

ICA'S MODERN CARTOGRAPHY

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Abstract

The International Cartographic Association was established in 1959. The mission of the ICA is to promote the disciplines and professions of cartography and GI science in an international context. The successful development of modern cartography requires integrated interdisciplinary approaches from domains such as information technology, communication science, cognitive sciences, and geospatial information management. It is those interdisciplinary approaches which make sure that we work towards human-centred application developments by applying innovative engineering methods and tools in a rapidly developing technological environment. Visualization of selected information means that some features present in reality are depicted more prominently than others, while many features might not even be depicted at all according to the theory of generalization, which is well-known for experienced cartographers; however, this can be absolutely obscure for the ordinary users. Abstract visualisation makes a map very powerful, as it helps to perceive and interpret complex situations efficiently.

Keywords: Cartography, visualization, ICA

INTRODUCTION

The information technology revolution of the last fifty-sixty years has transformed all disciplines, including cartography. As the International Cartographic Association (ICA) was established in 1959, we can state the IT development has influenced its operation that since the first years of the organisation. The history of the ICA, the focus of our international cartographic conferences clearly reflect to this development. During this time (mostly from the internet era) cartographers invented various terms to describe the rapid development process, like cybercartography, neocartography, cartography 2.0 or modern cartography. (Recently, the last two terms seem to be used most frequently.). This paper identifies the most important moments (milestones) of these decades based on the development of cartography, information technology and their effect on the organisation.

The role and place of cartography amongst other sciences have changed time to time. Cartography, as a practice of map making was known even in the ancient times, but became an independent science only in the first decades of the 20th century. If we need to list the recent tasks of cartography, our statements can be quite general:

- Cartography wants to understand and represent the global problems.
- Maps are the best tools to visualise the spatial, economic relationships.
- Cartography provides a global forum for experts: the universality of science is one of the most important opportunities of researchers. Cartography was always open towards other sciences, which is proved by the fact that the ICA was accepted as a union member of the ICSU (International Council for Science) in 2014.
- The adoption of new and more global aims, reflecting the international vision of the ICA's foundation years, has led to a more expansive policy of interaction with sister societies and with international organisations.
- Cartographers have to follow the technological and IT developments, if necessary they even have to develop applications.
- Using their knowledge and experience of the technological developments, cartographers have to support the education, the national mapping activities including the preservation of cartographic heritage (Gercsák and Elek, 2012).

20TH CENTURY MILESTONES IN CARTOGRAPHY

The cartographic milestones of the 20th century were not based only on the development of informatics (except the last one or two decades), but there were some other innovations which had a significant role in the history of cartography. The themes of the ICA's international cartographic conferences (ICC) reflect on the most relevant new technologies, so the scientific presentations at the ICCs is one of the most prominent evidences of the rapid technological development.

Aerial photography, photogrammetry

The technology developed quite slowly in the beginning of the 20th century, but it became soon (especially after World War II) the most important method for creating topographic maps. Due to the complexity of the technology and the necessary infrastructure, this method was used first by the national mapping agencies (at that time mostly military mapping agencies). It is also important to mention that nowadays, thanks to the digital cameras and UAVs, this technology is much more affordable even for individuals supposing that they can handle big data, which definitely requires very powerful IT devices and sophisticated software solutions. Naturally, the recent users are not really focusing on the classical topographic mapping (because these data are already available in digital form), but other thematic applications, like crisis management (flood, forest fire), archaeological, vegetation mapping or similar surveys.

Nowadays the technology is still frequently used, but we have to emphasize two important changes, improvements: the technology has totally changed to digital and the resolution is also increasing continuously allowing larger scale thematic applications.

Remote sensing

The space race was one of the most prominent areas of the Cold War era. Both parties (the rivals) wanted to prove their technological state of development. The Soviet Union launched the first artificial satellite (1957), they successfully completed the first satellite impact on the Moon (1959) and they completed the first manned satellite mission (1961). At that time remote sensing was used only for military surveillance and reconnaissance purposes, but due to the limitations of the early remote sensing technologies the analogue photo films had to be transported back to the earth for developing. The first digital remote sensing solutions were developed only in the beginning of the 1970s: it requires the evolving of the sensors, the data transfer methods and the data processing technologies. We have to emphasize the role of the first earth resources technology satellite, the Landsat, which is the longest running civil acquisition. The success of the Landsat satellites made the civil areas understand the role of this technology.

