An Evaluation of the Flood Warning Information System

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EXTENDED ABSTRACT

The focus of this paper is on a prototype information system called the Flood Warning Information System (FWIS) that has been developed for the purpose of communicating flood risks to the public. The system explores the use of a graphic and spatial interface for presenting and accessing flood warning messages. Graphics are being used to challenge traditional flood warning modes because they appear to be a natural and instinctive form of communication that have been used since early Mesopotamian times and are considered to be an almost universal language.

At present in Victoria, there are numerous flood prone regions which have had detailed flood studies completed. The flood modelling and simulations from these flood studies have produced a wealth of information but as with most areas of expertise, it is a challenge to interpret this information effectively so that it is understood by the majority of the public. What the FWIS does is provide users with a 3D map that depicts the extent of flood inundation based on Average Recurrence Interval (ARI) design flood events. The map is scaled locally so users are able to click on local features shown on the map and obtain flood information and safety information relevant to that feature or property.

The FWIS is deployed over the Internet. Therefore, river height readings collected by the Bureau of Meteorology (BoM) and displayed on the BoM website are used to determine which map should be shown. During times of emergency it is crucial that messages not only reach those at risk but also reflect in a clear, simple and timely manner the forecast risks. As the fastest growing communication medium in the world, the Internet has the potential to provide timely and up to date flood warnings and risks that can be accessed from any computer system with an Internet connection.

In developing the prototype FWIS, three primary factors controlled the choice of the development environment. These are a development environment that: 1) provides a format in 3D that can be accessed via the World Wide Web; 2) allows map information and metadata to be updated from a database to improve the efficiency of updates; and 3) is open source. The chosen development environment was the combination of two scripting languages; the Virtual Reality Modelling Language (VRML) and Hypertext Preprocessor (PHP). The prototype is comprised of three geographic visualization (GeoVis) tools. These are the 1) Flood Warning tool; 2) Find Property tool; and 3) Safety Information tool.

The FWIS has been designed as a template so that it can be customized to suit various locations providing the appropriate data exists. For this research, the town of Myrtleford in north-east Victoria has been chosen as a study area for which the prototype FWIS has been customised. Thirty people who reside or are familiar with Myrtleford evaluated the system. Test participants were required to evaluate the usability of the FWIS and to compare the FWIS to traditional flood warning modes: radio and fax. Results regarding the comparison of communication modes indicate that the majority of participants would use the FWIS and were generally impressed with the idea of using an online map to view flood warnings. Most participants also indicated that current warning content needs to be more specific and appreciated the ability to obtain property or street specific information and safety suggestions via the FWIS.

1. INTRODUCTION

In the 1999 Flood Warning Guide composed by Emergency Management Australia (Emergency Management Australia 1999), a model for the Total Flood Warning System was published. The system consisted of several components, being prediction, interpretation, message construction, communication and protective behaviour. For the Total Flood Warning System to work, each component needs to be present and equal amounts of consideration needs to be given to each component. Over the past several years, greater attention has been given to computational and analytical components of the Total Flood Warning System (Handmer 1997) and less time, research and funding has been allocated to message construction and dissemination (Handmer 1997), resulting in a low success rate of effective flood warning communication in Australia (Handmer 1997). This is a common occurrence in many countries with serious flood problems (Handmer 1997).

In response to this, a research project has been implemented which compares and evaluates three different flood warning formats and dissemination modes and determines how human subjects respond to each mode. The desired response to a flood warning is one where the message is understood and the recipient is provided with information that motivates appropriate and timely actions (Emergency Management Australia 1999). Two of the communication formats compared and evaluated are commonly in use during times of flooding. These are broadcast media (radio) and text (fax). The third communication format is a graphic (map) that is disseminated over the Internet. The maps are a part of the Flood Warning Information System (FWIS). Designed specifically for this research project, the FWIS uses maps to interpret numerical quantities such as river heights that are provided in a typical flood forecast. A main emphasis in the design of the system is to provide those at risk with what they need to know in order to maximise safety and minimise damages.

