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An investigation in the requirements and design of an online cartographic data comic editor

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Abstract

Many interfaces exist to create a single map, but few for creating a sequence, or story from a collection of maps. Taking a 3 stage user centred design approach, this thesis designs an interface which addresses this technological gap by focusing on the requirements of the journalist. In the first stage, semi-structured expert interviews elicit user requirements and use case scenarios for the new interface. Second, existing candidate software was evaluated based on these requirements. Significant shortfalls were found particularly in guidance for the structure of a story and the ability to share the output to social media. An interface focusing on six of the requirement shortfalls was then designed and evaluated through use case scenarios, using a case study from the Malaria Atlas Project. The research concludes that a redesign of the walkthrough to aid the novice user in creating an online cartographic data comic is required before a full working prototype system can be developed.

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1 Introduction

1.1 Prologue: On the Commuter Train

You are on a rush-hour commuter train in the year 2007. You observe your fellow passengers. Many are reading newspapers. An article on the front page reads that the Apple Computer Company is entering the phone market with the "iPhone".

Skip forward 10 years to the year 2017. The passengers' newspapers are replaced by iPhones, or another type of smart phone. Most are performing their daily morning ritual of scrolling through their personalised Facebook or Twitter feeds. Many of the passengers click on links to news articles.

One passenger is viewing the German election results, a story accompanied by a series of maps highlighting an east/west divide in political opinion. Another on the North Korean Missiles flown over Japan and is worried whether their range could reach their country: a map explains that they cannot (yet) reach Europe. Yet another is reading a story about how Vienna road names disproportionately represent males. The passenger uses the accompanying interactive map to see whether their street is named after a male or female.

One passenger is wearing headphones and watching a Youtube video about the War in Syria. A map forms the main backdrop with annotations and videos and pictures showing the leaders of the competing sides. This video, like many similar ones, has been viewed over 3 million times.

1.2 New Forms of Journalism

Smartphones and the internet have had a large impact on the news industry, changing the way people consume the news; and what news they are seeing. The phrase “Digital journalism” describes this shift. Another shift comes from open data: journalists are increasingly analysing available data sets, and reporting the results to their readers (Coddington, 2015; Schwabish, 2017).

Interactive visualisations, compared to static text and charts, are increasingly used to tell news stories and the results of data analysis. This term is known as narrative visualisation. Examples include graphics with simple annotations, to videos explaining trends using animated charts. In his bestselling book "Prisoners of Geography", Tim Marshall outlines the increasingly unstable world, fractured along geopolitical lines (Marshall, 2015). The subtitle of the book is intriguing: "Ten Maps that tell you everything you need to know about world politics". As the above examples show, many news stories are well aided with the use of maps. In many circumstances, they are the centre of the story.

The Economist notes that modern data visualisation designers are “melding the skills of computer science, statistics, artistic design and storytelling” (Economist, 2010). The high level of interdisciplinary skill required, often means that they are time consuming and expensive to create. Therefore, only few publishing houses have the resources to create these visualisations. This thesis will look to resolve this problem and design a system in which journalists can quickly create a narrative visualisation which has maps as the main form of visualisation.

1.2.1 Problem Statement

The creation of narrative visualisations with maps is a long and expensive procedure. Therefore, only a few media outlets have the resources to create them.

1.3 Structure of Investigation

Chapter 2 will conduct a literature review of the fields of persuasive mapping, web mapping, storytelling and visualisation sequencing. This will narrow the investigation into designing an interface which can help journalists create one specific type of narrative visualisation: online cartographic data comic. Specific research questions based on this subject will be formulated in chapter 3. Chapter 4 proposes a four step research framework adapting the user-centred design approach from Roth et al (2015). Chapter 5 will answer research questions 1 and 2 (RQ1, RQ2) by defining an online cartographic data comic and user requirements for an editor- interface, based on expert/user interviews with data journalists and academics. Chapter 6 will systematically evaluate existing candidate software and web frameworks, assess whether they meet the user requirements of the previous chapter, and look for ways which user requirements have not yet been met (answering research question 3). Chapter 7 will answer research question 4 and present a static mockup of an interface allowing the user to create an online cartographic data comic. It will then evaluate this static mockup with three use case scenarios which together cover the user requirements of chapter 5. Chapter 8 will discuss the methodological limitations of the investigation and suggest directions where the research could be extended. Chapter 9 concludes the investigation by summarising the results of the research questions and briefly discussing future directions of the online cartographic data comic genre.

2 Literature Review

This review starts by looking at examples of maps in journalism and current events before addressing theories in why maps in particular have been used to tell stories. It will then turn to specific techniques used by journalists to tell stories on the internet, with a focus on the data comic genre of narrative visualisation. It will conclude by highlighting two gaps which will form the basis of the research questions in chapter 3. First, in the theory connecting cartography and narrative visualisation. Second, in a technology which allows cartographers to easily create a data comic narrative visualisation.

2.1 Background: Maps as a Form of Storytelling

2.1.1 The Use of Maps as Stories

Maps have an important role in explaining news and current affairs. The Franco-German television series *Le dessous des cartes / Mit Offenen Karten* has created a fifteen minute video explaining a current geopolitical issue using animated maps every week since 1990 (SensCritique, 2017) . Atlases of world history attempt to tell past events through a collection of printed maps (Wildermuth, 2015). Vujakovic (1999) describes how British newspapers in the 1990s used maps to explain the emergence of new political entities in post-Cold War Europe. Maps are also common in other fields. For example thematic maps have been used to describe processes in epidemiology and environmental studies (Chen, 2010).

Various theories have been described to explain why maps in particular can have a powerful effect on the reader. Woods and Fels (1992) posit the notion of intrasignficant and extra-significant codes – things which users see as common sense but help to convince the user to a specific point of view. Muehlenhaus (2010) analysed maps through the lens of rhetoric- which he defines as "discourse that is used to better inform, persuade or motivate audiences via a variety of communication techniques". The rhetorical style is central to an argument and is an attempt to persuade the audience, often through omitting data. From an analysis of 256 maps, Muehlenhaus (2010) identified four rhetorical styles: authoritative, understated, propagandist and sensationalist. For example an authoritative map "looks scientific, official, and magisterial" by following most of the rules established in academic cartography. An understated map presents as few graphics elements as possible; a propagandist map is designed to show and highlight a specific point. Sensationalist maps are most often found in the news, and are visually exciting but tend to incorporate a number of visualisations which are confusing. In a follow up user test, the author found authoritative rhetoric was most trusted and propagandist most memorable (Muehlenhaus, 2012). This dual effect: the ability to inform and persuade, explains why maps are commonly found in news media.

Rarely does a map appear in isolation, but rather in context surrounded by other information. Gershon and Page (2001) describe storytelling as the world's second oldest profession, and as a result innumerable stories have been created throughout history across cultures. Kosara (2013) defines a story as an "ordered sequence of steps with a clearly defined path through it". Sequence, and timing (at what point each element of the story is revealed) are therefore important.

2.2 Maps on the Internet

2.2.1 General Trends

The large increase of internet usage in the 21st century has influenced both cartography and the news media. Crampton (2009) lists many names for the shift of maps from paper to the screen including "the geoweb" and "map hacking". Muehlenhaus (2014) grouped online maps under the labels mashups, which describes the use of existing cartographic APIs such as Google Maps; tailored dynamic representations, creation of a custom graphical user interface and static maps where a single map is created in PNG, GIF, JPEG or PDF format.

2.2.2 Narrative Visualisations

A survey conducted by the Reuters news agency found a rapid increase in the number of people who access news through the internet (Newman et al., 2016). Due to, or possibly a cause of, this shift, journalists are increasingly using web technologies to tell stories in novel ways. For example, allowing the user to zoom in on a map or to tell a story through a timeline of what happened where. These are known as narrative visualisations. News outlets such as the *New York Times* and *Guardian* have highly influenced this shift and most narrative visualisation designers tend to be journalists turned into data analysts rather than the other way round (Schwabish, 2017). Maps are often a common visualisation technique used in narrative visualisation since, as Huhmann & Burghardt (2013) report, more than half of data is geospatially referenced. Sometimes maps are the *dominant* form of visualisation. Green et al. (2009) for

example uses an interactive choropleth map to show the development of nation building activities in Afghanistan between 2005 and 2009.

A second trend noted by the Reuters survey was that the percentage of people using smartphones as their main source of news has risen sharply over the last four years (Newman et al., 2016). Narrative visualisations must therefore be designed to be viewed on both small and large screens, a process known as responsive design.

The next part of the review focuses on the theory of narrative visualisations. It will first look at the distinctions between different types of narrative visualisations (their genres) before looking at one in more depth: the data comic. It will then turn to how the specific ordering of maps can affect the outcome and effectiveness of the narrative visualisation.

2.3 Theories of Online Storytelling

2.3.1 Mechanics and Genres of Narrative Visualisations.

Segel & Heer (2010) split the design of a narrative visualisation into three parts: visual narrative tactics, narrative structure and genre.

Visual narrative tactics describes the use of visuals to tell a story. This is split into three. First, visual structuring shows the user their position in the narrative. Second, highlighting directs the user's attention to important parts of the narrative. Third, transition guidance investigates how one moves from one scene to another, ideally without disruption to the viewer.

Narrative structure describes how the author creates narrative. This is achieved through the three variables of 1) ordering (random or fixed) 2) interactivity and 3)

message (short or long messages). The authors note a tension between a fully ordered author driven story and user-driven stories which allow some interactivity. They conclude that a compromise seems to be the most effective: "constrained interaction at various checkpoints within a narrative, allowing the user to explore the data without veering too far from the intended narrative" (Segel and Heer, 2010). They posit three structures of this author-user driven hybrid. First, the martini glass, which describes when an author driven stage introduces the visualisation before opening up to a reader driven interactive element. Second, slideshow, which follows an author driven narrative but the user can interact with each slide; and a drill down story, where the visualisation introduces a general theme but allows the reader to explore different aspects further, for example different locations. This tension was similarly noted by Muehlenhaus (2014), who states that by allowing the producer to control the information, less interactivity could result in clearer and more persuasive map sequences.

Genre describes the overall look of the narrative visualisation. Genres are distinguished by the number of frames (distinct visual scenes) and it's ordering (whether they are loosely or strictly ordered). The authors identify seven of these genres, although do not describe in detail differences between them. For example, the user has random access to the visualisations in a magazine style, whereas in a multi-partitioned poster and annotated chart/map the ordering is user-directed. Comic strips, slide shows and data videos are strictly ordered by the creator. These genres are briefly illustrated in Figure 2-1.

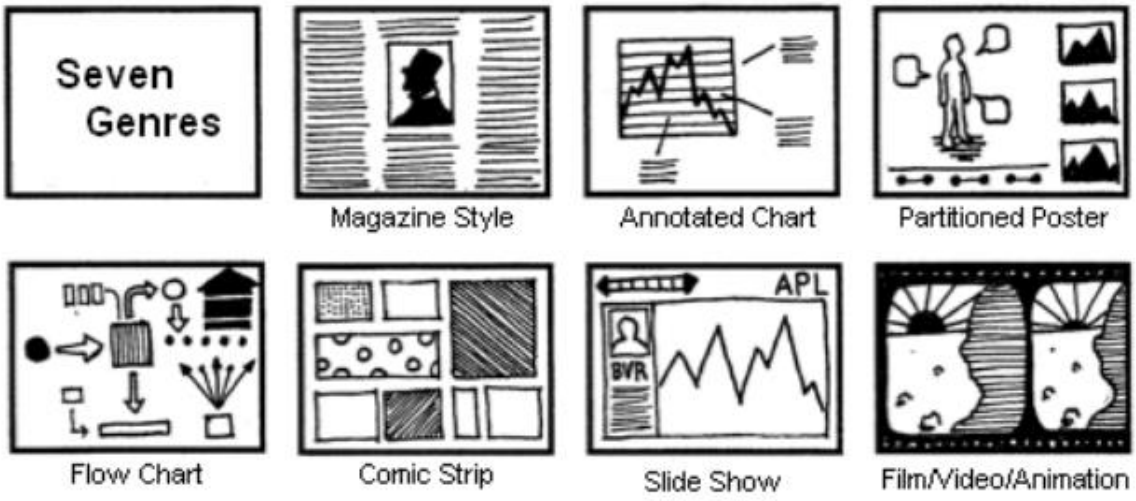


Figure 2-1: The seven genres of narrative visualisation. From Segel & Heer (2010)

Due to the constraints of this thesis, this thesis will turn to look in detail at the data comic. This genre was chosen in particular for the potential it has to be an effective form of narrative visualisation which can be adapted to cartography and responsive design.

2.3.2 Data Comics: a sequenced form of narrative visualisation.

In a review of the field, itself in the form of a comic (but not a data comic), Bach et al (2017) cited four parts of the data comic: visualisation, flow, the synergy between narration and words, and pictures. Visualisation describes how the graphs and data appears, grouping them into realistic and abstract interpretations. Next comes flow: that is a sequence of visualisations. Like Segel & Heer (2010), they highlight a difference between undirected and directed, but say that linear flow can often be too simple. The authors highlight that there should be "one message per panel" and label seven types of transition including visualisation to visualisation, moment to moment, detail to detail, level of detail, data to data, visualisation to context and message to message. What makes a data comic unique, and not merely a "sequential visualisation", is the addition

of narration. Narration through text or speech adds context to data. The authors state that this "symbiosis" of words and pictures are important to a data comic. Some data comics are mainly text with few diagrams, others are mainly diagrams with few annotations. Zhao et al (2015) further add to this definition by defining a comic as

> *"[consisting] of a sequence of panels organized into one-dimensional tiers (or strips) and separated by gutters, or spacing, between the panels".*

2.3.2.1 Cartographic Data Comics

Similar to the general relationship between cartography and narrative visualisation as outlined in section , many of the data comics on the author's website contained at least one map (Bach, 2017). A few (e.g. Figure 2-2) contain only maps. This thesis will term this form of data comic- one where over half of the frames are maps- as a *cartographic data comic*.

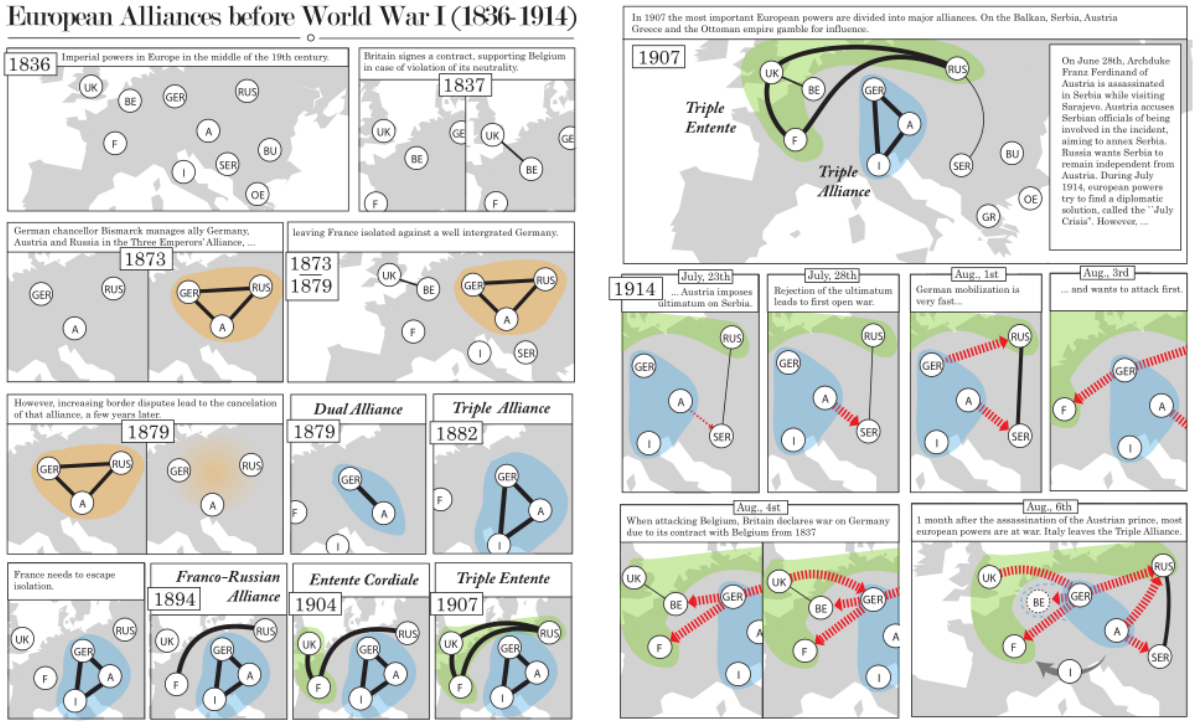


Figure 2-2: An example of a cartographic data comic. From Bach et al. (2016)

2.3.3 Sequencing Techniques

Bach et al (2017) mention further research in "inventing narrative patterns" for data comics. These narrative patterns could adopt previous theories from the storytelling literature which describe effective ways to structure stories and reports. It is these theories that will next be addressed.

Schwabish (2017) reviews the literature on the different types of narrative structure used in stories and presentations. These have elaborate titles such as: boy gets girl; the hero's journey; and overcoming the monster. Possibly the most famous structure is Freytag's three act structure. Everything starts well until an inciting (often negative) incident which changes the character's fortune. The remainder of the narrative concerns the outcome of this incident until the return to normality. At the end, the character must prove themselves when a final "catastrophe" takes place (description from (Cartwright, 2009)). Many films, especially those of Disney and Pixar, exhibit this structure (Adams, 2013).

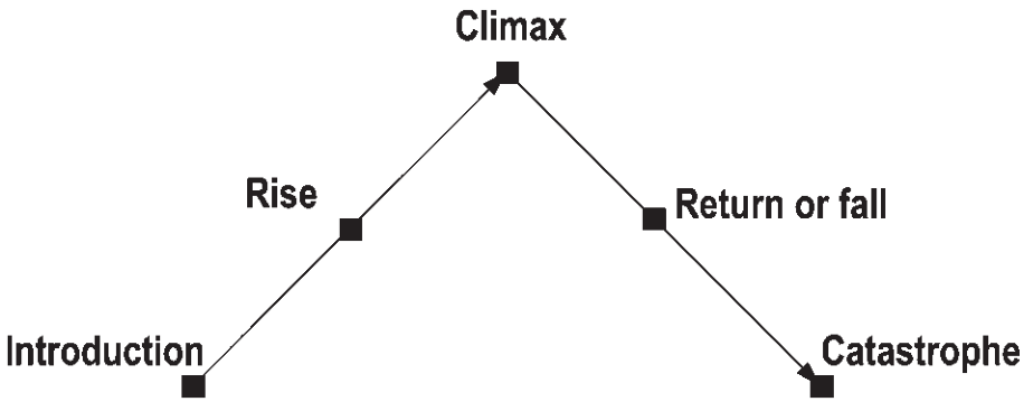


Figure 2-3: Aristotle's / Freytag's Three Act Structure from Cartright (2009)

Cohn (2013) adapted Freytag's structure for use in comics: with the terms establisher, initial and peak. Amini et al (2015) summarise these as:

- Establisher (E): sequences that "provide referential information without engaging them in the actions or events of a narrative."
- Initial (I): sequences that "set the action or event in motion."
- Peak (P): sequences where "the most important things happen; the culmination of an event or the confluence of numerous events."
- Release (R): sequences that show "the aftermath of the peak."

