

Emergency Warning and Management in Dam Rupture using Online Mapping

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Summary

The work presented in this paper was developed in the context of a NATO Science for Stability project (NATO PO FLOODRISK- Dam Break Flood Risk Management in Portugal) that aimed to develop tools to improve the management of flood hazards in downstream valleys of dams. The results of the project were applied to the Arade Valley, in the south of Portugal.

The tools developed by the project involved the following: the Daminfo system, which incorporated a database holding relevant information on Portuguese dams associated with geographic data; a set of dam break models, developed in the context of the case-study in order to identify and display a range of critical inundation areas; and DamAid, an emergency warning and management system for dam ruptures.

This paper describes the design and development of DamAid. Its main purpose is to provide authorities with enough information to produce decisions in real time, with a step-by-step reminder of the emergency plans' procedures, and with sufficiently robust tools to enable the gathering of decision-makers that are geographically apart. The system is based on existing plans' definitions and procedures for emergencies that may occur in the Arade valley and includes the necessary (pre-emergency) information to aid decision-makers during the emergency period. It also includes an online mapping application integrating the information developed to evaluate the situation during the several steps of the emergency plan.

Keywords: Emergency warning and flood management, Online mapping, Internet, geographic information system, land use management, inundation maps.

1. Introduction

Emergency planning and management in Portugal is the function of the Portuguese National Service for Civil Protection (SNPC). In this country, emergency planning is organized in two dimensions: specificity and geographic jurisdiction. Specificity defines the functional application of the plans, either general or special (e.g. Special Plan for Flood Operations). Emergency plans can also be defined according to their jurisdictional application, which means that they can be National, Regional, District and Local.

One of the aims of the PO-FLOODRISK project was to provide Civil Protection Agents with new information and means to update current emergency plans on the management of Dam Rupture Emergencies. The DamAid system incorporates this information to improve the performance of the plan, in emergency planning and management. DamAid is the result of the evaluation of current emergency procedures, discussions with civil protection officers and the project's resulting information and it was developed for National and District civil protection officers.

This paper begins by describing the process used by civil protection officers in the case of a dam rupture emergency. This process was evaluated in terms of its sequence, interdependencies and information needs. The results were used as the basis (for the methodology) for the development of



DamAid. The system's architecture and its development are also described. The paper ends with the evaluation of the results of the work and some considerations for future developments.

2. Dam Rupture Emergencies in Portugal

Dam rupture planning and management in Portugal is based on the existing special plan for flood operations (PEOC). This plan enables the management of general flood emergencies and is being updated with the aim of creating a specific special plan for dam ruptures. The development of the DamAid system was based on the measures contemplated by this plan and on its information needs.

According to SNPC, the aims of PEOC are [6]:

- To enforce the continuous update of the emergency situation;
- to make a contribution towards the co-ordinated management of dam discharges during emergency situations;
- to enable support from the SNPC to their district counterparts, in terms of information and means.

During this type of emergency, SNPC officers are constantly informed about the situation and work in strict collaboration with their district counterparts, The Portuguese Meteorology Institute, The Portuguese Water Institute, relevant dam management organisations and other civil protection agents.

The current state of the emergency situation, as dictated by the PEOC, is based on two concepts, which will be described in the next section: Emergency colour phasing and periodic briefings.

2.1 Special Plan for Flood Operations (PEOC)

As stated above, the state of the current emergency situation is mapped into three possible phases (each one with a colour associated): Yellow, Orange and Red. Blue is used to describe a normal situation. These phases are similar to the Levels 1, 2, 3 and 4 used by the United States [7] and can be described in the following way:

- Blue – Normal situation;
- Yellow – Occurrence of disruption or event which may compromise either the structural and/or operational safety of the dam, or the dam's observation and control facilities (with possible effects in the downstream valley);
- Orange – High probability of an accident, possibility of loss of control of the situation in the downstream valley;
- Red – Inevitable catastrophe situation.

The decision on which is the current phase of the plan is based on several factors: hydrologic values, downstream valley discharge levels and the water level of the reservoir. Once this decision is made, the measures relevant to each phase (for each jurisdiction) are also specific.

Phase Blue is mainly a planning phase, where infrastructures and communication facilities are checked, updated and evaluated, to maintain the emergency system prepared for any abnormal occurrence. Updates of the current emergency plan are executed and prevention actions and exercises take place.

If an hazard takes the plan to its Yellow Phase a set of key people in this type of emergency are called and information between civil protection officers starts flowing. Public information warning may be generated but no evacuations are in order. Periodic briefings take place to acknowledge the current state of the emergency at hand.

Orange means the intensifying of the measures taken in the yellow phase and the preparation or the activation of rescue measures and resources. The group of people gathered at civil protection centres are now aiming for response measures, instead of simply evaluating the situation.