We also have to mention that the use of satellite images, the continuously improving resolution made it possible to cease the secrecy of aerial photographs and topographic maps. Practically this technological improvement coincided with the political change in Eastern Europe, so it was easier to make the political decision on the free access of such cartographic products.

Computers

The wider industrial use of computers started at the beginning of the 1960s mostly in North America, but the IT and electronic support had a very important role on the Japanese industry (particularly on car manufacturing) developing robot technologies. At that time mostly the governmental organisations (mainly the military and administration) had access or had enough resources to the information technology. Although the idea of geographic information software was invented at that time (1960s), it was far from being widely used.

The release of personal computers in 1981 (IBM) brought the real breakthrough in the number of computer users. Although at the beginning the PC prices were quite high, the prices dropped down very quickly thanks to the clones and it let even simple home users buy such machines. The very first wide-spread use of computers was word processing to replace type writing and to allow saving and easy text modification. We have to emphasize the role of other developments, like computer games, which dramatically increased the number of amateur computer users and increased the multimedia capabilities of personal computers. The second important step was the development of web in 1990 (Tim Berners-Lee). After a few years – partly thanks to the more and more user-friendly PC graphic environments and operation systems – the richer and richer content on the websites and new web-based services have made the computer usage even more attractive for even the non-computer users.

The PC era also supported higher education (and later all lower levels of education) to use personal computers in the education, which practically influenced not only the training courses and subjects related to information technology, but all other areas, especially natural sciences. Nowadays it is difficult to find any scientific or scholarly area which is not influenced by the rapid changes of the information technology.

Geographic information system

From cartographic point of view the most relevant milestone was the invention of the geographic information system. As mentioned previously, the GIS was invented about fifty years ago by geographers to process scientifically digital statistical information. At that time the IT hardware and software environment was very limited. There were two main constraints in GIS at that time:

- digital maps were not available in the early era of GIS; in most of the countries national mapping agencies have started the digitization of their topographic maps only in the PC era (1980-90s); depending on the size of the country and the largest available scale, the digitizing process took as many as 10-15 years;
- although the visualisation part is not the most important function of GIS (in the early GIS ages it was probably more important, because the visualisation on computer screens was even more limited), the output technologies – computer printers – were not suitable for sophisticated output before the maturing of laser and inkjet printing models.

The continuous development of GIS was a very important contribution to modern cartography. GIS itself is not able to solve all problems of cartography, but nowadays even the most complex cartographic processes (like the generalisation or 3D representation) are supported in some GIS packages or the national mapping agencies themselves develop solutions.

Global Navigation Satellite System

Intercontinental transportation (flights, ship transportation, submarines) required a global navigation system even in the first part of the 20th century. After World War II several methods were invented, but the first real solution was Navstar, the first satellite-based global navigation system. The theoretical background was invented in the 1960s, but the space technologies were able to provide user-friendly and reliable solution only after some decades, in the middle of the 1990s. This solution was also dependent on the development of information technology, where even the simplest devices were able to manage the required measurements and calculations.

Nowadays the technology is available in more and more simple devices (mobile phones, smartphones, tablets, digital cameras) allowing practically each citizen to locate their positions continuously and share it with other people on social media or use any types of location based services.

Laser scanning

Laser scanning is a remote sensing technology, which has already been developed around the 1960s, but the real cartographic application became available only since the middle of the 1990s. Nowadays this is definitely one of the most prominent applications which generates big data; the fast and efficient processing requires specially designed software environment.

Terabytes of data can be generated by laser scanning even in one day or shorter time, so powerful IT solutions are really necessary to achieve a simple goal: the data processing have to keep pace with the generation of laser scanning data. In many countries laser scanning data are freely available on the websites of national mapping agencies (thanks to the continuously developing bandwidths), but unexperienced users have no practice on big data (at least not on common desktop or laptop computers).

Unmanned Aerial Vehicles

Nowadays when we are talking about modern cartography we regularly mention one of the most prominent characteristic features: the democratised process of mapmaking. Unmanned aerial vehicles (UAVs) or drones are one of the most prominent tools of this democratisation, but the state cartography and the national regulations are still working on the proper regulation of these devices. Previously all aerial photography or remote sensing technologies were used by national mapping agencies or larger companies, because it required large financial investment and technological experience.

