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MASTER'S THESIS

Development of a web map for a traditional map publishing company

– An usability engineering approach –

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Kurzfassung

Mit der Einführung des online-Kartendienstes GoogleMaps im Jahr 2005 hat sich der Umgang mit interaktiven webbasierten Kartendiensten verändert *[Schmidt und Weiser 2012]*. Das Potential dieser sogenannten „web maps" ist enorm und sie werden in sehr vielen Bereichen des täglichen Lebens, zum Beispiel zur Routenplanung, genutzt.
Im Zuge dieser Masterarbeit wird die Entwicklung einer „web map" für einen traditionellen Kartenverlag diskutiert. Hauptaugenmerk liegt hierbei auf der Frage wie eine solche „web map" auszusehen hat und welchen Inhalt sie haben soll. Diese „web map" soll grundlegende Funktionalitäten und eine Bestellfunktion für gedrucktes Kartenmaterial besitzen. Es wird hierbei auf dem Arbeitsablauf von der Idee bis hin zum fertigen Produkt näher eingegangen.
Um herauszufinden was die Anforderungen der Nutzer einer solchen „web map" sind wird als erstes eine online-Umfrage unter den Kunden eines Kartenverlages durchgeführt, bei der besonders auf den möglichen Inhalt der „base map" eingegangen wird. Mit dem Ergebnis der Umfrage und zusätzlichen Optimierungen im Bereich Design wird das Konzept für die „web map" erarbeitet. Mit Hilfe von Richtlinien für optimale website Benutzerfreundlichkeit, die speziell für diese Anwendung entwickelt werden, wird das Konzept näher umschrieben.
Anschließend wird aus Sicht des Verlages, dem Entwickler und der Nutzer besprochen wie eine solche „web map" entwickelt wird. Dabei werden die Möglichkeiten für den Verlag, die technischen Aspekte die der Entwickler zu beachten hat und die Anforderungen für den Nutzer aufgezeigt.
Das Endprodukt soll bestmöglich den Anforderungen von möglichen Nutzern entsprechen und einen gehobenen Qualitätsstandard besitzen.

Abstract

Since the introduction of the online map service GoogleMaps in 2005 the online mapping experience changed *[Schmidt and Weiser 2012]*. The usability and possibilities of those so-called “web maps” are numerous and they are used in our everyday life. The most important function is route determination.

In this Master's thesis the development of a “web map” for a traditional map publishing company is discussed. The central question is what this “web map” should look like and what content it should have. The “web map” should have basic functionality and a purchase function where the user can buy printed map material. The workflow from the initial idea to the final product is examined in detail.

In order to find out the requirements of the user, an online survey is developed and carried out. The main focus here lies on the possible content of the “base map”. With the result of the survey and additional optimisations in the fields of design, the concept of the “web map” is determined. With the aid of a framework for website usability, explicitly developed for this application, the concept is outlined more specifically.

Following that the development of the “web map” is discussed from different point of views: The publisher's, the developer's and the user's point of view. In doing so the possibilities for the publisher, the technical aspects concerning the developer and the requirements for the user are demonstrated.

The final product should fulfil the user's requirements and have a high quality standard.

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Index

Images

Tables

Abbreviations

#	Number
KB	Kilobyte
MB	Megabyte
GB	Gigabyte
TB	Terabyte
PB	Petabyte
URL	Uniform Resource Locator
Σ	Sum

1 Introduction

1.1 Motivation

The development of interactive maps provided by online map services like **GoogleMaps**[1] initiates that information is connected to an appointed location with increasing frequency. When information is connected to a location it gains geospatial reference. The knowledge of geographic locations leads to better decision making by developing problem solutions and constructing geographic knowledge in the first place *[Kraak 2002]*. The main reason why maps are produced is to help people make better decisions. You need the most relevant and accurate information to make the right decision. The motivation of cartographers is to communicate relevant information through maps in order to support the map reader's decision. The problems that have to be solved or decisions that have to be taken are as numerous as they are different. Some may refer to a simple question of going right or left. Some may concern more complex tasks like route determination or spatial analysis.

A cartographic product like an online map service is suited to fulfil many tasks at once. In order to provide the best information suitable for any task the base maps of any online map services have a quite general content. At the beginning of web mapping only static web maps about street networks existed. Their only application was to get an overview of a Region Of Interest (ROI). With the introduction of the **Xerox PARC**[2] **Map Viewer** in 1993 it was possible to add functionality to web maps. The Map Viewer could be used to create on-demand maps from a geographic database *[Perterson 2011]*.

1 An online map service
2 Palo Alto Research Center, a research and development company in Palo Alto, California

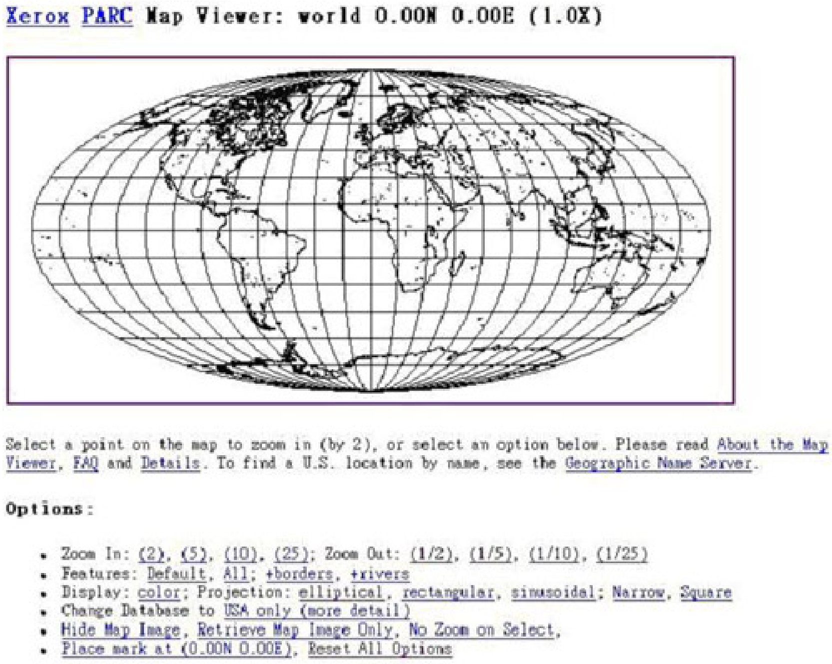


Fig. 1: The Xeroc PARC Map Viewer as of 1993

In figure 1 you can see a screenshot of the Xerox PARC Map Viewer as it looked like back in 1993. You can see a few functions like zooming, a simple layer control and an opportunity to change the map's projection, implemented in this simple interactive web map. The Map Viewer was able to produce on demand maps embedded into a web page. Therefore you could produce a relevant map extraction that displayed only your ROI. Since 1996, with the introduction of **MapQuest**[3], an automatic on-demand Route determination function became common in most web maps *[Peterson 2011]*. Route determination is a fundamental function of a map. The map helps to make the right decision which route you have to take to get from position A to position B. In 2005 Google[4] introduced the online map service GoogleMaps. GoogleMaps is based on Asynchronous JavaScript and XML (AJAX), a type of server/ client interaction that maintains a constant connection between the server and the client browser in order to optimize the transition speed of the map data *[Peterson 2012]*. GoogleMaps made it possible to search for specific features on the map. Google added, where it was possible, geospatial reference to the information from its search engine and displayed this information on their map. This resulted mostly in points of interest (POI) or line objects, like paths, within the web maps. In the following years more and more functions

3 A free online web mapping service
4 A multinational corporation specialised in Internet-related services and products

were developed and online map services implemented them in their web maps *[Peterson 2011]*. The information provided by those web maps became more and more relevant for a greater variety of tasks. In the same year Google introduced GoogleMaps, they also released the GoogleMaps API[5]. With this API it was now possible for non-experts to produce their own web maps. Previously it was very complex to carry out web mapping, requiring expensive and complex hardware and software as well as skilled experts in programming and cartography. The base map is now provided by GoogleMaps and the user is able to add more content from a variety of sources with little programming skills. The result is called a “mashup”, which is a trend in modern information technology. It is now possible to add content from any information source to a web map and distribute it via the web. Therefore the content of the maps vary a lot and thus fulfilling many different tasks. For any spatial related task you can produce a map communicating relevant data *[Stefanakis 2012]*.

1.2 Aim of the thesis

Goal of this thesis is to develop a working and useful web map with regards to the demands of potential user of the web map. The term web map is henceforth construed as the digital and interactive map transmitted via the World Wide Web (WWW) as a whole, including the map itself, interactivity and the website it is embedded in. The question is what content and functionalities should be included in such a web map, meaning what a desirable web map for a traditional map publishing company should look like in detail. In cooperation with the traditional map-publishing company **Freytag&Berndt und Artaria KG**[6] (Freytag&Berndt) a web map will be developed which fulfils special tasks and has customised content. The content and the functionalities which should be included are worked out with the aid of an online survey. The concept of the product is determined during the development of the web map itself. The principle of directly addressing the potential user before the concept is worked out in detail is called an usability engineering approach *[Nielsen 1993]*. The benefits of this approach are that the final product is precisely aligned to the user's demands and that redundant work, meaning functionality or content in any kind of way which is not demanded by the user, is held to a minimum. As source for the base map, map material from Freytag&Berndt is used. The challenge is to make the development of such a web

[5] Application Programming Interface

[6] Frytag&Berndt und Artaria KG is a traditional map-publishing company from Vienna, Austria

map as efficient as possible but not neglecting quality nor content issues. In order to develop a web map you have to handle spatial data varying in source, format, scale, quality, reliability and area of coverage. The harmonization of the data is a difficult task and has to be taken into consideration. In order to work out an efficient wokflow, it is desirable that existing map material can be used to create a customised web map. The question if existing map material, produced to be printed and not to be used on a screen, can be used as data source for the base map will be worked off in this thesis. At the end of this thesis a useful and practical workflow should be worked out. In order to do so, the basic principle of Spatial Data Infrastructure (SDI) serves as an example. The most significant difference is that this thesis refers to a smaller level of sources and complexity. The number of tools, services and data sources is not more than a fraction of a global framework like SDI. Nevertheless the aim of this thesis is to point out a minimum set of rules, techniques and tools to assure the best result possible, just like SDI does on a global level. In order to develop a web map for a traditional map-publishing company the state of the art in web mapping will be described. Suitable literature will be examined and compared. Afterwards a quantitative online survey seems useful to find out the user's demands of the final product. The range of an online survey is wide and the target audience can easily be selected. Following the findings in web mapping literature and the online survey as well as practical tools will be combined to develop the final web map.

During the development of the web map many facts are taken into account. The basic content of the map is worked out with the assistance of the online survey. This survey is carried out with the assistance of Freytag&Berndt. After that, the functionality of the web map is worked out. The web map should be intuitive, user-friendly, as good as possible and fulfil all demands of the possible future user of the web map *[Nivala et al. 2008]*. In order to do so principles of website usability are taken into consideration.

The workflow is developed with the intention to use as many provided elements as possible, like software libraries, and not coding an entire online map service from scratch. If you use these software libraries, the development of a web map can be done with only basic programming knowledge and is comprehensible for both, experts and non-experts in the field of web mapping.

1.3 Structure of the thesis

Web mapping is a rich field of research. Since the technological developments in the last 20 years enable more and more applications, a lot of research has been done. At the beginning of this thesis the state of the art in web mapping is pointed out. The term web mapping is explained as well as the possibilities it offers. Everything that you have to consider when implementing a web map is worked out with the formulation of the concept of a web map. Following the functionality of web maps are examined. At this point the necessary functionalities and practical backgrounds are not known and therefore cannot yet be limited. These functionalities have to be structured and explained. All these basic questions in research in the field of web mapping are dealt with in a scientific manner. In the next point of this thesis the fields of application of web mapping are examined. The development of APIs simply enables the use and distribution of geographic information in a very simple and reasonable way. APIs can be used for a variety of applications.

Following some examples of online map services and other relevant realizations of online web maps are discussed.

Afterwards the content of a base map is worked out. In order to do so an online survey is developed to find out what content the user demands. The survey is especially addressed to customers of Freytag&Berndt. The survey is therefore carried out with the help of Freytag&Berndt. The results of the online survey are discussed and conclusions are drawn. These conclusions refer to problems at map reading, functionality and the base map of the web map.

Afterwards the concept of the web map will be developed. The development is approached with three different points of view. The position of the provider, the developer and the user. The position of the provider refers to the provider of the data and user of the web map as an information distribution platform. The provider, in this case, is Freytag&Berndt. The position of the developer refers to the developer of the web map. The position of the user of aforementioned web map refers to the customers of Freytag&Berndt. Freytag&Berndt has the possibility and ultimate goal to use the web map as an additional distribution platform of their products. The question for Freytag&Berndt is what do they want to provide and, of course, what can they provide. The developer's task is to develop a product that fulfils as good as possible the worked out demands to a web map with the given data and technology. Also the developer must have knowledge of the field of research of web mapping to develop a good product. The developer also has to take into account the results of the thesis so far. The question for the customer is on the one hand what he demands of a web map and on the other hand how he will use the final product. Of course all these questions are linked and mutually influenced because they interfere with each other. This segregation of responsibilities is done to clearly define how to approach each of the responsibilities. The theoretical work of this thesis is concluded with the outlining of the concept of the web map.

The next part is the description of the practical part of this work. A prototype of the web map is developed and implemented with respect to all precedent theoretical work. Problems are worked out and an extensive documentation of the development is given. After that a prototype of the final product is presented and examined. Following the a workflow of the development is presented and described. At the end of this thesis future work in the field of web mapping is suggested.

2 State of the art

In the last chapter, the motivation and idea of this thesis were pointed out. In the upcoming chapter the technology necessary to fulfil the aim of the thesis is introduced.

2.1 Web mapping

2.1.1 Definition of web mapping

The term web mapping concerns all aspects related to a form of information transmission via digital online maps. Web mapping is defined as "(...) the process of designing, implementing, generating and delivering maps on the World Wide Web."*[Neumann 2008]*. This includes all tasks concerning visualisation, technology and transmission of digital maps via the WWW. Web cartography is often used as a synonym for web mapping, but it is somehow different. While web mapping only addresses the technological aspects, web cartography additionally studies the theoretical aspects *[Neumann 2008]*. This thesis is mainly about the practical development of a web map, therefore the focus lies on web mapping, hence web mapping is used as the predominant term. Web mapping consists of three major aspects. First of all the map navigation tools to integrate interactivity to the map, secondly a static map image with general content of a base map and thirdly supporting spatial databases *[Strode 2012]*. The map navigation tools are implemented client-side with the aid of APIs. The navigation tools are the interface between the user and the map. The static map image is a map that follows a specific request from the client to the server and consists of map tiles with general content. The supporting spatial databases form the server-side of the web map. All geospatial data of the web map is stored in databases and the server produces a map from that data to a particular request. The process of web mapping can be described as following:

First of all a digital map has to be made. This map can contain any kind of geospatial referenced information. The design and extent of such a map depends on the application of the map. The digital map whether topographic, thematic or both, is then stored on a computer which has an constant connection to the WWW. This computer is called the server and can be an ordinary desktop computer but most likely, because of the huge amount of data, is some sort of web server physically consisting of server plates with a much bigger memory than an ordinary desktop computer *[Peterson 2012]*. The map can be transmitted to any computer in the world that has access to the internet. The computer which receives the map is called the client. After a particular request from the client to the server, a map is produced at the server. Following several responds of the server, the data, meaning the digital map, is transmitted to the client. According to Neumann, this process is called web mapping *[Neumann 2008]*. Geospatial information can be distributed incredibly fast and with few cost. Also the up-to-date nature of the information can be easily achieved by updating the data stored on the servers. The data can be updated frequently without increasing the costs *[Neumann 2008]*. Furthermore the map is virtually and platform-independent, which means it is not physically bound to paper or any other media and can therefore be distributed repeatedly also without increasing costs *[Neumann 2008]*. Web mapping simplified the distribution of maps by communicating them via the internet.

2.1.2 Development of web mapping

The history of web mapping starts in the early 1990s with the introduction of the Mosaic web browser which enabled the display of graphics transmitted via the internet. Shortly after that one of the first online mapping applications was developed: The Xerox PARC Map Viewer, introduced in 1994. This Map Viewer was a simple web application that created on-demand maps from a geographic database. The Map Viewer used the basic principles of web mapping: After a request for a specific map from the user, the server generated individual maps in a graphic file, embedded them into a web page and transmitted the produced web page to the client. These early web maps already included some client-server interactivity. The client was able to choose between the display of national boundaries and rivers, change the map scale, change the map projection and add placemarks *[Detwiler and Dutton 2009]*. Several years later, in 1996, the GeoSystems[7] MapQuest was introduced. MapQuest is an online map service which included route-finding and address matching in its functionalities *[Neumann 2008]*. This development was a big step in web mapping. Route-finding still is one of the most important functions of a web map. MapQuest used a simple synchronous client-server communication model where data transmission between client and server only occurs after specific client requests.

[7] A map publishing company from Lancaster, Pennsylvania; Now MapQuest

In 2005 Google introduced their online map service called GoogleMaps. GoogleMaps provided an interactive web map as an extension of Google's search engine. GoogleMaps made it possible to search for features on the map by adding geospatial reference to information. Also GoogleMaps had a different business model than earlier online map services: To finance the distribution of their map, they charged other companies to be found on their map *[Peterson 2012]*.

The most recent development in the field of web mapping is the distribution to mobile devices. Applications developed especially for mobile devices made it possible to add an important content to the web maps: The current location of the user. This information derives either from GPS, cell phone tower triangulation or the wireless local area network (WLAN) to which the device is currently connected. The knowledge of the current position enables web maps to take it into account when a specific request for a map is made by the user.

2.2 Base map

2.2.1 Definition of a base map

“A base map is the core of any online-mapping service.”*[Zaychenko et al. 2011]*. That means, a base map is the fundamental and essential part of an online map service. A base map, in general, has no customized features and is static. The content is very general and its coverage matches the maximum coverage of the respective provider. The major online map services like GoogleMaps, BingMaps[8], OpenStreetMaps, etc. have global coverage of their base maps *[Peterson 2012]*. The creation of a base map requires cartographic knowledge as well as mapping skills. The most prominent task in creating a base map is the assuring of good cognition and visual perception. The designer of the base map has to make sure that the map is readable *[Neumann 2008]*. In order to do so the designer has to carry out cartographic generalisation to enable the best readability of the base map. According to Sarjakoski, the choice of the colour palette is also very important *[Sarjakoski 2007]*. Interactivity is added afterwards client-side. GoogleMaps has not only one base map but three. The ordinary Roadmap, the Satellite map, where the content originated mostly from satellite imagery or aerial photography and the Terrain view. The three base maps form three independent map layers that can be displayed in the online map service.

[8] An online map service

The data sources for base maps are various. The data used to produce the content of a base map can be public, originated from governmental organisations. Sometimes commercial companies give away data. The data of collaborative projects like Open-StreetMaps however mostly derives from User-Generated Content (UGC). Also the data can origin from business directories, e.g. real estate. Like all digital maps the data sources can be very dynamic and enable simple updating of the data making the maps more current and reliable *[Neumann 2008]* . All in all a base map is the core of any web map. Therefore the term base map will be used when issues concerning the content are addressed. When issues concerning functionality or appearance are addressed, the term web map will be used.

2.2.2 Layers

The content of base maps can be made adjustable, expanding the functionality of the web map from static to dynamic *[Neumann 2008]*. These content layers can be overlaid to the base map by adding a topic to these base maps. This principle of layers of content is a major improvement of digital maps in comparison to printed maps, because you can change the content of the whole map without the need of republishing it *[Neumann 2008]*. A simple request from the client to the server is sufficient and the altered map is transmitted to the client browser.

The type of layers vary a lot. The most frequent layers are infrastructure or other traffic related types like public transport and street networks. Other layers add multimedia information to the web map, clickable additional information transferred to the user via various media channels. More thematic customised maps offer layers with hiking or biking routes. New technologies in Photogrammetry enable the creation of 3D models of buildings and overlaying them onto the base map. GoogleMaps has the possibility of overlaying a topographic layer on the base map, closing the gap between thematic and topographic map. BingMaps has the possibility of overlaying an oblique “Bird's-eye view” that shows areal photography from a 45°-angle *[Peterson 2012]*. There are many other types of layers you can add to a base map.

2.2.3 Level Of Detail (LOD)

In web mapping maps are provided in several LODs. LOD, in the field of web mapping, refers to representations of the same extent of a map but with different scales, different amount of content and alternative detail. These several representations are a consequence of two facts: On the one hand the trade-off between complexity and performance *[Luebke et al. 2003]* and on the other hand due to cognition and visual perception of the user. In web mapping complexity refers to the amount of content represented in the map. Performance refers to the maximum transmission rate of the map via the internet. The struggle between the complexity and performance in web mapping is overcome by faster internet connections, the technique of map tiling and the AJAX-concept[9]. The task to assure good cognition and visual perception is more complicated. One has to find the right amount of data for each map so that the map contains all necessary data for its specific task, but still has not too much content to overflow the user with information. If there is too much information represented on the map, it is not possible to perceive all of it and the map's purpose has failed. The user is not able to separately perceive every single object of the map.

To overcome the problems in cognition and visual perception, different levels of zooming are implemented in most web maps. There are base maps in several scales and they are linked to one or more levels of zoom. In different scales the base map has different amount of content or even a completely different content. The combination of different scales and levels of zoom can be referred to as view-dependent LOD. Online map services implement this technique for any of their base maps and make sure that every layer can be overlayed in every LOD. Therefore the user is able to extract as much information from the maps as possible and the maps fulfil their tasks, respectively. Furthermore it is important to optimise the base map's LOD due to restrictions of the display of the user. The display has a finite expanse and the LOD has to take that into account. Especially displaying the map on mobile devises, which have even smaller displays than ordinary desktop computers, is a challenge. Other technical restrictions like the resolution of the display have to be noticed as well *[Peterson 2012]*.

2.3 Technology

2.3.1 Map-tiling

In the last years the demand for extremely fast online distribution of maps is increasingly growing *[Pridal 2011]*. To overcome this task major online map services store their maps as numerous fractions, so-called tiles.

9 See chapter 2.3.1/ 2.3.3

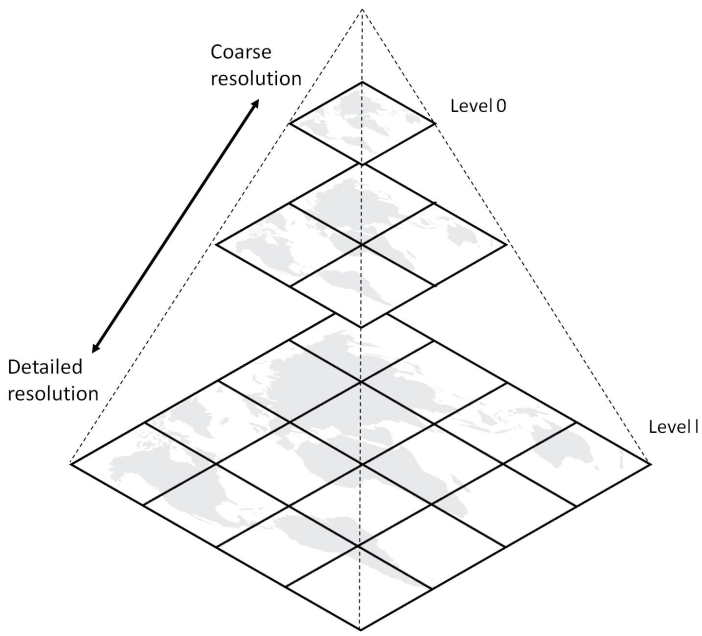


Fig. 2: The principle of map-tiling in different LODs

As you can see in figure 2, the number of tiles is increasing with an increasing LOD. Therefore you need more and more individual tiles with increasing LOD to cover the whole earth or rather the maximal extent of the respective base map. Tile-based online mapping systems are typically published via a web server with support of the OGC[10] Web Map Service (WMS) standard *[Pridal 2011]*. The WMS application is installed and configured on a server with connection to the internet. It is then possible to distribute maps due to clients' requests. The problem is that for every request the map is drawn on-demand from the source data. The creation of a map is very CPU intensive. In order to not have to trade-off the quality of the map to ensure fast transmission of the maps, the map is pre-rendered and cached in tiles. An additional software is placed between the client and the server with support of the OGC Web Map Tile Service (WMTS) standard *[Pridal 2011]*. The most frequently requested tiles are pre-cached and can be transmitted to all clients immediately. This technique speeds up the distribution of the web map because there is no need to carry out the CPU intensive creation of the map. Also the displaying of the maps is faster because the map tiles can be sent individually through the internet *[Peterson 2012]*. The map tiles travel faster because they can take different routes to the client and then are reassembled at the client. The

[10] Open Geospatial Consortium

responsiveness of the entire web map application is significantly higher. The hosting of a web map is simpler, thus increasing the reliability of the web map application. But there is one disadvantage of this approach: The required storage space increases tremendously.

2.3.2 Data storage

The online base maps of online map services like GoogleMaps represent a huge amount of data. It is here explained with the example of the GoogleMaps Roadmap. The Roadmap is the default map of GoogleMaps *[Peterson 2012]*.

LOD #	Number of tiles	Storage requirement at 15 KB per tile	Disk storage costs at US $100 per Terabyte	RAM storage costs at US $30 per Gigabyte
1	4	60 KB	$0.000006	$0.002
2	16	240 KB	$0.00002	$0.007
3	64	968 KB	$0.0001	$0.03
4	256	3.75 MB	$0.0004	$0.11
5	1,024	15 MB	$0.001	$0.44
6	4,096	60 MB	$0.006	$1.76
7	16,384	240 MB	$0.02	$7.03
8	65,536	960 MB	$0.09	$28.13
9	262,144	3.75 GB	$0.37	$112.50
10	1,048,576	15 GB	$1.46	$450
11	4,194,304	60 GB	$5.86	$1,800
12	16,777,216	240 GB	$23.44	$7,200
13	67,108,864	968 GB	$93.75	$28,800
14	268,435,456	3.75 TB	$375	$115,200
15	1,073,741,824	15 TB	$1,500	$460,800
16	4,294,967,296	60 TB	$6,000	$1,843,200
17	17,179,869,184	240 TB	$24,000	$7,372,800
18	68,719,476,736	960 TB	$96,000	$29,491,200
19	274,877,906,944	3.75 PB	$384,000	$117,964,800
20	1,099,511,627,776	15 PB	$1,536,000	$471,859,200
Total	**1,466,015,503,700**	**20.480 TB or 20 PB**	**$2,048,000**	**$629,145,600**

Tab. 1: The number of tiles, storage requirements and storage costs used by a tile-based online mapping system to represent the world at different LOD [Peterson 2012]

The Roadmap is available in 20 LODs, with LOD #1 is the map with the smallest scale and LOD #20 is the map with the biggest scale. Every LOD is divided into tiles, thus forming a tile-based online mapping system. LOD #1 is divided into 4 tiles. The amount of tiles of every LOD with a higher number is in this case four times the preceding LOD. Therefore the GoogleMaps Roadmap consists of almost 1.5 trillion tiles.

