Project Summary

Organization
Lisbon City Council (subcontracted by HIDRA, Hidráulica & Ambiente, Lda.)

Location
Lisbon, Portugal

Project Objectives

- Mitigate flood risk in Lisbon through intervention in the existing infrastructure.
- Enhance drainage capacity of existing stormwater systems
- Deviation from critical areas of excess stormwater, by the construction of two new tunnels

Products Used
MOHID Studio, OpenFlows™ FLOOD™

Fast Facts

- MOHID Studio and OpenFlows FLOOD was used to implement a detailed, high-resolution 2D model of the most critical area of Lisbon. By combining the stormwater model with an overland model, it was possible to make different scenarios and assess what would be the best solution to deviate water from the critical zones.
- Historical events were reproduced for model validation during implementation; the validated model was used to analyze different return periods.
- The best trajectory and size of the tunnels was determined by evaluating the model scenarios.

ROI

- The new flood mitigation infrastructure will avoid 20 big floods over 100 years, saving hundreds of millions of euros.

Moving Toward a Proactive Paradigm Supported by Accurate and Complex Integrated Modeling

Bentley's State-of-the-art Flood Modeling Software Studies the Effectiveness of the New Drainage Master Plan for Lisbon Municipality

Repeat Flooding in Downtown Lisbon

Climatic changes, including sea level rise and frequent extreme rainfall events, has increased the risk of flood events in the city of Lisbon. The surrounding areas of the Portuguese city have also seen rapid urbanization in recent years, leading to soil imperviousness that has resulted in even more flood occurrences in the region. Most of the time, flood events are a consequence of heavy rainfall, which occur in single or multiple subcatchments.

Lisbon's existing infrastructure is not adequate to ensure efficient drainage during these storm events. Consequently, inundations in Lisbon, particularly in the downtown, have become a recurring event in recent years. Between 1900 and 2006, Lisbon registered 84 inundations, and between 2008 and 2014, 15 inundation events occurred.

Beyond the material costs, the impacts can affect human health and life, which brought the urgent need for a disruptive approach with a new EUR 170 million Drainage Master Plan for the Lisbon Municipality.

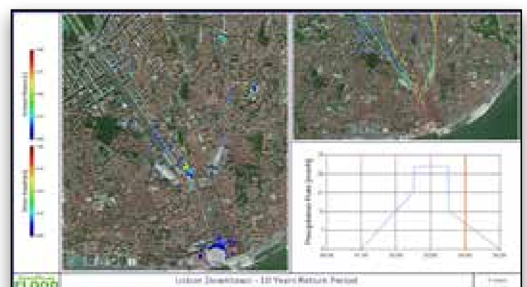
Adopting a Disruptive Solution, Shifting from Reactive to a Proactive Mindset

Building underground water reservoirs in downtown Lisbon is one possible strategy to contain and prevent flood events in the city. However, it was determined that the impacts of construction in the historic downtown area was not an option. Therefore, the alternative strategy was to deviate the flow of water from the risk areas and tunnel it to the Tagus Estuary.

However, the viability, effectiveness, and advantages of this complex and disruptive engineering solution needed to be fully analyzed and quantified prior to implementation. To avoid the reactive management approaches from the past (build first and check the consequences later), this time a proactive approach was presented. The strategy in the Lisbon municipality was to take advantage of all the available information, knowledge, and technology to develop a comprehensive plan and to study different scenarios before implementation. Bentley's state-of-the-art urban flood simulator became a key element on the development of this proactive approach, allowing the city to comprehensively model alternative scenarios.

Complex Realities Require Complex Modeling

The urban flood simulator was used for the development and implementation of a dynamic and integrated model to study the drainage and overland flow for several return periods. The main purpose was to compare the existing situation with the future scenario after the implementation of the tunneling strategy.



Flood simulation in downtown Lisbon. The image shows ponded water on the surface (on the left), capacity of the stormwater system (upper right), and the design storm (lower right).

The urban flood simulator integrates two advanced numerical modeling engines: i) MOHID Land engine to simulate the hydrologic processes in the watersheds and the hydraulic processes from the 2D overland flow; and ii) SWMM engine to simulate the flow in urban stormwater systems.

Water exchange between MOHID Land and the 1D pipe flows is computed based on hydraulic gradients, allowing the overland water to be transported from MOHID Land to the stormwater system through inlets and street gutters and – in the case of drainage surcharge – overflowing through the manholes (water flowing back from stormwater system to MOHID Land).

The main advantage of using this mathematical modeling approach is that it eases the implementation of a proactive paradigm to accurately analyze and visualize the impacts from multiple scenarios with an economical technology.

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High-resolution computational meshes were applied with more than 500,000 nodes, corresponding to a spatial resolution of 4 meters. These computational meshes were based on interpolations from up-to-date topography and planimetry data layers.

The rainfall considered was based on different return periods and historic events, the soil conditions were assumed to be high humidity (low infiltration capacity), and two different sea level scenarios were analyzed.

Validating Expensive Interventions with Economical Technologies

The implemented modeling system allowed the team to positively reproduce the frequent inundations occurring in downtown Lisbon recently.

The comparisons between the existing situation and the proposed solution allowed the team to clearly identify the proposed solution as a valid and effective option, significantly reducing the inundation area.

Flood simulation in downtown Lisbon. The image shows a comparison of two different scenarios.

The main advantage of using this mathematical modeling approach is that it eases the implementation of a proactive paradigm to accurately analyze and visualize the impacts from multiple scenarios with an economical technology. This benefit allows the decision makers to reduce the risks of inadequate and unsustainable decisions on the rehabilitation of drainage infrastructure, which is usually an expensive process.

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