Drones are known as trendy and simple presents, rather toys for ordinary people. Thanks to continuously improving developments, like modern advanced batteries, digital cameras (CCD sensors), affordable memory cards or solid state drives as storage devices, remote controlling technologies, simple drones became cheap commercial products. But from professional point of view unmanned aerial vehicles are real tools not only for cartographers, but all other areas where fast and affordable remote sensing devices are required. Although the professional UAVs are quite expensive, these are

still much more flexible and affordable compared to the real airplane based air-borne remote sensing technologies (no need for close airports/airfields). In addition to autonomous operation, certain drones carry a myriad of various sensors. The convenience of inspecting vast infrastructure without significant time and manpower invested is enough of a reason for GIS experts, surveyors, and construction firms to deploy drones.

WORLD-WIDE MAPPING, GLOBAL MAP SERVICES

Map of the World and its digital realisations

It is difficult to imagine that even fifty years ago the largest scale in which the whole earth (every continent) was mapped was 1:1 million only. In the Cold War era it was important for both sides to have precise information, detailed maps of the most relevant areas, but they also tried to collect information on all continental (and marine) areas. The ICA was established in 1959 by Western countries and socialist (Eastern Bloc) countries were able to join only after 1964. Eduard Imhof, the first ICA President mentioned at the first General Assembly of the ICA in 1961: *Good, accurate topographical maps at scales larger than 1:100 000 scarcely exist today for more than about 1% of the earth's surface. For vast regions it is not even possible to compile the International Map of the World to 1:1 000 000 with uniformly good topographic quality* (Ormeling, 1984). Although the project on producing the International Map of the World begun in 1913 to create a complete map of the world according to internationally agreed standards, finally only 800 to 1000 of 2500 planned maps were completed, when the United Nations Organisation stopped the project (the idea was originally suggested by the German geographer Albrecht Penck at the end of the 19th century).

Only forty years ago from now socialist countries were able to present their 1:2 500 000 scale Map of the World (Karta Mira) at the ICC 1976 in Moscow (altogether 224 sheets), but certain sheets were not really easily available for Western countries (Figure 1).

