Develpments in the automation and remote operation of locks and bridges
The main objective of the new PIANC InCom Work Group 192 is to update the 2008 WG 96 report on 'Developments in the Automation and Remote Operation of Locks and Bridges' to reflect technological advancement and new considerations related to remote operation. Since the publication of WG 96 in 2008, significant technological advancements have been made at an increasingly rapid pace. Today, multiple ports and waterways have implemented remote operation technology or are planning this step in the nearby future. At the same time, events around the world have led to a much tighter security posture for marine and inland waterway transportation. This development has a significant impact on remote operation of locks and bridges, which was not fully addressed in the 2008 report. The Work Group shall collect recent developments and case studies from different countries and will publish a comprehensive summary of lessons learnt and best practices that can be incorporated into the future design of remote operation of locks and bridges. Technical developments, organisation of the total chain of command, human factor engineering, traffic management, self-learning technology, simulation technology & certification of operators, security of the infrastructure and safety requirements will be some of the main topics, included in the final report. The primary objective of this report is to assist owners/operators who are approaching the upgrade of their security posture or want to implement remote operation of their structures by providing them industry best practices so they can leverage the experience gained by other organisations.

The kick-off meeting of our Work Group was hosted by the St. Lawrence Seaways Management Corporation in their St Lambert offices in Montréal, Canada on October 26-28, 2016. Mr. Stephen Kwok (Vice-President Operations of St. Lawrence Seaway Management Corporation and sponsor of WG 192) welcomed the WG during the opening session and expressed his high interest in this WG. Subsequently, the members of the WG presented their organisation, focusing on references and experiences in the field of remote control of locks and bridges. Thanks to the kick-off, our Work Group was able to make a strong start in further discussing the scope and aims of the WG 192 activities.

This report is an intermediate status update and presents an overview of the topics covered in our Work Group and on some reference projects illustrating recent developments. Further working activities, timeline and deliverables of WG 192 will be communicated through the PIANC websites to be made available for all PIANC members, port authorities, waterway organisations and technology partners.

As chairman of our WG 192, I am confident that we will have an excellent working time based on the impressive professional experience and on the positive personal commitment from each one of our Work Group members!
The first three meetings of PIANC WG 192 on ‘Developments in the Automation and Remote Operation of Locks and Bridges’ made clear that the work group is composed of members covering all expertise on the topic. The meetings at the St. Lawrence Seaway offices in Montreal (Canada), De Vlaamse Waterweg nv and Port of Antwerp (Belgium) and Lyon (France), already showed the recent developments and interesting case studies in these countries.

All meetings included two days of discussions on all relevant topics of the report and visits to local remote control centres. Also, specific technical developments were presented to the Working Group. The Working Group was able to view the innovations at the lock in Montreal, where the St. Lawrence Seaway control centre is located. The locks of St. Lawrence Seaway are equipped with vessel self-spotting, self-positioning and hands-free moorings, to enhance safe and automated moorings. During the second meeting in Belgium, the Working Group made time to visit the construction site of the new lock in Harelbeke, as part of the European Seine-Scheldt project to improve and stimulate waterway traffic. Also, control centres of the Flemish waterway and the Port of Antwerp were visited. At our last meeting in Lyon, visits were combined with report discussions, organised on a boat on the Rhone. A visit of the control centre of CGN, the simulator technology of CNR and a presentation of VNF’s technical solution of user operation by the skipper, gave a very interesting idea of current technical developments. These visits, combined with the exchange of experiences and technical knowledge on developments in the automation and remote operation of locks and bridges, made our Working Group meetings very interesting.

Past meetings of WG 192 all focused on references and experiences in the field of automation and remote control of locks and bridges. By the next meeting, the Working Group members will be focused on writing down best practices and technical developments on all topics relevant to their country. On following meetings, the Working Group will be focusing on the similarities and differences between all references. The best practices in this field shall be reviewed critically and recommended if and when appropriate as part of the final report. Important topics will be, for example, the responsibilities of waterway managers, CE certification, differences in safety regulations and certifications (Europe vs USA/Canada), safety stops, remote control room design, instrumentation and automation systems, etc.

The Working Group will combine its next meeting with the PIANC-SMART Rivers Conference in Pittsburgh, USA. Chairman Lieven Dejonckheere will present the activities and the work of PIANC Working Group 192 on ‘Developments in the Automation and Remote Operation of Locks and Bridges’, giving an insight into recent developments and case studies from different countries covering automation and remote control of locks and movable bridges.

