GI Science versus Cartography? – Consequences of Separating Data and Visualisation Expertise in 21st Century Mapping Processes

Bennet Schulte, M.Sc. Dipl.-Ing. (FH) EUR ING

Beuth University of Applied Sciences Berlin

Abstract. Cartography was replaced by GI sciences with consequences for the quality of geo data visualisation. Especially in the commercial sector quality issues arise through missing ability of quality assessment for many reasons.

Keywords: Cartography, Visualisation, Quality

1. Introduction

Today anyone should be able to create maps by themselves without professional mapping skills, experience and expense. The consumer should at the same time be the producer, making him a "prosumer" (Toffler 1981:273f). All topics related to that objective, such as interoperability of spatial data, web mapping 2.0 and web GIS services are therefore important and popular topics within the geo-community. This process of transformation of the cartographic business driven by advancements in information technology and commercial interests has led to an important consequence: digital maps for location-based services and navigation, as well as user-generated maps or mashups including user-generated content have become an integrated part of the digital life of our modern digital human society. This development has affected commercial cartographers, their business and the value and quality of maps and data. On the one hand, a large active community of prosumers is useful to generate data quickly and for free, e.g. for crisis mapping. On the other hand, these prosumers are mostly non-professionals having no knowledge of cartographic rules (Hoffmann 2011:76f). If anyone is able to visualise data and make maps, the services of an expert become valueless. Nevertheless, experts create better maps and know how to handle data.

From history we know how technology has constantly changed many professions. Cartography has also changed over time, but remained a scientific and engineering profession requiring a great deal of expertise. Just as the weaver, the scribe and the crossing keeper were made more or less unnecessary by technology, the developments in computer cartography devalue many areas of the profession. The high implementation of cartographic products into the daily life of people that we see today was bought at the price of a devaluation and despecialisation of cartography. Like some extinct professions of the past, cartography has already died and was replaced by geographic information science (GI science) and a free-for-all/all-for-free visualisation discipline.

2. Expertise

2.1. Prelude

Even before the era of web mapping 2.0 cartographic products were gradually turning into products of minimal value. In the beginning, maps were unique items, extremely valuable and an immense store of knowledge that served to understand relationships, to plan operations and, of course, to navigate. They were always regarded to be an aesthetical and work of art. Before the industrialisation, cartographers were mostly polymaths like Gerhard Mercator, Claudius Ptolemy and Leonardo da Vinci. Some collected their own geographic data by surveying, making them experts on the topic they visualised. All stages of the cartographic process, the data processing and visualisation lay in their hands (*Figure 1)*.

With the development of low-cost printing technologies for the reproduction of maps they became more common and affordable for more people. Nevertheless, the data collecting and visualisation of maps remained a time-consuming process to be carried out by experts and therefore remained relatively expensive. Updates were only carried out by the publishers when it was absolutely necessary to be able to compete on the market. As an example, the Andrees Allgemeiner Handatlas by Velhagen & Klasing was only revised about every six years between 1881 and 1937.

Thematic cartography has become increasingly important since the 18th century (Dipper & Schneider 2006:13f), geographic data and geometry were degraded to auxiliary data regarded just as basic reference and a mere container for thematic data. Before commercial printed maps became devaluated by free online service providers, the advent of computer cartography at the end of the 20thcentury radically changed the conditions of map production. As part of a more efficient division of labour and to produce more fa-

vourable products, many publishers outsourced the mass creation of auxiliary data to low-wage countries and quality issues have arisen. Only the revision and final visualizing was still done by cartographers permanently employed by publishing houses. Later even traditional publishers of cartography products do outsource the complete visualisation process and get rid of all their cartography capacities for cost reasons.

Publishers of historical atlases e.g. appointed editors to collect the thematic data and to supervise the visualisation work done by the cartographers. This lead to a fateful separation between those having the expertise necessary for visualisation and those having the thematic expertise of the data to be visualised (*Figure 1)*.

