Coastal Informatics:
Web Atlas Design and Implementation

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Chapter 17
Creating a Usable Atlas

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ABSTRACT

Knowing user audiences for coastal web atlases is important for designing atlas capabilities that address different user skill levels. This chapter presents guidelines about how to better understand coastal web atlas users, how to undertake user-centered design and development, and how to avoid major pitfalls with web interfaces. User groups are formed based upon understanding user characteristics. User-centered design for different user groups can take advantage of a logic model; that is, a series of steps for scoping, designing, implementing and testing the capabilities. The end result of design and implementation should be a usable system, thus software usability is an important goal. Regardless of how well designers know users, web interface pitfalls inevitably arise during the development process, some of which are discussed based on personal experience of the chapter authors.

INTRODUCTION

Coastal Web Atlas (CWA) specialists at a workshop about coastal mapping and informatics (O'Dea *et al*., 2007) concluded that existing atlases are sometimes too complicated for general audiences. Recommendations were made to suggest that: (1) development must be responsive to user needs; (2) developers should consider designing multiple interfaces and capabilities to offer a range of services; and (3) regular user feedback is crucial for atlas success. This chapter is written in the general spirit of providing guidelines for creating a usable CWA; it is directed at designers and developers. Previous chapters have already provided insight about the capabilities of a CWA, and therefore the focus here is on what makes those capabilities more or less usable.

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Design information including basic constructs for developing CWAs has been presented in previous chapters. However, it is important to reiterate that basic CWA constructs such as map data layers with various themes and tool capabilities such as pan, zoom and search form the basis for generating information for a user. Users develop an understanding of a CWA in their heads based on what they know and as they experience the tools and information in a CWA. Developers must be able to "connect" their intended designs of constructs to what users already understand, at least partially to begin with, and to help users learn about the world.

The chapter begins by helping the reader understand the general nature of users based on their backgrounds and associated abilities, their information needs, and their expectations for a CWA. We continue the chapter by providing a bit more detail about how to conduct usability studies as a systematic approach for evaluating CWA user interfaces and capabilities accessible through those interfaces. We end the chapter by examining some of the pitfalls that developers might incur while developing user interfaces.

UNDERSTANDING USERS

When understanding use of GIS-based CWA applications, whether they are supported by single-user workstation or web-based technologies, it is crucial to take into account the nature of users. Users can be described in terms of characteristics of people as in their abilities, user needs for information, and expectations of users (Nyerges, 1993). Combining some of those characteristics helps us form user groups, whether we consider the whole of the group or individuals. When understanding user groups, some developers might emphasize an "audience" perspective while others might emphasize an individual user perspective. An audience is a user group whereas the user is an individual with certain qualities. One way to bridge the divide between the two perspectives is to articulate "prototypical users," as we can never fully understand all the details of single users, nor all the characteristics of an aggregated audience. We need to make some simplifying assumptions about who will use a CWA. Toward that end, the subsections that follow emphasize how we characterize user abilities, the information needs of users, and the expectations of users.

User Abilities

Users have different abilities. For example, some people are more technically-skilled than others, and thus can understand complex information displays as part of the user interface of tools, while other users are more challenged to understand such displays. Some users have more experience problem solving within a particular substantive area, while others have less experience with such problems. Such qualities are rather difficult to track, and thus difficult to generalize across, hindering our understanding of users. More general qualities that can give us a better understanding about user abilities include user background and perspective. Our understanding of background and perspective make it easier to develop user group categories.

USER BACKGROUND: A QUALITY INHERENT TO A USER (GROUP)

People have certain qualities gained through living their lives based on choices and constraints in social settings.

- Age – years of personal experience being exposed to various topics
- Education/experience – formal / informal training
    - Problem solving ability
- Number of years addressing a problem
    - Technical/computer ability

- Number of years working with computerized information systems
- Hours per week spent working with computerized information systems
- Culture – community context / worldview based on upbringing

User Perspective: A Quality Characterizing how People View Information

People have roles largely due to responsibility, authority, and/or interest in a topic, for example as technical specialists, executives, members of a public, and educators. A person might have one or more of those roles at any given time.

