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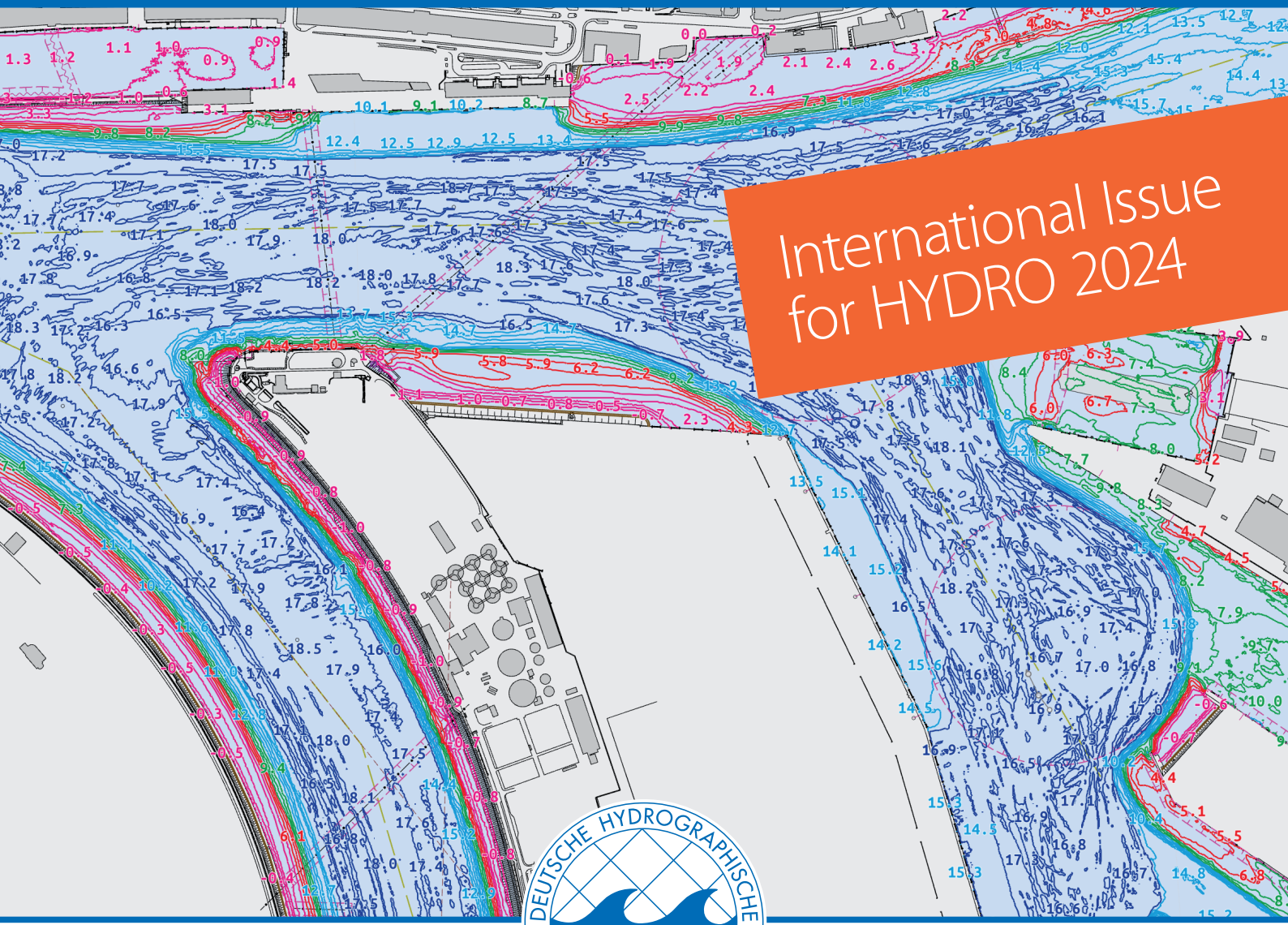

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Hydro Portal

Enhancing hydrographic data management in the Port of Hamburg

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The Port of Hamburg has experienced significant modernisation in hydrographic data processing and presentation through the development of the Hydro Portal. This web-based platform, which provides an integrated view of harbour operations, is the result of collaboration between the Hamburg Port Authority (HPA) and Hamburg-based software company SenseLabs. The Hydro Portal serves as an efficient interface to Teledyne Geospatial's Caris Bathy DataBASE, providing access to HPA's more than 30,000 survey data records, expanding daily.