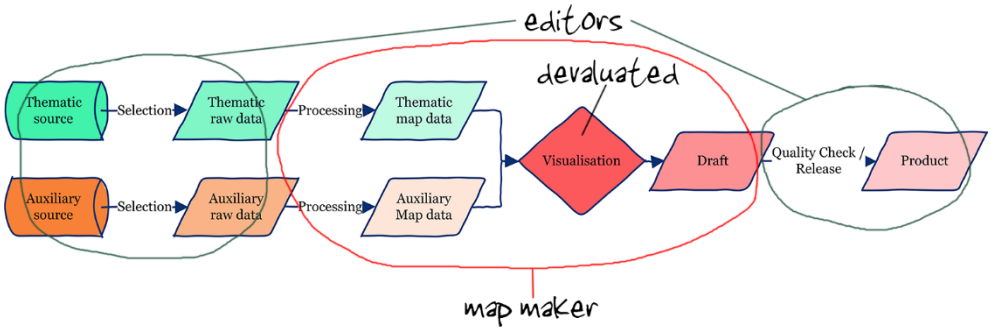

Figure 1. Cartographic process at cartographic publishing houses

This process was flanked by the development of semi and fully automated visualisation methods, opening the last remaining domain of traditional cartographers, the cartographic visualisation, to non-experts. According to Schweikart & Kistemann (2013:8) thematic maps are increasingly generated by visualisation amateurs using GI systems allowing a particularly easy generation of choropleth maps. However, due to inadequate cartographic communication, even properly collected thematic data can lead to misinterpretations. The use of a specialized GI system for merging thematic and auxiliary data is still a challenge. Driven by commercialised location based services, web mapping 2.0 service providers allow prosumers to automatically visualize their own thematic data with the help of the auxiliary data provided by such services. Since this visualisation needs to be a simplified process with a low level of possibilities to be influenced by the prosumer, it can hardly be referred to as “cartography”.

2.2. Consequences

Supported by beginner-friendly visualisation tools, non-experts and amateurs are able to produce cartographic visualisations. The products can be created either for free or for little money. As a logical and economic conse-

quence, well-paid experts become entirely unnecessary since one of the most important areas of expertise of traditional cartography lost its value. The cartographic community reacted and conformed to the new situation. Visualisation of geo data remains a part of the discipline but the focus was shifted to more profitable remaining areas of expertise like data analysis and management. Since nobody wants to study a low-wage non-expert profession or be in any ways connected to it, what was before called “cartography” was relabeled to superficial modern terms like GI science, geomatics or geomedia engineering. Except the Dresden University of Technology, no other German university offers a postgraduate academic master´s or diploma degree involving the term “cartography” in 2013. There are only apprenticeships and undergraduate academic degrees featuring the term. Originally a holistic profession, cartography was technically reduced to a drawing craft, similar to the profession of a graphic artist. It is precisely this group that is increasingly hired as map makers.

Moreover, the human resources needed for correcting are often omitted. There are reasons for this: maps are a commercial product that needs to be produced at a reasonable cost, there is a downward spiral of prices for geographic products. Quality assurance is an expensive commodity making the production process more costly. Since cartographers are degraded to simple technicians of visualisation for extremely heterogeneous topics instead of being responsible for the whole process of map making, they cannot be familiar with any topic alike and are not able to acquire sufficient experience for assessing the quality of the data for all these topics (Schulte 2011).However, thematic expertise is the key for identifying errors in data or avoiding thematically improper visualisations. Particularly in commercial products, errors are commonly accepted as long as they do not impede the sale. Various initiatives showed that no publisher is interested in professionals offering free quality assurance services to them. Although publishers may be grateful if errors are pointed out to them to be corrected in later editions, the correction and quality assurance of the new edition is again in exclusive responsibility of those who did not recognize the previous mistakes. Publishers fear complex review processes, thereby delay of production and too many accomplices who could reveal details of the upcoming product to competitors. This factors created massive reliability, quality and accuracy issues.

3. Examples of Administrative Boundaries

For many map authors, administrative boundaries usually play a minor role in quality management in contrast to numerical data. Although they are not

verified, they are considered stable or generally correct. But it is especially this kind of data that has a variety of pitfalls revealing the massive issues of quality assessment and misuse of geo data and references. It is also interesting how superficial mental maps often are, even if they were developed by geo-experts, government agencies or the press. The following examples are not single cases but a general phenomenon.