Every tile is 256 x 256 pixels in size and require about 15 KB a piece to store in PNG[11] format. All 20 LODs combined require a approximately 20 PB of memory. The cost of storing such an immense amount of data is not published by Google. With an estimation of US $100[12] per Terabyte disk storage cost the storing of the entire map of the world would cost about US $2 million[13]. There are indications that Google caches the most popular map tiles as faster RAM[14]. With an estimation of US $30 per Gigabyte RAM storage cost the storing of the entire map of the world would cost about US $630 million[15]. The real cost is anywhere between US $2 million and US $630 million because only popular map tiles are cached as RAM *[Peterson 2012]*.

These figures exclusively refer to one single base map of GoogleMaps, the Roadmap. GoogleMaps has additional two types of base maps: The Satellite map and the Terrain view. The Satellite map is available in 20 LODs, the tiles are stored in JPEG[16] format and the required amount of storage space is approximately the same as for the Roadmap. The terrain view is available in 15 LODs, thus the required storage space is less as for the Roadmap. All in all the required amount of storage space is around 42 PB and the data storage costs are perhaps as much as US $2 billion[17] *[Peterson 2012]*.

These are incredible huge figures and indicate that the data is handled with great effort and great care. The data is not just stored anywhere on dozens of servers distributed randomly anywhere on the globe. The data is stored in big data centres exclusively used and owned by Google itself. These are huge complexes with secure energy supply and disaster-proofed buildings. Google operates several data centres distributed all over the globe. The data is easily accessible for anyone on the globe with a working internet connection *[Peterson 2012]*.

The figures concerning the data storage of GoogleMaps are of course immense, but the principle of storing said data is always the same for any online map service. The map is created from a certain data source then fractioned into tiles and pre-cached on a web server to ensure fast data transmission *[Pridal 2011]*.

[11] Portable Network Graphics; Raster file format for lossless data compression
[12] US $100 ≈ €73; exchange rate at February 25, 2014 (US $1 = €0.7275)
[13] US $2 million ≈ €1.5 million; exchange rate at February 25, 2014
[14] Random-Access Memory; A form of computer data storage where it is possible to directly access data in any random order
[15] US $630 million ≈ €458 million; exchange rate at February 25, 2014
[16] Joint Photographic Expert Group; Image format with lossy compression for digital photography
[17] US $2 billion ≈ €1.5 billion; exchange rate at February 25, 2014

2.3.3 AJAX-concept

AJAX is a concept of asynchronous data transmission between a client browser and a server. AJAX was introduced with GoogleMaps in 2005 as a major innovation in the relationship between the client and the server *[Peterson 2012]*. AJAX leads to faster responses of a web map by maintaining a continuous connection between the client and the server. AJAX can be interpreted as an application which runs in the background and exchanges small messages with the server even when the user has not made a specific request. It enables HTTP-requests and changing a HTML-page while the page is simultaneously displayed without having to completely reload the page *[Peterson 2012]*.

In the field of web mapping it enables a fast loading of map tiles adjacent to the currently displayed map tiles by pre-caching them. The pre-cached map tiles can be adjacent in the sense of their location is next to the current map tiles or adjacent in the sense of the next LOD *[Peterson 2012]*.

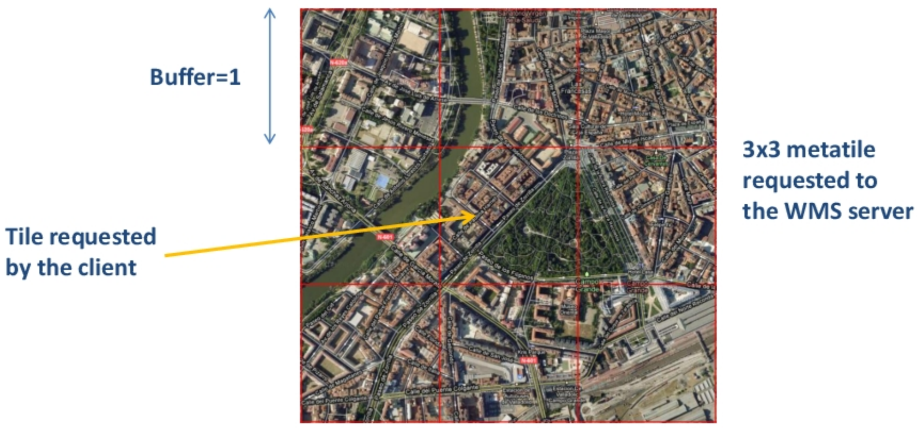


Fig. 3: The principle of AJAX map-tiling in one LOD

In figure 3 you can see the principle of AJAX map-tiling. AJAX is an expansion of map tiling to increase interactivity and transmission rate. It leads to an improved user interface. The AJAX-concept works as follows: An AJAX engine, a JavaScript code, is located between the client and the server and exchanges data, permanently *[Peterson 2012]*. An user action on the map which would typically generate a HTTP-request from the client to the server leads to a call to the AJAX engine instead. If the AJAX engine is able to respond to that request no further response from the server is required and the request can be fulfilled immediately. If the AJAX engine needs additional data from the server it automatically produces a request to the server without interrupting the user's interaction with the map *[Peterson 2012]*. AJAX excludes redundant client-server data transmission thus optimising the client-server relationship to be more effective.

2.4 APIs

Application Programming Interfaces, or short APIs, are that what made web mapping tremendously present in our everyday life. APIs are online software libraries which "(...) provide the means to acquire, manipulate and display information from a variety of sources" *[Peterson 2012]*. That means that APIs provide all tools necessary to gather data, process the data and to produce a digital web map from the data. APIs exist for a variety of web services besides web map services. In this thesis, the term API exclusively refers to APIs concerning web map services. APIs make it very easy to add spatial reference to any information and displaying said information on a map. Even non-experts can produce extensive and interactive web maps with the aid of APIs. Before the introduction of APIs it was necessary to possess a considerable amount of programming skills to connect information from a certain source to a geographical location and producing a map. With APIs you are able to add customised content to a web map provided by any online map service and distribute the resulting map via the internet. APIs also include map-related functions to manipulate the map. Basic functions are controlling the appearance of the map, including the scale, position, and any added information, whether points, lines or areas *[Peterson 2011]*.

If you overlay additional information from any source, you produce a so-called mashup. Mashup means the combination of several web sources, in this case the combination of a provided base map and any added information from any source. Mashups are only possible through the availability of APIs.

The first API was introduced by Google in 2005 shortly after the launch of GoogleMaps: The GoogleMaps API. This API allowed any user to create their own customised map. It caused a major change in the field of cartography. "The relative ease of overlaying all types of information with online mapping APIs has (…) transformed cartography from a passive to an active enterprise." *[Peterson 2012]*. Before the introduction of APIs it was only possible to use maps which were produced for a certain user. The maps could be printed by a map publishing company or the result of a specific client request to an online map service. With APIs it is now possible to actively produce interactive digital web maps and therefore become an active cartographer.

2.5 Functionality

2.5.1 Types of web maps

A high usability of a web map depends on how sophisticated the functionality of the interactive web map is. The first web maps were static, due to technical restrictions, whereas today's web maps are interactive and able to integrate multimedia information. This information can be presented through text, graphics, digital video, digital audio sound, computer animation and virtual reality (VR) *[Hu 2012]*. The process of including multimedia information from various sources into a web map is called multimedia mapping.

According to Neumann you can differentiate between 10 types of web maps with increasing sophistication:

1. **Static web maps** are view only and allow no interactivity between the user and the map. They are created only once and embedded into a HTML-page.
2. **Dynamically created web maps** are created on-demand from dynamic data sources, such as databases.
3. **Distributed web maps** are created from distributed data sources.
4. **Animated web maps** have a temporal variable and show changes over time.
5. **Realtime web maps** show the situation of a phenomenon with only a short time delay. The data displayed in realtime web maps is collected by sensors.
6. **Personalized web maps** allow the map user to apply his own data filtering, select content and apply personal styling and map symbolisation.
7. **Open, reusable web maps** are complex web mapping systems that allow the reuse in other web pages. Open, reusable web maps are realised through the use of APIs.
8. **Interactive web maps** are all maps that allow the user to interact with the map. The user can explore the map, change parameters, reveal additional information and hide undesired information.

9. **Analytic web maps** or **Web GIS**[18] are web maps with an emphasis on analysis, processing and exploitation of geographic information.
10. **Collaborative maps** are maps where the content is completely user-generated UGC *[Neumann 2008]*.

In recent times the boundaries between these types of web maps became blurry. Current web maps of online map services have qualities of several of those web map types. From a scientific point of view a really good web map combines qualities of several types of web maps in one web map. Of course it is important that these qualities are not contradicting each other and do not overwhelm the user with information and functionalities one cannot or do not want to use.

2.5.2 User Interface (UI)

UI describes the functionalities of a web map that can be addressed and used by the user. UI refers to the interface the user can see and interact with in an interactive web map. Interactivity is achieved through “(...) the combination of events, scripting and DOM[19] manipulations.” *[Neumann* 2008]. The interaction with a web map is typically written in JavaScript. The JavaScript code within the browser is event driven. From a technical point of view, when the user interacts with the map, certain consequent events are triggered. A specific program is then expected to listen to the generated events and execute code. According to the GoogleMaps API documentation, the events can be classified into two types of events:

1. Simple **UI events** that are mostly triggered by clicking a mouse button or a key on the keyboard. Basic UI events are:
   - Click
   - Double-click
   - Mouse-up/ down
   - Mouse-over/ out
2. **Model-View-Controller** (MVC) **state changes** that refer to changes of the map view such as zooming and dragging *[Google Maps JavaScript API Version 3 2013]*.

18 Geographic Information System
19 DOM, or Document Object Model, is an interface to represent and interact with objects in HTML, XHTML and XML documents. It is platform and language independent.

These events are implemented in most recent web maps . The events are not necessary linked to a specific control button and therefore do not occupy display space. Control buttons increase the interactivity of web maps. Basic controls are:

1. **Zoom control** enables the change of the zoom level to another LOD.
2. **Pan control** enables to move the point of view in any direction.
3. **Layer control** controls which layers are displayed on the map.

The UI can be extended by adding almost any imaginable function. It is only necessary to have enough programming skills to realise new customised UI events. It is desirable that any web map needs its own customised web map UI design to fulfil the user's demands as good as possible and assure high usability. Web maps have different goals to achieve and there are several approaches for achieving these goals. One approach is to focus on a minimalist view, where only basic UI is implemented so that the user is not distracted and can still carry out his interaction with the map. Another approach is to implement an extended UI on the web map but only displaying the basic UI. The extended UI is then only shown if requested by the user *[Kettunen et al. 2012]*.

If an extensive amount of functionality is implemented to a web map it forms an interactive web map which can be seen as an "(...) interface to geospatial data that can support information access and exploratory activities, while it retains its traditional role as a presentation device." [*Kraak 2002]*. This means the map itself becomes an interface between the user and the data behind it.

2.6 Field of application

The fields of application of web maps are numerous. Basically web maps are used to present geospatial data and act as an interface between user and data in order to solve geospatial tasks of any kind. The most common applications of web maps are still address matching and route-finding. The web map is used to find a specific POI, route from A to B or even ROI and display the result as an overlay on a base map. These two applications are the most common and most often used applications of web maps. Since mobile devices use almost the same web maps as desktop computers the route-finding application is used even more frequently. When the current location of the user is included into the web map and can be used to deliver more specific information or better responses it is called Location Based Services (LBS). LBS become more and more frequently used because they are very useful. More and more people own mobile devices which are capable of carrying out LBS. The web maps produced for mobile devices to carry out LBS are specially designed, taking into account slower internet connection, smaller screen space and lower resolutions of mobile devices.

Realtime maps can be used to change decisions during a process or help making fast decisions. Applications for Realtime maps are, for instance, weather maps and traffic maps. Traffic maps become more frequent because more and more sources, in this case traffic sensors, are implemented and produce information to be used for traffic maps. Web maps with analytical GIS functionality are used to work on an even more professional level. A realisations of a Web-GIS delivers very accurate information. On the one hand a Web-GIS assures good decision making and on the other hand spare separate information gathering. This only applies if the map is trustworthy of course.

Other applications of web maps went through a renaissance when they made the transition from printed media to web based projects: Online Atlases. Online Atlases are a collection of digital maps distributed via the internet. The production and updating of atlases is cheaper when distributed via the internet. Online Atlases can even integrate other web sources and therefore offer a greater variety of maps and applications. Some atlases even ceased their printed editions after switching to the distribution via the internet *[Neumann 2008]*. Last but not least a relatively new application of web maps is e-learning. In e-learning any multimedia source can be integrated into web maps and the map then is used for educational purposes.

2.7 Conclusion regarding the technological aspects

The technology presented in this chapter should be sufficient for a sophisticated web map. The state of the art technology enables high usability web maps. To develop the web map, a base map must be produced. This base map must have certain content which will be worked out in the next chapters. Also, because of the limited data available, it has to be worked out with what data the base map will be created. In addition to that possible layers to overlay onto the base map must be worked out.

The question is what technology should be used for the Freytag&Berndt web map and what content the base map as well as certain overlayed layers should have. Any issues concerning data storage and a suitable API will be worked out as well as the user interface.

3 Online survey

In the last two chapters, the technological and scientific basics of web mapping were discussed. In the following chapter an online survey is introduced and the results are presented and examined. The online survey is carried out in order to perform an user-centred development and find out what the user demands of a product before developing it.

3.1 Goal of the online survey

The intended goal of the online survey was to point out which field of application of a Freytag&Berndt web map would be desirable for Freytag&Berndt customers. In addition to that the online survey should give the possibility to be able to state what the user of a customised Freytag&Berndt web map demands of such a web map. Also, with the results of the survey it should be possible to state what content a Freytag&Berndt web map should have. The advantage of an online survey is of course low costs and a wide range of participants *[Oberzaucher 2012]*. To guarantee the development of a map that will fulfil the user's demands the development has to be carried out with focus on the user's demands. According to Nielsen, this approach is called usability engineering *[Nielsen 1993]*. To achieve that goal a survey was carried out in which customers of Freytag&Berndt were questioned in regard to the content of a base map. Therefore, the research question was: “According to Freytag&Berndt customers, what is the desired field of application of a future Freytag&Berndt web map, and what content should the respective base map have?” In order to optimise the result of finding out what a possible user demands of a web map, it was also necessary to find out what purpose the user uses cartographic products like maps in the first place. The product range of Freytag&Berndt is mostly printed map material with the exception of some digital maps especially for tablet computers. The intention was to find out what kind of maps a typical Freytag&Berndt customer purchases and for what purpose. Additionally it was asked how frequent the customers use electronic devices, in order to assess the future opportunities in the area of digital map products for any kind of electronic devices.

Furthermore the goal was to point out common usage problems of maps. The survey focussed on issues concerning printed map material. The findings will be applied to digital maps afterwards.

The online survey was carried out as a quantitative survey. The participants were addressed via the internet. This was done in three ways:

1. A link to the online survey was included twice into the Freytag&Berndt newsletter (July 25 and September 6, 2013).
2. A link to the online survey was included on the home page of Freytag&Berndt over a period of time (June – September, 2013).
3. A link to the survey was posted on the official Freytag&Berndt Facebook page (September 9, 2013).

In total the online survey took place during the months June – September[20].

3.2 Development of the online survey

The online survey was developed with respect to rules of quantitative market research according to Oberzaucher *[Oberzaucher 2012]*. The questionnaire of the online survey focusses on issues concerning existing, meaning deliverable, map content of Freytag&Berndt.

The questionnaire consisted of 17 questions. The online survey was carried out in German to fit the target group's native language. The sequence of the questions was chosen from more basic questions to more specific questions. At the end two demographic questions were stated. All questions were developed in consideration of the research question.

20 Author's note: The survey was online from June 25 – September 15, 2013

Question block	subject matter	# of questions	question type
1	usage of cartographic products	2	half-open
		2	closed-ended
2	problems at map reading	1	closed-ended
		1	open-ended
3	usage of digital map material	3	closed-ended
4	POI content	2	closed-ended
		1	open-ended
5	Route content	1	closed-ended
		1	open-ended
6	Further comments of the respondent	1	open-ended
7	demographic information	2	closed-ended

Tab. 2: Overview of question blocks and question types

In table 2 you can see an overview of the questions of the online survey. Three different types of questions were used in the online survey: Half-open, closed-ended and open-ended questions. A half-open question is a question where a list of possible answers is given and in addition to that one open field where the participant can bring in additional answer possibilities. A closed-ended question is a question where a list of possible answers is given and the participant can only choose from the given possibilities. In both, half-open and closed-ended questions, it has to be defined in advance how many of the given answer possibilities the participant may choose. Last but not least, an open-ended question is a question where there is no given answer possibility and the participant brings in his own answer *[Oberzaucher 2012]*. The intention was that this mixture of question types will lead to a satisfying result. Closed-ended questions were chosen when the respondent had to answer a question with a rating scale, except for the demographic questions. When a question was stated in a rating scale, in order to avoid a moderacy bias[21], the rating scale consisted of an even number of possibilities. Half-open questions were stated to give the respondent the opportunity to add a further option which was not stated in the questionnaire. Open-ended questions were stated in order to gain more information from the respondents. The number of open-ended questions was kept low because open-ended questions take more time to answer and the cancellation rate of respondents increases when the complete survey becomes

[21] A phenomenon in social research where respondents tend towards the midpoint of a rating scale

too time-consuming. The final questionnaire should take between 5 and 10 minutes to answer in order to get most respondents to work through the whole questionnaire. The first few questions are more general and only later the most important questions are stated. This gives the participants the opportunity to warm-up first and then answer the main topic of the online survey, the answers about the map content. At the end of the online survey two demographic questions were stated to find out more about the audience of the online survey.

The online survey was carried out with the Google Docs[22] form survey tool. In Google Docs it is possible to create an online survey with provided modules. It is also possible to add imagery and text between the question modules. The advantage in using this tool was that Google Docs provided a link where the working online survey could be addressed directly. No further work was needed in order to put the survey online. Also a summary of all responses to the questionnaire could be produced automatically visible only for the developer of the online survey. Unfortunately in question 3, question 5, question 7, question 10, question 11 and question 13 a problem occurred: If there was a question stated with possible answers in a rating scale with four different answer possibilities and the two middle answers were not labelled, the Google Docs form survey tool was not able to distinguish on which of the two middle answer possibilities the participant clicked during the survey. Therefore in the results of those questions there are only three possible answers in the results with a moderacy bias.

The complete online survey, as it was online in the summer of 2013, is annexed at the end of this thesis.

3.3 Results of the online survey

A total of 90 respondents answered the questionnaire. The most respondents participated in the online survey after the first and second newsletter of Freytag&Berndt was distributed, equipped with a link to the online survey.

[22] A web-based office suite offered by Google

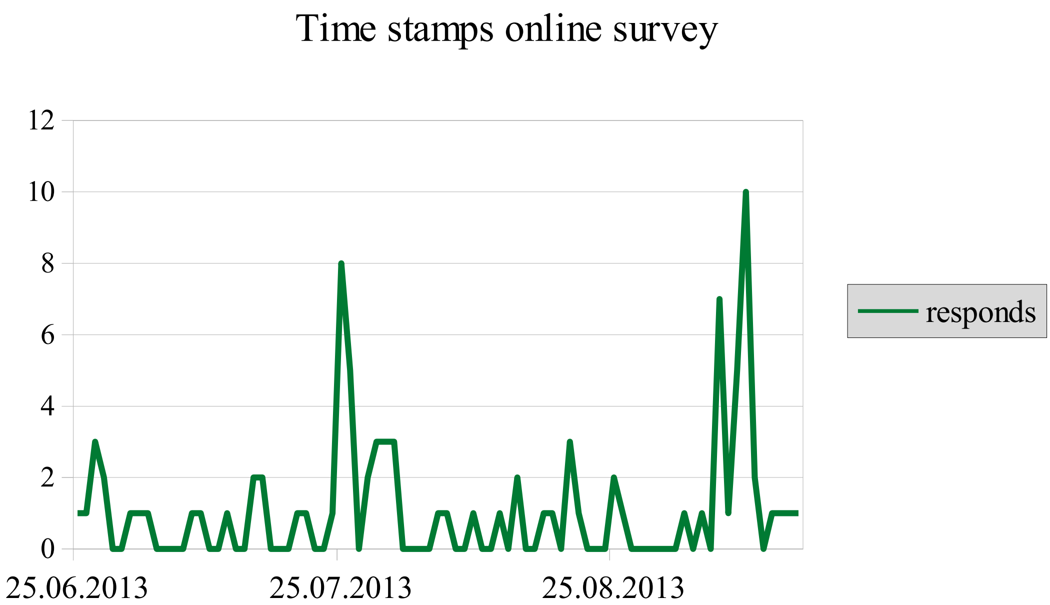


Fig. 4: Time stamps of all responds of the online survey

As you can see in figure 4, peaks with the most responds occur approximately at July 25, September 6 and September 9. The first two dates are the release dates of the two Freytag&Berndt newsletters and the third date is the date when the Freytag&Berndt Facebook page stated a link to the online survey. As you can see, it was clearly necessary to distribute the survey through other channels besides a link on the Freytag&Berndt homepage in order to reach more participants.

3.3.1 Results question block 1

The first question block was about usage of cartographic products in general. The first two questions of this block were half-open, therefore the respondents could give further answers to the already stated ones. The second and the third question were closed-ended.

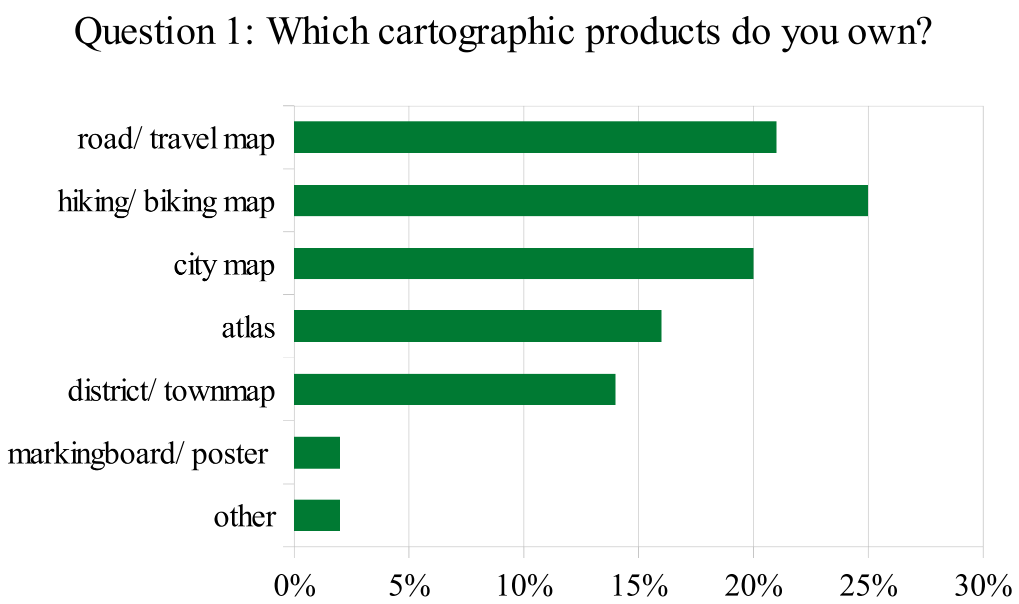


Fig. 5: Result of question 1 of the online survey

Figure 5 depicts the results of question 1 of the online survey. Question 1 of question block 1 was a multiple choice question where the respondents could allocate unlimited answers. The categories were chosen according to Freytag&Berndt's own classification of map products. As far as the questionnaire focusses on deliverable map data of Freytag&Berndt these categories were used here. Otherwise the examination of the survey results would have been more difficult. 21% of the respondents claimed they have road or travel maps. 25% of the respondents claimed they have hiking or biking maps. 20% claimed they have city maps. 16% answered that they have atlases, 14% answered that they have district or townmaps and 2% claimed they have marking-boards or posters. 2% answered they have other cartographic products than mentioned. As additional answers the respondents mentioned that they have Austrian Map[23], maritime maps, motorcycle maps and topographic maps.

[23] A digital map of Austria provided from the "*Bundesamt für Eich- und Vermessungswesen (BEV)"* a state-owned department of Austria concerning surveying and calibration issues.