hydrographic data management | digital transformation in maritime operations | collaborative software development | user-centred design | GIS | cloud technology
hydrographisches Datenmanagement | digitale Transformation im maritimen Bereich | kollaborative Softwareentwicklung | nutzerzentriertes Design | GIS | Cloud-Technologie

Der Hamburger Hafen hat durch die Entwicklung des Hydro Portals eine bedeutende Modernisierung in der Verarbeitung und Darstellung hydrographischer Daten erlebt. Diese webbasierte Plattform, die einen integrierten Überblick über den Hafenbetrieb bietet, ist das Ergebnis der Zusammenarbeit zwischen der Hamburg Port Authority (HPA) und dem in Hamburg ansässigen Softwareunternehmen SenseLabs. Das Hydro Portal dient als effiziente Schnittstelle zur Caris Bathy DataBASE von Teledyne Geospatial und liefert somit den Zugang zu über 30 000 Peildatensätzen, deren Anzahl täglich wächst.

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Context and motivation – digitalisation at HPA

The Hydro Portal is a prime example of a successful digitalisation initiative at the Port of Hamburg (Fig. 1). What once began as an innovation project has now become an indispensable part of port management and is extensively used by various departments within and outside HPA in their daily operations. The success of the project is attributed to the close collaboration of experts from the fields of hydrography, navigation, geoinformation and software development. Particularly noteworthy is the consistent application of methods such as user-centred design and agile development, along with modern solutions in IT security, DevOps, cloud technology and modular architectures. The long-standing cooperation between the development team and the specialised departments has also fostered a deep understanding of hydrographic data processing within the software team.

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Fig. 1: Hydrographic data acquisition forms the foundation of the Hydro Portal's depth data display. Five survey vessels are deployed daily in the Port of Hamburg to collect this data

To understand the success of the digitalisation, it is worthwhile to look at the path the Port of Hamburg has taken in providing depth data (Köster and Thies 2015). In 1994, the first software system for processing hydrographic data was introduced at HPA. Until 2004, both the processing software and measurement technology were supplied by the provider Atlas. Atlas already used Caris GIS for hydrographic data processing, but in 2004, the components were diversified, and HPA started to implement the whole processing and data management with Caris software like HIPS, BEAMS and HPD. This expansion increased the service capabilities of the hydrographic department, but also broadened the software landscape, including the amount of data that could be processed, which presented new challenges for HPA's IT department. Thus, the hydrographic department adopted digi-

tal practices early on, but consumers still relied on traditional hydrographic paper charts.

A major paper chart user was the Vessel Traffic Centre (Fig. 2), which used them to monitor water depths in the Port of Hamburg. This required about 200 square metres of paper. At the end of 2010, the project »AHOI – Arbeitsgerechte Neugestaltung der Nautischen Zentrale des Hamburger Hafens und Innovative Mensch-Modell-Interaktion« (User-Centred Redesign of the Vessel Traffic Centre of the Port of Hamburg and Innovative Human-Model Interaction) was launched. As part of this project, cutting-edge concepts were developed, including the use of interactive touch tables. In 2014, these ideas became a reality with the so-called »Peiltisch« (Survey Table), initially as a feasibility study. The application was precisely tailored to the needs of the Vessel Traffic Centre, allowing tasks such as planning ship manoeuvres to be performed digitally. The forms of interaction closely followed the established analog working methods of the navigators, resulting in high acceptance and gradual replacement of paper charts in the Vessel Traffic Centre.

The Peiltisch pilot project was a success and quickly sparked interest in other departments of HPA. It soon became clear that a desktop version was needed to make the application accessible to as many users as possible. The hydrographic department of HPA was responsible for developing the desktop version of the Peiltisch, known as the Peildesk. Once again, requirements for this desktop workstation were gathered, and processes were identified to be mapped into the software. The application also attracted interest beyond hydrography, extending to areas such as asset management and dredging operations.

As further requirements were implemented, it became evident that the technical foundation of the original pilot project was reaching its limits. Fundamental rework was necessary, leading to the decision for a redevelopment that would build on the extensive knowledge gained from the pilot project. At the same time, the modernisation efforts of the HPA IT department introduced new requirements for the security and operation of the application. Therefore, in 2020, the platform »Hydro Portal« was redeveloped in collaboration with the Hamburg-based software company SenseLabs, whose team had partially been involved in digitalisation initiatives since the AHOI project. This modern cloud solution was designed for efficient hydrographic data visualisation within a web interface (Fig. 3), closely integrating with Caris software.

