A REPORT ON THE ACTIVITIES OF COMMISSION 6 (ENGINEERING SURVEYS), OF THE INTERNATIONAL FEDERATION OF SURVEYORS (FIG)

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ABSTRACT

The International Federation of Surveyors (FIG) is an international, non-government organization whose purpose is to support international collaboration for the progress of surveying in all fields and applications, as stated on their web site (www.fig.net). The FIG's technical work is accomplished through ten commissions that pursue different topics of importance to surveyors. Commission 6 - Engineering Surveys, has a goal of supporting and promoting the discipline of surveying within the various professional fields of engineering. Our mission includes supporting development and multidisciplinary expertise leading to integrating survey methods with relevant data and instrumentation for various types of engineering problems; providing a forum for exchange of knowledge related to survey and organizations with links to topics of interest to surveyors, like metrology and quality control; and working with other groups and FIG Commissions to develop best practices, standards and co-operation on topics of common interest. To this end, Commission 6 has the following four Working Groups, each with a topic of concern to pursue:

Working Group 6.1 – Deformation Measurements and Analysis
Working Group 6.2 – Engineering Surveys for Industry and Research
Working Group 6.3 – Engineering Survey Data Bases and Facility Management
Working Group 6.4 – Engineering Surveys for Construction Works and Structural Engineering

This paper is an update on the activities of this varied and dynamic group of professional survey engineers that comprise FIG Commission 6.

INTRODUCTION

The International Federation of Surveyors (Fédération Internationale des Géomètres, FIG) is an international, United Nations recognized, non-government organization whose purpose is to support international collaboration for the progress of surveying in all fields and applications. It was founded in Paris, France in 1878 and is comprised of national associations and affiliate, corporate and academic members from more 100 different nations, representing all survey disciplines (FIG, 2004).

The FIG aims to promote the disciplines of surveying, to insure that the profession meets the needs of the market and communities they serve and to encourage the development of professional standards. The FIG activities are governed by a current work plan that is reviewed and updated each 4-year

period to respond to the changing world (technically, socially, economically, professionally) yet still meet the longer-term strategic plan of the organization (FIG, 2004). To accomplish these goals, there are ten Commissions, each with a different focus, that perform the technical and professional work to accomplish the current work plan of the organization. This information is disseminated to the profession at international congresses held every four years, at working weeks held annually and at regional conferences annually. Each of the ten Commissions host additional meetings and events to address their specific topic. This paper will focus on the activities of Commission 6 – Engineering Surveys. For further information on FIG and the other Commissions, refer to the FIG web site (http://www.fig.net/).

FIG COMMISSION 6

Within Commission 6 (www.fig.net/commission6), there are four major working groups with a definite focus of interest. Each working group uses task force groups, symposia, workshops, seminars, partnerships, publications and cooperation/collaboration with other groups and organizations to accomplish their particular focus. The following list is a summary of the current organization within Commission 6:

Working Group 6.1–Deformation Measurements and Analysis
Working Group 6.2–Engineering Surveys for Industry and Research
Working Group 6.3–Engineering Survey Data Bases and Facility Management
Working Group 6.4–Engineering Surveys for Construction Works and Structural Engineering

Working Group 6.1 – Deformation Measurements and Analysis

Chair – Dr. Adam Chrzanowski, Canada; Vice Chair – Cecilia Whitaker, USA

Working Group 6.1 (WG 6.1) is currently, the oldest (formed in 1972) working group in Commission 6. It is also perhaps the most active working group on the subject of deformation measurements of any international group focusing on this subject. The focus of WG 6.1 is the multidisciplinary study of deformation measurements and the analysis and modelling of these measurements. This includes pursuing and disseminating knowledge of the newest technologies and how they can be applied correctly and accurately for deformation measurements for a wide array of physical structures and geographical features. (For an excellent summary of the history and past activity of WG 6.1, see Chrzanowski, 2003.)