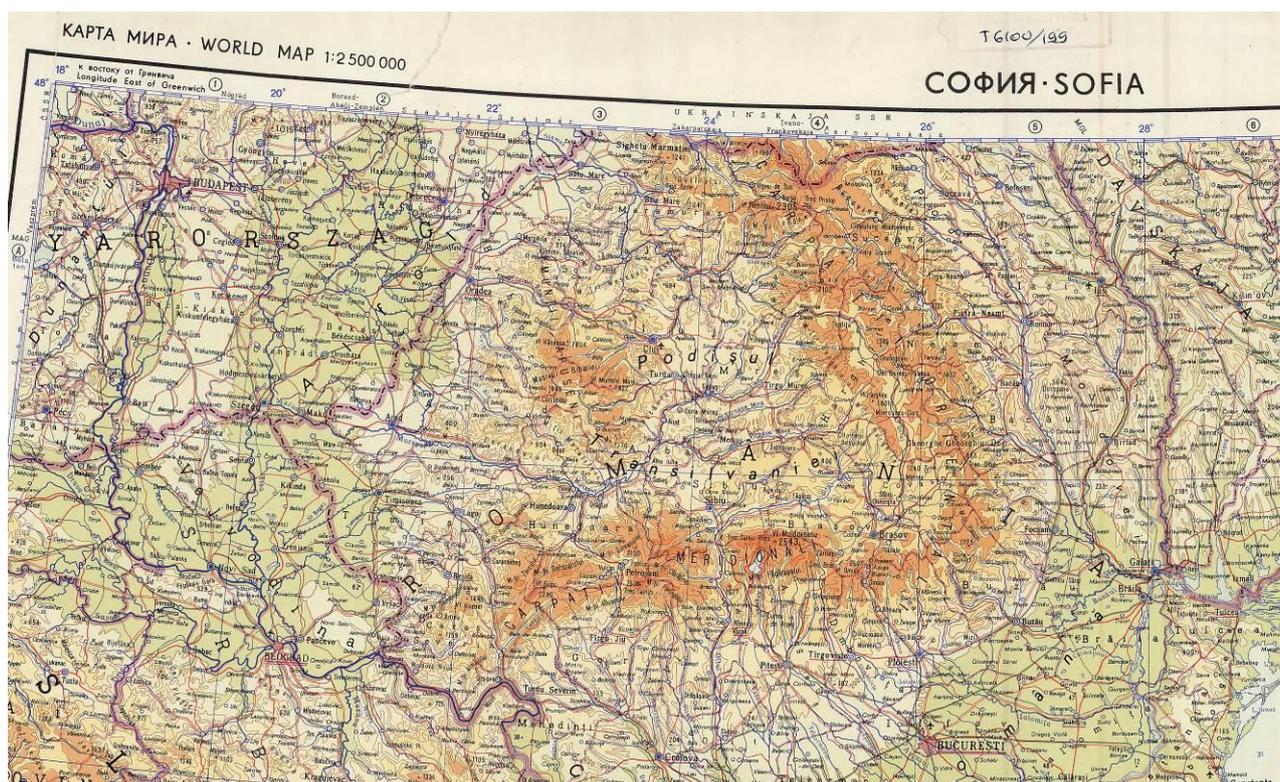


Figure 1. A small section of the 1:2 500 000 scale Map of the World

In the GIS era it was important to have a global digital map (database) available, but without having it in paper form it was not easy to complete this mission (such maps were created mostly for military purpose). Finally, the first version of the *Digital Chart of the World* was released in 1992; this is a consistent world-wide cartographic database at a scale of 1:1 000 000. Since then this unique public domain global GIS database of 1.7 GB has been translated into most major GIS formats and distributed to several thousand GIS users world-wide. This database became freely available after 2006.

On-line global mapping services

For ordinary people, for common computer users the best -known cartographic milestone is the appearance of on-line global mapping services. Even in the very early stage of the web era such services were developed. The first (experimental) one was the Xerox ParcViewer (1993), but comparing it to the recent services it was a very embryonic static service, providing only shorelines, country borders and limited hydrography in a raster image. The first commercial map service was MapQuest (1996), but street-level maps were provided only for US cities. America Online acquired the company in 2000, but it had the second highest share of the online mapping market in 2015. A UK-based company, Multimaps provided a similar service for United Kingdom. This company was acquired by Microsoft in 2007 and merged into Bing Maps in 2010.

It is also necessary to mention some other, non-commercial (partly experimental) services, which mostly provided satellite images:

- TerraServer (1998–2000): this service was a joint effort of USGS (which serves USA by providing scientific information to describe and understand the Earth, so we can treat it as a national mapping agency), Microsoft and HP. It was created as a demonstration system to advertise the scalability of Microsoft's Windows NT Server and SQL Server, and used satellite images from the USGS and the Russian Federal Space Agency.
- NASA World Wind (2003): World Wind was an open-source, graphically rich 3D virtual globe, which was first developed by NASA in 2003 for use on personal computers in Windows environment. The program overlays mostly NASA and USGS satellite imagery (Blue Marble, Landsat 7, SRTM, MODIS), aerial photography, topographic maps.

For most of the ordinary web users (desktop computers and mobile devices) the best -known (and most frequently installed) map service application is GoogleMaps/GoogleEarth. Since 2005, when Google released this service, its technological solution (tiles) became a standard. Its user interface and technology became a model of all other web mapping services. GoogleMaps also provided an API (application programming interface), which made the creation of mash-up applications possible, thus allowing individual users to combine their own data with the map service. This option has really democratised the mapping process. Later, Google invented additional applications connected to GoogleMaps/GoogleEarth in order to provide additional functionality for their users, like Camera, MapMaker and Fusion Tables (Figure 2).