The first half of this paper describes the FWIS and the motivation behind its conception including an outline of the framework devised as a guide for the development of the prototype FWIS. The framework addresses several issues identified as reasons for why flood warnings are failing in Australia. The second half of this paper provides an overview of the prototype FWIS. The FWIS has been customised to a study area and has been evaluated by test participants who reside within or at least are familiar with the study area. Results that focus on the usefulness of such a system and how it compares to traditionally used modes of dissemination and message formats are also presented in this paper.

2. THE FLOOD WARNING INFORMATION SYSTEM

The FWIS is an interactive, online information system that provides the public with early flood warnings through a spatial interface. The system works in real time by providing a spatial representation of the forecast flood extents based on upstream river heights collected by the Bureau of Meteorology (BoM). The association between a river height at a gauged location along the river and forecast flood extents has been made by engineers who have completed comprehensive flood studies on the flood prone area (Sinclair Knight Merz 2000). The FWIS takes advantage of this information so that when a user visits the FWIS website they are presented with a flood map that provides a visual and spatial interpretation of the river height that is displayed on the BoM website. Thus, the user is shown what the recorded river height, a certain distance upstream, will mean in terms of their neighbourhood.

The FWIS is equipped with tools that require basic user interaction. Users can complete such tasks as search properties on the map and obtain safety and flood information for that property by using a computer mouse. Before those at risk can effectively respond to a message, they must first understand the message. Therefore, user interaction has been kept to a basic level as simplicity and clarity is the key in providing users with a meaningful flood warning message.

A prototype FWIS has been developed and consists of three GeoVis tools: 1) Flood Warning tool; 2) Find Property tool; and 3) Safety Information tool. The Flood Warning tool is not an interactive tool but has been developed to associate BoM river height readings to the appropriate flood map. The other two tools are interactive and have been built so that users can access information stored in the map as well as search for specific properties on the map. Each tool is discussed in greater detail in section 2.2.

2.1. Motivation for conception

The FWIS was developed as part of a research program that is investigating whether the use of a graphic and spatial interface can improve flood risk communication to the public. As part of this research a framework was devised and to test the practicality of the framework the FWIS was designed and a prototype developed.

The framework addresses several issues identified by Handmer (2000) as the likely causes for the low success rate of flood risk communication in

Australia. Three reasons were provided by Handmer (2000) as to why warnings fail or appear to fail in Australia: 1) Methodological and definitional issues; 2) Meshing the warnings with those at risk; and 3) Macro issues of warning system design and operation. In the research framework, greater focus was placed on the second point given by Handmer, as the framework emphasises the role and advantage that graphics can provide in flood risk communication. An overview of the four proposed framework components is provided in the following paragraphs.

1. Framework component 1 - Graphics: an almost universal language
   This component concentrates on the use of a graphic interface to communicate flood warnings. The major benefits of using graphics as a communication format for flood warnings are that: graphics transcend lingual and cultural communication barriers; graphics can be static for a period of time long enough to give a person a chance to reassess a flood warning message; and the human mind reacts to visual information quickly (Reisberg 2001).

2. Framework component 2 - Personalise the flood warning
   The initial concern of those at risk revolves around the safety of close family and friends as well as property belonging to the risk bearer. Therefore by personalising flood warning information it is expected that people will pay more attention to warnings and safety information when the potential damage is put into perspective.

3. Framework component 3 - "Spice it up" with aesthetically pleasing graphics
   Humans are incredibly visual creatures and are generally attracted to objects that are visually pleasing and engage interest. By improving the appearance of a flood warning message, it is expected that more people will pay attention to the warning.

4. Framework component 4 - The Internet and the World Wide Web
   The Internet is the fastest growing communicating medium in the world (Cornford 2003). Statistics indicate a 146.2% growth in world Internet usage between 2000 and 2005. Major benefits of using the Internet for disseminating flood risk messages includes: the ability to access messages at any time of the day from a computer with an Internet connection; simultaneous access to information by many people; and updates are easily received by monitoring websites.