3.1. The Eastern German States Boundary Problem

If there was a cartographic representation you might expect most citizens of the Federal Republic of Germany to be familiar with in detail, it would be the first-level administrative units of Germany, the federal states. They are the most prominent geographic geometry due to their occurrence in all media and most of the thematic fields. Weather forecast, newspaper articles, navigation through websites and many other pieces of information are very often visualised in relation to this geometries.

Figure 2.

Figure 3.

Figure 4.

Figure 2. Map of Germany showing changes of the federal state boundaries since 1949 in red, current boundaries in black.

Figure 3. Commemorative stamp of 1997 showing Brandenburg as of 1990 to 1993 (Schnadt 1998).

Figure 4. Newspaper overview map showing the 1952 boundaries used until today (Berliner Morgenpost 2007).

Whereas the boundaries of the West German states are visualised invariably correct, the cartographic misrepresentation mentioned above occurs when it comes to the federal states in the area of the former German Democratic Republic (GDR). Although the eastern states exist since 1990, misrepresentations of the boundaries occur on a regularly basis. There were no geometrical changes of the boundaries of the Western states since 1949 that could be visualised on small scales. Neither the merger of three states into Baden-Württemberg in 1952, nor the reunion with the Saarland in 1957 or the return of small territories occupied by Belgium, Luxembourg and the Netherland after the Second World War between 1958 and 1963 created any significant changes.

Although the Eastern states were established in the Soviet zone in 1945, they were subject to minor changes in 1950 that are clearly recognisable in small scales. In 1952, they were completely replaced by ahistorical central governmental districts of the GDR during the massive socialist reorganisation and modification down to the lowest administrative levels. When the Eastern states were re-established during the reunification in 1990, they were no longer based on the boundaries of 1950/52, but on the grouping of the third-level administration units modified during the socialist era to a similar geographical extend. In order to increase the similarity to the historical boundaries, several smaller territorial changes of forth-level administration units were carried out in 1992 and 1993. There are major differences between the geometric shapes of the 1950, 1990 and the current boundaries (*Figure 2)*. These differences are clearly visible even in smallest scales. As an example the map of the state of Brandenburg on an official stamp was modified in 1993. In 1997, a commemorative stamp (*Figure 3*) again used the outdated geometries of 1990 to 1992 (Schnadt 1998). Therefore, most misinterpretations are not “wrong” but just show absolutely outdated boundaries.

It is certainly possible to say that this are only small errors in a degree of detail most consumers do not need to be familiar with and which do not affect the information functionality. This is acceptable in the most cases. However, if a country publishes misrepresented maps of its own borders, questions about the usage of data, the producers’ scrupulousness and quality control do arise.

The misrepresentation of the German federals states is so common in present references that the creation of a list of publications does not make any sense. You can expect to find such misrepresentations anywhere. For reference, some examples:

- Newspapers and magazines: Berliner Kurier (2010), Berliner Morgenpost (2007:3) (*Figure 4*), Die Welt (2009), Frankfurter Allgemeine Zeitung (2009), Der Spiegel (2009), Focus (2008:166)
- Public authorities: Ministry of Defence (BMVg 2011) (*Figure 5*), Ministry of Transport, Building and Urban Development (BMVBS 2000), Berlin Senate Department for Urban Development (SenStadt 2007), Statistical Office for Berlin-Brandenburg (AfS 2009:1) (*Figure 7*)
- Companies: Deutsche Post (DP 1997) (*Figure 3*), Deutsche Bahn (DB 2011)
- Geo-Experts: German Association of Surveyors (VDV 2007) (*Figure 6*), German Cartographic Society (DGfK 2005:237)
- Commercial Publishers: Klett (2010:270), RTL Disney (2007) (*Figure 8*), National Geographic (2004), ADAC (2013:18)

Figure 5.

Figure 6.

Figure 5. Cover map of a brochure of the Ministry of Defence showing 1952 boundaries (BMVg 2011).