If the plan reaches the Red Phase, the evacuation of the population is automatic and the staff at civil protection offices is reinforced. If needed, reinforcement of rescue measures and resources is

executed.

The measures taken at each step (briefly described above) are decided at periodic briefings, which take place at the civil protection situation centre. Therefore, the description of the proceedings of these briefings and its integration with the several phases of the emergency plan are of major importance, as they will constitute a log of the step-by-step execution of the plan. At these briefings, the hydrologic situation is evaluated along with the current phase of the plan, which determines the following actions to take. Thus, the logging of the periodic briefing should be integrated in the management of the emergency.

At the periodic briefings, the current emergency situation is evaluated (and described) based on the following: event analysis, weather situation (past, present and foreseen), water resources situation in the river basin, seismic situation and news press information given to the public. From this analysis, a set of planning and emergency measures is taken.

Currently, the execution of PEOC is based on an event database and on the execution of these measures, supported by the writing of the plan and on decisions made at briefings. However, in an emergency situation, particularly in dam ruptures where events may develop very rapidly, an automatic system to facilitate decision-making in real time may prove very efficient.

3. The development of Dam Aid

3.1 The need for DamAid

DamAid was first conceived as the possibility for several types of operational staff, which could be geographically apart, being able to manage the same dam rupture emergency at different levels. The need for the use of the Internet as the interface for this type of system was obvious. The system includes two types of components: the emergency manager component and the geographic information (GI) component. The former would follow the plan's rules and sequence, in order to serve as a step-by-step reminder of the plan's actions at each phase. The latter would improve the evaluation capacity of the civil protection team by providing information on disruptions taking place at each phase and on the needs of populations at risk. The logging of actions and briefings would enable the evaluation of the situation both during and after the emergency.

In the following sections, the complete system is described. The emergency manager component was developed using Internet technology, specifically Java Beans and Java Server Pages [5]. The GI component is based on ESRI ArcIMS tools [4].

4. The DamAid System

The development of the Emergency Manager component is currently independent from the GI component. However, further developments will include the integration of both components in terms of data access. Therefore, the Emergency Manager component was developed using Java Server Pages (JSP) and Java Beans with the aim of providing a portable solution in terms of Application Server and Client Browser as well as later integration with the ArcIMS solution.

The use of Java Beans in the server part of the Emergency Manager component has enabled the modelling of the relevant entities in the system, which include the management of emergencies in terms of *Colour Phases* and *Emergency briefings*. Java Beans classes implement the Application Program Interface (API) for these entities, which compose the relevant information in an Emergency. JSP complements this server view as the basis for the development of different portable client interfaces, each one as a presentation layer applicable to every jurisdictional level in the system.

The development of DamAid is based on the idea of managing one emergency from several locations. This implies the existence of one server, holding the information about the current emergency as well as the log of the actions taken in its context. Depending on the several roles played by civil protection officers, there may be several types of clients communicating with the server.

The need for distributed management in the emergency manager component implied the use of several client applications connecting with one server. Therefore, this component had to be divided

in several parts (*Fig. 1*):

- SNPCAgent: The National level client, which obeys to the National plan's alert-based rules;
- DDPCAgent: The District level client;
- BriefingLog: The periodic briefings client, which may be associated with any level clients;
- Emergency Manager Server: the central server, capable of managing the information arriving from the two client sources, deciding the currently relevant measures to be taken and requesting final decision from the responsible civil protection officer.