Past meetings
- Canada (Montreal): 26 October 2016 – 28 October 2016
- Belgium (Antwerp/Zemst/Harelbeke): 31 January 2017 – 01 February 2017
- France (Lyon): 18 May 2017 – 19 May 2017

Future meetings
- USA (Pittsburgh): 18-22 September 2017
- 2018: UK, Germany, Canada (final meeting)
Presentation of individual members

Belgium

Lieven Dejonckheere
Head of Division at De Vlaamse Waterweg nv

Lieven Dejonckheere has 20 years of experience in managing technology projects at the University of Ghent, in the aviation industry and in both the maritime and inland shipping sectors. He is responsible for remote operation of locks & bridges and for vessel traffic management on the inland waterways in Flanders.

De Vlaamse Waterweg nv works towards a dynamic management of the waterways in Flanders, Belgium, including the areas along it. De Vlaamse Waterweg nv stimulates the use of these waterways and this land, while taking into account the interests of all stakeholders involved and paying attention to sustainable growth, flood protection and integrated water management.

Wim Van Santvoort
Senior Program Manager at Port of Antwerp

Wim Van Santvoort started his career as engineer for locks and bridges at Port of Antwerp in 1988. Throughout his career, he was involved in several projects concerning the automatization of locks and bridges. Furthermore, Wim was an active member of PIANC INCOM WG N° 96 from 2005 -2008, where he followed and discussed the latest developments in the automation and remote operation of locks and bridges. Wim is since 2013 the senior program manager for the ARGUS project, where he is responsible for two sub-projects concerning remote control and automatization. In the first project, he is responsible for the development of a full scale Proof of Concept for the remote control of locks and bridges in the Port of Antwerp. The second sub-project concerns the development of a proof of concept concerning full automatic surveillance of lock doors and movable bridges before and during opening or closing.

The 1,650 employees of the Antwerp Port Authority play an important role in the day-to-day operation of the port. They make sure the port is able to function and work on a sustainable future for the Port of Antwerp to ensure it can continue playing a leading role as an international seaport. The positions and responsibilities within the Port Authority are very diverse. The Port Authority manages and maintains the docks, bridges, locks, quay walls and land. It is also responsible for the efficient passage and safety of the shipping traffic in the Antwerp port area. It provides tugs and cranes, carries out dredging work and promotes the port in Belgium and abroad.

Kim Geylen
Project Engineer at Tractebel

Kim Geylen works as project engineer at Tractebel in the department Ports & Waterways. She is specialised in the automation and remote control of port and waterway infrastructure, such as locks, movable bridges and pumping stations. In these projects, safety is one of the important parts, both the controlling of the compliance of the design with the Machinery Directive as the safety objectives specific for each project. Kim has developed a specific experience in the field of machine safety and the principles of risk assessment and risk reduction for port and waterway infrastructure. Kim has a key role in several automation and remote control projects for Belgian waterway and port authorities. She is involved in projects of full automatic bridge and lock operation (Port of Antwerp), remote control strategy of locks and bridges (Flanders waterway authorities), work load analysis of remote control rooms for inland navigation and optimal design and camera plan of the human machine interface (operator desk) for waterway infrastructure.

