
Research and Practical Trends in Geospatial Sciences: the Five to Seven Year Vision

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Abstract:

Recently professional societies have been undergoing fundamental restructuring brought on by extensive technological change and rapid evolution of geospatial science. Practically all professional communities have been affected. Communities are embracing digital techniques, modern equipment, software and new technological solutions at a staggering pace. In this situation, when planning financial investments and intellectual resource management, it is crucial to have a clear understanding of those trends that will be in great demand in 5-7 years. The paper reviews current scientific and practical activities of such non-governmental international organizations as International Federation of Surveyors, International Cartographic Association, and International Society for Photogrammetry and Remote Sensing, analyzes and groups most relevant topics brought up at their scientific events, forecasts most probable research and practical trends in geospatial sciences, outlines top-most leading countries and emerging markets for further detailed analysis of their activities, types of scientific cooperation and joint implementation projects.

1 Introduction

Permanent and rapid evolution and diversity of science and technology makes us take a stop and then jump forward in the future to have a look backwards for a better understanding of which of the current and advanced tendencies will be in use in 5 or 7 years from now. In this line it is essential to have a clear assessment procedure allowing us to understand which of the technologies and scientific fields the society concentrates its intellect and forces at present will be in great demand at that time, as well as to find out the spheres for efficient actions to be done in the nearest future.

For this purpose it was decided to analyze the current scientific research, review and practical papers presented at the congresses, conferences, working weeks, and workshops of several well-known non-governmental international organizations, published from 2009 to 2014. As a rule, the missions of these organizations are dedicated to the development of an active international cooperation for the advancement of knowledge, research, development, education and training in spatial sciences, their integration and applications to contribute to the well-being of humankind and the sustainability of the environment. Due to the fact that both current research and practical activities incorporate areas of different sciences dealing with acquisition, analysis, processing, storage, integration, and visualization of spatial information in our study we investigated all of the theoretical, practical, and review papers published at the congresses and other scientific events of such international organizations as

International Federation of Surveyors (FIG), International Cartographic Association (ICA), and International Society for Photogrammetry and Remote Sensing (ISPRS).

The results of the analysis gave us some ideas about:

1. Topmost scientific subject domains which lie in the area of interests of the professional societies
2. A number of leading countries that make major contribution in research and implementation of advanced practices both in the field of geospatial sciences (GS) and other sciences related to GS
3. The number of the countries, presenting innovation technologies and research, that can be considered as potential partners in future research and project activities
4. The external emerging markets for the development of international cooperation
5. A list of national research and development centres and institutions whose work and experiences should be studied and analyzed properly, and then taken into consideration for planning one's own activities.

For this study we used such research tools as target group surveys and interviews; analysis of the 2009 – 2014 scientific works published at the FIG, ICA, and ISPRS congresses, working weeks and conferences; analysis of national institutions, planning, research and production cycles, web-sites.

In this paper we will describe only the results of our study concerning scientific activities of FIG, ICA, and ISPRS, leaving the rest of received information beyond the scope of this work.

2 International Federation of Surveyors

FIG is a recognized non-governmental organization of national member associations that covers the whole range of professional fields within the global surveying community. It represents more than 120 countries throughout the world. The aim of the Federation is to ensure that the disciplines of surveying and all who practice them meet the needs of the markets and communities that they serve. FIG provides an international forum for discussion and development aiming to promote professional practice and standards. From this point of view it was quite interesting to study current activities applied by professionals in their everyday life.

FIG's technical work is led by ten commissions. Major element, providing successful work of FIG Commissions, is the human resource capacity building and resources of their members, representing national professional federations, associations and societies.

Within our study we analyzed 890 papers published at different scientific FIG events from 2012 to 2014.

The results of our analysis allowed marking out the most mentioned topics in the field of development and use of advanced techniques, devices, tools, and software. Later, the study of these topics enabled us to group them into fourteen major subgroups, describing current topmost practical and scientific interests, see Table 1.