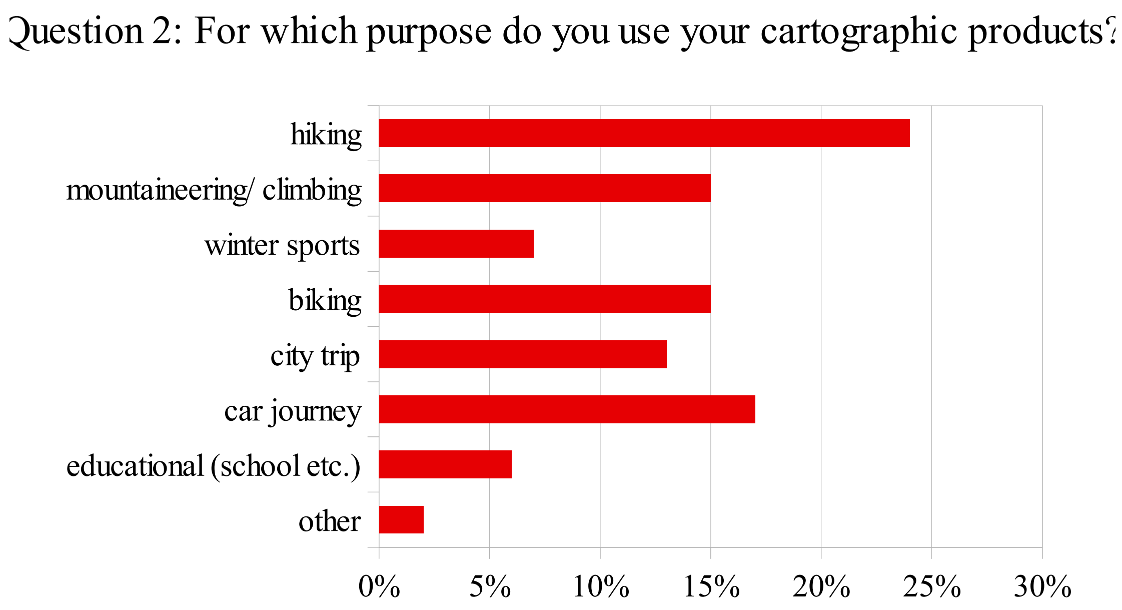


Fig. 6: Result of question 2 of the online survey

Figure 6 shows the result of question 2 of the online survey. Question 2 of question block 1 was also a multiple choice question where the respondents could allocate unlimited answers. The categories here were refer to the classification of map products used in the previous question. The categories refer to possible fields of application of these map categories. 24% of the respondents claimed they use their cartographic products for hiking. 15% of the respondents claimed they use their cartographic products for mountaineering or climbing. 7% answered that they use their cartographic products for winter sports. 15% of the respondents claimed they use their cartographic products for biking activities. 13% of the respondents answered they use their cartographic products for city trips, 17% answered they use their cartographic maps for car journeys and 6% claimed they use their cartographic products for education. 2% claimed they use their cartographic products for other, not mentioned activities. As additional answers the respondents mentioned professional activities, canoeing, hunting activities, other sport activities and train journeys.

The next two questions of the first question block were closed-ended with a rating scale. Question 3 of question block 1 was a single choice question and consisted of three parts. This question was stated in order to find out on what occasion the customers of Freytag&Berndt use their cartographic products.

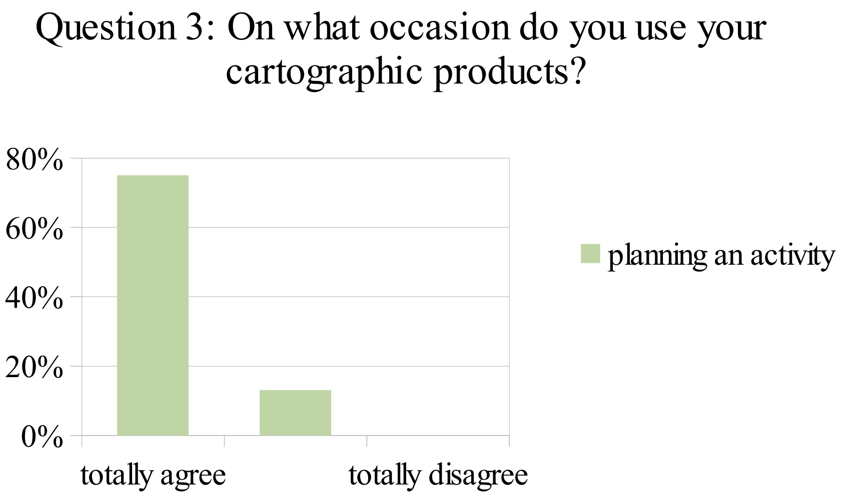


Fig. 7: Result part 1/3 of question 3 of the online survey

Figure 7 shows results of the first part of question 3 of the online survey. A majority of 75% of the respondents totally agreed, 13% of the respondents were indecisive and none of the respondents did totally disagree that they use their maps before the respective activity.

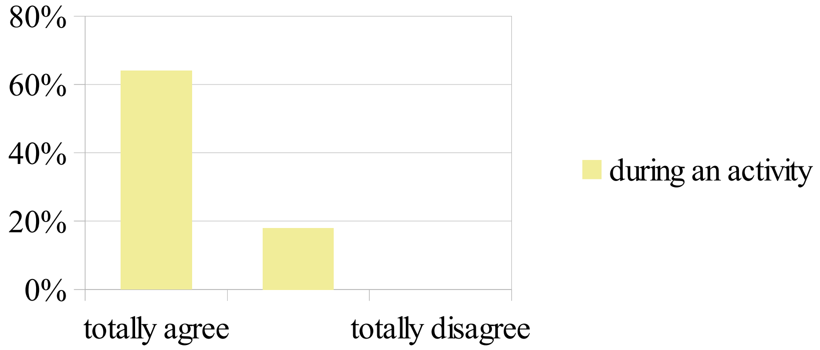


Fig. 8: Result part 2/3 of question 3 of the online survey

Figure 8 shows results of the second part of question 3 of the online survey. 68 % of the respondents totally agreed, 18% of the respondents were indecisive and none of the respondents did totally disagree that they use their maps during the respective activity.

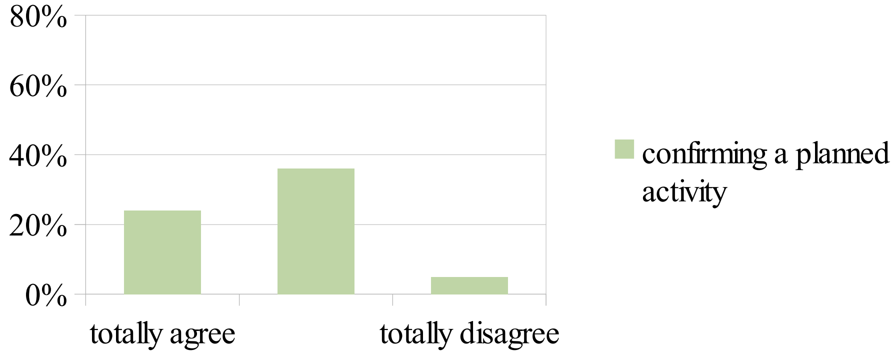


Fig. 9: Result part 3/3 of question 3 of the online survey

Figure 9 depicts the results of the third part of question 3 of the online survey. 24% of the respondents totally agreed, 36% of the respondents were indecisive and 6% of the respondents totally disagreed that they use their cartographic products at home after planning the respective activity.

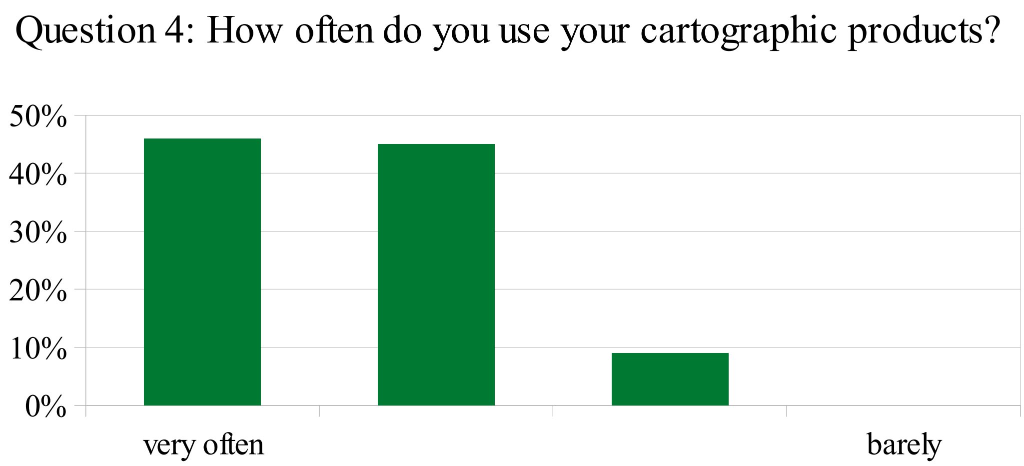


Fig. 10: Result of question 4 of the online survey

Figure 10 shows the results of question 4 the online survey. Question 4 of question block 1 was a single choice question. 46% of the respondents claimed that they use their cartographic products very often, 45% claimed often, 9% of the respondents claimed more likely barely and none of the respondents stated barely. The 4th question was the last one of the first question block about usage of cartographic products.

3.3.2 Results question block 2

The second question block of the online survey was about difficulties the user encounters when reading maps. Question 5 was a closed-ended single choice question, consisting of seven parts and a rating scale. Question 6 was open-ended so the respondents could type in their answers, freely. It was expected that in this question block the respondents will mostly agree with all of the map reading problems. Any suggested map reading problem was thought to be comprehensible and even been experienced by a majority of the participants.

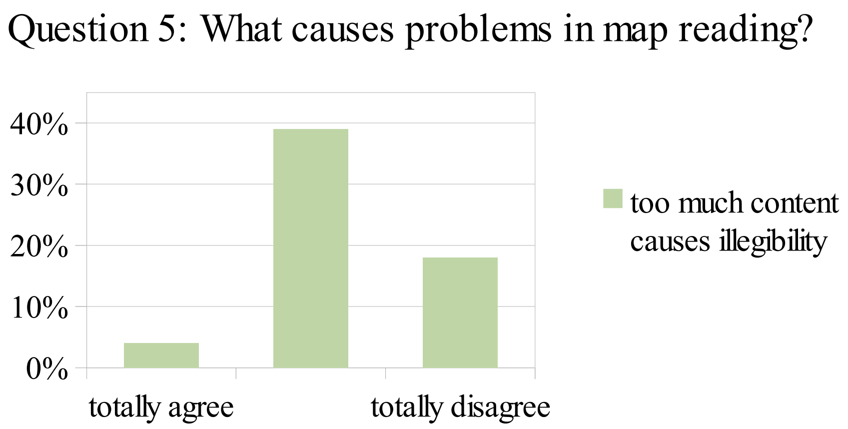


Fig. 11: Result part 1/7 of question 5 of the online survey

Figure 11 shows results of the first part of question 5 of the online survey. 4% of the respondents totally agreed, 39% were indecisive and 18% of the respondents totally disagreed that too much content causes illegibility of the map.

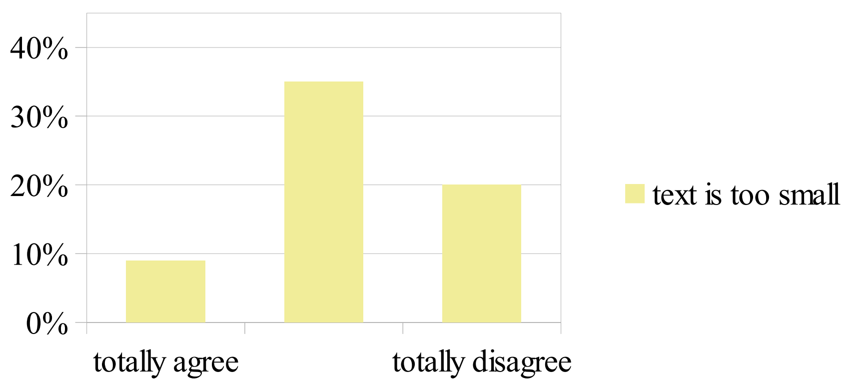


Fig. 12: Result part 2/7 of question 5 of the online survey

Figure 12 shows results of the second part of question 5 of the online survey. 9% of the respondents totally agreed, 35% of the respondents were indecisive and 20% totally disagreed that small text causes problems at map reading.

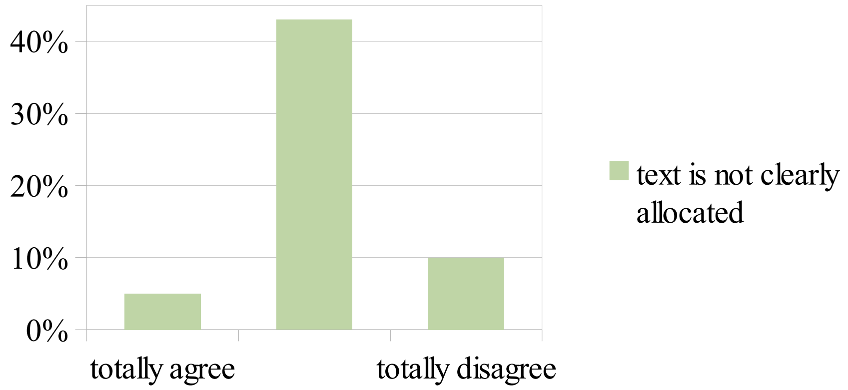


Fig. 13: Result part 3/7 of question 5 of the online survey

Figure 13 shows results of the third part of question 5 of the online survey. 5% of the respondents of the online survey totally agreed, 43% were indecisive and 20% totally disagreed that not clearly allocated text causes problems.

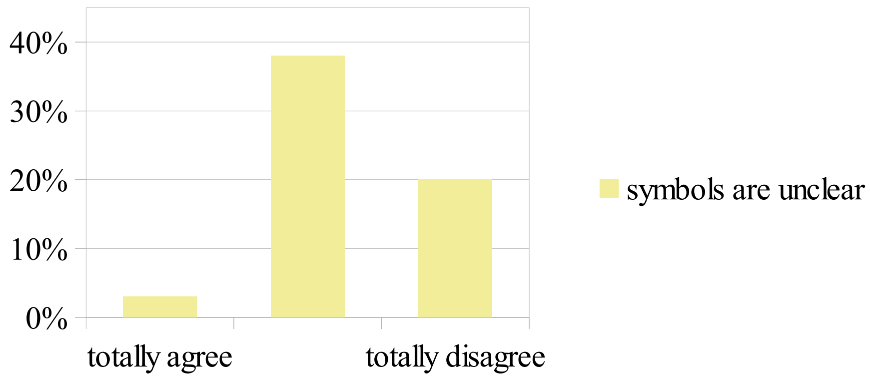


Fig. 14: Result part 4/7 of question 5 of the online survey

Figure 14 shows results of the 4th part of question 5 of the online survey. 3% of all respondents totally agreed, 38% of the respondents were indecisive and 20% totally disagreed that unclear symbols cause problems.

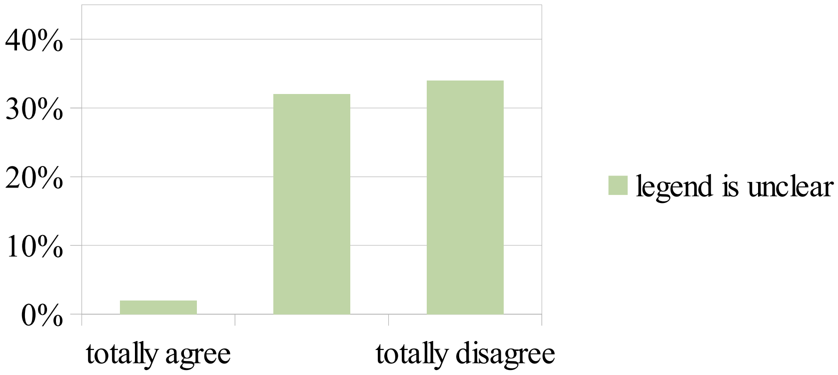


Fig. 15: Result part 5/7 of question 5 of the online survey

Figure 15 shows results of the 5th part of question 5 of the online survey. 2% of the respondents totally agreed, 32% were indecisive and 34% totally disagreed that an unclear legend causes problems.

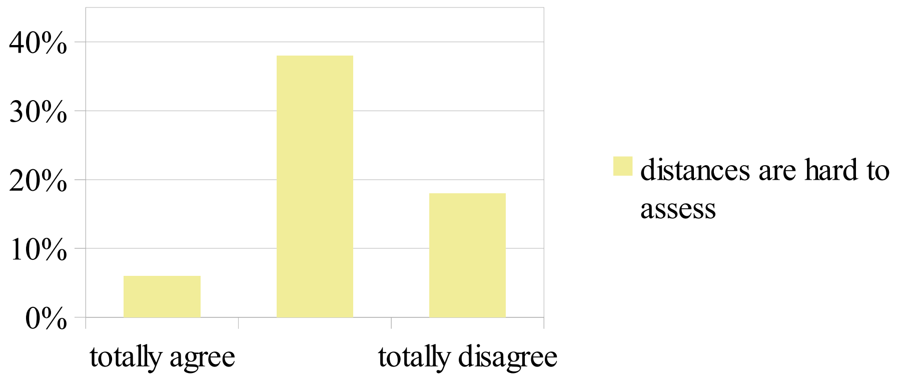


Fig. 16: Result part 6/7 of question 5 of the online survey

Figure 16 shows results of the 6th part of question 5 of the online survey. 6% of the respondents of the online survey totally agreed, 38% of the respondents were indecisive and 18% totally disagreed that distances are hard to assess at maps and that this fact causes problems.

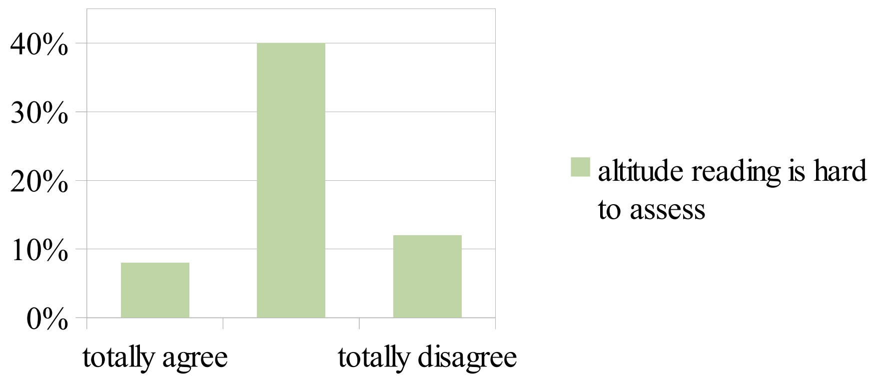


Fig. 17: Result part 7/7 of question 5 of the online survey

Figure 17 shows results of the 7th part of question 5 of the online survey. 8% of the respondents of the online survey totally agreed, 40% of the respondents were indecisive and 18% totally disagreed that altitude reading is hard to assess at maps and that this fact causes problems at map reading.

Question 6 was open-ended to give the respondents the opportunity to give additional ideas what causes problems at map reading. The question was: “Which additional problems do you encounter while reading a map?” The most common answer referred to the transition from one part of the map to another, where the map is folded, the map is hard to read. It was also several times mentioned was too imprecise depiction of content may cause problems at map reading. Most of the further answers referred to problems at map reading caused by lack of important map content, too imprecise depiction caused by generalisation flaws or flawed colour options.

3.3.3 Results question block 3

The third question block of the online survey was about usage of digital map material. This question block consisted of three closed-ended questions with rating scales. Question 7 was a single choice question and consisted of 4 parts. It was expected that the participants use Notebooks/ PCs more than any other device to use digital map products and therefore it would be reasonable to develop a Freytag&Berndt web map for such a device.

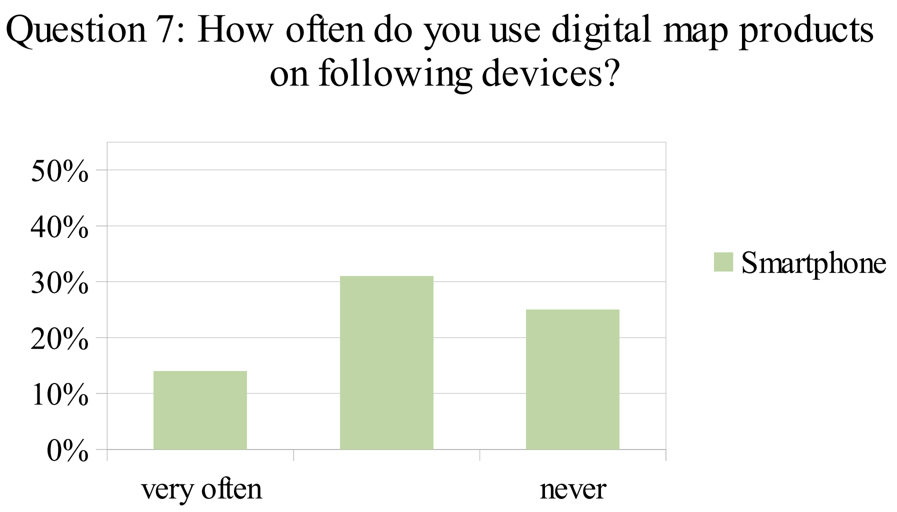


Fig. 18: Result part 1/4 of question 7 of the online survey

Figure 18 shows results of the first part of question 7 of the online survey. 14% of the respondents claimed that they use digital cartographic products very often, 31% claimed often or more likely never and 25% claimed they never use digital map products on smartphones.

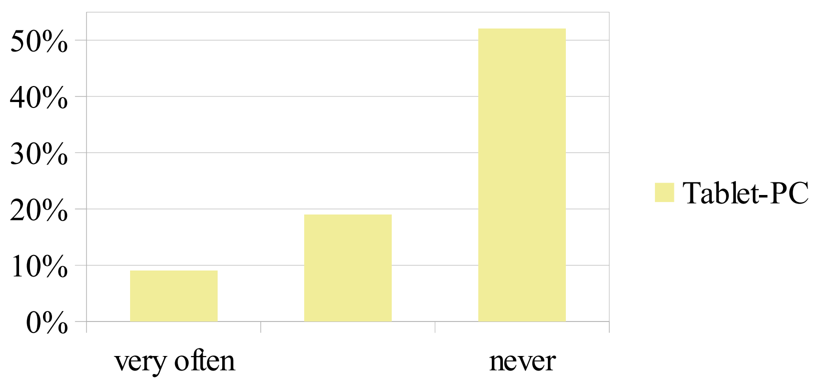


Fig. 19: Result part 2/4 of question 7 of the online survey

Figure 19 shows results of the second part of question 7 of the online survey. 9% of the respondents claimed that they use digital cartographic products very often, 19% claimed often or more likely never and 52% claimed they never use digital map products on tablet-PCs.

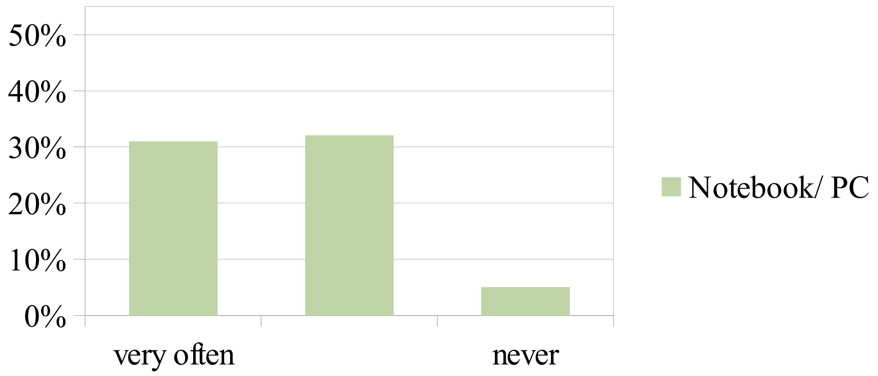


Fig. 20: Result part 3/4 of question 7 of the online survey

Figure 20 shows results of the third part of question 7 of the online survey. 31% of the respondents claimed that they use digital cartographic products very often, 32% claimed often or more likely never and 5% claimed they never use digital map products on Notebooks or PCs.

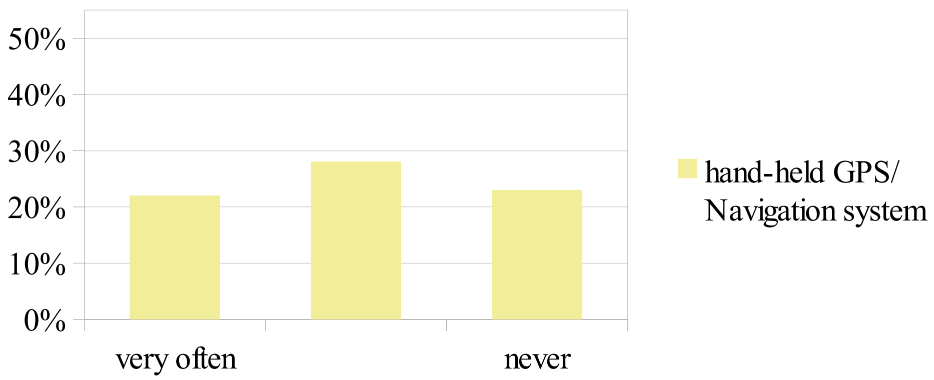


Fig. 21: Result part 4/4 of question 7 of the online survey

Figure 21 shows results of the 4th part of question 7 of the online survey. 22% of the respondents claimed that they use digital cartographic products very often, 28% claimed often or more likely never and 23% claimed they never use digital map products on GPS devices or Navigation systems.

Question 8 was a single choice question about the usage of online map services by the participants of the online survey. It was expected that a considerable amount of the participants state that they use online map services very often.

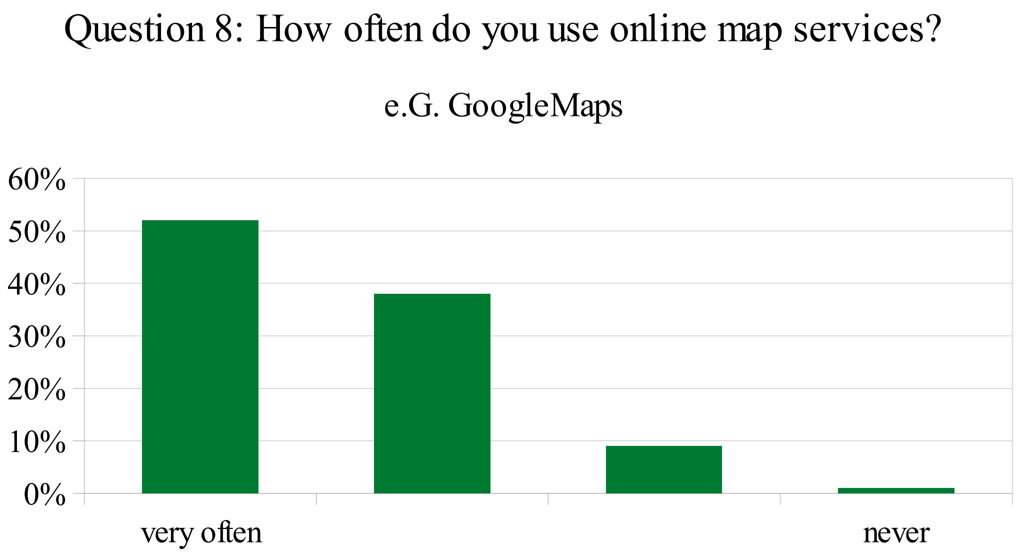


Fig. 22: Results question 8 of the online survey

Figure 22 shows the results of question 8 of the online survey. 52% of the respondents claimed they use online map services very often, 38% claimed often, 9% claimed more likely never and a minority of 1% of the respondents claimed they never use online map services like GoogleMaps.