The working group achieves these goals in several ways. There have been eleven international symposia and two major workshops organized by this group since 1975 (Chrzanowski, 2003). These symposia attract an internationally varied group of engineers, scientists, academics, physicists, geologists and other disciplines that come to share and discuss methodology and results of their particular expertise in the area of deformation measurements. (The next symposium is scheduled for September 2005, in Shandong, China.) Additionally, international cooperation to solve specific problems relating to deformation measurements has been achieved by forming ad hoc investigating committees or task forces. We have had two task forces complete their investigations and publish the reports for the use of the international community (Task Force 6.1.1 (Chrzanowski and Chen, 1986); Task Force 6.1.2 (Welsch and Hennecke, 2001)). Currently, there are four task force groups in WG 6.1 with a specialized topic of interest:

Task Force 6.1.1 – Measurements and Analysis of Cyclic Deformations and Structural Vibrations
Task Force 6.1.2 – Optimal Use of Interferometric Synthetic Aperture Radar (InSAR)
Task Force 6.1.3 – Applications of Laser Scanning Technology in Deformation Measurements
Task Force 6.1.4 – Crustal Deformation

Current Activities of Working Group 6.1

The current activity of WG 6.1 concentrates on the automation of deformation surveys, use of Synthetic Aperture Radar (SAR) in interferometric determination of displacements, monitoring and analysis of structural vibrations and cyclic deformations, and physical interpretation, modelling, and prediction of deformations. Through the interdisciplinary approach to deformation studies, the FIG Working Group 6.1 links surveying and geodetic specialists with specialists in structural, mining, geomechanical, and geophysical disciplines.

The most recent event of WG 6.1 was the 11th International Symposium on Deformation Measurements that was held in May 2003 at Santorini Island, Greece. This symposium attracted more than 130 participants from 29 countries. There were 9 technical sessions with 55 presentations and 47 poster presentations. The topics included Tectonics and Seismology; Volcanology; Instrumentation and Techniques; Studies of Ancient Remains; InSAR; Monitoring Deformations of Engineering Structures; Geotechnical and Mining Engineering Applications among others. At the end of the three days of technical sessions, a business meeting was held to discuss the future plans of WG 6.1.

Several issues were brought to the floor and discussed. The Chair of WG 6.1 discussed the formation and implementation of a working group council to aid in the decision-making processes of the working group. This council is comprised of the Chair, Vice Chair, Task Force leaders, Past Chair and the last symposium organizer. The purpose of this Council is to help with deciding the locations and organization of the symposia, to decide on the formation of task forces, and to help with other issues that affect the workings of the whole group. Another topic that was discussed and implemented is the use of email distribution processes to provide a venue for the exchange of information and dissemination of new developments and/or information relative to deformation topics. The WG now is able to send out to all interested individuals, information about upcoming events, FIG newsletters, requests for information, updates from various sources and/or any information deemed related to deformation measurements or FIG that would be of interest to the distribution group. (Individuals wishing to be added to this list can contact the Vice Chair at cwhitaker@mwdh2o.com to be included in the next update.) Another purpose of this communication between members is to aid in cross-disciplinary communications since many members have connections to other organizations with similar interests. A goal of our group is to keep open lines of communication between all organizations/groups with an interest in deformation topics and techniques. The last order of business at the 11th Symposium was the formation of two new task forces, 6.1.5 and 6.1.6. These will be discussed below.

Task Force 6.1.1 – Measurements and Analysis of Cyclic Deformations and Structural Vibrations

Chair – Dr. Gethin Roberts, United Kingdom

This task force was also established at the FIG Congress in Washington in April 2002, and is chaired by Dr Gethin Roberts. Various members of the FIG showed interest in this task force topic, and contacts were established. One of the main aims of this task force is to establish techniques to enable cyclic deformations to be measured and analysed. This type of work is already underway at the University of Nottingham, whereby kinematic GPS, servo driven total stations, accelerometers and pseudolites are being used to measure dynamic deformations of structures. The types of structures currently under observation are bridges. This work is currently funded by the UK's Engineering and Physical Sciences Research Council under a joint project with Cranfield University entitled "A Remote Health Monitoring System Using Computational Simulation and GPS Sensors". In addition to the two research centers, Railtrack, W. S. Atkins and Pell Frishmann are also involved with this £500,000 (approximately $750,000) research project. The results from this project are presented at the various relevant FIG meetings.