Narrative structures are also seen in narrative visualisations. Amini et al (2015) found that data videos tended to follow the overall flow of Cohn's (2013) establisher, initial, peak release model, albeit with minor variations. For example, some videos exhibited multiple peaks. They noted that creating sample templates for the structure of a data video could be useful. They however noted that it was important for the author to be allowed some degree of freedom and improvisation depending on the story of their data.

Journalists use techniques to structure their stories including anecdotal lead and nut graf (Segel and Heer, 2010). Kosara (2017) summarises three theories of structure seen in journalism: leading with the end, hour glass structure, and "inverted pyramid". Most stories use the "inverted pyramid" structure: stating the most important information first then adding more and more information. Whilst one can quickly gather the story's gist from the opening sentence, Kosara critiques them, saying that they "peter out" and thus do not have a definitive or strong ending. Schwabish (2017) echoes this critique by saying that clear distinction must be made between a report, which offers a series of statements; and a story, which comes to a definitive ending. Bach et al (2017) say that "a good story has a rhythm, it draws readers in it immerses, but *most important it has a message to the world*" (emphasis added). Therefore, a story is different to a report.

Kosara (2017) provides a fourth type of structure not previously theorised, but seen in some narrative visualisations. These:

> *"begin with a claim or question, but do not immediately present it as a conclusion. They then present pieces of evidence. These are only tied together to back the initial claim at the end".*

As opposed to Cohn's (2013) Establisher, Initial, and Peak (EIP), this structure offers Claim, Fact, Explanation and Conclusion (CFXO). The author argues that the pattern can be seen in the news-story types of providing proof, question and long explanation.

2.3.4 Transition Techniques: Which map to show next?

The CFXO and EIP narrative structures provide a framework for the overall arc of a story. If a sequence is an ordered series of maps, a transition describes the change from one map to another. The works of Hullman et al (2013; 2017) investigate what makes a good transition.

Through an analysis of 42 narrative visualisations, Hullman et al (2013) created a framework of 5 transition types. In a dialogue transition, "a question asked in one state is followed by a visualization that answers that question ". In a temporal transition, visualisations are ordered based on a time variable. In a causal transition "one visualization state follows another to explicitly hypothesize a causal relationship". A granularity transition orders visualisations based on level of detail. In a comparison transition, either the dependent or independent variable is held constant and the other is changed. A subset of this is spatial transition where "the same dependent variable is shown for different spatial areas in sequence". The author then quantified a transition through a *transformation cost* metric, which is the difference between one map and another.

> *"Transformation cost is the total number of changes to the independent variable, dependent variable, time and level of granularity required to transform a first visualisation to a second visualisation in a state-to-state transition irrespective of the type of transition".*

For example, a transition from a map showing the population of US by state to a map of population of US based on county, has a transformation cost of one. A map showing population of US by state to a population of New York City 10 years ago has a transformation cost of 2. She does not give more details on the effect of a greater

difference within the measure (e.g. 10 years ago compared to 30 years ago). Through results of a user test, she suggests that minimising the transformation cost is preferred by the user.

Hullman et al (2017) continue in this vain. They look into the effect that of sequence order to the clarity perceived by the user. They found that a hierarchical structure (zooming in from the general to the specific) and parallelism (repeating a sequence of measures) was perceived to noticeably increase understanding. They tested the hypothesis using a sequence of thematic maps and bar charts.

2.3.5 Gap in the Theoretical Literature

These studies on narrative visualisations have been absent of cartographic literature, just as the cartographic literature has been absent of narrative visualisations. A study is therefore required linking these two fields of theoretical thought, specifically in creating a map focused narrative visualisation. This thesis attempts to link these two fields by introducing theories of narrative visualisation into the work of cartography.

The previous sections focused on the theories surrounding the creation of a sequence of maps for use in an online format. The International Cartographic Association define cartography as the "art, science and technology of making and using maps" (International Cartographic Association, 2003) . The previous discussion focuses on the design (art) of the maps, and the science behind the sequencing of maps. It will now turn to investigate the technology available to create a sequence of maps, and in particular an online cartographic data comic.

2.4 Technology of the Production of a Cartographic Data Comic

2.4.1 Existing technology to create a data comic

Due to the interdisciplinary nature of creating a narrative visualisation, it is common for the designers to utilise numerous tools and software including statistical and graphic design packages such as Microsoft Excel and Adobe Photoshop and web frameworks like the D3 Javascript library.

Zhao et al (2015) created a system allowing the user to create a data comic. This consisted of four parts: clipper, decorator composer and presenter. Other potential software this studied mentioned as potentially suitable for the creation of a data comic was Tableau's Storypoints and Microsoft Powerpoint. Graphscape, a tool based on the transformation cost theory, can automatically sequence charts (Kim et al., 2017). Some products can create a sequence of maps with accompanying text, the main components of a cartographic data comic. These include ESRI Story Map's, StorymapJS, Mapme and MapStory (Mapme, 2017; MapStory, 2017; ESRI, 2012). ESRI's StoryMaps helps to guide the user in creating their first story using a wizard. This is the process by which the interface asks the user to complete each step of a multi-stage process one step at a time. Each step is dependent upon previously entered information. Budiu (2017) says that wizards are particularly useful when a complex process needs to be completed by a novice user.

2.4.2 Possible Gap in the Technology

There has been a lack of research into how these software fit into the journalist's pragmatic challenges and specific requirements. For example, the wizard available in ESRI's story map cannot create a full story. Roth et al (2015) advocate a user-centred approach for online interactive maps. This process describes gathering feedback from target users throughout the design and development of an interface. To the knowledge of this author, the user- centred approach has not been applied either narrative visualisations or cartographic data comics.

The following chapter outlines the precise research questions which will be addressed in this thesis. The first step of the investigation will be to generate user-requirements for a data comic creator. The investigation will then analyse existing software, seeing whether they fit into these requirements. If there are gaps in the coverage of requirements, a static mockup interface will be developed fulfilling these requirements, and validated by the use of case studies.

3 Research Questions

In response to the previous discussion, this thesis commences by proposing the following research questions:

RQ1. What are the characteristics of an online cartographic data comic?

- What are the different ways in which an online cartographic data comic can be presented?

RQ2. What are the requirements for a software which will allow someone to create an online cartographic data comic (i.e an online cartographic data comic editor):

- What existing software is available for this to be carried out?

RQ3. What are the requirement/ feature deficits in the existing software?

RQ4. Do the derived requirements, when implemented into a software, allow the creation of an online cartographic data comic?

- Does the designed software fulfil the requirements of three example use case scenarios for an online cartographic data comic creator?

4 Research Framework

4.1 User Centred Design in Cartography

The proposed research method will adopt principles from the field of user-centred design (UCD). Nielsen's (1992) seminal work on the subject, also known as "usability engineering", noted a lack of interfaces that were "easy to learn and pleasant to use". The author stressed the importance of prototyping and iterative design: querying the user multiple times with partially completed products, and changing the product based on this user feedback. This approach makes it easier to implement fundamental design changes. The usability engineering model has become well used in both industry and academia. Greenberg and Buxton (2008) report that "almost all accepted papers [in the field of Human Computer Interaction] have some evaluation component".

User Centred Design has been applied in the fields of Cartography and Geovisualisation. For example, Robinson et al (2005) used three methods to receive user feedback in the creation of ESTAT, an "exploratory geovisualization toolkit for epidemiology". First users were asked "think aloud" their thoughts whilst they used a prototype. Second, a focus group revealed that a complete redesign was required for one part of the interface. A final method involved an ethnographic in-depth case study with the researcher sitting and taking notes for four months in the user's workplace. This revealed specific scenarios which the interface could address. Roth et al (2015) and MacEachren et al (2008) also use user centred design to respectively create a visual analytic software for crime data and a GIS-enabled cancer atlas.

The original usability engineering framework as proposed by Nielsen (1992) is flexible, and can be modified based on the type users and their availability for feedback. Roth et al (2015) for example outline a 10 stage process:

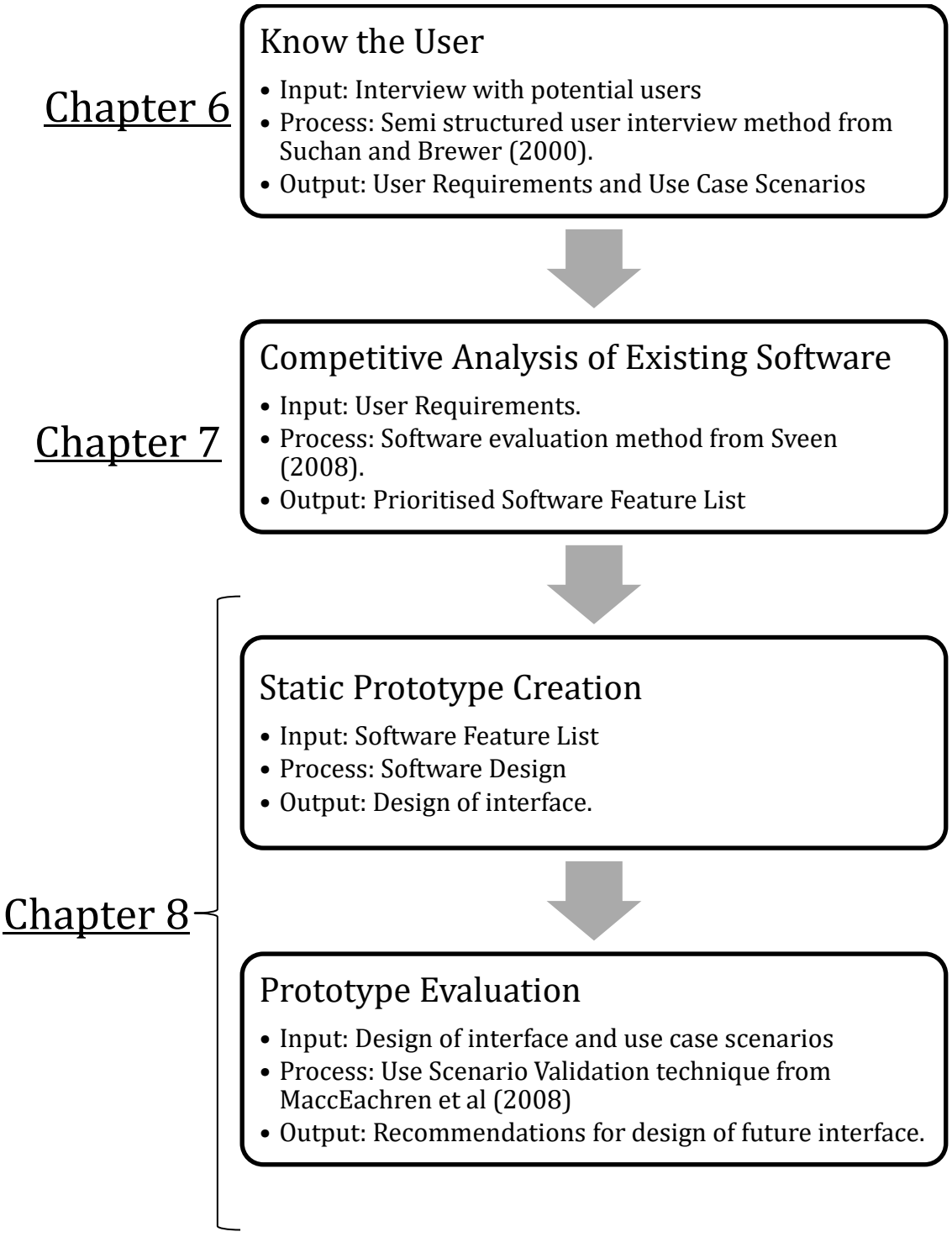
1. "Know the User" through completing a needs assessment study to establish user profiles and use case scenarios.
2. Competitive analysis: Comparing the existing software, and seeing where "unmet needs" are.
3. Setting goals: Use results from needs assessment and competitive analysis to create a requirements document/ feature list of the proposed functionality of the system.
4. Participatory Design: Conceptually designing the interface with target users.
5. Coordinated design: If in a large team, creating a product identity (look and feel).
6. Guidelines and heuristic analysis: Recruit experts during design and development to evaluate interface.
7. Prototyping: Create static or interactive mockups/prototypes/wireframes of the interface.
8. Empirical Testing: Evaluate the utility and usability of prototypes by questioning target users.
9. Iterative Design: Revise the interface based on feedback from empirical testing.
10. Collect Feedback from field use to inform future product releases.

To answer the proposed research questions, this thesis will simplify the above 10 stage framework and focus on steps 1, 2, 3, 7 and 8. This process is outlined in section 4.2.

Chapters 5 and 6 focus on steps 1 to 3, with interviews to elicit user requirements for an online cartographic data comic editor and an evaluation of candidate software based on these requirements. Chapter 7 focuses on steps 7 to 8, creating a static mockup and evaluating it through the scenario-based evaluation framework.

4.2 Proposed Research Framework

The overall methodological approach of the research is outlined in the figure below.



5 User Requirements

The following chapter outlines the methods, results and discussion in sourcing the user requirements for an online cartographic data comic creator. It will use results from expert and user semi-structured interviews to produce three outputs: a list of user requirements, three potential use case scenarios for the interface and a list of characteristics of an online cartographic data comic.

5.1 Methods in Collecting User Requirements

Since this research focuses on a cartographic interface, it has reviewed cartographic research methods, which offers considerable overlap with the user- based interface evaluation methods as proposed by Roth et al. (2015). Cartographic research methods, according to Suchan & Brewer (2000) can be split into: quantitative and qualitative methods. Quantitative approaches, uses a deductive scientific approach to test pre-existing hypothesis with the "the researcher seeks to confirm or challenge previous theory". Examples of this approach include surveys and controlled experiments. A qualitative method on the other hand uses an inductive scientific approach and generates theory based on observations. The sampling size is likely to be smaller, but the sample purposefully chosen "because they are likely to be rich in the desired information". The authors cite questionnaires, interviews, participant observation as examples of qualitative methods. The authors argue that this approach is preferred for

many research questions, especially those interested in “real-world problems” and reveals more pragmatic, practicable results.

Since the research question will generate a theory and ideas which will be used in a design of an interface, a qualitative technique was selected. Below is a discussion on the different types of qualitative techniques as outlined by Suchan and Brewer (2000) and how they could be approached in generating the requirements for a cartographic data comic editor . The section concludes with reasons behind why the semi-structured interview method was chosen as the most suitable technique.

5.1.1 Qualitative Approaches in Cartography

5.1.1.1 Verbal Data Acquisition:

This term refers to a range of methods which use open or closed questions with one or many participants over one or many sessions to get information.

A *questionnaire* uses closed questions with participants selecting from responses by the researcher or open questions, with participants responding "on their own terms". (Davies and Medyckyi-Scott, 1994) sent out a questionnaire to GIS practitioners in order to research an effective GIS user interface. Another example is the Stack Exchange survey to see the state of the field of various programming related topics, including the correct pronunciation of GIF (Economist, 2017).

A possible research method in gathering requirements for the online cartographic data comic interface is that a questionnaire could be sent out to a range of journalists, data journalists, and academics asking what software they use when designing a map and the challenges they face. This will be beneficial in generating a range of responses from

many countries and backgrounds. A pragmatic problem is getting people to respond to the questionnaire. People are more likely to respond if the questionnaire has simpler and fewer questions, although this will compromise on the detail of the data.

Interviews are a social interaction where the researcher asks the interviewee(s) a series of questions. Like questionnaires, there are varying degrees of structure in an interview. In a focused interview, also known as "semi-structured", the researcher uses an interview protocol/guide to ask questions. Lofland et al (1984) term this a "guided conversation". The advantage of this approach is that it allows the researcher to go into more depth on a topic, and can respond more freely to responses. Roth et al (2015) point out that the researcher needs to take care that the participants represent the target uses and the results are time-consuming to analyse.

A *focus group* is a type of interview with a number of people interviewed at the same time. This research could ask a variety of researchers concerning their experience with data comic creation software and discuss their responses as a group.

Think-aloud : "Participants voice their internal running dialog simultaneous with a stimulus situation" (Suchan and Brewer, 2000). This research could have asked the participant to create a data comic at the computer and talked the interviewer through how the experience in real time.

5.1.1.2 Direct Participant Observation

Another form of qualitative technique is direct observation where the researcher participant performing their daily tasks. For this research, the researcher could sit in a data journalist's office and observe them creating narrative visualisations. However, as the intended interface will perform only a small set of tasks, it is was highly probable

that the researcher would spend many hours observing actions which have little relevance to the research questions.

5.1.2 Chosen Method: Semi-Structured Focused Interview

A semi-structured interview technique was chosen to generate the user requirements. This follows previous work by Roth et al (2015) who used a "needs assessment interview" to generate requirements for crime analysis visual analytic software. They posit that this technique is beneficial when the user requirements are poorly known and the software will "support a small set of user profiles". Both these cases apply to the research question due to the relatively small number of data journalists in Austria, the location where this thesis was conducted. This thesis will take a qualitative data analysis approach and code the interview responses based on the research requirements. The precise interview approach will be discussed in the next section.

5.1.3 Chosen Approach

Six interviews were conducted. Two participants were academics working with spatial data. They had no previous experience of creating narrative visualisations themselves, although were involved in a project where the result was presented as a narrative visualisation. Four were data journalists at national media outlets in Austria and had experience creating narrative visualisations with maps. Three were recruited through contacts of the thesis supervisor, three through the snowballing technique of asking participants for further contacts (Flowerdew and Martin, 2013). The interviews were conducted in a quiet room at the participant's place of work and lasted between 40 and 60 minutes. The interviews were recorded at the participants' permission onto a

handheld recorder, with partial transcripts taken immediately after the interview. The interviews were conducted in English, and all participants were native German speakers.

The researcher had a list of key questions for discussion and, based on the work on Tolochko (2016), was split into five sections: (1) introduction questions (including time and recording restrictions); (2) Design process of Stories (how they create narrative visualisations); (3) User response to their narrative visualisations (do they record the user responses and do they track them or not) (4) Knowledge of narrative visualisation theory (including whether they have seen other examples of narrative visualisations and what choices they have); and (5) A question on the possible next steps of narrative visualisations. The interview protocol can be found in appendix 11.1.

The interview responses were coded based on the four research questions. Whether the response revealed: i) the characteristics of an online cartographic data comic (RQ1) ii) a requirement for the data comic creation software (RQ2) iii) gaps in software/ reaction to an existing software (RQ3) iv) a use case scenario (RQ4). The results are presented in the following section.

5.2 Results & Discussion of User Interviews

The results reveal:

i) Characteristics of a data comic (RQ1), a full discussion of which are found at the end of the chapter.

ii) The software requirements (software evaluation criteria) for an online cartographic data comic editor (RQ2).

5.2.1 Software Requirements

A discussion of the software requirements as revealed by the interviews are discussed below. After the responses coded with “user requirements” were collated, these were further sorted into six groups. Overall, 16 software requirements were created from the results and are presented in appendix 1.1.