Table 1: Frequency of publications devoted to particular topics in the FIG materials 2012-2014

No	Most popular subgroups of topics, brought up at FIG events from 2012 to 2014	Percentage
1	Cadastre: reforms, systems, innovation, administration, 3D and 4D cadastre, taxation, rights	36.4
2	GNSS: precise point positioning, applications, spatial data infrastructure, multi-sensor systems	11.6
3	Applied geodesy: professional standards and practices, tools and methods	9.7
4	Laser scanning: techniques and applications, 3D modelling, remote sensing, BIM	8.1
5	Hydrography: planning, environment, water resources management	6.3
6	Web-GIS and GIS: mapping, GIS algorithms and techniques, maps and new trends in cartographic products	5.5
7	Professional education: teaching methods, retraining	5.4
8	Spatial algorithms and techniques, spatial data processing	4.9
9	Deformation monitoring, geodynamics	4.1
10	Global networks	2.5
11	Geodetic methods for studying climate change	1.8
12	Gravity field: geoid, heights	1.6
13	UAV in geodesy, remote sensing data	1.4
14	Electronic management systems	0.6

Since FIG represents professional practices and experiences, the next step of the analysis was to find out those countries that make major contribution in implementation and research of the marked out subgroups, see Figure 1.

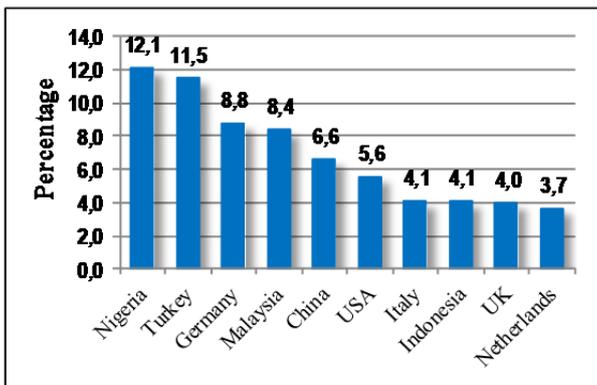


Figure 1: Countries that made major contribution in publishing advanced scientific papers at FIG International scientific events (2012-2014)

Due to the fact that the topics of subgroups 10, 11, 13 and 14 were brought up by just certain professionals and scientists representing various countries, it was difficult to mark out

the leading countries. In this regard it is possible to make an assumption that here we can speak about:

- New trends that have not received wide distribution among specialists yet, but may become very popular in future
- Trends losing their relevance
- Trends that need advanced material base and further investigation.

We also did not analyse subgroup 7 (Professional education: teaching methods and retraining) in view of the fact that it was beyond the scope of our study.

While analyzing metadata on leading countries of the marked out subgroups we noticed a clear correlation between the place of an FIG event and a large number of papers presented by the local professionals and scientists. Thus, the obtained results may not form a clear view, concerning such countries as Malaysia, Nigeria, Italy, and Uruguay.

The carried out analysis of the FIG publications, devoted to current needs and practices, allows drawing the most likely scenarios that may take place in the development of geodesy in the nearest future:

1. Further development of GIS
2. Development and integration of different GNSS
3. Wide use of crowdsourcing and open-source software for data processing
4. Considerable changes in traditional approaches used in geodesy (geodetic survey) with tendency shift towards multi-sensor systems, remote sensing, UAV, on-line data exchange and processing
5. Automated processing of geodetic observations
6. Special attention will be paid to the development of general approaches, techniques, and applications to solve problems and satisfy needs of the first subgroup, see Table 1.
7. Emergence of specialized personnel training and retraining centers providing life-long training.

3 International Cartographic association

International Cartographic Association is a non-governmental organisation that was founded in 1959. ICA promotes the development of cartography and related sciences; covers coordination and carrying out cartographic research requiring international cooperation. The Association provides international discussion platforms for scientists and professionals enabling professional society to exchange experience and advanced achievements in cartography.

ICA's technical work is led by 27 commissions, most of which cover a wide range of cartography related areas.

Within the study slightly more than 600 papers that were published by the ICA from 2009 to 2013 were analyzed.

The thing, that came out from the preliminary study of ICA's papers, was that recent publishing record of the Association is rather poor (only 610 papers for 5 years), covering a narrow area of the discussed topics. Most papers deal with disciplines which have traditionally belonged to the field of other professional organizations.

Analysis of ICA's scientific interests enabled drawing a conclusion that most commissions provide summarization and transfer of existing knowledge and technologies that can be adopted in cartography. From our point of view, exceptions to this rule are only commissions Cartography in Early Warning and Crisis Management, Generalization and Multiple Representation, Cognitive Issues in Geographic Information Visualization, Geospatial Analysis and Modelling, and Planetary Cartography. For further analysis the activities of only mentioned above commissions were taken into consideration.

At the same time, since 2009 to 2013, dynamic changes were noted in the content of published papers, showing clear deviation from reviewing character to discussion of new trends and technologies that can be adopted in cartography.

