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Master thesis

Map-based Storytelling in Spatial Augmented Reality: Projection of Interactive Layers

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Map-based Storytelling in Spatial Augmented Reality: Projection of Interactive Layers

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Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled:

"Map-based Storytelling in Spatial Augmented Reality: Projection of Interactive Layers"

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Munich, 21/10/20 Nikita Slavin

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I would like to say big thank you to my friends on both sides of the Corona-wall – without your support, sometimes paradoxical, I will have no chance to make a job, have no place to live and work, I'd be hungry and sad. I love you, mates.

Abstract

Mixed reality technologies are already widely used in the Cultural Heritage field, especially in museums to make the exhibition more entertaining and enjoyable for the visitors. In order to inform the visitor about the displayed exhibition piece or about the event happened, museums often use the storytelling method, particularly with texts, images and videos. There are currently no conceptual and technical solutions to put a paper map in such a mixed reality environment to tell a story in a museum. Additionally, there is no research investigating if building an interactive environment around the cartographic piece of art could be useful for cultural heritage interpretation.

This thesis investigates how a paper map can be projected and enhanced with interactive layers in such an environment, called Spatial Augmented Reality (AR). Furthermore, this thesis evaluates the impact of this method in the user experience.

In a first step, the hardware and software technology suitable for the realization of an example exhibition was investigated and finally selected. The way of user interactions in the AR space were defined, as well as types of connected media that could be integrated in the exhibition were explored. Two prototypes have been built using the example of the map of Charles Minard “Napoleon ventured East”. One prototype placed the map in a Spatial AR environment, the other one presented the map in a classical exhibition example. Finally, both exhibitions have been evaluated by 25 exhibition visitors within a comparative study. Users have been asked to solve various tasks and comment on their experience.

The results show that the visitors liked both exhibition samples with a slightly better result of the Spatial AR realization in terms of task solving. Additionally, the users confirmed that using paper maps in such an environment makes the exhibition more entertaining and is enhancing the potential museums visitors experience.

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1 Introduction

1.1 Background and Motivation

Digital technologies are transforming all kinds of museums into hybrid and complex spaces, where the virtual lives of characters and stories are blended with the physical form of artefacts (Irace et al., 2013). The design of museum exhibitions and museum experience often uses the storytelling method. Within this method, the visitor is guided through the story, using museum pieces in the interactive and non-interactive exhibit environment. It could create a more comprehensive experience, increase engagement and improve the emotional response(Dal Falco & Vassos, 2017).

Maps can be an instrument of storytelling as well: “it makes information more personal and arrests user's attention to the map”. (Mocnik & Fairbairn, 2018). Of course, maps are used in the exhibition design widely: as showpieces itself or as supporting material to other showpieces. However, maps used as a core instrument for storytelling in museums is not common. As the author is not aware of any solution where an original map or a reprint is used, this thesis will investigate the possibility and profitability of using printed maps for storytelling in museum exhibitions.

One technology that is widely used in the Cultural Heritage (CH) field is Mixed Reality (MR). Some of MR solutions are enhancing original historical objects or their replicas by putting them into the interactive virtual environment. It helps to overcome traditional limitations like time, space and non-interactivity (Bekele et al., 2018). The usage of such MR technologies for telling stories via maps could enhance visitors experience, the quality and the quantity of the acquired knowledge further.

MR techniques, including Spatial Augmented Reality (Spatial AR is AR accessible without any special user devices), are used on three-dimensional objects, giving the possibility to look inside, or show lost parts of it. A popular spatial AR technique is Projection Mapping, a technology that turns the object into the screen. Mixed Reality, mostly Spatial AR solutions, can provide a spectacular effect to viewers by showing insights of historical showpieces using projection mapping techniques. Figure 1 shows an example where Projection Mapping is used to turn the relief model to the interactive map, by the projection of the image of the map, connected content and interface.

However, there are currently no technical and conceptual solutions to put paper maps in Spatial AR. Additionally, there is no research investigating if building an interactive environment around the cartographic piece of art could be useful for cultural heritage interpretation. The usage of a map as a core for storytelling in Spatial AR could give generous dividends, based on the map’s high information density and aesthetic. It is essential to put the user in a comfortable environment with a low entry threshold – that is why Spatial AR techniques, accessible without any user’s devices, seems perspective for the usage.

Figure 1 Part of the museum of Gorky Park exhibition in Moscow. Projection-Mapping technique is used.

The development of the new method could provide museums with a new instrument of exhibition design where the story is told with and by the map. An important part of method development is finding a balance between education and entertaining part; the exhibition should tell stories and bring new knowledge and insights. Toa find that balance, it is essential to compare and measure different approaches for an exhibition design - Classical and AR.

1.2 Research Identification

Within this Master thesis, the applicability of the Spatial AR technology for Map-based Storytelling exhibitions should be investigated. The current practice of using maps in exhibitions in most cases involves one of two methods: traditional non-digital exposition or digital copy showed with the screens or projections.

There is a gap between these two methods – currently no solutions, known to author, where the printed map is exposed within the digital environment.

1.2.1 Research Objectives

The main objective is to propose and evaluate a method of Map-Based Storytelling in Mixed Reality in order to enhance user experience.

This overall objective can be divided into four sub-objectives:

I. Make an overview of current MR technologies for CH. Identify the most

common limitations of classical exhibitions and ways to avoid them.

II. Chose the technologies that can be used for the projection of interactive layers on the map.
III. Find the ways of user interactions with maps in AR-space. Figure out what kinds of connected media and information could be integrated into the exhibition.
IV. Evaluate the proposed method concerning its impact on the user experience.

1.2.2 Research Questions

To reach the four research objectives and to provide the structure for the method development and evaluation, the following research questions need to be answered:

I. Which MR methods are used in CH applications, especially in exhibitions, how do they guide user through story? What are the limitations of traditional exhibition methods while storytelling using maps and how to overcome them?
II. How can the projection of interactive layers on printed historical maps in a Spatial AR environment be realised?
III. How can users interact with a paper map in the Spatial AR environment? What kinds of connected media and information can be added? Furthermore, how can it be realised for different types of media (e.g., are there differences)?
IV. Can the new method make storytelling using maps more enjoyable/entertaining, and enhance the user experience and quality and quantity of the acquired knowledge?

1.3 Innovation aimed at

A new method combining printed maps and Spatial AR will be proposed,
filling the gap between non-interactive and fully digital solutions.

The hypothesis is that the proposed Map-Based Storytelling in Mixed Reality method could enhance user experience: the way of the story exploration will become more entertaining and flexible, and as one of the results, the quality of acquired knowledge will be better than with traditional solutions.
The proposed method (solution) could find a field of usage in all kinds of museum exhibitions and various educational projects.

1.4 Outline of the thesis

The thesis is divided into six chapters: in the first chapter, background and motivation are given, research objectives and questions are defined. The second chapter provides an overview of state of the art in related topics: MR techniques for CH, MR and maps, usage of

AR in exhibitions, storytelling with maps. The third chapter is introducing the Minard map and its different interactive and non-interactive interpretations: books, posters, web-applications. The research approach, the methodology, including AR and Classical exhibition prototypes development and the key aspects of the user evaluation, are described in the fourth chapter. The results and their discussion are presented in the fifth chapter, that is followed by the conclusions and outlook for future research in the sixth chapter.

2 State of the art

This chapter focuses on the state-of-the-art of fields of storytelling in general, and storytelling in museums and storytelling in/with maps, usage of Mixed Reality (more specific Spatial Augment Reality) in Cultural Heritage field and its applications which are using maps.

2.1 Storytelling

The term ”storytelling” is used in a wide range of fields and applications. What’s why there is no single agreed-upon definition. But, according to (Lee et al., 2015) most of the descriptions “require some sort of controlled delivery or presentation of the information”, this delivery always contains ”components of that forms the “story” (structures, elements, and concepts) and those that influence the “telling” part of the storytelling (people, tools and channels)”. Let’s note elegant definition for the maps telling stories: “Stories, like maps, are a method for documenting and explaining, for meaningfully abstracting our experiences, for communicating and sharing, and for asserting a particular worldview.” (Roth, 2020)

This thesis is focusing on the storytelling as a method of the museum exhibitions design, storytelling in maps design and storytelling with maps.

The Visual Data Storytelling Process proposed by Lee (2015) is designed in terms of Data Journalism, but it could be successful used in other fields.

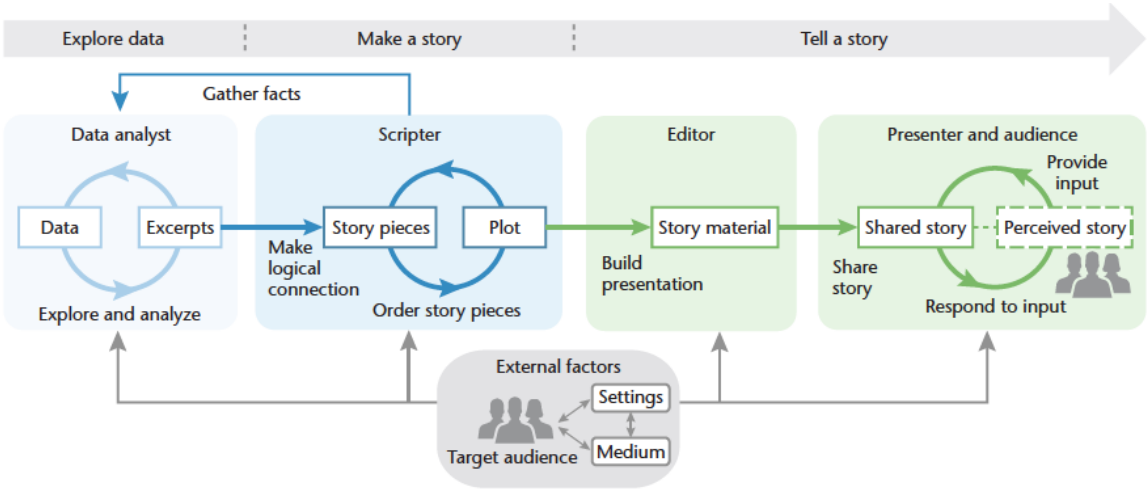


Figure 3 The visual data storytelling process by the (Lee et al., 2015)

The three main stages are: Explore the data, make a story and tell a story. The process is not linear: some of the parts should be repeated recursively. Different studies show different approaches to the structure of the stories and storytelling design. For example, a story could be divided into the linear three-act spatial narrative: setup-conflict-conclusion (Roth, 2020).

2.1.1. Storytelling in museums

The usage of the storytelling method in modern museums is closely connected to the usage of modern technologies, including AR, VR, and MR technologies.

The exhibition museums the main attraction and principal benefit. “Museum exhibitions are goods of research, organised and designed to communicate ideas. They communicate through the senses the primary sense being visual, by process both that it is both cognitive and cultural. This process incorporates the way people think about they see and meanings they attach to it.” (Ahmad et al., 2014)

According to Dal Falco and Vassos (2017), the aim of using modern technologies in the Museum Design is “to achieve higher integration between the artefacts and information they carry and the visitor experience, based on new forms of new forms of technology-based narrative experiences”. Dal Falco, in his work proposing a new paradigm of Museum Experience design, facilitating traditional communications methods with a new type of interaction they are calling Storytelling experience. It is underlined that museum experiences require broader lifecycle, involving visitors before and after their visit using different ways of communication.

Serota (1996)is discussing the changing role of the visitors in the modern museum: by the interaction with the artefacts and artists visitor gaining first-hand participating experience and integrates themselves with performances and events.

Digital technology is transforming museums into hybrid and complex spaces, where the virtual lives and characters and stories are blended with the physical form of artefacts (Irace et al., 2013). Del Falco (2017) suggests that “the CH and museums artefacts may represent a live storytelling experience, benefiting from the fact that technology-driven design can open up innovative opportunities to pass on knowledge and information through experience”. The story is specified and managed by story points, tracing the development step-by-step. The approach is similar to videogames. Similar personalised stories and adventures are applying to create interactive narratives for the museums.

The usage of the storytelling approach and cutting-edge digital technologies in museums can bring rich dividends. It is important to be careful and don't let the form take precedence over the content.

2.1.2. Storytelling in and with maps

Most of the works discuss how maps to shown de created and designed to tell stories.

The paper “Maps Telling Stories?” is comparing texts and conventional maps as instrument for storytelling and coming up with a new concept of map design for storytelling. (Mocnik & Fairbairn, 2018)

Mocnik is underlining that “maps are fat worse in telling stories” compared to the text “because they have different functionalities and affordances”. Another essential point in the context of this study is: “The story is in many cases, rendered by additional information which is not part of the map, e.g. extensive supplementary accounts about historical living conditions leading to the demographic development, or information conveyed by multimedia elements which enrich the map”(Mocnik & Fairbairn, 2018).

In this study, different types of contents are going to be used. That’s why it is important to compare two of the most common types in our case: texts and maps. Text and maps are very different in representing landscapes, map representations despite all its advantages have a lot of limitations: of scale, symbology, classification and categorisation, interactivity. It is fascinating to compare cartographically with text representation of the same landscape, here is an extract from Silt Macfalarene (Macfarlane, n.d.) about his walk in the area in Essex, England:

“The air was grainy and flickering like an old newsreel. The sea wall had hazed out to a thin black strip. Structures of unknown purpose – a white-beamed gantry, a low-slung barracks – showed on the shoreline. […] The light had modified again, from nacreous to granular to dense. Sound travelled oddly. The muted pop-popping of gunfire was smudgy, but the call of a cuckoo from somewhere on the treeless shore rang sharply to us. A pale sun glared through the mist, its white eye multiplying in polls and ripples. The miniature sandscapes of ridge and valley pressed into the soles of my feet […]”

Of course, there is no way to the conventional topographic map shown in figure 4 evoke similar emotions, tell the story.

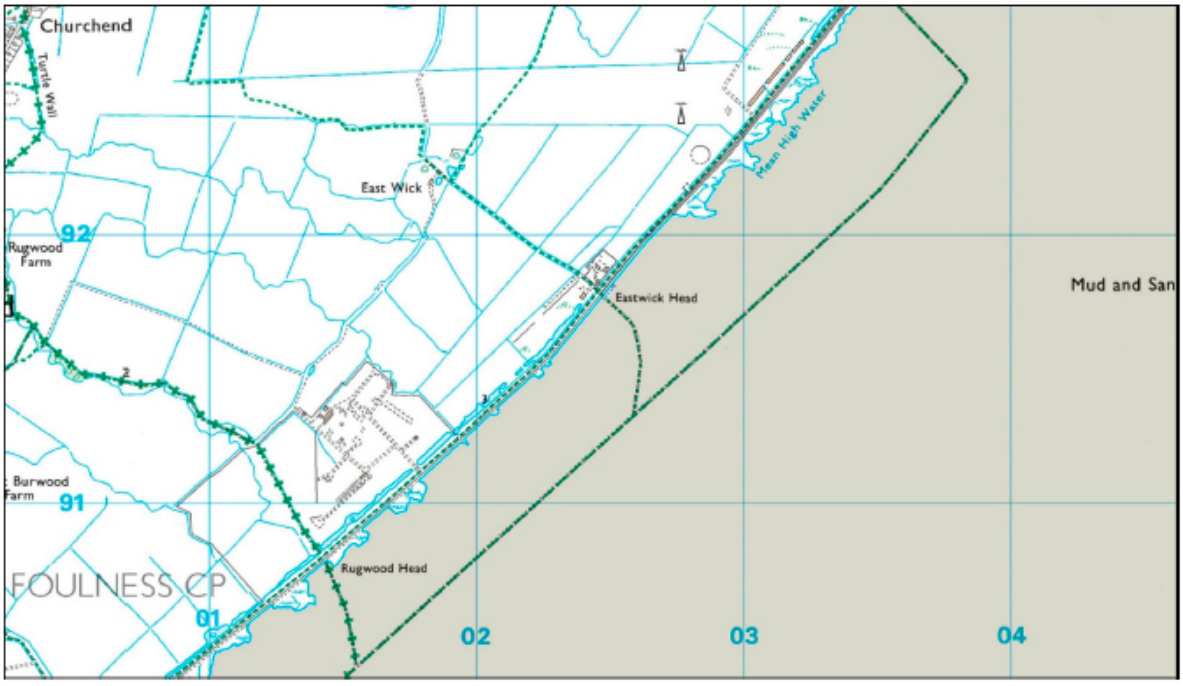


Figure 4 Topographic map representation of coastal mud flats, Essex, England (grid interval 1 km). © Crown Copyright and Database Right 2015 Ordnance Survey (Digimap Licence).

However, maps are the storytelling instrument. Many researchers agree that the famous Charles Minard map of Napoleon's army in the Russian campaign 1812 is probably the first storytelling map. (see figure 5). Case study of the thesis is based on this map – it will be described in the next chapter.

