PROJECT TO-SEALERT . FIRST DEVELOPMENTS

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ABSTRACT

The project To-SEAlert aims to develop, implement and validate a set of tools/methodologies for an early warning, forecast and alert, emergency planning and risk management WebGIS system, based on the existing HIDRALERTA system. This updated WebGIS system will help responsible authorities to monitor, prevent and/or manage overtopping and flood emergency events in coastal and port areas and to plan investments on a long-term basis. The new system includes the use of satellite and video images, numerical and physical modelling, and quantitative risk assessment techniques to enhance the reliability and efficiency of the system. It will also establish/implement/monitor emergency plans to help authorities handle these events. The test cases are Costa da Caparica and Ericeira harbour, sites with significant occurrence of wave driven overtopping and flooding with significant consequences for the infrastructures, goods, and people.

This paper aims to describe the project, namely its objectives, methodology and main expected results, as well as the achievements attained so far.

Palavras-Chave: To-SEAlert; overtopping; flooding; early warning; risk assessement

1. INTRODUCTION

The Portuguese coast is directly exposed to the action of the Atlantic Ocean waves. High-energy storms are frequent, endangering populations/port/coastal infrastructures and causing serious local economic and environmental consequences. For this reason, it is essential to provide responsible authorities with tools to manage the hazards and risks associated with the effects of waves and tides.

Although there are already some early warning systems that take into account coastal zone flooding caused by high tidal levels or storms surge, very few consider the water volumes associated with wave overtopping in those areas. Moreover, only very few early warning systems deal with floods in port areas.

The HIDRALERTA (Sabino *et al.*, 2018, Poseiro, 2019), is one of the few systems that consider wave overtopping of maritime structures and associated flooding in both coastal and port areas. The HIDRALERTA system was developed in a python framework and it is accessible from a Web platform (www.aurora.lnec.pt). The HIDRALERTA system encompasses four main modules: I - Sea-state Characterization, where the offshore wave conditions are propagated to inshore and inside ports using numerical models; II - Wave Run-up and Overtopping determination, using empirical formulae or ANN tools; III - Risk Assessment, which defines a risk level for the predicted overtopping values; IV - Warning System, which integrates all the information and disseminates warnings.

This system was implemented at Praia da Vitória, Madalena do Pico, and S. Roque do Pico ports and it currently provides 72 hours in advance the waves characteristics as well as of the overtopping and flooding risk levels at

that port. The system has already proved its usefulness to local authorities during the Alex storm in January 2016, providing exact indications for the closure period of Praia da Vitória port and waterfront. However, the system has not yet been thoroughly validated and still needs some improvements, namely in the accuracy of the forecasts for the flooded area and in the implementation of more quantitative approaches for risk assessment. In addition, the early warning component still needs to be validated, the robustness and flexibility of the system has to be improved and a decision support component in emergency situations should be introduced.

The objective of the To-SEAlert project is thus the development, implementation, and validation, in a WebGIS system, of a set of tools and methodologies for overtopping and flood forecasting in port and coastal areas. The main purpose of this project is to assist the responsible authorities in the monitoring, prevention and management of emergency situations. The system to be developed will be a long-term management tool for ports and coastal zones that will support decision makers (Civil Protection, Port Authorities), enabling the prevention and management of emergencies, adding value and potential benefits to areas under their responsibility.

The main results of the project will be: a) a system for monitoring, forecasting and early warning, as well as emergency response planning and risk assessment associated with overtopping and consequent flooding of neighboring areas; b) methodologies for assessing ocean overflows from satellite and video images and numerical models; c) sufficiently versatile video image processing methodologies for prototype and physical modelling applications; d) a validated numerical model for overtopping and flooding simulation; e) a set of quantitative risk assessment methodologies; f) a new emergency planning system on a WebGIS platform; g) To-SEAlert prototypes operational and validated for Ericeira port and Costa de Caparica coastal zone; h) higher preparedness in Portugal to address vulnerabilities associated with coastal flooding and climate change and better tools for monitoring and forecasting these phenomena.