Question 9 was a single choice question about the usage of location-based social media like Foursquare[24]. Location-based social media refers to social media which focusses on the position of the individual user. The position of the user can be shared with other users and/ or other groups of interest. The position can be used customise advertisements for the user or to find other users nearby. According to Scellato, the usage of location-based social networks is recently increasing immensely *[Scellato et al. 2011]*. That means the market for location-based social networks is growing. Question 9 was stated in order to find out if the customers of Freytag&Berndt already use location-based social media. It was expected that the usage of location-based social media is quite low amongst customers of Freytag&Berndt because this technology is very new.

[24] A location-based social service

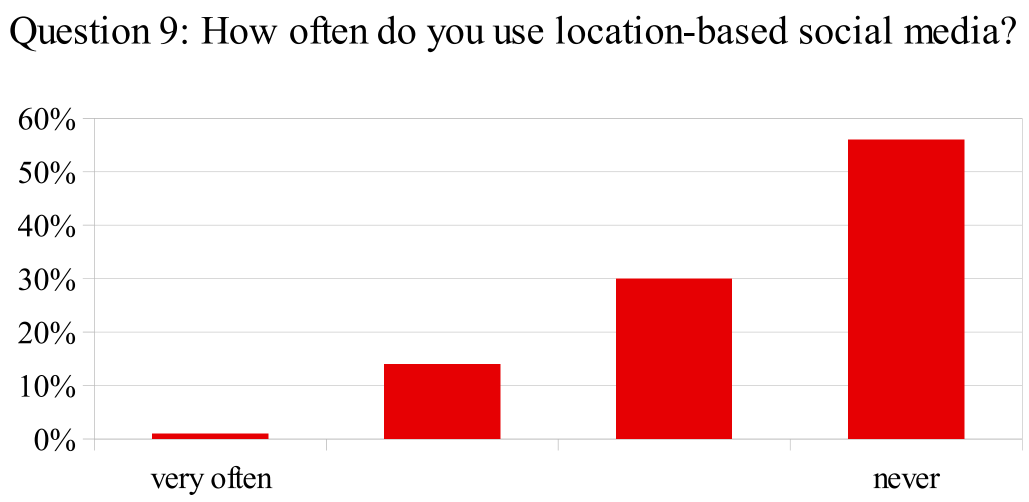


Fig. 23: Results question 9 of the online survey

Figure 23 shows the results of question 9 of the online survey. A minority of 1% of the respondents claimed they use location-related social media very often, 14% claimed often, 30% claimed more likely never and 56% of the respondents claimed they never use location-related social media.

3.3.4 Results question block 4

With the 4th question block of the online survey answers about the content of a base map of an online map service began to be stated. The term base map was not stated in the questionnaire because the participants might interpret it incorrectly, that is why the term web map was used in the questionnaire instead of base map. The questions refer to a general kind of maps and do not go into detail like map scale because it would have made the survey tremendously longer and more complex. The duration of a survey is directly connected to the number of participants who quit the survey before finishing it *[Oberzaucher 2012]*. The 4th question block was about possible point content of such a base map. Question block 4 consisted of two closed-ended and one open-ended question. The first two questions in question block 4 had rating scales whereas the last question gave the participants the opportunity to give additional ideas about which point content of a base map might be important as well. The intention was that this question could serve as a guideline for what the majority of the Freytag&Berndt customers want to be included and what to be neglected in a base map of a

Freytag&Berndt web map. Question 10, the first question of question block 4, was a single choice question and consisted of 7 parts.

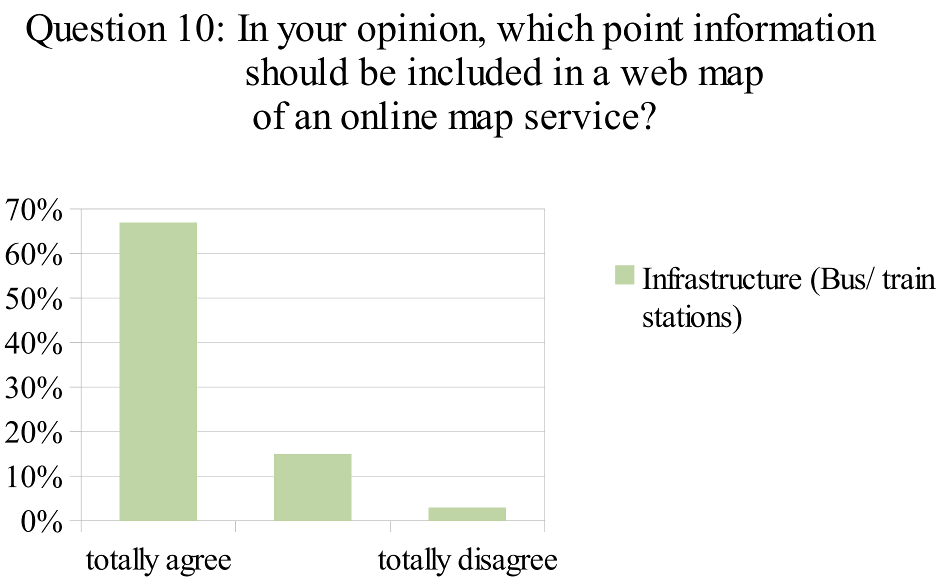


Fig. 24: Result part 1/7 of question 10 of the online survey

Figure 24 shows results of the first part of question 10 of the online survey. 67% of the respondents of the online survey totally agreed, 15% of the respondents were indecisive and 3% totally disagreed that point information about infrastructure should be included in a web map of an online map service.

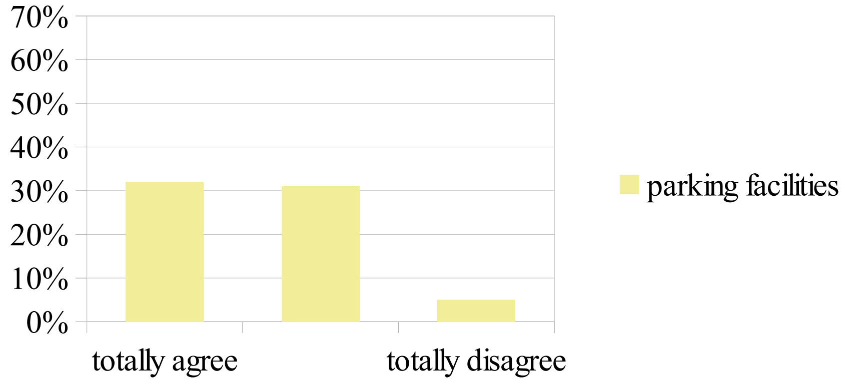


Fig. 25: Result part 2/7 of question 10 of the online survey

Figure 25 shows results of the second part of question 10 of the online survey. 32% of the respondents of the online survey totally agreed, 31% of the respondents were indecisive and 5% totally disagreed that point information about parking facilities should be included.

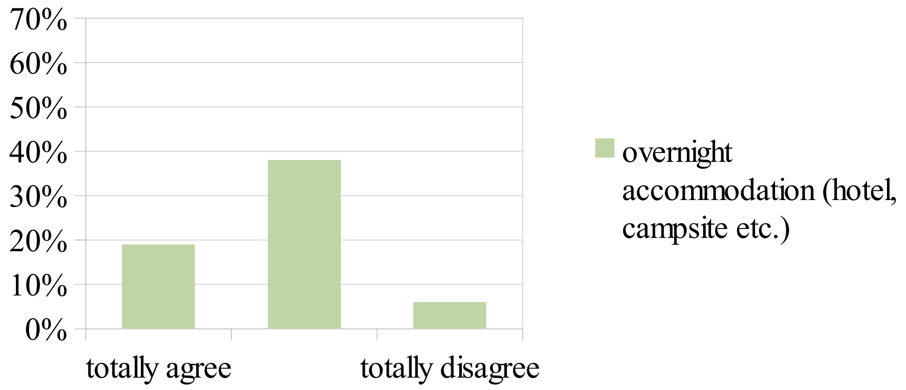


Fig. 26: Result part 3/7 of question 10 of the online survey

Figure 26 shows results of the third part of question 10 of the online survey. 19% of the respondents of the online survey totally agreed, 38% of the respondents were indecisive and 6% totally disagreed that point information about overnight accommodations should be included.

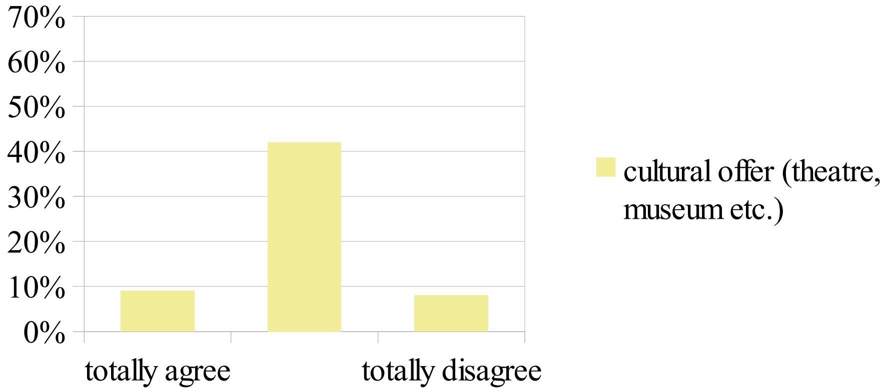


Fig. 27: Result part 4/7 of question 10 of the online survey

Figure 27 shows results of the 4^{th} part of question 10 of the online survey. 9% of the respondents of the online survey totally agreed, 42% of the respondents were indecisive and 8% totally disagreed that point information about cultural offers should be included.

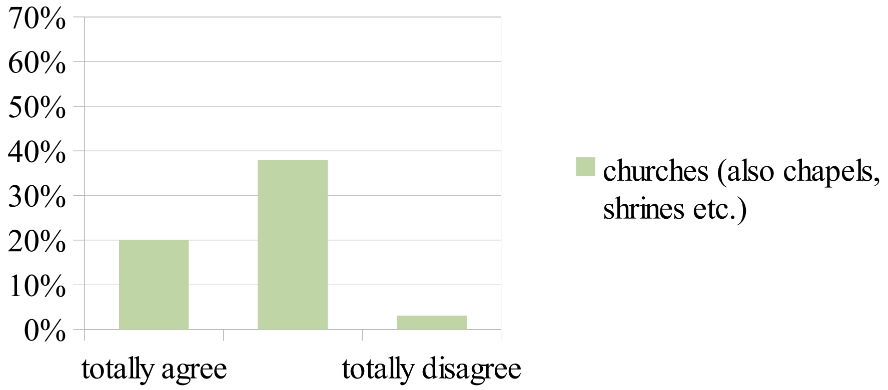


Fig. 28: Result part 5/7 of question 10 of the online survey

Figure 28 shows results of the 5th part of question 10 of the online survey. 20% of the respondents of the online survey totally agreed, 38% of the respondents were indecisive and 3% totally disagreed that point information about churches should be included.

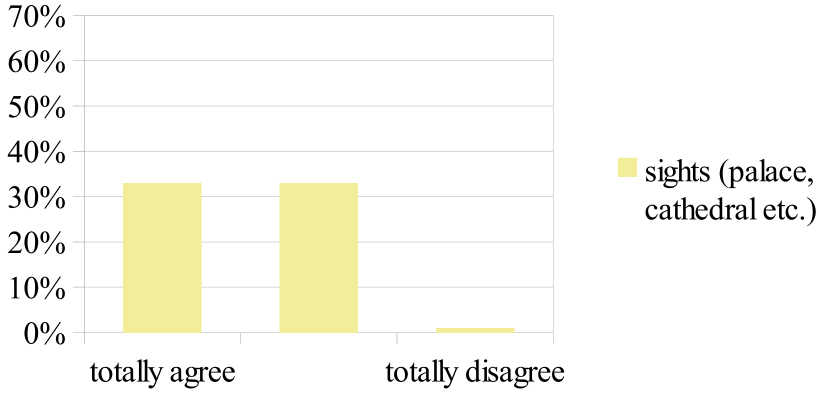


Fig. 29: Result part 6/7 of question 10 of the online survey

Figure 29 shows results of the 6th part of question 10 of the online survey. Respective 33% of the respondents of the online survey totally agreed or were indecisive and 1% totally disagreed that point information about sights should be included.

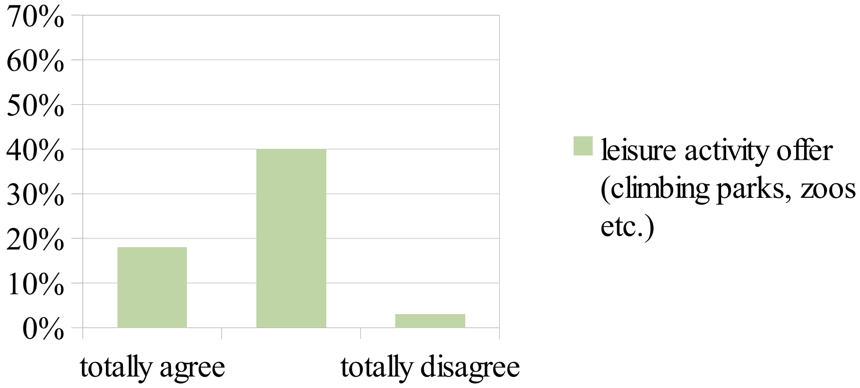


Fig. 30: Result part 7/7 of question 10 of the online survey

Figure 30 shows results of the 7th part of question 10 of the online survey. 18% of the respondents of the online survey totally agreed, 40% of the respondents were indecisive and 3% totally disagreed that point information about leisure activity offer like climbing parks, zoos or similar should be included in a web map of an online map service.

Question 11: In your opinion, which additional point information should be included in a web map of an online map service?

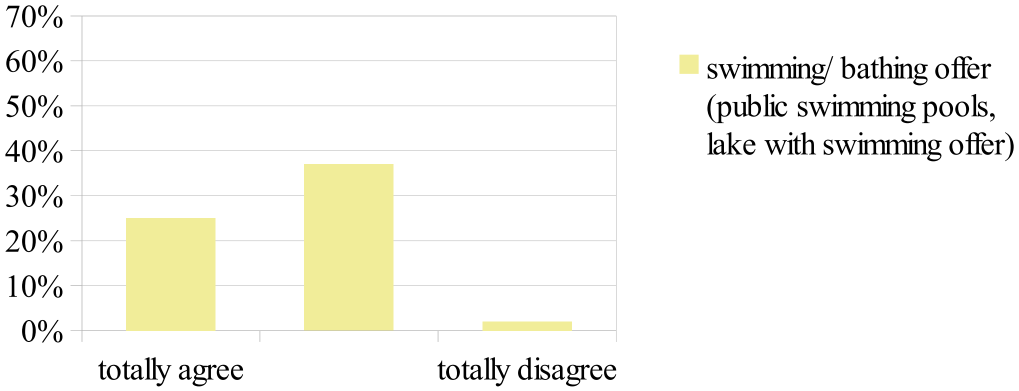


Fig. 31: Result part 1/4 of question 11 of the online survey

Figure 31 shows results of the first part of question 11 of the online survey. Question 11, the second question of question block 4, was a single choice question and consisted of 4 parts. 25% of the respondents of the online survey totally agreed, 37% of the respondents were indecisive and 2% totally disagreed that point information about swimming or bathing offer like public swimming pools, lakes with swimming offer or similar should be included in a web map of an online map service.

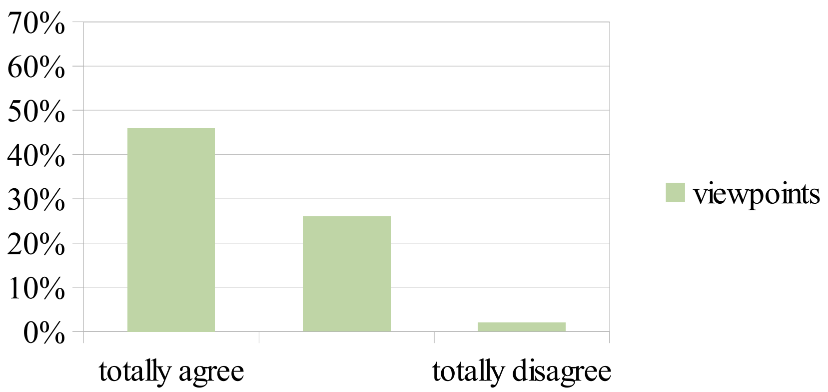


Fig. 32: Result part 2/4 of question 11 of the online survey

Figure 32 shows results of the second part of question 11 of the online survey. 46% of the respondents of the online survey totally agreed, 26% of the respondents were indecisive and 2% totally disagreed that point information about viewpoints should be included.

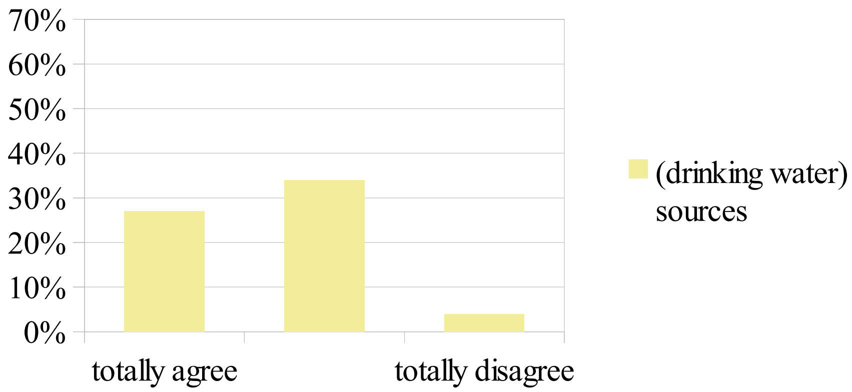


Fig. 33: Result part 3/4 of question 11 of the online survey

Figure 33 shows results of the third part of question 11 of the online survey. 27% of the respondents of the online survey totally agreed, 34% of the respondents were indecisive and 4% totally disagreed that point information about viewpoints should be included.

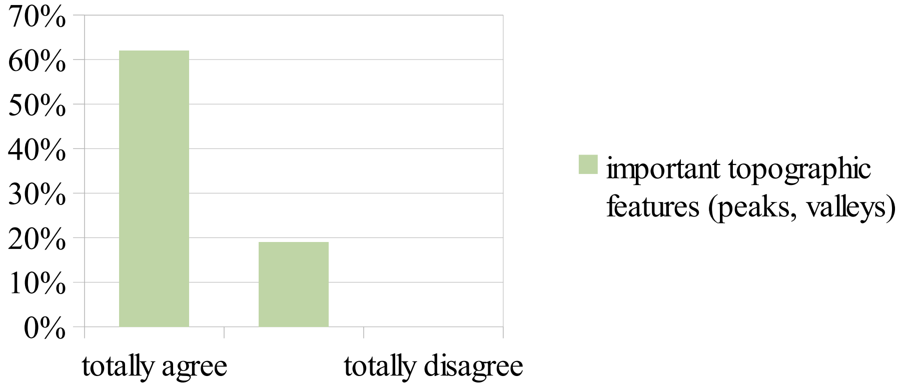


Fig. 34: Result part 4/4 of question 11 of the online survey

Figure 34 shows results of the 4th part of question 11 of the online survey. 62% of the respondents of the online survey totally agreed, 19% of the respondents were indecisive and none of the respondents totally disagreed that point information about important topographic features like peaks, valleys or similar should be included in a web map of an online map service.

Question 12 was open-ended to give the respondents the opportunity to add additional ideas what should be included into a web map of an online map service. The question was:"In your opinion, what point information might also be important?" Here is an excerpt of the most important ideas of the respondents.

- Public buildings
- Medical facilities
- Educational institutions
- Petrol stations
- Canoeing related POIs

3.3.5 Results question block 5

In question block 5 the participants were asked what route content may be important to add in a web map of an online map service. Just like Question 10 and Question 11 of the previous question block, the intention of this question was to use the results as a guideline for what the majority of the Freytag&Berndt customers want to be included and what to be neglected in a base map of a Freytag&Berndt web map. The questions are kept quite general and do not go into detail like map scale, because it would have increased the danger of participants quitting the survey before finishing it. Question block 5 consisted of two questions. Question 13, the first question of question block 5 was a closed-ended question consisting of three parts with a rating scale. Question 14 was open-ended to allow the respondents to add additional ideas about route information in web map of an online map service.

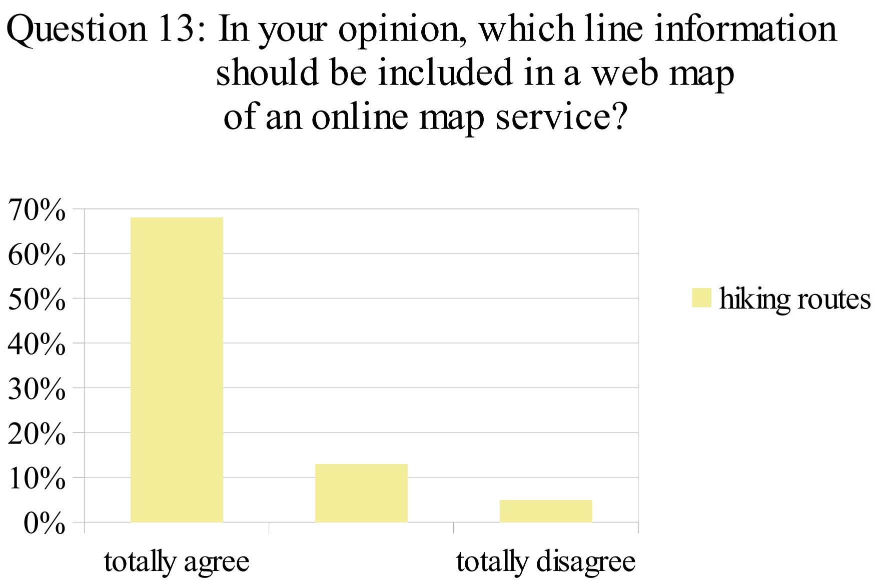


Fig. 35: Result part 1/3 of question 13 of the online survey

Figure 35 shows results of the first part of question 13 of the online survey. 68% of the respondents of the online survey totally agreed, 13% of the respondents were indecisive and 5% totally disagreed that route information about hiking routes should be included in a web map of an online map service.

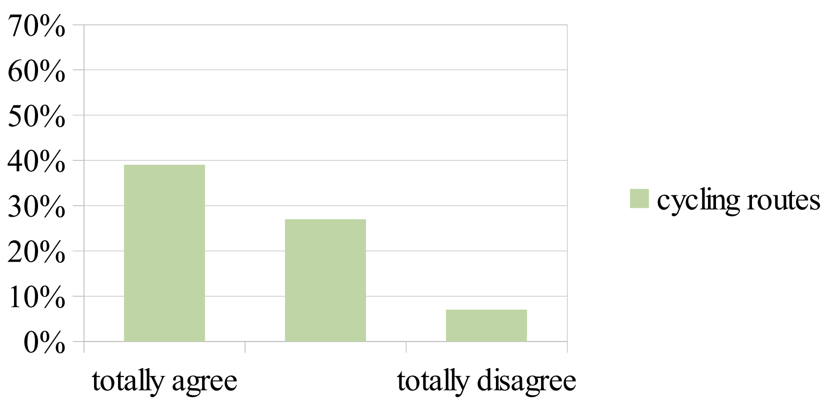


Fig. 36: Result part 2/3 of question 13 of the online survey

Figure 36 shows results of the second part of question 13 of the online survey. 39% of the respondents of the online survey totally agreed, 27% of the respondents were indecisive and 7% totally disagreed that route information about cycling routes should be included.

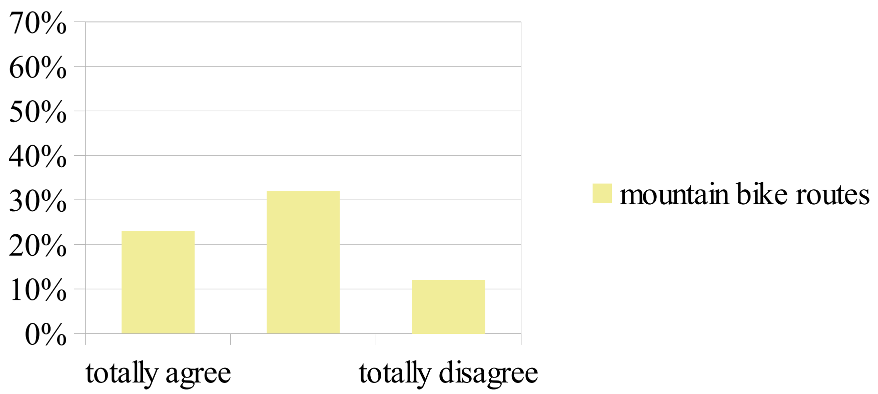


Fig. 37: Result part 3/3 of question 13 of the online survey

Figure 37 shows results of the third part of question 13 of the online survey. 23% of the respondents of the online survey totally agreed, 32% of the respondents were indecisive and 12% totally disagreed that route information about mountain bike routes should be included.

Question 14 was open-ended to give the respondents the opportunity to name additional route content that might be important in a web map of an online map service. The question was:"In your opinion, what route information might also be important?" Here is an excerpt of the most important ideas the respondents added:

- Ski touring routes
- canoeing routes
- climbing routes
- motorcycling routes
- scenic routes

3.3.6 Results question block 6

In question block 6 the participants were given the opportunity to give any comment about the content of a web map of an online map service. Question block 6 consisted only of one open-ended question. Question 15 was:”Do you have any additional comments about map content of a web map?” Here is an excerpt of the most important ideas the respondents stated:

- Map content must be current
- Elevation profile might also be important
- Thematic information must be ordered in optional layer
- As simple as possible print functionality
- Offline version

This was the last subject-related question of the online survey.

3.3.7 *Results question block 7*

In the last question block, question block 7, the participants were asked two demographic questions. One about their gender and one about their class of age. The classes of age took a bearing on the classes of age defined by Statistik Austria[25] (STAT). STAT defined three individual classes of age: Children and adolescents (varies between <14 and <19 years old), working age (varies between 15-59 and 20-64 years old) and later life (varies between >60 and >75 years old) *[Statistik Austria 2013]*. As far as the working age include the majority of the Austrian population, this class of age was subdivided into two classes. It was assumed that people of either the one or the other middle class are the most physically active ones and therefore use maps for outdoor activities more frequent than the other two classes of age.

