

flows, as well as for container traffic on relevant routes and changes in the correlation between gross domestic product and containerised trading volumes.

Research and development

One of HHLA's strategic objectives is to continuously improve the efficiency of its operating systems, and consequently its competitiveness, by developing application-oriented technologies. The main focus of these activities is therefore on engineering and IT-based innovation projects. Due to close collaboration with technical universities, institutes, industry partners and government authorities, joint projects can be planned, managed and developed by working groups.

In the 2020 financial year, HHLA mainly focused its resources and available capacity on research as part of the subsidy programme for Innovative Port Technologies (IHATEC).

Container terminal 4.0

The Container Terminal Altenwerder (CTA) is one of the most highly automated container terminals in the world. Since it opened in 2002, HHLA has constantly been researching and working on improving and expanding automation at the site. Right at the start, a paradigm was established whereby automated work areas are separated, isolated and off-limits to staff in order to guarantee occupational safety. This principle has always been upheld. Today, however, this paradigm is preventing the ramping up of automated processes, as it inevitably excludes them from areas used by people. The research project "Container terminal 4.0 – a paradigm shift in the automation of container terminals via human-machine interaction rather than separation" is to be conducted as part of the IHATEC subsidy programme (supported by the Federal Ministry of Transport and Digital Infrastructure). The project's main objective is to develop automation solutions for various container crane systems used at the terminal in work areas shared by people and machines (e.g. alongside ships and trucks) and to implement them as prototypes. At the same time, the experience, knowledge and evidence gathered during this process should play a fundamental role in establishing the safety standards needed to create a reliable framework for future automation projects.

INTERACT

HPC and Container-Transport-Dienst GmbH (CTD) initiated the IHATEC research project INTERACT (integration of autonomous trucks in container terminal operating processes) in conjunction with the Karlsruhe Institute of Technology (KIT). As part of the project, a feasibility study and a subsequent gap analysis determined the extent to which self-driving trucks can be deployed simultaneously on public roads and in closed-off terminal areas – and what technical, operational and legal

requirements should be imposed on the vehicles themselves as well as on the transport service providers and terminals involved.

For this purpose, relevant terminal categories were first defined and their current typical processes with regard to handling trucks were analysed. Handling processes were then defined, including for self-driving trucks. On the basis of these target processes, it was possible to define the requirements for the vehicles, terminals and vehicle operators. A total of 84 requirements were identified for ten different terminal categories.

Solutions that appeared suitable for fulfilling the respective requirement were identified for each of these requirements. A total of 177 technical, structural and organisational solutions were found and their feasibility assessed.

The project was successfully completed in 2020. It became evident that the current status of technology does not yet allow for the use of self-driving trucks for all terminal categories considered. At the same time, however, it was shown that there are at least technically feasible solutions for each requirement, which will have to be developed in the near future. The development themes identified were systematically categorised in the form of a road map.

Hamburg TruckPilot

With the Hamburg TruckPilot field test, MAN Truck & Bus and HHLA are conducting a highly innovative research and testing project to develop automation solutions in road transport. The aim is to analyse the requirements for the customer-specific deployment and integration of self-driving trucks in the automated container handling process under realistic conditions, and to review its feasibility. The prototype trucks equipped with the corresponding electronic automation systems should be able to operate automatically within CTA. The project is split into three phases: the preparation phase, which ran until the end of 2018, served to define the underlying technical conditions. The test phase, which was slated for completion by June 2020, was largely carried out despite the restrictions resulting from the coronavirus pandemic. This comprised the technical development of the system at MAN's testing centre in Munich in accordance with the specific requirements identified during the preparation phase. The scheduled field test between July and December 2020 could only be carried out with restrictions. All parties involved are now checking whether a test phase may be possible in 2021 in more practical settings based on customer needs.