Furthermore, the FIG meetings allow researchers from all over the world to gather and discuss various issues concerning the work. Consequently, individual links are firmed and research collaboration is

established. For example, there has been a great deal of collaborative research and exchanges with the University of Nottingham and the University of New South Wales. It is hoped that more similar collaboration will be established and encouraged through the FIG meetings. This means that such work will not simply concentrate within the FIG meetings themselves, but will expand outside of the meetings, but will then hopefully report back to the meetings and conferences through paper presentations. Members of this task force attended the IAG/FIG conference in Berlin in May 2002, and presented a variety of papers relevant to the field. This was a good meeting and an opportunity to talk with more colleagues about the variety of international work. A variety of papers on this subject were also presented at the FIG WG 6.1 meeting in Santorini in May 2003.

A workshop will be held at Nottingham during the summer of 2004. This will be in conjunction with a meeting of Working Group 6.4. It is anticipated that the attendees will be more than just surveyors, and will include structural engineers and other people interested in this type of work.
Anyone wishing to participate and contribute to Task Force 6.1.4 should contact Dr. Gethin Roberts.

Task Force 6.1.2 – Optimal Use of Interferometric Synthetic Aperture Radar (InSAR)

Chair – Dr. Xiaoli Ding, Hong Kong SAR, China

Task Force 6.1.3 was formed at the XXII FIG Congress held in Washington, D.C. in 2002. Dr. Xiaoli Ding, from the Hong Kong Polytechnic University was elected to lead to task force. The task force was formed for the purpose of further developing the technology of InSAR and its applications for deformation measurement uses.

Although InSAR has become an important technology for measuring deformations of the earth, especially in large-scale situations like earthquake studies, there are still significant issues that need to be refined for the more routine applications where InSAR could be used for deformation measurements. Difficulties associated with more routine applications include the effects of the atmosphere on the propagation of radar signals, the temporal/spatial decorrelation and the shadowing/overlapping of images in heavy vegetation or urban environments (Chrzanowski, 2003).

To try to resolve these issues and to make full use of this technology for deformation measurements, the task force has developed research directions and objectives. The main focuses are as follows (Chrzanowski, 2003):

- Development, test and standardization of algorithms, software and procedures for measuring deformations with InSAR
- Study of accuracy, reliability and sensitivity of InSAR measurements under various atmospheric, field and imaging conditions
- Characterizing and mitigation of atmospheric effects on InSAR measurements
- Integration of InSAR with other deformation measurement methods
- Study of deformations related to various engineering and geophysical problems

To facilitate these objectives, the task force will conduct research; organize conferences or workshops; carry out test campaigns; and facilitate discussion/collaboration of research and results among colleagues. Current activities have included members of the task force attending an advanced workshop on InSAR held in Hong Kong (Dec 2002), presenting papers at the InSAR sessions at the 11th International Symposium in Greece and planning for a workshop to be held in 2004 (Chrzanowski, 2003). Anyone wishing to participate and contribute to Task Force 6.1.3 should contact Dr. Xiaoli Ding.

Task Force 6.1.3 – Applications of Laser Scanning Technology in Deformation Measurements

Chair – Dr. Maria Tsakiri, Greece

Task Force 6.1.3 was newly formed at the 11th International Symposium held on Santorini Island in May 2003. Dr. Maria Tsakiri, from the National Technical University of Athens, Greece put forward a proposal to form a task force for the purpose of studying terrestrial laser scanning techniques for

deformation uses. Although the task force is newly formed, the research directions and objectives are laid out here.

The primary objective of this Task Force is to promote *the use of terrestrial laser scanning* as a recognised tool for spatial data capture in engineering projects. More specifically, the group will aim to advance the use of this new technology for geometric documentation and deformation monitoring in a variety of environments, particularly those at high risk and in need of remote measurements (e.g. structures, slopes, underground surveys, structural deformations of cultural heritage monuments). Further objectives are to investigate the integration of laser scanning measurements with other measuring techniques, such as conventional geodetic systems and photogrammetric techniques, and to explore the 3D modelling and visualisation issues of laser scanning data. Also, the group aims to investigate quality control and metrological aspects of the laser scanner data in order to provide recommendations for checking that the terrestrial laser scanner instrument is working correctly prior to its use as well as recommendations on its field use regarding issues such as data collection, storage, instrument independent exchange data format, use of targets for registration etc.

At the time of writing this report (January 2004) the chair of the group has finalised the regular members and is creating a Task Force website which will provide a focus for terrestrial laser scanning research with links to member's websites. It will also include a comprehensive reference list for terrestrial laser scanning studies that will be regularly updated as this technology is rapidly progressing. Also, the site aims to include a number of standardised terrestrial laser data sets to allow comparison between different software and processing methods.