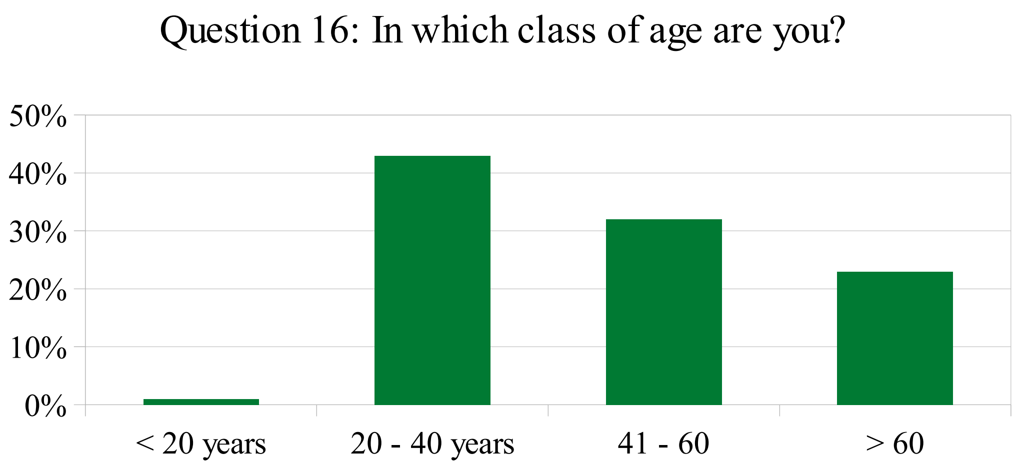


Fig. 38: Results of question 16 of the online survey

[25] An Austrian federal institution responsible for performing scientific services in the area of federal statistics

Figure 38 shows the result of question 16 of the online survey. Only 1% of the respondents of the online survey claimed to be in the class of the under 20 years old. 43% of the respondents answered they are in the class of the 20-40 years old, 32% of the respondents claimed to be in the class of the 41-60 years old and 23% answered they are in the class of over 60 years old.

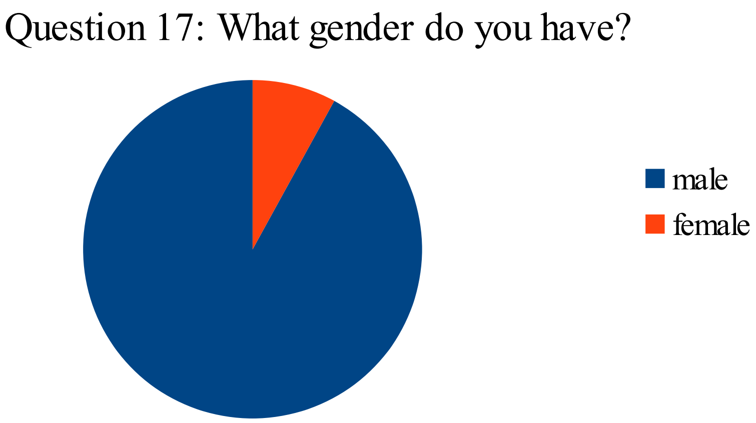


Fig. 39: Results of question 17 of the online survey

Figure 39 shows the result of question 17 of the online survey. 8% of the respondents answered with female and the majority of 92% answered with male. Question 17 was the last question of the online survey.

3.4 Examination of the results of the online survey

To draw conclusions from the online survey, the results have to be examined. The results are examined block by block and conclusions are drawn. The conclusions ultimately lead to decisions what content will be included in the online base map thus answering the research question of the online survey.

3.4.1 Examination of question block 1

In order to find out what kind of audience the participants are, the first question block consisted of general questions. As the online survey was exclusively distributed to customers of Freytag&Berndt, those customers would be also the main audience of the future web map. Question 1 shows, that more paper maps than other cartographic products were mentioned. A quarter of the respondents answered that they have hiking or biking maps thus forming the biggest share. The second and third most frequent answers were road or travel maps and city maps. You can clearly see that the customers of Freytag&Berndt prefer bigger scaled paper maps with a scale of 1:100,000 or bigger.

In question 2 the respondents clarified the assumption that Freytag&Berndt customers prefer bigger scaled maps, because the most frequently stated answer was hiking. Furthermore mountaineering or climbing and biking maps had a big share. Because those map types have a similar scale as hiking maps and these three answers have a major share in the given answers, the conclusion of the first two questions is, that the usage and functionality of the possible web map of Freytag&Berndt must be closely related to those big scaled maps. The development of a web map with a field of application that is the most important field of application for the customers of Freytag&Berndt would be the most useful and guarantees the most usage. According to an usability engineering approach, the most desired demands of a possible user should be implemented in the developed product *[Nielsen 1993]*.

Question 3 lead to the assumption that the most important usage of the web map must be for planning purposes. This fact implicates a more extensive functionality of the map, as all the planning of the activity should be possible with this web map. Functionalities like a route determination function should be included in order to be able to plan a particular activity in detail. Because many respondents also stated that they use their cartographic products during the respective activity, either a mobile version or a printing possibility should be implemented. Ultimately it would lead to a so-called “Multipublishing Environment”. A Multipublishing Environment is a service which is able to deliver different kinds of maps through a number of channels from a single data core *[Kettunen et al. 2012]*. The map would be published as a web map for planning, a printed map for usage during the respective activity and a mobile version for further information during the respective activity. An implementation of a Multipublishing Environment is beyond the scope of this thesis, therefore the focus lies on a individual web map which fulfils the demands as good as possible by offering a print function of a specific extent of the web map or an offline version for either smartphones or Tablet-PCs.

In question 4 an absolute positive trend is detectable: Participants of the online surveys use their cartographic products often. This implicates that there is a demand for cartographic products.

3.4.2 Examination of question block 2

In question block 2 the goal was to find out which problems the participants encounter most frequently with map reading. Unfortunately a clear moderacy bias is detectable in the results of question 5. It is hard to draw conclusions with the information but it can be done by directly compare the results of the individual parts of question 5. Doing so, the most common problem encountered by the participants is that text is not clearly allocated in the map. The conclusion is to ensure clearly allocated text in the map. Also hardly assessable height information is a common problem among the participants. The legend being unclear is the most neglected answer to question 5. Of course, in order to make a good map all points of question 5 should be taken into consideration. The answers were less clear than originally assumed.

The additional answers given in question 6 point out four additional problems at map reading. First of all, the most frequently stated answer was that at the transition from one part of the map to another it is hard to assess the information. This issue is of no concern at a digital map and therefore will not be taken into account in the further development of a web map. Secondly a multi-referencing answer was inaccurate representations in the map. This answer is quite general but nevertheless will be taken into account by ensuring a clear and detailed map. Another multi-referencing answer was problems concerning the readability of the map because of too small content, thus forcing the user to use their glasses. A fully accessible map should be assured. Last but not least it was pointed out by the participants that the content of the map should be current. Thus it must be ensured that the base map and all other parts of the web map will be updated frequently.

3.4.3 Examination of question block 3

The third question block focussed on what potential lies within modern digital online cartography according to the participants of the online survey. Question 7 showed that the most common device used for displaying digital cartographic products is the PC or notebook whereas very few of the respondents claimed they use digital cartographic products on a tablet-PC. According to the answers, Smartphones and hand-held GPS or navigation systems are used quite similarly. Because of these results and also because it would go beyond the purpose of this thesis, henceforth all issues concerning mobile mapping and hand-held GPS or navigation systems will be left out. The question confirmed the assumption that it is reasonable to develop a Freytag&Berndt web map for a Notebook/ PC.

Question 8 showed, as expected, that the average customer of Freytag&Berndt uses the services of online map services often. This fact implies that online map services have a huge potential.

In question 9 the respondents claim that they use location-related social media barely. According to Scellato, there lies great potential in this area and it is not used to its full potential, yet *[Scellato et al. 2011]*. All in all, the third question block showed that the participants of the online survey see definitely see potential in web maps.

3.4.4 Examination of question block 4

In question block 4 the participants were directly addressed which point information content should be included into a digital base map. Fortunately the moderacy bias was less present than in question 5. As far as question 10 and 11 refer to the same issue the results can be combined. The results of question 10 and 11 are combined to one ordered ranking of the possible answers from most important to most unimportant:

1. Infrastructure (Bus/ train stations)
2. Important topographic points (peaks, valleys)
3. Viewpoints
4. Sights (palace, cathedral etc.)
5. Parking facilities
6. Swimming/ bathing offer (public swimming pools, lake with swimming offer)
7. (Drinking water) Sources
8. Churches (also chapels, shrines etc.)
9. Overnight accommodation (hotel, campsite etc.)
10. Leisure activity offer (climbing parks, zoos etc.)
11. Cultural offer (theatre, museum etc.)

This is an order of importance. If a problem occurs at adding two or more classes of content to the base map the decision which one will be selected is always done in favour of the one class with a higher ranking. The fact that important topographic points have a high ranking confirms the assumption that the focus of the base map should lie on big scaled maps like hiking maps or similar.

In question 12 the respondents stated additional ideas about point information in a web map. Practical content of a base map are petrol stations and medical facilities. Other ideas were either covered in other classes or line information which is covered in the next question block. Question block 4 of the online survey is very important and the results give a very important starting point for the development of the web map.

3.4.5 *Examination of question block 5*

In question block 5 the participants were directly addressed what line information content they think should be included into a digital base map. The results are combined to one ordered ranking of the possible answers from most important to most unimportant:

1. Hiking routes
2. Cycling routes
3. Mountain bike routes

This order was not very surprising because it mirrors the frequency of participants actually performing the respective activity. Again, just like in question block 4, this is the order of importance and if a problem occurs the decision will always be made in favour of the content with a higher ranking.

In question 14 the respondents stated additional ideas about line information in a web map. What attracts the attention here, is that for the third time during the online survey canoeing-related matter were mentioned. The participants of the online survey have a certain amount of interest in canoeing and therefore content about it could be practical. Also information about winter sports was mentioned for the second time thus could be practical as well. As a third idea for line information in the base map scenic routes could be practical. Other line information mentioned in this question is either covered in another class or not practical.

3.4.6 *Examination of question block 6*

In question block 6 the participants were asked what additional comments about content of a web map they have. It turned out that the respondents took this chance to mention functionalities of a web map they find practical to be implemented. Some of them are very practical and can be implemented. Most of them refer to a function which enables you to choose which thematic information layer is displayed and which is hidden. The layer-structure of digital maps is one of the most important advantages of digital maps compared to printed maps and will be implemented in the web map. The concern of several respondents that the map content must be current is of course an issue and will be taken into consideration in the further development of the web map. Several respondents also pointed out that height information is very important and, according to the results of question 5 part 7 not perfectly implemented, yet. A simple print function is also practical, but can only be implemented with restrictions. The same applies to an offline version of the map, because if the later user is able to download or print the map in a whole, he would not have to purchase a map.

3.4.7 Examination of question block 7

The resulting age distribution of question 17 lead to the assumption that the addressed customers of Freytag&Berndt are for the most part in a very active age between 20 and 40 (43%) and between 41 and 60 (32%). Therefore it is not surprising that many participants answered the online survey in a favour for all information concerning sport-related outdoor activities (See results question 1, 2, 12 and 14).

The resulting gender distribution of question 18 showed that the main group of Freytag&Berndt customers is male.

3.5 Conclusions drawn from the online survey

As far as the participants of the online survey are most likely the future users of the web map, the results of the online survey showed that the general focus of the web map should lie on a big scaled map with content about hiking, cycling or similar outdoor activities. The participants of the online survey were clearly less interested in smaller scaled overview maps. Also city maps and atlases were of less concern. Therefore, as an initial working map, a hiking map of Freytag&Berndt and all its possible content will be used in order to develop the web map. The results of question 3 showed that the participants of the online survey use their cartographic products for planning or during a particular activity and less after planning to reconfirm decisions already made. The participants stated they do make decisions with the aid of their cartographic products, therefore give the map a very important role and force it to be reliable *[Bailey and Pearson 1983]*.

The research question of the online survey was: “What content should a Freytag&Berndt online base map have?” It is now possible to answer this question. The web map should be based on hiking maps with a scale between 1:30,000 and 1:50,000. Freytag&Berndt hiking maps in particular have mostly a scale of 1:50,000, hence serve the purpose here.

4 Framework: Quality of the web map

In the last chapter guidelines for the content of the Freytag&Berndt online web map were worked out. In this chapter a framework for such a map is established. A web map is an online information system where information is visually presented. In order to guarantee a high quality of such a map, one has to take certain rules into consideration. These rules are usually very general and applied to all kinds of websites, but these rules can also be applied to an online presence that is a web map. In order to optimise the quality of the web map a framework is developed to ensure high quality. According to the DeLone and McLean Model of Information System Success[26], the quality of an information system has three dimensions:

1. System quality dimension
2. Information quality dimension
3. Service quality dimension *[DeLone and McLean 2003]*

Each of these quality dimensions covers different views on the subject. To develop a specific framework for the development of the web map, criteria of a high-quality web map must be defined and assigned to each dimension *[Sadauskas 2011]*. These criteria are specifically defined for a web map.

System quality dimension refers to technical characteristics of the web map, how the web map works and its ease of use. According to Sadauskas the following criteria are assigned to the System quality dimension:

- **Accessibility** means that the software and hardware requirements to use the web map should be as low as possible. Every browser should be supported and no plug-ins necessary.
- **Functionality** means the web map is working without any failures and that it meets the claimed purpose.
- **Navigation** refers to a simple and clear navigation design within the online presence of the web map. Content should be easy to find.

[26] The DeLoneand McLean Model of Information System Success is an information system theory which defines reasons for the success of information systems by identifying, describing and explaining relationships between the most important criteria of success of information systems *[DeLone and McLean 2003]*

- **Reachability** means that the web map can be found. Whether it refers to the promotion of the web map's URL to several search engines like Google or within the website.
- **Reliability** means that the web map should be accessible at any time.
- **Response time** means that the web map should load in a reasonable amount of time in order to be useful for slower internet connections.
- **Security** means that the interaction between a client and the web map is secure and it is not possible for third party members to access data from this interaction.
- **Website design** means that the design of the web map as well as the website where the web map is embedded, should be attractive to the user *[Sadauskas 2011]*.

According to Sadauskas the information quality dimension refers to the content of a web map and the following information quality criteria are assigned to it:

- **Accuracy** means that the content of the base map should be accurate and without any faults.
- **Completeness** means that the amount of information does not change throughout the web map.
- **Ease of understanding** means that the presented information should be easy to understand.
- **Personalisation** means the possibility for the user to alter the amount or class of information displayed in a web map.
- **Relevance** means that on the one hand the web map can deliver the information the user is looking for and fulfil a task, but on the other hand the web map is not overcrowded with information.
- **Up-to-date** means that the information presented on the web map should be current *[Sadauskas 2011]*.

According to Sadauskas the service quality dimension refers to the relationship between the user and the provider of the web map and the following service quality criteria are assigned to it:

- **Empathy** means that the user should have the feeling that the provider of the web map cares about the goal of his or her use of the web map.

- **Trust building** means that the user trusts the provider of the web map to not give away his or her personal information.
- **Communication** means that there is a possibility to contact the provider of the web map *[Sadauskas 2011]*.

These criteria have to be taken into consideration. If all of these criteria are applied to the web map, a high usability of the web map can be guaranteed.

5 Development of the web map

In the last chapter a framework for developing a web map is established. In this chapter the development of such a map is worked out in detail and a concept for a possible map product is outlined. In order to develop a web map for a traditional map-publishing company, it is important to know what a future user demands of such a product. According to the usability engineering approach defined by Nielsen, this can be done by directly addressing the possible future user of the product *[Nielsen 1993]*. This was done by carrying out the online survey described in chapter 3. It is important to know what is technically possible to implement. Furthermore, it has to be defined which information will be included as content in such a map and what data can be provided in the first place. The question what to include and what data can be provided interfere with each other of course. The question what the user demands provides a guideline. Data that can be provided will then be included and data that can not be provided will be left out.

There are three major subjects that have to be taken into consideration:

1. The user's demands
2. The data that can be provided
3. The technical development of a web map

In order to deal with these subjects in a correct way, the subjects are dealt with as three different points of view. In this chapter it is pointed out what has to be taken into consideration at developing a web map from these three different points of views. It is taken into account that the quality of the web map should be as high as possible, therefore the three quality dimensions of chapter 4 are allocated to each point of view. Of course not all of the 17 mentioned quality criteria can be applied to each point of view, but maybe to more than just one of them.

It is now the task to order this chapter in a correct way, meaning which point of view should be dealt with first. In order to work out a usable work-flow, the best way to deal with the point of views is to apply an usability engineering approach. Therefore, the user's point of view is examined first. It is easier to deal with the other two points of views when you know what the user's demands are. Secondly the view of the provider is dealt with. The second view gives restrictions what data can be delivered.

The third view is the view of the developer of the web map. In the third view it is pointed out what functionalities are possible, what data and functionalities should be included and, from a cartographic point of view, should be taken into consideration.

The field of application of the web map, which is developed here, has to be defined. As pointed out in this thesis to this point the possible user of a Freytag&Berndt web map has most interest in hiking maps and other related outdoor activity maps. From the user's point of view the map should therefore be able to deliver information about hiking. From the provider's point of view, meaning Freytag&Berndt, the map should have a function which makes sense for them as well. As far as the user demands hiking maps and Freytag&Berndt is selling hiking maps, the web map can be used to distribute these cartographic products. The task of the developer of the map is to ensure a correct and optimal implementation from a scientific point of view. New technologies and applications from the field of web mapping can be implemented in order to develop an optimal product. In addition to that the developer must take into consideration that the map should be able to be run with a minimum set of expenditure to maximise the benefit and minimise the cost. In summary the three points of view can be assigned to the following topics:

1. The user's point of view: The user demands a product he can use to gain information about hiking, cycling or mountain biking activities in order to plan his next activity.
2. The provider's point of view: The provider wants an opportunity to distribute and sell products. Therefore it is not considered desirable for the provider to give away too much information for free. The user must consider buying the product the provider sells after he used the web map.
3. The developer's point of view: The developer must ensure that both, the provider and the user are satisfied with the final product. In order to do so the developer implements the map with respect to all scientific rules and state of the art technology. Also the developer can suggest combinations of technologies.

These three points define the concept of the web map developed in this Master's thesis.

5.1 The user's point of view

The potential future user of the web map provided from Freytag&Berndt has special demands on such a map. This approach is of course the execution of the usability engineering approach on the development of the web map. A user-centred approach can provide financial benefits, because you are able to meet the future customers' needs more precisely. According to Bailey and Pearson, if a user is not satisfied with an information system of any kind, he will cease any interaction with the system at all *[Bailey and Pearson 1983]*. This means that no products at all could be sold via the web map because if nobody uses the web map, nobody will purchase anything via the web map. As seen in chapter 3, the online survey gave the result that the customers of Freytag&Berndt use cartographic products mostly for outdoor activities like hiking. Therefore the base map is based on a Freytag&Berndt hiking map with a scale of 1:50,000. The content of such a map is quite extensive and contains a variety of point line and area information.

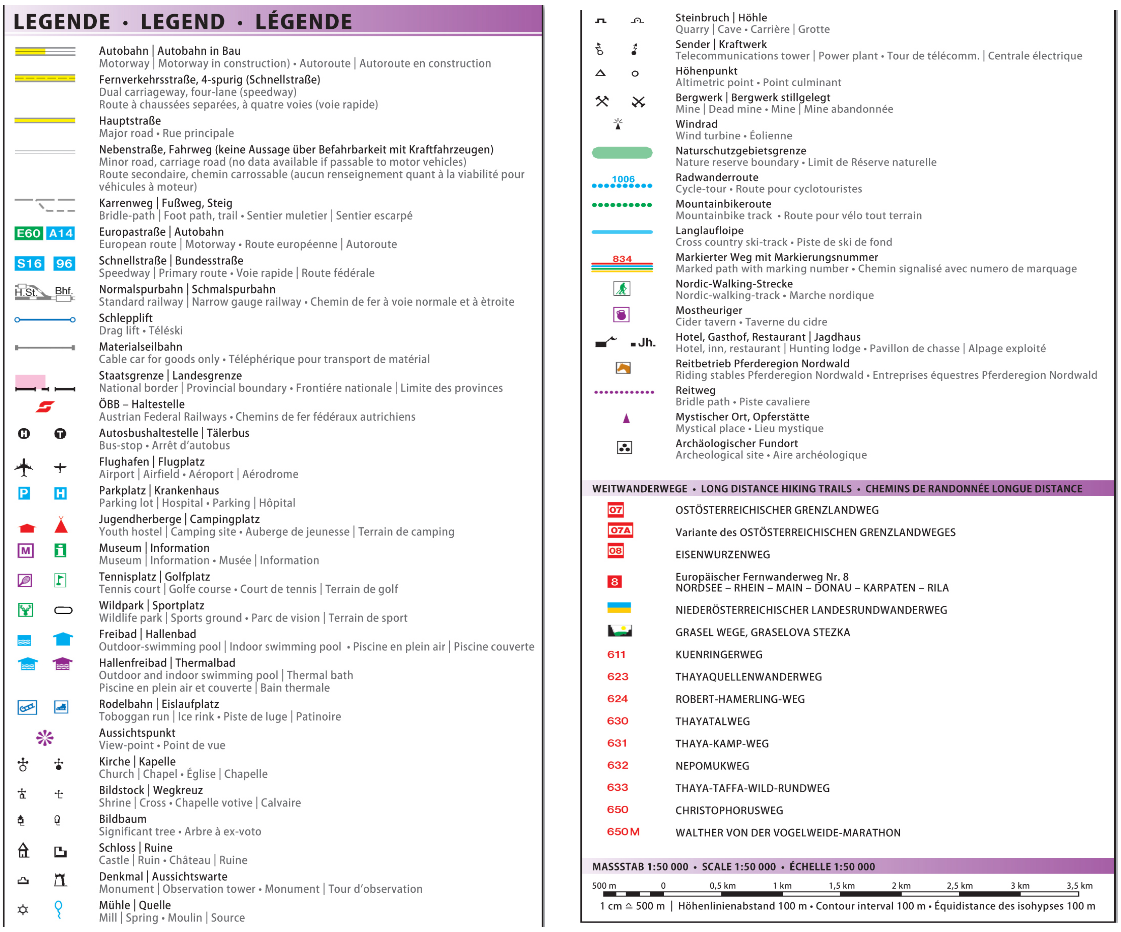


Fig. 40: Legend of a Freytag&Berndt hiking map 1:50,000

In figure 40 you can see the standard content of a Freytag&Berndt hiking map with a scale of 1:50,000. The content covers point information about infrastructure, parking facilities, medical facilities, overnight accommodation, cultural offer, leisure activity offer, swimming or bathing offer, winter activity offer, viewpoints, churches, sights, sources and important topographic features. This covers all mentioned features in question block 4 of the online survey (see chapter 3.3.4 and 3.4.4). The map contains line information about the street network, rail network, drag lifts or cable cars, borders, a variety of hiking routes, cycling routes, mountain bike routes, cross country ski tracks and bridle paths. Therefore even more features than mentioned in question block 5 are covered by the hiking map content (see chapter 3.3.5 and 3.4.5). Additional content that should be included into the online base map should be information about canoeing related content as discussed in question block 5. This content should include the routes as well as entry and exit points. Also scenic routes as mentioned in question block 5 could be included. The Freytag&Berndt hiking map also contains area information about nature reserves. No additional area information will be included into the base map.

It is important that the demanded information is included into the future web map, but it is also important to not overwhelm the user with information. Therefore a layer structure of the displayable information is inevitable. In addition to that it is possible to implement a function that filters the content you may exclude in advance. Just like Kettunen proposed a floating window which pops up before using the web map *[Kettunen et al. 2012]*. You can choose the display parameters for the map usage beforehand using the web map in the first place. Some content may be completely irrelevant for some users, for example a bridle path could be irrelevant for the majority of the target group. Not only the content on the map must be relevant but the whole website. Additional information as well as advertisements must be carefully chosen and should be held to a minimum in order to optimise the website's usability. According to Tufte, the actual information-transmitting content of a website must occupy 92% of the screen space *[Tufte 2010]*, therefore there is not much space left for additional information. When the user visits the web map, not too much space of the display should be covered with advertisements or other task-unrelated content. Additionally, the user may have low software and hardware standards and therefore all major browsers should be supported without the need of any plug-ins following the World Wide Web Consortium (W3C)[27] standards *[Sadauskas 2011]*.

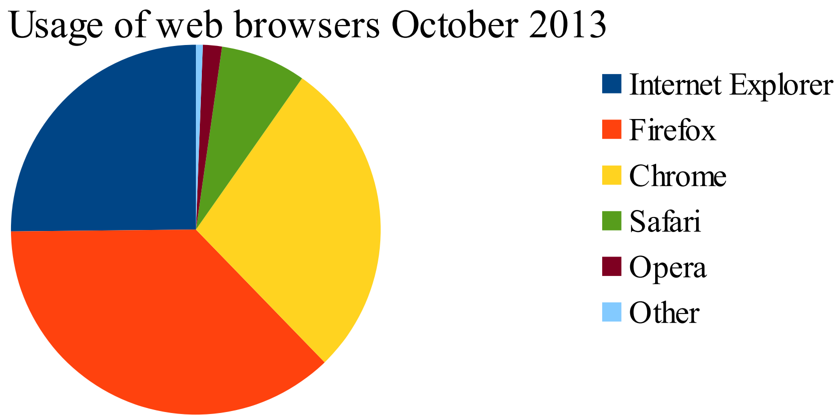


Fig. 41: Usage of web browsers in Austria Jan. 2013 – Jan. 2014 [StatCounter 2014a]

In figure 41 the distribution of the usage of web browsers on desktop computers in Austria is displayed. As you can see Firefox, Chrome and Internet Explorer have a share of more than 90%. Therefore the map must be tested on all three major web browsers. According to Sadauskas it must be possible to use the web map even with low hardware standards, including a slow internet connection *[Sadauskas 2011]*. This is enabled by implementing modern technologies like Map tiling and AJAX. Modern technologies and browser support ensures a high accessibility of the web map.