Figure 6. Title map created shortly after the reunification. Mind the much different degree of generalisation of the eastern states showing the 1950 boundaries compared to the Western states (VDV 1991/2007).

The examples are drawn from major German newspapers, public administrations, rail and postal companies, large and small internet sites, educational institutions and even geo scientists. These map producers are experts and they are major information sources for the public. Despite there have

not been any significant modifications for 20 years and 63 years have passed since the 1950 boundaries were in place, map authors still are “able” to access this data for reference. There is one possible explanation for this: the recreation of the Eastern states took place when computer-cartography was about to start. At this time, digital data was much needed but hardly accessible. It might be the case that just one distributor missed the new geometries in 1990, used the 1950 boundaries instead, and created the base for others who were unable to assess the quality and simply took over the representation, thus starting a downward spiral. The misrepresentation cannot be explained by incorrect or excessive generalisation, but solely by the misuse of basic data. As it is so widespread, there is only one general explanation: the geometric shape of the most common geographic representation is not part of a detailed mental map of most map authors. It also allows us to draw conclusions on the underlying data bases, the workflow of creating maps and the handling of basic data. Basic data seems to be acquired from unqualified web or local sources, despite free-date data that can be accessed easily at Wikipedia e.g. and it seems that qualified proof readers are not consulted. The change of cartographic production conditions mentioned before may also have contributed to this situation. According to the Staff Office for Public Relations of the Ministry of Defence the map used in *Figure 4* based on geometries provided by the Bundeswehr Geoinformation Office (AGeoBw) in 1994 for the white paper which describe the first time the security situation of the united Germany. Since then the 1950 boundaries have been used in various defense publications of the ministry.

Figure 7.

Figure 8.

Figure 7. Choropleth map using the 1990 to 1993 boundaries (AfS 2009).

Figure 8. Screenshot of an educational internet portal for children using the 1952 boundaries for a learning puzzle (RTL Disney 2007)

3.2. Quality of Online Sources

To study the evolution of online sources for easy accessible references samples where taken in 2007 and 2013 on the Google Images Search. The top 20 map results for the keywords “Bundesländer” (federal states) and “Deutschland” (Germany) showing the first-level administrative units were analyzed on boundaries issues (*Table 1*).

Year →	2007				2013			
Keyword →	Bundesländer		Deutschland		Bundesländer		Deutschland	
Boundary	**results**	**%**	**results**	**%**	**results**	**%**	**results**	**%**
since 1993	5	25	12	60	10 +5	50	14 +9	70
1990-1993	13	65	4	20	9 -4	45	6 -7	30
1945-1952	2	10	4	20	1 -1	5	0 -2	

Table 1. Results of Google Image Search 2007 and 2013

In 6 years, an improvement for both results can be recognized, which leads to a reduction in incorrect references searchable via Google. In 2007, the first 1952 boundary map appeared at the second place and at the first place of the search results for “Bundesländer” and for “Deutschland” respectively. In 2013, it was found on the first place when searching for “Bundesländer” and there was no occurrence of the 1952 map in the case of “Deutschland”. As far as Wikipedia sources are concerned, all were correct.

3.3. Creating and Adding Up of Errors

Many impressive examples can be identified in the delicate field of history and political cartography. Here, especial care has to be taken concerning quality assurance, because every detail of the visualisation can change the story being told and the interpretation of the map.

For example for a new edition a visualisation technician was assigned by the editors of a publishing house to create a map of Germany before the adding of Austria and the Sudetenland in 1938 showing the National Socialist first-level administrative units. As a source he used two older reference maps, one showing Germany and surroundings as of 1923 to 1933 and another of 1933 to 1945. He merged both maps and named it “Germany 1933 to 1938”. Unfortunately, in the source for the pre-1938 boundaries a legend box covered the eastern part of Czechoslovakia. Since he did not use another source and did not have enough thematic knowledge, he simply used the boundary of the post-1938 source (Schulte 2007:80), which causes an inaccurate temporal mixed boundary of Czechoslovakia (*Figure 9*). This was not recognized or corrected by any of the controlling instances until it was pub-

lished. Afterwards, the publisher was informed and in the following edition this mistake was corrected, but replaced by multiple new misrepresentation in related maps. These officially approved educational materials are essential references for derived products.

