to the employability of surveyors. Institutions providing professional education and training have to respond to the new technologies and to the extended tasks of managing, controlling and developing land. The following paragraphs summarizes the paradigm change in knowledge, skills and competences.

From 'Measurement of geometry' to 'Assessment of thematic information'

Previously surveyors were experts in measuring only the geometry of objects by using conventional surveying instruments or photogrammetric methods. Thematic information about the objects was assessed by pure visual interpretation. Nowadays, new platforms and sensors provide images with high geometric, radiometric, spectral, and temporal resolutions, which enable a largely automated assessment of thematic information (e.g. land cover, soil moisture, tree heights) and monitoring the changes.

Surveying professionals have to gain additional knowledge, skills and competences about

- available platforms and sensor types (e.g. high resolution satellite images, Unmanned aerial vehicles / UAV, Laser Scanners);
- image processing methods (e.g. matching algorithms, geometric and radiometric corrections, classification methods, time series analysis); and
- quality assessment of results (e.g. verification and validation of automatically gained data sets).

From 'Mapping" to 'Geo-Information-Services'

In the past the result of surveying activities were often maps (topographic maps, site maps, cadastral maps). Surveyors were trained in drawing techniques and printing methods. The implementation of information technology (IT) led to a paradigm shift. Geographic Information Systems enable the storage, modelling, visualization and dissemination of various geodata sets, which describe the physical, ecological, economical, legal, and demographic characteristics of land.

Surveyors are becoming the experts for spatial data infrastructure, who generate and provide detailed, homogeneous, complete, verifiable, timely and easily accessible information on land. To meet this ongoing challenge, academic institutions have to integrate new training courses into their study programs to provide students with state-of-the-art knowledge on

- Geographic Information Systems (e.g. database management, data modelling, spatial analysis and geostatistics);
- Visualization and distribution of geodata (e.g. web-GIS technologies);
- Big Data technologies (e.g. crowd sourcing, cloud technologies);

From 'Land administration' to 'Land management':

The implementation and maintenance of the cadastre and in some countries of the land register is closely linked with the surveying profession. However, surveyors have performed other important tasks of state administration. The provision of the national grid, the production of topographic maps and the valuation of land are mentioned here. Nowadays, surveyors cooperate transdisciplinary with other professionals managing land and natural resources.

This new role as land professionals requires additional knowledge, skills and competences, as documented below:

- basic knowledges about natural processes and cultivation of land;
- environmental management (e.g. nature protection, environmental impact assessment)
- planning technologies (e.g. participation processes);
- land reform techniques (e.g. land consolidation);
- real property valuation approaches (e.g. sales comparison approach, cost approach)
- land policy, civics and ethical fundamentals;
- legal issues (e.g. land rights, gender law, public law) and
- negotiation and mediation skills (e.g. dealing with land conflicts)
- knowledge sharing, communication and decision making skills

***From 'Local knowledge' to 'International expertise*:**
International cooperation is an essential success factor for achieving the SDGs. Communication, cooperation and common actions of politicians, professionals and societies on a global level are the keys for poverty reduction, climate change response, gender equity and sustainable development. In the past, surveyors acted in local working areas in their own country or they were employed for small scale or national projects in foreign countries. In a globalised world, the challenges of our profession today are international (and joint) academic education and training programs, staff and student exchange on international level, international joint research activities as well as transboundary projects. They only can be met by

- knowledge of world languages;
- willingness for global mobility;
- trans-cultural thinking; and
- wide professional expertise.

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7. IMPACT ON PROFESSIONAL EDUCATION

The surveying profession is facing crucial supply and demand problems. On the one hand, modern land surveying profession demands from the graduates a broader range of knowledge and skills as land surveyors. On the other hand, in many countries, especially in the third world formal surveying education is often traditional and inadequate when compared to the required need for education programme. Moreover, educational institutions teaching surveying often suffers from a lack of new students. This gap between demand for and supply of quality and quantity of surveying education challenges surveying profession to explore its new dimensions.

Geomatics is a global industry with rapidly changing working procedures and corporate cultures. The traditional geodetic culture is disappearing and graduates need to be able to work in a global market. The need to understand geospatial data at different levels and to be cognisant of dynamics in both time and scale is now paramount to the profession. The importance is shifting from the mere map to the data input into maps and models, and thus the emphasis is shifting from the production of information to the role of information in making strategic decisions. In addition, the process involved in capturing and organising data across the globe is becoming harmonised as international standards are applied (Molenaar, 2012). To meet international industry and corporate demand geomatics professionals increasingly need to attain specialisms and exhibit competencies beyond traditional expectations. Thus programmes of education need to prepare innovative graduates to work with high competence, using specialised skills and deep knowledge, as producers, managers and users of geospatial information in many related disciplines.

In looking to the future of the surveying profession, educational institutions should endeavour to meet the challenges of the new requirements of the surveying profession by adapting curricula and by providing continuous professional development / Life Long Learning. It is important to have a well-defined sense of future direction and a clear plan including internationalization and networking, new teaching approaches and ways to achieve the new teaching approaches (Box 1).