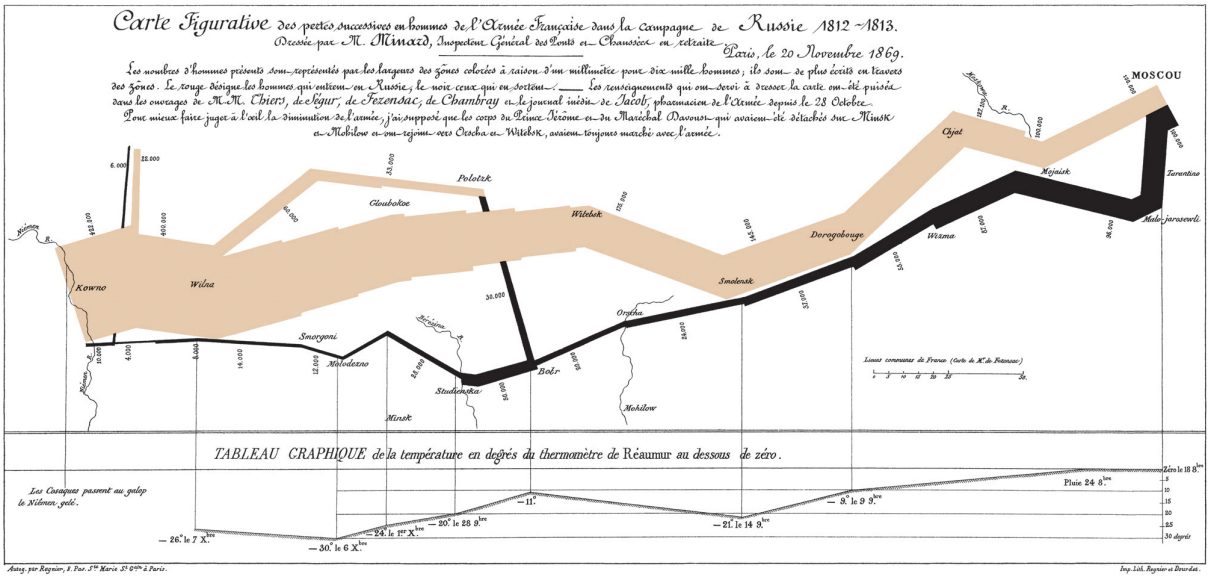


Figure 5 Map of Napoleon's Russian Campaign by Charles Minard, first published in 1869.

Some of the abovementioned limitations could be overcome with incorporating different media like graphs, pictures and over the content. It could be seen in various Multimedia cartography applications. (Cartwright et al., 2007)

In their work, Mocnik and Fairbairn are proposing a new approach for storytelling using maps the "story focus": "from a cartographic perspective … a variable generalisation technique, designed for adaptation to a story which represents reality with varying layers of content, levels of detail, scale, precision and uncertainty, emotion and mood. "(Mocnik & Fairbairn, 2018). The approach is clearly shown in Figure 6

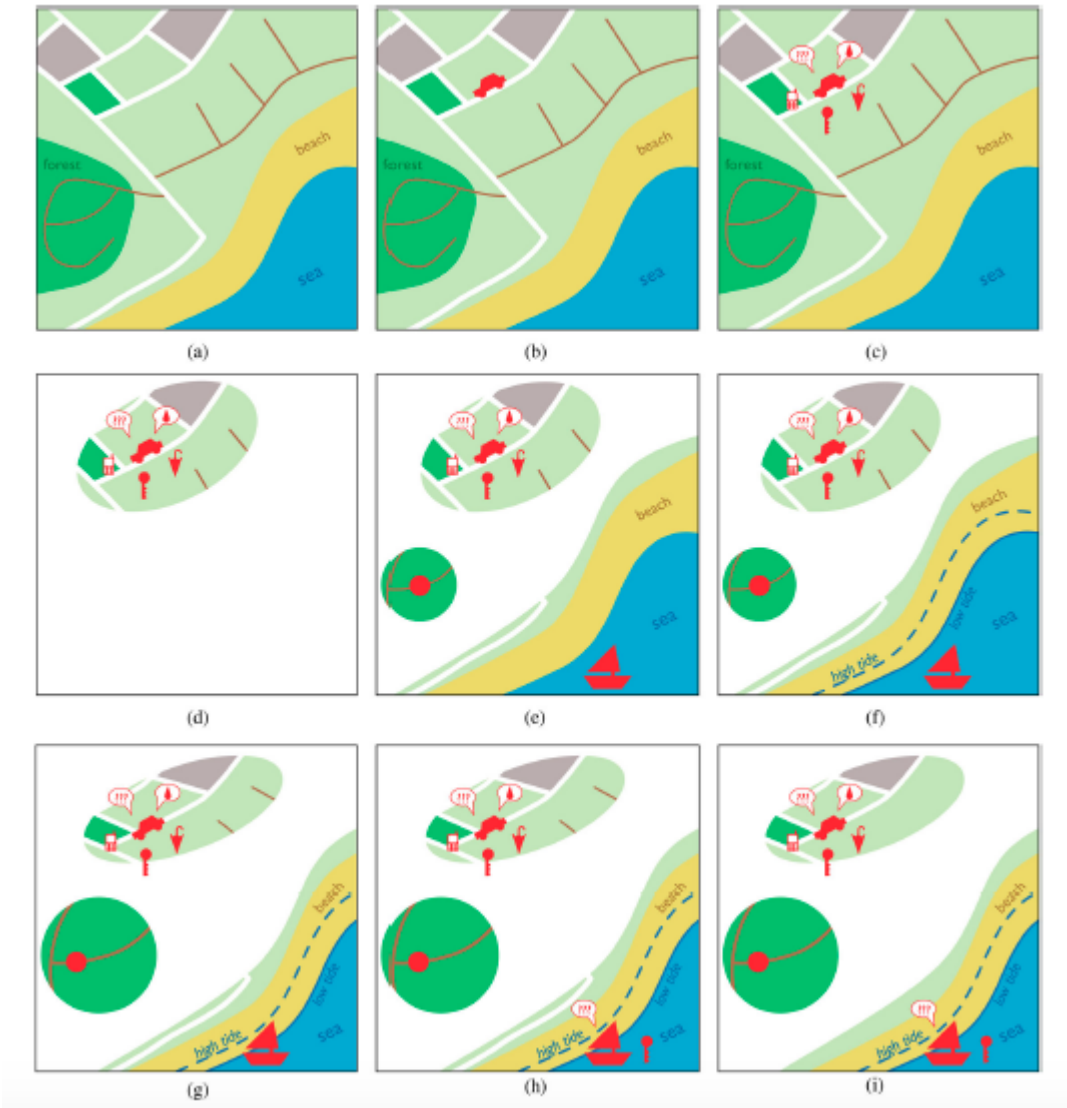


Figure 6 Some aspects of story focus. (a) A classical map; (b) a character moving around through space; (c) non-spatial information provided for the character; (d) only the character's neighbourhood depicted; (e) several characters; (f) the position of the tide as a temporal aspect; (g) flexible scales: the characters' neighbourhoods with different non-uniform scales; (h) dynamic concepts: a car driver having lost his or her way and a skipper being unable to determine his or her position have very different challenges (both issues represented by the question marks), and cars and boats are locked in different ways (both cases depicted by a 'key' symbol); (i) open-world assumption: some paths and roads are not depicted, because they are unimportant to the character at that point in time. (Mocnik & Fairbairn, 2018)

2.2 Mixed Reality for Cultural Heritage

The studies in the field of Augment, Virtual and Mixed Reality for Cultural Heritage are part of a broader field called "Cultural Computing". According to Fei-Yue Wang (2009) Cultural Computing is "an emerging field that applies computer technology and scientific methods to culture, arts and the social sciences to represent, enhance transform creative products and processes".

CC is used for analysing, studying, preserving and visualising CH assets (Gonizzi Barsanti et al., 2015). The rapid development of IT technologies involves immersive technologies in the CH field (Bekele et al., 2018).

The reality-virtuality continuum proposed by (Milgram & Kishino, 1994) makes clear the distribution and hierarchy of the terms Mixed Reality (MR), Augment Reality (AR), Augment Virtuality (AV) and Virtual Reality (VR), see figure 7. The Spatial AR which will be studied in this thesis is between AR and AV on this graph.

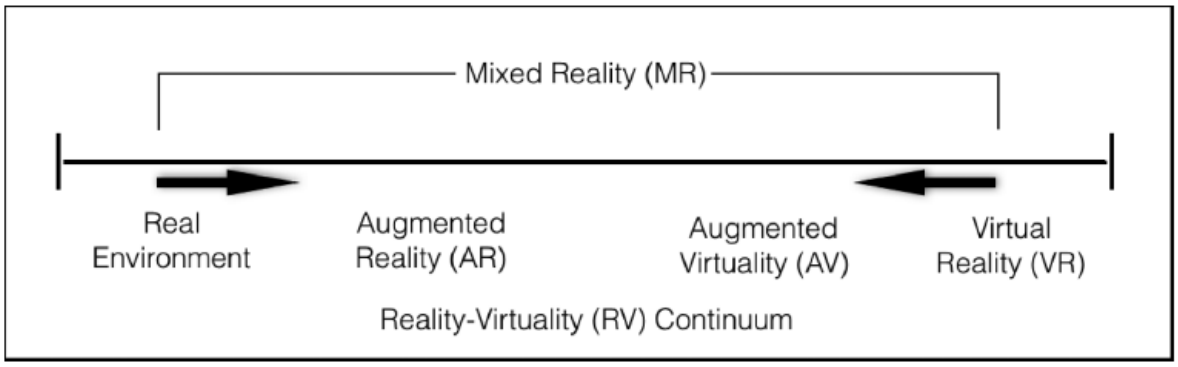


Figure 7 The reality-virtuality continuum consists of environments ranging from real to virtual and all possible variations and compositions of real and virtual objects in these environments. Copyright content permission granted by IEICE TRANSACTIONS on Information and Systems.

In a comprehensive review of MR technologies for CH Bekele gives the following definitions for this scope of terms:"

- Mixed Reality: aims at blending real and virtual environments.
- Augmented Reality: aims at enhancing our perception and understanding of the real world by superimposing virtual information on our view of the real world.
- Augmented Virtuality: aims at augmenting the virtual world with scenes from the real world.
- Virtual Reality: aims at enhancing our presence and interaction with a computer-generated environment without a means to interact with or see the real world." (Bekele et al., 2018)

Bekele highlights the following essential aspects of AR, VR and MR applications:

- Tracking and registration
- Virtual environment modelling
- Computers, display, and devices for input and tracking
- Interaction interfaces

The classification for tracking and registration methods, displays and interaction interfaces by Bekkele are represented in Table 1.The information collected in it will help to choose the right software and hardware technologies stack for the project. This work will focus on Spatial AR solutions: the AR solutions using the same name displays, which are providing access to the Mixed Reality without any user's devices. More specifically, it is planned to

develop a Spatial AR solution that is using camera-based, markerless tracking system, hybrid Spatial AR and desktop projection display, with hybrid interaction interface.

Tracking and Registration		Displays		Interaction interfaces
Camera-based		Head-mounted display	AR, VR	Tangible
	Marker-Based tracking	Spatial AR displays	AR	Collaborative
	Markerless tracking	Hand-held devices	AR, VR	Device-based
	Infrared Tracking	Desktop screen and projection	AR	Sensor-based
Sensor-based		CAVE (Cave Automatic Virtual Environment)	AR	Hybrid interfaces
	Electromagnetic tracking			
	Acoustic tracking			
	Inertial tracking			
Hybrid tracking				

Table 1 Tracking and registration methods, displays and interaction

Most of the papers agree in significant value added to CH objects by the usage of the immersive reality technology stack. However, many researchers point to the danger of technologies become the first order of visitor attention, and art to the background (Fiona Cameron and Sarah Kenderdine, n.d.). The MR solutions for the CH can provide education, exhibition enhancement, exploitation, reconstruction and virtual museum functions(Bekele et al., 2018).

But there is a worrying trend towards “the show and glamour of innovation rather than a focus on solving specific problems with digital” (Pierdicca et al., 2016)

Most of the studies in the Spatial AR field are based on the real cases: exhibitions projects around outstanding artefacts, software and hardware solutions.

Spatial AR could be realised as a projection on two-dimensional or three-dimensional objects. It allows users to explore hidden insights or narratives of the artefacts (Basballe & Halskov, 2010). The vivid example is the interactive projections on the Mejlby stone at the Kultur Historisk Museum in Randers, Denmark (see Figure 8). This solution engaged communication process, showed the history of the Stone, involved visitor in the game to explore the object. The traditional solution assumes communication via the small exhibition labels placed beside the stone. That is obviously not so easy in perception and attractive as Spatial AR solution.

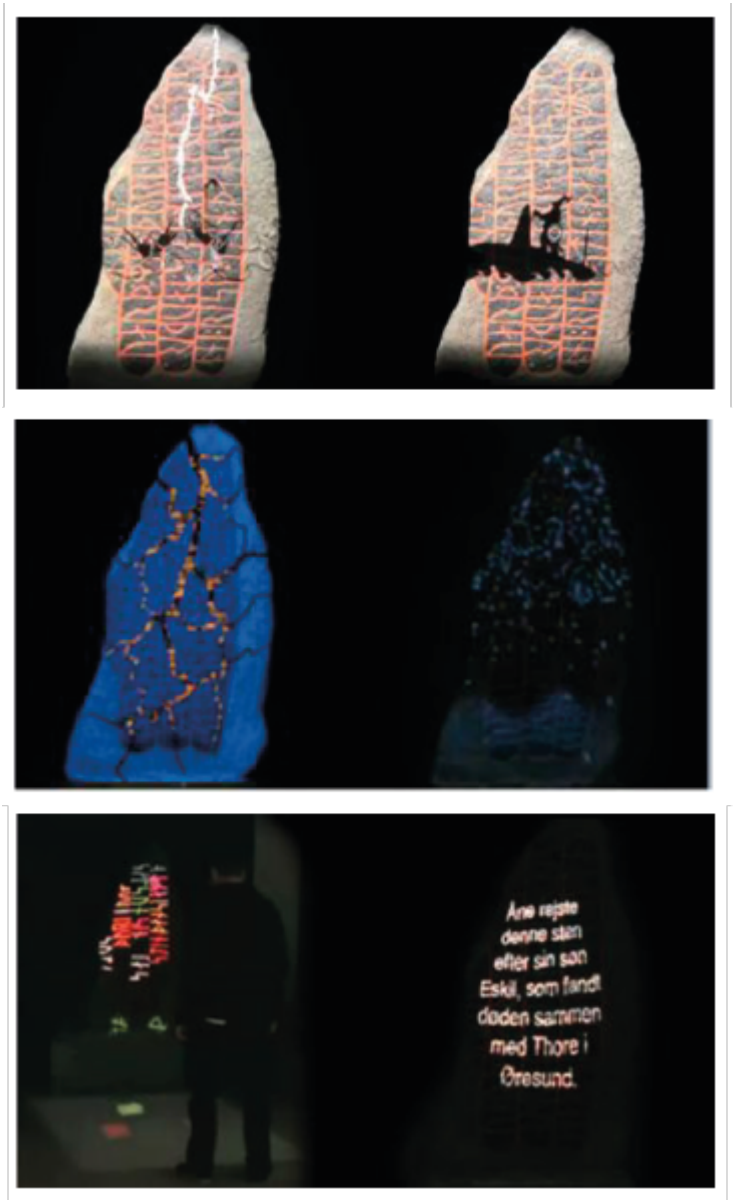


Figure 8 The Mejlby stone exhibition

A noteworthy solution of Spatial AR on a two-dimensional screen surface is proposed by the Resee Muntean in the paper "ʔeləẃkʷ– Belongings: A Tangible Interface for Intangible Cultural Heritage." "The tabletop uses replicas of Musqueam belongings excavated from c̓əsnaʔəm, as well as contemporary objects that are a part of everyday Musqueam life to access information about the long history of salmon fishing and the continuity of related knowledge at c̓əsnaʔəm."(Muntean et al., 2015). This approach allows to overcome limitations of exhibit space, showing the digital copies of items and its replicas, realising way interaction that is impossible with the original objects. The interface is shown in Figure 9

Figure 9 ʔeləẃkʷ – Belongings (Courtesy Reese Muntean)

The good design of the museum exhibition will use a wide range of traditional and innovative solutions in order to create the best visitor's experience. The prototypical exhibition "Macedonia from fragments to pixels." compromises seven different interactive systems. Our particular interest is in the "Multimodal diverse travel" item: "The table surface is covered by a printed map of Macedonia, Greece. The printout does not contain any text or other kind of data. Initially, the location ... and names of ancient Greek cities with archaeological interest (in English and Greek) are projected on the map surface. At the one side of the table surface, brief bilingual instructions are also projected."(Grammenos et al., 2013) The system is multiuser; through the interaction with cardboards, users can explore different kinds of related content.

2.3 Mixed Reality and maps

Map definition in cartography is changing because of technologies changing our world and everyday life. Printed maps, as well as printed photos, are in more and more rare everyday use. (Werner, 2018) This transition period gives rise to the different MR applications with maps: Reality augment with maps, maps augment with mixed reality. There are different ways to access this MR with/or without user's devices, online and offline. Potentially combination of the properties of printed maps with virtual information could combine the best of both real and virtual worlds. "AR maps could be used to 'boost' paper maps digitally"(Pereira et al., 2017)

The thesis specific interest is in Paper maps in Spatial AR solutions. It seems like works in this topic are rare and practice-oriented.

Gerhard Reitmayr in his work (Reitmayr et al., 2005) proposes a way of augmenting paper maps via the projection of new layers, as a controller, the PDA device is used or cardboard with projection on it. (see figure 10)

Figure 10 An augmented map, showing the flooded River Cam.

The tourist map solution based on the interactive stylus is proposed by (Norrie & Signer, 2005). After “clicking” on the map paint pen provides audio information (see figure 11)

Figure 11 Edinburgh Festivals System

There are no more recent examples of putting maps in Spatial AR about that author is aware of.

3 Data Description and Study Area

The third chapter will give a brief introduction to the map that will be used as a core of the prototype storytelling exhibition, designed with proposed method. The map itself and the related studies background, as well as modern interpretations of the map will be presented; after the process of data preparation and processing will be described.

The Charles Minard “Napoleons” map is enjoying longstanding fame in both cartography and statistics (Kraak, 2014). Some call it “the first data visualisation”, others “the first example of the storytelling” (Sandra Rendgen, 2019). The map has its pros and cons, is very well studied and has a lot of interpretations. There are a lot of digital materials about the map available (scans, web-sites, databases). The story the map tells is dramatic. All these points indicate that the map is perfectly suited as case study for the research conducted within this thesis.