5.2.1.1 Responsive Design

For a data comic to be effective, it must be able to be viewed on a mobile phone. Two of the participants noted that most of the readers accessed their website on their mobile phone. One respondent noted a mobile –first approach: "everything [we in our journalism team] do we scratch on mobile templates… and then we scale up". This anecdotal evidence supports the trend seen in the Reuter’s state of news survey (Newman et al., 2016). This indicates the importance of a responsive design of a cartographic data comic.

Some unique challenges are posed for creating responsive maps. First, it is difficult to show a map of a large area (for example the world or continent scale), due to the small screen size. Second, one participant noted the particular problem posed by Austria, a country which “has the wrong shape”, because it has long west to east axis compared to

north to south. This makes its representation particularly challenging. In addition, the participant also mentioned the advantage of *scrolling* vertically rather than swiping horizontally or clicking on a button

> *"If you want to design your cartographic comic thing, do not make them click horizontally but scrolling is much more native. They are used to that mode of navigation and will just scroll by".*

This technique is often called "scrollytelling" (Kosara, 2016). Another participant gave a more nuanced answer in response from being shown an example of a narrative visualisation with scrollytelling:

> *"we've thought about that but we'd prefer not to hijack scrolling … yeah this is fine but on the other hand if we just put the text and the map next to each other and just do the same we would probably annoy people less and probably not lost a lot of effect… Our CMS people would be a bit closer to killing me if I [used scrollytelling]… I did that once and I was told never to do it again… it involves writing custom Javascript which disables all of the other front-end".*

This means that the scrolling should fit with the scrolling of the overall page.

One participant said they did not consider responsive design in their data visualisations: "it doesn't really make sense because it's simply just too small of a display". He noted though that this was a "problem" but felt like it was not worth the effort in investing in responsive design.

Another factor to consider particularly with mobile phones, – with its slower processing ability and internet connection- is speed. A participant reported that most people switch pages if they need to wait more than a few seconds. For this comment they were possibly inspired by Nielsen (1993) who noted three important limits to the speed of a

webpage : 0.1 seconds makes the user feel that the system acted instantaneously, 1.0 seconds is the limit for the user to feel uninterrupted, 10 seconds is the limit for keeping the user's attention.

From the interviews the following user requirements related to responsive design in cartographic data comics were created:

For a cartographic data comic (RQ1):

- Mobile ready maps produced
- Vertical scrolling of created maps
- Horizontal and vertical maps.
- Fast loading of comic.

5.2.1.2 Sharing on social media

A data comic must also be shared. The transitions from Web 1.0 to Web 2.0, with the ability to share and upload your own data is reflected in the interviews. Four participants had active Twitter Channels, and posted their narrative visualisations on them. Some also posted to the official channel of the media group.

However, all four of the narrative visualisation designers did not have a methodical way of tracking the responses, and did so on an ad-hoc basis such as looking at the comments or receiving emails.

> *"We do not currently measure interactions… I've been promised that for a year or so [but it was not implemented]".*

However the participant noted that it is not "a huge priority because we have this huge community and if there is something wrong they will yell at us". However, the comments do not necessarily relate to the visualisation

"the first few comments will discuss the article and then the rest will be on the general topic, for example people moving away from the countryside to the city"

Muehlenhaus (2014) states that despite the availability of HTML5 standards, which offers the possibility of interactivity, static images are widely shared due to their simplicity. One participant for example said that they created an animated GIF map: "just another adaptation of the story but tailored for social media". This was the "the best Tweet [he] ever had" as it was his most shared Twitter post. However, they did further mention that the success of the animation "depended much more on the story itself rather than the technology used".

The following user requirements related to social media in cartographic data comics were created:

For the cartographic data comic editor:

- Ability to show the result of the interface on social media: (Twitter and Facebook).

5.2.1.3 Sequencing

The next topic addresses the need for a walkthrough, which can guide the user in creating a sequence of maps. As shown in chapter 2, authors have proposed two main structures of narrative visualisation: CFXO and EIP (Cohn, 2013; Amini et al., 2015).

None of the participants knew a theoretical technique in arranging a sequence. One participant said that the "story comes out of the data", another said that, when designing a narrative visualisation, they had two or three main points and then:

> *"I think the structure more or less builds itself... how I can get the viewer to this point, what does he need to know beforehand and what maybe is the consequence for the core point that I also want to show...See this hexmap. I knew I wanted to show this hexmap, and the question is what should the people know so they can understand this hexmap"*

Another had formal journalism training and, when prompted, noted that "we assume that time is precious" and therefore "of course the most important point comes first". The structure, he said, was "journalistic intuition". This result shows a lack of formal guidance in sequencing, but also implies, that guidance in sequencing is not considered important since, as one participant explained, it is "common sense".

It is interesting that the theory seems to disagree with the practice. Although many narrative visualisations follow similarities in formal structure, participants could not recall any of them. This equally applied for those participants who created and did not create narrative visualisations. Although this implies that no sequencing guidance is required, this author included it in the evaluation criteria. This was due to the strong theoretical framework, as discussed in section 0, arguing that a good structure helps to create an effective story.

From this discussion came the following evaluation criteria for the cartographic data comic editor:

- Ability to guide the user in different narrative structures.
- Ability to tell a story.

5.2.1.4 Visual Design

A data comic should have a distinct visual style. Many publishing houses, companies and universities have their own visual design scheme and styles, with a newspaper's website having a content management system to allow the pages to be organised.

Comic strips often have distinctive elements. For example the font on an XKCD comic the colours in Dilbert. One participant said that for the novice user, colour guidance, for example using ColorBrewer (Harrower and Brewer, 2003) would be a useful addition.

> *"What people I think are really grateful for is help with colours, just links… I'm sure you know Color Brewer. I at least always struggle with colours on maps. I think it makes a big difference if something looks great or looks terrible if you've got the colours right or things like that".*

For an effective cartographic data comic therefore, an ability to add and use a distinctive style would be beneficial. This style should be able to conform to the cartographic best practices, such as those used for ColorBrewer (Harrower and Brewer, 2003).

One participant mentioned the ability to add annotations (text, arrows, highlights) to the map, which could help to tell the story. Another noted:

> *"Just assume that the reader knows nothing about how to use a special type of visualisation. It means that scatter plots are pretty useful for us but most readers will not know how to read it… that's why we use annotations, the annotation layout in visualisations are hard work but it's our job as graphics editors. ".*

This idea is similar to the symbols library used in DataComicsJS (Zhao, Marr and Elmqvist, 2015)).

The following requirements are thus proposed:

For the data comic:

- Each frame fits in with an overall visual theme.
- Annotated with highlighting, arrows and boxes

For the cartographic data comic editor:

- Ability to use colour themes
- Ability to add annotations
- Ability for the output to be a comic design (precise definition is found in section 5.2.3).

5.2.1.5 Ease of Use

Since most of the target users will be non-programmers a cartographic data comic editor should have a high usability (be easy to use). The following section addresses the specific requirements related to the ease of use of a cartographic data comic editor.

With the question: "how would a non-programmer create a narrative visualisation?", many of the participants had a long pause, indicating they lacked knowledge of a way to easily create a sequence of thematic maps. Software was available to create a map without programming- for example openJUMP, datawrapper and myMap. However, they were not aware whether these offered the ability to create a sequence of maps. Participants gave a variety of responses to the possible tools to create a map, indicating there is no *definitive* one. Two of the data journalists replied that they had trained some non-technical journalists to use a software to create maps and graphs. D3, a javascript library which specialises in data visualisation and commonly used for narrative visualisations is known for its steep learning curve.

Describing how they created a specific story, one participant noted: "I think the story itself took less than a week before publication but it was one of the quicker big ones, we prefer to spend a little more time on them".

They later acknowledged that, due to the investigative nature of their stories, they had “a lot more freedom” compared to traditional journalists when they were published. One estimated that “if I sat down and did nothing else it would take maybe a week... but it’s quite time consuming [often due to the long planning stage]”.

When prompted, two of the participants noted they used wizards, albeit only rarely. One replied “"Not so often, we’ve just changed our statistics from SPSS to Excel. I sometimes look into some of the tutorials how to do some of the specific statistics in Excel". Another, "I usually use it when I'm using [the software] for the first time”. This tentatively suggests that a wizard may be useful when a user is creating a cartographic data comic for the first time, but a user familiar with the system should not be forced to use one.

From this the following requirements were created for the cartographic data comic editor:

- No existing knowledge of programming
- Usability to be enhanced using a wizard.

5.2.1.6 Export Functions

How the final map should be seen, and the specific technologies required for a data comic, are discussed in this section.

There were differences of opinion in the most suitable level of interaction within a narrative visualisation. One participant remarked that they preferred their narrative visualisation to have some level of interactivity, so the expert user can independently analyse the data. Moreover, the visualisation can be personalised so people can for example zoom in on a place of interest, such as their home town: "the nearer we can get

[the data concerning the user's house] the better it is". Much of the interactivity used by the participants for their own narrative visualisation was quite basic, for example hovering and clicking next to progress the slides. One participant mentioned that most users do not use interaction:

> *"We also have to acknowledge that most people do not click on buttons. There has been an article from Gregor Aisch [a data journalist], making everything clicky is the kind of thing you would do in 2013, but in 2017 we now tell stories like tell what we found in the data and if you want to you can dig in yourself but adding interactivity costs a lot of resources and making it look and feel good on every device". "It's kind of lazy if you put in the data visualisation and say 'just find the story yourself".*

This indicates that extra effort to implement these features may not achieve greatly beneficial results.

Muehlenhaus (2014) stated that static maps are possibly most likely to be shared. One participant said that though they used Adobe Photoshop to create a GIF it was very difficult to change the duration of each slide and the ability to loop the animation.

> *"One of the ways I usually use when I tweet out a story, animate several different steps and put it into a GIF… usually it is a pain in the arse because I usually use Photoshop for it and it never really works the way I want it to… I exported a bar graph from Excel and made it pretty in Photoshop… but it didn't work properly… it's a lot of work actually".*

Another used the R statistics package but said it was difficult to export it in a file size suitable for online sharing (R Core Team, 2013).This result does not imply there is *no* function, rather than any possible function is hidden or difficult to use.

Given the previous discussion the requirements: a cartographic data comic can be in the following formats:

- Web application using HTML, CSS, and Javascript web technologies.
- Animated GIF

Therefore the "perfect" data comic editor would have the following export functions:

- Web application of an interactive map using HTML/CSS.
- Creation of a GIF
- Creation of an interactive *sequence* of maps using HTML/CSS.
- Ability for the output to be a cartographic comic design (precise definition is found in section 5.2.3).

5.2.2 Use Case Scenarios

Following the work of Nielsen (1993) and Roth et al (2015), use case scenarios were constructed for an online cartographic data comic editor . These scenarios label the potential ways in which the cartographic data comic editor can be used. They have been designed so they will use many of the requirements listed in the above software requirements. The scenario structure is based on Ambler (2014):

1. I am a data journalist who want to quickly show a sequence of maps which I have already created and annotated them. The sequence will be shown online and in a responsive website.
2. I am a data journalist who wants to share a snippet of a news story on social media using a GIF.
3. I am a journalist with little experience of using software who wants to structure and present a sequence of thematic maps online.

5.2.3 Characteristics of a Cartographic Online Data Comic

This section will provide an answer to research question one by outlining precise characteristics of an online cartographic data comic:

RQ1. What are the characteristics of an *online cartographic data comic*?

- What are the different ways in which an online cartographic data comic can be presented?

Since an online cartographic data comic is a subset of a data comic, it will adopt the characteristics of a comic as outlined in Zhao et al (2015), then specifically a data comic as outlined in Bach et al (2017). A discussion and proposal of a definition of a cartographic data comic will follow based on the interviews. Characteristics of an online-cartographic data comic will then be proposed.

5.2.3.1 Data Comic Characteristics

In defining a cartographic data comic, it is helpful to utilise the theories set out in chapter 2. The basic model of the visual design of a comic is proposed by Zhao et al (2015):

> *A comic consists of a sequence of panels organized into one-dimensional tiers (or strips) and separated by gutters, or spacing, between the panels [15, 29].*

Bach et al (2017) added their own definition for a data comic, which contain the following four points:

1. Visualisation: The charts and graphs (data graphics) on a comic.
2. Flow: A series of panel. One message per panel.
3. Narration: Words which adds context to the data.
4. Words and pictures: Containing both words and pictures.

From these two definitions it can be seen that a data comic must consist of a sequence of separated panels. Each panel contains a data graphic which displays one message. Words are added to the panels to add context to the graphics, and creating a story.

5.2.3.2 Cartographic Data Comic Characteristics

What is unique about a cartographic data comic? The results of the interviews, as shown in section 5.2.1 , revealed a few possible characteristics on what made a cartographic data comic unique. These included the ability for maps to have either horizontal or vertical orientation, the use of thematic maps over simple locator maps; and the ability for different parts frame to be annotated with text, highlights, arrows and boxes.

5.2.3.3 Online Cartographic Data Comic

Though many narrative visualisations appear online, they do not necessarily need to be online. A data comic for example, can be viewed on paper. An online cartographic data comic therefore must include at least basic user interaction, for example a button press or scroll. They should be responsive, with the ability to be viewed on a range of screen sizes. Each frame should fit with the overall branding of the media outlet and the maps shareable on social media such as Facebook or Twitter.

A list of elements of an online cartographic data comic can be seen in appendix 11.2.

5.2.3.4 What are the different ways which an online cartographic data comic can be presented?

For the answer to this question I used the export functions as discussed in section 5.2.1.6. This showed that the two main methods of showing an online data comic were for presentation as a web application, for example using HTML, CSS and Javascript

technologies. The second type is an animated GIF, which the participants commonly used to tell the change in an indicator over time.

6 Software Evaluation

6.1 Methods of Formal Software Evaluation

This chapter implements the second part the research framework from 4.2 by adapting Sveen's (2008) software evaluation approach. The author argues that adopting a formal evaluation framework is preferred over an informal approach since it reduces evaluator's prejudice and results in a wider range of software considered. The author proposes a "tailored" method, which adapted three popular existing methods. This tailored method is as follows:

1. Define the evaluation criteria. This can be split into two steps:
    a. Defining the use case scenario. That is how the software is intended to be used by the people. Similar to "user stories" in the agile software development framework (Ambler, 2014).
    b. Defining the specific requirements of the system. What should the characteristics of the system be? These requirements are further split into i) what the software will *do* (functional requirements) and ii) the software *characteristics*.
2. Gather Candidate Projects and create a list of potential software.
3. Initial filtering. From the large list of candidate software, an initial filtering is done through selecting a number of the functional requirements.
4. Gather data on selected candidate projects and present them using identity card and an evaluation sheet.
5. Rank the project based on the requirements.

6.1.1 Adapted Approach

An important difference between the implemented approach and the one proposed by Sveen (2008) above is that this thesis focuses on functional gaps in existing software,

whereas the one above was designed to select the "best" software based on the situation. Therefore the final step (step 5 from above) will change: instead of ranking the software, this research will look for a gap in the user requirements.

Chapter 5 implemented stage 1 of the schema and found specific use case scenarios and requirements for the system. The following chapter implements stages 2 to 5. 46 candidate software were initially gathered, filtered down to 19 based on the ability to display a sequence of maps. These 19 were evaluated based on the user requirements. From this list, the user requirements deficient in the candidate software were prioritised on the new feature list.

6.2 Results from Software Evaluation

6.2.1 List of Candidate Software

6.2.1.1 Unfiltered List of Possible Candidates

A list of 46 candidate interfaces which could create maps, presentations or GIFs was created. The list was initially populated using feedback from the interviews and the answer to the question: *If I told you or a member of your team to create [a narrative visualisation], what software would you use?*

Additional candidates were added through a web search. Four websites in particular were used. First, Product Hunt, a website where people can upload and share links to new products (Product_Hunt, 2017). The keywords "storytelling", "maps" and "GIF" were searched and sorted by relevance, with, depending on the relevance the first 2 to 5 software selective. Second, alternativesTo.net (alternativeTo, 2017), a website which suggests alternative software. "ArcGIS", "QGIS" and "Tableau" keywords were searched,

since they were commonly used software by data journalists. Third, software from the websites newsroom.tools and journalismtools.io were used to populate the list further, in particular their sections on "storytelling" (Newsroom.tools_Team, 2017; Tow Knight Center, 2017).

The 46 candidate tools produced by this technique are shown in appendix 11.4.

6.2.1.2 Filtered list of Candidates

Candidate software was filtered based on whether the output of the product could display a sequence of maps. Two additional products (Datawrapper,R) were chosen since they were cited by more than one interview participant. Magrit was additionally chosen as it could provide an open source alternative to Datawrapper.

The 19 candidate products which will undergo a more thorough evaluation of features are seen in Table 1.

ArcGIS	*Leaflet*	*PowerPoint*
D3	*Magrit Thematic cartography*	*QGIS*
Data wrapper	*Mapbox*	*R*
DatacomicJS	*Mapme*	*StorymapJS*
ESRI Story Maps	*MapStory*	*Tableau*
Flourish	*Openlayers*	
Giphy	*Photoshop.*	

Table 1: Candidate Software chosen for more thorough examination

6.2.2 User Requirement Gaps in Candidate Software

This section will address step 5 in the tailored approach (section 6.1): looking at the gap in the functional requirements and export features. For each software, each requirement was given a number between 0 and 2 indicating how much it fulfilled the requirement: 0 was the worst; 2 was the best. Appendix 11.5 shows the full list of

filtered software with calculated scores. The results of the software inspection were collated and analysed using Microsoft Excel. The scores were at first sorted by software, to see if any one candidate software addressed all of the requirements. It then sorted the scores by user requirements, looking to see if any one user requirement was lacking in the scores.

Each requirement was given an abbreviation to allow them to be easily identified. These abbreviations are described in Table 2 .

Code	Criteria	Code	Criteria
Responsive Design		**Map Visual Design**	
M1	Responsive Design produced	V1	Ability to use themes
M2	Vertical scrolling of created output	V2	Text Annotations
M3	Horizontal and vertical maps can be created	V4	Symbol Annotations
Sharing		**Ease of Use**	
S1	Share on social media	E1	Programming requirements
S2	Fast loading of maps	E2	Walkthrough/ Wizard
Export Functions		**Sequencing**	
Xp1	Export as a single Interactive Map	Se1	Ability to guide the user in different narrative structures
Xp2	Creation of a GIF	Se2	Ability to output a sequence
Xp3	Data Comic Design		
Xp4	Creation of an interactive *sequence* of maps.		

Table 2: User Requirement Codes

6.2.2.1 Sorting by Software

The scores given to each software were viewed as a stacked bar graph. A perfect software would display 2s and 1s in every requirement, which is not the case since each

software has at least requirement which is not met. This indicates that there is no software available that will address the gap, and hence a new one could be developed.