Terrestrial Laser Scanning in Engineering Applications
While three-dimensional laser scanning systems have been used for years in high precision, small-scale industrial metrology applications as well as for airborne surveys, the use of laser scanning for large-scale (i.e. greater than a few meters in horizontal range) ground-based measurement operations is still in its infancy. Little published research considers high precision, three-dimensional resolution of ground or structural movement. Several commercial terrestrial laser-imaging systems have been recently released. These have ranges of up to 350m and can acquire up to 20,000 points per second. These imaging systems provide a user with a dense set of three-dimensional vectors to unknown points relative to the scanner location. The volume of points and high sampling frequency (a full scan can be captured in few minutes) of laser scanning offers users an unprecedented density of spatial information. For this reason, there is enormous potential for use of this instrumentation in monitoring applications where such dense data sets could provide great insight into the nature of structural deformations for risk assessment, change detection and structural model validation.

Two main factors influence the growth of users in engineering and surveying applications, one being the often wide gap between the commercially available scanners and the traditional surveying instruments which users are familiar with and secondly, the effective management and processing of laser scanner data. Furthermore, the emergence of laser scanning in engineering and surveying has led the need for the development of the necessary calibration protocol and the requirements for quality control assessment not only for the instruments but also for the data collection and field procedures.

Some of the Current Work of Task Force Members
One area where terrestrial laser scanning has been accepted as a very useful tool is in cultural heritage, as it is a natural progression from photogrammetry and the two technologies do possess many similarities. Applications vary from detailed documentation and 3D modelling to close-range structural recording (Boehler *et al.* 2003a, b, Barber *et al.* 2002, Ioannidis & Tsakiri 2003, Tsakiri *et al.* 2003)**.** On the other hand, most commercially available laser scanning systems make little attempt to integrate well into existing field survey practice, although many users such as the mining industry would benefit greatly from remote surveying tools.

A critical area of any new technology is the control check of the performance and metrological aspects of the instrumentation and field operation. Experiments to define the mechanical-optical stability of a number of instruments have indicated that the large weight of the currently available commercial laser scanners may be affecting a number of mechanical parameters such as eccentricity of axis (Ingensand *et al*. 2003).

The resolution and accuracy of the distance measurement provided by different types of long-range terrestrial scanners (pulse-range or frequency type) has been the subject of study of many groups. The experiments include comparison with EDM calibrated baselines (Boehler *et al.* 2003c, Licthi *et al.* 2000a, Gordon *et al.* 2001b) or laboratory tests with an interferometric calibration line (Ingensand *et al.* 2003). Most tests indicate that the range accuracy and resolution are within manufacturers' specifications.

Further to calibration analysis, the study for the establishment of suitable test sites and control facilities for laser scanner instruments is a topic under investigation (Iavarone & Martin 2003). It is important for the test facilities to provide adequate range and dispersion of control points in order to identify range and angular errors. Also, setting the standard practices involved in the collection and archiving of data from terrestrial laser scanners is a priority area for clients and contractors alike and there is work undertaken in this area by some members of the group (Barber *et al*. 2003).

Further advantages of the three-dimensional coordinate observations provided by the dense laser scan data sets, is that these are coupled with returned laser beam intensity. They become, therefore, radiometric data, which results in extending the scanner's capability from a geometric sensor to a multi-spectral imaging system. Studies on spectral filtering and classification of the point clouds allow for more effective processing of the data in a spectral feature sense rather than being dependent on the spatial sampling resolution of a scanner (Licthi 2003, Lichti & Harvey 2002).

The use of terrestrial laser scanning in deformation monitoring engineering applications at first may be questioned because of the relatively large single-point precision (about 5-6mm). However, the dense data sets allow for surface-wise modelling instead of point-wise analysis and provide in this way an almost ten-fold improvement in accuracy at the resultant surface model (Gordon *et al*. 2001a). This approach has shown that the technology can be used alike in large scale deformation applications such as in dam slope monitoring (Lichti *et al.* 2000b) and in small scale studies such as in precision measurements of laboratory loading tests (Gordon *et al*. 2002, 2003a, b). By allowing the 3D representation of a structure or testing object, the analytical models representing the bending and deforming mechanisms can be developed thus enhancing the understanding of their structural mechanisms.