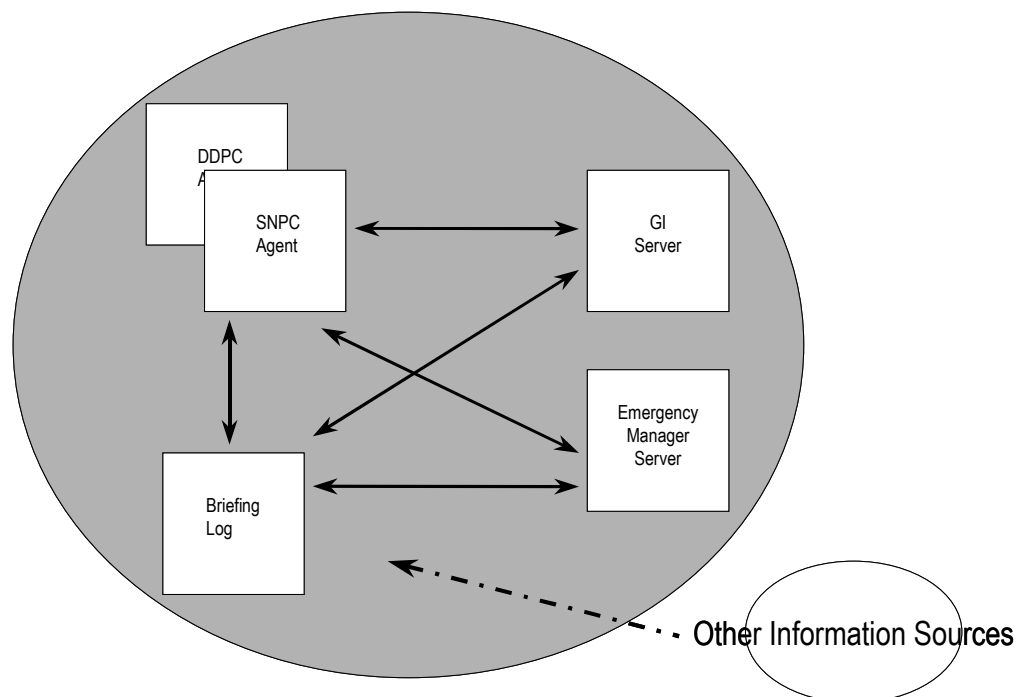


Fig. 1 – DamAid Architecture

Because the system was conceived for the National and District levels, only two level clients were built. Associated with SNPCAgent and DDPCAgent is the briefings client that enables the storage of the measures taken at the several decision levels. The Emergency Manager Server does not have its own user interface, it communicates with the user through the several clients (*Fig. 2*).

The briefings log interface enables the connection with several information sources used by civil protection agents to evaluate the emergency situation. Therefore, it is possible to use this part of the system to access these sources (weather, water resources, seismic and press information), to immediately decide on the measures to take and consequently, to store the decisions made in the briefings log.

The Emergency Manager Component is developed using Java Server Pages technology [5], which means that each emergency is handled as an information object composed of several other types of objects (phases, logs, events) stored in the server and updated from each type of client. However, because there may be differences in the management of the emergency at the district and national level, the information concerning each of the levels is handled separately, as well as their current colour phases. Once an emergency (or a phase of it) is over, its sequence of actions is mapped into an HTML document, which becomes available for access and evaluation.