- Technical Specialists focus on problem articulation/elucidation
  - Scientists
  - Resource analysts/researchers
- Executives focus on responsibility for managing community well-being
  - Policy/Decision makers
  - Elected officials
- Public at large focus on valued concerns about their place/identity in the world
  - Stakeholder interest groups
  - Property owners
- Educators focus on what/how/why people learn
  - Primary and secondary school age
  - Higher education
  - Life-long (social) learning

An enumeration of the types of user groups targeted by the developers of a selected set of CWA is shown in Table 1 (O'Dea *et al.*, 2007). A variety of user groups have been targeted. Clearly, different organizations have different purposes in mind for respective CWA's.

Developing software systems for all intended user groups identified in Table 1 is not easy, particularly if developers want to gain empirical insight into the goals and motivations of groups. How we collect information about users and what they like, do not like, how they perform tasks and work with information are key concerns. However, in this chapter, we want to continue to explore more about the general issues associated with a usable atlas. To do that we recognize that the groups listed in Table 1 have different responsibilities to work with information. As such, the different groups have different information needs. We now turn to how to understand better user information needs.

User Needs

User needs for information differ depending upon the user group targeted. Thus, the first step is to know your audience as discussed in the previous section. Once the target audiences have been identified, then information needs can be elicited for each of the groups. Below is an example from experience with the Belgian Coastal Atlas.

- Scientist users need detailed and complex information (about diverse aspects of the coast) perhaps presented using graphs, maps, etc.
- Policy and decision maker users need selected information directed towards policy advice, with clear interpretations and/or indications. The interface must be user-friendly and less scientific, avoiding technical complexity with clear messages and comprehensible figures. The atlas could be integrated with policy supporting tools (e.g., sustainability indicators, scenario building, case studies, etc.).
- Public users need easily accessible and transparent capabilities that contain basic information of interest for a wide audience.

Table 1. User groups (target audience) of selected CWA's (based on targeted audiences identified in O'Dea et al., 2007)

User groups	Coastal Web Atlas[1]					
	A	**B**	**C**	**D**	**E**	**F**
General Public		√	√			√
Tourists		√	√			
Students		√	√			
Researchers/Scientists		√	√	√	√	√
NGOs		√	√	√	√	√
Government/Public Bodies	√	√	√	√	√	√
Commercial/Industry	√	√	√			
Consultancies	√	√	√	√	√	√
Coastal/Environmental Managers	√	√	√	√	√	√
Decision Makers	√	√	√	√	√	√
Other:				Outreach		

[1]Coastal Web Atlas column identifier
A. The UK Coastal and Marine Resource Atlas
B. DE Kustatlas Online, Belgium
C. The Marine Irish Digital Atlas
D. The Oregon Coastal Atlas
E. North Coast Explorer, Oregon
F. Mapping Tools for Coastal Management, Virginia

- Educational users need information prepared in ready to use education tools/ packages.

Once a general idea of the content has been articulated, a next step is to define the geographic area(s) to be covered by the themes and overall by the atlas including both the seaward and landward boundary. The Belgian Coastal Atlas was unique in its approach, as it covered the land as well as the seaside of the coast from the very beginning. Many atlases still cover either the land or the seaside. From an integrated coastal zone management perspective, it is important to stress the need for integrated coastal and marine maps and information because of the intricate link between the two environments and the need for an integrated policy and management over the land-sea interface. This has been stressed in the European Maritime Policy and in the integrated coastal zone management communication (European Commission, 2000). Opportunities for stimulating integrated management and policies are missed if developers do not consider the landward side as well as the coastal seaward side.

Having defined the area, the more detailed themes/sectors that are to be included need to be considered. Will the content cover one theme/ sector (biological atlas, social atlas) or several themes? One way to enumerate the themes is to aggregate the topics across a series of use cases.

The concept of use case has been developed as a way of characterizing complex tasks addressed through information technology capabilities. At its core, a use case contains a description of a series of invoked software actions to accomplish a task that are characterized from the point of view of a user. A use case scenario sets specific assumptions/parameters about a use case. The scenario

helps to refine (putting constraints on) the use case actions to address the task goal.