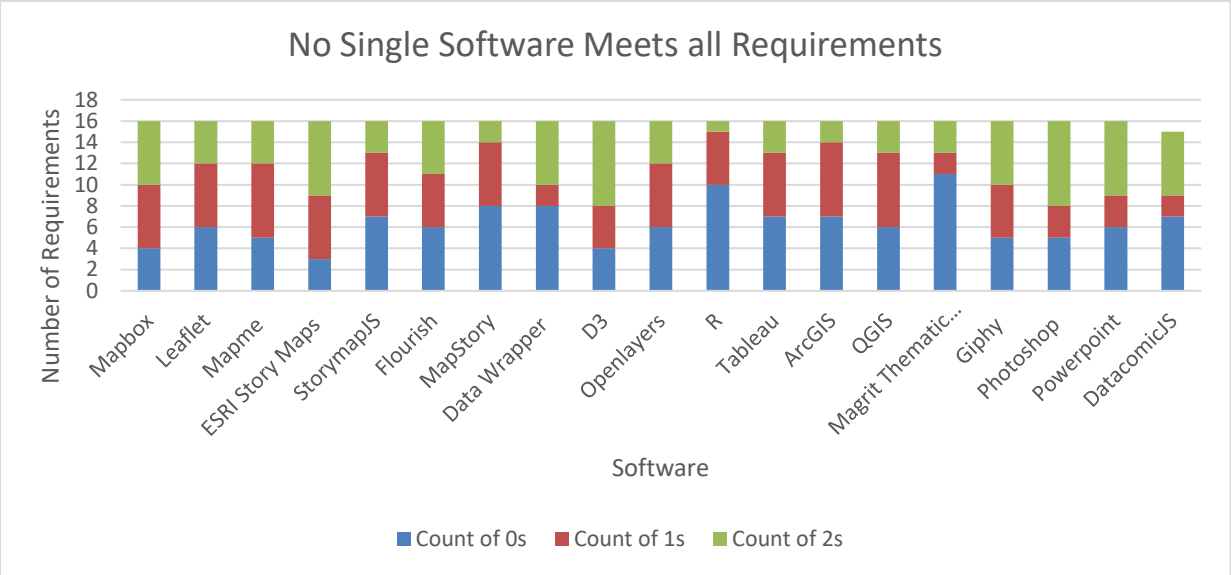


Figure 6-1 User Requirements for each candiadate software, sorted by score

The following sections 6.2.2.2 and 6.2.2.3 reveal the exact feature deficits in the existing software.

6.2.2.2 Sorting by feature requirement

Figure 6-2 shows the score of each requirement, averaged across the 19 candidate software. This will shows how well each requirement is served in general by the existing software.

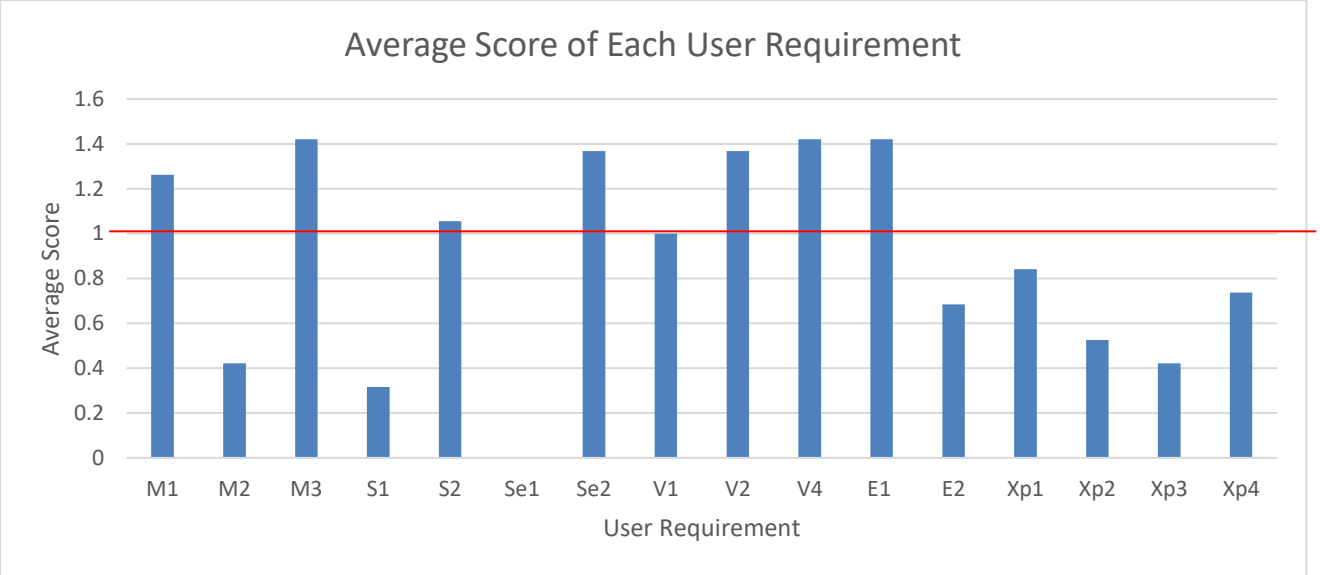


Figure 6-2 Average score of each user requirement across candidate software

Requirements were grouped according to whether they were well served, partly served or poorly served by existing software. These are summarised in Table 3. This shows that exactly half (8/16) of the requirements were found to be well served, 4 were partly served and 4 poorly served. (i.e had an average of below 0.5).

Requirements which are well served (above 1):	**Requirements which were below the line (below 1):**	**Requirements poorly served (below 0.5):**
M1	E2	M2
M3	Xp1	S1
S2	Xp2	Se1
Se2	Xp4	XP3
V1		
V2		
V4		
E1		
Count: 8	*Count: 4*	*Count: 4*

Table 3: Requirements sorted by how well they are served by existing software

6.2.2.3 Distribution of Feature requirements.

Figure 6-3 shows the distribution zeros, ones and twos for each user requirement. This is a more detailed description of the graph above and shows how well the user requirements are served in the software where they are available. A high percentage of 2s shows the requirement is served very well in the software. A high percentage of 1s shows that, where available, the software did not fulfil all of the desired attributes of the requirements. A mixture of zeroes and twos (e.g. Xp1 – export as a single interactive map) indicate that the feature is rarely seen, but if it is seen, it is well implemented. This is seen in the requirements S2 and V2.

Six criteria had 60% of zeros – not served at all by a significant percentage of the software: M2, S1, Se1, XP3, Xp2. The two lists are very similar, further supporting the idea that there is a need for a software to address these specific requirements.

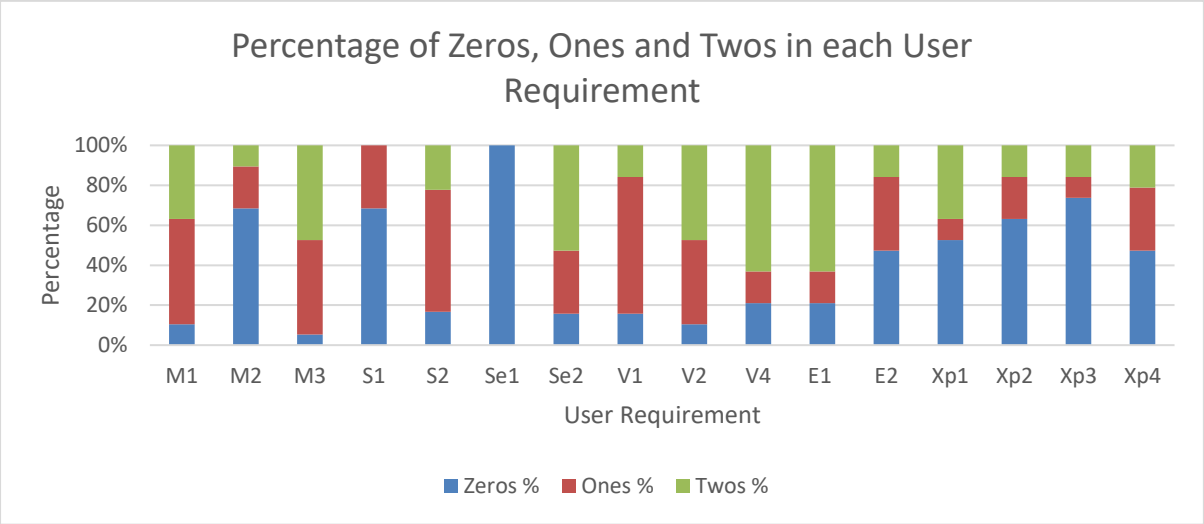


Figure 6-3 Distribution of 0, 1 and 2 scores for each user requirement

6.3 Discussion of Software Evaluation

This discussion will directly answer research question 3:

RQ3. What are the requirement/ feature deficits in the existing software?

6.3.1 List of Requirement deficits

The above analysis showed that four requirements (in no particular order) were poorly served by existing software:

1. M2: Vertical scrolling of maps.
2. S1: Share on social media
3. Se1: Ability to guide the user in different narrative structures
4. XP3: Data Comic Design

Other deficits were also seen but these were of a lower priority:

1. E2: Availability of a walkthrough.
2. Xp1: Export as interactive map.
3. Xp2: Creation of a GIF
4. Xp4: Creation of an online sequence of maps.

6.3.2 Utility of Requirements

Initial filtering was performed according to whether the software could produce a sequence of maps (Se1). Therefore, this was not shown in the user requirements although it is a high priority requirement.

The two user requirement lists above will be compared to the results from the interviews to discuss their utility. This will help determine a holistic priority of the for a feature list of a proposed interface. The designed interface will aim to increase the

usability of the high priority requirements, possibly at the expense of the usability of a lower priority requirement.

First, two lists show a lack of an interface available to guide the user in creating a story for a narrative visualisation. No interface referenced narrative structures and the CFXO and EIP the theory of transition costs. One reason for this may be the relative new dates (and obscurity) of theories. Graphscape (Kim et al., 2017) has incorporated the transition cost theory to automatically create a sequence of charts, but not maps from a structured data set. If narrative structures are as common in narrative visualisations as the literature suggests, incorporating their ideas into software would be a useful step.

Second, there is a deficiency of walkthroughs and wizards to help the novice the user create a narrative visualisation. The adoption of these techniques could help novice users, who are short on time to create narrative visualisations. Esri's Story Map's and Carto's Odyssey.js both use a user onboarding technique to help the user select the type of narrative visualisation. However, neither process creates a full narrative visualisation. Therefore, one which incorporates this technique is recommended.

A further omission is the availability of built-in functions to easily share the finished sequence on social media. Due to the importance of social media to the number of readers of a narrative visualisation, the ability to easily share it is important. Sharing on social media is still limited to images and videos. Therefore, of the programs which had a social media function, most allowed only to share a link to the narrative visualisation and not embed it directly. The advantage of a GIF is that it can be seen directly on a social media feed. Giphy.com is a good example of how to share the result of a visualisation to social media.

The lack of vertical scrolling capabilities was surprising, given the importance given by one of the researchers and the relatively simply way this feature can be implemented. Some products have this feature, but most offer it only on desktop, and seem to "hijack the scrolling" which is neither recommended by a participant or Kosara (2016).

Only DatacomicsJS, Photoshop and PowerPoint could output in comic design (XP3), and of these only the result of DatacomicJS was able to be shown directly online. (Bach et al., 2017) note that data comics is still a new field and it is therefore possibile that software has not caught up with the recent theory. It could also indicate a lack of desire but since comics are popular on the internet and not too dissimilar to existing narrative visualisations, this seems unlikely.

There was a further lack of export functions. No software was able to output to all of the requirements. What particular was lacking was export to a physical printout. This is to be expected given the trend away for media to be viewed on screens rather than paper. One participant only used pen and pencil to design the output, so perhaps the ability to output the map for offline use may help in the design stage of a narrative visualisation (for example in the creation of story boards). Only 50% of software could export as a web application and only 40% to a GIF. These exporting functions will be given priority because of a general lack in other things.

6.3.3 Prioritised Feature List

It is important to prioritise a feature list due to the "competing forces" of utility and usability (Roth, Ross and MacEachren, 2015). This describes the tradeoff between the number of user tasks which the interface can support and the usability of the system. A

system which supports a smaller number of use requirements is likely to require less training compared to a system that supports a large number of use requirements.

A prioritised feature list based on table 4 in Roth et al (2015) was then created based on a combination of the level of deficit in existing software, and the utility of each requirement discussed above:

1. Se1: Ability to guide the user in different narrative structures.
    a. E2: Seen through a walkthrough of the creation of a story.
2. XP3: Data Comic Design.
3. S1: Share on social media.
4. Xp1: Export as web application.
5. Xp2: Creation of a GIF.
    a. Ability to change the time of each frame.
6. M2: Vertical scrolling of maps.

The next chapter is a description of the creation and evaluation of a static mockup which aims to fulfil all user requirements of chapter 5 but has a particular focus on the prioritised feature list above.

7 Static Mockup Creation and Evaluation

This section, in accordance to third and fourth stages of the framework proposed in section 4.2 focuses on the creation and evaluation of a static mockup intended to help the user create an online cartographic data comic. The design is built upon the user requirements created in chapter 5 and prioritised feature list created as a result of the software evaluation in chapter 6. Screenshots are provided in section 7.2.

7.1 Method of Static Mockup Evaluation

The methods are split into the mockup creation method and the interface evaluation method.

7.1.1 Static Mockup Creation Method

Static mockups, as opposed to dynamic prototypes or a functional system were developed. This was chosen since they offer more flexibility, and their design can be easily modified based on results of evaluation.

Mockups were created using the Balsamiq Mockup Web Application (Balsamiq, 2017). This website was chosen since it allowed for a static mockup to be developed and easily modified based on evaluation, using their graphical user interface. An advantage in this particular software is that the created wireframes have a comic-like look and feel, similar to the final intended design.

9 screens were developed based on the feature list from section 6.3.3 and are briefly described below. A further description of the prototype, with accompanying screenshots is found in section 7.2.

1. Homepage screen. This will direct the user to either the story guidance or to the cartographic data comic editor.
2. Story Tutorial. Tutorial guiding the user to create a story and output it into various formats using either the EIP or CFXO technique. The full tutorial questions and guidance can be seen in appendix 11.7.
3. Comic strip editor. Designing the story – this is the overall view of the story with options to edit each individual frame.
4. Theme Settings: Setting the overall "look and feel" of the comic through changing the colour scheme and fonts.
5. Frame Editor: Editing individual frame.
6. GIF Publisher: One of the export functions. Exporting the design as a GIF.
7. Iframe Publisher. One of the export functions. Exporting the design as a web application / iframe.
8. Mobile Phone preview: How the data comic will look like on a mobile telephone.
9. Desktop preview – displaying how it will fit in within the content management system of a newspaper's website.

7.1.2 Static Mockup Evaluation Method

Roth et al (2015) organise interface evaluation methods into three categories. Expert based methods which use input from consultants in interface design and evaluation. Examples include heuristic evaluations and cognitive walkthroughs. Theory based methods are performed by the designers themselves, who evaluate the design through a theoretical framework. User-based methods, such as those outlined in chapter 5 ask for feedback from a representative set of target users.

The authors recommend a “convergent approach” by using methods from each category but emphasise the importance of user-based methods. Since a user-based method was adopted to generate user requirements, a different evaluation technique is preferred to broaden the investigation. A *scenario-based design,* theory-based method was chosen. In this approach, the designer creates a user story describing the context and objectives of a hypothetical user. The designer then uses the system from the point of view of this user and scenario. MacEachren et al (2008) implements this approach in the context of the creation of a GIS-enabled cancer atlas. This research will use the use case scenarios and user requirements from chapter 5 since these are based on examples from actual potential users.

7.1.3 Chosen Evaluation Technique

The static mockup is evaluated through 3 use case scenarios set in a journalist’s office. They have been designed to evaluate whether the user requirements from chapter 5 have been met. All of the requirements and 3 of the 6 export functions are included in these use case scenarios.

The next two sections will present and discuss the results from this evaluation method.

7.2 Results from Static Mockup Evaluation

7.2.1 Background: Malaria Atlas Project

The first two of our scenarios feature Bob, a hypothetical data journalist working for the fictional "Vienna Daily News" Newspaper. Bob has relatively high web and computer competency and is able to create maps using simple map tools such as google Charts,

dataWrapper and myMap. Due to the pressures of journalism, Bob needs a quick way created narrative visualisations.

Bob has received a press release from Malaria Atlas Project (Malaria Atlas Project, 2010). The press release contains information about the number of infections of malaria in Africa between 2000 and 2015. He would like to create a narrative visualisation about the main story detailed in the press release: Bed Nets are largely responsible for the 50% reduction in malaria infections between 2000 and 2015.

Bob has created a series of maps in QGIS (Appendix 11.6) based on the data from the website and would like present the story as a narrative visualisation. Bob has decided to use the cartographic data comic editor for this purpose.

Three use case scenario from section will be addressed:

1. To create an interactive GIF showing a time progression of the charts.
2. To create a longer form of narrative visualisation or data comic which will allow the user to scroll down and interact with the data on their own terms.
3. A third scenario introduces Thomas, Bob's less technically aware colleague: who would like use the maps Bob has already created to create his own online cartographic data comic.

7.2.2 Use Case Scenario 1: Animated GIF Creation

In the first scenario, Bob want to create a simple animated GIF of the time progression of between 2000 and 2015. This simple story will be in the style of CFXO.

This use case scenario outlines the following user requirements:

* denotes a "priority" user requirement as outlined in section 6.3.3.

- Xp2: Creation of a GIF *
    - Ability to change the duration of each frame *
- S1: Share on social media *
- V1: Ability to use themes
- Se2: Ability to tell a sequence of stories.

7.2.2.1 Welcome Page

First, the user is taken to the welcome page. On this page, the user is given two choices: either to go to a walkthrough or straight to the editor. Since Bob is a confident computer user and storytelling, he chooses the cartographic comic editor.

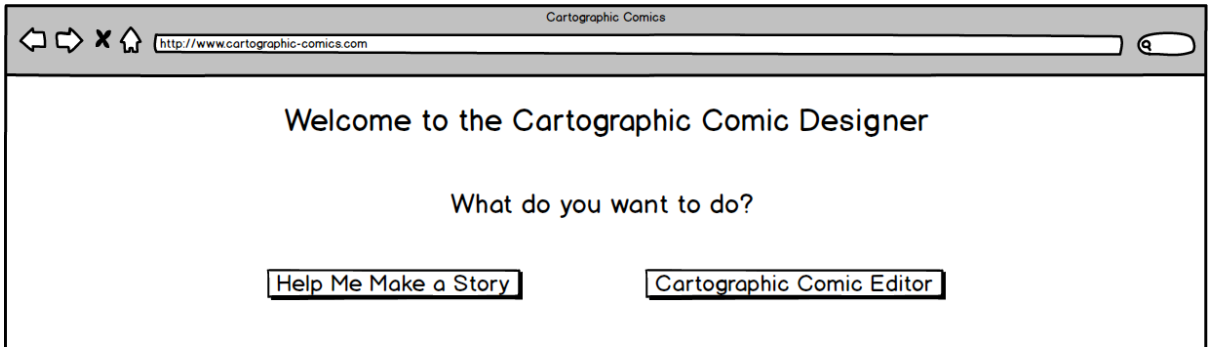


Figure 7-1 Welcome Page for Cartographic Data Comic Editor

7.2.2.2 Comic Strip Overview (Se2)

The page which appears is the central focal point of the comic strip editor. This includes options to add a new frame, or clone an existing frame, and the text and image size.

Bob chooses to create a new frame by clicking the “add frame” button on the right of the previous frame. He hovers on the first frame and selects “edit frame”.