Figure 9. Combining two maps into new one (bottom) with misrepresentation of boundaries (Leisering 1992:112f/Bruckmüller & Hartmann 2001:166).

The following example is taken from a completely new historical atlas with a renowned name but mostly low quality content, “Der grosse Ploetz Atlas” of 2009. Although the atlas is one of few which at least give some references and admit that not all sources could be identified, as it is common in publishing cartography where most auxiliary and thematic references are obtained from other market participants and internet sources. The visualisation is good in parts, and base data is detailed and correct. However, misrepresentations occurred at a later stage during the thematic post processing of the auxiliary data of the boundaries. As he was unable to geometrically identify the area of the Memel Territory, which was already there in the base data, he added it a second time (*Figure 10*). As a result, all following maps show an inaccurate boundary geometry. The editors responsible for quality assurance did not notice this and many other errors, even obvious printing errors by layer orders. When requested for this article, the publisher first asked for a fee of € 50 per 1000 units for the map, then was not even sure to own the rights at all, since all of the editors no longer work for the publisher and contracts with the map author cannot be found.

Figure 10. A second “Memelland” and Lithuania labeled Soviet Union (Ploetz 2009:196).

4. Conclusion

The fact that even the most common geometry is not in detail part of the mental map of most official and expert map producers is off topic, but shows the handling and quality management of geo data. Especially the details of the boundaries of the German federal states in small scales seem to be not much relevant as long as the function of the map is not compromised. In other regions of the world any misrepresentation, for example on Google Maps, could constitute a provocation and cause real conflicts (AFP 2010, Jacobs 2012). Boundaries limit the most important capability of humans, the power to influence others, therefore boundaries are often auxiliary data but also always an underrated primary theme.

For economic reasons, quality control seem to be irrelevant for many commercial publishers as the printed maps are becoming increasingly unprofitable. Quality improvements are not even desired, as this article illustrates. Unfortunately, it is their products that are used as references for further products, thus supporting a downward spiral of geo data quality. The inability to assess the quality of reference or the trust readily placed in other producers potentiates the probability of producing an inaccurate map product. Therefore, the pool of inaccurate references is growing and falsely verifying other products. Since the commercial publishers are unable to find business solutions that can compete with the free online data, their only solution is to try to produce at minimum costs at the expense of quality. This will continue as long as customers trust them, are unable to critically review their products and are willing to pay for them. As the end of commercial publisher cartography is foreseeable, it will hopefully be succeeded by data bases of higher quality that are gradually being corrected by the collaborative crowd intelligence of open communities and then made accessible free of charge.

In a utilitarian digital world of cartography, a renaissance of the intrinsic value of maps and an increasing will to invest in expertized visualisation is not to be expected. Most consumers will regard this only as a necessary, non-expert and free medium for transmitting spatial information. Only a few cartographers will be able to sell special maps as art work and decorative pieces. In this context, one could expect a decline in the number of enrolling for cartography as well as a reduction of university chairs in Germany, a country that has traditionally played a leading role in this science. It was neither technological developments nor the devaluation of visualisation that “killed” cartography. Instead, it was the geo-community itself by abandoning the term and switching to modern labels like “geospatial information” with its primary focus on thematic data, which also accepts the fact that visualisation is separated from the expert sovereignty. Nevertheless GI

science generates useful and valuable knowledge about complex data by analysing expertise.

If you expand your view beyond the visualisation, analysis focused GI science could soon follow the fate of visualisation and become a devaluated area of expertise because of the development of Web GIS with full or semi automatized processing, exploration and analysing methods (Fu & Sun 2010).

Since anyone can simply produce maps, it is impossible to rely on the prosumer when it comes to assessing data quality and visualisation based on expert cartographic rules. An idea could be, however, to reliably qualify "approved" data sources by comprehensible metadata, allowing organized collaborative corrections by experts in the relevant theme or area (Hoffmann 2011) as Wikipedia or Open Street Maps do. If the prosumer is granted the easiest access possible to that data, easier than to any other possible sources, he will automatically use this verified data. Moreover, the automated visualisation capabilities have to be expanded and designed based on cartographic rules. This is not only true for navigational maps, but also for other thematic maps.