Benchmarking and validation of the terrestrial laser scanner data is usually performed using surveying and photogrammetric methods either in a point-wise sense or surface-wise approach. Comparison with GPS measurements (Lichti *et al*. 2000a) and photogrammetry-derived point coordinates (Lichti *et al*. 2002) has shown successful results. There is still the need to investigate rigorous methods of benchmarking the laser scanner data. Anyone wishing to participate and contribute to Task Force 6.1.5 should contact Dr. Maria Tsakiri.

Task Force 6.1.4 – Crustal Deformation Chair – Dr. Stathis Stiros, Greece

Task Force 6.1.4 was newly formed after the 11th International Symposium held on Santorini Island in May 2003. Dr. Stathis Stiros, from Patras University, Athens, Greece, put forward a proposal to form a task force for the purpose of studying the crustal deformations due to plate boundaries, magma movement and volcanic eruptions. This task force is just newly formed and the proposed areas of study are laid out here.

This Task Force will consist of a small number (~4-8) of research centers in different parts of the world, and its main aims will be:

⇒ The identification of a few promising study areas, on the basis of their seismo-tectonic history and the availability of geodetic data
⇒ The collection and analysis of existing historical and modern geodetic and other data (satellite, triangulation, trilateration, spirit levelling, tilt data, tide-gauge data, etc.)
⇒ The encouragement of new, repeat surveys in the study areas
⇒ The adaptation of techniques and methodologies permitting an easy and approximate comparison between older, low accuracy data with modern data

This work, which will be based on data that currently exists, is expected to contribute to answers to certain of the following problems:

⇒ How does the rate of deformation change with time in test areas over periods 10^0-10^2 years long? Are current rates representative of longer-term ones?
⇒ Why apparent high rates of deformation are/have been observed in certain tectonically quiescent areas? Does this reflect measurement or geotechnical (near-surface effects) noise, or real effects? In this last case, what might be their implications?
⇒ Will a comparison of historical data and of data to be collected in the future permit to model certain old earthquakes, etc?
⇒ What is the reason for the discrepancies in the parameters of seismic faulting deduced from geodetic and seismological or other data- do such discrepancies reflect errors in certain type of data or over-simplifications in their modelling?
⇒ Are elastic deformation models suitable for all crustal deformation studies, or should geophysical studies also involve elasto-plastic, thermo-elastic or numerical analysis models in cases of specific geologic structures and environments (for instance volcanoes, etc.)?

Obviously, these problems are very important and complex, and cannot be answered by a small group of people. However, it is expected that a Task Force in the framework of FIG 6.1 will permit to bring to light and analyse very useful data and to inspire various researchers to investigate problems ignored so far; this will accelerate research in certain fields of crustal deformation and elucidate some at least of these matters. Anyone wishing to participate and contribute to Task Force 6.1.4 should contact Dr. Stathis Stiros.

Anyone wishing to participate and contribute to WG 6.1 should contact Dr. Adam Chrzanowski.

Working Group 6.2 – Engineering Surveys for Industry and Research

Chair – Dr. Thomas Wunderlich, Germany; Vice Chair – Dr. Alojz Kopáčik, Slovakia

The current activity of WG 6.2 concentrates on items of interest relevant to engineering surveys in industry like large-scale metrology and specialized measurement techniques. Current projects include engineering survey procedures for power plants, accelerators and nuclear research facilities; new techniques for as-built documentation and facility inventory like terrestrial laser scanning; industrial metrology for processes; and in-situ calibration of industrial robots. WG 6.2 works to provide a multidisciplinary, collaborative effort between survey, civil, structural and mechanical engineers, and research scientists to develop better approaches (better algorithms, instrumentation, methods, etc.) for solving complex engineering problems. Beneficiaries of this work include surveyors, engineers, manufacturers, scientists and university researchers interested in these more specialized areas of instrumentation and highly precise, large-scale metrology.