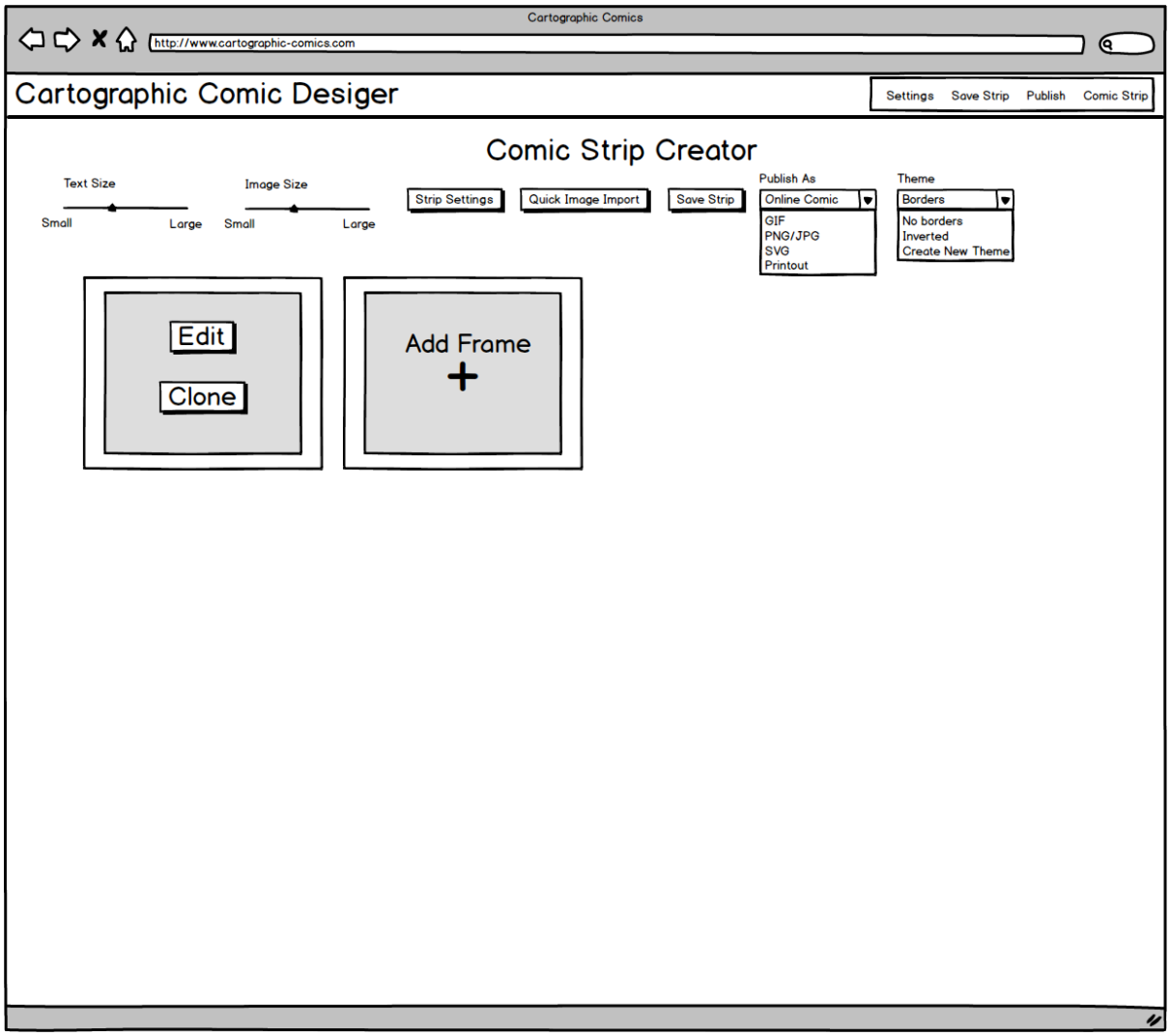


Figure 7-2 Comic Strip Overview Page

7.2.2.3 Frame Editor Page

Bob is able to construct the frame on the page which appears. He has the following options: i) setting the scene text ii) the frame number iii) Whether it contains only text (i.e a title page) iv) Only a map v) the option to insert an image or a Google Map vi) image orientation.

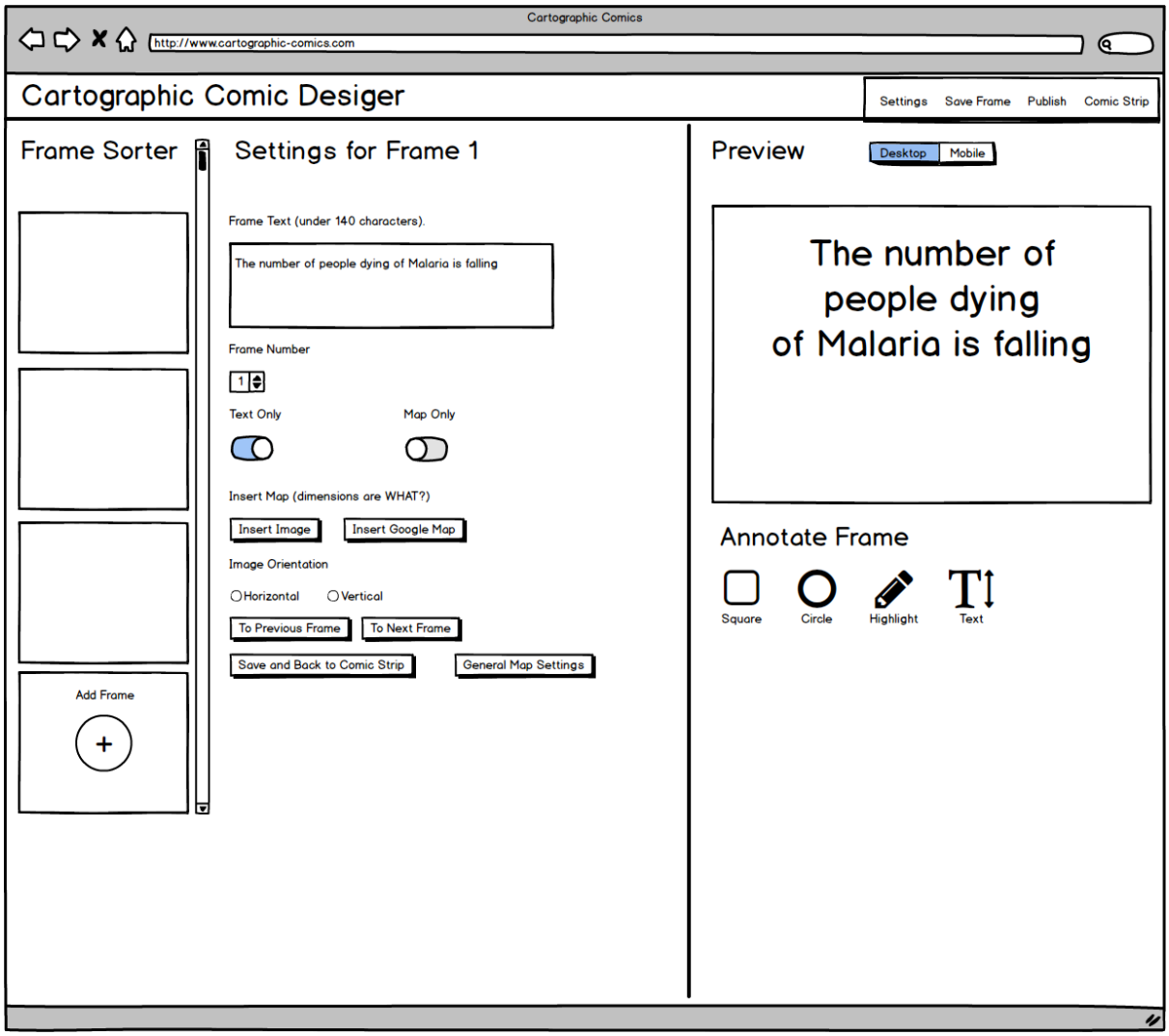


Figure 7-3: Comic Strip Frame Editor

As this is the title page, Bob inserts a text-only frame the title. Bob goes back to comic strip by clicking “save and back to comic strip”.

Bob repeats this process for the next frame. In this frame, Bob want to insert a map he has previously created in QGIS. On the frame editor, he presses insert image and selects the image from the file explorer (a further option in a later version would be to drag the image). He inserts the comic's first image: Malaria rates in 2000.

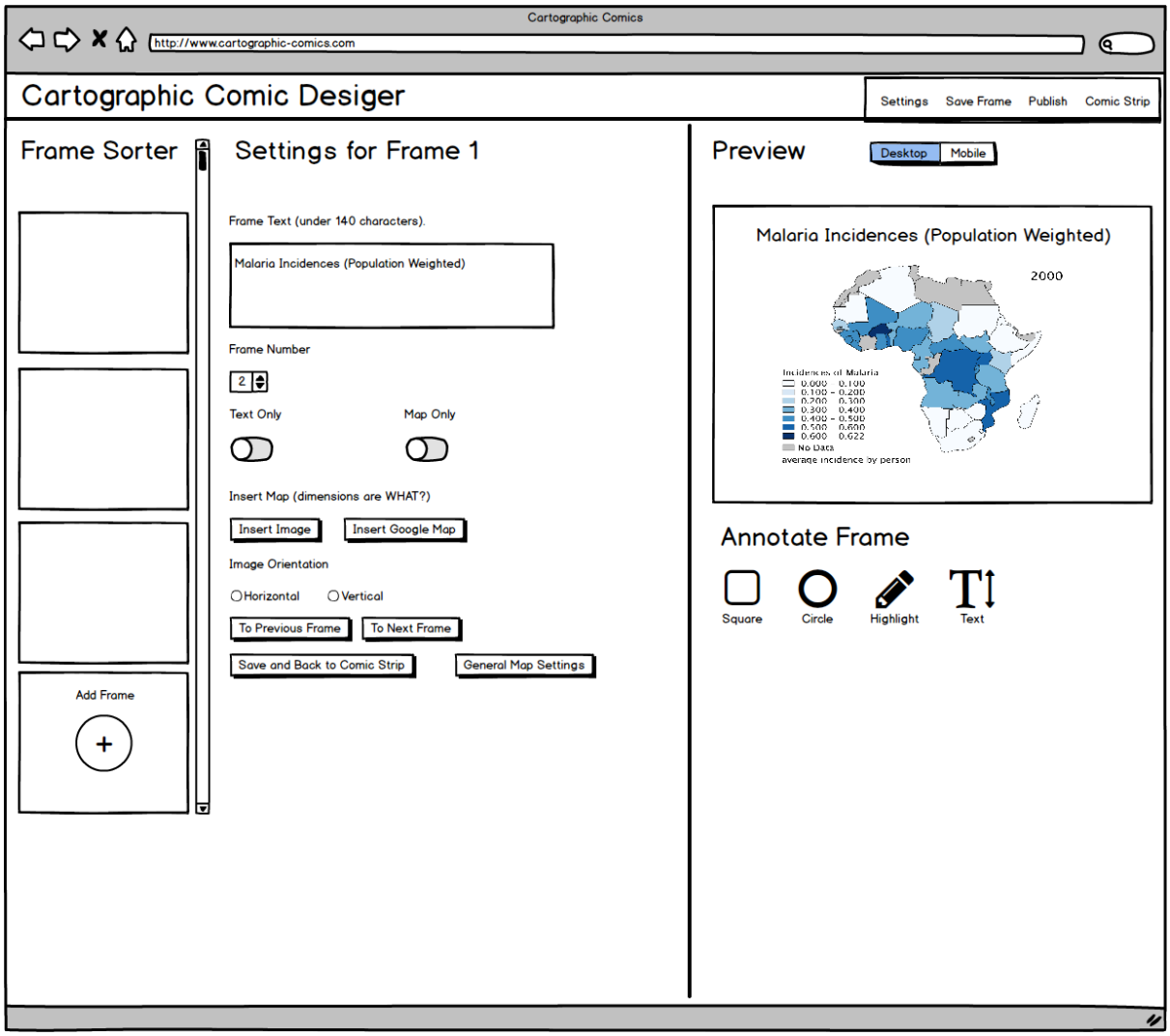


Figure 7-4 Comic Strip frame editor with map

Bob repeats these steps to complete his progression of the map sequence.

7.2.2.4 Theme Editor (V1)

Bob's publishing house has the following corporate design which the final narrative visualisation must follow if it is to be published:

Font:

Colour Scheme (primary colour #08306B , secondary colour #3E8EC4, tertiary colour #B0D2E8).

For this, Bob will go to the theme settings. As his newspaper's theme has not been created he selects "create theme" option.

On the box which appears, he will select the font, primary colour, secondary colour. (note: a limitation of Balsamiq Mockups is that the font is unable to change).

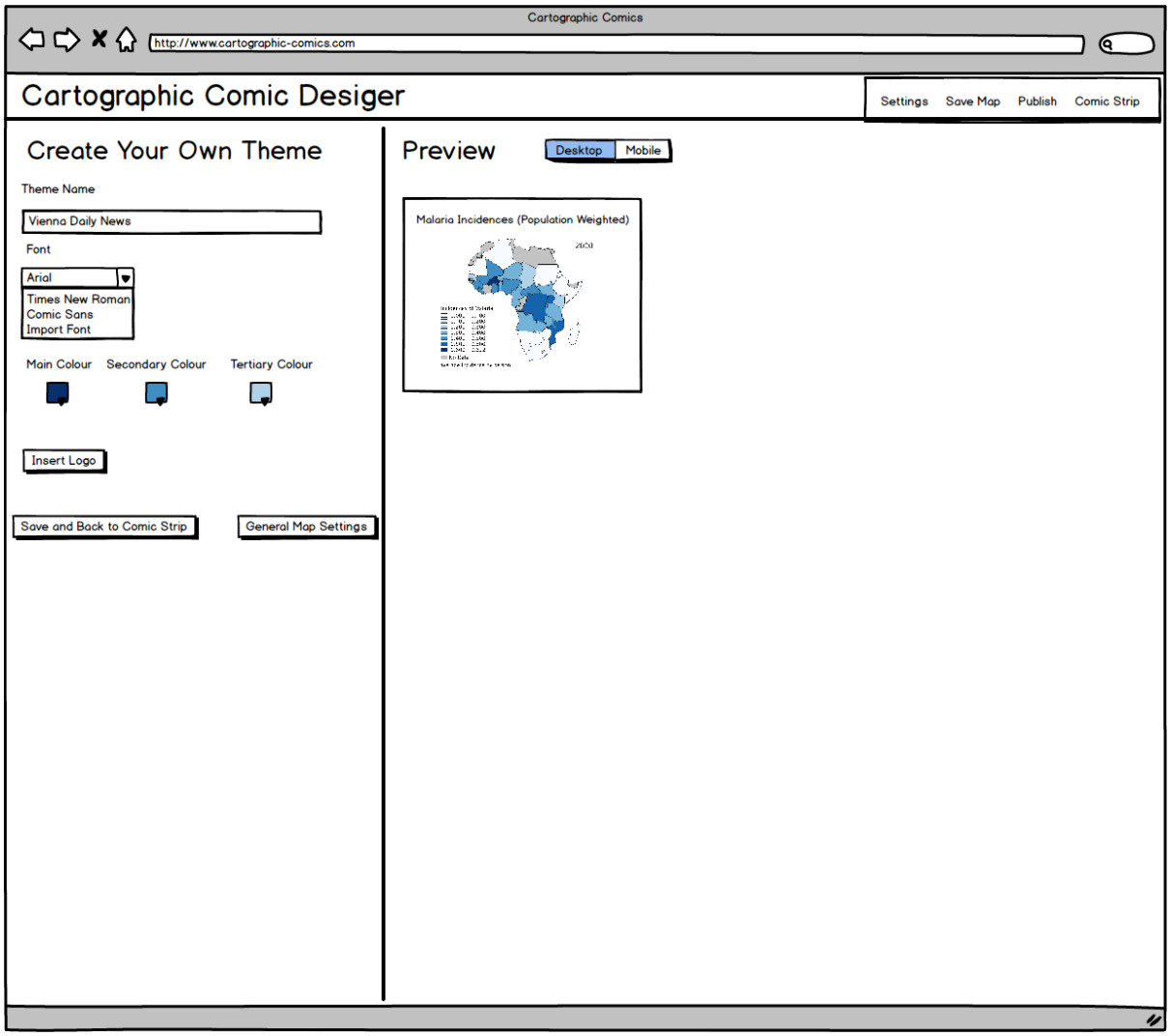


Figure 7-5 Theme Designer

7.2.2.5 GIF Export (Xp2)

Now that each individual frame has been created, Bob selects “publish as” and then “GIF”. This will open the GIF publisher panel. On this panel Bob can i) select whether the GIF is vertical or horizontal ii) set the frame duration iii) change the specific frame duration iv) reorder the frames as required and v) see an animated preview.

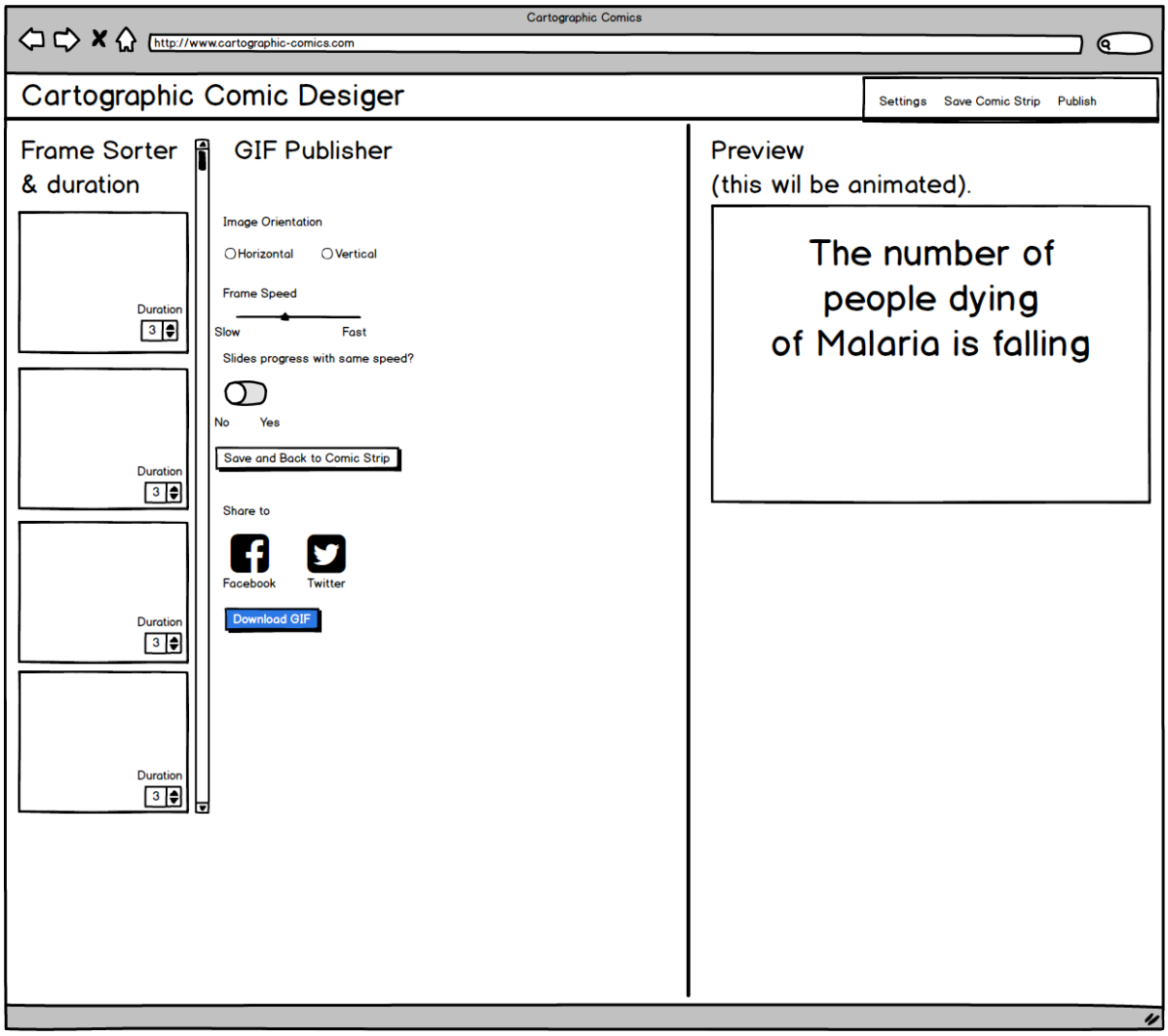


Figure 7-6 GIF Publisher Page

7.2.2.6 Sharing (S1)

The GIF export page also offers the ability to download the GIF or share to Facebook or Twitter. Bob selects “share to Twitter”.