Aerolnspekt

Storage cranes at the automated container yard are the linchpin of HHLA's cutting-edge, high-performance container terminals. The crane rails are subject to extreme requirements in terms of their position and height. However, the geomorphological

composition of the port terrain continuously results in significant subsidence and shifts in the track network, which have to be monitored, measured down to the exact millimetre and rectified on a regular basis. The measurement work results in significant operational interruptions. One of the aims of the IHATEC subsidy project Aerolnspekt – which HHLA is running in conjunction with the Technical University of Braunschweig – is to develop software which will enable the use of drones for this measurement work in future. The project was successfully completed in October 2020. Several test flights with various camera lenses, software settings, weather conditions, etc. confirmed that the necessary precision (~ 2 millimetres) could be achieved at an altitude of 50 metres while at the same time reducing interruptions to port operations. The challenge for the future will be transferring the findings and tools developed into regular operations.

BiSchi

In much the same way as feeder ships, calls at the port and the transfer of containers by inland waterway ship require a tremendous amount of coordination, as several terminals are served during each port call. To deal with this, the Hamburg Vessel Coordination Center (HVCC) has developed an inland waterway ship platform, which went live in May 2020. Around 400 terminal calls for barges and pushed convoys are now being coordinated by the software every month. From scheduling for the inland waterway shipping company, to vessel management, to the terminals and HVCC, the platform enables the synchronous planning of all parties involved in real time in a single overview and data set. The intelligent linking of terminal berths with ship position and environmental data is having a positive impact, particularly in the dynamic planning environment of a complex port. This accelerates communication while reducing the efforts involved in coordination. The IT systems for the new inland shipping platform were developed by DAKOSY Datenkommunikationssystem AG. Funded by Hamburg's Departmental Authority for Economic Affairs and Innovation, the project enhances shipping's position as an effective and environmentally friendly mode of transport in order to make use of its great potential as a key pillar of hinterland traffic.

Hyperloop transport system

In December 2018, HHLA established a joint venture with the US-based research and development company Hyperloop Transportation Technologies (HTT) to explore possible applications of hyperloop technology for transporting shipping containers. The hyperloop concept is based on the idea of transporting people and goods at high speed through a tube. Using magnetic levitation technology, the transport capsules are to be sent through a tube system with a partial vacuum at speeds of up to 1,000 km/h. Hyperloop is thus regarded as an additional mode of hinterland transport together with rail and road.

In partnership with HTT, HHLA has developed a technical, operational and commercial solution for a hyperport for sea containers. This involved simulating the layout and operational processes, establishing models for calculating the economic viability and various operator models, and evaluating target markets. As things stand, a virtual model of the hyperport, along with a transfer station and transport capsule, is to be developed by October 2021, followed by the implementation of further steps in the product development process.

ZETT

Another project carried out by CTA as part of the IHATEC subsidy programme focuses on the Zero-Emission Terminal Tractor (ZETT). Within a port/terminal or logistics centre, containers are usually transported using diesel-powered terminal tractors. In order to reduce exhaust emissions and noise pollution, there is a need for alternative drive systems. At present, there is no cost-effective alternative drive technology for these tractors with the technical maturity required for industrial use. The primary objective of this project is to develop a system solution for battery-powered internal transport that will allow the cost-effective achievement of environmental benefits in the medium term. Both the vehicle and the charging technology need to be designed in such a way that they can cover a very broad range of applications. The resulting economies of scale will support the goal of enabling cost-effective operation. The project is primarily being run in conjunction with KONECRANES GmbH, the Institute for Automotive Engineering at RWTH Aachen University and BMZ GmbH.

FRESH

Harnessing consumer flexibility with regard to their energy demands is expected to play an important role in the success of the energy transition. The FRESH project (flexibility management and control reserve provision of heavy goods vehicles in the port, sponsored by the German Federal Ministry for Economic Affairs and Energy) builds a bridge between commercial electric vehicle fleets and the energy market in practice, thus tapping the potential for flexibility. At CTA, transport between the quayside cranes and the block storage units is fully automated with the use of driverless vehicles (automatic guided vehicles, or AGVs for short). The entire fleet of these heavy goods vehicles is currently being replaced by battery-powered vehicles using lithium-ion battery technology and fully automated charging stations. On average, however, an AGV spends about a third of its operating time in a waiting position. During this time, it is possible to postpone or interrupt the charging process, vary the charging capacity or even feed electricity back into the grid. The challenge is to continuously forecast the transport capacities that will soon be required of the vehicles and to plan the potential battery capacities and allocations of charging stations and vehicles, thus paving the way for the optimised use of available flexibility.