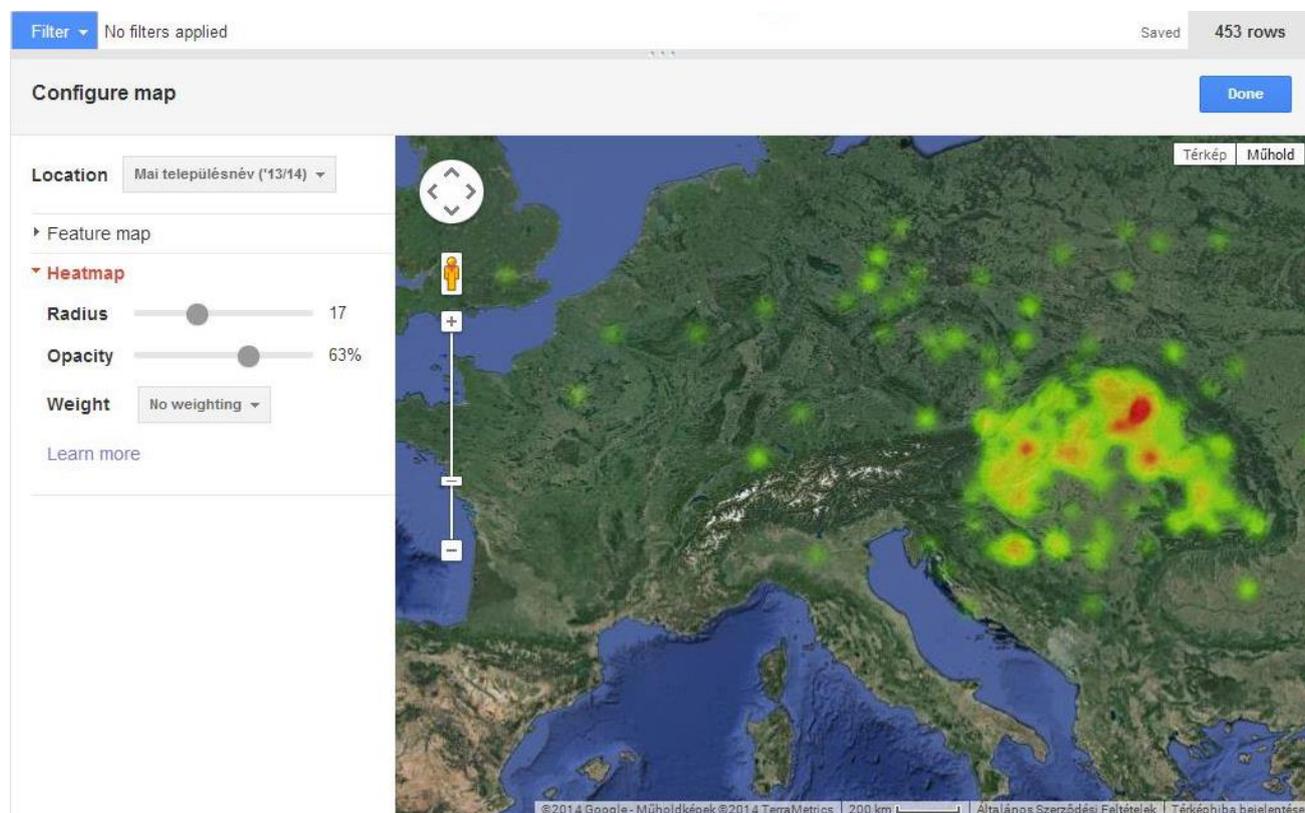


Figure 2. A Google Fusion Table, from a degree thesis of a Hungarian cartography MSc student, Réka Kis, 2014

Other global commercial mapping services (MapQuest, BingMaps, YahooMaps, Here) are also providing similar services, mostly using satellite images and vector-based topographic (street) maps, enriching the content with POIs (point of interest features). One of the most important functions of these services is the up-to-date map content, which requires continuous efforts from the companies.

Another great example of global mapping services is OpenStreetMap (OSM), which was inspired by the success of Wikipedia in 2004. This is a non-commercial, collaborative project to create a free editable map of the world. Two major driving forces behind the establishment and growth of OSM have been restrictions on use or availability of map information across much of the world and the advent of inexpensive portable satellite navigation devices which allowed crowd-sourcing based contribution. Since then, it has grown to millions of registered users, who can collect data using manual survey, GPS devices, aerial photography, and other free sources.

THE MILESTONE OF SENSORS

Data collection is the initial part of the map making process. Nowadays data are collected by digital sensors. This was probably the most revolutionary change of the last fifty years: since all the sensors have changed to digital, the quantity of data are dramatically and continuously increasing. We also have to note that this development was supported by the continuous development of IT devices: CCDs, memory chips, solid state drives and the increasing data transfer speed. The development of sensors and the development of IT devices are regularly independent processes: so sometimes the slower development on one side negatively effects the development on the other side. Now we feel that the data collected by sensors is overwhelming us and our IT devices are not able to convert these data into useful information; sometimes even storing the data is a challenge.