On the modal box which appears, the user will be given a link which will be pasted into the Bob’s Twitter timeline

7.2.3 Use Case Scenario 2: Online Interactive Cartographic Data Comic

In the second scenario, Bob wants to create a “scrollytelling” interactive data comic (web application). This will use many of the frames from use case 1, but will increasing the complexity to the story by adding more frames and text. Specifically, explaining that an increase in bednets has caused the decrease in malaria.

This use case scenario outlines the following user requirements:

- M1: Responsive maps created
- M2: Vertical scrolling of maps *
- M3: Horizontal and vertical maps created
- S2: Fast loading of maps
- XP3: Data comic design *
- V2: Annotations
- Xp1: Export as interactive map. *
- Xp4: Creation of a sequence of maps.

7.2.3.1 Frame Creation (M3)

Many of the frames use the same technique as scenario 1, and therefore will not be explained here. There are two things of note. First, Bob can check the display of a map on a small screen by clicking on the mobile tab in the frame designer. Second, one of the maps is of the country of Burkina Faso, which is best to displayed horizontally.

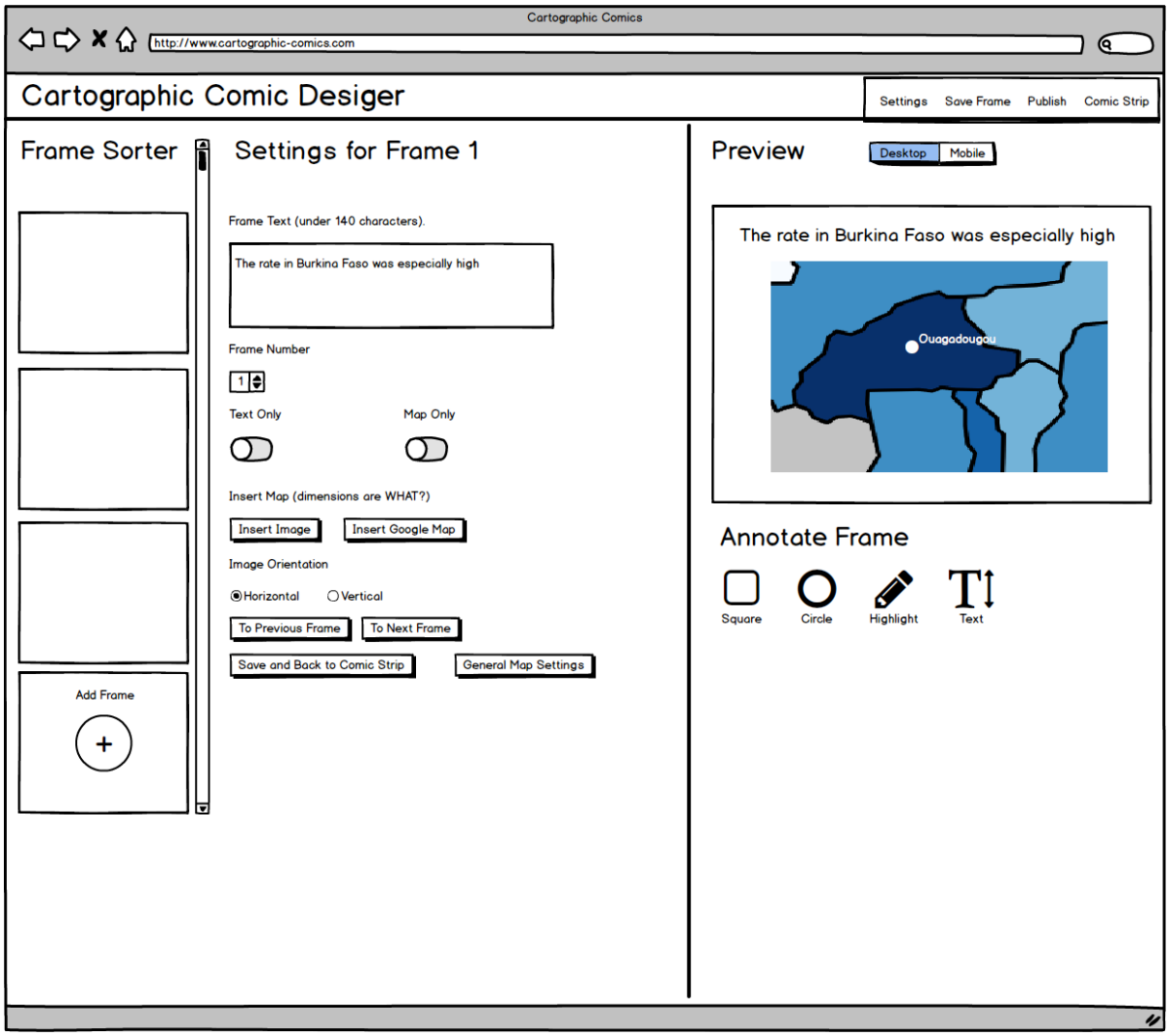


Figure 7-7 Frame Designer Page with horizontal map

7.2.3.2 Annotation Editor (V2)

On one frame, Bob wants to highlight the country Burkina Faso because of its high rate of Malaria in 2000. He does this by selecting the add arrow button.

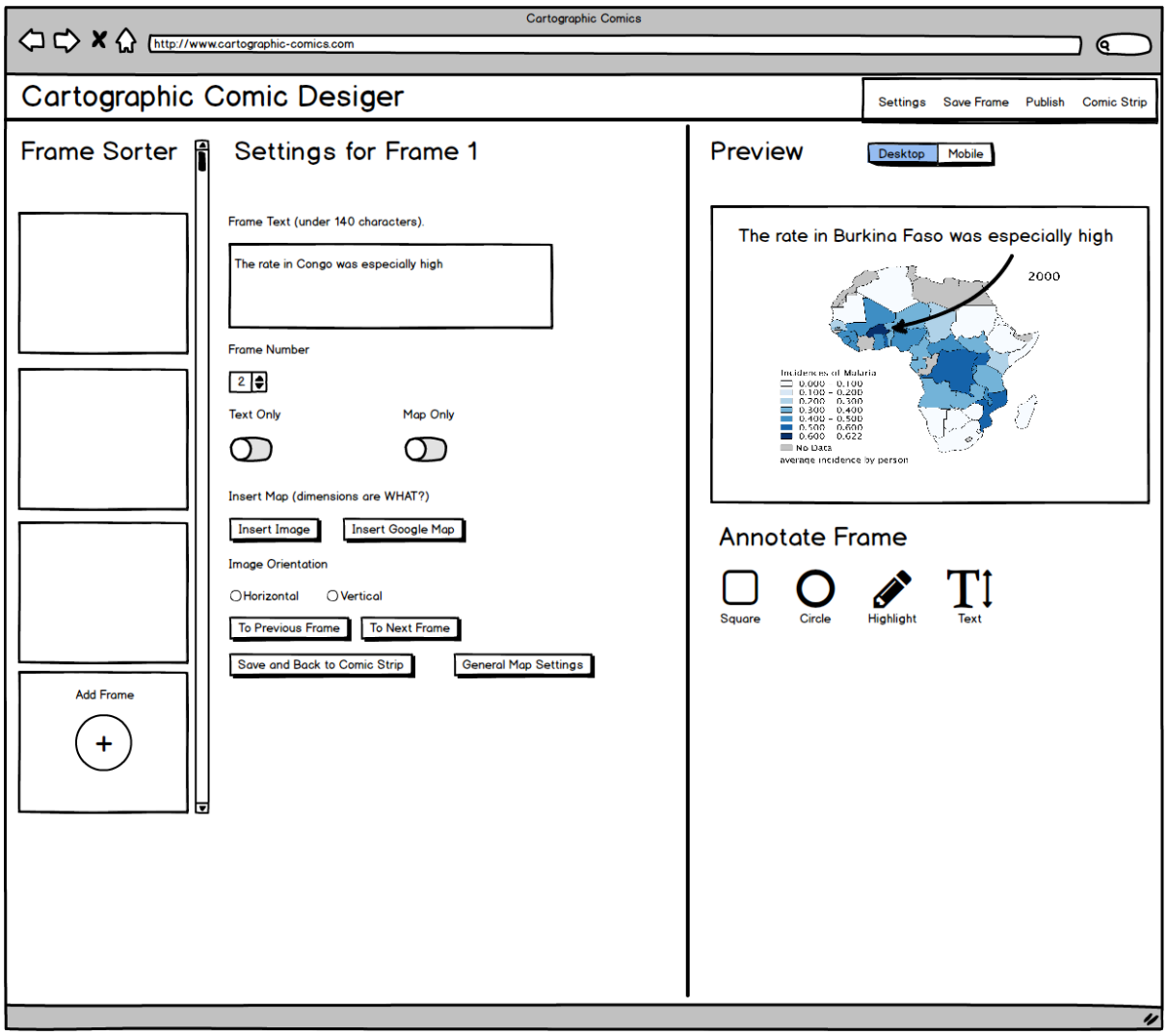


Figure 7-8 Frame designer page with annotations

7.2.3.3 Publishing

On the “publish map”, an option is displayed to publish the map online. From this iframe the comic can be inserted into the website in a similar technique to StormapJS and Mapme.

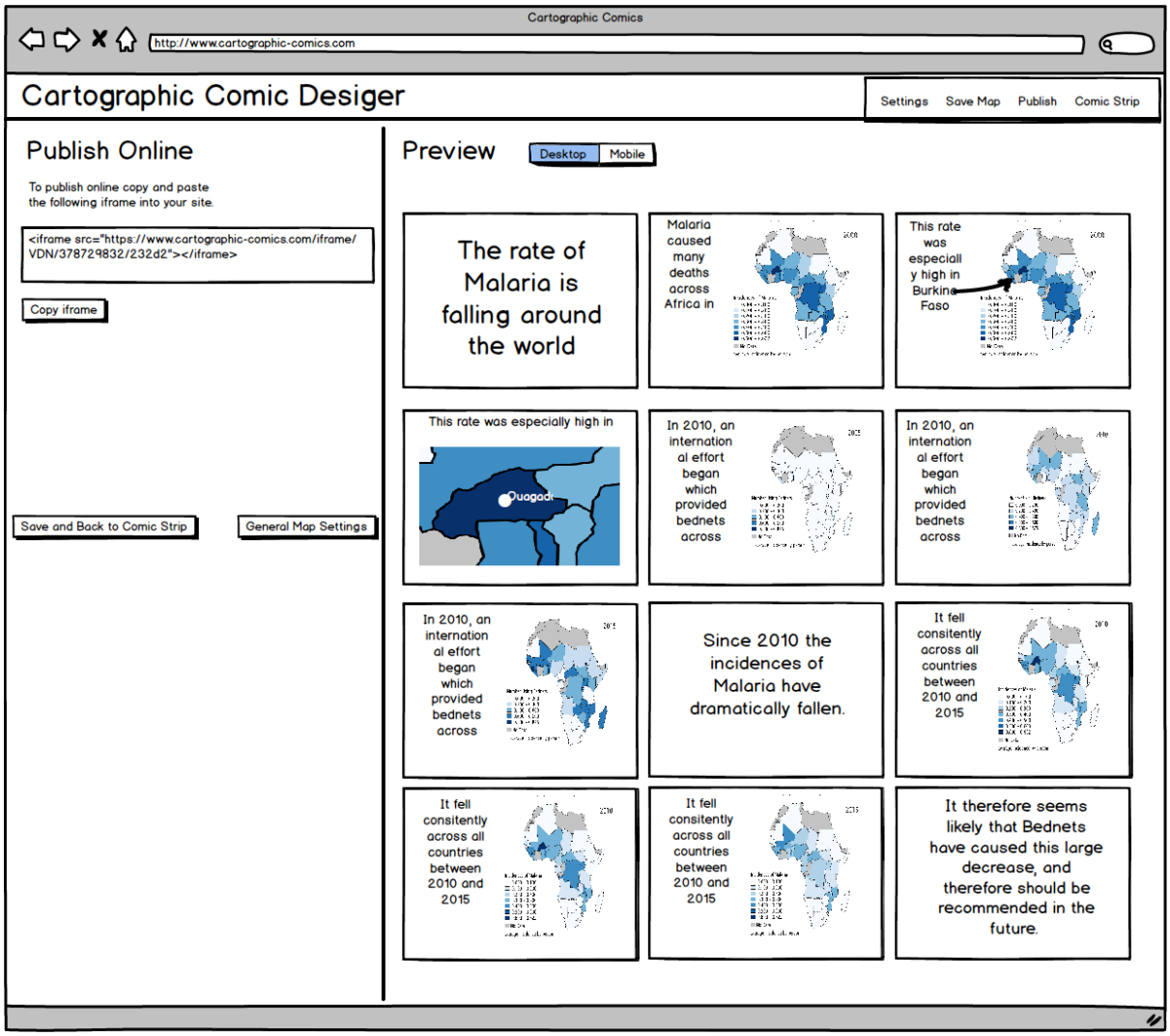


Figure 7-9 Publish to iframe screen.

7.2.3.4 Output (XP3, Xp1, M1, M2, Xp4)

The final outputs as it may appear on the “Vienna Daily News” desktop and mobile websites are shown below.

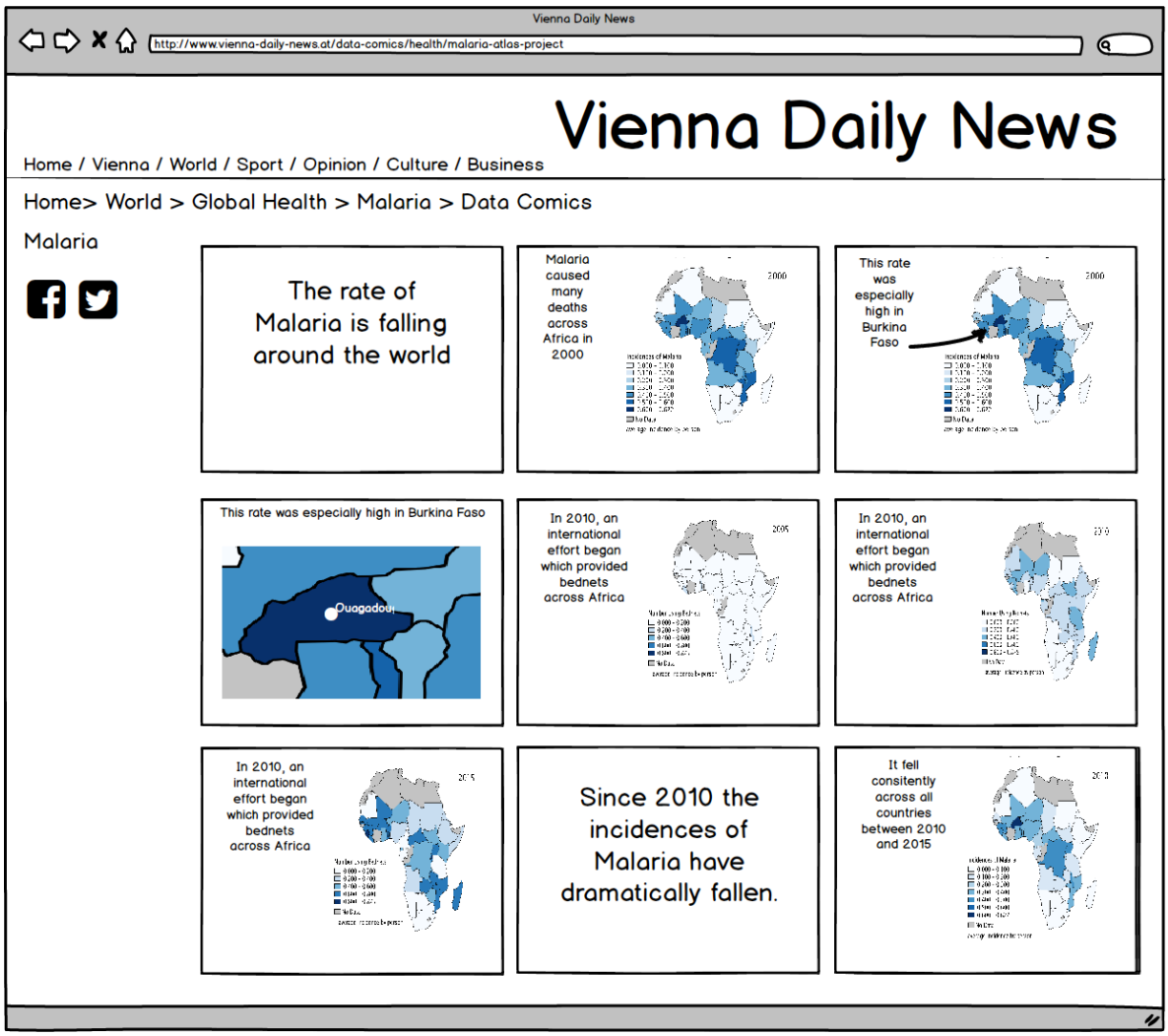


Figure 7-10 Final output as it may appear on a desktop website.