Tractebel is a multidisciplinary engineering and consultancy company. Tractebel supports their customers in both the private and public sectors in defining their strategic choices and master plans, advising them on how to create policy and feasibility studies, and in performing detailed engineering and project management. They offer these services in a variety of areas: regional and urban development, buildings, marine ports and waterway projects and transport infrastructure. Contemporary topics like climate change, energy efficiency and infrastructure intelligence are spearhead products. Waterways are an essential component in any sustainable transport system. Tractebel carries out feasibility studies, and does conceptual and detailed design for waterways and port (sea and inland) projects. Tractebel assists the authorities from master plan level down to tender specifications and detailed design (civil, electro-mechanical and E&I engineering). They have experts in the fields of locks and (movable) bridges, quay walls and barra- ges, dikes and bank protection, hydroelectric power stations, etc. To optimize the efficiency in waterway management, Tractebel offers consultancy in corridor management, automation and remote control of locks, movable bridges and pumping stations with attention to safety, reliability, availability, work load analysis, risk analysis, technical requirements and standardisation. Centralized control and further steps in automation will lead to a more efficient way of operation, a better control of the navigation on the waterways and a more efficient water management on rivers and canals.
Leonard Swift has thirty-four (34) years of hands-on Electrical Engineering experience in designing, developing and implementing remote operation, automation and operator interface systems. Bailey Controls and ABB are where Leonard gained the skills and experience leading automation projects and managing engineering teams. Leonard came to the St. Lawrence Seaway Management Corporation (SLSMC) in early 2004 as the Senior Engineer and then Manager of the Operating Technology Department. During this period, Leonard was involved in the design and implementation of systems for the remotely operated bridges. In 2013, Leonard was asked to develop and promote a corporate technology roadmap describing the steps required to remotely operate the lock structures and a plan for future automation. Since 2014, Leonard has led the corporate design team responsible for the implementation and commissioning of the robotic vessel mooring systems and for the control system changes required to facilitate remote operation.

The St. Lawrence Seaway Management Corporation is a not-for-profit corporation responsible for the safe and efficient movement of marine traffic through the Canadian Seaway facilities, which consists of 13 of the 15 locks between Montreal and Lake Erie. The Corporation plays a pivotal role in ensuring that the waterway remains a safe and well-managed system, which it shares with its American counterpart, the Saint Lawrence Seaway Development Corporation. The Corporation’s mandate promotes efficiency and responsiveness to the needs of shipping interests, ports, marine agencies, and provincial and state jurisdictions.

Laurent Luchez is a 25 year experienced civil engineer in the field of inland waterways. He is an expert in the automation and remote control of locks and bridges, in the water level management (including hydraulics and dam management), and is also a specialist of the geotechnical works issues (riverbanks, canal dikes and reservoirs). He has been working at the “Water, Sea and Waterways” direction of the Cerema, in Compiègne, since 1991.

Cerema (Centre for Studies and Expertise on Risks, Mobility, Land Planning and the Environment) is an interdisciplinary scientific and technical resources center, placed under supervision of the ministries in charge of sustainable development, town planning and transportation. In addition, representatives of local authorities sit on Cerema’s board of directors. Thanks to its strong regional footing, Cerema is able to connect the needs and policies of central government, government's decentralized offices, local authorities and of all those who contribute to implementing public policies. Cerema supports the energy transition in France.

Cyrille Chaussat
Chief of the Rhone Traffic Management Centre
Cyrille joined CNR in 2007, where he started as Chief Safety Officer. Since July 2015 he is the chief of the Rhone Traffic Management Centre, which remotely controls 14 large gauge locks on the Rhône. In this role, he is responsible for a team of 40 employees and the correct implementation of the rules, procedures and instructions relative to the exploitation, safety and security of the center. Furthermore, Cyrille is in charge of the further improvement of the navigation process and is in close contact with both the French authorities (Voies navigables de France) as well as customers (excursion boats, commercial vessels,...). Concerning automatization and remote control, Cyrille has extensive expertise in the navigation process, especially in the areas of regulation, customer contact and IT systems (control, video, audio and IP network systems).

The Compagnie Nationale du Rhône (CNR) designed and now operates the Rhône Traffic Management Centre in Châteauneuf du Rhône. Since 2012 the Centre remotely controls 14 wide gauge locks on the Lower Rhone on a 24/7 basis. This innovative system, the only one of its kind in France, satisfies three main challenges: guaranteeing maximum safety on the Rhône through increased monitoring of the installations, improving information for the users of the Rhône by providing full information on traffic in real-time and improving the service available for skippers by optimizing lock passages (less than 20 min). With a monitoring system that operates 24/7 (video, VHF, telephone), the Navigation Management Centre provides permanent surveillance along the navigable section of the Rhône and increases the safety of lock operations.
Germany

Rainer Strenge
Head of Traffic Technologies Centre at the German Federal Waterways and Shipping Administration

Rainer Strenge is heading the Traffic Technologies Centre (TTC). After receiving a university degree in electrical engineering he joined the Administration in 1990. His professional career started at the regional office Cuxhaven where he was in charge of the Elbe VTS renewal and gained experiences in leading technical projects. Since he moved to Koblenz TTC he has been involved in various remote operation projects and in the development of standards for remote systems and operation centers. He has also expertise in the implementation of River Information Services (RIS) on German inland waterways.