HITS-Moni

In partnership with the Department of Informatics at the University of Hamburg and DAKOSY, HHLA is conducting the IHATEC-funded project Harbour IT Security Monitoring (HITS-Moni). The project seeks to develop port company-specific processes, measures, concepts and rules for detecting and blocking cyberattacks on IT systems, improving and increasing IT security at companies in the port sector by linking the IT security tools of different companies, as well as expanding and implementing automation to protect employees against sensory overload. Newly designed monitoring systems aim to detect and escalate attacks and attack patterns automatically and in good time. It is expected that the establishment of innovative IT security concepts and technologies within autonomous systems will boost productivity and efficiency by reducing the risk of potential system failures or data manipulation caused by cyberattacks.

UniPort 4.0

Hansaport has set up the IHATEC project UniPort 4.0 in partnership with Brunsbüttel Ports GmbH and other companies. Digitalisation in the field of all-purpose ports is still at an early stage. The often conventional work procedures and comparatively low level of maturity in terms of organisational and information technologies at all-purpose ports represent a significant obstacle. Whereas digitalisation at container ports is developing swiftly on account of global growth in consumer goods and the standardisation offered by containers, the core business of an all-purpose port lies in the handling of all kinds of break bulk, dry bulk and large quantities of general cargo. These pose challenges for the ports in terms of handling technology and in relation to the various shapes, weights, volumes and batch sizes, as well as in terms of storage, safety regulations and the required transport modes. In light of the ever-changing goods and product sizes/weights, the processes at an all-purpose port must be structured in a sophisticated manner and, from a digitalisation standpoint, usually offer significant optimisation potential. The idea behind UniPort 4.0. is to apply digitalisation in a comprehensive manner at the various ports involved.

Artificial intelligence and machine learning

With its artificial intelligence (AI) initiative, HHLA is pursuing three key business aims: tapping new revenue streams, boosting customer loyalty and increasing terminal productivity. HHLA also feels that AI offers considerable potential when it comes to increasing occupational safety among the workforce.

The first AI pilot projects have been successfully completed. AI-based forecasts of container collection times and the outgoing carriers result in increased yard productivity. The collection time of a container, along with the outgoing carrier, is a key factor in optimising yard operations, even though the dwell time of the container is often not known when it arrives at the yard. This situation occasionally results in avoidable restacking in the yard.

In a bid to optimise block storage, an algorithm was developed using machine learning methods which can forecast container dwell time and the outgoing carrier. Further AI-based projects with different areas of focus are to be implemented in future in order to leverage additional optimisation potential at various stages of the value chain.

Performance certified

In order to document its performance, HHLA Container Terminal Altenwerder (CTA) once again completed certification in accordance with the Container Terminal Quality Indicator (CTQI) in the reporting year. The standard, which was developed by the Global Institute of Logistics and Germanischer Lloyd, checks criteria such as the safety, performance level and efficiency of a terminal on both the water and onshore, as well as its links to pre- and onward-carriage systems. With its successful certification, the terminal once again confirmed its high level of performance and compliance with all quality standards.

ABC-Inspekt

Container gantry cranes that load and discharge ships are a key element of a container terminal. Qualified inspections are therefore exceptionally important for maintaining the uninterrupted, round-the-clock operation of such seaport gantry cranes (24/7, 365 days a year). Until now, the critical parts of a container gantry crane were inspected individually by qualified experts. Carrying out and evaluating these inspections is becoming more and more difficult with the steadily increasing size of container gantry cranes, and the amount of image data to be inspected is becoming more extensive.

In order to boost the efficiency and quality of the photographic analysis, as well as improve workplace safety and ultimately the reliability and availability of the container gantry cranes, a self-learning, automated image recognition system based on artificial intelligence is to be used to analyse image material. Over an extended period of time, the system conducts an automatic comparison of any changes in the same areas of the container gantry cranes.

The ABC-Inspekt research project, supported by the IHATEC programme, is being implemented in partnership with the Technical University of Braunschweig with the aim of developing an intelligent image recognition system. This self-learning image recognition system (AI) will be used to analyse image material from the critical points on container gantry cranes.