The Hydro Portal's success over its predecessor lies in its efficient, secure provision of depth data over the internet to external HPA customers, the ability to generate the familiar PDF survey charts directly, and its support for various devices with

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Fig. 2: The Vessel Traffic Centre of the Port of Hamburg, a central hub for monitoring and managing maritime traffic

appropriate forms of interaction like touch tables. As a result, in 2022, HPA completely phased out hydrographic paper charts.

Data integration and visualisation – user-centred design

Feature scope of the Hydro Portal

The Hydro Portal supports users with diverse professional backgrounds in a wide range of tasks by providing integrative geo-referenced and temporal visualisation of multiple datasets. For example, the hydrographic data acquisition team plans survey operations by combining tide, depth, bridge and berth occupancy information. The visual integration of this data allows complex relationships to be easily understood, enabling efficient and reliable decisions about route planning for survey vessels, determining which areas to cover and when.

Another user group, the Vessel Traffic Centre, receives daily updates on the depths throughout the Port of Hamburg and is informed about areas where the data has changed. This data, coupled with additional information such as tide, enables ship manoeuvres to be planned collaboratively, with the visualisation of ship silhouettes providing additional support. Dredging operations also benefit from the comprehensive data integration for planning operational activities, for example volume calculations based on comparison with target depth models. These examples illustrate

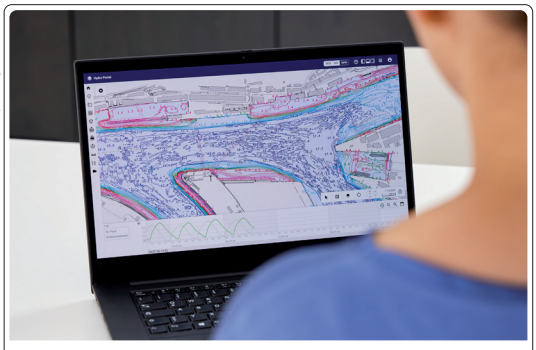

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Fig. 3: The Hydro Portal, a modern cloud solution for hydrographic data visualisation and integration, supporting various professional tasks

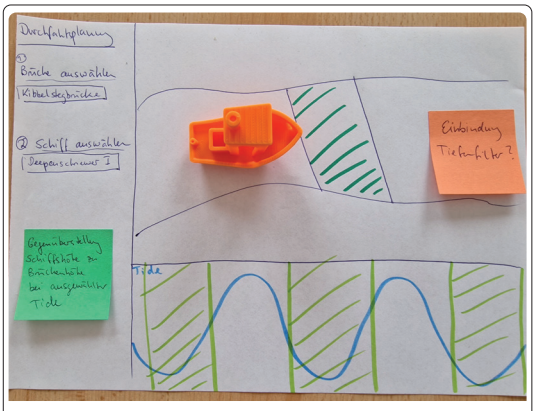

Fig. 4: Paper mock-up used in the early stages of bridge passage planning development, serving as an informal tool to align user requirements

only a part of the potential applications – the Hydro Portal offers many more features that support various professional fields.

User-centred design and agile development

A key factor in the Hydro Portal's success is the consistent application of user-centred design principles. Users are involved from the very beginning in the agile, iterative development process. Requirements are gathered collaboratively using methods like user interviews. The development team then creates paper mock-ups (Fig. 4) as informal discussion tools to present initial solutions to identified problems. This early alignment ensures the development team truly understands the domain and its key aspects and can implement the requirements correctly. Any change requests from the department can be optimally integrated at this stage.

Once the mock-ups are reviewed, implementation begins. In the next iteration, the feature is introduced in a test version. Because customers are involved from the outset, they build a deep understanding of the software, significantly reducing the need for extensive onboarding or training.