To facilitate these goals, WG 6.2 is involved in special meetings, workshops, tutorials, FIG Working Weeks and Congresses to implement the interaction between the disciplines. The group was co-sponsor of the 2nd International Conference on Engineering Surveying (INGEO 2002, November 11-13, Bratislava, Slovakia) where specialists from 9 countries participated in the proceedings. The

presentations were aimed at discussion of actual problems of engineering surveys; specifically conclusions of knowledge and results acquired utilizing new technologies. Eighty participants attended four technical sessions: Model Building and Data Processing; Deformation Measurement; Photogrammetry Applications; Sensors and Laser Equipment. In addition to the presentation of 29 technical papers, much discussion was held on the various topics. An exhibition highlighted measurement and computer techniques/products developed for engineering survey activities like structural monitoring, automated systems and terrestrial laser scanners. Participants also toured the Gabčíkovo Hydro-electric Power Station to view the automated monitoring systems at the facility. Final recommendations from the individual sessions of this conference are as follows:

- In the area of Model Building and Data Processing, a Theory of Robust Estimations will be used more often
- New processes of the refraction coefficient determination presented at the conference can evoke a development of the instruments with the automated correction of the refraction in a measurement process
- CCD sensors and the technologies working on a CCD base have become main technologies in engineering surveying and in the future it is expected the strong influence of these technologies on measurement systems development
- The most productive technology for data acquisition in surveying will be terrestrial laser scanners together with aerial scanners, their exploitation enabling creation of spatial (3D) information systems (including 3D Cadastre)
- Use of robotic total stations (RTS) in the area of kinematic applications (e.g. dynamic loading of the construction) requires resolution of the characteristics of RTS, which can be determined, e.g., with help of the dynamic tests presented at the conference

WG 6.2, along with Commission 6 and WG 6.3 and also two Slovakian survey organizations, is now actively engaged in preparation for the 3rd INGEO conference to be held in Bratislava in November 2004. The aim of the conference is to bring together professionals in the field of engineering surveying and facility management, to discuss the new technologies, their applicability and operability. This conference discussion will be focused on present-day questions of laser scanning, usage of laser scanners in industry surrounding, for dynamic deformations, data acquisition for facility management. The topics of the conference are the following:

- Present-day problems of engineering surveying
- Methods and technologies, trends in development of engineering surveying
- Engineering surveying procedures for industry (power plants, nuclear facilities, etc.)
- Industrial metrology in production, assembling and finishing processes, in-situ calibration of used technology
- Lasers and laser measurement systems, with special emphasis on terrestrial laser scanning,
- New technology for deformation measurement
- New techniques for as-built documentation and facility inventory
- Data integration in facility management, exchange, provision and presentation of facility management data in computer networks
- Industrial and city information systems

Deadline for submission of abstracts for this conference will be April 30, 2004. More information about this upcoming event is available on the FIG web site. WG 6.2 is also actively preparing tutorials to be included as part of the International Course for Engineering Surveying to held in Zürich, Switzerland March 15-19, 2004. Anyone wishing to participate and contribute to WG 6.2 should contact Dr. Thomas Wunderlich.

Working Group 6.3 – Engineering Survey Data Bases and Facility Management

Chair – Dr. Lothar Gründig, Germany; Vice Chair – Dr. Hande Demirel, Turkey

The current activity of WG 6.3 concentrates on items of interest relevant to the survey engineer and his role as the responsible manager of spatially referenced information. Current projects include concepts of the spatial data models; the handling of this data in computer networks; data integration; and automation and combination of data acquisition techniques. In addition to WG 6.3 contributions to FIG events, a Workshop on Engineering Survey Databases and Facility Management is being organized. Anyone wishing to participate and contribute to WG 6.3 should contact Dr. Lothar Gründig.

Working Group 6.4 – Engineering Surveys for Construction Works and Structural Engineering

Chair – Dr. Gethin Wyn Roberts, United Kingdom; Vice Chair – Dr. Jin Fengxiang, China

The current activity of WG 6.4 concentrates on items of interest relevant to promoting the use of adapted survey techniques and multidisciplinary collaboration between survey engineers and professional engineers in industry and the use, study and understanding of fibre optic sensors and embedded sensor array techniques in structural monitoring. Current projects include a Task Force on Fibre Optic Sensors to monitor the use of this technology on structural monitoring; precise methods and equipment for staking out during construction surveys, for structural works, for remote surveys and surveys for visualization and photo match; quality control and documentation for as-built plans; and dynamic monitoring of structures.