The innovation of the To-SEAlert system results from the combination, interconnection and validation of different methodologies, the use of the latest numerical models for the assessment of overtopping and flooding, the use of new methods to validate / calibrate the numerical overtopping simulations (with the help of satellite and video images), as well as from the implementation of a new emergency planning and risk assessment module. It is foreseen that in the near future the To-SEAlert prototype for the Ericeira harbour will be operational and delivering overtopping and flooding forecasts.

Methodologies and accomplishments of the HIDRALERTA project achieved so far are herein described.

2. METHODOLOGY AND FIRST DEVELOPMENTS

The tasks of To-SEAlert project and also the indication of the main work made so far is described in what follows:

- T1 Satellite Image Methodologies: Procedures will be developed to allow both coastal zone characterization and the identification of flooded areas from satellite imagery according to the methodology of Roque *et al*. (2014). This is a very relevant source of information for the validation of numerical models involved in coastal flood modelling. In this task a link will be established with the European Earth observation program Copernicus. A compilation of the events occurred in Costa da Caparica was undertaken, as well as of the available satellite images and Copernicus impact maps of the January 2014 storm, the Hercules storm.
- T2 Integration of video monitoring systems for in situ monitoring and characterization of waves, overtopping and flooded areas: implementation of video monitoring systems in the study zones to characterize overtopping and flooded areas during the project period, according to the methodologies developed by Taborda & Silva (2012) and Andriolo (2018). These systems will allow real-time observation of these phenomena and the construction of long data series to support the calibration and validation of numerical models. Two video monitoring stations were installed, one in Costa da Caparica and one in Ericeira, both with IP cameras. The cameras are already operational and acquiring images. The image processing and analysis has already started for Costa da Caparica and the assessment of the impacts of an artificial nourishment project that occurred in September 2019 is presently undergoing. Fig.1 shows two overwiew photos taken by the cameras installed in each site.
- T3 Physical modeling: construction and exploration of 2D and 3D physical model of one of the zones under study, to characterize the wave overtopping and the flooded area in controlled situations, in order to validate numerical modelling. The work made so far consisted on the establishement of the setup of the 2D physical modelling, that represents one of the sections of Ericeira harbour, namely the section which includes the quay. Tests will begin in February 2020.

Fig. 1 – Camera Overview at Costa da Caparica (left) and Ericeira (right)