Based on the results of the analysis of the publications, the most relevant topics in the field of development and use of advanced techniques, devices, tools, and software were marked out. The study of the topics allowed their grouping into nine subgroups, reflecting highest scientific and practical interests, see Table 2.

Table 2: Frequency of publications devoted to particular topics in the ICA publications 2009-2013

No	Most popular subgroups of topics brought up at ICA scientific events from 2009 to 2013	Percentage
1	Automatic generalization of spatial data	20.2
2	GIS applications	15.2
3	Processing of high-resolution satellite imagery (data acquisition, analysis, recognition and classification; visualization)	15.2
4	Geospatial analysis	14.1
5	Photogrammetry and remote sensing	8.1
6	Spatial data infrastructure	8.1
7	Multi-dimensional thematic mapping	8.1
8	Cartographic web applications and services	7.1
9	Spatial data quality	4.0

Table 2 shows than a notable part of the presented topics has never been in the ICA's field of study. Figure 2 demonstrates those countries that made major contribution in publishing of advanced scientific papers at ICA's scientific events from 2009 to 2013.

4 International Society for Photogrammetry and Remote Sensing

International Society for Photogrammetry and Remote Sensing was founded in 1910. ISPRS is a non-governmental organization devoted to the development of international cooperation for the advancement of remote sensing and photogrammetry together with their applications. The ISPRS's scientific interests include: photogrammetry, remote sensing, spatial information systems and related disciplines, as well as applications in cartography, geodesy, Earth and engineering sciences, environmental monitoring and protection, along

with industrial design and manufacturing, objects of historical heritage preservation, medicine and so on.

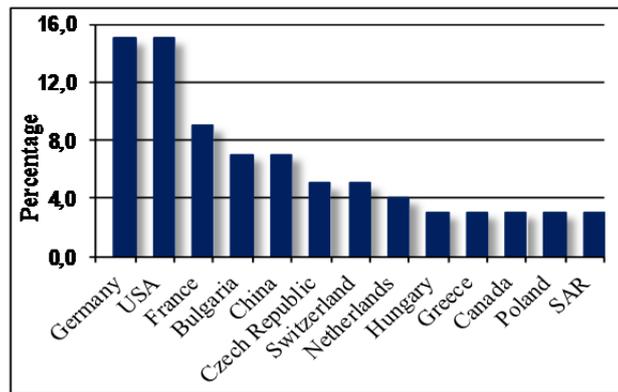


Figure 2: Countries that made major contribution in publishing advanced scientific papers at ICA International Cartographic Conferences 2009-2013 (percentage)

Scientific activity of the Society is coordinated by its eight Technical commissions: Sensors and Platforms for Remote Sensing, Theory and Concepts of Spatial Information Science, Photogrammetric Computer Vision and Image Analysis, Geospatial Databases and Location Based Services, Close-Range Imaging, Analysis and Applications, Education, Technology Transfer and Capacity Development, Thematic Processing, Modeling and Analysis of Remotely Sensed Data, Remote Sensing Applications and Policies.

Within our study we analyzed the ISPRS materials, altogether 546 papers, published at various scientific events of the Society between 2012-2014.

The results of the analysis of the materials published in 2012 allowed marking out and grouping the most relevant topics brought up at ISPRS scientific events, see Table 3, and selecting the most active countries involved in research activities of these groups.

The analysis of the published in 2012 papers allows making an assumption that world scientists are interested in the search and development of new algorithms, methods and technologies of data acquisition (including automatic), analysis, processing, storage, exchange and updating into practitioners' everyday life activities. First of all it concerns such activities as terrestrial and aerial laser scanning, usage of UAVs and services.

Comparing 2012 to 2013-2014, a significant reduction of topical subdivision was noticed, see Table 4. The analysis of papers for the period from 2013 to 2014 made it possible to conclude that scientists, previously conducting their research in highly specialized fields, found common grounds with a number of inter-disciplinary matters dedicated to geospatial sciences.

The study of scientific activities, demonstrated at 2013-2014 ISPRS congresses, conferences, symposiums and workshops (altogether 484 papers) allows pointing out the leading countries that conduct their research at the cutting edge achievements in science and practices, see Figure 3.