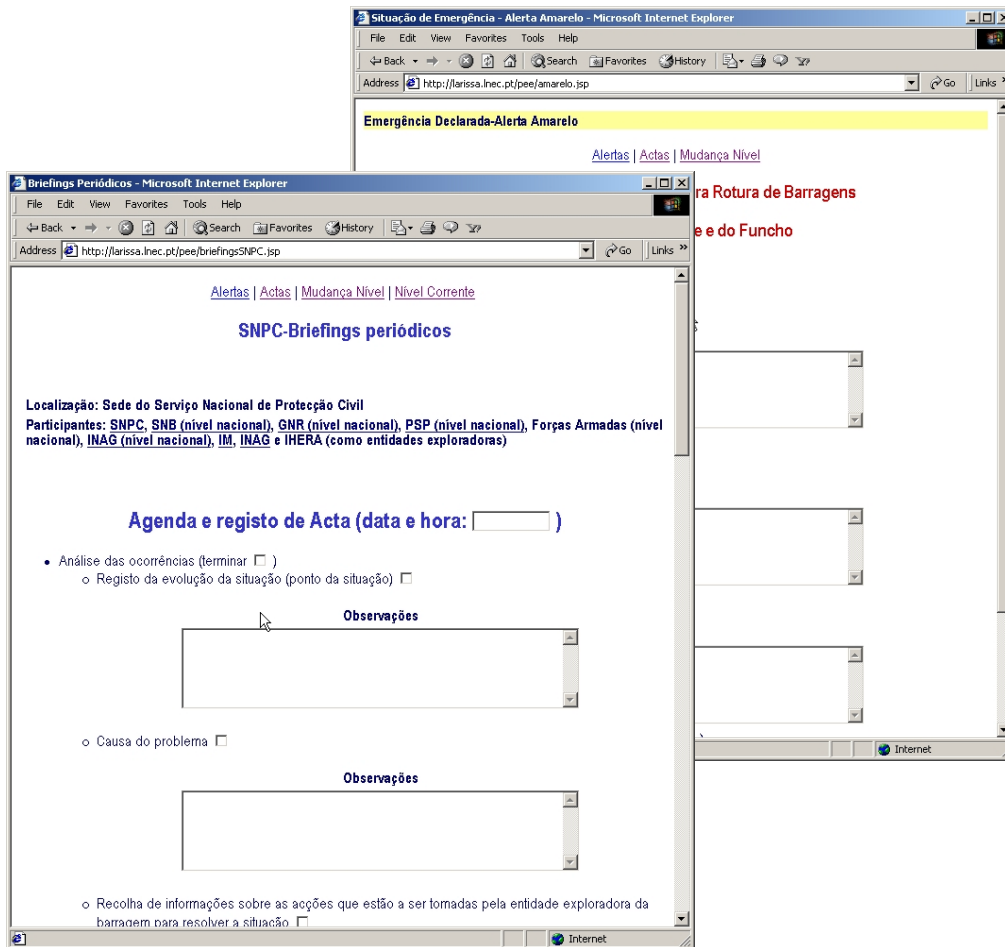


Fig. 2 – DamAid: The Emergency Manager Component

Along with the Emergency Manager Component, the GI component was also developed, as an information support tool. The information contained in the GI component includes not only base data from the area at risk but also results from the project itself, which enable the evaluation of the specific areas at risk (e.g. important services and infrastructures) [1,2]. This component is still under development but some of the work is already available (Fig. 3).

5. Conclusions and further developments

The fundamental advantage of DamAid is the possibility of managing dam rupture emergencies in a distributed manner, at different levels, while generating centralized information about the event. Moreover, the use of object-oriented technology for building the server facilitates the update of the features available as well as the rapid availability of changes. In fact, the update of emergency plan can be quickly applied to the system implementation and thus evaluated by civil protection agents.

The operational advantages of the system will reflect themselves in an improved planning and management of emergency situations. However, they will also imply methodological improvements. The mapping of the emergency plan into an application interface will enable the identification of structural problems in the process used to manage events. In fact, information or processing needs, which had not yet become apparent, may arise from the use of the application.

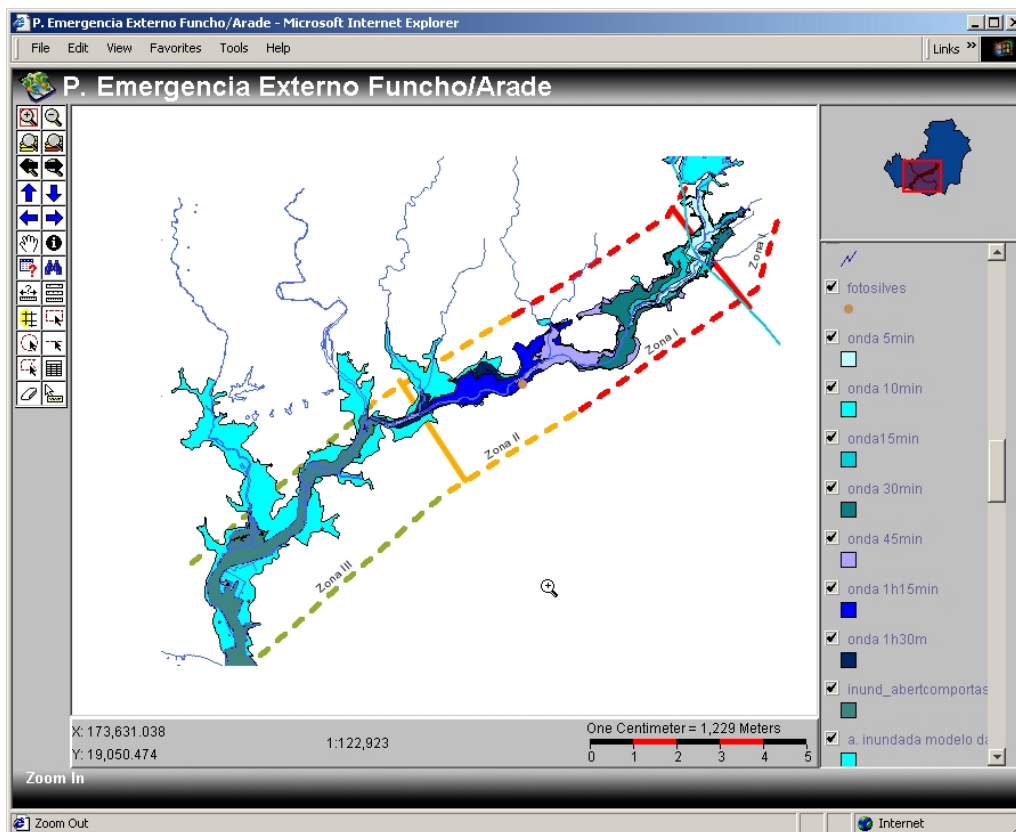


Fig. 3 – DamAid: Interface for the GI component

The next step is to test the system in a real situation and subsequently identify problems and possible extensions to it.

One major development would be to integrate decision-making according to the plan with the information sources (as seen in *Fig.1*) used by civil protection officers. This could improve the performance of the system in aiding decision making, although it is clear that it cannot replace it. Also needed are extensions to other jurisdictional levels of civil protection (local and regional). The development of software components that could be accessed through different types of device (e.g. personal digital assistants) would be very important, specifically if enabling communication between officers in the situation centre and on the field, with the possibility of exchanging real-time information.

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