SuStEnergyPort

The topic of sustainable energy has been gaining importance within the port industry in recent years. Against this backdrop, HPC and the University of Duisburg-Essen have teamed up with HHLA and Vattenfall Trading GmbH to launch the IHATEC research project SuStEnergyPort. Part of the project involved

developing an innovative, model-based process and content enabling port businesses to identify suitable measures for boosting their energy efficiency and use of renewable energies. The process comprises various newly developed tools – such as a catalogue of sustainability measures, an energy simulation tool, life cycle assessment models and efficiency models – with which energy sustainability measures can be analysed as comprehensively as possible and from four key perspectives: energy, ecology, economy and operations. Overall, with the aid of this structured process and these tools, it is possible to come up with a tailored road map for the efficient attainment of individual sustainability targets of any port.

Cookie

In the world's export nations, the demand for empty containers far outstrips their availability due to imbalances resulting from the flow of goods. This is causing frequent bottlenecks when it comes to supplying empty containers because, until now, the necessary upstream process for identifying and remedying any damage has had to be conducted primarily manually by highly skilled experts. The result is an increased potential for error, as well as delays caused by the semi-digital process steps previously employed. Furthermore, the necessary experts are not always available, which further diminishes the reliable scheduling of repair jobs and availability of repaired containers, resulting in unnecessary stockpiling and excessive repositioning.

The IHATEC project Cookie, funded by the Federal Ministry of Transport and Digital Infrastructure, therefore seeks to optimise the process of damage identification and assessment in the empty container depot with the aid of artificial intelligence. The project name Cookie stands for "COntainerdienstleistungen Optimiert durch Künstliche Intelligenz" (container services optimised by artificial intelligence). Together with our research partner, the Fraunhofer Center for Maritime Logistics in Hamburg-Harburg, the aim is to develop an adaptive algorithm for image recognition processes. The aim is to help inspectors identify and assess any damage to empty containers with the aid of machine learning methods (specifically, deep learning) and the explicit linking of CEDEX codes, which are subject to syntax rules. The integration of an AI-based system for identifying damage is expected to reduce error rates, increase the uniformity of damage assessments and improve process speed in order to further boost efficiency and achieve reliable availability planning for containers within the processes at the empty container depot.

BVLOS

HHLA Sky has developed a globally scalable, end-to-end drone system that allows the secure operation of drones beyond the visual line of sight (BVLOS). The industrial drones are extremely robust, very light and equipped with safety technology. Customers can integrate the system into their own business processes independently, or use it as a service operated by

HHLA Sky. HHLA Sky has also developed software and related information systems. The HHLA Sky software can be purchased for use on a licensed basis. The control centre is used operationally for drone flights, including the inspection of container gantry cranes at the HHLA terminals.

HHLA Sky is also contributing its expertise to the UDVeO (urban drone traffic efficiently organised) research project. The project is funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI) from 2020 to 2022, under the leadership of the Helmut Schmidt University in Hamburg. The aim of the project is to develop the basis for a drone management system for efficient and safe transport within densely populated urban spaces. The focus of development in 2020 was on controlling the drones and a live-streaming application.

Modility booking portal

Together with eleven partners in the transport and freight-forwarding sector, HHLA has initiated the development of a new booking portal for intermodal transport. As a booking and placement portal, Modility seeks to connect intermodal operators' available transport capacities with the transport needs of freight forwarders and to strengthen intermodal transport as an efficient, environmentally friendly transport system.

Purchasing and materials management

Purchasing is a shared service provided by the HHLA Group's management holding company in Hamburg. HHLA Group purchasing supports corporate strategy by means of its professional management of procurement activities. The aim is to establish a consolidated supplier base that is characterised by maximum value added, top quality and optimum life cycle costs.

HHLA's supply chains comprise capital goods (such as port handling equipment) as well as consumables and other services (such as maintenance). The overwhelming majority of suppliers are from Germany and other European countries.

The strategic purchasing function supports and advises Group companies as part of its holistic management of product groups, suppliers and contracts so that the service and performance requirements of internal customers are met as completely as possible. Market developments relating to new technologies, innovations and the service performance of specific suppliers are considered in close cooperation with the operations and technology departments. In this regard, the purchasing department ensures that all Group requirements for the procurement processes are observed in accordance with the framework guidelines. These guidelines are binding for all employees.