Referring to the functionality of the web map you have to take into consideration that a base map is quite general and not a thematic map. When considering a base map or general map, as defined in chapter 2, it is a static map with no customised features. Since the demand for a general map without any possible interaction is obsolete nowadays the term base map must be extended . As a direct consequence to the results of the online survey the web map is defined as a web map for hiking applications. Therefore the functionality and content are optimised for user who use maps for outdoor activities like hiking, cycling or mountain biking. The web map has to meet the claimed purpose. Unnecessary functions must be excluded. Acording to Nivala, the interactive map must have the principal role within the website *[Nivala et al. 2008]*. The purpose has to be clear, simple and understandable for the user. Intuition is very important, a user should not have to learn how to use the map but being able to start us-

27 International organisation for standardisation of the World Wide Web

ing it right away when entering the website *[Nivala et al. 2008]*. As far as the purpose of the web map is defined and the importance of the respective content of the map is worked out the presented information can be structured. The content must be structured in a way that the more important features are more obviously present than less important features. According to Sadauskas, another important subject is the navigation within the website containing the map *[Sadauskas 2011]*. Simplicity applies here as well as being able to find a specific part of the website or a possibility to know exactly where you are within the navigation structure. It should also be possible to get back to the starting point of the website. “There should always be a short cut back to the home page.” *[Nivala et al. 2008]* This means, that a link to the first page of a website should always be provided on every page of the website. The web map must also be reliable. A user will never use something twice when it has not worked properly the first time, meaning the user satisfaction is not guaranteed *[Bailey and Pearson 1983]*. Therefore it has to be assured that the online web map is accessible at any time.

Since the future user of the web map is most certainly a customer of Freytag&Berndt, the map must be mainly distributed as a part of the website of Freytag&Berndt. In order to address a possible user with a similar task as discussed earlier, according to Sadauskas, it should be possible to reach the map with the aid of common search engines *[Sadauskas 2011]*. The user interface of a modern web map must also be attractive to the user. According to Sadauskas, the website design as well as the design of the map itself must be appealing *[Sadauskas 2011]*. As far as design and attractiveness is often a question of personal preference this subject is hard to elaborate. According to Nivala, the simplicity and clarity of the website is the most important point here *[Nivala et al. 2008]*. The design of the web map is somehow considerable limited by Freytag&Berndt's design guidelines. In order to achieve a hgh user satisfaction a clear corporate identity has to be defined and rules following that CI have to be obeyed *[Abratt and Kleyn 2011]*. The design issue is mostly part of design rules given by the provider's CI and therefore not covered here. According to Sadauskas, it is also important for the user of the map that the content of the map is complete *[Sadauskas 2011]*. Any information presented somewhere on the map should be available anywhere on the map. A function that could optimise the usability of the web map tremendously is a personalisation function as proposed by Kettunen *[Kettunen* et al.

2012]. The user should be able to thin out the displayed amount of information so that the user's task could be fulfilled much faster. This could be implemented by a function where you could choose your task topic in advance to the usage of the map or with the implementation of a layer-structure of the function tools where you are able to choose which layers displayed. Furthermore in order to ensure a high usability quality standard of the web map, the website where the map is embedded should spread out empathy towards the user *[Sadauskas 2011]*. The user should have the impression that the provider cares about the user's request towards the map. In order to do so, HTTP Cookies[28] can be used to temporarily store data about the user's last visit to the website.

In summary, the user delivers the framework for the implementation of the web map by providing information of what the user wants the product to be. This information is mostly about content and functionality.

5.2 The provider's point of view

The provider of the web map is, of course, Freytag&Berndt. Freytag&Berndt provides all the data used and included into the web map. To optimise the benefits for the provider the product must have some sort of economic value or at least has the potential to cause one. In order to fulfil this demand, the product's concept must be precisely aligned to the user's demands to increase the potential usage of the map.
The provider's demands are:

1. Potential economic value of the final product
2. Distribution or rather advertisement of the provider's products via the product
3. The final prototype should fulfil all demands and it should be possible to develop a sophisticated product with the prototype as basis

The first and the second point will be fulfilled automatically by developing the web map with regards to all demands and restrictions. The third point will be addressed by precisely documenting the practical work, meaning the source code.

As worked out in chapter 3 the map should be based on the hiking map material from Freytag&Berndt. The hiking maps of Freytag&Berndt have a scale of 1:50,000. The hiking map material of Freytag&Berndt covers almost the whole of Austria and a few regions in the neighbouring countries Germany, Slovenia and Italy. For the sake of

[28] Piece of data stored in the user's web browser while the user is browsing said website. Every time the user loads the website, the browser sends the Cookie back to the server to notify the website about the user's previous activities on the website

completeness it should be mentioned here, that hiking maps are furthermore available for three regions in Spain. Consequently Freytag&Berndt is able to provide data from hiking maps in a scale of 1:50,000 for the bigger part of Austria.

On the website of Freytag&Berndt all cartographic products the company produces are presented and made available for the visitor in an online shop[29] to purchase. The products are structured in the following classes:

- road and leisure
- hiking and cycling
- citymaps and atlases
- district and townmaps
- markingboards and poster
- multimedia and leisure
- books and specials

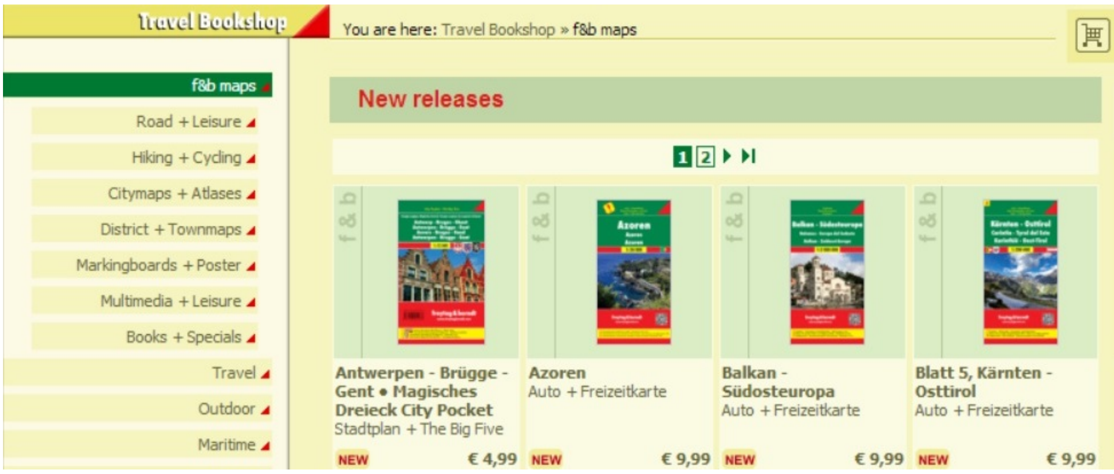


Fig. 42: Structure of the map shop of Freytag&Berndt

As figure 42 depicts, there are more product classes visible, but these classes do not refer to cartographic products of Freytag&Berndt and are therefore neglected. When you browse the product class of hiking and cycling you can find a very useful feature of the website you can download: A hiking maps sheet index.

29 http://www.freytagberndt.at/rtc-freytagberndt/en_EN/1174 (Accessed 25.2.2014)

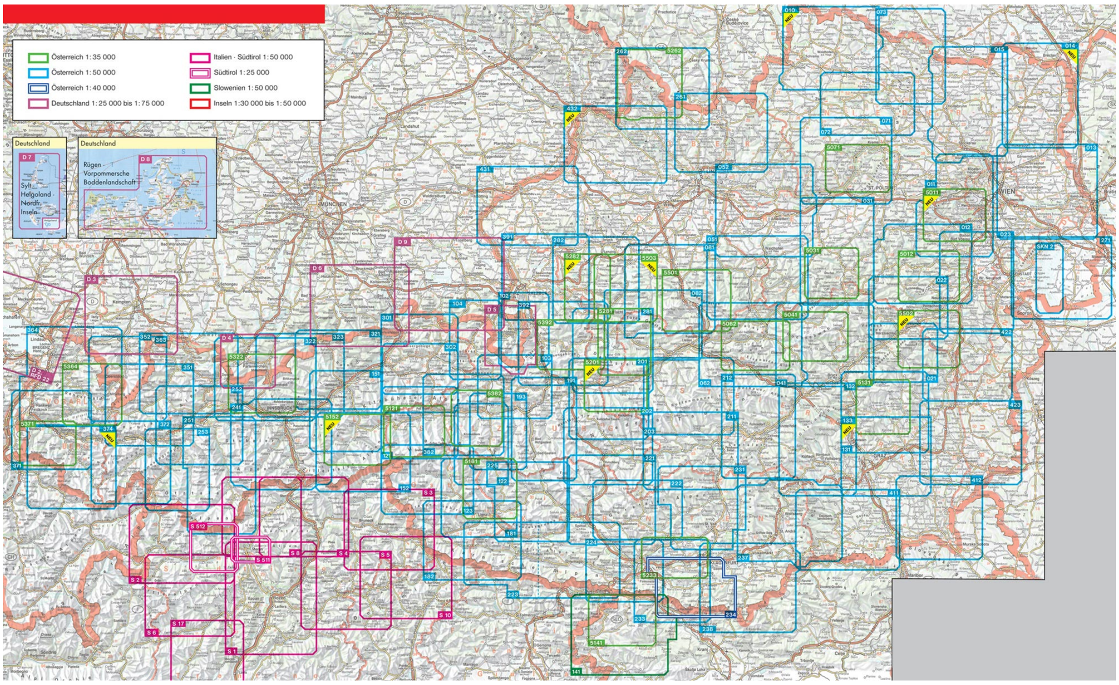


Fig. 43: The Freytag&Berndt hiking maps sheet index

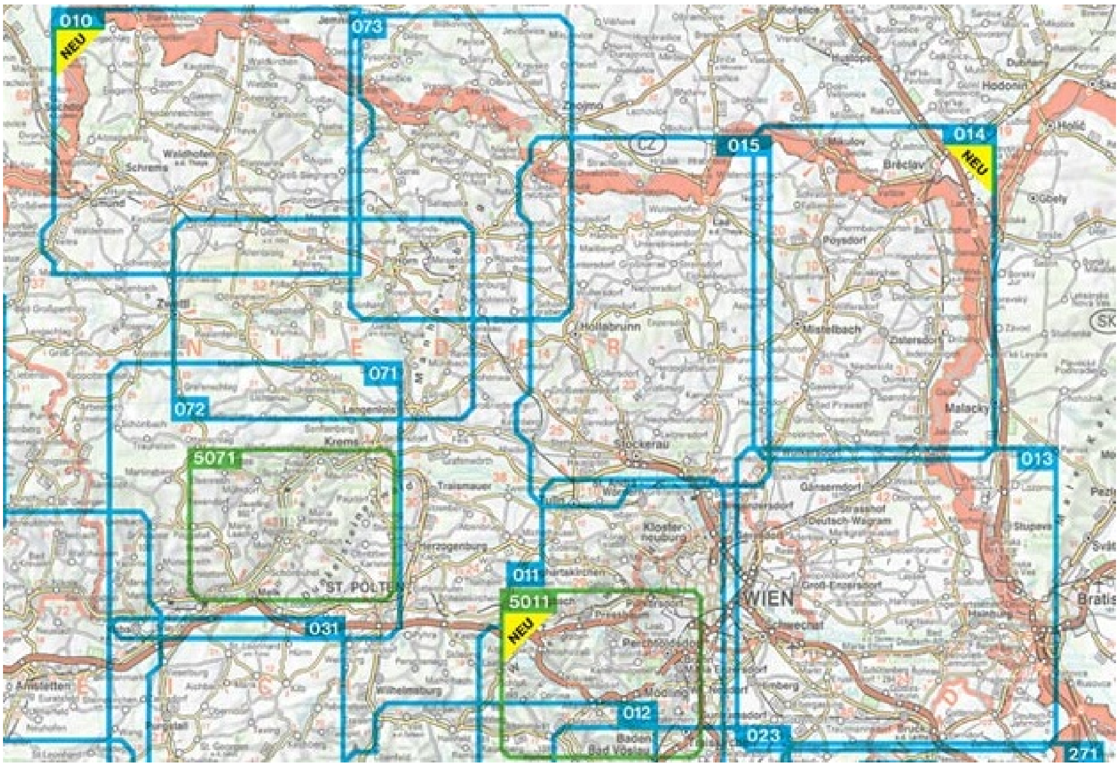


Fig. 44: Excerpt of the Freytag&Berndt hiking maps sheet index

Figure 43 and figure 44 show the Freytag&Berndt hiking maps sheet index. The index shows the exact extent of all Freytag&Berndt hiking maps. The extents are indicated by polygons and a map number. The goal of this static map is to show the user which regions the Freytag&Berndt hiking maps cover. If a customer is looking for a hiking map in a particular area then it is possible for him or her to look up this map and find the right hiking map which covers the requested area. In this case it is just a low resolution JPEG image but Freytag&Berndt can also deliver a PDF[30] file with a higher resolution. The map sheet index is very useful and will be used to support the development of the web map.

As discussed in chapter 3, the hiking-maps turned out to be the most desirable maps for the customers of Freytag&Berndt, therefore the web map will be used to optimise their distribution. The sheet index is a good starting point. The usage of the web map for Freytag&Berndt, the provider, will be an optimised additional possibility for the distribution of their hiking maps. The concept is that the web map will contain a considerable amount of data from the hiking maps, the extents of the hiking maps and a possibility for the user to purchase the hiking maps. You have to take into consideration that the amount of data of the freely available web map is not too extensive so that the customers do not have the need to purchase the printed map product. But still it has to contain a certain amount of insight in what the final product may look like in order to hold the user's attention. The web map should not be too general and the information displayed on the map should be sufficient enough to support decision-making *[Nivala et al. 2008]*.

One of the provider's tasks is to assure reliability of the web map. Any needed data in order to use the map should be accessible at any time *[Sadauskas 2011]*. According to Martin and Richter, in order to assure a high website usability, the design of the web map and the whole website must be consistent *[Martin and Richter 2008]*. In addition to that, the web map must be designed in order to fit in the Freytag&Berndt website. If the web map will go online, then as part of the Freytag&Berndt website. Therefore the design of the website where the web map will be embedded must be adapted to the company's CI design. Additionally the criteria of navigation must be taken into consideration at this point. The final web map must be included into a clear and not too complex navigation structure of the Freytag&Berndt website *[Sadauskas 2011]*. As far as Freytag&Berndt already has an online shop where you can purchase products via a se-

30 Portable Document File: Software, Hardware and Operating system independent File format to represent documents

cure HTTPS[31] connection, it should be possible to ensure a secure personal data exchange. The implementation of a secure order opportunity should be able to support trust building towards the company. According to Sadauskas, trust building is an important issue concerning a high usability of a website *[Sadauskas 2011]*. Another factor that supports trust building and empathy towards the provider is a functional communication possibility between the user and the provider. One possible communication channel between user and provider can be an online contact form or an e-mail address especially for requests about the products.

According to Sadauskas, the provider also has to ensure the up-to-date nature of data *[Sadauskas 2011]*. When a new map is available or an old map is no longer on offer, it must be removed immediately. Furthermore it is not desirable that inconsistency occurs somewhere within the website. The consequence is, if a product is no longer on offer it should not appear anywhere within the website.

Since the hiking maps with a scale of 1:50,000 do not cover the whole of Austria it is not possible to implement a consistent map in one LOD. As far as the most important part of the web map is this LOD, a lower LOD with only basic content must be made available. Freytag&Berndt offers road maps with a scale of 1:200,000.

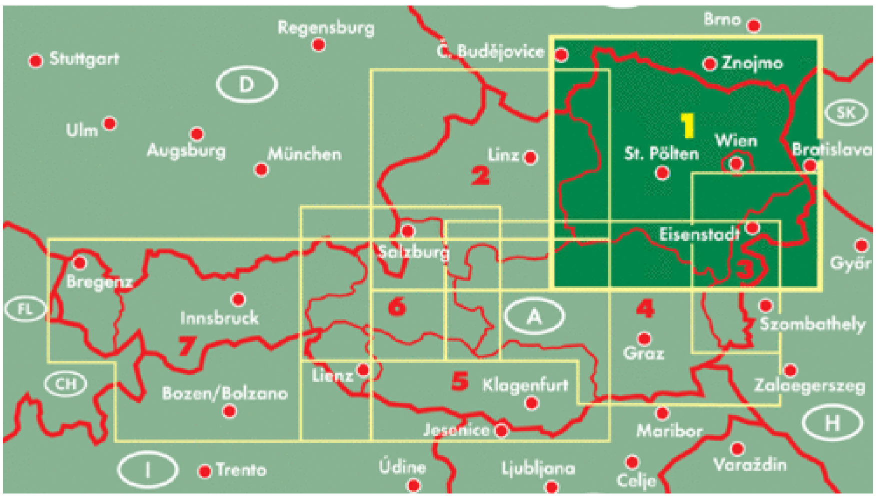


Fig. 45: The Freytag&Berndt road maps 1:200,000 sheet index

As displayed in figure 45, the Freytag&Berndt road maps with a scale of 1:200,000 reach a coverage of whole Austria with 7 individual map sheets. As a third even lower LOD the Freytag&Berndt road map of Austria with a scale of 1:500,000 could be used.

[31] Hypertext Transfer Protocol Secure: A secure communication protocol for network communication through the internet

Fig. 46: The Freytag&Berndt road maps 1:500,000 sheet index

As you can see in figure 46, the Freytag&Berndt road map with a scale of 1:500,000 covers the whole of Austria with one sheet. The online base map will consist of three LODs with three different scales. LOD 1 will consist of the hiking maps with a scale of 1:50,000, LOD 2 will consist of the road maps with a scale of 1:200,000 and LOD 3 will consist of the road map with a scale of 1:500,000. With the determination of the scales of the LODs a high usability of the web map is ensured. The scales of the three adjacent LODs are not too close but also not too far from each other.

LOD #	Map scale
1	1:591,657,551
2	1:295,828,775
3	1:147,914,388
4	1:73,957,194
5	1:36,978,597
6	1:18,489,299
7	1:9,244,649
8	1:4,622,325
9	1:2,311,162
10	1:1,155,581
11	1:577,791
12	1:288,895
13	1:144,448
14	1:72,224
15	1:36,112
16	1:18,056
17	1:9,028
18	1:4,514
19	1:2,257
20	1:1,129

Tab. 3: The approximate scales of the 20 LODs of GoogleMaps

As you can see in table 3, the three suggested scales of the three planned LODs are comparable to the scales of LOD #12, #13 and #14 of the GoogleMaps Roadmap, therefore the developed online base map should be usable with the suggested scale gaps between the LODs.

Furthermore, it is the provider's concern to deal with the data storage of the map.

Fig. 47: Tile of a Freytag&Berndt hiking map 1:50,000

In figure 47 you can see a tile of a Freytag&Berndt hiking map. To be more specific, a tile of the WK 010 hiking map "*Nördliches Waldviertel*", a hiking map of a part of northern Lower Austria near the border to the Czech Republic. The image is shown in its original size (9 cm x 9 cm). All tiles are stored in a PNG format and this specific tile requires 44 KB of storage space. Assuming that the way the map is tiled and stored is similar to that of GoogleMaps, as presented in chapter 2, the required storage space can be described.

WK 010		
Size	256 x 256	pixels/ tile
E-W extend	50.00	km
E-W extend	175	tiles
N-S extend	40.00	km
N-S extend	140	tiles
Ground pixel Distance	1,12	m
Map coverage	2,000	km²
Number of tiles	25,000	
Average tile storage size	20	KB
Σ required storage	500	MB

Tab. 4: The required storage and extend of the Freytag&Berndt hiking map WK 010 "Nördliches Waldviertel"

In table 4 you can see the requirements of the Freytag&Berndt hiking map WK 010 "*Nördliches Waldviertel*" in detail. The pixel size of each tile and the file format is equal to those of GoogleMaps, but the Ground pixel Distance differs a lot from the estimated Ground pixel Distance for a map with a scale of 1:50,000. The required storage space for each pixel varies a lot, because tiles at the edges of the map are completely black and do not contain any information. The required storage space varies from approximately 1.12 KB for a complete black tile to more than 50 KB for tiles with a lot of content.

The total required storage space for this single hiking map in s a scale of 1:50,000 is approximately 500 MB. In total Freytag&Berndt can provide about 75 different hiking maps in a scale of 1:50,000. This sums up the required storage space for LOD 1 to approximately 35 GB. The required storage space for LOD 2 and LOD 3 can be calculated similarly. At this point you have to consider that all these hiking maps are produced to work as a printed map for its own. That means, as you can see in figure 43, 44 and 45 that the maps overlap. When the map data is used for the online base map, these redundant overlapping parts of the maps can be left out completely, reducing the required storage space.

LOD #	Scale	# of maps	required storage	
1	1:50,000	75	24.7	GB
2	1:200,000	7	251.0	MB
3	1:500,000	1	22.5	MB

Tab. 5: The required storage of LOD 1, LOD 2 and LOD 3 of the proposed online base map

In table 5 you can see the actual required storage space for the online base map according to Freytag&Berndt. This amount of required storage space verifies the calculations of the storage space in this chapter.

Another task of the provider is to ensure accurate and faultless map data as well as clear map design from a cartographic point of view. These tasks should already been taken care of in previous steps of map production. Considering that the maps are produced primary for printed map purposes, bordering parts between two different maps could have flaws.

Fig. 48: Map flaws at the border of two source maps of the Freytag&Berndt 1:50,000 hiking maps

In figure 48 you can see an example of flaws of LOD 1 of the online base map. The reason for this phenomenon is that LOD 1 is generated from several source maps and assembled for the web map. As you can see the text of the mountain called "*Säusenstein*"[32] is at two different locations in the two bordering source maps and therefore a part of the text appears twice. Also the contour lines of the two maps do not overlap correctly. A relating issue that falls into the provider's responsibility is the criteria of completeness. The provider has to make sure, that the information available for any part of the map as well as the whole website is consistent. According to Sadauskas consistency is an important criteria of high website usability *[Sadauskas 2011]*.

All in all the provider provides the complete map data which will be presented in the final web map. Therefore the provider has to make sure, that the processing of the data is fulfilled properly. Map-tiling in order to assure a reasonable response time is very important at this point as well as the implementation of the AJAX concept. To put it all in a nutshell, the criteria of chapter 4 which the provider has to take into consideration, are navigation, response time and website design from the system quality dimension, accuracy, completeness, ease of understanding and up-to-date form the informa-

[32] A small mountain near the municipality of Wildalpen in northern Styria

tion quality dimension and empathy, trust building and communication from the service quality dimension.

5.3 The developer's point of view

The developer's task in developing the web map is to assure that the user's demands will be fulfilled by the final product, that the provided data by the provider and his demands are fulfilled and that all of this is combined in a scientific correct manner. The framework in chapter 4 must be worked through in detail in respect to all scientific methods and practical cartographic technologies. The developer has to make sure that accessibility is fulfilled. In order to ensure accessibility all programming must be done with low software and hardware requirements. The web map is embedded in a website, therefore it is not necessary to download a complex and extensive stand-alone application running on a desktop computer. According to Sadauskas, this is also very important to assure a high website usability *[Sadauskas 2011]*. The source code must be tested if it is working on the three major browsers: Internet Explorer, Firefox and Chrome and is W3C conform. The web map must also be implemented without the need of any plug-ins. The accessibility can be enabled by using open source libraries which are compatible with all major browsers.

The developer has to assure that the extent of the functionality meets the purpose of the final web map. This includes a possible personalisation function in order to alter the amount of displayed data as proposed by Kettunen *[Kettunen et al. 2012]*. A minimalist design paradigm, also suggested by Kettunen is useful here *[Kettunen et al. 2012]*. This means that only necessary functions are implemented and that the user is not overwhelmed with displayed information. Recent trends in the field of information access via the internet lead to the transition of rather just reporting the existence of data or products then to provide access to actual data or products *[Veregin and Kennedy 2012]*. Of course, in order to avoid overcharging the provider, the access has to be limited or only made possible with charging the user. The technological imperative, the ultimate consequence, of the Web is that more and more tasks are offloaded onto the user *[Veregin and Kennedy 2012]*. Ordinary tasks at which you once had an expert to assist you, in this case the search for the right cartographic product, is now completely offloaded to the user when accessing the necessary information via the internet. According to Veregin and Kennedy, it is very important to ensure a certain amount of straightforwardness to make it possible for the user to keep pace with these technological developments *[Veregin and Kennedy 2012]*. This can be made possible by giving the user the possibility to customise the displayed information and to offer an interface as intuitive as possible. Making an online map intuitive is hard, but necessary in order to let the user become more self-sufficient in this area and enable the absence of a supporting expert. A simple way to implement an as intuitive as possible web map application is to take major online web services like GoogleMaps as a guiding point. GoogleMaps has the biggest share of all online map services available[33]. Therefore most people have experience with it. Being intuitive does not appear by coincidence, developer work hard on it to ensure a certain amount of it, it is the fact that the interface between the interactive map and the user and the functionality of said map is similar, at least a bit, to the functions and usage of a traditional printed paper map *[Veregin and Kennedy 2012]*. For example the pan-function which is implemented in almost all online map services is similar to the gesture of someone's hand when he or she tries to move the paper map in order to focus on another part of the map. The more intuitive the web map is, the more user satisfaction can be achieved.

Another factor in website usability mentioned in the preceding chapter is reachability. The ultimate goal is to reach a high ranking in search engine results. In order to get a high ranking in search engine results it is necessary to clearly and as precise as possible explain the purpose of the website in which the web map is embedded *[Gavrilete 2013]*. A few other optimisations like design issues and links to and from the website may increase the ranking as well. The distribution of maps via the internet opens many new opportunities ,as mentioned in chapter 2, but also implicates new challenges due to technical restrictions, copyright and security issues, reliability issues and technical complexity *[Yadav and Singh 2010]*. These issues have to been taken care of by the developer as well. The technical restrictions are the various display resolutions of the users' devices. Additionally the needed information exchange should be possible in a fast way, meaning the response time of the map should be kept as short as possible. As far as this thesis is focussed on the usage of the web map on desktop computers, the resolution must focus on the most common desktop computer resolution. In Austria, the present most common screen resolution is 1366 x 768 pixels *[StatCounter 2014b]*.