The full name of the map (translated from French) “The Figurative Map of the successive losses of men of the French army during the Russian Campaign 1812-1813” is placed on the top of it. The map was first time published in 1869 and has a now-forgotten map sibling about Hannibal’s Italian campaign in 218 BC during the Second Punic war (figure 12). Both maps are showing losses of armies during the campaign and use the same cartographic language. The cartography defines these works as flow line maps (Kraak, 2014). The size of Napoleon’s campaign map is 63*25 cm. The labels are given in French, main colours are black and specific “brown” colour, which causes discussions among researchers.

Despite a large number of studies were made about the map, it still quite popular: from authors experience almost in every university course involving topics related to cartography, statistics or infographics, the map appeared. In his book “Mapping time” Kraak studied a complicated task of showing time on maps and infographics using the Minard Map as example (Kraak, 2014). It is important to notice that the map is not only one that was created by Minard, but interested reader will find all his graphical works in the book “The Minard System: The Complete Statistical Graphics of Charles-Joseph Minard” by Sara Rendgen (Rendgen, 2018).

Additionally, the number of modern interpretations proofs the popularity of the map. Minard’s map is available for order as a poster today, moreover reinterpreted patterns are used for different merchandise from mugs to the T-shirts. The last are shown in figure 13 (Sandra Rendgen, 2019).

Kraak (2014) emphasises some shortcomings of the Minard’s map:

- The exact time references rarely occur.
- Map express the disaster, but not why it’s occurred. The temperature graph temps reader to make cold was a reason. But an inquisitive reader will notice that there is no direct connection between temperature and loses.

- There is no indication of the most important dates and battles, but it could help explain the disaster very well.
- Some places have only names, not the exact location.

This thesis is another contribution that tries to overcome the shortcomings of the map using a modern technology. The shortcoming will be kept in mind during the design process. The web interpretations described below have already shown that these problems are solvable and significantly increased the value of storytelling. This research will make interpretation based on the printed map.

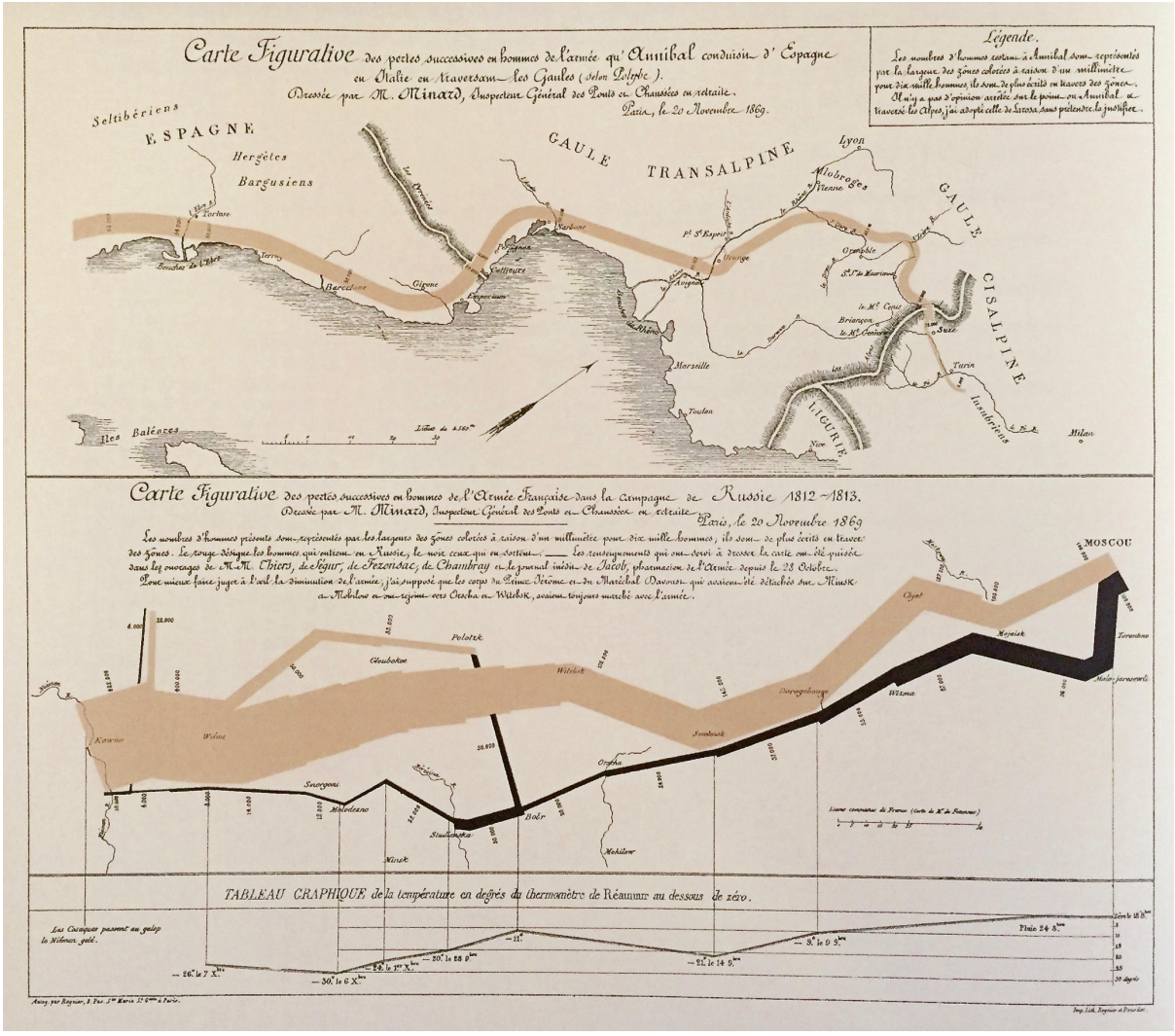


Figure 12 Minard's map: top, Hannibal's campaign; bottom Napoleon's campaign

Figure 13 Minard inspired T-shirts (https://www.zazzle.com/charles_minard_in_black_t_shirt-235775886405738885)

In the paper “Re-Visions of Minard” in 2012, Michael Friendly draws the reader's attention to other Minard’s work and tells his personal story of its exploration. He also describes some digital interpretations of Minard’s Napoleon map (Friendly, 2002). On Friendly’s website http://www.datavis.ca/gallery/re-minard.php the basic dataset and different recreations of the map are presented. Most of them are dated the 2000s, but still entertaining.

Taking a look into more modern web-interpretations of the map, these interpretations are enhancing the maps functions by adding interactivity. An interactive chart by “mass:werk” studio (masswerk.at/minard/) shows the translations on hover, adds a the slider which helps to track the number of troops in armies, dates and temperature. The map and these indicators are shown in figure 14.

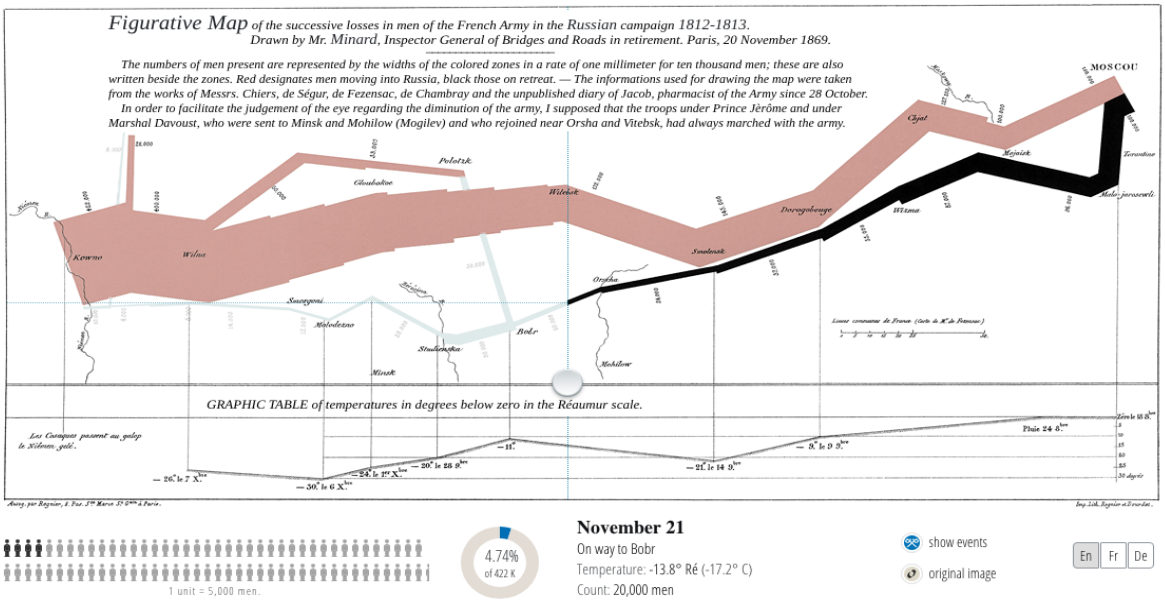


Figure 14 An interactive chart by the mass:werk (Mass:werk, 2020)

The storytelling project “When Napoleon Ventured East” by the Russian news agency “TASS” (https://1812.tass.ru/en) is a deep revision of the original map. The map is recreated as a set of 3D bar charts with the height corresponding to the number of troops at the specific moment. The web browser screen is divided into two parts: On the left is an interactive map, on the right is a richly illustrated article telling the story (see Figure 15). The parts are syntonized - the map is showing the moment that is described in the article. Some additional info like location and distribution of forces is added at the start of the story or points of important battles.

With the permission of the TASS Agency, the storytelling text, some illustrations and graphic elements will be used for the case study exhibitions created within this thesis.

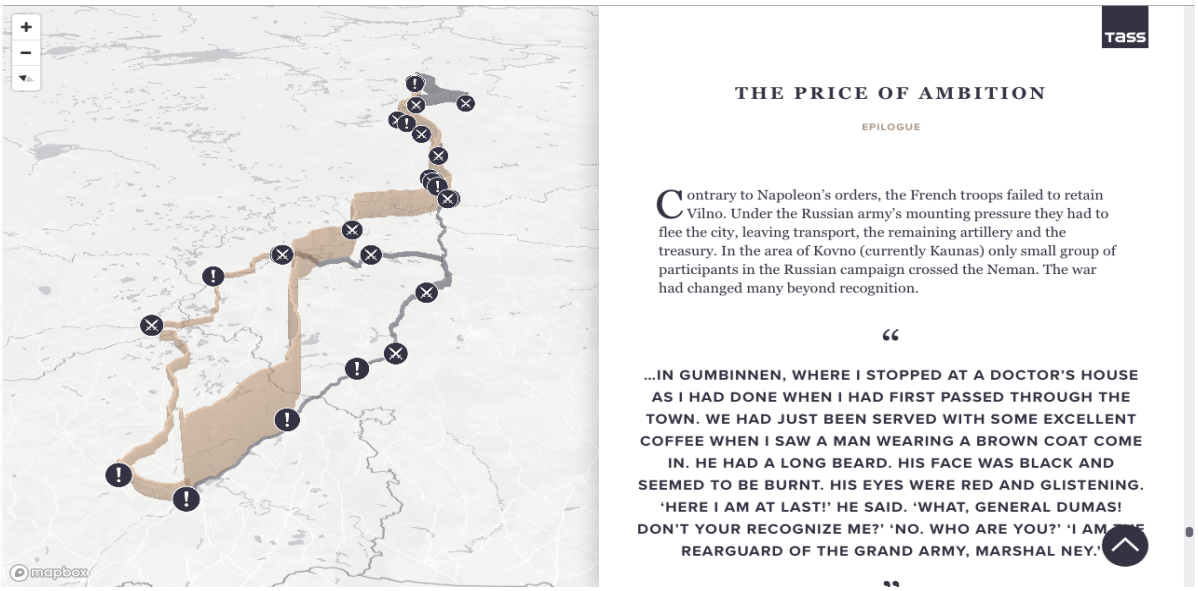


Figure 15 “When Napoleon ventured east” project” (TASS, 2020)

The structure of the story used as case study example follows the narrative by the TASS agency. For the prototype design, the following data were collected and processed (Table 2):

Data	Source	link
Vectorized and georeferenced original Minard map	NEH workshop on digital methods for military history	https://web.northeastern.edu/nulab/dmmh/
Georeferenced points of main battles and events	NEH workshop on digital methods for military history, TASS	https://web.northeastern.edu/nulab/dmmh/, https://1812.tass.ru/
Borders of Alliances and army's distribution	TASS	https://1812.tass.ru/
Day by day information about troops amount	multiple	-
Main events by the dates	multiple	
The geographical position of the army by the date (the connection between map polygons and the dates)	multiple	

Table 2 Data and its sources

4 Methodology and conduct of the Research

The fourth chapter will describe the research methodology chosen to distinguish the thesis goals. After that the case study maps and applications will be represented in detail. As defined in the thesis introduction, the main goal is to propose and evaluate a method of Map-Based Storytelling in Mixed Reality in order to enhance the user experience. The case study will test the method on the example of Napoleon's Russian Campaign and Minard's map, describing it via map-based infographics.

4.1 Chosen Research Approach

The research approach is schematically shown in the figure 16.and consist of literature review, method concept, exhibition protopypes realisation: MR and Classical and comparative study/user evaluation.

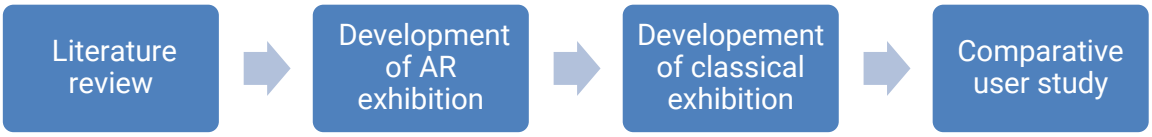


Figure 16.a Research schema

4.1.1 Concept of the exhibitions

In the second chapter in Table 1, tracking and registration methods, displays and interaction are listed. The table is the basis for choosing the exact MR technologies for the realization of the exhibition prototypes and implementing the MR method in order to reach the stated research objectives.

The goal of telling a map-based story in Spatial AR will be reached by putting the Minard map of Napoleons campaign into the MR environment. The map as peace of art should be valued and it is therefore important to highlight it and build an exhibition around the map itself.

In order to enhance the user experience, "the user entry threshold" should be as low as possible: visitor should not have to use any devices and learn how to work with it. The attractiveness of the exhibition itself should be increased by adding a magic effect to the exhibition.

The above-mentioned requirements dictate the following choices (table 3):

Type of MR	Spatial AR
Tracking and Registration	Any markerless solution
Display:	Desktop screen and projection
Interaction interfaces	Sensor-based

Table 3 MR solution description

Spatial AR is the solution which doesn't use any user devices. Markerless tracking and registration methods follow "low threshold" requirements. The maps are mostly printed on the paper - they are flat.

The classical way of showing maps in exhibitions is putting the map on the wall or on the table, sometimes in the horizontal showcase (Figure 16). Because the user wants to interact with the map and its surroundings - the solution then the map is on the table, and it is overlayed with an interactive projection - seems reasonable. That's why the desktop screen and projection as display type is proposed..

Figure 16 Cartographic British Library exhibition design by the Northover&Brown (https://www.designweek.co.uk/issues/5-11-december-2016/cartographic-british-library-exhibition-places-visitor-map/)

As seen from the related studies, a wide range of technologies could be used for museum exhibits. The selected Spatial AR solution as well could be realised in different ways. For the method, mass and affordable solutions were chosen, that will help its replicability and usability. The hardware setup is shown in figure 17.

The Spatial AR is created on the surface which is an intersection of the image projected on the table with a map by Ultrashort distance projector and field of view of the depth camera. The printed map is in Spatial AR and could be enhanced by interactive projection or become a part of the interface.

The ultrashort distance projector is turning the table surface into the screen. There is a wide range of projectors on the market the hi-end models could project a HD picture with high geometry quality even in bright lighting conditions. However, no market analysis is part of this research. The ultrashort distance beamer available will be used for the prototype.

Kinect cameras are used as markerless tracking and registration devices. They are providing RGB and depth (distance to points in a field of view from camera sensor) images. Kinects are widely used in interactive museum exhibitions. There are developer's kits available and ready to use software.

The depth camera alternative is touch tracking systems integrated to the projectors by their manufactures.

There are some aspects of design a specific implementation that could radically change the perception of the exhibition: the hardware could be easily hidden in the wall, so the devices are invisible for the user. The height of the table should be comfortable for all user groups or stand should be presented. If the exhibition is activated, means a person is appearing in the field of view of the sensor it can have an interesting "magic" effect: it becomes alive then person starts interaction.

