Real-time monitoring of the rivers Boven-Rijn and Waal to support dredging operations

Andries Paarlberg [a*], Nicole Jungermann [a], Martijn de Graaf [b], Pepijn van Denderen [a]

[a]HKV, [b]Martens en van Oord

Keywords — Dredging, river morphology, real-time monitoring

Introduction

The river Waal is an important shipping route connecting the harbour of Rotterdam with the hinterland. Obstructions in the navigation channel have a large financial impact on the economy of the Netherlands. Continuous dredging is needed to ensure sufficient water depth and channel width for navigation.

From July 2021, Heijmans carries out the maintenance work with subcontractor Martens en Van Oord (MvO) for a minimum of 5 years. For dredging operations, MvO is supported by De Jong Zuurmond. HKV develops a monitoring system to collect and process all relevant morphological data in near real-time: a Digital Twin of the navigation channel of the rivers Boven-Rijn and Waal. This system provides continuous insight in the morphological development of the riverbed and the dredging activities for both the contractor and Rijkswaterstaat (client). The Digital Twin offers unique opportunities to get a better insight in riverbed morphology while optimizing dredging operations.

A Digital Twin for real-time insight

The Digital Twin is set up in Delft-FEWS. This software is originally developed as flood early warning system (FEWS) and can store and process huge amounts of data as scalar or grid time series. We configured this powerful software to meet the needs of monitoring the riverbed dynamics and dredging operations.

The system is fully automatic and runs predefined workflows automatically in a set interval. Logs and alerts are automatically created based on the incoming data and triggered workflows. Therewith the system fits the needs of the contractor to deliver automatically (weekly) maps of the riverbed compared to the required bed level to Rijkswaterstaat without the interference of staff. Missing or erroneous data streams are detected in real-time to allow for proper response.

To meet the contractor's needs, two interfaces are developed. The Delft-FEWS interface with full access to the database and a huge variety of functionality (see Figure 1). Next to this, a web-based dashboard (see Figure 2) is developed to provide easy access, but also limited in the amount of data shown and functionality.

Data sources

Within the Digital Twin relevant data sources are collected and processed to support dredging operations and perform (trend) analysis:

- Measured and forecasted water levels and discharges at Rijkswaterstaat measurement locations.
- Multi-beam measurements of the riverbed in a 1x1 m spatial resolution carried out by the contractor in set intervals: per week for so-called dredging Hotspots and per 8 weeks for the entire river Waal.
- Daily single-beam measurements of Covadem on a 10x10 m spatial grid.
- Daily grids of the dredging operations (suction hopper and ploughing) carried out by the vessels of the contractor.
- Least Available Depth measurement performed by Rijkswaterstaat (in Dutch: MGD = Minstgepeilde Diepte).
- Various more or less static sources, such a navigation channel geometry, fixed layers, typical flow patterns, grain-size distributions and river dune statistics.
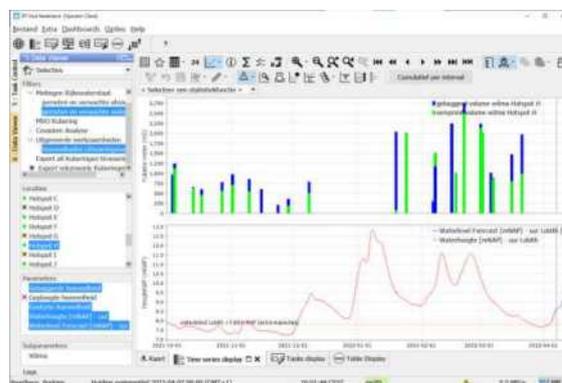

Figure 1: The Delft-FEWS interface of the Digital Twin showing the dredged and dumped volumes together with observed and forecasted water level at Lobith.

---

* Corresponding author
Email address: a.paarlberg@hkv.nl (Andries Paarlberg)

Optimizing data flows

To enable data (trend) analysis, the data needs to be consistent and error-free as much as possible. This sets certain requirements on soft- and hardware, but also on the data collection processes on the maintenance vessels, including human actions involved. Most importantly, dredging operations need to be performed safely. Together with the (sub)contractors and Rijkswaterstaat, we are optimizing the data collection process to minimize 'human errors' and to detect possible errors in data in an early stage, by processing and visualizing the data in real-time.