As an example, a coastal erosion use case is being developed as part of the initial ICAN effort addressing data interoperability (Wright *et al.,* 2007). The initial user focus of ICAN is on regional planners/resource managers, property owners, emergency response teams, and local CWA system administrators (aka atlas administrators) that address coastal erosion. Hazard-related information and the boundaries of regulatory jurisdictions are routinely required for land and ocean planning, regulatory, and enforcement work. Eventually, the outcomes are meant to improve the ability of agency staff to quickly and efficiently analyze local geographic patterns of hazards, community development, and jurisdiction in a regulatory and/or planning context. The use case can be used to characterize and evaluate issues and impacts related to coastal erosion, but could also be used to inform and educate the public and coastal zone management community. Generalizing across the information needs of the information users listed above, a collection of key datasets for this use case includes the following:

- Coastal access and recreation
- Coastal armoring
- Cadastral datasets with assessor attribution
- Geology
- Land use and zoning
- Current shoreline position
- Historic shoreline positions
- Permit tracking systems and a dynamic link to cadastral data
- Aerial imagery
- Streams
- Beaches
- Bluff and dune fields
- Regulatory jurisdictions
- Community development
- Geomorphology profiles
- Erosion Risk study results – Risk Zones or Lines
- Topography
- Wave climate data
- Shallow water bathymetry
- Transportation networks
- Public utilities
- Public lands

Aggregating the data themes across applications provides a first pass summary of the information content of interest to users, or what users might expect to find in an application.

User Expectations

Software can have widely varying degrees of consistency. User expectation refers to the consistency that users expect from products. Interaction design deals with the organization of design elements, such as CWA constructs employed for a user interface, particularly when implemented as a sequence of actions. A good *design principle* to use in interaction design is to follow the "Principle of least astonishment". In the case of interactive software applications, for example, users form expectations based on their experience with similar kinds of software. Effective interaction design aims to conform to norms for user behavior about software interfaces and responsiveness. Many design features were identified at the 1st Coastal Mapping and Informatics Workshop that are relevant to the expectations of a user-centered interaction design (O'Dea *et al.,* 2007). These features were organized using a framework for strengths, weaknesses, opportunities, and threats (SWOT).

Strengths of CWA Design

- Intuitive structure of web sites and map pages;
- Inclusion of contextual information in order to better understand the data;
- Hierarchical data organization;

- Multiple user pathways to retrieve maps and layers of interest;
- Tools for data analysis and creating reports.

Weaknesses of CWA Design

- The cartography / design challenge of displaying many layers;
- Inadequate database management system for efficient management of information; metadata and data;
- Inadequate search functions for data and content;
- Failure to meet user needs where atlas developments are technology-driven;
- Lack of distributed systems to enable data owners to share and manage their own data.

Opportunities for Better CWA Design

- Improved cartographic display of large quantities of layers in coastal atlases;
- Potential for sharing data through distributed networks (e.g., utilizing Web Map Services and Web Feature Services);
- Potential to develop regional nodes that tie in with larger atlases (e.g., national or statewide).

Threats to CWA Design

- Keeping up with design expectations of users (e.g., Google Earth);
- User interpretation: misunderstanding of how to use atlases or their components.

Developers can address surprises with user expectations by detailing *use cases* to the extent that both users and developers can agree on the sequencing of CWA actions. Having users participate in the articulation of use cases with developers, called user consultation, fosters shared understanding among users and developers with regard to atlas capabilities, and will also make it easier to identify pitfalls and eventually the problems once the system is developed. Influences on use case action sequencing might consider each of the SWOT issues raised above. Developers and users should agree on which to address and which can be left for another time. More details about developing use cases are presented below.

USER-CENTERED DESIGN

User-centered design can be used to help guide the development of a CWA (Lazar, 2006). By the nature of its name, user-centered design is an approach to system design that makes users important participants in the design process. User-centered design is a design philosophy and a process in which the needs, wants, and limitations of the end user of an interface or document are given extensive attention at each stage of the design process. User-centered design can be characterized as a multi-stage problem solving process that not only requires designers to analyze and foresee how users are likely to use an interface, but also to test the validity of their assumptions with regards to user behavior in real world tests with actual users. Such testing is necessary as it is often very difficult for the designers of an interface to understand intuitively what a first-time user of their design experiences (Wikipedia, 2008). When one considers users to be an important part of the broader process of implementing, testing and evaluating systems, then one is engaging in a user-centered development process.

A productive approach for engaging users within design and development of a CWA is the use of a LOGIC Model. A LOGIC model is a structured process that integrates project design and evaluation (Mayeske & Lamber, 2001; McLaughlin & Jordan, 1999). Developers pose the design from input provided by users. Evaluation involves an

assessment of how well the design features support the use case (user) actions.

Kramer (2008) describes one type of LOGIC model consisting of three stages for user-centered design within the context of user-centered development of the Canadian Atlas. The first stage is an examination of business requirements. The second stage is detailed user requirements. The third stage involves systems design, including product design. Others might see more steps, but seldom would we have fewer steps in the development process. An important point, no matter whose version of user-centered design one might take, the user is always placed "front and center" in the overall process.