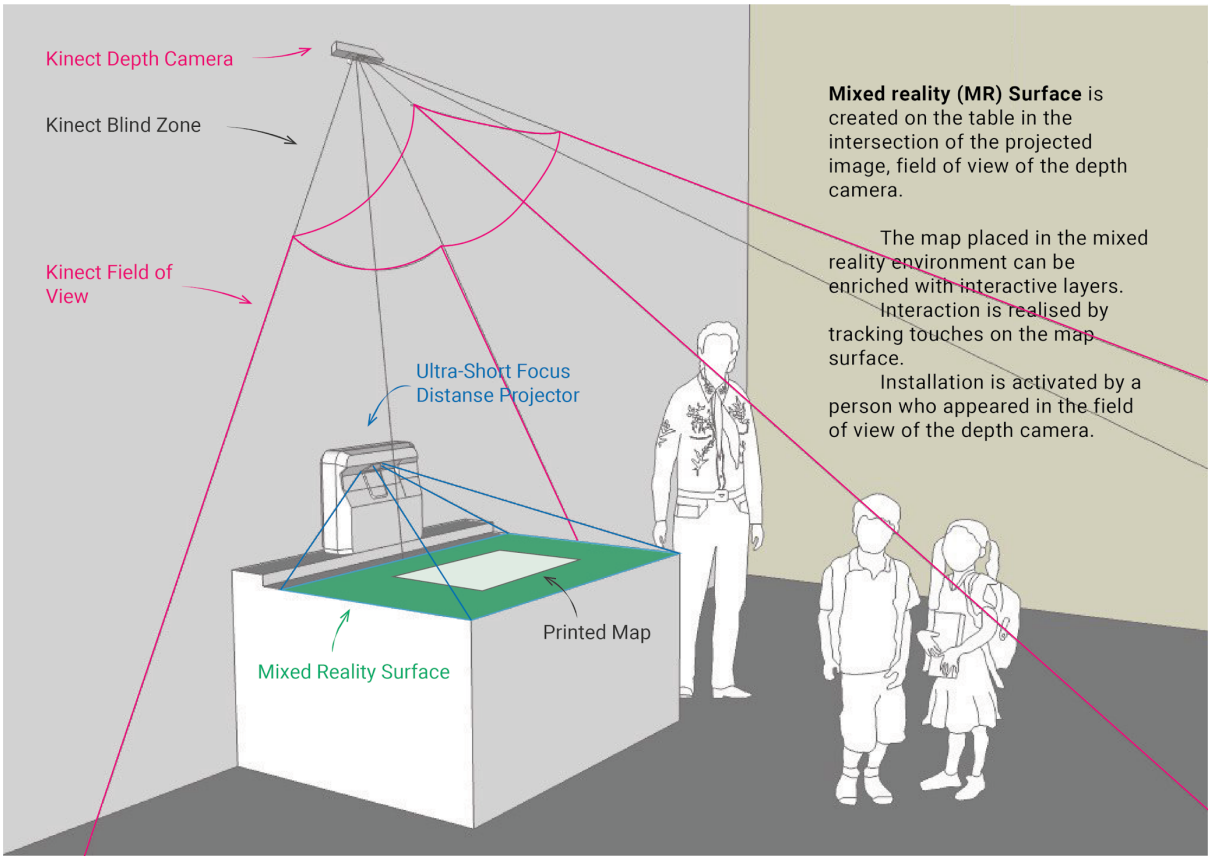


Figure 17 Hardware setup concept

The storytelling with and in maps, of course, should use all kinds of media to tell the story. Each story needs its own set of tools and user interface in order to be heard by the maximum number of souls. The AR application development platform for the method should give the designer this flexibility of media integrated and user interface design.

The most common types of media that could be used in the AR application, according to the studies about storytelling, are:

- Text
- Pictures and graphics
- Audio
- Video and animation
- Maps

The storytelling conception could be different: the long read, story-focus map, a game, or timeline and etc. The chosen conception and the content will define the graphical and interface design.

The map becoming the core element in telling a story. To become the core, it could be overlayed by the other maps: static or dynamic, with the same extent or extending it to the table surface. These overlaying maps could be different for each part of the story; the designer could make as many the story needs.

The Unity cross-platform game engine for the AR application will be used within this thesis. It provides the requested content and design flexibility, uses common C# language and has visual coding add-ons. The licening is free for personal use or small companies, which is certainly an advantage.

4.1.2 Evaluation of the exhibitions

A prototype of an AR exhibition will be developed within this thesis using the proposed method. The case study will tell the story of Napoleon's Russian Campaign with Charles Minard's map. The main user interface element integrated will be a timeline. Media types that will be used are maps, text, graphics and sound background.

In order to evaluate the method in terms of efficiency, effectiveness and satisfaction, a Classical version of the exhibition will be created. The classical exhibition will tell the same story, with the same content, but no digital technologies will be used. The test user group will be divided into two equal parts: one will work with AR exhibition; another will work with Classical exhibition. This aims to find strong and weak elements of each solution, compare them from practical and user experience sides.

Both exhibitions are displayed in the same room under the same conditions. Participants are invited to visit the exhibition and giving feedback. During the user test, the participants can ask questions or can get help when needed. The study is monitored. The time needed to answer each question about the story, as well as self-exploration time and notes are fixed by the experimenter.

After the introduction and filling the personal data into the evaluation form, the users are asked to self-explore one of the exhibitions. Afterwards, participants will be ask to answer questions about the story that has been told. While answering these questions, users are allowed to interact with the exhibition. Finally, experience feedback without access to the exhibition will be collected. .

The proposed experiment design allows comparing two approaches, AR and classical. Thus, the proposed method will be evaluated. However, the experiment is limited to the selected story; it's content and associated media.

4.2 Conduct of the Research

The research is divided into three parts: development of (1) AR and (2) Classical versions of Minard map exhibition and (3) evaluation.

4.2.1 AR exhibition development

As explained in chapter 4.1, the method's hardware and software stack were selected. The specific implementation on the example of the Minard map will be described in the following.

Hardware setup

For the study, the following hardware was available:

- NEC NP-U310W projector
- Kinect for Windows v1
- White Table 80*115*70(H) cm

The draft hardware setup with the calibration grid is shown in figure 18

Figure 18 Hardware setup

NEC NP-U310W is a 3100-lumen Widescreen Ultra Short Throw Projector, released 2011, specifications are shown the figure 19. The projector is quite old and cannot provide the HD resolution; however, it has all the necessary characteristics to use it in the prototype.

Product Specifications

Display

Aspect Ratio	16x10	**Native Resolution**	WXGA 1280x800
Maximum Resolution	UXGA 1600 x 1200	**Contrast Ratio (typical)**	2000:1

Synchronization Range

Horizontal (Analog/Digital)	15-91.1 kHz	**Vertical**	50-120 Hz

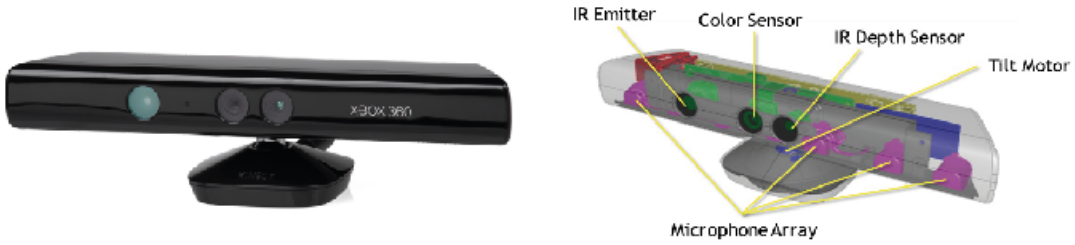
Signal Compatibility/Connectivity

Supported Video Standards	NTSC, NTSC4.43, PAL, PAL-M, PAL-N, PAL 60, SECAM	**SD/HD Video Signal Compatibility**	480i, 480p, 576i, 576p, 720p, 1080i, 1080p
PC Signal Compatibility	VGA, SVGA, XGA, WXGA, WXGA+, SXGA, SXGA+, UXGA	**Macintosh Signal Compatibility**	Yes
Sync Compatibility	Separate Sync / Composite Sync / Sync on G	**External Control**	RS-232, IR, Wired LAN, USB

Input Terminals		**Output Terminals**	
RGB1(analog):	VGA 15-pin D-sub, Component video using ADP-CV 1F	Audioout:	Yes (variable)
RGB2(analog):	VGA 15-pin D-sub, Component video using ADP-CV 1F	Monitor Out:	VGA 15-pin D-sub
RGB3(digital):	HDMI		
Video 1:	RCA		
Video 2:	S-Video		
Audio 1:	1/8 in. stereo		

Figure 19 NEC NP-U310W technical specifications

The Kinect camera is RGB-D camera, which can detect and track users and their movements; It will be used as an input device with software “Touchless touch”: the projection becomes a touchscreen if it is in field of view of camera and pre-calibration is executed. The camera, it’s equipment and specifications are shown in figure 20



Kinect	Specifications
Viewing angle	Field of View (FoV): 43° vertical x 57° horizontal
Vertical tilt range	±27°
Frame rate (depth and color stream)	30 frames per second (FPS)
Audio format	16-kHz, 24-bit mono pulse code modulation (PCM)
Audio input characteristics	4-microphone array 24-bit analog-to-digital converter (ADC) onboard signal processing (including acoustic echo cancellation & noise suppression)
Accelerometer characteristics	2G/4G/8G accelerometer configured for 2G range 1° accuracy detail limit *(can help detect when the sensor is in an unusual orientation)*

Figure 20 Kinect camera, hardware and specifications

The size of the table (80*115*70(H) cm) that was used for the prototype was chosen carefully: the aspect ratio is almost 16:9 which allows you to use the maximum area for projection.

It is needed to evaluate the preciseness of the touch tracking of the prototype hardware setup. In order to do that the calibration was executed: the mesh with a grid size 5 cm was projected, each touch to the grid centre was traced by a line on the screen. The calibration setup is shown in the Figure 21.

Figure 22 shows the results of the calibration. The dependence of accuracy on the location of the sensor is clearly visible. Most of the traces are within the cells - it gives the size of the element of the future interface - 5 cm. Usage of this size will guarantee the uniqueness of response of interface elements, and satisfaction from its work.

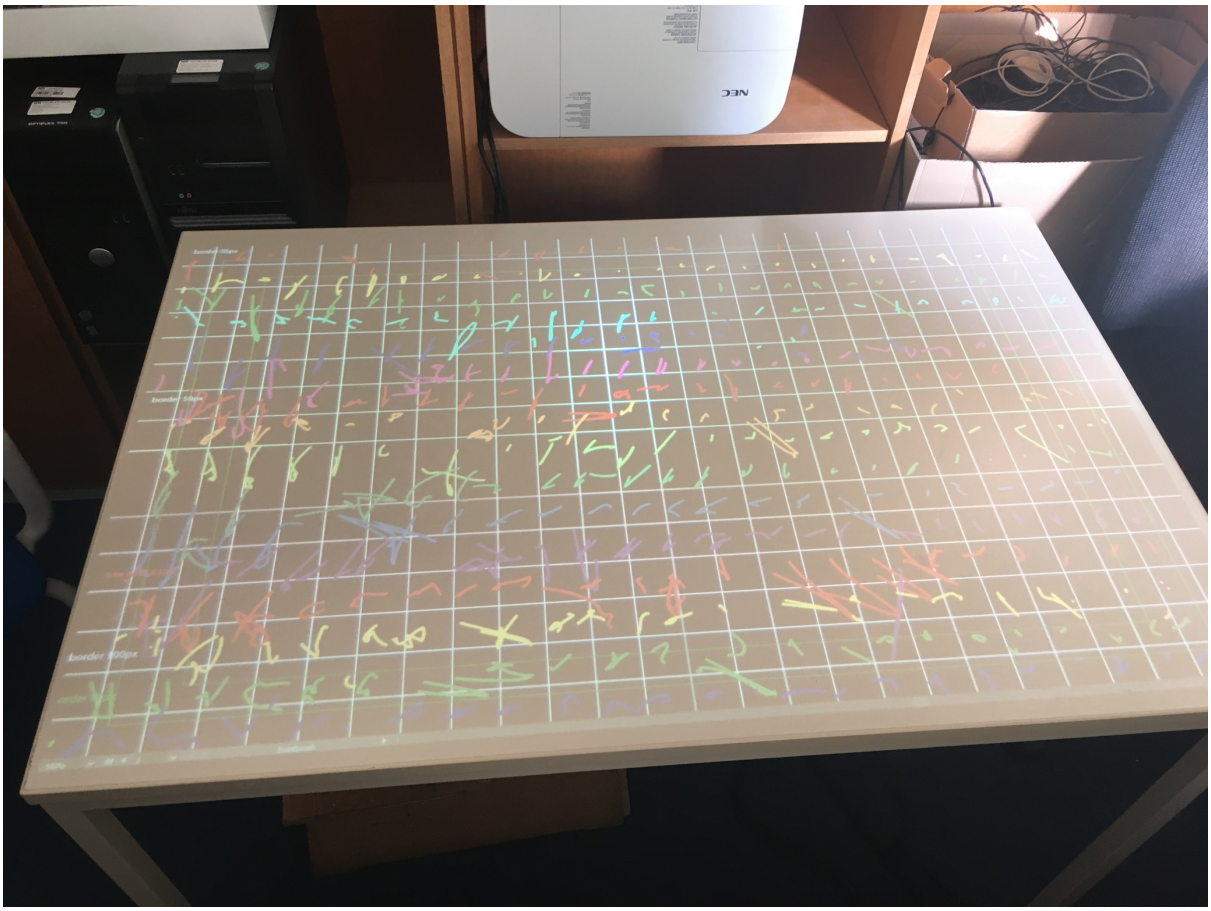


Figure 21 Calibration setup

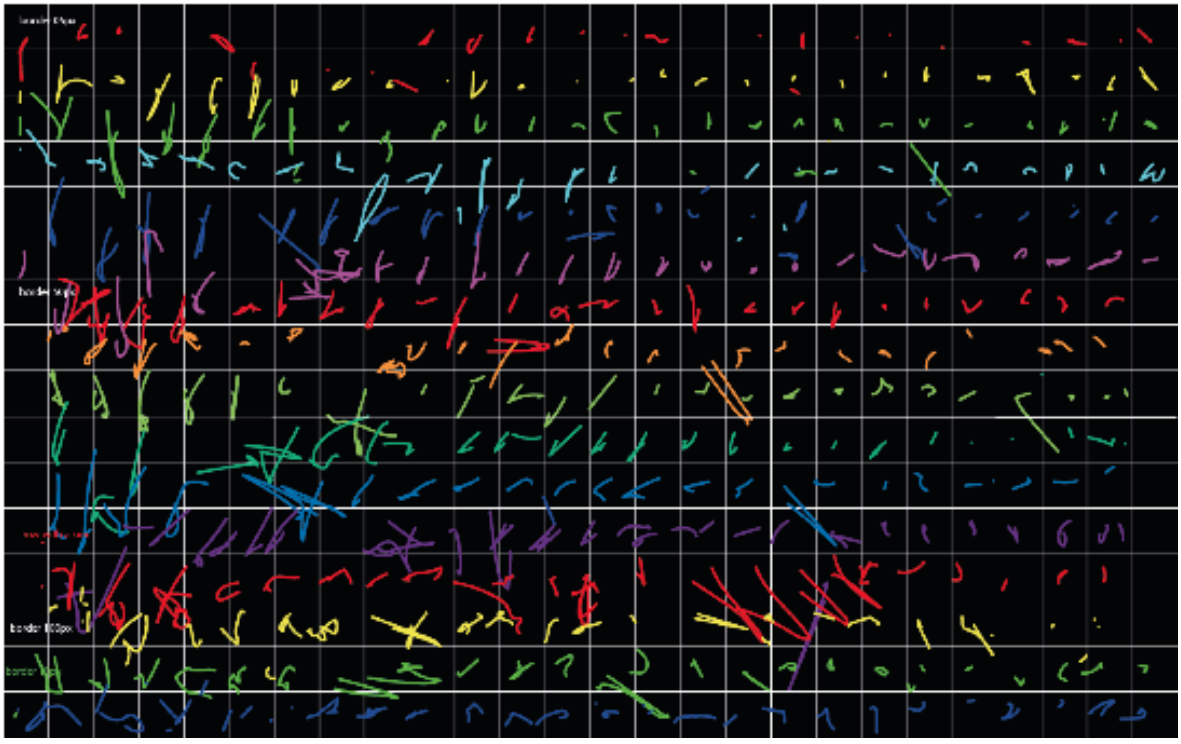


Figure 22 Calibration results

Application development

The application development environment was defined in previous subchapters. Unity is a cross platform game development engine. The application will be an 2D game, controlled by the touches of the projection on the table. The language which is used in Unity - C#, but for small and not sophisticated applications it makes sense to use visual coding addon called “Bolt”.

The core part of the exhibition is a 1:1 Minard map reprint. After considering several options for a possible composition, it was decided to place it on the right side of the table, orienting it as if the short side of the table was the direction of North-South (figure 24).

Interface, chapters, design workflow

The storytelling of the prototype will follow the structure of the 1812.tass.ru “When Napoleon Ventured East” project as mentioned before. It is a very well structured and clear told story that the author is going to tell using the proposed method. So, there are 12 chapters plus Intro and Epilogue. They are dividing the period of the story to the subperiods, each period contains a list of the dates with the related content. More clear structure is seen in the source table which is shown in appendix III and in the figure 23.

Figure 23 Story structure

This structure leads automatically to the interface of the prototype: the main component is a timeline, divided by the chapters. The control buttons navigate the user to the previous and next date. There is a special field to show the current date. One of the first versions of the interface is shown in figure 24.

Each chapter of the story includes several dates. They are connected by the common background, but each date has its own design. Each date is a picture which is designed in Adobe Illustrator, considering the physical size of the map and interface. The navigation between the pictures is realised by the back and forward buttons and short links to the chapters. The interface elements were made from the paper and cut with cutter plotter, after that it was glued to the table. The final interface can be seen in the figure 25.