2.2. The prototype FWIS

The prototype FWIS has been developed and customized to a study area. The chosen study area is the town of Myrtleford in north east Victoria which has a population of around 3000 residents. The town frequently suffers from flooding mainly caused by the overflow of the Ovens River. The choice to use an existing study area and live data was made so that the prototype FWIS could be tested and evaluated by members of a community that are at least aware of the fact that they live in a flood plain. Such test participants provided valuable data regarding the usability of the system as they themselves are the targeted and potential users. At this point the FWIS is restricted to riverine flooding only.

In applying framework component 3: "Spice it up" with aesthetically pleasing graphics, it was decided to test whether the use of a 3D map would attract a users attention and relay the message in a more effective manner than a 2D map. Since framework component 4 specifies that the FWIS is to operate and be accessed over the Internet, it was necessary to use a development environment that produces a map in a 3D format that can be viewed and accessed online. The Virtual Reality Modelling Language (VRML) in conjunction with scripting language Hypertext Preprocessor (PHP) met this requirement and was therefore used to build the prototype. Both VRML and PHP are open source Internet technologies.

It was also decided to develop the FWIS as a template so that the system can be customised to various locations without the implementer requiring extensive knowledge of programming languages used. The template was designed so that all the data used to make the 3D VRML map such as object locations (x y z coordinates), colours, labels and images can be stored in a text file database. PHP is used to access this data from the text file and store it in an array within the script. A powerful feature of PHP is its ability to generate code. PHP is used to generate VRML. The fact that all the data used to make the map is stored within text files means that implementers of the system who need to update the map can do so using the text files, thus minimising the amount of programming required. The data input into the prototype arrives from a comprehensive, government funded flood study that has been completed in Myrtleford (Sinclair Knight Merz 2000).

As mentioned in earlier sections of this paper, the prototype FWIS is equipped with three geographic visualization (GeoVis) tools (Figure 1). A summary of each tool follows.

Figure 1. A screen grab of the prototype FWIS interface. Numbers in white boxes refer to: 1) The 3D map displayed by the Flood Warning tool; 2) the Find Property tool; 3) Information displayed by the Safety Information.

Flood Warning tool

The Flood Warning tool is not an interactive tool, but a tool that controls which Average Recurrence Interval (ARI) design event map (e.g. a 1 in 100 year flood map) should be displayed for a particular river height reading. It links the BoM river height readings that are tabulated and displayed on the BoM website to a map of a particular ARI design event. The tool associates a numeric value (river height) to a visual representation. The map displayed is the visual interpretation of the numeric river height. PHP was used to make the Flood Warning tool. At this point, parameters influencing which flood map should be shown is limited to river heights only as the research presented here is primarily concerned with the application of graphic interfaces for flood risk communication. Other parameters such as rainfall, local knowledge and other weather patterns can be built into the system at a later stage.

The Find Property tool

The Find Property tool is a search tool that allows users to find properties on the map. Users are able to specify the property using an index or by typing a business name or a street address into a text input area. Once the property is specified, the view of the map changes so that the opted property dominates the viewing space. This tool is interactive and works with the map provided within the Flood Warning tool. Although VRML browsers are equipped with navigation controls, it was felt that the standard VRML browser controls were not user friendly. Therefore they were disabled for the FWIS. A Java applet was used to make the Find Property tool. Therefore an External Authoring Interface (EAI) was required so that the Java applet could communicate with the VRML browser.

The Safety Information tool

The purpose of the Safety Information tool is to provide users with a way to access safety information and safety suggestions that are particular to different properties on the map. Access to the safety information is provided by standard map roll-overs where the cursor changes when a user has rolled over an anchored[1] property. Clicking on the anchored property will display the safety information in the lower frame of the Internet browser. This information is accompanied by an image of the property,

[1] "Anchored" refers to an object that has a VRML Anchor node associated to it and therefore, in this case, creating a link to text.

property description, property address and flood warning information (Figure 2). The FWIS has been designed as a template, therefore emergency management operators are able to customize the system so that additional flood warning information may be added or removed from the table shown in Figure 2.