The University of Wisconsin Sea Grant Institute and its partners are utilizing a LOGIC Model in developing the Wisconsin CWA. The process includes conducting an inventory of potential CWA partners to ascertain data capabilities, contact information, etc.; forming an advisory committee with broad representation of coastal constituencies; completing the LOGIC model for the project; documenting objectives, outputs, and outcomes; and utilizing collaborative technologies to share the LOGIC Model with members of the ICAN for review and critique. It is worth noting that the U.S. National Oceanic and Atmospheric Administration (NOAA) has adopted the LOGIC Model as a means to ensure that coastal management projects are well designed and that it is easy to measure the performance of projects as they are implemented and offers training courses on project design and evaluation that features the LOGIC Model (NOAA CSC, 2009).

In the user-centered design paradigm, some of the users become actual or *de facto* members of the design team. The term *user friendly* is often used as a synonym for *usable*, though it may also refer to accessibility of capabilities. *Usability* is a term that denotes the ease with which people can employ a particular tool, display, or other capability to achieve a particular goal. For several years Haklay (2009) has been researching the advantages of usability engineering for development of geographic information systems (GIS), including web GIS. That research has "…focused on the way in which 'common users' of GIS and geospatial technologies use these systems. The aim is to understand how the interfaces work and how to improve them so they will be effective, efficient and enjoyable to use" (Haklay, 2009). Usability can also refer to the methods of measuring usability and the study of the principles behind an object's perceived efficiency or elegance. To continue the theme of what makes a usable atlas, we focus on the issues concerned with the former rather than the latter.

The primary notion of usability is that an object designed with the users' psychology and physiology in mind is, for example:

- More efficient to use – it takes less time to accomplish a particular task;
- Easier to learn – operation can be learned by observing the object;
- More satisfying to use – a sense of productivity; and
- Understanding CWA usability develops from understanding both user-centric and technology-centric issues. User-centric issues address the abilities, needs, and expectations of users. Technology-centric issues address the capabilities presented to users for addressing their needs and expectations.

Usability evaluation starts with the development of a set of use cases (defined earlier in the user needs section) that are representative of the kinds of activities users will perform. Use cases can be drafted and adopted jointly by users and developers as "agreements" about the kinds of information linked to the kinds of capabilities to be offered within a CWA. A single use case as a narrative can contain many elements. However, to make a narrative somewhat systematic, some designers recommend using templates for devel-

oping use cases. Below is a template based upon the Wikipedia description that is quite thorough in comparison to several academically-oriented descriptions of a use case (Wikipedia, 2008). Developers can use this template as a quick guide for detailing use cases, adding or removing characteristics as appropriate to each case.

- *Use case name*: A unique descriptor, short and to the point.
- *Version*: Versions help users and developers track what changes, as use cases can be revised through iterative steps of creating and/or updating an atlas.
- *Goal*: With a user in mind, in its simplest sense the goal of a use case could take the form of a question that is posed. Questions beg answers. Since every (or at least almost any) statement can be transformed easily into a question, we use the questions because they motivate users to seek information.
- *Summary*: The brief description of the use case that can be consulted when someone wants to scan an overview.
- *Actors*: The user groups identified in section 17.1 form the basis for describing actors in a use case. As mentioned above various user groups have different needs for information, and thus the questions are likely to vary depending on user group actors.
- *Preconditions*: Preconditions are the basic inputs to a question, perhaps assumptions being made about the circumstances under which a question would be asked.
- *Triggers*: Triggers are what activate the questions, perhaps in the circumstances set up as part of preconditions.
- *Basic course of actions*: The basic course of actions in the use case is the sequence of capabilities to be invoked by a user group actor once the preconditions are in place. These events would be the button pushing, keystrokes or screen picks made to initiate computer activities within the atlas.
- *Alternative paths*: A work-around to the basic course of events, if it is possible.
- *Postconditions*: What results from the execution of the basic course of events?
- *Business rules*: Business rules are the general guidelines established by an organization for the ways of carrying out activities. Such rules might or might not apply to the use of certain information within certain conditions of seeking information, e.g., constrains on accessing information from certain sources.
- *Notes*: An ancillary information that could help interpret the use case, e.g., if there are special circumstances for its inclusion in development effort.
- *Author and date*: Sometimes, the template has variations, and it would be good to know whose creative input was used to establish that variation.