[33] GoogleMaps market share in Austria was 64% as of April 2012 (see http://futurezone.at/b2b/open-streetmap-freie-karte-statt-google-maps/24.578.931 accessed April 2014)

As discussed in the field of data visualisation, the map, meaning the actual information-transmitting content of the website, must occupy most of the display space. Edward Tufte[34] for example recommends 92% for the actual content of a website reserved for the main part of the website *[Tufte 2010]*. A reasonable response time of the final product, as discussed earlier in chapter 4, can be achieved by applying the techniques of map-tiling and the AJAX concept. According to Sadauskas, the response time is another criteria to assure high usability of a website *[Sadauskas 2011]*. Copyright issues of the web map have to be taken care of by communicating with the provider what may be used and what may be refused to disseminate. A high security level can be assured by using a secure HTTPS connection as discussed in chapter 5.2. Reliability has also already been addressed in chapter 5.2. In summary, the criteria of chapter 4 which the developer has to take into consideration are accessibility, functionality, reachability, reliability and security from the system quality dimension and personalisation and relevance from the information quality dimension.

5.4 The concept of the web map

With the results of the online survey, the framework for website usability and the organisation of the responsibilities, the concept for the web map can be worked out. The web map will be an interactive map with a map coverage of the whole of Austria including a presentation and purchase function of all hiking maps of Freytag&Berndt with a scale of 1:50.000. The provided data of Freytag&Berndt is a layer of map data compatible with the open-source API called leaflet[35]. This API was chosen because it "*(...) is designed with simplicity, performance and usability in mind. It works efficiently across all major desktop and mobile platforms out of the box, taking advantage of HTML5 and CSS3.*" *[leaflet 2014]*. Therefore this API is up-to-date and uses recent technological standards.

The map data from Freytag&Berndt, consisting of a road map with a scale of 1:500.000 and a map coverage of the whole of Austria and a road map with a scale of 1:200.000 also with a coverage of the whole of Austria form LOD 3 and LOD 2 of the online base map. LOD 1 is given by customised hiking maps with a scale of 1:50.000. These hiking maps only cover approximately 80% of Austria and have lower resolu-

[34] American scientst in information science, data visualisation and graphic design

[35] Leaflet is an open-source JavaScript Library for mobile-friendly Interactive Maps. Website: http://leafletjs.com/ (Accessed 25.02.2014)

tion and fewer content as the respective printed map material. This is done in order to retain the necessity of purchasing the map products. Otherwise the user could be tempted to simply download the map material or making a screenshot and the provider would have very few benefits from the web map. The provider provides three LOD consisting of own map material with already carried out map-tiling. The map tiles are already uploaded to an online server by the Freytag&Berndt. This online server must be accessible at any time in order to assure a high website usability according to Sadauskas *[Sadauskas 2011]*. The amount of required storage space on the online server is, according to Freytag&Berndt, approximately 30 GB for all map tiles.

From the provider's point of view the web map is used to allow the user to gain insight into their map material for hiking purposes and therefore sell said hiking maps via the web map. To maintain the necessity of purchasing the hiking maps, the presented map material of those hiking maps has to be pre-processed. First of all the content has to be thinned out. This can be done with the aid of the results of the online survey in chapter 3. The results are applied on the actual content of a Freytag&Berndt hiking map displayed in figure 40 earlier in this chapter.

include	class	neglect	class
motorway	line	cable car for goods only	line
dual carriageway	line	bridle path	line
major road	line	youth hostel	point
minor road	line	camping site	point
foot path	line	hotel	point
railway	line	inn	point
drag lift	line	restaurant	point
cycle tour	line	cider tavern	point
mountainbike track	line	hunting lodge	point
cross country ski-track	line	riding stables	point
marked path with number	line	museum	point
Nordic-walking-track	line	church	point
long distance hiking trails	line	chapel	point
national border	line	shrine	point
nature reserve boundary	line	cross	point
european route	point	significant tree	point
speedway	point	tennis court	point
railway station	point	golfe course	point
Bus-stop	point	wildlife park	point
airport	point	toboggan run	point
parking lot	point	ice rink	point
hospital	point	outdoor swimming pool	point
View-point	point	indoor swimming pool	point
altimetric point	point	outdoor and indoor swimming pool	point
castle	point	thermal bath	point
ruin	point	mill	point
monument	point	spring	point
observation tower	point	quarry	point
mystical place	point	cave	point
archeological site	point	telecommunications tower	point
		power plant	point
		wind turbine	point
		mine	point
		dead mine	point

Tab. 6: Proposed selection for the content of LOD 1 of the Freytag&Berndt hiking map WK 010 “*Nördliches Waldviertel*”

In table 6 you can see a proposed selection for the content of LOD 1. This selection is applied to the content of the Freytag&Berndt hiking map WK 010 “*Nördliches Waldviertel*”. Only content that is either for the purpose of orientation within the map or one of the first 5 points in chapter 3.4.4 is proposed to be included into the online base map. Hence the map can be used to get an overview of the situation but still, in order to use the full potential of the map, the user has to purchase the product. Secondly the resolution of LOD 1 can be reduced in order to prevent the user to simply use a screenshot of the web map. The web map will still be usable and the area of extent of the respective hiking maps stays clear. The concept of the content of the web map is hence outlined.

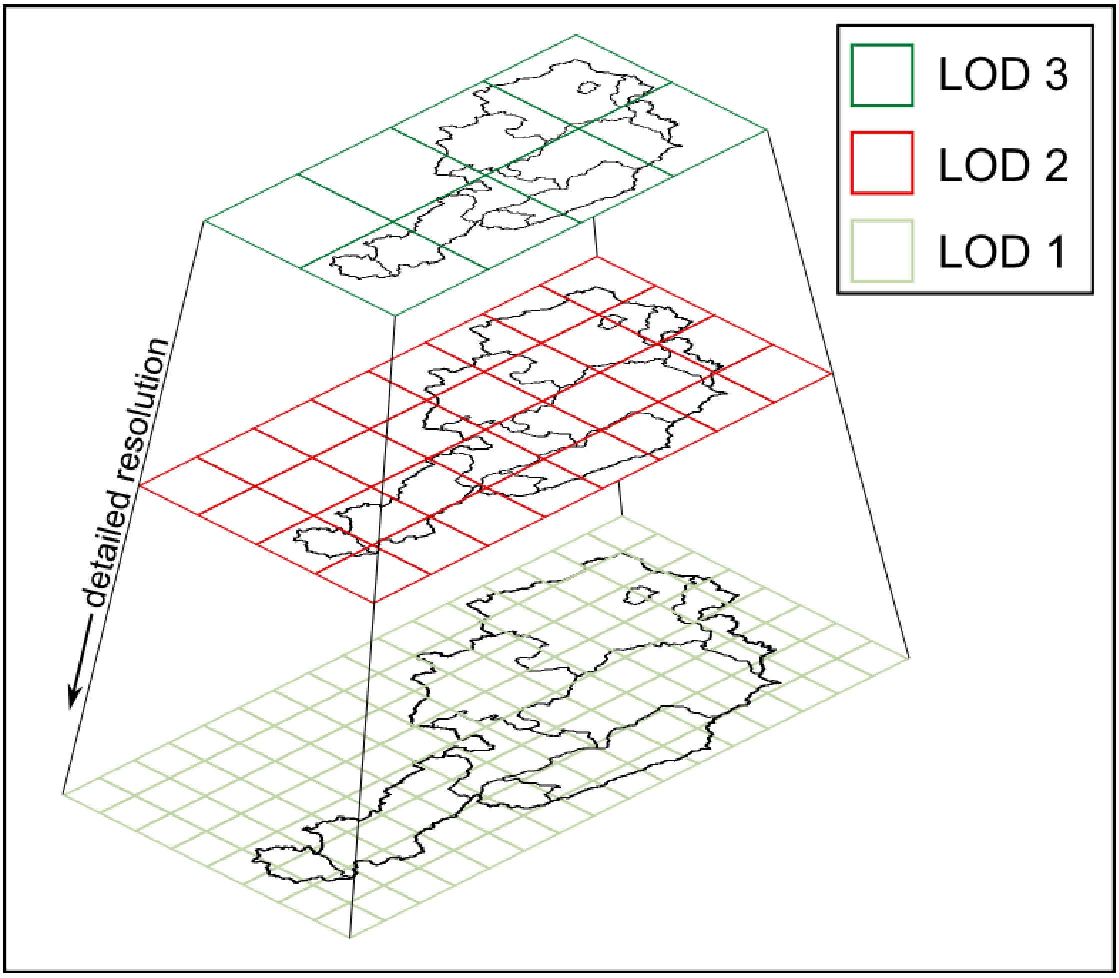


Fig. 49: Concept of the Freytag&Berndt custom layer of the online base map

Figure 49 depicts the concept of the custom layer provided by Freytag&Berndt and its three LODs. The amount of tiles per LOD is of course just outlined and refers not to the real amount of required tiles per LOD. LOD 3 refers to the Freytag&Berndt road map with a scale of 1:500.000 whereas LOD 2 refers to the Freytag&Berndt road map with a scale of 1:200.000. As far as LOD 1 refers to the Freytag&Berndt hiking maps with a scale of 1:50.000 with a coverage of only 80% of Austria, it is not possible to display the map in the whole of Austria in LOD 1. Therefore LOD 2 and LOD 3 are added in order to create a consistent map of the whole of Austria.

A second layer will be provided consisting of an OpenStreetMaps map layer. This is done in order to enable an optimal overview of the covered area of the Freytag&Berndt

map layer. A third layer will be provided with information about the extents of the hiking maps that can be purchased by the user. These extents are implemented as being clickable and therefore offer access to additional, mostly non-geographical information, about the individual map in a pop-up. According to Ota, the concept of a geometric feature on the map, in this case a polygon, with the opportunity of delivering additional information to their geographical extent is called an informed feature *[Ota 2011]*. The implementation of informed features instead of images or markers give the opportunity to include more information into a map without overlapping any other content of the map *[Ota 2011]*.

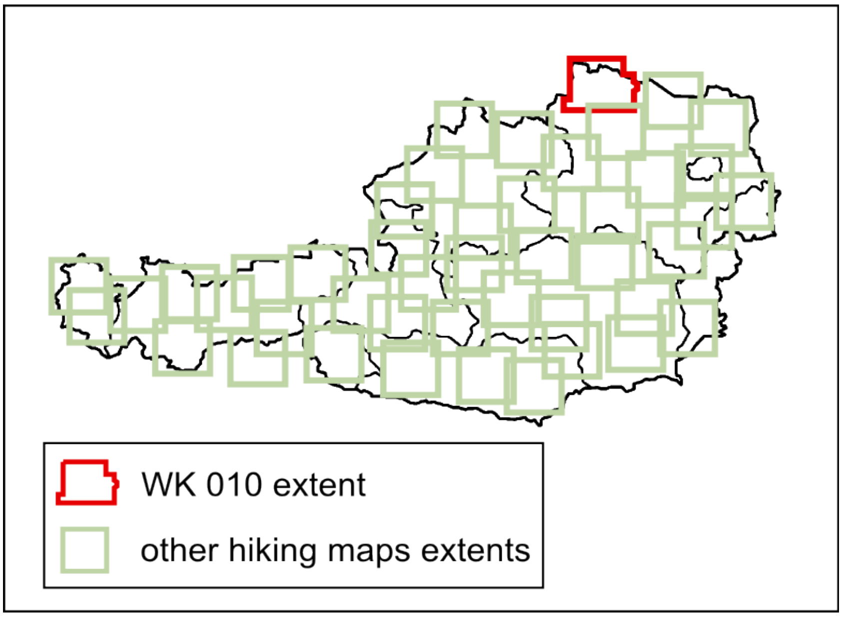


Fig. 50: Concept of the map extent layer of the web map

In figure 50 you can see the concept of the hiking map extent layer of the online web map. The geometry of the polygons in figure 50 is only outlined, as well as the amount and the position of the polygons. The actual number of polygons is, as far as there are 75 individual hiking maps with a scale of 1:50.000, 75. The polygon of the WK 010 hiking map is emphasised in order to explain the concept in more detail with the WK 010 map as an example.

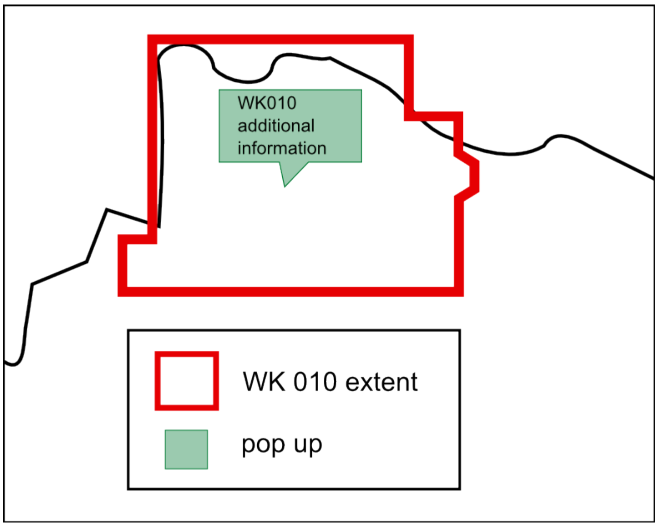


Fig. 51: Concept of an informed feature of the online web map

In figure 51 you can see the concept of an informed feature of the web map. Every polygon represents the extent of every individual hiking map similar to the map sheets of Freytag&Berndt described in chapter 5.2. A simple UI event is implemented, so if the user clicks on an individual polygon a pop-up appears with additional information about the respective hiking map. In the pop-up a link is embedded which leads to the Freytag&Berndt online shop where the product can be purchased via a secure HTTPS connection. A similar concept is used to include KML[36] format hiking routes into the web map.

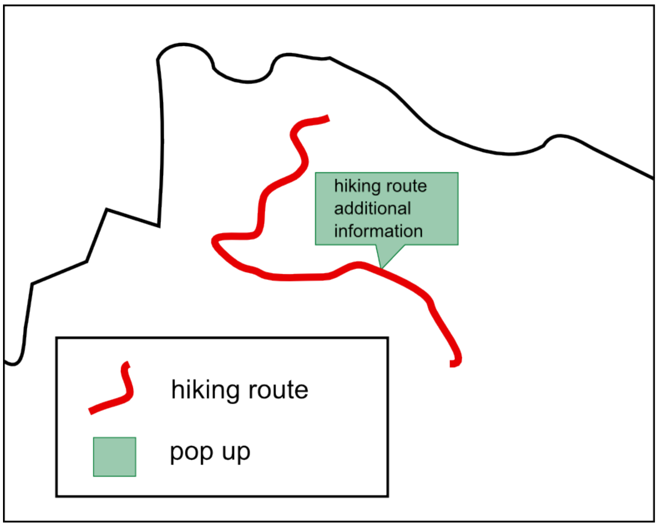


Fig. 52: Concept of a KML format route feature of the web map

[36] Keyhole Markup Language; KML is an XML notation for the visualisation of geographic information in web maps

In figure 52 you can see the concept of a KML format hiking route of the web map. Just like the informed feature before it provides additional information when the user clicks on the line segment. Within the pop-up additional information about the hiking route is displayed as well as an embedded link which leads to the Freytag&Berndt online shop of the respective hiking map that contains the hiking route.

In a next step, the functionality of the web map is described. In order to assure high usability of the web map, a minimalist way of implementing is suggested, as described by Kettunen *[Kettunen et al. 2012]*. Only a few simple UI events and MVC are suggested to be implemented. That way, the user will not get distracted from too extensive functionalities of the web map and, in addition to that, the user will find the map easy to use.

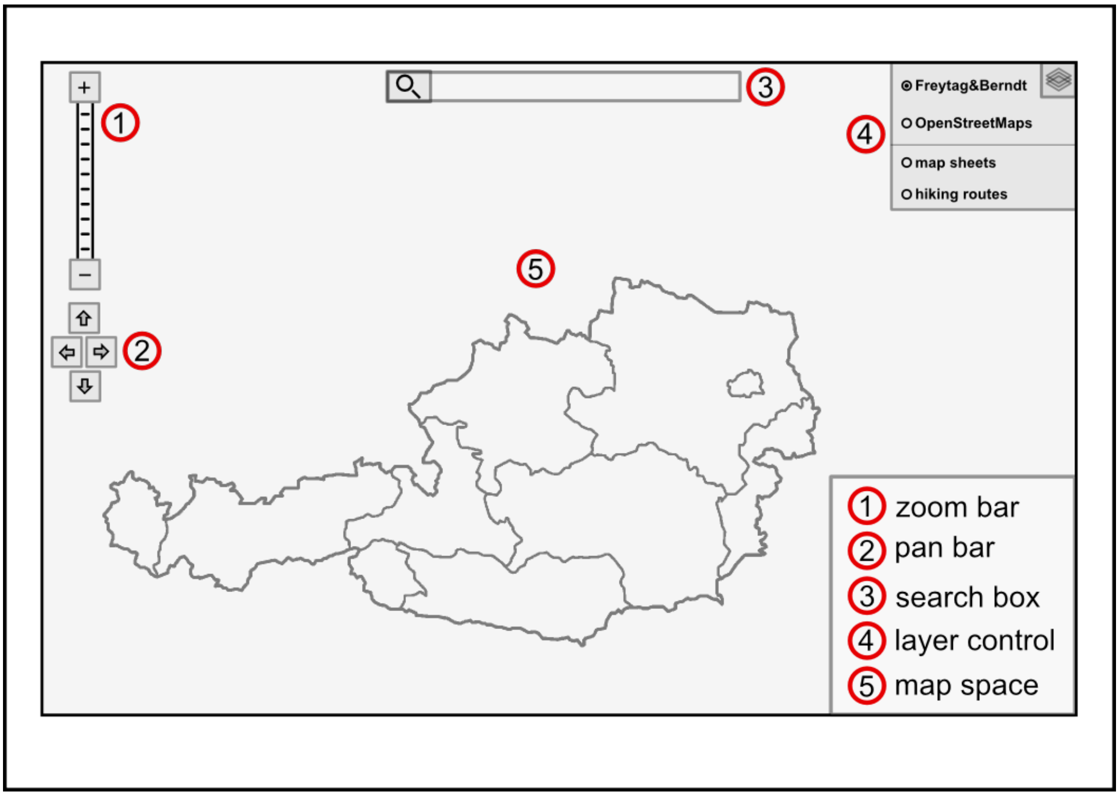


Fig. 53: Concept of the functionalities of the web map

In figure 53 the concept of the suggested functionalities of the web map is displayed. As you can see only few functions are implemented. (1) refers to a pan bar in order to move around the map. Although panning around the map extent is also possible by clicking and holding the left mouse button, this function is considered to be useful. (2) is an extended zoom bar that allows the user to navigate through the different zoom levels and respective LODs. The map is implemented in 8 different zoom levels and three different LOD. In order to assure a smooth navigation throughout the zoom levels, the zoom bar is implemented. (3) is a search box where the user can state queries for locations or addresses. The map will then centre onto the exact position of the searched location or address. This is done in order to occupy as few screen space as possible, leaving more space for the map itself. (4) is the layer control where the user can choose which layers are displayed and which are hidden. The Freytag&Berndt layer is the map layer of the customised map material provided by Freytag&Berndt. The OpenStreetMaps layer refers to a map layer with content from the OpenStreetMaps collaborative project. One of the two layers must be activated. By default the Freytag&Berndt map layer is activated. The layer control only appears after clicking on the layer button and collapses when the cursor leaves the layer control, in order to occupy as few screen space as possible. (5) refers to the map itself. As far as the map can be panned by a left click of the mouse and the zoom level can be changed with the mouse wheel, the map itself becomes an interface between the user and the map and therefore inherits functionality. Furthermore, because of the simple UI events implemented with the informed features and the route features on the map, the map must be considered to contain functionality for itself.

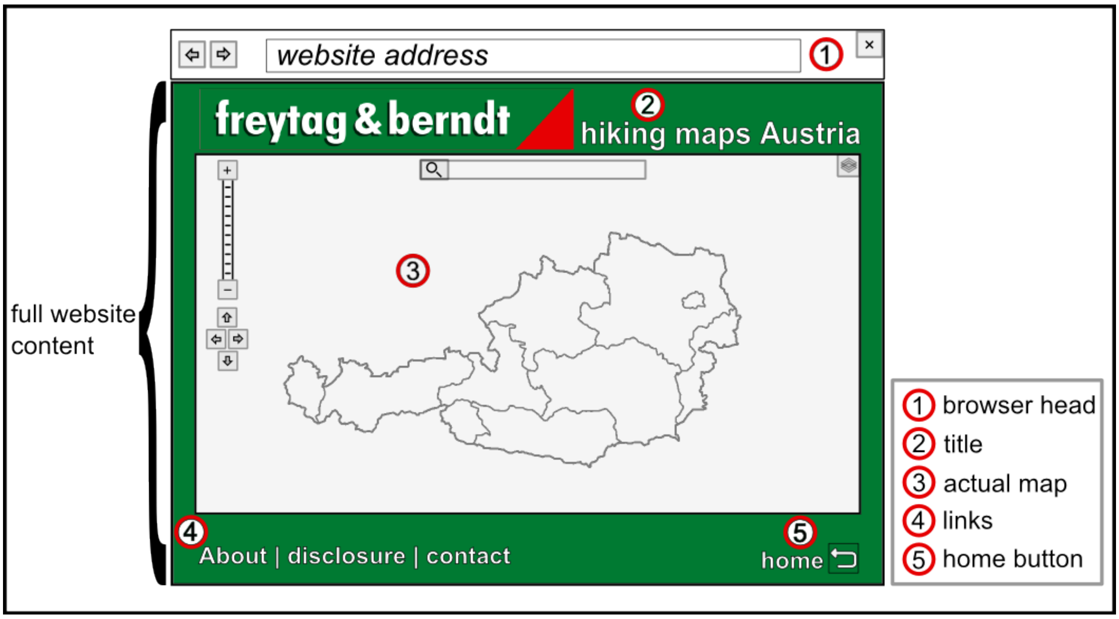


Fig. 54: Concept of the website of the web map

In figure 54 you can see the concept of the website where the web map will be embedded. (1) is the respective browser head. This section differs, depending on which browser the user is using. (2) is the space reserved for the title of the web map. The design and appearance of this section depends on the CI of Freytag&Berndt mainly and therefore will only be outlined in the prototype. (3) is the space assigned for the main purpose of the website, the web map itself. This area ought to be as big as possible. This section occupies most of the available screen space. (4) is a small section on the bottom of the website where links of organisational matter are placed. (5) refers to a home button. According to Martin and Richter, a possibility to navigate and forth within a website is very important and can improve website usability tremendously *[Martin and Richter 2008]*.

This concludes the proposed concept for the Freytag&Berndt web map. The concept is developed with respect to all previously worked out regulations concerning website usability, map content and technological matters. The concept however just outlines an idea for a specific product. Alterations may appear due to CI and other design issues.

6 Practical work

In the last chapter the concept of a web map was developed and in this chapter the practical development of a prototype for the Freytag&Berndt web map is described. The prototype is developed with the leaflet open source API, as mentioned in chapter 5.4. In the leaflet API basic functions are already implemented and more elaborate functions can be implemented with the aid of various plug-ins provided by the leaflet community.

The implementation of the customised Freytag&Berndt base layer was quite easy, because the whole dataset was preprocessed by Freytag&Berndt, meaning the map layer was already disaggregated into tiles and uploaded on a server. Therefore only few instructions had to be included in order to create the map with the Freytag&Berndt map data. There were few things that had to be taken into consideration: Firstly, the Freytag&Berndt base map was not available in all zoom levels, therefore the zoom was limited to a certain maximal and minimal zoom level. In addition to that a consistent map of the whole of Austria was implemented in two additional LODs as discussed in chapter 5.4. Secondly, the Freytag&Berndt base map covers only Austria, therefore restricting bounds were implemented. These bounds made it impossible to pan outside a certain ROI of the map. An additional second layer was implemented with OpenStreetMap map data. This was done for orientation purposes and because the Freytag&Berndt base map layer is not continuous in LOD 1. The basic implementations of the map layers and a basic functionality is included in the leaflet.js[37] file.

In order to meet the concept developed in chapter 5.4 more accurate, several plug-ins were included to add more sophisticated functionality to the web map. With the aid of a plug-in, a search box was included which allows the user to search for locations and addresses on the map. This search function is based on the OpenStreetMap location search implemented on the OpenStreetMaps web map. Furthermore a pan fucntion was implemented with the aid of a plug-in. Also, the basic zoom control implemented in the leaflet.js file was neglected and a more elaborate zoom control with an adjustable leveller was added via another plug-in.

[37] The basic JavaScript library which includes all basic functionalities of the leaflet API

The appearances and positions of the functionalities were optimised in the respective Cascading Style Sheets (CSS). Also, the map's size and position on the website was optimised with the respective stylesheet. Additionally, the website's appearance was optimised via the stylesheet. Because this is just a prototype and because the overall design lays in the provider's responsibility, this task was kept to a minimum.

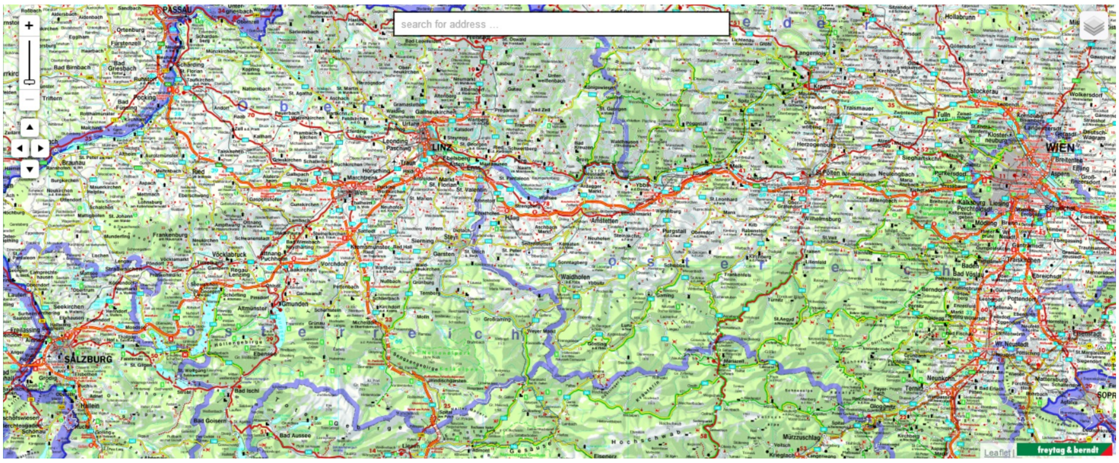


Fig. 55: The Freytag&Berndt base map layer

Figure 55 depicts a screenshot of the Freytag&Berndt base map layer of the prototype with all functionalities. The size of the respective buttons is kept low in order to assure as much screen space as possible for the map itself.