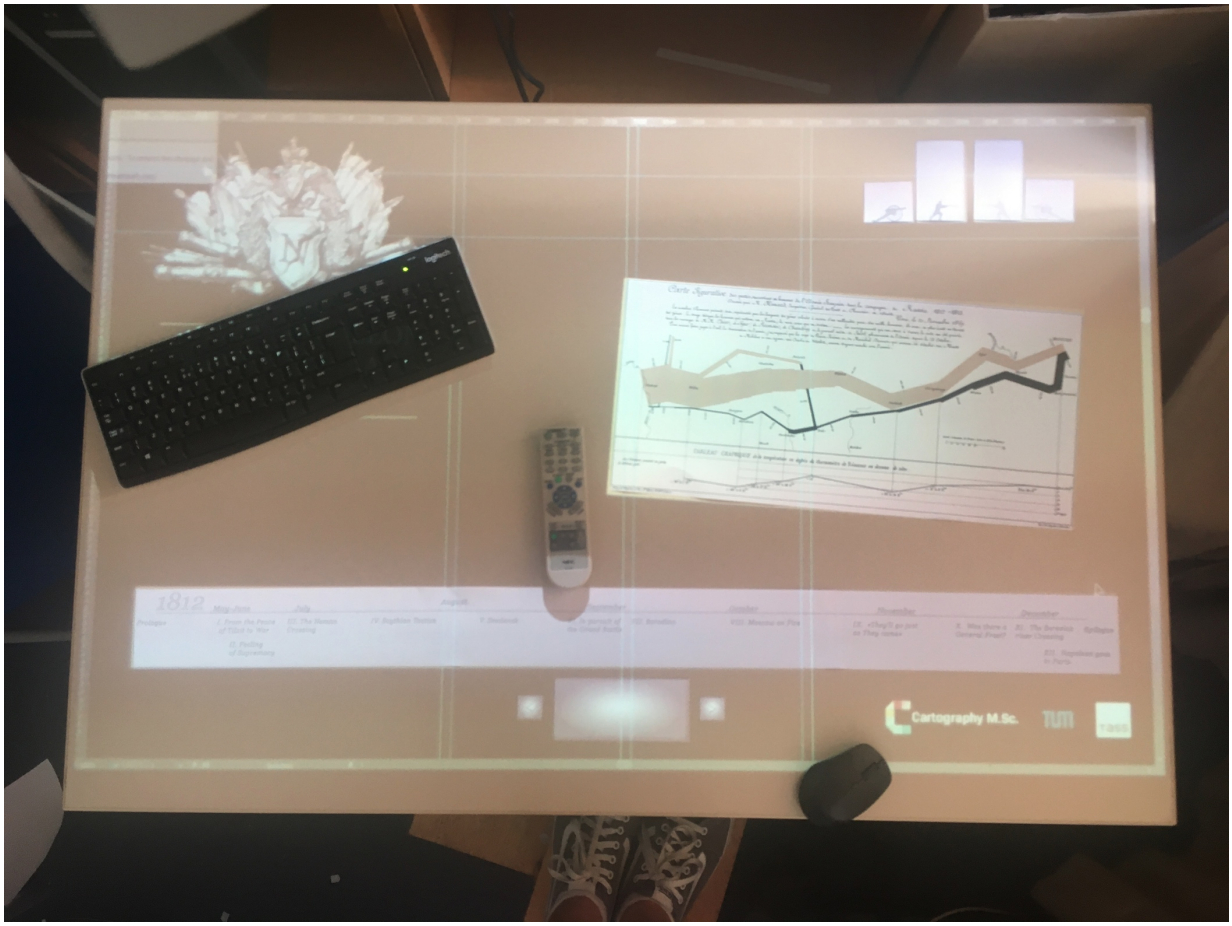


Figure 24 The early version on the interface

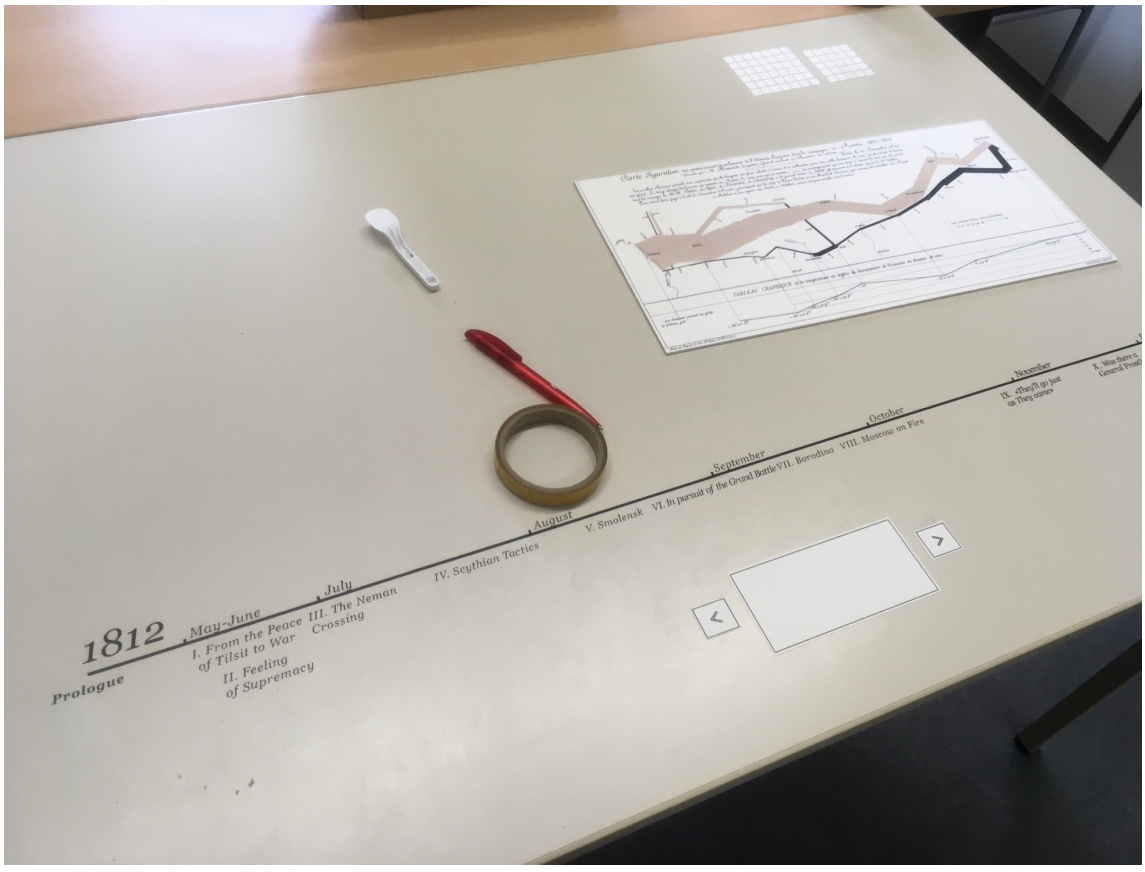


Figure 25 The interface at the final stage of installation

Types of content and it's representation

All the dates as a pdf file and the application could be found in electronic attachment to the thesis. In the following, the main types of content and the ways of its representation will be described.

Background images

Each chapter has its own background. figure 26 shows the introduction screen, a painting "Napoleon near Borodino" by Vereshchagin. The background image is overlaid with different design elements and is darken on the position where the Minard map will be shown in the next scenes in order to smooth the brightness.

figure 26 The introduction screen

Dates

The dates are displayed on a special paper rectangle placed in the centre of the interface (figure 27).This has been done because user always need to see the date, it is effective and elegant solution of story navigation task.

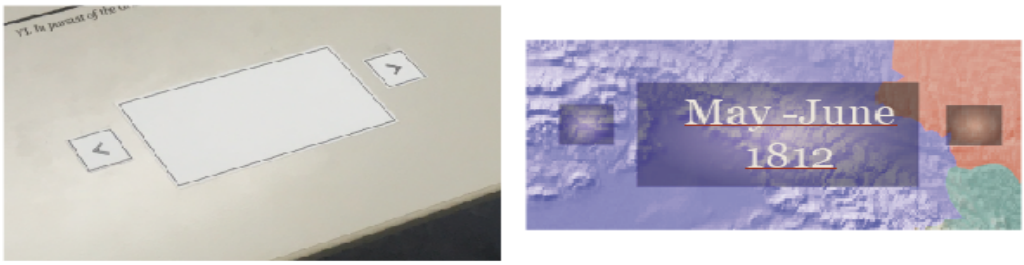


Figure 27 The paper rectangle for dates projection on the left and screenshot of projected date from of the application.

Text

The contrast design solution was found to show text in special boxes using the same style in the all chapters and dates (example is shown in the figure 28).

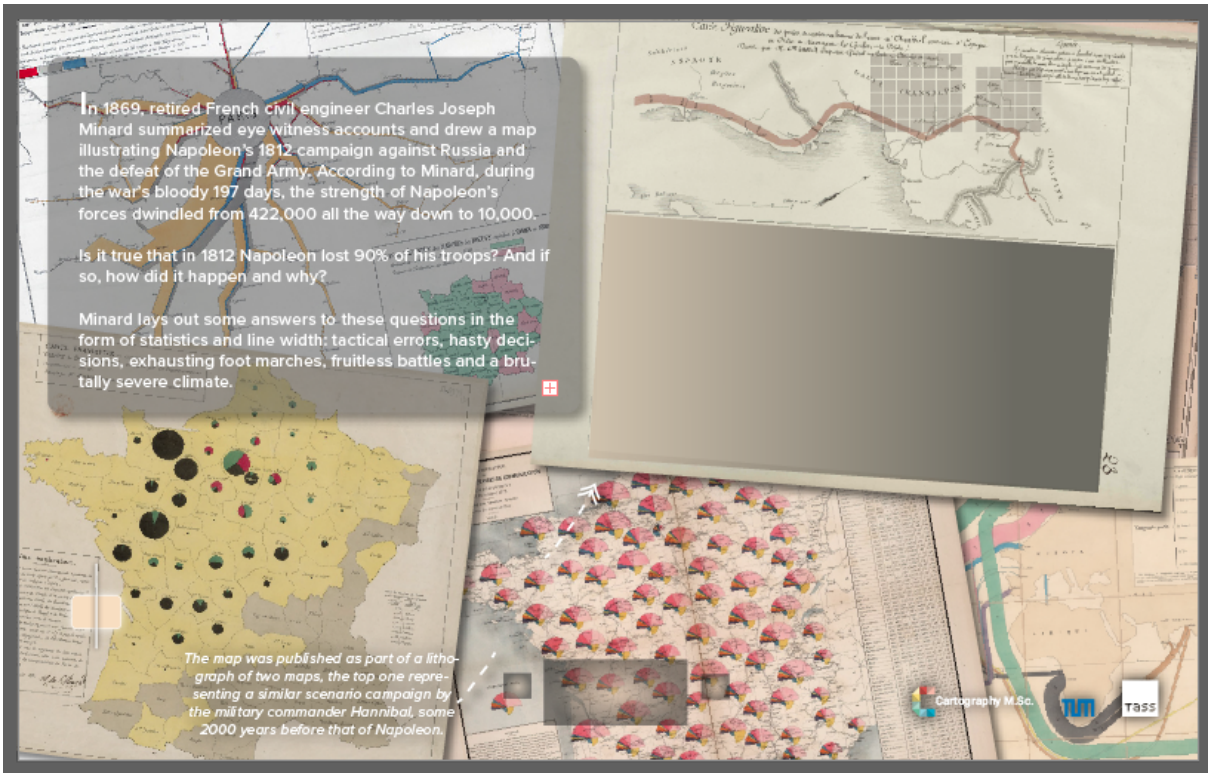


Figure 28 The Introduction chapter screen

Map overlay

One of the main goals is to incorporate the map as a storytelling instrument. In order to highlight the essential information of the map, the map is overlaid with an extra layer to place special emphasis on the route and the specific dates and locations. The graph is accumulated from the beginning of the campaign to the current date. In the figure 29 (left)

the highlighting is shown and the extra layers projected on the map and the table is shown on the right.

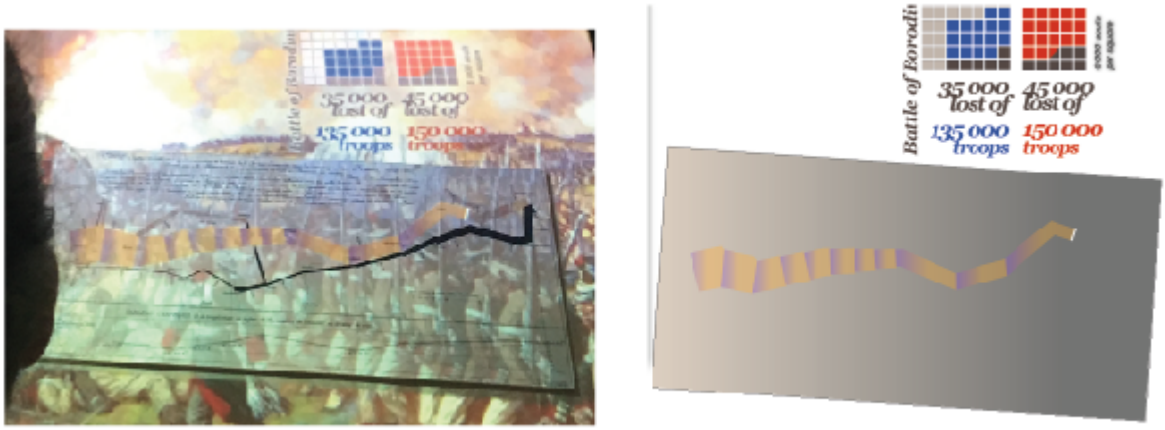


Figure 29 The extract from chapter IX and it's overlays.

Timeline indicator

The current date displayed is shown with a vertical line on the timeline. The chapter is highlighted by a bright rectangle (figure 30).

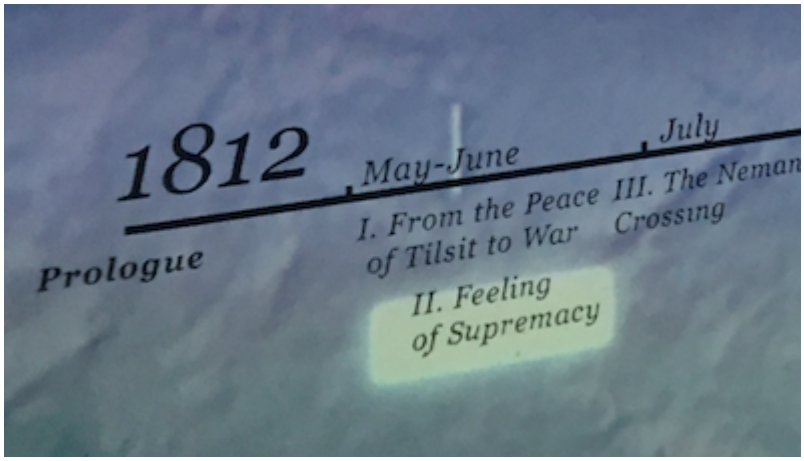


Figure 30 Timeline indicator

Overview maps

On the data preparation stage, the Minard map was georeferenced and aligned to the overview maps. With the help of the overview maps, the story background could be defined. Alternatively, some thematic maps could be shown - for example armies' disposition and amount in the begging of the campaign (figure 31). In this case, the Minard map becomes part of the overview map.

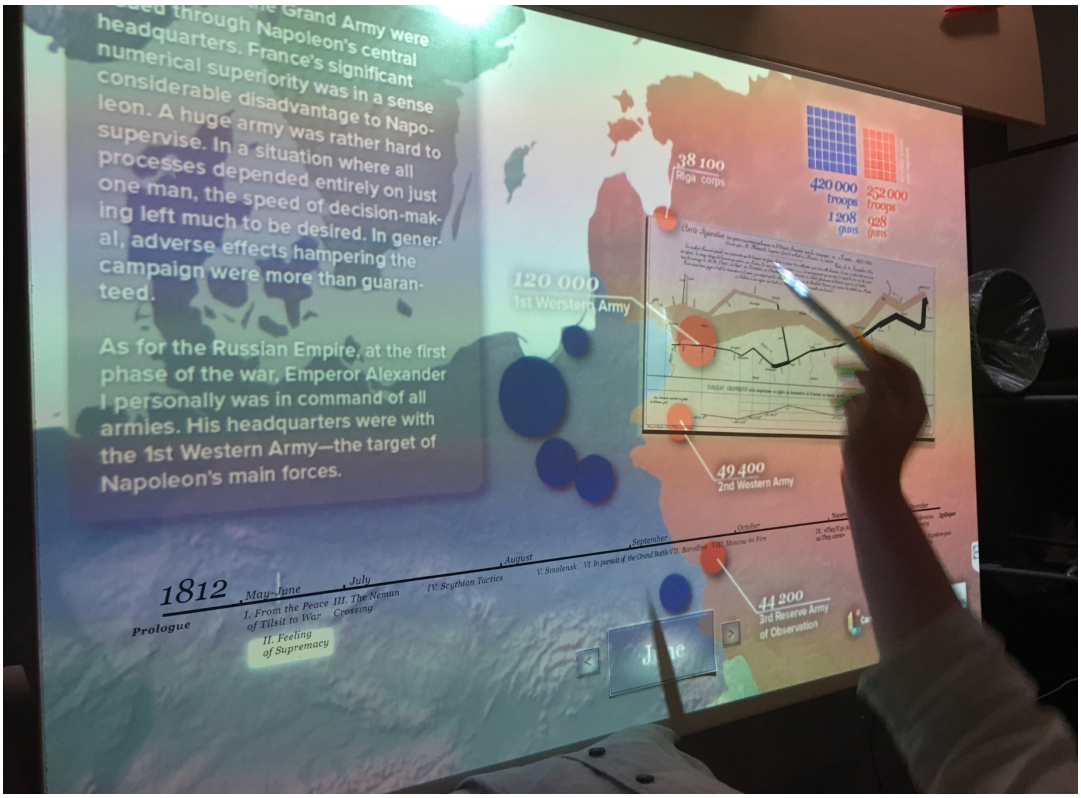


Figure 31 Armies disposition on the overview map

Map in the text

If a more detailed map connected to the story is needed it could be included in the text. An example is realized in the chapter informing about the Moscow fire (figure 32).