It is nearly impossible to specify all the capabilities and information to be designed, and thus a diverse collection of use cases, each with perhaps two or more scenarios, provide a sampling of what is to be created, and when tested, what was actually created in the software. Use cases can be prioritized to provide developers and users with a shared understanding about what is more important and less important.

WEB INTERFACE PITFALLS

All CWAs are websites, and thus need to consider and avoid common web interface mistakes that can materially detract from any user experience. In addition, due to the importance of maps and interactive map interfaces in CWA implementation, certain interface "caution areas" related to maps should also be considered.

In regards to common web interface mistakes, Nielsen & Loranger (2006) present a long list of web interface characteristics that can pose significant usability problems for users. They note that over the past decade, some old interface problems have become no longer relevant, while many others continue to be serious. If possible, designers should avoid or minimize use of features that those authors deem persistent "high-impact usability problems". Such serious issues include the following:

- Links that don't change color when visited.
- Breaking the back button.
- Opening new browser windows.
- Pop-up windows.
- Design elements that look like advertisements.
- Violating web-wide conventions (e.g., what can be clicked, and how).
- Non-existent content and empty claims.
- Dense content and unscannable text.

These items are provided as a checklist overview of typical web usability problem areas, and it is recommended that designers research the issues more thoroughly to understand how these problems might impact their design.

With regards to the particular hazards of incorporating maps and interactive map interfaces into a CWA, the issues are different depending whether static or interactive maps are being considered.

With static maps, many of the important issues to consider are those that are standard in conventional cartography. Legibility, ease of interpretation, and communication of essential information such as scale, map projection, metadata, etc. are all typical issues. These are complicated slightly on the web by issues of screen resolution (different screen resolutions can alter the scale of a displayed map if it has been rendered to display at a certain number of pixels per inch), available colors (some web image type palettes may be limited, causing maps to render poorly), and the inconsistencies of print vs. on-screen display renderings (typical rendering for print requires higher resolution than screen display, and this can alter the size of map elements such as labels and symbols). Coping with these cartographic challenges is inherent in any map-making exercise, while mastering the specific challenges of web maps will require close study of and experimentation with the specific map rendering software employed by each CWA.

When discussing interactive map interface hazards, all those items that pertain to static maps remain of concern, and in addition, the designers must consider the usability difficulties that might come with the addition of interactions such as panning, zooming, feature identification, feature search, and any other advanced map widget used in the mix. Harrower & Sheesley (2005) make the point that an interactive map that feels "natural" or "intuitive" to the user is not something based purely on design, but is a combination of the predisposition of the user (their level of need to accomplish a task, and their prior experience with similar tasks), as well as their level of exposure to any one specific design and the amount of repetition (or practice time) they have had with that design. As a result, testing of complex interactive map tools with real users asked to perform real tasks is the primary way that designers can obtain insight into how specific map interface features perform for the intended audience.

CONCLUSION

Knowing who the user groups are for coastal web atlas design, development, and evaluation is a necessary factor in successful user-centered design, but it is not sufficient for success. A systematic approach to user-centered design should use a logic model to frame the series of steps for engaging with users. Usability comes about by having users test software in multiple phases.

Inevitably, web interface pitfalls will arise. Sometimes this occurs because of "feature creep",

that is, users ask for this and that feature as the system moves forward in development. Designers should stay vigilant for the "high impact" usability problems as part of the design; as such vigilance can reduce and/or eliminate problems before they enter the development phase.

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KEY TERMS AND DEFINITIONS

Logic Model: A structured process that integrates project design and evaluation as part of the overall steps in development of software systems.

Usability: The ease with which people can employ a particular tool, display, or other capability to achieve a particular goal.

Use Case: Contains a description of a series of invoked software actions to accomplish a task.

User: A person that makes use of software.

User Abilities: The level of skills that a particular user possesses, but can also be attributed to a user group.

User Background: A collection of characteristics relevant to a particular user group.

User-Centered Design: A perspective on software system design that places the user 'front and center' in the design process.

User Expectations: Refers to the consistency that users expect from products.

User Group: A collection of users with the same set of characteristics for which the system is designed and intended.

User Needs: A collection of information (composed of information products and/or outcomes) that is relevant to a particular user and/or a user group.

User Perspective: An outlook on information that derives from responsibility and/or role within an organization.

Web interface: The style and tools presented to users for the purpose of interacting with the atlas.