The size and price of sensors is continuously decreasing, so the expenses of data storage is also decreasing. Due to the continuous development, cartography and geoinformatics are now facing with the problem of big data, which requires considerable contribution from IT experts (Table 1):

Table 1. Typical sensors of cartography

Device	Navigation sensors	Imaging sensors	Communication capability
Smartphone	GPS, compass	CMOS (still and video)	4G/5G/wifi/USB
Digital camera	GPS	CMOS (still and video)	wifi, USB
Hobby GPS	GPS	No	wifi, USB
Car navigation	GPS	CMOS	wifi
Social networks	Access point location, GPS	webcamera	internet access

Open Source

In a scientific and academia environment the sharing of the results of research is more and more important. Thanks to the sensors we have more and more data available. It is also essential that we are not just publishing the results of our work in a scientific paper, but the open access of the collected data (whenever it is possible) would also be useful for the further development.

Without effective long-term preservation, the environmental data (both current and historical) face the risk of becoming unusable over time. From this perspective, there is a pressing need for the long-term preservation of the data made available through Spatial Data Infrastructures (SDI) like the European Union's INSPIRE directive. An effective and coherent approach is required to preserve the individual data repositories made available through the SDI over the long-term. This needs to address various complex issues, such as compatibility of data with future repository technology and

ensuring its continued access even after its provider has ceased to exist. Long-term preservation of environmental data exposed through uniform and interoperable SDIs is not currently explicitly addressed in the INSPIRE directive but is highly important for applications that require continued access to both current and historical data, for instance for monitoring climate change (Shaon and Woolf, 2011). Most of the SDIs are definitely not freely available, but there is a tendency of publishing these information freely (Figure 3).

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CDs	Copies of datasets distributed via CDROM
abacus	Arctic Biosphere-Atmosphere Coupling at multiple Scales (ABACUS)
accacia	ACCACIA dataset - using the FAAM aircraft
accmip	Atmospheric Chemistry & Climate Model Intercomparison Project (ACCMIP)
acsoe	Atmospheric Chemistry Studies in the Oceanic Environment (ACSOE)
active	Aerosol and Chemical Transport in Tropical Convection (ACTIVE)
adriex	Aerosol Direct Radiative Impact Experiment (ADRIEX)
amma	African Monsoon Multidisciplinary Analysis (AMMA)
amps_antarctic	Antarctic Mesoscale Prediction System (AMPS): 4.5 and 6 km data
apposite	Arctic Predictability and Prediction On Seasonal-to-Inter-annual Time scales (APPOSITE)
appraise	Aerosol Properties, Processes and Influences on the Earth's Climate (APPRAISE) Directed Mode Programme
armagh	The Armagh Observatory Climate Data (1838 - present)
autex-wintex	Autumn and Winter Experiments (AUTEX / WINTEX)
bas	British Antarctic Survey Data
bodeker-scientific-ozone	Bodeker Scientific global vertically resolved Ozone database
bolton	The Bolton Experiment (1999-2002)
bortas	BORTAS: Quantifying the impact of Boreal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites
caesar	CAESAR - Cirrus and Anvils: European Satellite and Airborne Radiation measurements project
cap	Coastal Air Pollution Project Data
capeverde	Cape Verde Atmospheric Observatory
cascade	CASCADE - Scale interactions in the tropical atmosphere
cast	CAST - Co-ordinated Airborne Studies in the Tropics
ccmval	CCMVal Data
ceh-pan	
chablis	Chemistry of the Antarctic Boundary Layer and the Interface with Snow (CHABLIS)

Figure 3. An international portal for providing free environmental data: <http://www.ceda.ac.uk/>

MODERN CARTOGRAPHY: TRENDS, MILESTONES OF THE FUTURE

The short-term development trends of IT and mobile devices are more and more unpredictable. There are definitely trends, which look evident, which are easily predictable, but what is really difficult to predict are the user's behaviour and the prediction of which applications will be really wide-spread and popular. Just think about the heavily promoted functions and products of the last years (like MMS or 3D television), but the users finally did not like these products or the products were ahead of their time.

- We have already mentioned the term **big data**. At the moment we are not able to predict the real effect of the big data, but it is very characteristic that for example the work of astronomers has totally changed due to the big data and 99% percent of their job nowadays is not what ordinary people think about astronomy: it is simply processing and analysing big data. They have to develop new software which can more effectively support this activity (data mining). So it is not enough to be an astronomer, because they have to be familiar with programming as well. We may predict similar effect in cartography.
- One of the potential answers to the big data problem is the **crowd sourcing**. Part of the data mining, data processing can be crowd sourced (like SETI, the search for extraterrestrial intelligence; they have already faced the big data problem in the 1980s). Cloud computing can provide application and storage solutions for

big data, but if we can provide the volunteers with suitable applications we can achieve better results. We can list projects in our domain where the crowd sourcing approach was successfully implemented; one of the most frequently cited examples is the Haiti earthquake in 2010.