Figure 32 The Moscow chapter screenshot from the application, map included in the text.

Troops indicator

For each date the information about of amount of the French troops was collected. In the physical interface the amount is shown by the square indicator infographics composed from the squares 10 000 souls each. The interactive projection fills with blue colour the part of the squares corresponding to the amount of the souls for the current date. When the amount of the Russian is known it is shown on the similar indicator on the right. Amount of the army is shown by the label down to the indicator as well. The example of indication is shown on the figure 33.

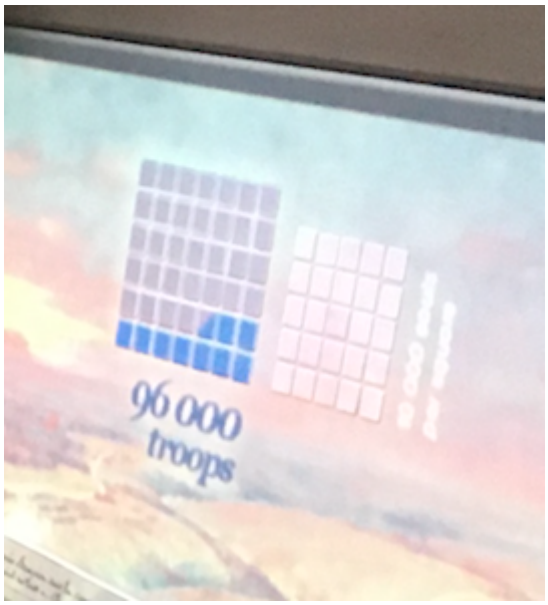


Figure 33 Troops indicator

Battles indicator

If dates contain battles, the troops indicator infographic switches to the battle mode. The amount of the soul's changes, information about of the losses is shown in figure 34. Red colour as everywhere in the exhibition is related to the Russian Army, Blue to the French army.

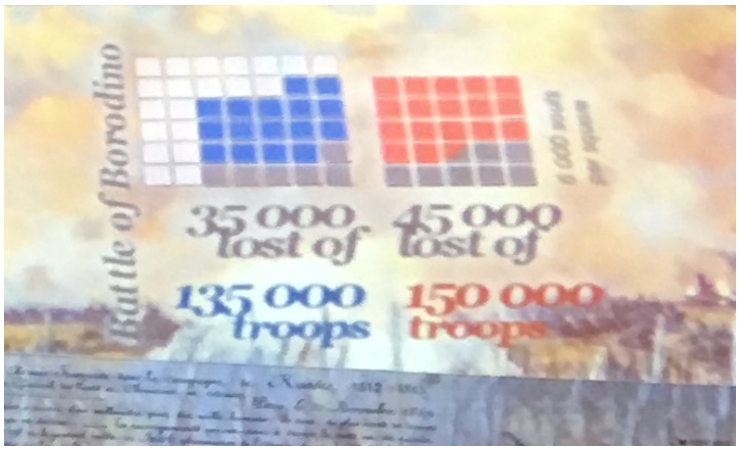


Figure 34 Battle indicator

Soundtrack

An important element of immersion in a story is sound. For both versions of the exhibition, the Prokofiev's "War and Peace Symphonic suite" was integrated and used as soundtrack. Figure 35 shows the mounted AR exhibition in the final design. In the real setup the devices should be mounted into the wall to increase the depth of the immersion further.

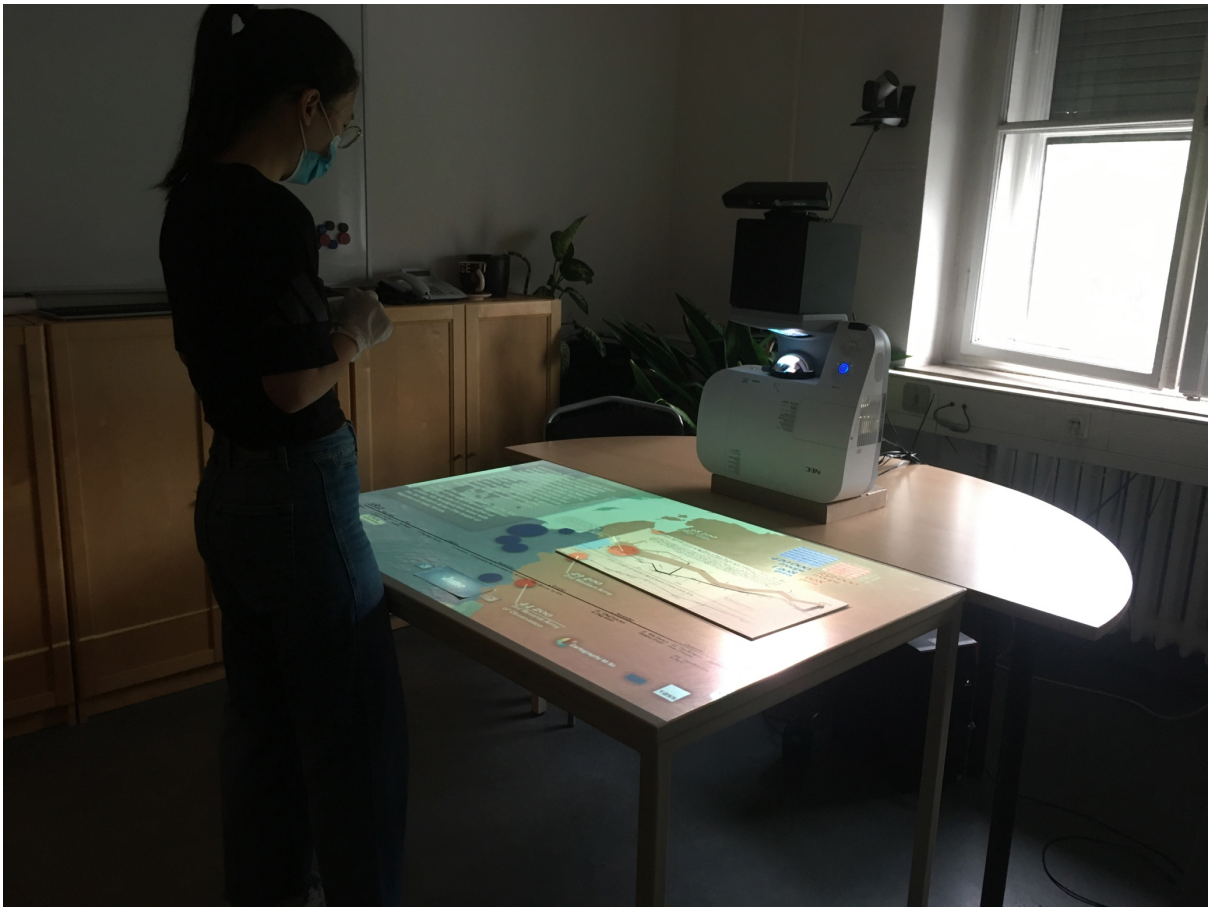


Figure 35 Mounted AR Exhibition prototype

4.2.2 Classical Exhibition Development

In order to reach research objective iV, a prototype telling the same story with only analogue instruments was developed. To emphasize the core exhibition element – the reprint of the Minard map- the map was placed identically to the AR exhibition.(figure 36) and accompanied with text, images, infographics and sound.

Figure 36 Mounted Classical Exhibition prototype

In the Classical version used the same structure as in the AR version. All same digital content was integrated in the analogue version.

- Each screen corresponding to the date were redesigned to the page of the brochure with a chapter shortcut (1).
- Overview map were glued to the table in two colours (2).
- Minard map overlays become a plastic list with overlay showing the positions of army in the different days (3).
- The initial armies' disposition and amount of the troops are shown with popups(4, figure 37).
- Timeline is replaced by the list of the contents (5).

Figure 37 Pop-up armies' indicator

4.3 Evaluation

In order to compare both exhibitions and to find the impact of the AR exhibition on the user experience, a user study needs to be conducted. The goal is to compare both exhibition prototypes, AR and classical.

4.3.1 Questionnaire and participants

Two paper-based questionnaires for both exhibitions with a similar structure have been developed. The questionnaires differ only in the user experience evaluation part.

The first block is a statistical block learning about geography, gender, age of the participants and measuring the familiarity with a map. The participants were asked to fill the block before they got time to explore the exhibition.

Second block consists of quantitative and qualitative questions about the Napoleons Russian campaign. Participants were asked to answer. The questions of the second block after the self-exploration of the exhibition. They were also asked to talk and think aloud while answering the questions with the help of the exhibition.

The last block is a user experience feedback. Participants were asked about their impressions about the whole prototype and different parts of the interface.

The questionaries could be found in the appendixes I and II.

4.3.2 Experiment setup

Figure 38 Classical exhibition prototype on the left, AR exhibition prototype on the right

Both exhibitions prototypes were installed in one room (Figure 38). Participants were randomly divided into two groups. One group was working with the AR exhibition (Figure 39), the other with the classical one (Figure 40). All the necessary COVID measures were followed and only one person was exploring the exhibition at one time. The whole user test took about 45-60 min per participant. The time was the same for both groups.

After completing the statistical block, participants were asked to imagine that they are in the Museum, and they want to explore the exhibition themselves. However, they were allowed to ask question like to a person guiding through an exhibition. After the self-exploration, participants were receiving the second part of the questionnaire, which they were filling using the exhibition. The time needed for the exploration and to answer each question was recorded. After that users were invited to fill the last part of the questionnaire.

Figure 39 Participant exploring AR exhibition

Figure 40 Participant exploring Classical exhibition

The results of the experiment will be discussed it the next chapter.

5 Results and Discussion

The data collected via questionnaires were digitised and processed in excel. The results analysis will follow the same structure as the questionnaire: (1) statistical block, then (2) tasks -to determine the quantity and quality of knowledge transfer and (3) user experience. Finally, (4) comments given in the open questions will be analysed and discusses. The questionnaires could be found in appendixes I and II.

5.1 Statistical block analysis

The total number of participants was 25. They were randomly divided into two groups. 13 participants explored the AR exhibition and 12 the classical exhibition. As shown in table 1 below, the two groups had almost the same size, male/female distribution, as well as age. The latter somewhat restricts the selection and should be taken into account during the analysis.

	AR	Classical
Number	13	12
Sex (Male/Female)	6/7	6/6
Age group(average/min/max)	21-29/21-29/41-49	21-29/21-29/41-49
Average familiarity with a map (0-4)	1,6	1,3
Self-exploration time, min (average/min/max)	11,7/3/44	7,7/5/13

Table 4 Groups statistics

On a scale where 0 means not familiar with the map, 4 familiars with the map, the “AR” group is little more familiar with a map, but most of them are in the same category. It is interesting that the time of self-exploration is longer in the “AR” group, which means that “Classical” users more easily become familiar with the interface of the prototype, and vice versa the “AR” interface needs more time to explore, maybe because of its attractiveness or complexity.

However, the groups are homogeneous in terms of age, sex, and number of participants which makes it possible to compare the results of test.

5.2 Tasks block analysis

The second block - tasks - was the same in both groups. Users were invited to answer some qualitative and quantitative questions (number A-K) about Napoleon's campaign using the exhibition prototypes. The time witch the participants spend while answering each question was recorded. The speed and correctness of responses can serve as indicators of both the quality of the transmitted information and the effectiveness of the prototype or its individual elements.

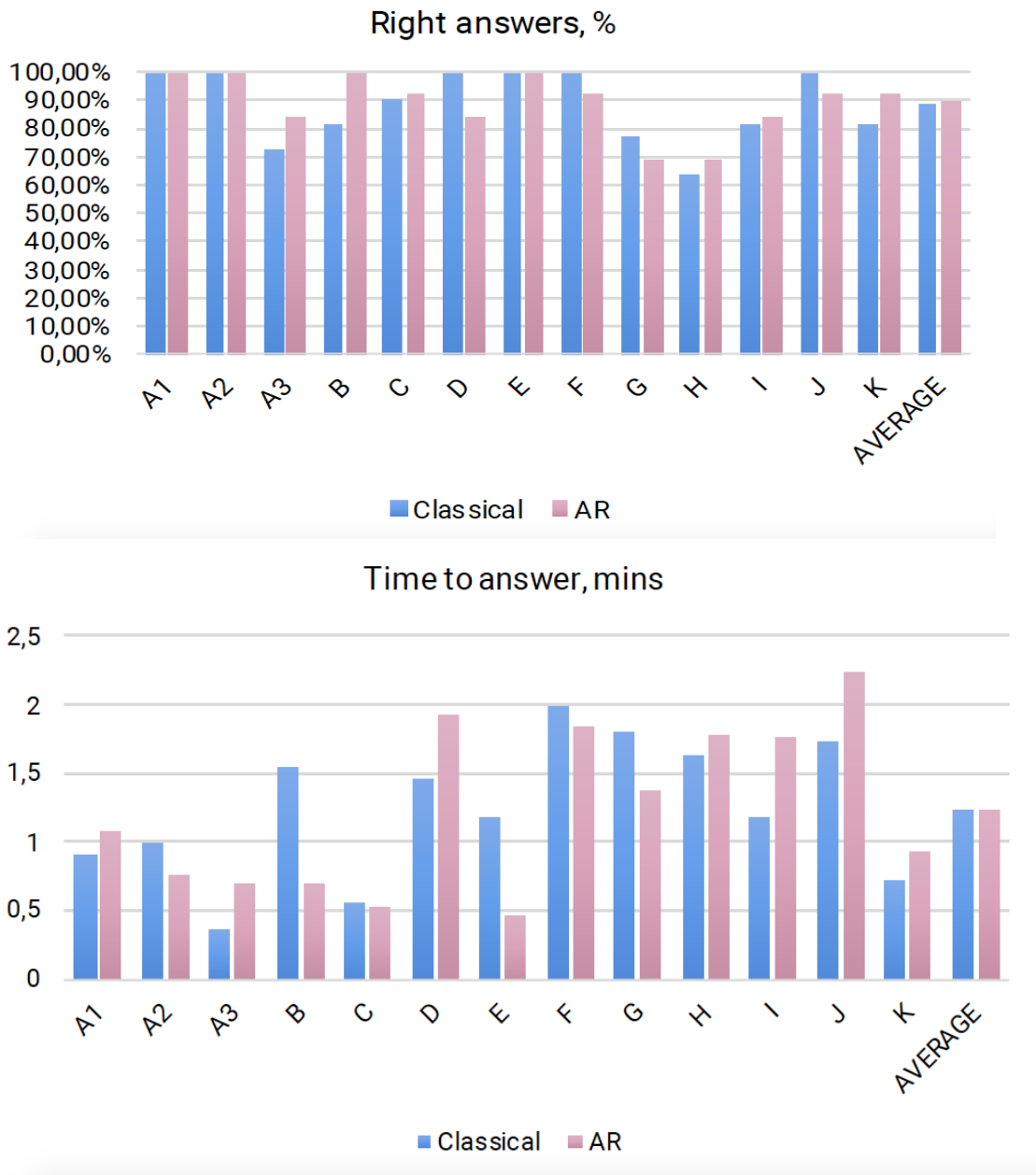


Figure 41 Percentage of right answers and time needed to answer the questionnaire

As it is seen in figure 1, the average percentage of right answers and time needed to answer are nearly the same in both groups. This could indicate that the quality and quantity of the acquired knowledge is the same for both prototypes. The difference in indicators for individual issues indicates more or less successful design solutions for specific elements of the exhibition and requires a more in-depth analysis.

5.3 User experience analysis

The third block - user experience evaluation - was different for each group, except for the first question. In that question, users were asked to rate the overall expression from the exhibition from three sides: (1) general, (2) the clarity of the interface, and (3) an opinion on the applicability of the exhibition in the real museums.

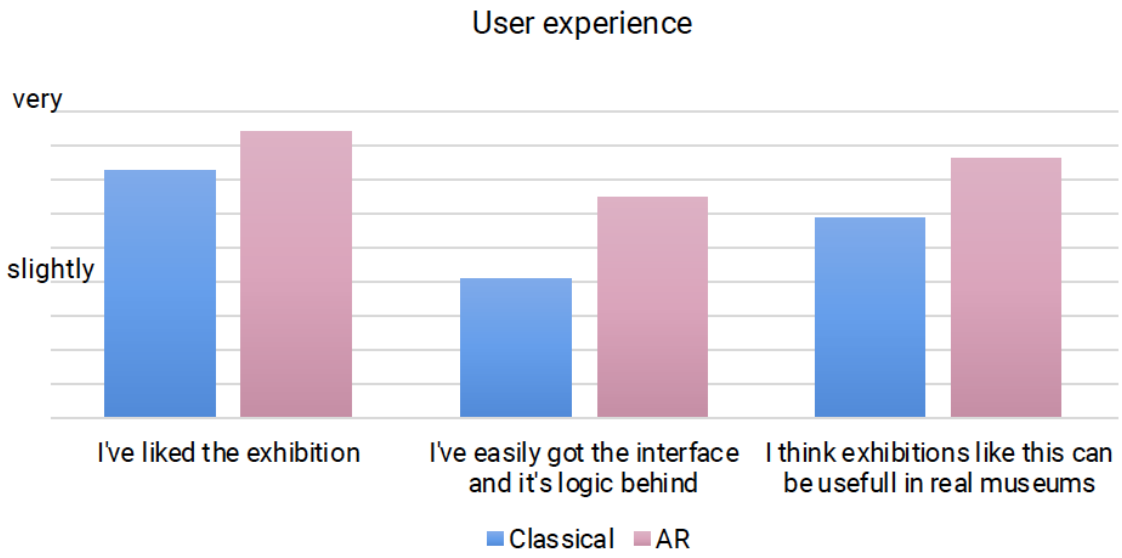


Figure 42 Overall user experience evaluation results

The results of direct comparison allow it to be said that the hypothesis “the use of the method makes the exhibition more entertaining and enjoyable” is correct.