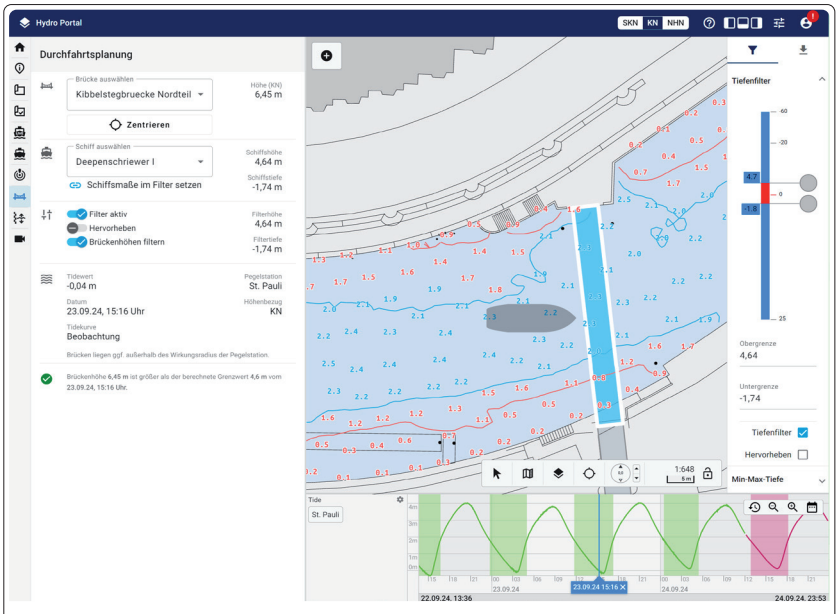

Fig. 5: Final implementation of the bridge passage planning feature in the Hydro Portal, visualising bridge passages based on tide, depth and survey vessel information

Use case: Bridge passage planning

An example of user-centred design is the redevelopment of the bridge passage planning feature, which was implemented in 2022 for survey vessel operation planning. In the Port of Hamburg, ship traffic is heavily dependent on the tides, making bridge passages possible only at specific times. The implementation of this software feature was closely coordinated with the relevant department and precisely executed following a feedback loop (Fig. 5).

The bridge passage planning feature is a prime example of the integrative functionality of the Hydro Portal. While the web interface can be operated with just a few clicks, the back end queries various existing services of HPA to link the necessary information – including depth information, water level data and bridge details from the ArcGIS Enterprise Server. The visualisation of this data is achieved through the close integration of several foundational UI components of the Hydro Portal: the map, the timeline, the browsing area and the depth filter.

The harbour map, based on ArcGIS Maps SDK for JavaScript, provides a geo-referenced visualisation of port data and, in this case, displays the position of bridges and their availability for passages at specific times. The map integrates seamlessly with the timeline, a proprietary SenseLabs development, which shows time-dependent data such as tides or ship movements. The depth filter is used to identify shallow water sections in the port, which are crucial for safe navigation and ship manoeuvre planning. Information about the survey vessels, such as ship height and draft, is stored in the department's collaborative workspace and can be easily adjusted by users when changes to reference data are needed.

The bridge passage planning feature was embedded into the extensible application framework of the Hydro Portal, specifically into one of the so-called browsing areas. The browsing area, a section of the Hydro Portal designed for data navigation, is typically used to display data in a table format, providing users with detailed insights and filtering options. Interestingly, in bridge passage planning, the browsing area offers a customised, interactive assembly of relevant information about bridges and survey vessels instead of its usual tabular structure, demonstrating its flexibility to support both general and specialised application scenarios.

Custom access control for different user groups

The bridge passage planning tool is essential for the hydrographic department but is not needed by other HPA departments. To ensure user-friendliness and manage access to sensitive information on a departmental basis, the Hydro Portal features a sophisticated role and permission system. A user from dredging operations, for example, has access to different software tools upon logging into the portal than a user from the hydrographic department. This is particularly important for external HPA users, like terminal operators, who are granted limited access to depth data.

Flexible front end architectures: From desktop to touchscreen

When customisation through role and permission management is not sufficient, developing additional user interfaces is necessary. An example is the replacement of the Peiltisch application with a web version optimised for touchscreens. The Hydro Portal Touch was specifically developed for the Vessel Traffic Centre and designed for use on a 4K 55-inch touch table, but it can also be used by other HPA departments on portable tablets. A highlight is the development of touch-enabled web tools. Thanks to the use of monorepo technologies, the infrastructure is shared and reused across front ends, all connected to the same back ends.

Technical foundation – hydrographic data processing within the Hydro Portal

Hydrographic data management at HPA

Accurate and continuous depth data acquisition is crucial for safe port operations. The hydrographic department of HPA provides up-to-date depth information for nautical assessments, maintenance and construction projects through hydrographic survey charts, as well as additional products like volume calculations and difference maps.

A core system supporting these activities is the Teledyne Caris Bathy DataBASE solution (BDB), which manages large volumes of hydrographic data and serves as the backbone for data collection and provision in various HPA applications.