- The appearance and wide spreading of **mobile devices** is as significant as it was in the 1980s, when personal computers became available. Mobile devices can be not only phones, but rather sensors, data collectors and sometimes even visualisation and presentation tools. In the last few years the development of the performance of processors of mobile devices increased the development of desktop processors. The younger generation of today prefers mobile devices instead of desktop computers or even notebooks.
- Digital sensors are really everywhere. Sensors are interconnected and forming the **internet of things** (IoT). IoT brought about such new terms like smart cars and smart homes: our main places of stay can communicate with each other even without the users. All large car manufacturing companies are working on self-driving cars. The technology is about to be ready, but it probably requires the transformation of the existing infrastructure (we need not only intelligent cars, but also intelligent roads), changing the legal regulations. Probably the most important obstacle of the rapid development of IoT-driven technology is the aversion of human users.
- **Virtual and augmented reality** technologies can help the visualisation of location-based services. The third dimension (and sometimes the time factor) has an increasing role in the digital databases: more and more SDI involves such information.
- We have already mentioned **open source** in this paper. Open source is not only a technology, but rather a philosophy. The continuous spreading of open GIS is similar to the spread of web 2.0. Thanks to the web 2.0 philosophy even the professional GIS users are able to solve their special problems. All national mapping agencies have their own specialities and sometimes the NMAs are not satisfied with the available commercial software solutions. We can recognise that some NMAs have already present in this environment and probably the role of open source data and technologies will be more and more important in cartography.

ICA'S MODERN CARTOGRAPHY

In 1997 Fraser Taylor, the former President of the ICA presented the term *cybercartography* to describe the changes in cartography brought about by new technology. In simpler terms, cybercartography involved using computers, and especially the Internet, to create multimedia and interactive maps. In the ICA term 2011–15 a Commission on Neocartography was nominated and accepted. The democratisation process of map making, the distinction between mapmaker and map user has been blurred, with the user having access to data and the ability to generate maps through using global map services. This kind of citizen mapping has generated a new term, *neocartography*, which refers to mapping on the web commonly by nonprofessional cartographers using open-source software and data. Neocartography operates through what has been called Web 2.0, which describes websites that go beyond static representations and utilize animation and sound. Cybercartography and neocartography have a similar meaning: both of them are reflecting the implementation of IT technologies in cartography and GI science (Taylor, 2015).

In the ICA we are continuously discussing these technological changes, the effect of this process on cartography itself, whether we have to re-define the term of cartography. We can also answer a simple question: are these developments also favourable for the cartographic discipline? The cartographic discipline cannot ignore these new trends that seem to happen on two sides of mainstream cartography: in the advanced scientific domain and in the public domain. These changes require a better utilization of our cartographic design knowledge, including visual and geocomputational knowledge from other graphics oriented disciplines to develop design guidelines (Kraak, 2011).

Today, maps can be created and used almost for any purpose by any individual having only modest computing skills at any location on Earth. In this new mapmaking paradigm, which we can even call *modern cartography* or *cartography 2.0*, users are often present at the location of interest, and they produce maps that address the needs arising instantaneously. A number of important technology-driven trends have a major impact on what and how we create, access and use maps, creating previously unimaginable amounts of location-referenced information and thus put cartographic services in the centre of the focus of research and development.

While the above advances have enabled significant progress on the design and implementation of new ways of map production over the past decade, many cartographic principles remain unchanged; the most important one being that maps are abstractions or models of the reality. Visualization of selected information means that some features present in reality are depicted more prominently than others, while many features might not even be depicted at all according to the theory of generalization, which is well-known for experienced cartographers; however, this can be absolutely obscure for the ordinary users. Abstracting reality makes a map powerful, as it helps to understand and interpret very

complex situations very efficiently. Maps are most efficient in enabling human users to understand complex situations. Maps can be understood as tools to order information by their spatial context.

Cartography is essential in many aspects of human societies. Modern cartography enables the general public to participate in the modelling and visualizing of the risks their neighbourhood may suffer from on a voluntary basis. Modern cartography also helps to quickly disseminate crucial information. Cartography is also most contemporary, as new and innovative technologies have an important impact on what cartographers are doing: we are inventing modern cartography/cartography 2.0.

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BIOGRAPHY



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