WG 6.4 was established at the Washington Congress of the FIG in 2002. The WG is chaired by Dr Gethin Roberts of the University of Nottingham, UK, and the vice-chair is Jin Fengxiang of China. There has already been some activity within this group at a one to one level. Members of this working group attended the FIG Congress in Washington and presented a variety of papers relevant to this field.

It is planned to expand this group to more than only surveyors. It is planned to include structural and civil engineers for example, who will benefit from the work being undertaken as well as contribute to the overall understanding. Furthermore, international groups concerned with structural engineering will be contacted and informed about forthcoming meetings. The WG has the following policy issues:

- Promoting the use of adapted survey techniques in industry & engineering
- Promoting a multidisciplinary collaboration between survey engineers, civil engineers, structural & mechanical engineers
- Promoting the understanding of fibre optic sensors, e.g. interferometric sensors, Brillouin and Raman scattering and Bragg gratings
- Study the use of embedded sensor arrays and the role of advanced surveying techniques for structural monitoring
- Creating an awareness of surveyors through a task force 'Fibre optic sensors' of the rapidly emerging technology of fibre optic sensors as "non-geodetic" sensors to measure deformations (strain) and temperatures in civil engineering structures

In addition, there are specific areas and projects that WG 6.4 will focus on:

- Precise methods and equipment for staking out during construction and structural works
- QC and documentation for as-built compared to as designed
- Precise methods and equipment for Engineering surveys for visualisation and photo match
- Precise methods and equipment for remote surveys (terrestrial laser scanners etc.)
- Dynamic Monitoring of Buildings and Structures
- Offshore construction surveys

WGF 6.4 participates in regular symposia and exchanges between researchers and concerned professionals. The WG 6.4 will have a workshop session at the Athens working week in May, and is

holding its own symposia at the University of Nottingham at the end of June 2004. In addition, future involvement with FIG Working Weeks and the 2006 FIG Congress will continue. The symposium will be aimed at surveyors and engineers, and will attempt to broaden itself to more than only the surveying and analysis of the data. Furthermore, a workshop will be held at the Nottingham Symposium, with papers and sessions covering the topic of Task Force 6.4.1 "Fibre Optic Sensors". The proceedings of the symposium at Nottingham will be published, and the organisers will look at the possibility of publishing selected papers in refereed journals soon after the symposium. In addition, papers from the symposium will be published on the Internet. Members of this group also participated in the IAG/FIG conference in Berlin in May 2002.

There are a number of beneficiaries from this working group including:

- Surveying profession becoming involved in this developing technology that will partly replace current geodetic techniques
- Surveyors wanting to acquire information about fibre optic sensors as used in "smart civil engineering structures"
- Engineers who have to decide about the best techniques to monitor civil engineering structures
- Universities teaching advanced sensor technology
- Engineering surveyors and engineers involved with construction and setting out will benefit, as well as structural engineers, current buildings and future building designs

Task Force 6.4.1 – Fibre Optic Sensors Chair – Dr. Fritz Brunner, Austria

There is one task force within WG6.4. This task force is lead by Prof Brunner of the Technical University of Graz, Austria. This task force focuses on the use of fibre optic sensors for monitoring structures, including real-time use and non-geodetic sensors in engineering. Anyone wishing to participate and contribute to Task Force should contact Dr. Fritz Brunner.

Anyone wishing to participate and contribute to WG 6.4 should contact Dr. Gethin Roberts.

SUMMARY

Commission 6 – Engineering Surveys, is a very active group within the FIG. We are enthusiastically working to fulfill the missions and goals of both Commission 6 and the FIG Council. Individuals interested in these topics of concern are encouraged to join our Commission and Working Groups. The next Commission 6 event, organized by WG 6.4 and WG 6.1.4, is the 1st International Symposium on Engineering Surveys for Construction Works and Structural Engineering to be held in Nottingham, England, June 28 – July 1, 2004. In November 2004, the 3rd International Conference on Engineering Surveys, organized by WG 6.2, will be held in Bratislava, Slovakia. In September 2005, the 12th International Symposium on Deformation Measurements, organized by WG 6.1, will be held in Shandong, China. The next FIG Working Week is scheduled for May 2004 in Athens, Greece and the next FIG Congress is scheduled for Munich, Germany in 2006. Commission 6 encourages participation at all these future events.

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