References

ADAC (2013) Weniger Autos in der Stadt, mehr auf dem Land. ADAC Motorwelt, 2013/3

AFP (2010) Cambodia rebukes Google over disputed Thai border map. Agence France-Presse, 2010-02-05. www.google.com/hostednews/afp/article/ALeqM5i6-zjeFCSkUnXXUlMU-Jv6zcIaLA. Accessed 11 March 2013

AfS (2009) Berlin in Zahlen. Amt für Statistik Berlin-Brandenburg, Potsdam

Berliner Kurier (2010) Der deutsche Sündenatlas. 2010-07-24.

Berliner Morgenpost (2007) Das Mordattentat auf Buback. 2007-04-24

BMVBS (2000) Bundeswasserstraßen – Informationen für Sportschiffart. Bundesministerium für Verkehr, Bau und Stadtentwicklung, Berlin

BMVg (2011) Die Stationierung der Bundeswehr in Deutschland. 2011-10. Presse- und Informationsstab Arbeitsbereich 2 ÖA, Bundesministerium der Verteidigung, Bonn

Bruckmüller E, Hartmann P (2001) Putzger Historischer Weltatlas. 103. Edition. Cornelsen, Berlin

DB (2011) ICE mit W-LAN Werbung. 2011-02. Deutsche Bahn, Berlin

DGfK (2007) 60 Jahre DGfK. Kartographische Nachrichten, 05/11

Dipper C, Schneider U (2006) Kartenwelten. Primus, Darmstadt

DP (1997) Briefmarke Hochwasserhilfe 1997. Deutsche Post, Bonn

Focus (2008) Raffinieren. 2008/39.

Frankfurter Allgemeine Zeitung (2009) Wieder Amoklauf an deutscher Schule. 2009-03-11, www.faz.net. Accessed 11 March 2009

Fu P, Sun J (2010) Web GIS: Principles and Applications. ESRI Press, Redlands

Hoffmann K (2011) Nutzergenerierte Karten im Web 2.0. Kartographische Nachrichten 2/11:72–78

Jacobs F (2012) The First Google Maps War. The New York Times, 2012-02-28. http://opinionator.blogs.nytimes.com/2012/02/28/the-first-google-maps-war. Accessed 11 March 2013

Klett (2010) Histoire/Geschichte – Europa und die Welt seit 1945. Klett, Stuttgart

Leisering W (1992) Putzger Historischer Weltatlas. 102 Edition. Cornelsen, Berlin

National Geographic (2004) World Atlas. 8. Edition. National Geographic Society, Washington D.C.

Ploetz Atlas zur Weltgeschichte, Der grosse (2009) Expansion Deutschlands 1938/39. Vandenhoeck & Ruprecht, Göttingen

RTL Disney (2007) Toggo Clever Club: Länderpuzzle. www.toggo-cleverclub.de. Accessed 17 June 2007

Schnadt J (1998) Grenzen ändern sich, Brandenburg bleibt. Vermessung Brandenburg 2/98:65–66

Schulte B (2011) Tradition und digitales Zeitalter – Der Putzger Historischer Weltatlas im 21. Jahrhundert. Kartographische Nachrichten 2/11:78–86

Schweikart J, Kistemann T (2013) Kartographie der Gesundheit. Kartographische Nachrichten 1/13:3–11

SenStadt (2007) Vertretungen der Bundesländer. Senatsverwaltung für Stadtentwicklung Berlin. www.stadtentwicklung.berlin.de/bauen/landesvertretungen/ Accessed 23 February 2013

Spiegel, Der (2009) Unispiegel – Was studieren kostet. www.spiegel.de/unispiegel. Accessed 27 November 2009

Toffler A (1981) The Third Wave. Pan Books, London

VDV (2001/2007) VDV Information flyer. Verband Deutscher Vermessungsingenieure, Wuppertal

Welt, Die (2009) Wie gut kennen Sie Deutschland? www.welt.de. Accessed 7 July 2009