Data management and services in Bathy DataBASE

Caris Bathy DataBASE (BDB) is a proven, secure and reliable software for storing and managing bathymetric data, ideal for organisations that manage large amounts of bathymetric surveys, including ports like HPA, and for instance also have to comply with open data policies and marine spatial data infrastructure (MSDI) initiatives. In this context, data interoperability between different (GIS) systems is essential. This project with HPA showcases how BDB has evolved into a data-centric and service-based solution powered by automation and leveraging cloud-native technology.

Furthermore, through workflow analysis and discussions with HPA, this project was used to further enhance the BDB solution. The result is a commercial off-the-shelf (COTS) solution which, thanks to its REST API approach, allows a direct access to data stored in a BDB database using relational database management system (RDBMS) technology such as PostgreSQL. The solution provides REST services to publish, discover, consume and process coverage and feature data. Open Geospatial Consortium (OGC) web services are also available, for example Web Coverage Service (WCS), Web Map Service (WMS) or Web Feature Service (WFS).

Several benefits are worth mentioning, including scalability and responsiveness through containerisation and load balancing, a microservices architecture ensuring that each service is responsible for each type of data request and can be scaled as needed by the business layer, and data security and integrity through robust authentication. Besides a cloud deployment of the REST-based services, the solution can also be deployed on premise, which was done in collaboration with SenseLabs for this project.

Together through several consulting phases Teledyne Geospatial and HPA implemented this new solution and migrated data. New automated workflows were also developed, and existing ones migrated. Caris processes and Python scripts can indeed be assembled and configured into custom automated workflows, allowing HPA technical experts to focus on work truly requiring their experience, input and skills.

Visualising hydrographic data in the Hydro Portal

The Hydro Portal utilises the Caris Bathy DataBASE solution as a data source to display depth data alongside other relevant port information. Depth data is presented as soundings and contours (Fig. 6)

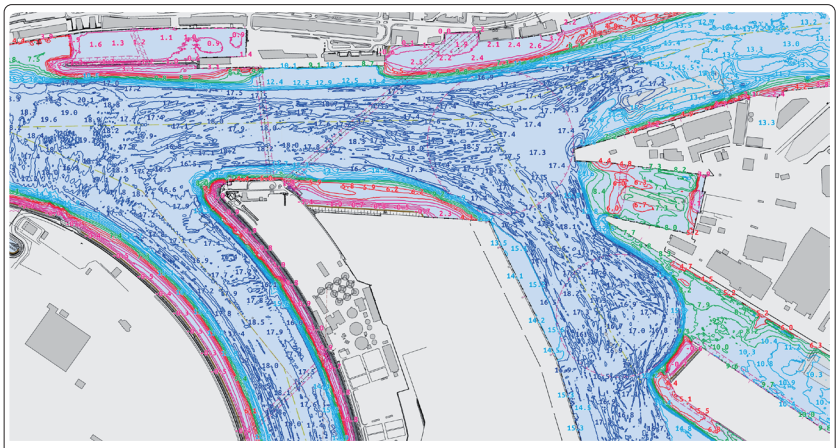

Fig. 6: Vector data visualisation in the Hydro Portal, showing soundings and contours for the harbour area

using standardised geoservices on the Hydro Portal's web interface. These services, developed by SenseLabs, include authenticated access controls for secure data provision to various user groups. Interfaces are optimised for both vector and raster data, enabling a smooth, tiled display of depth data in the front end. Soundings adjust in detail based on the map's zoom level, with back end filtering ensuring a clear and nautically safe display.

The Hydro Portal also supports raster data display (Fig. 7) in COG format (Cloud Optimised GeoTIFF) for efficient front end use.

Back end strategies for flexible and high-performance data processes

Efficient back end data processing is crucial for real-time or near-real-time data availability, ensuring a smooth user experience. The Hydro Portal's back end supports real-time calculations, precomputed data for immediate access and processes with acceptable wait times. For instance, generating a PDF survey chart takes about two minutes in the background, allowing users to continue working. Fast sounding filtering algorithms eliminate the need for precomputing individual datasets; for large, combined datasets, precomputed values are cached. The software architecture allows easy swapping of processing workflows without major changes, facilitating the implementation of faster methods as they become available.

Modular architecture, microservices and containerisation

The modular architecture of the Hydro Portal allows for a seamless integration of external systems and processes from various vendors. For example, this enables the use of processes from Caris COTS products, which can be assembled into custom workflows by hydrographers from HPA using the software Caris Process Designer.

The modular architecture of the Hydro Portal is implemented using various microservices. These microservices are designed, segmented and containerised in a way that allows them to be easily scaled. For instance, if the number of users increases, additional containers with a highly demanded microservice can be spun up. The automatic scaling is orchestrated by Kubernetes. This orchestration and containerisation allow new software versions to be deployed without downtime and prevent outages through redundancy management. To meet the high security requirements of critical infrastructure, extensive security measures are implemented within operations.