The extends of the Freytag&Berndt hiking maps were provided in a QGIS[38] project file by Freytag&Berndt. The extents had to be georeferenced first and later on exported as a shapefile[39]. With the aid of another plug-in, the shapefile can be displayed as an additional layer on the map.

[38] A free and Open Source GIS programme for creating, editing, visualising, analysing and publishing geospatial information

[39] A geospatial vector data format

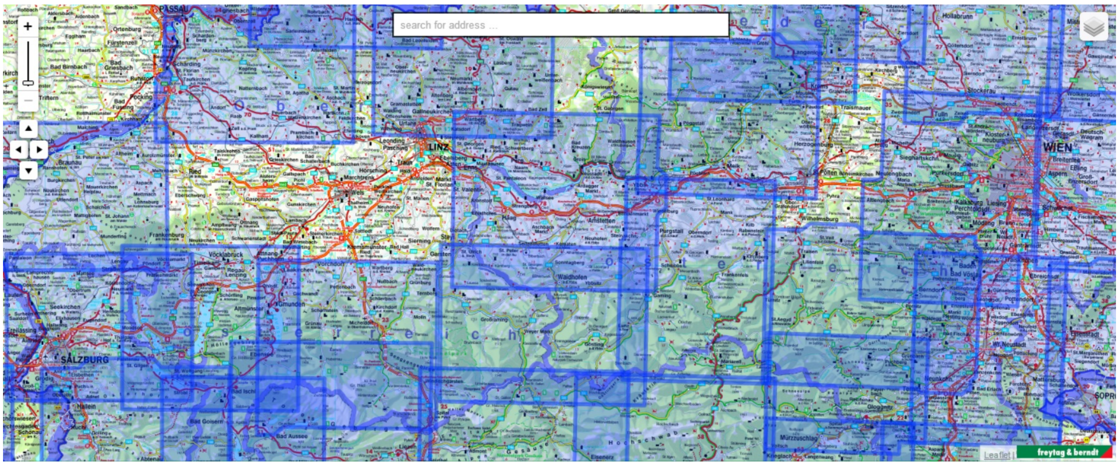


Fig. 56: The Freytag&Berndt base map layer with hiking maps extend polygons

In figure 56 you can see a screenshot of the Freytag&Berndt base map layer of the prototype and the displayed map extents of the individual hiking maps. Every single polygon represents an individual hiking map and is clickable. When clicking on a polygon, a pop-up will appear with additional information about the respective hiking map and a link to the Freytag&Berndt online shop. A problem which occurred here is that the design of the polygons, meaning the colour and filling of the polygons, was already pre-defined in the leaflet.js file and therefore it is very hard to alter the appearance of the polygons on the map. You ought to find the exact position in the source code where the appearance of the polygons is defined and then alter the leaflet.js source code and save it locally. This was neglected because of two reasons: First, it would have been too time consuming to implement a correct function and secondly because it was not desirable to have the need of the leaflet.js file to be locally stored. Any optimisations of the leaflet.js file by the leaflet community would not appear in a local leaflet.js and that would be disadvantageous for the web map's accessibility.

The implementation of KML format hiking routes was left out, because Freytag&Berndt could not deliver KML format data about hiking routes. During the practical work the implementation of a KML format route into the web map was successfully tested but not included into the final prototype.

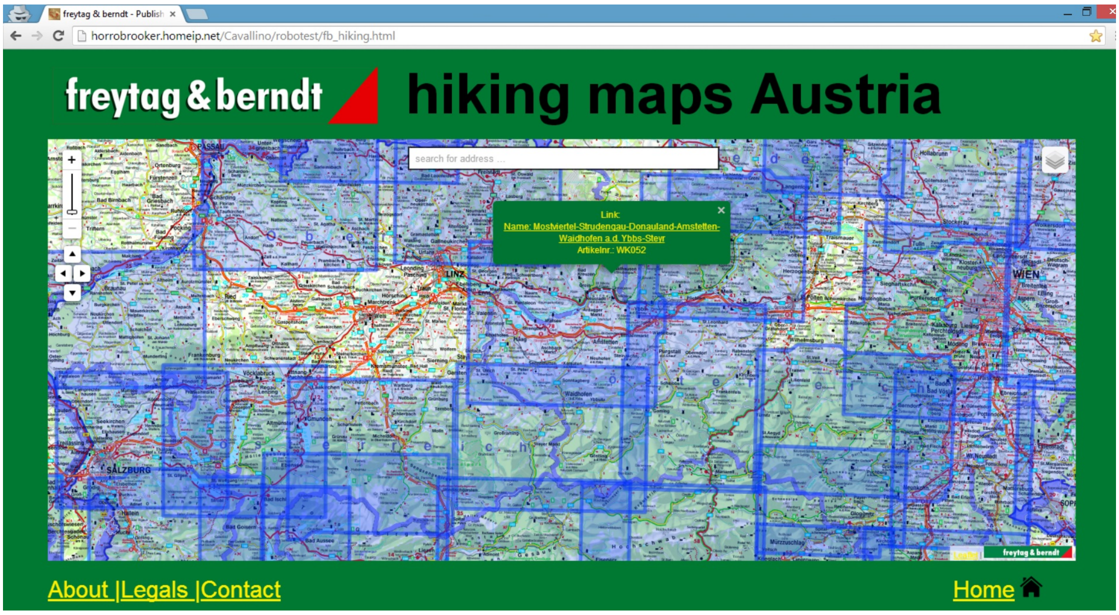


Fig. 57: The Freytag&Berndt web map prototype

Figure 57 depicts the final Freytag&Berndt web map prototype as developed in this Master's thesis. The respective source code is annexed at the end of this thesis. As you can see, the reserved screen space for the map itself is tremendous and the functionality and complexity of the map is held to minimum, hence a possible user can start using the web map instantly. In the small pop-up additional information about the respective hiking map is displayed as well as a link to the Freytag&Berndt online shop.

This concludes the development of a web map for a traditional map publishing company. The prototype as depicted in figure 57 is the result of this development in this thesis. As you can see in figure 55, 56 and 57, it is possible to create a working web map from data specifically made for the purpose of being printed. Therefore it is possible to use an additional distribution channel for Freytag&Berndt's printed map material without the need of producing a whole new data set.

7 Conclusions

In the last chapter a prototype of the Freytag&Berndt web map was developed. In this chapter the final workflow, which was worked out during this thesis, is pointed out and described in detail.

7.1 The workflow

The ultimate goal of this thesis was to develop a web map that is useful for the provider as well as the user. Starting from the initial idea of developing a useful web map you have to consider a lot of things. In a first step it is necessary to establish a certain amount of knowledge of what is possible to implement as well as what data can be made available. After that it is important to narrow down the list of possible functionalities, map content, field of applications and usable technology. This can be done mostly by a process of elimination because of incompatibility of your available data and functionalities, field of application and usable technology. In summary, the first thing done here, was to get an overview of what is possible in the field of web mapping.

As a very important second step towards a really useful final product an usability engineering approach as described by Nielsen *[Nielsen 1993]* was carried out. Carrying out an usability engineering approach means to find out what the possible user of your product expects the product to be like. Otherwise the product will fail and not be used much *[Bailey and Pearson 1983]*. In order to do so, the user has to be directly addressed. A voluntary and not too time consuming online survey seems to be the perfect way to do, because in doing so the right audience may be addressed and the survey would have a considerable range *[Oberzaucher 2012]*. Within this survey it is very important to find a good equilibrium between clear and straightforward questions and complex questions that go more into depth in order to be able to draw conclusions of the answers. Following the answers of all participants must be examined and summarised into direct conclusions concerning your project. The conclusions have to be applied on your available data to carry that out in a correct way. The stated orders of importance in chapter 3.4.4 and 3.4.5 can be used for further improvements of the web map. The base map of the Freytag&Berndt web map developed here does not include any optimisations following those orders of importance because the base map was produced by Freytag&Berndt beforehand. In summary, the second step was about describing what technology will be used in the web map and what exact content the web should have.

In the third step towards the final web map, it was very useful to figure out which criteria of usability can be allocated to which area of responsibility, hence creating a framework for the further development of the product. This framework must than be applied to every involved party of the project. In this case there were three involved parties with different points of views: The user, the provider and the developer. The focus was here to assure some sort of benefit for every party. For the possible user this task is done by the usability engineering approach. The developer's benefit of the project might be either some sort of financial benefit or just the realisation of the project itself. In summary, the third step was about allocating responsibilities.

Further on with the knowledge gained from the usability engineering approach and the framework that guarantees a high usability a concept must be outlined for the final product. This can be done by describing the concept very precisely and elaborate and, what turned out to be even more useful, by creating sketches of what is the intention. By doing so it became easier to translate the project into practice. Another advantage is that you can easily explain your project to anyone. The concept is then translated into practice, tested and should then fulfil every party's requirements for the project.

To put it all in a nutshell, the five steps that were worked off in this thesis can be described as the following:

1. What is possible to translate into practice? This can be done by literature research.
2. What are the user's demands of the product? This can be done by directly addressing the possible future users of the product, in this case an online survey.
3. What are the respective party's responsibilities? This can be done by developing a framework which ensures a high usability and afterwards applying this framework to the specific application.
4. What does the concept look like? This is done by outlining a concept of the product.
5. The translation into practice.

This workflow turned out to be very useful. It seemed, that the first two steps could be switched with each other, but it was not possible to work out a useful survey without elaborating the state of the art in the appropriate field of research. The third step was worked out because it was hard to retain an overview after developing a framework which ensures high usability of the product. Every criteria of usability was assigned to a party. It was possible to take a more specific look at every criteria of usability by doing so. After assigning all criteria to a specific party, the concept of the product was outlined in the fourth step. In step five all findings and the concept were combined and a prototype was translated into practice.

7.2 The Leaflet open-source JavaScript library

The practical work of this thesis was done completely with the leaflet open-source JavaScript library. Basic functionality, for example a layer control or zoom buttons, are very easy to implement with this library. Unfortunately the documentation for more sophisticated functionality is lousy. The step from an absolute beginner with leaflet to an absolute professional is very hard. One has to learn it for oneself because it is not well documented how the plug-ins work and what they exactly do. For a non-expert it is absolutely impossible to figure out why some things just do not work. Because sometimes the respective plug-ins contain JavaScript functions or stylesheets that might contradict each other and it is very hard to find the right line in thousands of lines of source code with few experience in coding. A problem related to that occurred at the implementation of the hiking map extend polygons. Freytag&Berndt provided the data about the map extends in a QGIS project file. After processing the data was exported as a shapefile as mentioned in chapter 6.. There is a plug-in where you can display shapefiles as a layer on your customised base map, but it is not documented anywhere how to address the appearance of the individual polygons. After an extensive search, it became clear, that the individual polygons can be addressed via the leaflet.js file. This approach was neglected because of the reasons also stated in chapter 6., though. To put it all in a nutshell one can say that a simple basic implementation of a web map with the leaflet library is really easy and possible with only few coding skills, but more complex coding is hard with few experience in this field.

8 Future work

In the last chapter conclusion drawn from the thesis and from the practical work were described. In this last chapter, future opportunities referring to this thesis are pointed out.

The first opportunity that comes to mind is of course a mobile friendly application of the web map. This is easy to realise because the leaflet open-source JavaScript library supports mobile applications. Just some alterations concerning the smaller screen size and the including of LBS have to be taken care of. Another future opportunity may lie in the complete conversion from printed map material to digital map material. In the future printed map material most likely will loose its major share in map material to digital platform-independent maps. This conversion is very costly though, because in this case, the hiking maps are produced especially to be printed out. A whole new set of hiking maps with different cartographic design rules would have to be developed. These briefly considered digital maps could than be offered to purchase in the Freytag&Berndt online shop in form of a download. According to Kettunen, a web map that distributs maps in more than one channel from a single data source is called a multipublishing environment *[Kettunen et al. 2012]*. An additional digital distribution form of the hiking maps via the web map transforms the web map into a multipublishing environment. As a further future opportunity a possible extension of the web map to other map topics can be considered. Other map topics than hiking can be included as extend polygons aggregated into individual map layers. Maybe, in order to not overwhelm the user with too much information displayed on the screen simultaneously, the map topic can then be stated to choose from before the user gets to use the web map in the first place. A personalisation function as mentioned in chapter 5 could be implemented for this purpose. Last but not least the implementation of hiking routes in a KML format can be carried out in order to produce an optimal web map.

9 Appendix

9.1 Appendix I: Image source index

9.2 Appendix II: Table source index

9.3 Appendix III: Online survey

Umfrage zur Gestaltung einer Webmap

Freytag&Berndt ist ein traditioneller Kartographie-Verlag dessen Ursprünge bis auf das 18. Jahrhundert zurückreichen. Trotz oder vielleicht gerade aufgrund der reichen Tradition ist die Geschäftsphilosophie eindeutig auf die Zukunft ausgerichtet.

In Kooperation mit Freytag&Berndt wird nun im Rahmen einer Diplomarbeit an der TU Wien eine Umfrage durchgeführt. Sie soll dazu dienen herauszufinden welchen Inhalt eine Grundlegende Webmap eines Internet-Kartendienstes haben sollte.

Wir würden uns freuen, wenn Sie die folgenden Fragen beantworten. Sie benötigen dafür ungefähr 5 bis 10 Minuten.

Sollten Sie Fragen bezüglich dieses Fragebogens haben, wenden Sie sich bitte an c0725692@student.tuwien.ac.at

Datenschutz
Dies ist eine anonyme Umfrage.
Sämtliche von Ihnen in der Umfrage gemachten Angaben werden vertraulich und unter Einhaltung der Datenschutzbestimmungen behandelt. Ihre Antworten in der Umfrage werden ausschließlich innerhalb der Forschung verwendet. Die Ergebnisdarstellungen aus den Befragungen werden außerdem aggregiert publiziert und erlauben deshalb keinerlei Rückschlüsse auf einzelne Personen. Sämtliche Bezeichnungen im Rahmen des Fragebogens sind geschlechtsneutral zu verstehen und in ihrer Anwendung sinngemäß für weibliche und männliche Personen gleichermaßen. Aus diesem Grund sowie zur Erhaltung der Lesbarkeit wird auf eine geschlechterneutrale Schreibweise verzichtet.

*Required

Seite 1/8

Allgemeine Fragen

1. **1. Welche kartographischen Produkte besitzen sie?**
   Mehrfachnennung möglich
   Tick all that apply.

   - ☐ Auto/ Freizeitkarten
   - ☐ Wandern/ Radkarten
   - ☐ Stadtpläne
   - ☐ Atlanten
   - ☐ Bezirks/ Ortspläne
   - ☐ Markiertafeln/ Poster
   - ☐ Other: ____________

2. **2. Bei welcher Aktivität nutzen sie diese Produkte?**

Mehrfachnennung möglich

Tick all that apply.

- [ ] Wandern
- [ ] Bergsteigen/ Klettern
- [ ] Wintersport
- [ ] Fahrradfahren
- [ ] Städtereise
- [ ] Autoreise
- [ ] Bildung (Schule etc.)
- [ ] Other:

Fragen 2/8

Nutzungsfragen

3. **3. Wann nutzen sie ihre kartographischen Produkte?**

Jeweils eine Antwort möglich

Mark only one oval per row.

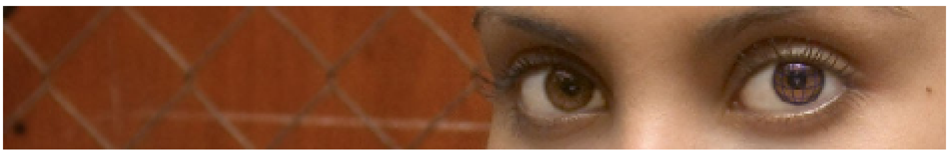
	Trifft voll zu	Trifft zu	Trifft nicht zu	Trifft gar nicht zu
Zu Hause zur Planung	⬭	⬭	⬭	⬭
Unterwegs	⬭	⬭	⬭	⬭
Zu Hause nach der Planung	⬭	⬭	⬭	⬭

4. Wie oft nutzen sie ihre kartographischen Produkte?

Nur eine Nennung möglich

Mark only one oval.

	1	2	3	4	
Sehr häufig	⬭	⬭	⬭	⬭	Selten



Fragen 3/8

Nutzungsfragen II

5. **5. Auf welche Schwierigkeiten stoßen sie beim Kartenlesen?**
Jeweils eine Antwort möglich
Mark only one oval per row.

	Trifft voll zu			Trifft gar nicht zu
Durch zu viele Inhalte ist die Karte schwer zu Lesen				
Schrift ist zu klein				
Beschriftung ist nicht eindeutig zuzuordnen				
Symbole sind schwer verständlich				
Legende ist schwer verständlich				
Distanzen sind schwer abzuschätzen				
Höheninformationen sind schwer erfassbar				

6. **6. Auf welche weiteren Schwierigkeiten stoßen sie beim Kartenlesen?**
Freie Eingabe, bei mehreren Angaben bitte durch Beistriche trennen

Fragen 4/8

Digitale Produkte

7. **7. Wie oft nutzen sie digitale kartographische Produkte auf folgenden Geräten?**
Jeweils eine Antwort möglich
Mark only one oval per row.

	Sehr häufig			Nie
Smartphone				
Tablet-PC				
Notebook/ PC				
GPS-Gerät/ Navigationssystem				

8. Wie oft nutzen sie Internet-Kartendienste?
Wie zum Beispiel Google Maps // nur eine Nennung möglich
Mark only one oval.

	1	2	3	4	
Sehr häufig					Nie

9. Wie oft nutzen sie standortbezogene Social Media?
nur eine Nennung möglich
Mark only one oval.

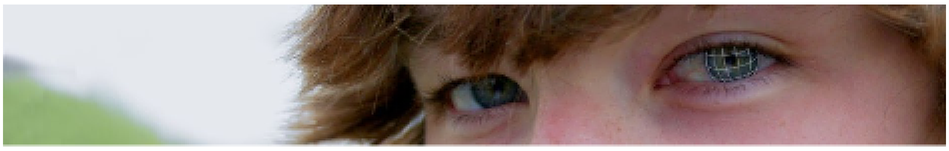
	1	2	3	4	
sehr häufig					nie

Seite 5/8

Punktinhalt I

10. **10. Welche Punktinhalte sollte die Webmap eines Internet-Kartendienstes ihrer Meinung nach haben?** *
Jeweils eine Antwort möglich
Mark only one oval per row.

	Trifft voll zu			Trifft gar nicht zu
Infrastruktur (Bushaltestelle, Bahnhof etc.)				
Parkmöglichkeiten				
Übernachtungsmöglichkeiten (Hotel. Zeltplatz etc.)				
Kulturangebot (Theater, Museum etc.)				
Kirchen (auch Kapellen, Bildstöcke etc.)				
Sehenswürdigkeiten (Schloss, Dom etc.)				
Freizeitangebot (Kletterparks, Zoo etc.)				



Seite 6/8

Punktinhalt II

11. **11. Welche weiteren Punktinhalte sollte die Webmap eines Internet-Kartendienstes ihrer Meinung nach haben?** *

Jeweils eine Antwort möglich

Mark only one oval per row.

	Trifft voll zu			Trifft gar nicht zu
Bademöglichkeiten (Freibad, Badesee etc.)				
Aussichtspunkte				
(Frischwasser-) Quellen				
Höhenpunkte (Gipfel, Tal)				

12. **12. Welchen Punktinhalt finden sie noch wichtig?**

Freie Eingabe, bei mehreren Angaben bitte durch Beistriche trennen

....

Seite 7/8

Routeninhalt

13. **13. Welche Routeninhalte sollte die Webmap eines Internet-Kartendienstes ihrer Meinung nach haben?** *

Jeweils eine Antwort möglich

Mark only one oval per row.

	Trifft voll zu			Trifft gar nicht zu
Wanderrouten				
Radwanderrouten				
Mountainbikerouten				

14. **14. Welchen Routeninhalt finden sie noch wichtig?**
Freie Eingabe, bei mehreren Angaben bitte durch Beistriche trennen

15. **15. Haben sie noch sonstige Anmerkungen zum Thema Karteninhalt einer Webmap?**
Freie Texteingabe

Seite 8/8

Fragen zur Person

16. **16. In welcher Altersklasse befinden sie sich?**
Nur eine Nennung möglich
Mark only one oval.

- < 20 Jahre
- 20 - 40 Jahre
- 41 - 60 Jahre
- > 60 Jahre

17. **17. Welchem Geschlecht gehören sie an?**
Nur eine Nennung möglich
Mark only one oval.

- weiblich
- männlich

Vielen Dank!

Bitte klicken sie unten noch auf "Senden" um die Umfrage abzuschließen

Sollten sie noch irgendwelche weiteren Fragen zu diesem Fragebogen haben dann wenden sie sich bitte an den Ersteller dieser Umfrage unter der e-mail-Adresse: e0725682@student.tuwien.ac.at

Hier geht es zur Website der Research Group Cartography an der TU Wien:
http://cartography.tuwien.ac.at/

Bildquellen:
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Seite 8/8: © johanna focke, Photocase.de

9.4 Appendix IV: Web map source code

```
<!doctype html><html lang="en">
<head>
	<meta charset='utf-8'/>
	<title>
		freytag &amp; berndt - Publisher
	</title>
	<link rel="stylesheet" href="http://cdn.leafletjs.com/leaflet-
0.6.4/leaflet.css"/>
	<!--external link to leaflet stylesheet-->
	<link rel="stylesheet" href="lib/fbmapstyle.css"/>
	<!--Freytag&Berndt stylesheet-->
	<link rel="stylesheet" href="lib/L.Control.Zoomslider.css"/>
	<!--stylesheet for the new zoom control-->
	<link rel="stylesheet" href="lib/l.geosearch.css"/>
	<!--stylesheet for the search box-->
	<link rel="stylesheet" href="lib/L.Control.Pan.css"/>
	<!--stylesheet for the pan control-->
	<!--[if lte IE 8]>
		<link rel="stylesheet" href="http://cdn.leafletjs.com/leaflet-
0.6.4/leaflet.ie.css" />
		<![endif]-->
</head>
<body>
	<div id="Logo">
		<a  alt="Logo" target="_blank"
href="http://www.freytagberndt.at/rtc-freytagberndt/en_EN"><img src
="img/FreytagBerndt_logo.png"></a>
	</div>
	<div>
		<h1>hiking maps Austria</h1>
	</div>
	<div id="map"></div>
	<script src="http://cdn.leafletjs.com/leaflet-
0.6.4/leaflet.js"></script>
	<!--external link to leaflet js-->
	<script src="lib/shp.js"></script>
	<!--script for shapefile display function-->
	<script src="lib/catiline.js"></script>
	<!--script for shapefile display function-->
	<script src="lib/leaflet.shpfile.js"></script>
	<!--script for shapefile display function-->
	<script src="lib/leaflet-tilejson.js"></script>
	<!--script for shapefile display function-->
	<script src="lib/Shapefile_data.js"></script>
	<!--script with shapefile path-->
	<script src="lib/leaflet-src.js"></script>
	<!--script with leaflet various leaflet functions-->
	<script src="lib/L.Control.Zoomslider.js" ></script>
	<!--script with new zoom control function-->
	<script src="lib/l.control.geosearch.js"></script>
	<!--script with the search box functionality-->
	<script src="lib/l.geosearch.provider.openstreetmap.js"></script>
	<!--script with OSM search function-->
	<script src="lib/L.Control.Pan.js" ></script>
	<!--script with pan function-->
	<script
src="https://ajax.googleapis.com/ajax/libs/jquery/1.7.1/jquery.min.js"></script>
	<!--script with search function-->

	<script>
		var cmAttr = '<a href=\"http://www.freytagberndt.at/\"
target=\"_blank\"><img src=\"img/fb_120x16.png\"></a>', <!--
attribution-->
			cmUrl =
'http://tile{s}.freytagberndt.at/TMS/1.0.0/freytagberndt/{z}/{x}/{y}.png', <!--
Freytag&Berndt base map layer link-->
```

```
                        cmUrl2 =
'http://{s}.tile.cloudmade.com/BC9A493B41014CAABB98F0471D759707/997/256/{z}/{x}/
<!--OSM base map layer link-->

                var karte   = L.tileLayer(cmUrl, {subdomains: '123', tms: true,
minZoom: 9, maxZoom: 15, attribution: cmAttr}), <!--
layer initiation-->
                        OpenLayers  = L.tileLayer(cmUrl2, {styleId: 22677,
minZoom: 7, maxZoom: 15, attribution: cmAttr}); <!--
initiation-->

                var southWest = L.latLng(45.900, 9.400), <!--bounds of map view-
->
                        northEast = L.latLng(49.100, 17.200),
                        bounds = L.latLngBounds(southWest, northEast);

                var map = L.map('map', { <!--initiation of default map-->
                        zoomsliderControl: true, <!--add new zoom control-->
                        zoomControl: false, <!--neglect default zoom control-->
                        center: [48.20591, 16.36826], <!--initial centre
coordinates-->
                        zoom: 9, <!--default zoom-->
                        layers: [karte, mapSheets], <!--add layers to map-->
                        maxBounds: bounds <!--add maximal bounds to map-->
                        });

                var baseLayers = { <!--definition layer group baseLayers-->
                        "Freytag&Berndt": karte,
                        "OpenLayers": OpenLayers
                        };

                var overlays = { <!--definition layer group overlays-->
                        "MapSheets": mapSheets
                        };

                new L.Control.GeoSearch({ <!--add search box to map-->
                        provider: new L.GeoSearch.Provider.OpenStreetMap()
                        }).addTo(map);

                L.control.layers(baseLayers, overlays).addTo(map); <!--add
layers to map-->

                L.control.pan().addTo(map); <!--add pan control to map-->
        </script>

        <div id="Links">
                <p><a href="http://www.freytagberndt.at/rtc-
freytagberndt/en_EN/843" target="_blank">About </a>|<a
href="http://www.freytagberndt.at/rtc-freytagberndt/en_EN/1154"
target="_blank">Legals </a>|<a href=
freytagberndt/en_EN/1131" target="_blank">Contact </a></p>
        </div>
        <div id="Home">
                <p><a href="http://www.freytagberndt.at/rtc-
freytagberndt/en_EN" target="_blank">Home</a></p>
        </div>
        <div id="Back">
                <a  alt="Back" target="_blank"
href="http://www.freytagberndt.at/rtc-freytagberndt/en_EN"><img src
="img/home.svg"></a>
        </div>
</body>
</html>
```

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Berlin, den

____

Robert Philipp

Lebenslauf

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