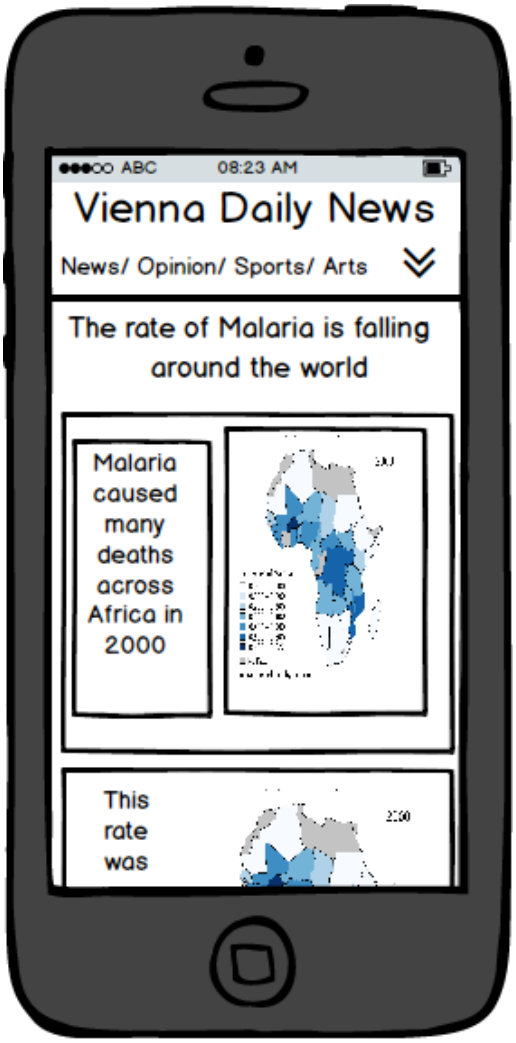


Figure 7-11 Final output as it may appear on a mobile website.

7.2.3.5 Speed (S2)

Since this is a prototype, the speed of the system cannot easily be measured. Further benchmark tests looks at the speed on various browsers are therefore recommended to see whether this system will meet the user requirement for speed.

7.2.4 Use Case Scenario 3: Guiding the user through narrative structures

Thomas is a colleague of Bob, and is less confident learning and using new software. Thomas wants to recreate Bob's narrative visualisation of use case scenario 2. He has access to Bob's PNG maps but does not know how to create narrative story for use online. The technique described in use case scenario 2 is too complicated for Thomas to implement quickly. Therefore, a walkthrough/ wizard is therefore required.

This use case scenario will show the following user requirements:

- Se1: Ability to guide the user in different narrative structures *
- E2: Walkthrough *

7.2.4.1 Story Walkthrough (Se1, E2)

When Thomas reaches the home page of the Cartographic Comic Designer he clicks "help me make a story".

His next screen opens up with the question: *Which type of story do you want?* He has three options "Quick GIF", "Journalist Report" (based on CFXO) and "Narrative" (based on EIP). An "I need help button" is found below the options. When the user clicks on this button a detailed description of the three narratives and options will be given.

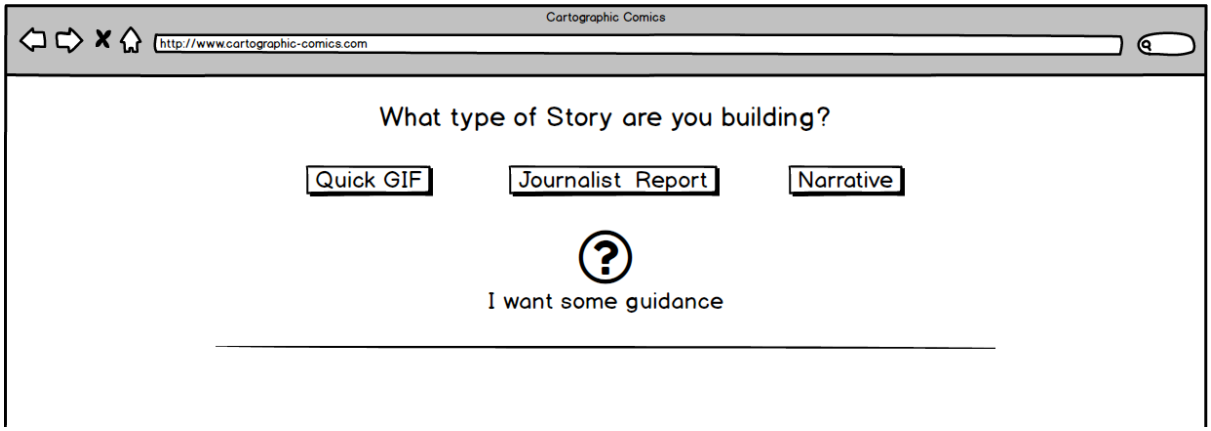


Figure 7-12 Question one of the story walkthrough tutorial.

Since this is a prototype, not all of the screens for the tutorial have been implemented. Appendix 11.7 outlines an example interaction which Thomas has with the system in order to detail the final story. The final story Thomas created was identical as the story Bob created in use case 2.

7.3 Discussion of Static Mockup Evaluation Results

The following section discusses at first the fulfilled requirements and then the omissions of the system revealed in the evaluation.

7.3.1 Success of the Static mockup

The evaluation process showed that the designed system satisfied at least to a basic level the use case scenarios. In use case scenario 1, Bob used the interface to create an ordered sequence of pre-made maps and output them as a GIF, sharing the results on social media. In scenario 2, Bob used the same frames in scenario 1, but made the story more complex and finalised the output as a CSS/HTML web application. In use case scenario 3, Thomas created a complex narrative visualisation based on a narrative structure using a walkthrough conversation with the interface.

The system was particularly effective creating an annotated sequence of maps which up to now no single interface has been able to do. A further advantage of this interface is that the sequence can conform to a range of existing website designs, as the frames can be easily rearranged to depending on the available width.

Empirical testing is effective at revealing gaps in the interface. These omissions are discussed below, sorted by case study and presented in the form of suggestions for a future interface design.

7.3.2 Suggestions

7.3.2.1 Suggestions from Use Case 1

One issue noticeable was the relatively long length of time required to create each frame, even if they were similar. An improvement to the interface therefore would be a multiple image upload option, each map image automatically inserted into a new frame, with title. In a similar vein, a drag and drop interface to insert a picture from file into the frame settings page is also recommended. A good example of this approach is found on giphy.com.

This evaluation also revealed deficiencies in the theme manager. It was not clear what part of the design the theme would change, and how much the change in theme affected the overall "aesthetic" of the comic. More "themable" objects such as a frame border or even an opportunity to add the company's logo is one further option. Moreover it would make sense to add a capability to edit the colour scheme of the map, since this the most noticeable part of the comic frame. One could add "filters" to imported raster images, or edit SVG images directly in the browser. A further addition would allow the user to create a map using their own data. However, since this feature is well addressed in Datawrapper and Magrit it was not implemented in this design.

7.3.2.2 Suggestions from Use Case 2

The image editor had no option to resize or crop the image. Therefore, at present, all of the images need to fit in the exact dimensions. It would be easier for the user if they were able to crop the image to fit in the frame. It will be important for continuity however, that every image is the same size.

It perhaps would have been helpful in use case scenario 3 if an image of a mosquito net was inserted. This adds further context to the map. The initial idea of no image was purposefully chosen to ensure maps were the central part of the editor. However, it now seems wise to have a basic image importer.

It was unclear how exactly the user could insert the iframe into their website. Since the interface is not aimed for web developers, having a simpler way to ensure this can be inserted or shared to the web developer team is recommended. Having a one click import into a WordPress blog or into other popular content management system would be another useful next step.

Moreover, since it is a design and not an implementation, it is very difficult to estimate system's speed, so could not be adequately measured at the moment.

It is confusing when the title of the story appears on the first frame and not where the story title usually appears on the website. When the output is a web application (not a GIF or printed), and the first slide is a title slide (text only), the text is instead deleted and given back.

7.3.2.3 Suggestions from Use Case 3

It was unclear in question one (Figure 7-12) what exactly the story types referred to, even if one knew about them before. It would have been better to include animated images of the three types of stories in question. Examples of clearer systems are seen for Esri Story maps and Odyssey.js by Carto.

Secondly, there seemed to be far too many questions in the creation of a relatively short, simple story. A new framework should be designed with a shorter sequence. Since maps, according to transition cost theory, should not vary too much between frames, it

would be beneficial to automatically load the description of the previous map and since only either the scale/ bounding box or the variable should change.

A form of input validation would also be useful. For example highlighting if too many characters were inputted to the text, or if the uploaded map image will not fit into the required dimensions.

7.3.3 Immediate Next Steps.

Following UCD process as outlined in section 4.1, the logical next step would be to revise the interface based on these proposed recommendations with the ultimate aim of creating a working online cartographic data comic editor. The next chapter will discuss further suggestions for future work.

8 Limitations of Study and Future Directions

This investigation attempted to answer the research questions by applying a thorough and methodological examination. This section outlines the methodological limitations and limits of the research scope, and proposes future research to address the new found gaps. It will address the three main chapters in turn: user requirements, software evaluation and static mockup evaluation.

8.1 User Requirements

A semi structured interview technique was chosen following the guidelines of Roth et al (2015): the user requirements were unknown and the future product is designed to support a small range of user profiles. Limitations relating to the demographic and number of participants are discussed below.

All of the participants came from Austria. Therefore some user requirements generated by the interview data may be country-specific; and some may be missed entirely. For example, the horizontal nature of Austria the reason why the challenge of horizontal maps on a mobile was brought to the attention of a participant. Although this requirement also applies for other countries, it may not have been brought up if participants came from "vertical" countries such as Great Britain. Other user requirements such as this may have been omitted as they do not apply to maps relating to Austria.

It is also possible that the user requirements may not apply to some cultures which have different forms of web site design and internet use. Similar studies on user requirements outside of Austria, and even Europe is recommended so they can apply globally.

English was spoken as a second language by all of the participants. Therefore, it may have been possible that some concepts or ideas may have been "lost in translation". One participant for example hesitated and noted aloud: "how can I phrase that in English". This is not considered a large problem since in general the participants' language and academic level were very high. Moreover, the participants were familiar to the concepts discussed in the interviews.

Secondly, the non-technical participants were academics and technical participants were journalists. A noticeable potential user group: the non-technical journalist would have significantly aided the result of the research. This limitation is especially noticeable in the design of the walkthrough system, which was particularly problematic in the user scenario evaluation.

Third, the sample size of six appears small. It was chosen due to the general shortage of visual data journalists which were able to be interviewed in Austria. Nielsen (2000) however notes that it only takes 5 people to take 90% of the problems for a software for a user test. Since a user test is a form of generating user requirements, it could be argued that this position holds somewhat when generating user requirements.

Thirdly, the specific questions asked could have been improved if a pilot was conducted beforehand. For example, some user requirements could have previously been formulated based on existing literature. Participants would then be asked to rank the requirements based on importance, or using a Likert-scale. This would have meant that each participant could have discussed each potential requirement in depth.

8.2 Software Evaluation

Sveen (2008) notes some limitations to their software evaluation approach which can also be applied to this study. First, the scoring of the user requirements. Though care was taken to use objective measures where possible, some of the software criteria, for example the learning curve, rely on subjective judgements. Sveen (2008) recommends that subjectivity can be decreased by having a number of people carry out the scoring and discussing the requirements in which the scores varies. This is also recommended for this study.

Carrying out specific tasks, rather than looking at the feature list on the websites, would have been a more precise method to grade each software from the user requirements. This approach was not carried out due to time limitations.

This project evaluated considerably more candidate projects compared to Sveen (2008) because it had a different aim in the evaluation. The aim of this evaluation was to find gaps in to look at gaps in requirements across software, rather than recommending a specific software. It seemed more suitable, therefore to increase the number of products but decreasing the depth to which they were studied. Adding identity cards, whilst certainly useful, would not have added considerable advantages to the evaluation.

8.3 Static Mockup Creation and Evaluation

The choice of a use scenario evaluation approach is discussed in section 7.1.2. A checklist of evaluation criteria was created based on the user requirements from the user interviews. This ensured an objective evaluation approach even though the process was undertaken by the interface designer.

Since the scenarios incorporated the specific user requirements revealed by the interviews, it is likely that they representative of many scenarios, as a number of common issues were revealed. However, a wider range of scenarios, for example by using different areas and types of thematic maps, could have revealed more interface issues.

The next logical step would be to implement the changes proposed in section 7.3 and to test the new scenario with a *different* set of users. Once the front-end design is reached the backend technology will need to be designed, compared and evaluated. But that will require a whole new thesis.

9 Conclusion

This thesis aimed to find out about the possibility of integrating maps into the data comic genre of narrative visualisation. In particular, looking at *how* it can be integrated; and looking at the requirements for a software which could help the novice user to create these visualisations. The final product of this research was a static mockup of an online cartographic data comic editor. This section will concisely answer the research questions proposed in chapter 3, and will finish by reflecting on future possible directions in the field of cartographic data comics.

9.1 Summary of findings on Research Questions

9.1.1 Findings from Research Question One

RQ1. What are the characteristics of an online cartographic data comic?

This question, looked at in detail in chapter 5, was answered methodically by defining comic, *data* comic, *cartographic* data comic, *online* cartographic data comic in turn. Taking inspiration from Zhao et al. (2015), this thesis defined comic through panel, tier and gutter approach. For a data comic, it used Bach et al. (2017) formulation that it was important to have a "symbiosis" between the data graphics and words, which were needed to add context to the graphics. Using data generated through interviews with 4 creators of data visualisation and 2 spatial data professionals, the cartographic component was added: the use of predominantly thematic maps plus the ability to highlight the map with text, highlights, arrows and boxes. The online portion contained

the characteristics of interaction, responsive; shareable on social media; branded with a theme. Finally, the output can appear in either interactive CSS/ HTML or GIF format.

9.1.2 Findings from Research Question Two

RQ2. What are the requirements for a software which will allow someone to create an online cartographic data comic (i.e the mapping editor)?

This stage looked at what precise technology would be required to create an online cartographic data comic as outlined in RQ1. It developed these requirements through interviews with data journalists and academics, the analysis of which found that the 16 requirements could be grouped into the following 5 characteristics: ability for the output to be in responsive design, ability for output to be shared, allow the creation of multiple maps (of which they can be sequenced); for the output to look like a comic and conform to the publication's design scheme, to be easy to use, and possess a variety of export functions. 3 potential use case scenarios were also created based on the feedback and these 16 requirements.

9.1.3 Findings from Research Question Three

RQ3. What are the requirement/ feature deficits in the existing software?

A methodological analysis of 46 software was performed, filtered to 19 software on the basis on whether they were able to output a sequence of maps. From these 19 software, an analysis on the 16 user requirements outlined in research question 2 was performed. This review concluded three things. First, that no software was available which sufficiently performed all of the user requirements. Second, half of the user requirements were poorly served in general by the existing software, indicating that a new software was required to use it. Third, six of the user requirements were very

poorly served by the software. The study then concluded that a new software should be designed focusing on the usability of the poorly served user requirements.

9.1.4 Findings from Research Question Four

RQ4. Does the designed software fulfil the requirements of three example use case scenarios for an online cartographic data comic creator?

A static mockup was developed focusing on the priority requirements outlined in RQ3 but aiming to fulfil all of the user requirements. This mockup was tested using three user scenarios developed in RQ2 and using a case study of the Malaria Atlas Project. Although most of the requirements were met, the evaluation found that the tutorial aimed at creating a story based on the story structures was not very usable. The study therefore recommended further tests, this time with users to find other potential deficiencies with the software, before moving on to the creation of an interface.

9.2 Concluding Comments: Automation in Cartographic Data Comics

An exhibit at The Museum of Applied Arts (MAK) for the Vienna Biennale in 2017, predicted a future in which many human jobs would be taken over by machines. This observation has historical roots: the Luddites in England vandalised machines in the 19th century as their textile jobs were replaced by weaving machines. A new phase of automation is approaching storytelling and journalism. Software can now write a sports match report when given match data and even writing poetry (Finley, 2015; Burgess, 2016). Mehmood et al. (2017) present a method which generates a story, with an accompanying map, from text from Wikipedia. Kim et al. (2017), using the theory of

transition costs, have automated the sequencing of charts from structured data. These few examples show that many of the steps for the creation of an online cartographic data comic have already been automated. Potentially the creation of a cartographic data comic will be fully automated in the future, with the journalist inputting to the interface a dataset which outputs a fully working story. Storytelling is a creative art, with the ways stories are told continually changing. With a few adjustments a working prototype could in the future provide a platform for the automation, whilst at the same time offering enough flexibility and user input changes user so they can use their own creativity to tell even more effective stories.

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11 Appendix

11.1 Interview Protocol

Introduction Questions
Are you happy to be recorded?
How much time do you have? Last interview took 40 minutes in total.
Design Process of Stories
I have seen this story [showed them a story which they have created] .
Can you describe to me the steps you used to create this story?
What is your aim with the story? i.e the editorial line? Do you report, or want to persuade?
Who was the target audience?
Was there a clear way in which you intended the infographic to be used?
Why did you chose these maps in particular?
Why did you chose this sequence in particular?
How did you try to highlight the central theme?
What other options do have when choosing the sequence of your stories?
For example: claim, fact, explanation, conclusion.
Establisher, initial, peak, release.
Does the sequence change if you want to persuade? Does it change if you want to inform?
How would it change if you wanted to change your central message or your purpose?
How did you structure these stories?
What tools or software do you use to create your maps?
Did you follow any guidance?
Response to Maps
Do you know how people understood these maps?
Do you know how people responded to the maps?
Did you conduct your own user studies on your readers?
Knowledge of Narrative Visualisation
Do you know what a narrative visualisation is?
Have you created one like this from Bloomberg [1]or Tampa Bay Times [2]before? Why? Why not?
If I told you (or a member of your team) to create one, what software would you use?
Why did you not decide to do a narrative visualization, but text interspersed with diagrams?
What would persuade you to make narrative visualization and not an essay with charts?
Have you ever used a cartographic data comic?
How often do you use a guidance methods such as wizards to create maps and presentations?[3]
Conclusion Questions
What future directions do you see the interactive department in your newspaper having?

[1] https://www.bloomberg.com/graphics/2015-whats-warming-the-world/
[2] http://www.tampabay.com/projects/2015/investigations/pinellas-failure-factories/chart-failing-black-students/
[3] Question asked only to two participants who did not create narrative visualisations.

11.2 Overview of Online Cartographic Data Comic Characteristics

Below is a table summarising the above findings, and showing the list of elements which are required for a cartographic data comic.

Characteristic	Source
Visual Element	
Sequence of panels	(Zhao, Marr and Elmqvist, 2015)
Panels separated by gutters	(Zhao, Marr and Elmqvist, 2015; Bach et al., 2017)
Data graphics	(Bach et al., 2017)
Text Element	
Narration	(Bach et al., 2017)
Contains both words and pictures	(Bach et al., 2017)
Cartographic Element	
Contains a map on more than half the frame	Author
Maps have horizontal or vertical orientation	Interview participant
Maps are predominantly thematic maps	(Bach, 2017)
Highlighting map content with annotations, highlights, arrows and boxes	Interview participant
Online Capability	
Interaction: Vertical scrolling of maps	Interview participant
Responsive Design.	Interview participant
Each frame fits with the website brand.	Interview participant
Maps can be shared on social media	Interview participant
Export functions	
Interactive Web Application (HTML/CSS).	Interview participant
Animated GIF	Interview participant

11.3 Software Evaluation Criteria Table

The evaluation criteria derived from 16 software requirements from the expert interviews and based on the evaluation system by Sveen (2008).