Table 3: Frequency of publications devoted to particular topics in the ISPRS materials 2012

No	Most popular topics brought up in ISPRS papers 2012	Percentage
1	Remote sensing: algorithms and methods	54.9
2	SAR, LiDAR, Radar	6.8
3	Data bases: automatic acquisition, processing, storage, and updating of spatial data	4.9
4	UAV	0.5
5	Spatial data infrastructure	2.9
6	Mapping, geospatial services	9.2
7	Virtual models, data visualisation	5.3
8	Web applications and services	7.3
9	3D models for disaster management, environmental monitoring	2.4
10	Point cloud processing	8.3
11	Spatial data: quality assessment	2.4

Table 4: Frequency of publications devoted to particular topics in the ISPRS materials 2013-2014

No	Most popular subgroups of topics brought up in ISPRS papers 2013-2014	Percentage
1	Close-range imagery: analysis and applications	28.6
2	Photogrammetric computer vision and image analysis	22.2
3	Remote sensing: sensors and platforms	12.8
4	Thematic data processing, modelling and remote sensing data analysis	12.5
5	Remote sensing data: development strategies and applications	9.4
6	Spatial data bases and services, web-services	8.4
7	Theory and concepts of geospatial sciences	6.1

Thus, the results of our analysis on ISPRS 2013-2014 scientific activities, as well as target group surveys and interviews, allow us to make an assumption that in the nearest future the following trends will most probably take place in the development of geospatial sciences:

- Gradual replacement of LiDARs by photogrammetry (creating dense and exact DSMs)
- LiDARs will keep their role for forest and transmission lines survey
- Creation of 3D city models will be done by photogrammetric survey
- There will be an increase in use of 3D city models and textures
- Probably there will be the increase of photogrammetric data processing for open-cast quarries
- Increase of small aircraft and UAVs (payload 3-5 kilograms) usage for surveying objects, located in the areas outside of the city's limits
- There will be further increase of UAV usage for aerial monitoring of linear objects
- Further development and use of high-end medium format camera solutions
- Significant development and usage of perspective aerial photography within city's limits

- Steady tendencies in the development of airborne multi- and hyperspectral imaging systems
- A lot of research will be done to find solutions for large volume digital data processing, including aerial and satellite surveys
- Development of new principles for data storage and fast availability
- Significant increase in speed and flexibility for updating of cartographic products.

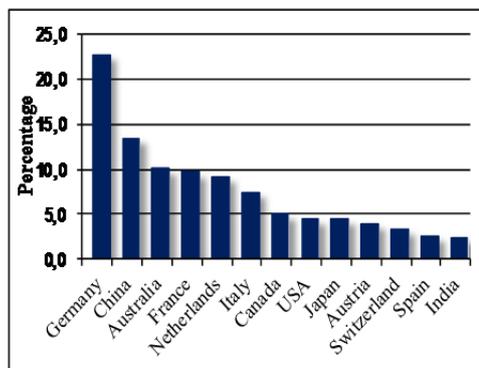


Figure 3: Countries that presented largest number of papers and reports at ISPRS scientific events in 2012-2014

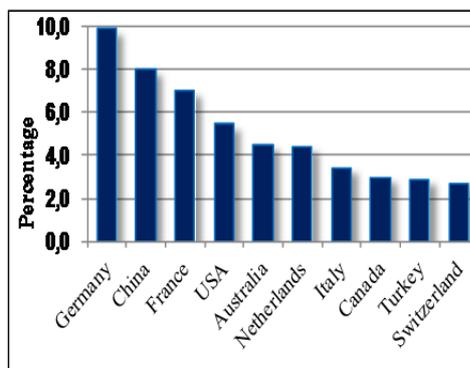


Figure 4: Top ten countries, making major contribution in research and implementation related to GS

CONCLUSION

Owing to the analysis of FIG, ICA, and ISPRS's scientific and practical activities it is possible to draw a general picture of those countries that are largely involved in work on top-most scientific domains lying in the area of interests of these organizations. Based on the results of our study we marked out ten leading countries making major contribution in research and implementation related to GS, see Figure 4.

From Figure 4 we can see that Germany and China are undisputable world leaders in conducting cutting edge research and practical implementation in fields related to GS. They are also in the top-five list of all of the studied organizations, which makes their experience interesting and needed to be properly studied. Special attention and deep analysis of innovation, research, practical implementation, as well as short and middle term planning must be paid to the activity of national agencies, research and development institutes, and professional organizations of such countries as Germany, China, France, USA, Australia, Netherlands, Italy, Canada, Turkey, and Switzerland.

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