. In all three aspects, the AR exhibition generated more positive feedback from participants. (figure 42). This shows that both prototypes got a positive response: there are almost no negative reviews of individual elements of exhibitions in the questionnaires.

The rest of the questions were formulated in the same way and related to various elements of the exhibition prototypes. The strongest and weakest elements of each of the prototypes are shown in Table 5.

	In general,		Interaction		Applicability	
elements	weak	strong	weak	strong	weak	strong
AR	-text -sound -interface	-Minard map overlay -overview map -timeline	-interface -map in the text	-sound -overview map	-text - background images	-timeline -map overlay
Classical	-map in the text -pop-ups	-minard map overlay -sound	-text -map integration	-pop-ups -booklet	-booklet -text	-Minard map overlay -sound

The last two questions were open questions identical in both groups; users were asked to write down their impressions and suggestions.:

AR prototype

«It is creative and informative way to communicate a historical information to a wider public using various representation and audio media. »

«That really fit to make historic events more interactive, so it could work for any war to illustrate troops movement»

« Any city history line would be great to be in an "interactive" exhibition like that»

The word “interactive” in positive context appeared in the user’s comments, it once more time proves the hypothesis. Many respondents note that prototype is overloaded with text, it should be taken into account in the future studies. Some of the respondents note that quality of the picture and traction control could be better – it could be solved with better hardware.

Classical prototype

«I think the tasks helped me to understand the map and booklet better to be honest.»

«Could be improved with better link and explanation between Minard’s map, the full table map and the booklet»

« I liked the part to look for answers while connecting different elements of the exhibition, this was a really pleasant and excellent activity»

In the classical prototype feedback regularly noted that the task is good instrument for the exploration, this idea as well as idea of gamification process should be considered in the

future research. As well as in AR prototype respondents are noting that exhibition is overloaded with a text.

The comparative user studies analyze shows that both exhibition prototypes find good users' feedback. Its elements provide all the instruments to solve the proposed tasks. However, the users found the AR prototype more entertaining and engaging. A more detailed look into the participants feedback shows that some elements could be improved or replaced, it will be discussed in the last chapter.

6 Conclusions and outlook

The main objective of this study was to propose and evaluate a method of Map-Based Storytelling in Mixed Reality in order to enhance user experience.

To reach this research objective, an overview of current MR technologies for Cultural Heritage was made and the applicable hardware and software technology stack was selected. The different ways and possibilities of user interactions in an AR space were defined. Types of connected media (maps, map layers and information) that could be integrated in the exhibition were found. Two user groups explored two different prototypes developed for an exhibition and their user experience was finally compared.

The hypothesis that the proposed Map-Based Storytelling in Mixed Reality method could enhance user experience is proven. The AR prototype was ranked as more entertaining and is can be seen as a flexible storytelling solution including maps in a Spatial Augmented Reality environment.

Within the literature review, it was found out that for CH applications, a wide range of MR applications can be used. For the proposed integration of maps in exhibition with the MR method, Spatial AR was chosen as most suitable and entertaining option. This solution can overcome the traditional exhibitions limitations as space, time and non-interactivity.

The projection of interactive layers can be realized with the creation of Spatial AR in the intersection of the field of view of a depth camera and projector on the table surface with a paper map on it.
In the proposed method, users can interact with a touchable flexible interface in Spatial AR. Text, audio, video, overview maps, paper maps with interactive overlays, as well as animations, and other content could be added to a paper map in an exhibition.

The method of Map-Based Storytelling in Mixed Reality, as it shows the comparative user experience evaluation, makes storytelling using paper maps more entertaining and is enhancing the potential museums Visitors experience.

Interactive map overlays, overview maps, a timeline and infographics have been identified as the most effective elements in Map-Based Storytelling in a Spatial AR environment and could be highly recommended for the priority usage in similar exhibitions.

The two developed prototypes however included too much text – in real museums visitors will not spend this amount of time near one object. The benefit of the usage of animations and sound effects should be investigated in future studies.
The infographic interactively displaying the troops indicator shows its effectiveness, but should be made more clear for interpretation, for example by including a gamification component to the exploration process. The author of this thesis believes that if these identified shortcomings are corrected in the AR prototype, the sample prototype can be recommended fully for use in museums.

In future studies, maps of different topics, scales and geography should be used as a core of storytelling. The user group participating in the experiment was limited in terms of age and mostly came from the cartography field. It is recommended to expand the user test and include more users with different background and age in future. The comparison between the AR and the classical approach could be supplemented with on screen solutions. All three solutions could be compared and evaluated to derive more specific answers on the user experience enhancement. It is not clear yet, which specific role the “wow” factor of the AR exhibition plays in the user experience because of the use of a new entertaining technology.

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APPENDIX I When Napoleon ventured East AR exhibition. User test questionnaire

When Napoleon ventured East AR exhibition. User test questionnaire.

I. General info

A. Name: _____

B. Gender:

- ☐ Female
- ☐ Male
- ☐ prefer do not comment

C. Age:

- ☐ 17 or younger
- ☐ 18-20
- ☐ 21-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60 or older

D. Country of origin : _____

E. Are you familiar with the map of Napoleon's Russian campaign by Charles Minard?

- ☐ never heard about it
- ☐ never seen it
- ☐ quite familiar – have seen it on the lectures/in the media
- ☐ very familiar – I've explored it a lot/ was using in the projects
- ☐ I'm fan - I have poster with it on my wall

II. Please give answers, which you can find in the exhibition materials, to following questions about Napoleon's campaign to Russia

A. What was the amount of troops of French army at:
   1. June 1812 _____
   2. 16 November 1812 _____
   3. 14 December 1812 _____

B. Biggest French army division at June 1812 amount and name
_____

C. Biggest Russian army division at June 1812 amount and name
_____

D. What was the temperature on 1 of December 1812
_____

E. Who is Charles Minard?
_____

F. Where was Napoleon's army located,
when the number of troops was 55 000?
_____

G. When and where was the biggest battle of the campaign?
_____

H. When Napoleon's army was indicated on the map with smallest amount?
_____

I. In which month did Napoleon leave for Paris?
_____

J. Who was Fyodor Glinka?
_____

K. When Napoleon arrived at Moscow?
_____

III. User experience feedback

Please fill this block after you have explored the exhibition and after you have answeried the questions from block II

A.What is your general impresion?

	very	slightly	neither	slightly	very	
I **didn't like** the exhibition						I've **liked** the exhibition
It was **hard** to understand how the interface works and it's logic behind						I've **easily** got the interface and it's logic behind
I think exhibitions like this **can't** be usefull in real museums						I think exhibitions like this **can be** usefull in real museums

B.Please score the different elements of the exhibition

B1. Interface elements: buttons, links to the chapters

	very	slightly	neither	slightly	very	
I **didn't like** the interface						I've **liked** the interface
It was **hard** to understand how to work with this element						It was **easy** to understand how to work with this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B2. Infographics: diagram wich indicate the ammount of troops

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand how with this element works						It was **easy** to understand how this element works
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B3. Full screen overview map with diagrams

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B4. Full screen images used as the chapters' background

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B5. Original Minard map overlay showing current army position

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B6. Integration of original Minard map with full screen overview map

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B7. Story text

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B8. Date indicator and timeline

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand how with this element works						It was **easy** to understand how this element works
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B9. Maps in the text block

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B10. Sound accompaniment

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

IV.

A. Do you have any comments, ideas or advices?

_____

B. If you think exhibitions like that can be useful, what comes to your mind? Which kind of stories could be told in this format_____

APPENDIX II. When Napoleon ventured East Classical exhibition. User test questionnaire

I. General info

A. Gender:

- ☐ Female
- ☐ Male
- ☐ prefer do not comment

B. Age:

- ☐ 17 or younger
- ☐ 18-20
- ☐ 21-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60 or older

C. Country of origin : _____

D. Are you familiar with the map of Napoleon's Russian campaign by Charles Minard?

- ☐ never heard about it
- ☐ never seen it
- ☐ quite familiar – have seen it on the lectures/in the media
- ☐ very familiar – I've explored it a lot/ was using in the projects
- ☐ I'm fan - I have poster with it on my wall

II. Please give answers, which you can find in the exhibition materials, to following questions about Napoleon's campaign to Russia

A. What was the amount of troops of French army at:
   1. June 1812 _____
   2. 16 November 1812 _____
   3. 14 December 1812 _____

B. Biggest French army division at June 1812 amount and name
_____

C. Biggest Russian army division at June 1812 amount and name
_____

D. What was the temperature on 1 of December 1812
_____

E. Who is Charles Minard?
_____

F. Where was Napoleon's army located,
when the number of troops was 55 000?
_____

G. When and where was the biggest battle of the campaign?
_____

H. When Napoleon's army was indicated on the map with smallest amount?
_____

I. In which month did Napoleon leave for Paris?
_____

J. Who was Fyodor Glinka?
_____

K. When Napoleon arrived at Moscow?
_____

III. User experience feedback

Please fill this block after you have explored the exhibition and after you have answeried the questions from block II

A.What is your general impresion?

	very	slightly	neither	slightly	very	
I **didn't like** the exhibition						I've **liked** the exhibition
It was **hard** to understand how the interface works and it's logic behind						I've **easily** got the interface and it's logic behind
I think exhibitions like this **can't** be usefull in real museums						I think exhibitions like this **can be** usefull in real museums

B.Please score the different elements of the exhibition

B1. Booklet: amount of army infographics

	very	slightly	neither	slightly	very	
I **didn't like** the interface						I've **liked** the interface
It was **hard** to understand how to work with this element						It was **easy** to understand how to work with this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B2. Pop-up armies indicator

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand how to work with this element						It was **easy** to understand how to work with this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B3. Full-table map

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B4. Original Minard map reprint

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B5. Original Minard map overlay showing current army position

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B6. Integration of original Minard map with full table map

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
It was **hard** to understand that it shows						It was **easy** to understand that it shows
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

B10. Sound accompaniment

	very	slightly	neither	slightly	very	
I **didn't like** this element						I've **liked** this element
I think this element **can't** be usefull in real museums						I think this element **can** be usefull in real museums

IV.

A. Do you have any comments, ideas or advices?

_____

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B. If you think exhibitions like that can be useful, what comes to your mind? Which kind of stories could be told in this format_____

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APPENDIX III Source data table

TASS_SCENE	DAY_ID	DATE	TASS_EVENT	TASS_EVENT	TASS_EVENT	MASSWERK_EVENT	MASSWERK_EVENT	CITY	Troop1_count		Troop2_count	Troop3_Count	otal_Troop_Cou	Poly_id	DATE_TYPE
PROLOGUE - Mirrard Map	9999														
I FROM THE PEACE OF TILSIT TO WAR	0	MAY-JUNE 1812													
II PEELING OF SUPREMACY	1	Tuesday, 23 June 1812 r.													
III THE NEMAN CROSSING	2	Wednesday, 24 June 1812 r.		Alexander I gets news the French forces set foot on the Neman's eastern bank.		The Grande Army crosses the Niemen River with 449,000 men and 1,298 cannons, opposed by The Russian Imperial Army combining 153,000 Russians, 982 cannons, and 15,000 Cossacks. Bashkirs Cossacks are galloping across the frozen Niemen.		Kovno	422 800				422 800	0	1
	3	Thursday, 25 June 1812 r.			Napoleon starts crossing the			Neman					0		
	4	Friday, 26 June 1812 r.											0		
	5	Saturday, 27 June 1812 r.											0		
	6	Sunday, 28 June 1812 r.	Marshal McDonald's corps embarks on the Riga route, its main task being to push towards St. Petersburg.			Napoleon enters Vilnius. Bridges and depots are left destroyed by the Russians		Wilna	408 800			22 980	422 800	1	1
IV SCYTHIAN TACTICS	7	Monday, 29 June 1812 r.					IV-1						0		
	8	Tuesday, 30 June 1812 r.											0		
	9	Wednesday, 1 July 1812 r.											0		
	10	Thursday, 2 July 1812 r.											0		
	11	Friday, 3 July 1812 r.											0		
	12	Saturday, 4 July 1812 r.											0		
	13	Sunday, 5 July 1812 r.					IV-2		375 800		60 000		435 800	2	0
	14	Monday, 6 July 1812 r.											0		
	15	Tuesday, 7 July 1812 r.											0		
	16	Wednesday, 8 July 1812 r.											0		
	17	Thursday, 9 July 1812 r.											0		
	18	Friday, 10 July 1812 r.											0		
	19	Saturday, 11 July 1812 r.											0		
	20	Sunday, 12 July 1812 r.					IV-3	Krakiv	350 800				350 800	3	0
	21	Monday, 13 July 1812 r.	Marshal Oudinot's corps storms Dinaburg (currently Daugavpils) three times only to be pushed back by the fortress's garrison.					Dinaburg (currently Daugavpils)					0		
	22	Tuesday, 14 July 1812 r.											0		
	23	Wednesday, 15 July 1812 r.											0		
	24	Thursday, 16 July 1812 r.											0		
	25	Friday, 17 July 1812 r.	The Russian Army's military council meets in Drissa to decide on leaving the camp and continuing the retreat.				IV-4	Globalice	320 800				320 800	4	0
	26	Saturday, 18 July 1812 r.											0		
	27	Sunday, 19 July 1812 r.	Alexander I leaves the 1st Western army in Polotsk for Moscow.				IV-5		300 800				300 800	5	0
	28	Monday, 20 July 1812 r.											0		
	29	Tuesday, 21 July 1812 r.											0		
	30	Wednesday, 22 July 1812 r.											0		
	31	Thursday, 23 July 1812 r.											0		
	32	Friday, 24 July 1812 r.											0		
	33	Saturday, 25 July 1812 r.						Ostrovno					0		
	34	Sunday, 26 July 1812 r.	The rearguard of Barclay de Tolly's 1st Western Army clashes with French forces near Ostrovno.				IV-6		250 800				250 800	6	0
	35	Monday, 27 July 1812 r.											0		
	36	Tuesday, 28 July 1812 r.											0		
	37	Wednesday, 29 July 1812 r.											0		
	38	Thursday, 30 July 1812 r.											0		
	39	Friday, 31 July 1812 r.											0		

II SMOLENSK	40	Saturday, 1 August 1812 r.													II		
	41	Sunday, 2 August 1812 r.						VI-1	Polotsk	225 800		39 008	258 800	7	0
	42	Monday, 3 August 1812 r.	Russian 1st and 2nd western armies merge near Smolensk.										II		
	43	Tuesday, 4 August 1812 r.											II		
	44	Wednesday, 5 August 1812 r.											II		
	45	Thursday, 6 August 1812 r.											II		
	46	Friday, 7 August 1812 r.											II		
	47	Saturday, 8 August 1812 r.											II		
	48	Sunday, 9 August 1812 r.						VI-2		200 800			200 800	8	0
	49	Monday, 10 August 1812 r.											II		
	50	Tuesday, 11 August 1812 r.											II		
	51	Wednesday, 12 August 1812 r.					Supply depot at Vitebsk. Napoleon waits for the army to recompose.	VI-3	Vitebsk	185 800			185 800	9	1
	52	Thursday, 13 August 1812 r.											II		
	53	Friday, 14 August 1812 r.	General Neverovsky detachment's clash with a superior enemy cavalry force near Krasnoye.						Krasnoye				II		
	54	Saturday, 15 August 1812 r.							Krasnoi				II		
	55	Sunday, 16 August 1812 r.			V-4 - Smolensk battle					175 800			175 800	10	0
	56	Monday, 17 August 1812 r.		engagement near Polensk between the Russian army's corps under Prince Bagration and the combined forces of Marshal Oudinot and General Saint-Cyr.	V-5				Smolensk	194 800			194 800	10	1
	57	Tuesday, 18 August 1812 r.	A two-day battle in Smolensk between Russian troops and Napoleon's main forces.				Fightings at Krasnoi Napoleon's 43rd birthday.	Battle of Smolensk:84% of the city are destroyed by the artillery bombardment, only 350 out of 2,250 buildings survive intact.					II		
III IN PURSUIT OF THE GRAND BATTLE	58	Wednesday, 19 August 1812 r.	A battle near the village of Valutina Gora near Smolensk.					VI-1	Valutina Gora				II		
	59	Thursday, 20 August 1812 r.											II		
	60	Friday, 21 August 1812 r.											II		
	61	Saturday, 22 August 1812 r.											II		
	62	Sunday, 23 August 1812 r.											II		
	63	Monday, 24 August 1812 r.											II		
	64	Tuesday, 25 August 1812 r.											II		
	65	Wednesday, 26 August 1812 r.											II		
	66	Thursday, 27 August 1812 r.											II		
	67	Friday, 28 August 1812 r.						VI-2, VI-3		145 800			145 800	11	0
	68	Saturday, 29 August 1812 r.	Prince Mikhail Golenishchev-Kutuzov takes over command of the Russian armies in Tsarevo-Zaymishche.						Tsarevo-Zaymishche				II		
	69	Sunday, 30 August 1812 r.											II		
	70	Monday, 31 August 1812 r.											II		
	71	Tuesday, 1 September 1812 r.	General Konovitsin's rearguard force battles the French advanced guard near Gzhatsk (currently Gagarin).						Gzhatsk				II		
	72	Wednesday, 2 September 1812 r.											II		
	73	Thursday, 3 September 1812 r.											II		
	74	Friday, 4 September 1812 r.											II		
IV BORODINO	75	Saturday, 5 September 1812 r.					Battle of Shevardino Redoubt		Shevardino				II		
	76	Sunday, 6 September 1812 r.											II		
	77	Monday, 7 September 1812 r.	The main battle of the 1812 Patriotic War near the village of Borodino, which carried on for about 12 hours.						Borodino	127 100			127 100	12	1
	78	Tuesday, 8 September 1812 r.					Battle of Borodino						II		
	79	Wednesday, 9 September 1812 r.					Napoleon transfers his headquarters to Mozhaysk.						II		