Results so far: insight in river dynamics and related dredging operations

The Digital Twin is operational for half a year and has already shown to be valuable:

- We ensure collection of consistent data sets which is beneficial for both the contractor and Rijkswaterstaat;
- The system gives a solid base for real-time monitoring of potential bottlenecks allowing for data-driven dredging without compromising on contract requirements;
- We have continuous and real-time insight into several data sources such as high-resolution multi-beam measurements and low-resolution, but high frequency single-beam measurements;
- Insight in Least Available Depth (Figure 3) that provide insight in the development of potential bottlenecks;
- We obtain insight in the efficiency of suction dredging/dumping (e.g. with hopper) and ploughing, and thereby create a consistent and complete and consistent database of dredging activities.
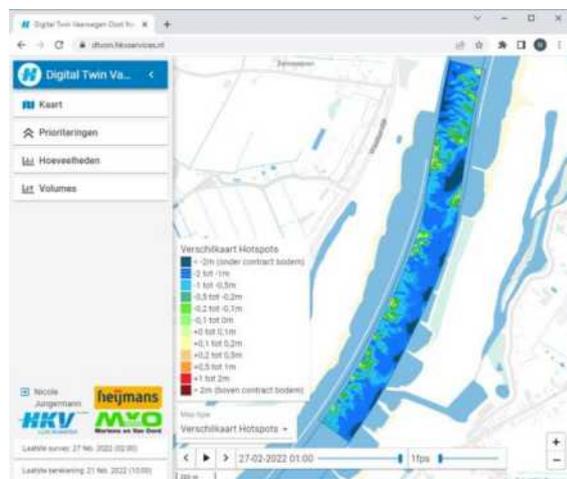

Figure 2: Difference map shown in the dashboard of the Digital Twin.

Future developments

The Digital Twin gives a lot of insight the river behaviour and how dredging operations influence this behaviour. By gaining more and more real-time insight in river behaviour and its relation with dredging operations, we aim towards efficient maintenance of the required bed level, thereby reducing the CO_2 footprint of the river maintenance. The Digital Twin provides a basis that can be easily extended with new data sources and insights in the morphological development of the river such as dune height predictions. There are several ideas to enrich the system with new data sources or optimize the data we have in the system. Think of using new opportunities in data collection (GPS, sensors), but also combining several data sources to reduce uncertainty or enlarge spatial coverage (e.g. increase spatial coverage of Covadem-data using multibeam measurements).
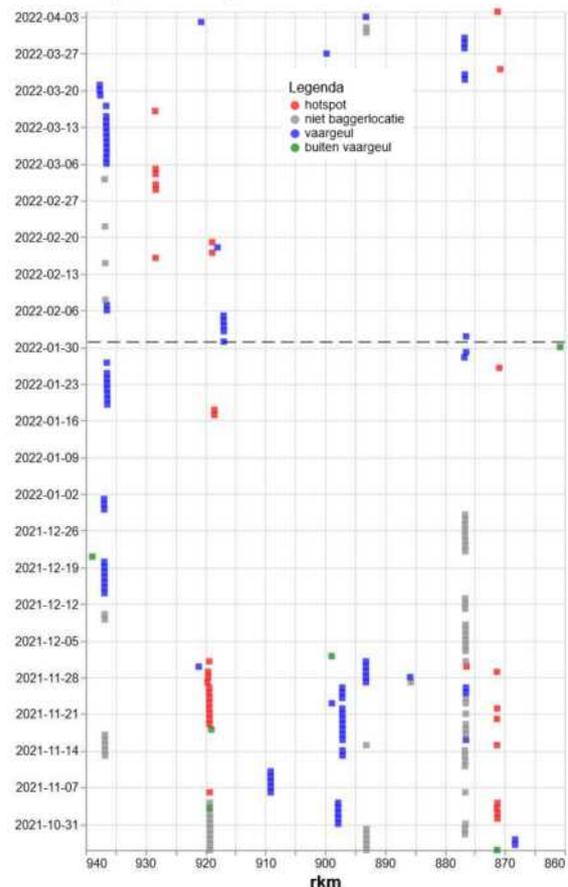

Figure 3: Visualisation of the Least Available Depth (Minst-gepeilde Diepte) along the Boven-Rijn and Waal.