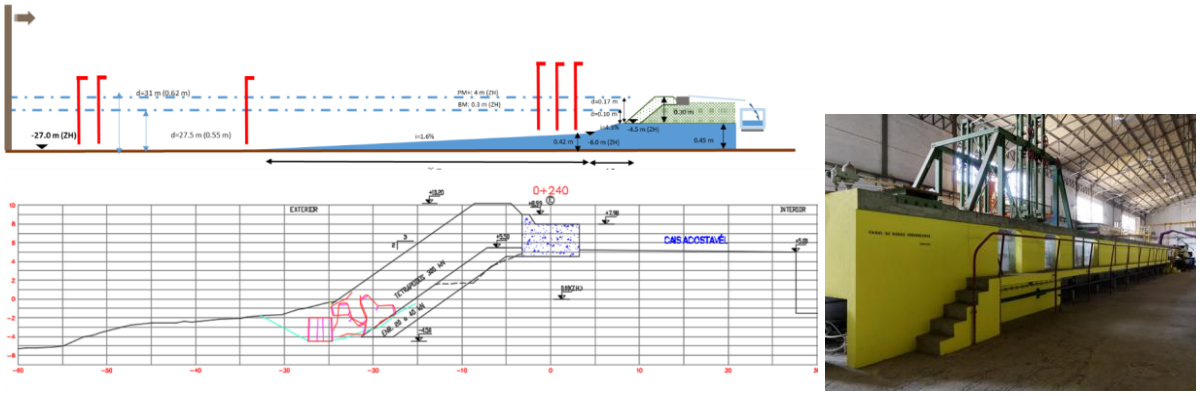

Fig. 2 – Set up of the physical model for Ericeira, Scale 1:50

- T4 Numerical models: implementation and validation of two procedures for overtopping and flooding simulation in coastal and port areas. For Costa da Caparica beach, the hydro and morphodynamic model XBEACH is used, which takes into account the modification of the beach profile for the determination of the overtopping and consequent flooding. First calculations of wave runup were already performed (Ferreira *et al.*, 2020). In Ericeira, the SWASH model (Zijlema *et al.*, 2011) based on the nonlinear shallow water equations and the IHFOAM model (Higuera *et al.*, 2013), based on RANS equations will be used.
- T5 Risk assessment and contingency plans: implementation of quantitative methodologies for assessing exposure, vulnerability, consequences and risk of ocean overflows and consequent cost for strategic infrastructure. Regarding the implementation, validation and operation of contingency plans, the procedures developed under the LIFESAVER project (Sabino *et al.*, 2008) will be used. This task has not yet started.
- T6 WebGIS tool: development of a Geographic Information System that includes all the information from previous tasks. Under this task, a set of procedures and modifications in the HIDRALERTA system have been made in order to improve the robustness and flexibility of the system so that it can be applied to other coastal and port areas. The implementation of an HIDRALERTA protopype to Ericeira port has already begun (Fig. 3);

Fig. 3 – Prototype of the HIDRALERTA for the Ericeira port.

- T7 Test Cases: The To-SEAlert prototype will be implemented and validated in the Costa de Caparica coastal zone and in the Ericeira port (Fig. 2). This task includes the adaptation of the WebGIS tool developed in the previous task, as well as filling in the relevant information on the study area and the validation of the complete system. The work done so far consists on the application of SWAN and DREAMS models for the characterization of waves and of the NN-Overtopping 2 for the overtopping assessment. A first risk evaluation was already performed. Fig. 4presents some results of the wave regime established with SWAN (Ferreira *et al*. 2020, Zozimo *et al.*, 2020);

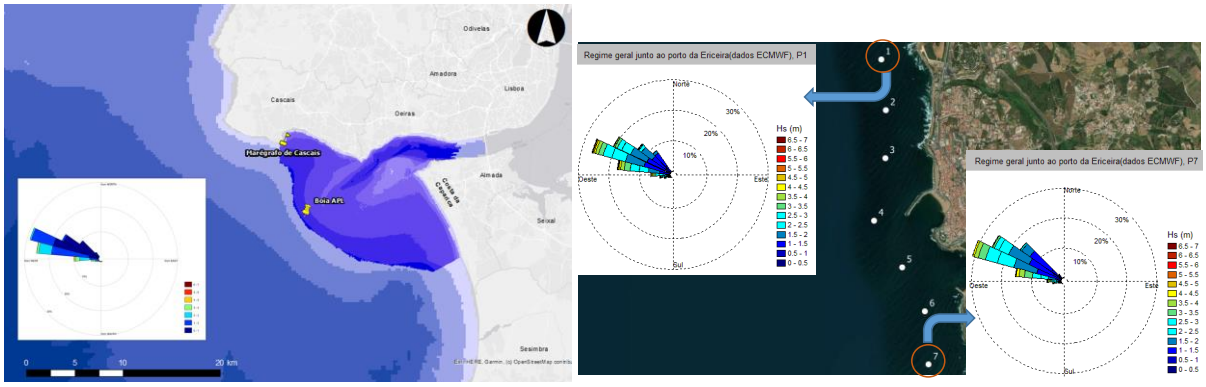

Fig. 4 –Wave regime at Costa da Caparica (wave buoy) and Ericeira (points1 and 7)

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