VIII MOSCOW ON FIRE	80	Thursday, 10 September 1812 r.													
	81	Friday, 11 September 1812 r.													
	82	Saturday, 12 September 1812 r.													
	83	Sunday, 13 September 1812 r.	The military council in Fili decides to leave Moscow without putting up any resistance.												
	84	Monday, 14 September 1812 r.	Napoleon's troops enter Moscow.	VIII-1	Napoleon enters the city of Moscow.		Moscow	100 000					100 000	13	1
	85	Tuesday, 15 September 1812 r.		VIII-2											
	86	Wednesday, 16 September 1812 r.													
	87	Thursday, 17 September 1812 r.				Fire of Moscow.									
	88	Friday, 18 September 1812 r.		VIII-II.4											1
	89	Saturday, 19 September 1812 r.													
	90	Sunday, 20 September 1812 r.													
	91	Monday, 21 September 1812 r.													
	92	Tuesday, 22 September 1812 r.													
	93	Wednesday, 23 September 1812 r.													
	94	Thursday, 24 September 1812 r.													
	95	Friday, 25 September 1812 r.													
	96	Saturday, 26 September 1812 r.													
	97	Sunday, 27 September 1812 r.													
	98	Monday, 28 September 1812 r.													
	99	Tuesday, 29 September 1812 r.													
	100	Wednesday, 30 September 1812 r.													
	101	Thursday, 1 October 1812 r.													
	102	Friday, 2 October 1812 r.													
	103	Saturday, 3 October 1812 r.													
	104	Sunday, 4 October 1812 r.													
	105	Monday, 5 October 1812 r.													
	106	Tuesday, 6 October 1812 r.													
	107	Wednesday, 7 October 1812 r.													
	108	Thursday, 8 October 1812 r.													
	109	Friday, 9 October 1812 r.													
	110	Saturday, 10 October 1812 r.													
	111	Sunday, 11 October 1812 r.													
	112	Monday, 12 October 1812 r.													
	113	Tuesday, 13 October 1812 r.													
	114	Wednesday, 14 October 1812 r.		VIII-5	The Grande Army leaves out of the city.										
	115	Thursday, 15 October 1812 r.													
	116	Friday, 16 October 1812 r.													
	117	Saturday, 17 October 1812 r.													
	118	Sunday, 18 October 1812 r.	Another battle at Polotsk on the way to St. Petersburg.				Moscow	100 000					100 000	14	1
	119	Monday, 19 October 1812 r.	Napoleon and the French army's main forces leaves Moscow.	VIII-6											
	120	Tuesday, 20 October 1812 r.													
	121	Wednesday, 21 October 1812 r.													
	122	Thursday, 22 October 1812 r.													
	123	Friday, 23 October 1812 r.													
	124	Saturday, 24 October 1812 r.	The battle of Maloyaroslavets, followed by the Russian army's counter-		Battle of Maloyaroslavets		Maloyaroslavets								
	125	Sunday, 25 October 1812 r.													

II "THEY'LL GO JUST AS THEY CAME"	126	Monday, 26 October 1812 r.							96 880				96 880	15	0
	127	Tuesday, 27 October 1812 r.											0		
	128	Wednesday, 28 October 1812 r.											0		
	129	Thursday, 29 October 1812 r.											0		
	130	Friday, 30 October 1812 r.											0		
	131	Saturday, 31 October 1812 r.	An engagement between Russian troops under Wintgenstein and French forces near Chudvelo.					Chudvelo					0		
	132	Sunday, 1 November 1812 r.											0		
	133	Monday, 2 November 1812 r.											0		
	134	Tuesday, 3 November 1812 r.	A clash between the Russian advance guard under General Miloradovich with retreating French troops near Vyazma.			Battle of Vyazma		Bitwa Vyazma	87 880				87 880	16	1
	135	Wednesday, 4 November 1812 r.											0		
	136	Thursday, 5 November 1812 r.											0		
	137	Friday, 6 November 1812 r.											0		
	138	Saturday, 7 November 1812 r.	The Russian army's advanced guard clears Dorogobuch of enemy forces.					Dorogobuch					0		
	139	Sunday, 8 November 1812 r.											0		
	140	Monday, 9 November 1812 r.	A mobile detachment under Orlov-Denisov and guerilla units under Davydov, Seslavin and Figner attain victory over General Augereau in the village of Lyakhovo, near Smolensk.					Dąbrowa Lyakhovo	55 880				55 880	17	0
	141	Tuesday, 10 November 1812 r.											0		
	142	Wednesday, 11 November 1812 r.											0		
	143	Thursday, 12 November 1812 r.											0		
	144	Friday, 13 November 1812 r.											0		
	145	Saturday, 14 November 1812 r.						Smolensk	37 880				37 880	18	1
II WAS THERE A GENERAL FROST?	146	Sunday, 15 November 1812 r.											0		
	147	Monday, 16 November 1812 r.						Krasnoe					0	19	1
	148	Tuesday, 17 November 1812 r.	Four-day long battle between Russian troops and the retreating French army near Krasnoye.										0		
	149	Wednesday, 18 November 1812 r.											0		
	150	Thursday, 19 November 1812 r.						Orsza	24 880				24 880	20	1
	151	Friday, 20 November 1812 r.											0		
	152	Saturday, 21 November 1812 r.											0		
	153	Sunday, 22 November 1812 r.											0		
	154	Monday, 23 November 1812 r.											0		
	155	Tuesday, 24 November 1812 r.						Borisov	20 880		28 008		50 880	21	1
	156	Wednesday, 25 November 1812 r.											0		
III THE BERESINA RIVER CROSSING	157	Thursday, 26 November 1812 r.					XII.1	Berezina					0		
	158	Friday, 27 November 1812 r.	A four-day battle between several French corps and Russian forces during Napoleon's crossing of the Berezina river.										0		
	159	Saturday, 28 November 1812 r.						Studenka	50 880				50 880	22	1
	160	Sunday, 29 November 1812 r.				Battle of Berezina (crossing the Berezina near Borisov)	XII.2						0		
	161	Monday, 30 November 1812 r.											0		
	162	Tuesday, 1 December 1812 r.					XII.3		28 880				28 880	23	1
	163	Wednesday, 2 December 1812 r.											0		
	164	Thursday, 3 December 1812 r.											0		
	165	Friday, 4 December 1812 r.	An engagement between the French rearguard and the Russian army near Molodechno.										0		
	166	Saturday, 5 December 1812 r.	In Smorgon Napoleon abandons the remains of his army and leaves for			Napoleon leaves for Paris to address an attempted coup.	XII.1						0		
	167	Sunday, 6 December 1812 r.						Smorhon	12 880				12 880	24	1

III: NAPOLEON GOES TO PARIS	168	Monday, 7 December 1812 r.					XII-2	Wilna	14 880				14 880	25	1
	169	Tuesday, 8 December 1812 r.											II		
	170	Wednesday, 9 December 1812 r.					XII-1		8 080				8 080	26	0
	171	Thursday, 10 December 1812 r.											II		
EPILOGUE THE PRICE OF AMBITION	172	Friday, 11 December 1812 r.							4 080			6 080	10 880	27	0
	173	Saturday, 12 December 1812 r.											II		
	174	Sunday, 13 December 1812 r.											II		
	175	Monday, 14 December 1812 r.				The Grande Army leaves Russian territory heading for Poland		Niemen	10 880				10 880	28	1
	8868														

APPENDIX IV Participants comments

AR exhibition

№16

A**. Do you have any comments, ideas or advices?**

I think it's a god idea to highlight the temperature and troop size with light. But I could not understand the Minard map easily, as it was the first time, I saw it and the letters were so small. I like the layout though. Also, the image is blurry. I gained some knowledge about the battle. But there are so many elements, as a first-time user, I sometime forget where to look for the information.

B. If you think exhibitions like that can be useful, what comes to your mind? Which kind of stories could be told in this format

Historical events like this, But maybe not very complex ones? With some many dates. Users may get lost.

№18

A. Do you have any comments, ideas or advices?

It is creative and informative way to communicate a historical information to a wider public using various representation and audio media. The combination of text and visual content gives **** overview. Along with the overview the details of the historical event can be discovered ****. The music playing along the exhibition makes the whole experience authentic. Vertical disposition would be preferred (my poor neck:))

B.If you think exhibitions like that can be useful, what comes to your mind? Which kind of stories could be told in this format

History of planet evolution? Animal movement. Regional development. Flooding. Etc. I see a wide range of different applications using the proposed method.

№19

A. Do you have any comments, ideas or advices?

No that was fun

B.If you think exhibitions like that can be useful, what comes to your mind? Which kind of stories could be told in this format

That really fit to make historic events more interactive, so it could work for any war to illustrate troops movement? Or it could also be used to *** exploration trip (e.g. discovery of America etc.)

№20

A. Do you have any comments, ideas or advices?

1) Because the exhibition is text based more that visual based in the sense that visitor will not be able to understand anything it he/she will not read the text, it exclude some visitors with reading disabilities. Maybe some smaller and clear summaries in the start of every chapter, additionally with the text now would be helpful. 2) I liked the visuals although I think a bigger table would help to un-crowd

the visuals. 3) It took me some time to understand the original map. I think an explanatory slide in the start might be more welcome for every visitor.

B.If you think exhibitions like that can be useful, what comes to your mind? Which kind of stories could be told in this format

Any city history line would be great to be in an "interactive" exhibition like that

№22

A. To make it more like game- open card with text etc.
too much text
static location of armies (blue/red pop-up)

B. first WW(two fronts)
second WW (two fronts + Asia)
civil men in USA
French - Prussian war 19 cents

№24

A. Temperature is hard to find. Add solder (солдатиков) to the Minard Map. 1 solder=20.000 etc. Integrate the solder count block from top right as *** block on the Minard Map. Use other place (for **** main **** position) to explain forces during battles.

B. II World WAR

№1

A. The diagram displaying troops could be made to be more easily understood/ Timeline sometimes didn't match.
B. Almost any historical event involving time. Ex. US westward expansion. Us railroad construction. cross country James Cook ship travel across the world

№3

A. It is a very informative and well-done exhibition piece. The **** made we realize the dimensions of the campaign (I thought Napoleon went a longer way!) and the troop indicators made it easy to understand the amounts of soldiers lost. Indicators was a little did **** but worked well after realizing the ****. A piece that could stand in an interactive museum! Maybe Minard's map could be clickable too!?

B. Everything that has a time - and space ****** ideas. Sailors like Columbus, Drake, Magellan, the search for the Poles, the northern passage (HMS Terror), journeys Marco Polo, Ernest Shackleton, Amundsen VS Scott etc. The Alaskan Gold Rush, the movement of settles to the Pacific coast the immigration stories of groups or individuals, maybe even the first landing on the Moon etc.!

№5

A. (B1)For a prototype I found it impressive. b) in Principal yes, but some links e.g. Between troops on the upper right **** Number on ****** **** are understood in a 2nd glance. General^ I found the prototype in general very explorative especially

since it is quite a complex topic. I also perceived it an intuitive with clicking on the button and supporting **** but exploratively and intuitively *** or **** themselves a bit ... So, in the beginning a small introduction video or explanation or a person or the basic function and links between ****, But very explorative, super useful for museums and quite impressive! Good job! =)

B. - all kind of great book story's e.g. Harry Potter, Star Wars, Lord of The Rings etc. e.g. exhibition of fantasy stories. -Fairytales would be awesome - Real Big happenings like you did French Revolution, but also cold war, DDR lite, Berlin war, Old Greeks, Old Egyptians Tutankhamunmnumnumnm, *** Single stories about Big happenings in *** The development of penicillin. How drugs work (scenically) ->over time --> Basically you could tell every story which has ****and*** reference

№7

A

B. More or less every story in place and time

№9

A. 1/ Colors on the Minard’s mao;s path blue, not purple-yellow, please. 2. **** scale on troops **** (reading "x souls per square" doesn’t help...). 3. I would like the timeline to be more precise, e.g. one *** tick per day, maybe with highlighted ticks for days where something happens. 4. Some indica**** of the number of pages each chapter has would be nice - **** without the chapters. 5. A possibility to look closer at each map 1 graphs (***) would be nice. 6. Being able to jump to places by clicking on the map

B. - The "discovery" of America -expedition like Alexander **** for example. - Any war campaign, **** - Travels of painters or poets along with their art, e.g. **** Holy Travels

№ 11

A. Very interesting idea and great *****. Some small details could be corrected from my point of view. Maybe it is not possible but would be better if the original Minard map was a bit bigger. On some slides I noticed that text on the left side from the diagram sharing the number of troops overlapped with squares. In general, would be better to have more time to explore this detailed exhibition

B. Historical events, every story that has timeline and geographical location or info

№ 13

A. Индикация битвы отдельно от количества армии. Название главы перед текстом. Дата на белом фоне. Подсветка температуры

B. Ход войны/сражения, смена границ государств с течением времени. МИИГаик народов. Потоки беженцев

Classic exhibition

№ 21

A. I liked the visual red/blue color coding for different armies.
maybe it could be useful to unify font sizes and their styles -> somehow map of Minard felt "disconnected" from the table map, booklet and content.
it would be nice to see stronger visual connection between map of Minard and booklet, e.g. indices on the map speeding up and showing in with part of the booklet I could find the info.
initially I thought indices on the booklet one month of 1912;).
I could somehow relate to the story because of my origin, somehow maybe it would be of a benefit for non-EU users to relate the numbers to the main cities populations? Also name of a Baltic see would be of a help ;)
B. I liked the part to look for answers while connecting different elements of the exhibition, this was a really pleasant and excellent activity

№14

A. I think the tasks helped me to understand the map and booklet better to be honest. Solely let myself just into explore the map and booklet I will lost and miss a lot of details. If I in the museum and just explore it by myself. I would assume to spend most of my time int the booklet, because it provides better derails

B. if the exhibition is located in thew museum, the reality is not everyone have chance to spend 30 minutes to explore it. In my opinion if we want to fully understander the whole storyline and got all details 30 mins is necessary. To make full use of the map is the most efficient way to speed up the process. But this exhibition didn't make very good use of map. Map looks the attachment to the booklet

№12

A. It is a very interesting implementation of already quite known historical fact. I liked mostly different means and ways of providing information. Separate content table is very nice element as in museum it would give a visitor opportunity easily find inters in booklet. Textual information makes map also mole fun with some historical facts. At the beginning I thought that thew Map of Minard was not attached to the table and tried to move it. Only after some seconds I've understood the concept which is really nice. Pop-up are always good idea. I think as people are usually curios what is hidden being then. Very nice and very well done.

B. historical stories, traveling stories, personal stories of interesting people, environmental aspect can be also shown, but I guess a human/history/culture related stories are the most exciting to tell in this diverse way

№ 17

A. The Minard map is in an unfamiliar language an overlap with language guide might help in better understanding go the map. It was hard to tell whenever the map is trying to represent the armies of both sides or just the napoleon army

B. Many historical stories of wars journeys migration and moment of human civilization can be shown such exhibitions

№ 2

A. 1) Duplicates, types, other errors to clean up 2) The tabs/bookmarks were confusing. 3) The red blue army locations on the map weren't very tied to the booklet info. 4) So much reading! Tiresome halfway through. 5) Very linear + length makes it feel like on exploration and more like a dense story. 6) Maybe state the purposes of the different piece upfront somehow. 7) Did not notice the dates at the bottom of the booklet at first. 8) The quotes are nice but distracting and break the flow for me; maybe different font/not capitalized would be less distracting. 9) I did not understand the use of the army markers and did not feel any need to use them while reading the booklet.

B. This format feels nice for journeys and explorations if the stages are not too dense with additional/unrelated information. Exploration, battles, colonization, migration, stuff like that with enough detail on a single scale.

№ 4

A. - Could be improved with better link and explanation between Minard's map, the full table map and the booklet. - Minard's map was hard to interpret quickly. - I feel the table map is a great idea, but could maybe contain more information and interactivity but I do understand this was just a prototype :-)

B. -I agree it is good for showing things relating to war. - Stories with timelines

№ 6

A. The music was too loud (at first). A more logic overview of the booklet could help. I.e. Clearer Chapter Separations. There could have been a little more information on the pop-ups. i.e. General/Marshal

B. The paper pop-ups could be *** out after short time. Only one person at a time can view it properly. Some French translations would help to make the items holistically more consistent. The map overlay should be fixed in an easier to understand way

№ 8

A. It was hard to find officers. If these would be served tables showing the important historic events would be better. The pop-up paper could be replaced with figures

B. It would be very interesting to show the marching environment, Eng., landscape, *** ....

№ 10

A. Maybe Minard's map an also be printed on transparent paper so its placement on the top of the table map looks mor intentional. Suggest moving the infographics lower on the page

B. I liked the part to look for answers while connecting different elements of the exhibition, this was a really pleasant and excellent activity

№ 15

A. Include Translation of Minard's original map. Instead of using a "flip book" to explain the stages, maybe find a way of showing all the information at once. For

example: set the map against a wall and use the wall to portray the information booklet -> no pages have to be turned

B. It is a great way of showing how people move across different regions over a certain period of time. It can be used in the context of army movements, but also migration.

№ 19

A. No that was fun

B. That really fit to make historic events more interactive. So, it could work for any to illustrate troops movement. So, it could also be used to ** exploration trip (e.g. discovery of America etc.)