Box 1: Future direction for long-standing professional education

Internationalization and Networking
- Increased mobility of students and teaching staff
- Study program in English language and joint study program
- Individual and institutional capacity building in developing countries
- Joint research activities
- Knowledge exchange (conferences, workshops, cooperation in national and international professional federations, e.g. FIG)
- Harmonization of curricula and education /training

New teaching approaches
- From teaching to learning
- From on-site lectures to off-site lectures
- From self-contained studies to life-long-learning

Ways to achieve the new teaching approaches
- Modern teaching and learning methods
- Quality Management
- Continuous Personal Development and Life Long Learning Program

8. CONCLUSIONS

The paper had identified that the key challenge for surveying education programmes is to keep pace with technological advancement and to supply skilled labour and multi-faceted professional competencies needed to respond global challenges. Furthermore, in acknowledging that surveying education systems vary in different countries, the need for the partnership with an objective to deliver a consistent global educational standard (i.e. using ECTS, leaning outcomes) should be recognized. A worldwide network of educational institutions can further drive interest in the surveying profession through joint programmes for students. Against this background, FIG commission 2 intends to publish a FIG guide to provide guidance by discussing and proposing a set of knowledge, skills and competencies a surveyor and land professional should gain through innovative professional education in order to meet the challenges posed by the emerging changes in the land profession. The commission members expect that the publication will come to light next year.

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BIOGRAPHICAL NOTES

Fahria MASUM is a consultant in Land Management and Land Policy. She gains more than 10 years of international experience in education and capacity development with key expertise in education strategy and policy development in land sector. She took part in consultancy projects funded by the World Bank, GIZ and GLTN/UN Habitat. She served Chair of Land Management at the Technical University of Munich (TUM), Germany as a scientific staff, 2007-2016. She was coordinator of the Master's Programme and Doctoral Studies Land Management and Land Tenure at TUM. Since 2010 she is guest lecturer 'land conflict management' at ITC, University of Twente, the Netherlands. Fahria Masum holds a PhD from the Technical University of Munich in urban land management.

Liza GROENENDIJK is the current chair of FIG Commission 2. She is a senior lecturer in Land Administration at the Faculty of Geo-information Sciences and Earth Observation (ITC) of the University of Twente, The Netherlands. Main areas of expertise: Land Administration, Securing Land Tenure, Women Land Rights. Further she is experienced in experience-based learning. Within the domain of land administration she worked in Africa with governments and academia and contributed to the creation of the Eastern Africa Land Administration Network.

Reinfried MANSBERGER currently works as an Assistant Professor at the Institute of Surveying, Remote Sensing and Land Information at the University of Natural Resources and Life Sciences, Vienna (BOKU Wien). In 1982 he obtained his Master's degree in surveying at the Vienna University of Technology. He obtained his PhD degree at the BOKU Wien. He is involved in FIG as Austrian delegate of Commission 2. Reinfried Mansberger is an elected member of the European Academy of Land Use and Development and Council member of the Austrian Society of Surveying and Geoinformation. His research work is focusing on Land Use Planning, Land Information, Environmental GIS Applications, and Cadastral Systems.

Audrey MARTIN is a senior lecturer with the Spatial Information Sciences group in the Dublin Institute of Technology where she is the Chair of the MSc in Geospatial Engineering. Her main area of expertise is Global Navigation Satellite Systems (GNSS) and Geodetic Surveying. Audrey has also been actively involved in the design and online international delivery of eLearning modules for CPD. She is a graduate from DIT in Geo-Surveying with additional academic qualifications from Germany and was awarded her PhD from the Engineering Faculty of University College Dublin in 2000. Audrey is a Chartered surveyor (SCSI/RICS) and is the current Chair of FIG Working Group 2.2 'Innovative Learning and Teaching'. Since 2017 Audrey has acted as the Irish academic delegate to EuroSDR.

CONTACTS

Fahria Masum
Land Management Consultant
Connollystrasse 26
80809 Munich
GERMANY
Tel: +49 89 35718704
Email: masum@landguidance.com

Liza Groenendijk (E.M.C.)
ITC - University of Twente
P.O.Box 217
Enschede 7500 AE,
THE NETHERLANDS
Tel. +31 (0)53 4874 528
Fax +31 (0)53 4874 575
Email: groenendijk@itc.nl
Web site: www.itc.nl

Reinfried Mansberger
Institute of Surveying, Remote Sensing and Land Information
Peter Jordanstrasse 82
A-1190 Vienna
AUSTRIA
Tel. +43 1 47654 85715
Email: mansberger@boku.ac.at
Web site: www.boku.ac.at

Audrey Martin
Dublin Institute of Technology
School of Surveying and Construction Management
Bolton Street, Dublin 1
IRELAND
Tel. +353 1 4023736
Fax +353 1 402 3999
Email: Audrey.martin@dit.ie

Web site: www.dit.ie