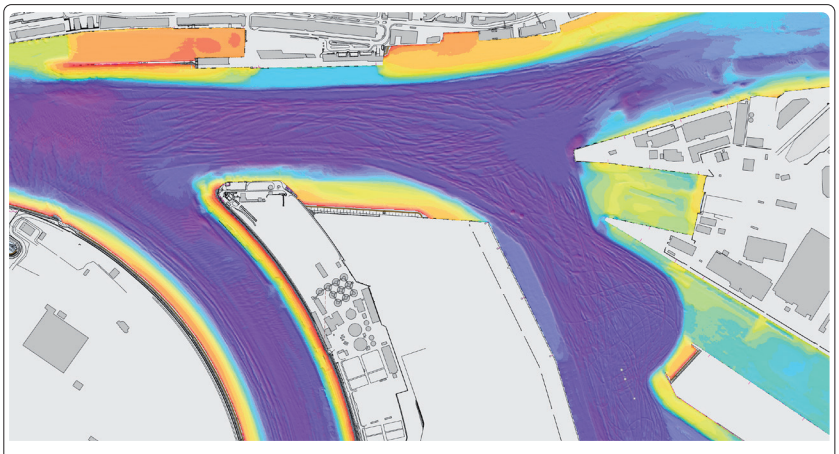

Fig. 7: Visualisation of raster data in the Hydro Portal, depicting the same harbour area

Strong partners – a success story through collaboration

The successful development of the Hydro Portal for HPA is based on a combination of proven technologies and custom-developed software components. A key success factor was the consideration of HPA's existing applications, as well as close collaboration with partners who provide central elements of this infrastructure, such as Teledyne Geospatial with Caris Bathy DataBASE and Esri ArcGIS solutions.

A crucial aspect of the project was understanding that HPA already had extensive experience in using these established systems. The solutions from Esri and Teledyne Geospatial were already deeply integrated into HPA's workflows, were technologically mature and offered advantages in terms of training and operating costs. The development of the Hydro Portal was not intended to replace any of the existing legacy systems, but rather to optimally integrate the various solutions.

For this, it was necessary to recognise the strengths of the existing systems and incorporate them strategically into the design process of the Hydro Portal. Where there were requirements not addressable by existing systems, the integration of open-source tools was beneficial. At the same time, the custom development of software components was essential to address the specific needs of HPA. The development of a high-performance component for securely filtering depth values across various zoom levels illustrates this approach. In this case, custom development was chosen to meet certain specific requirements that were not fully covered by existing systems or open-source tools. This functionality enables efficient and precise representation of depth data at different scales, which is crucial for the daily operations of HPA.

In addition to the ongoing collaboration with HPA, close coordination with partners like Teledyne Geospatial ensured seamless system integration. APIs were directly coordinated between SenseLabs and Teledyne Geospatial teams, facilitating tasks like migrating to a new Caris Bathy DataBASE version.

This project demonstrates how successful collaboration and the targeted use of proven technologies, combined with tailored solutions, can lead to flexible and efficient system integration. Custom development bridged specific functional gaps and complemented existing systems, contributing to a sustainable and economically viable implementation.

A glimpse into the future – integration in other ports through cloud solutions and user-centred approaches

The Hydro Portal's success at HPA offers valuable insights for other ports. However, a test system at the Port of Bremerhaven showed that features considered intuitive for HPA did not achieve the same acceptance in this new context. This experience highlights the importance of a user-centred design approach: workflows and requirements vary significantly from port to port, even within the same domain.

The Hydro Portal incorporates a comprehensive set of proven components, adapters and methods that were developed by SenseLabs, based on the experiences gained at HPA. This flexible toolkit enables the rapid development of customised Hydro Portals for various ports, tailored to meet the specific needs of each customer. The modular design allows efficient reuse of key UI components and back end infrastructure, while specific adjustments are made through a user-centred design process.

Cloud support is another critical factor in success. It enables rapid and seamless deployment of the system by allowing the infrastructure to scale flexibly and adapt to local conditions. Additionally, it ensures future-proofing by supporting continuous development and straightforward maintenance of the system.

Overall, the combination of a flexible architecture, modular components and a user-centred design approach enables the successful adaptation of the Hydro Portal to the specific needs of other ports, laying the groundwork for future projects. //

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