Image	Description	Address	Warning	Safety suggestion	Suggested exit
	Myrtleford Hotel	59 Standish Street	There is a high risk that floodwaters will surround and possibly enter this property today. Low-speed waters can be expected.This property is in an area that can expect floodwaters of around 0.25 meters or less, above ground level.	Raise valuables and any potentially harmful solvents (including petrol, paint) to a level at least 0.5 meters above floor level. Sandbag the front and back entrances. For sandbags, contact the local SES on (55) 55 55555.	

Figure 2. Information accessed by the Safety Information tool.

3. EVALUATION

Thirty participants familiar with Myrtleford and having at least a basic level of experience with computers evaluated the prototype. Participants ranged in age and gender and most had reasonable map skills. It was important that test participants have some experience with computers because it was expected that real-life users of the system would be familiar with computers and basically ‘like’ computer use. Using test participants who are representative of the intended users is a strong trait of usability testing (Nielson 1993). As well as testing the usability of the FWIS, participants were required to evaluate how useful a tool the FWIS was for interpreting flood forecasts and communicating local flood warning and safety information. Therefore, it was preferred that the test population consisted of people who were affected by flooding or at least knew that the town is flood prone. The results discussed here include those that reflect how participants felt about using a map to receive a flood forecast and their thoughts about using a computer to access flood warnings and general safety information. How the FWIS compares to other dissemination formats that are traditionally used before and during periods of flooding (radio and fax) are also addressed here.

3.1. Test procedure

Before the results are discussed, an overview of the test procedure is provided. The test procedure involved several phases. During each phase participants were allowed to ask questions and were encouraged to criticise and comment on any aspect of the FWIS.

Pre-phase introduction

Participants were asked to describe what it was they saw on the map. They were also asked to indicate the direction to other towns and to locate local landmarks. Opinions regarding the colours and the overall design of the interface were encouraged. The purpose of this phase was to determine how well participants are able to orientate themselves within the map and if the level of map abstraction is adequate.

The pre-phase introduction was concluded with an introduction to the FWIS including a demonstration of how it worked. Participants were given a few minutes to familiarise themselves with the FWIS.

Phase 1

The purpose of phase 1 was to examine whether participants were aware of current flood warning dissemination modes in use in Myrtleford – radio and fax, and if the messages disseminated via these modes were clear enough to prompt a positive response to safety warnings.

Phase 2

Here, the learnabiliy of the system was tested by timing how long it took participants to locate properties on the map and how long it took participants to access the flood warning information and safety suggestions for a specific property.

Phase 3

Phase 3 examines the usefulness of the system.

Phase 4

Phase 4 required participants to compare a 3D map to a 2D map. They were asked their preference and why they made this choice. The purpose of this phase was to test whether the novelty of a 3D map attracted the participants’ attention more so than a standard 2D map. Participants were also asked to compare and evaluate four different versions of the 3D map where each version varied in Geographical Dirtiness (Cartwright, Miller and Pettit 2004). Geographical Dirtiness refers to the visual complexity of the spatial environment depicted on a representation.

Phase 5

Participants were asked to complete a "measurement of satisfaction" questionnaire which was to be followed by a short debriefing session.

Results from Phases 1, 2, 3 and 5 are discussed in the next sub section.

3.2. Results

The usefulness of the system simply refers to whether or not the participant would use a system like the FWIS. This was evaluated by asking participants if they would use the FWIS. In response to this question, 82% of participants said that they would use the FWIS and 89% would encourage others to use it. Those who indicated that they would not use such a system to obtain flood warnings gave reasons such as: having a lack of self-confidence when using the Internet; and having enough trust in community networks, local knowledge and personal experience not to need to refer to a secondary source of information.