Code	Criteria	Score 0 = not all essential requirements met	Score 1 = fulfilled all essential requirements	2: all desired requirements fulfilled	RQ1 (online cartographic data comic characteristic) or RQ2 (online cartographic data comic editor)
Responsive Design					
M1	Responsive Design produced	Maps produced are unsuitable for mobile (i.e need to scroll across, too small or too large).	Maps produced are satisfactory for small screen.	Maps are designed for small screen.	RQ1
M2	Vertical scrolling of created output	Cannot vertical scroll.	Can vertical scroll.	Can vertical scroll on mobile device but horizontal scroll on other device.	RQ1
M3	Horizontal and vertical maps can be created	Either horizontal *or* vertical maps, but not both.	Both can be created but cannot easily be changed.	Both can be created and easily changed within the system.	RQ2
Sharing					
S1	Share on social media	No ability to share result on social media	Can share a link to social media (but not embed)	Easy export to social media and embed to Twitter/ Facebook.	RQ1
S2	Fast loading of maps	>10s.	1.0 -10seconds	< 0.1 second	RQ1
Sequencing					
Se1	Ability to guide the user in different	No ability in guiding the user to use difference narrative structures.	Uses either EIP, CFXO, transition costs but not all three.	Can guide using EIP and CFO, and transition costs.	RQ2

	narrative structures				
Se2	Ability to output a sequence	No way to produce a story.	Has a way to produce a sequence.	Has a way to produce a complex sequence/ story.	RQ2
Map Visual Design					
V1	Ability to use themes	No theme manager	Simple theme manager- i.e can be linked between maps. Not just colour changes.	Ability to import themes from other programs and palettes (e.g. photoshop palette).	RQ2
V2	Text Annotations	No ability to add text to the map	Ability to add text to the map, but limited font and text sizes.	Ability to add text, with full functionality of fonts and text size.	RQ2
V4	Symbol Annotations	No ability to add symbol annotations (e.g. arrows and circles) to the map	Ability to add symbols to the map, but limited in design.	Ability to add text, with full ability to change visual design (e.g. colour, border size).	RQ2
Ease of Use					
E1	Programming requirements	Complex programming skills required.	Basic programming skills required to extend capabilities.	No programming Required	RQ2
E2	Walkthrough/ Wizard	No walkthrough/ wizard	Limited walkthrough/ wizard	Full walkthrough / wizard with ability to save final design.	RQ2
Export Functions					
Xp1	Export as a single Interactive Map	Only static maps created	Maps can be hovered over (i.e tool tips) but not clicked on.	Full interactivity export.	RQ2
Xp2	Creation of a GIF	No GIF export tool.	Creation of GIF, possible but complex.	Easy GIF creation.	RQ2/RQ1
Xp3	Data Comic Design	Cannot export as a comic design.	Can export as a slideshow, but not comic.	Can export as a data comic, with image and text.	RQ1
Xp4	Creation of an interactive *sequence* of maps.	No ability to view on a webpage.	Ability to view on webpage is complex.	Designed to be viewed on webpage/html for comic.	RQ2/RQ1

11.4 Unfiltered Candidate List

The table below is the unfiltered candidate list, as described in section 11.4 .

Name	Description	Website or Reference	On Filtered List?
Mapping Libraries			
Mapbox	Creates custom online maps. *	https://mapbox.com	Y
Google Maps	Webmapping service by Google.*	https://maps.google.com	
Leaflet Story Map	Scroll-driven storymap is built on an open-source Leaflet template. **	http://jackdougherty.github.io/leaflet-storymap/index.html	Y
MapStory	Atlas which offers the tools to create a story using maps.	https://mapstory.org/	Y
Maps with Story Element			
Mapme	Interactive Map builder	https://mapme.com/	Y
ESRI Story Maps	Using ESRI's platform to create stories.	http://storymaps.arcgis.com/en/	Y
StorymapJS	A free tool to help you tell stories on the web **	https://storymap.knightlab.com/select/	Y
Flourish	Templates for animated storytelling. Designed for organisations.	https://flourish.studio/	Y
Cartographic plugins			
Map Stack	Map styles from stamen map studio	http://mapstack.stamen.com/.	
Snazzy Maps	Styles for google maps. Has an API too.	https://snazzymaps.com/	
EZ Map	Create customised google maps	https://ezmap.co/	
Mapkit		https://mapkit.io	
MapHub	Creating interactive maps.	https://maphub.net/	
Maps4news	Creates branded maps for news organisations. Not open source.	https://maps4news.com/	
Data wrapper	Easily creating SVG and embeddable charts and maps.	https://www.datawrapper.de/	Y
Javascript Tools			
D3	JavaScript library for producing dynamic, interactive data visualizations in web browsers. *	https://d3js.org/	Y

Name	Description	Website or Reference	On Filtered List?
Q	Storytelling tool from NZZ paper based in Zurich. Software was not evaluated as it is not open to the public, and only available as an internal tool.	https://medium.com/@davidbauer/why-newsrooms-need-storytelling-tools-and-what-weve-learned-building-them-87df4802b737#.fqutcyrui>	
Kartograph	Simple and lightweight framework for building interactive map applications without Google Maps or any other mapping service. **	http://kartograph.org	
Openlayers	Free open source javascript library to display map tiles	http://openlayers.org/	Y
Data Analysis			
R	Comprehensive data analytics library. Using ggplot for maps.	http://ggplot2.org/	Y
Tableau	Interactive data visualisation focused on business intelligence (from Wikipedia). Robert Kosara, an leading researcher in data storytelling works for them. Has a "story points" feature allowing the user to create stories.	https://www.tableau.com/solutions/topic/maps	Y
Plot.ly	Complex graphing library. Has an API to export to JS (and probably as image too)	https://plot.ly/javascript/choropleth-maps/	
Carto	(Formally Cartodb). Provides online GIS and mapping tools. Uses odessy.js to provide an interactive story *	https://cartodb.github.io/odyssey.js/	***
Google Fusion Tables	Spreadsheet software with plugins for quickly creating thematic maps.	https://support.google.com/fusiontables/answer/2571232?hl=en	
Excel	Spreadsheet software. Has plugins for creating thematic maps.	https://products.office.com/en/excel	
Google Charts.	Data analysis library from Google.	https://developers.google.com/chart/interactive/docs/gallery/geochart	
Rawgraphs	Simple chart creator	http://rawgraphs.io/	
charted	Automated charts (not maps).	http://www.charted.co/	
GIS Software			
ESRI ArcGIS	Most used GIS suite in the world.	https://www.arcgis.com/	Y
QGIS	A widely used open Source GIS suite.	http://www.qgis.org/	Y
Mango	Online GIS	https://mangomap.com/ Y	
Magrit Thematic Cartography	Web based map creator	http://magrit.cnrs.fr/	Y
Multimedia storytelling			
Pageflow	Interactive storytelling tool	https://pageflow.io/en/	
Thinglink	Interact with pictures.	https://thinglink.com	
Shorthand	Visual storytelling platform	https://shorthand.com/	
GIF Maker			

Name	Description	Website or Reference	On Filtered List?
Data GIF maker by Google.	Tool to create a data GIF	https://datagifmaker.withgoogle.com/edit	
Giphy	GIF creation website.	https://giphy.com/	Y
Imaging Tools			
Adobe Photoshop.	Professional raster Graphics Editor	www.adobe.com/products/photoshop.html	Y
Adobe Illustrator	Professional vector Graphics Editor	www.adobe.com/products/illustrator.html	
Inkscape	Open source vector graphics editor	https://inkscape.org/	
GIMP	Open source raster graphics editor	https://www.gimp.org/	
Presentation			
Powerpoint	Standard Microsoft presentation software.	https://products.office.com/en/powerpoint	Y
Shower	Open source HTML slide creation and presentation engine.	https://shwr.me/	
Webslides	Making HTML presentations with Scrollytelling.	https://webslides.tv/	
Academic Work			
DatacomicJS	Academic article outlining the creation of an online data comic creator.	Zhao, Marr and Elmqvist, 2015	Y
Graphscape	Automating the sequence of graphs.	Kim et al., 2017	

***** description adapted from Wikipedia.org
** description adapted from company's website.
*** since Carto's OdysseyJS was not operational on the two test dates (20/08/2017 and 21/09/2017), this was not part of the final filtered list.

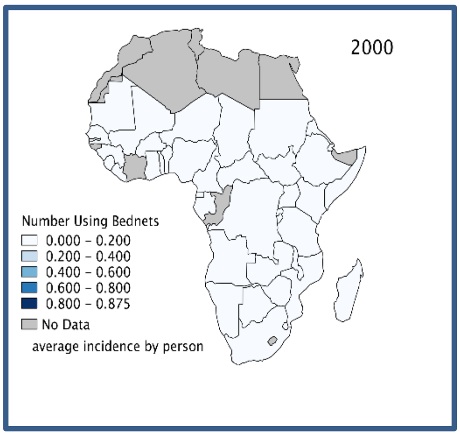
11.5 Filtered List with Results

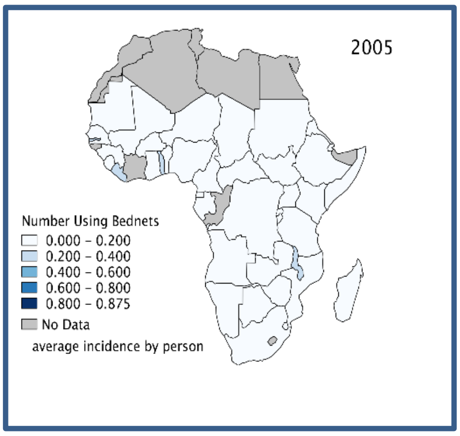
The table below is the candidate list with the calculated scores of the 16 software requirements.

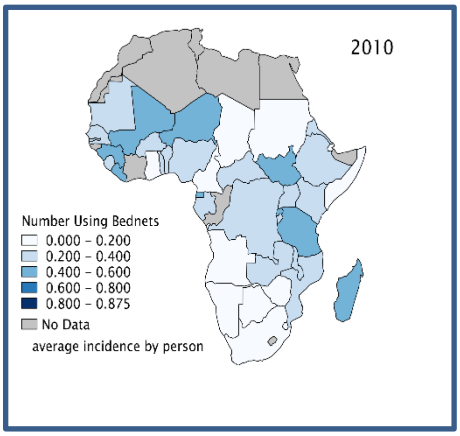
Name	M1	M2	M3	S1	S2	Se1	Se2	V1	V2	V4	E1	E2	Xp1	Xp2	Xp3	Xp4
Mapping Libraries																
Mapbox	1	1	2	1	1	0	2	1	2	2	1	2	2	0	0	0
Leaflet	2	1	1	0	1	0	2	0	2	1	0	1	1	0	0	2
Maps with Story Element																
Mapme	2	0	1	1	1	0	2	1	1	0	2	1	2	0	0	1
ESRI Story Maps	2	2	2	1	1	0	2	1	2	1	2	1	2	0	0	1
StorymapJS	1	0	0	1	1	0	2	1	2	0	1	0	2	0	0	1
Flourish	2	0	1	0	1	0	2	1	1	0	2	0	2	0	1	2
MapStory	0	0	1	0	1	0	1	0	0	2	2	1	1	0	0	1
Cartographic plugins																
Data Wrapper	2	0	2	1	2	0	0	1	0	0	2	2	0	2	0	0
Javascript Tools																
D3	2	2	2	0	1	0	2	1	2	2	0	0	2	1	1	2
Openlayers	2	1	1	0	2	0	1	1	1	2	0	0	2	0	0	1
Data Analysis																
R	1	0	2	0	0	0	0	1	1	1	0	0	0	1	0	0
Tableau	1	0	1	0	1	0	2	1	1	2	2	1	0	0	0	0
GIS Software																
ArcGIS	1	0	1	0	1	0	1	2	1	2	1	0	0	1	0	0
QGIS	1	0	1	0	0	0	1	1	2	2	2	1	0	1	0	1
Magrit Thematic cartography	1	0	2	0	0	0	0	0	1	2	2	0	0	0	0	0
GIF Maker																
Giphy	1	0	2	1	2	0	1	1	1	2	2	2	0	2	0	0
Imaging Tools																
Photoshop	1	0	2	0	2	0	1	2	2	2	2	1	0	2	2	0
Presentation																
Powerpoint	1	1	2	0	1	0	2	2	2	2	2	0	0	0	2	0
DatacomicJS	0	0	1	0	n/a	0	2	1	2	2	2	0	0	0	2	2

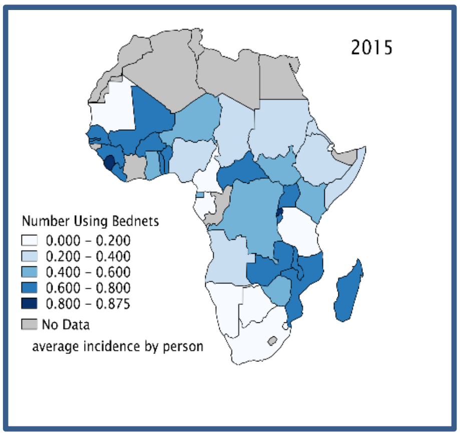
11.6 Base Maps for Use Case Scenarios

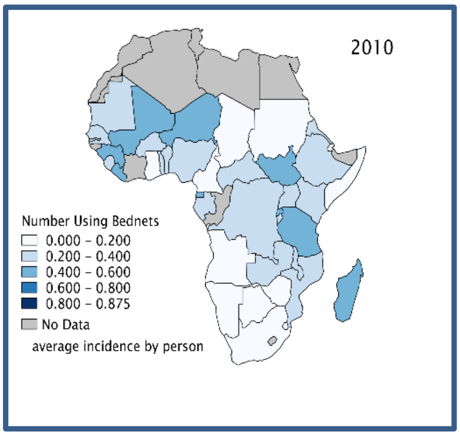
Below are a series of base maps created by “Bob” for the use case scenarios in section 7.2.1.

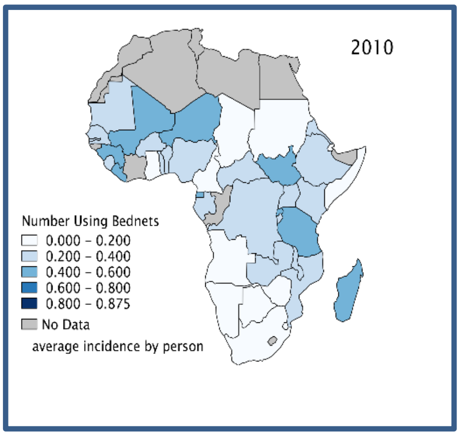


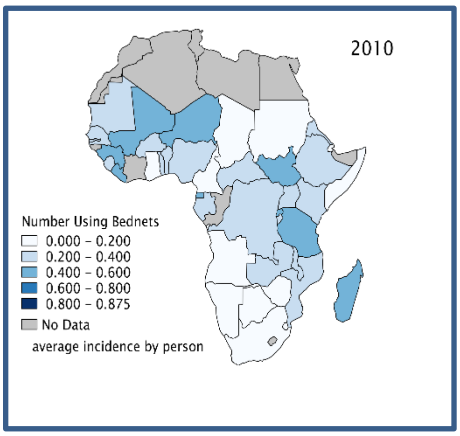


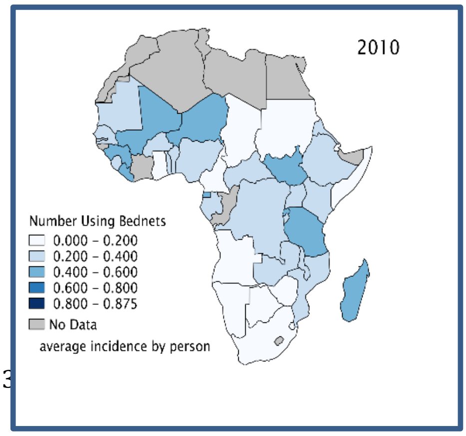












11.7 Evaluation of Walkthrough

Below is a simulated walkthrough, walking Thomas through the creation of a narrative data comic.

Question	Response from Thomas. *Responses in italics are those chosen by Thomas.*
What do you want to make?	Options: Short story, Journalism Report, Simple time progression GIF.
What is the title?	Good News: Fewer People of Dying of Malaria than before
What is the fact?	Malaria rates in 2000 were very high
Do you want another fact?	Yes
What is the fact?	Malaria rates in 2005 were high.
Do you want another fact?	Yes
What is the fact?	In 2010 an international effort began which provided bednets across Africa.
What is the fact?	Bednets across Africa in 2005 were low
Do you want another fact?	Yes
What is the fact?	Bednets across Africa in 2010 were higher.
Do you want another fact?	Yes
What is the fact?	Bednets across Africa in 2015 were the highest.
Do you want another fact?	Yes
What is the fact?	Since 2010, the incidences of Malaria have dramatically fallen.
Do you want another fact.	Yes
What is the fact?	Incidences of Malaria from around the world 2000 to 2015.
Do you want another fact?	No
What is the conclusion?	It therefore seems likely that Bednets have caused a this large decrease, and therefore should be recommended in the future.
System prompt	*Showing the story as a series of frames*.
System prompt	Here is your story. Drag and drop to change your story and change the text to change the story.
Are you happy with your story?	Yes
System prompt	Good News: Fewer People of Dying of Malaria than before
What type of frame do you want?	Options: map, title, chart. Thomas selects title
System prompt	Malaria rates in 2000 were very high
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2000.

What is the map extent?	Africa
System prompt	Malaria rates in 2005 were very high
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2005.
What is the map extent?	Africa
System prompt	Malaria rates in 2010 were very high
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2010.
What is the map extent?	Africa
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2000.
What is the map extent?	Africa
System Prompt	In 2010 an international effort began which provided bednets across Africa.
What type of frame do you want?	Options: map, title, chart. Thomas selects title.
System Prompt	Bednets across Africa in 2005 were low
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2010.
What is the map extent?	Africa
System Prompt	Bednets across Africa in 2010 were higher.
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2010.
What is the map extent?	Africa
System Prompt	Bednets across Africa in 2015 were the highest.
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2010.
What is the map extent?	Africa
System Prompt	Since 2010, the incidences of Malaria have dramatically fallen.
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2010.
What is the map extent?	Africa

System Prompt	Incidences of Malaria from around the world 2000 to 2015.
What type of frame do you want?	Options: map, title, chart. Thomas selects map
What type of map is it?	Options: Choropleth, location marker. Chooses choropleth.
What is the variable to be mapped?	Malaria in 2010.
What is the map extent?	Africa
System Prompt	It seems likely that Bednets have caused a this large decrease, and therefore should be recommended in the future.
What type of frame do you want?	Options: map, title, chart. Thomas selects title.
Please insert a map of Malaria in Africa in 2000.	Bob clicks on insert button and selects appropriate map.
Please insert a map of Malaria in Africa in 2005.	Bob clicks on insert button and selects appropriate map.
Please insert a map of Malaria in Africa in 2010.	Bob clicks on insert button and selects appropriate map.
Please insert a map of Bednets in Africa in 2000.	Bob clicks on insert button and selects appropriate map.
Please insert a map of Bednets in Africa in 2005.	Bob clicks on insert button and selects appropriate map.
Please insert a map of Bednets in Africa in 2010.	Bob clicks on insert button and selects appropriate map.
Please insert a map of Bednets in Africa in 2015.	Bob clicks on insert button and selects appropriate map.
What theme is it?	Selects Vienna Daily News Theme
What output do you want?	Selects iframe.
System prompt	iframe preview
System prompt	Here is the iframe which you can give to the website controller on your team.