Participants were generally impressed with the idea of using a map to obtain flood and flood safety information. The ability to specify present warnings in an efficient manner to areas or properties within the town was appreciated. Many liked the fact that they were provided with a visual representation of the forecast opposed to numbers with comments such as:

"Heights don't say much to me. I don't know the difference between the normal and raised river height…using a visual aid helps me understand what is happening"; and

"The FWIS seems really good. Instead of sitting around, you can get online and view more information".

Some participants liked the idea of using the FWIS to confirm radio forecasts and warnings. Many felt that radio was a mode that transmits a forecast quickly, providing the right station is tuned into and being listened too, which is important when dealing with emergency situations. Eighty-nine percent of participants indicated that radio was a good mode of warning but many commented on the lack of message clarity. A typical radio flood warning will include the forecast river heights upstream. After hearing the simulated radio broadcast, several participants did not know what this river height meant to them. They also felt that a radio warning did not provide listeners with enough information on Myrtleford. Eighty-two percent of participants stated that they would prefer flood warning information that was particular to specific areas within their town or properties.

Seventy-five percent of participants indicated that they did not mind using the Internet to access the FWIS. The majority of participants used the Internet at least twice a week and thirty two percent incorporate Internet usage into their daily routine. Several participants commented on the possibility of receiving warnings by email, as they liked the idea of a static message that could be read many times. This was apparent during Phase 1 where participants were handed a simulated fax flood warning on paper. Seventy one percent of participants liked the format of the warning as they had enough time to thoroughly examine the information. Issues regarding the fax warning that were identified by participants include the relevance and clarity of the information provided and the fact that seventy five percent of participants did not know that faxed warnings existed. In regards to the relevance and clarity of the warnings, many felt that more information specific to Myrtleford was needed and that the necessary safety information was missing.

Although the concept of communicating flood risks in a spatial format and over the Internet was appreciated by most participants, a particular comment was made in regards to simplicity and common sense:

"The idea is feasible but not applicable to all people… It (the FWIS) might work in East Ringwood, but not here…I see the value in this for those who can not handle a situation and would need to look in a book for the answer…rural oriented people make up their own mind"

These were reasonable comments for some, but for those who had never experienced a flood or merely needed a reminder of how to deal with such a situation, clear, efficient and relevant messages need to be constructed and disseminated within the allowed timeframe. A few participants also commented on simplicity where they felt that it was important to allow humans to think for themselves and therefore simplify messages. These participants felt that it was necessary to provide warnings that include risk information and safety suggestions but not to over saturate the recipients with information.

4. DISCUSSION

The importance of effective flood risk communication is often underestimated and as a consequence messages are not understood, therefore the effort put into getting the numbers right can be wasted. Through the research presented in this paper it is evident that showing people where the floodwaters are expected to flow for certain forecasts does help a person understand a situation presented. People like pictures. They like information to be internalised through vision, especially when dealing with a spatial phenomenon like floodwater extents, where truth is applied to the saying 'a picture is worth a thousand words'.

Before such a system as the FWIS is made available in the public domain, obvious issues need to be addressed. One of these is the guarantee that an Internet connection can be established during extreme weather conditions. During extreme weather conditions there are limitations to Internet technologies that rely on telephone lines for transmission such as dial-up or Integrated Services Digital Network (ISDN) as generally, extreme storm conditions and high velocity waters will damage lines and prevent transmission. Other Internet technologies such as Broadband Cable where transmission cables are laid beneath the earth's surface or Broadband 2-way Satellite can surpass the communication disruptions experienced during extreme weather conditions. The major drawback of implementing such technologies is the installation costs.

There is also the issue of uncertainty in the displayed floodwater extents. The maps used in the FWIS are not designed to show the exact spread of water extents. The idea is to provide the public with a guide for inundation preparation and to basically inform of the potential risks. Maps provide an efficient way in which to disseminate property specific information. Participants involved with the testing procedure understood that the water extents shown do not represent the exact location of where the water will flow. They also appreciated that the maps are able to give them information that is relevant to their property opposed to general warnings that are broadcast over the radio. This was especially the case for residents who have recently settled in the study area and are still to experience a flood.

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