Walif Achim Schneider
Project engineer at the German Federal Waterways and Shipping Administration

Walif Schneider is project engineer in the Traffic Technologies Centre which is part of the German Waterways and Shipping Administration. His expertise is in automation of locks and weirs. He supports the German Ministry of Traffic and Local Offices in in the wide field around automation, simulation of technical plants, test of PLC-software and EU Directive on Machinery respectively risk assessment. He is also involved in the work of several national working groups for the development of standards for automation and remote control concepts and systems. He is currently head of working group “Machine Safety” in charge to update the national guideline with regard to safety issues considering locks and weirs.

The Traffic Technologies Centre (TTC) is an engineering and consultant office of the German Federal Waterways and Shipping Administration. TTC, located in Koblenz next to the two international waterways Rhine and Moselle River, was established to support all sections of the German Federal Waterways and Shipping Administration. TTC is also an advisor for the Ministry of Transport and Digital Infrastructure (BMVI). The various fields of competencies include electrical and mechanical engineering for locks, weirs, ship lifts etc. Further activities comprise all kind of aids to navigations and also systems with regard to the implementation of River Information Services (RIS).

The Netherlands

Leon Uijttewaal
Lead Architect at Rijkswaterstaat

Leon Uijttewaal is working for 10 year at Rijkswaterstaat in the function of Lead architect for the development of “building blocks” for operating and control systems in the infrastructure. Infrastructure such as, locks, movable bridges, surge barriers, tunnels and Trafficcenters. He is also specialized and TuV certified Machinery Safety Expert for the machinery in the infrastructure. Previous employers are Frames Energy Systems (Oil & Gas), Province Zuid Holland (infrastructure) and Strypes Netherlands (Consultancy).

Rijkswaterstaat is part of the Dutch Ministry of Infrastructure and the Environment and responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. This includes the main road network, the main waterway network and the main waterways.

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Ad Kloppenburg
Electrical Engineer at Witteveen+Bos

Ad Kloppenburg is since 1988 employed at Witteveen+Bos. He is now a senior consultant for electrical installations in inland water transport related structures such as movable bridges, navigation locks, tunnels under rivers and canals. He was involved in several major projects such as the inspection and preparation of a tender for the Djerdap navigation locks overhaul in Serbia and the design and cost calculation of the 18 km long immersed Fehmarnbelt tunnel between Germany and Denmark. As a member of a big international team in 2013 he carried out a conceptual design and validation of the electrical and mechanical installations of the Sharq crossing Doha, Qatar. He was also active in remote control related projects, such as the supervision, review of contractor documents, testing and commissioning of a remote command control center for 5 bridges and 10 navigation locks in Lelystad. Ad also carried out several feasibility studies including conceptual design and cost estimate for the remote control of 11 movable bridges from one command and control center in the province Fryslân in the Netherlands.

Witteveen+Bos is a company based in the Netherlands that provides consultancy and engineering services worldwide in the fields of infrastructure, water, the environment, spatial development and construction. Their multidisciplinary approach to projects is the distinctive feature of the way they work. Their clients are governmental, commercial and industrial organisations, including various types of joint ventures and public-private partnerships. Witteveen+Bos serves their clients from six offices in the Netherlands and ten international offices. The company has a workforce of more than 1000 specialists. They take pride in delivering quality. Partnership is their keyword – partnership with clients and with Witteveen+Bos. Personal development and acquiring new expertise are key drivers because the work constantly demands new knowledge and responsibilities. Employees feel at home at Witteveen+Bos because it is a company firmly committed to delivering quality and making an extra effort for the clients and personnel.
United Kingdom

Jason Hudson
Principal Electrical Engineer at RoyalHaskoningDHV

Jason is a Chartered Electrical Engineer with 25 years’ experience working within a wide range of industries in the UK and overseas, with a particular focus on large moving structures. Prior to joining Royal HaskoningDHV, he was employed by the Canal & River Trust (formerly British Waterways) where he was responsible for the safe automation of their canal and navigation locks and bridges. His experience includes feasibility studies, design, specification preparation, and commissioning and inspection work associated with link spans, water control equipment (valves, gates and penstocks), moving bridges, dock and lock gates, port and dockyard moving machinery and associated systems. His particular interest is in the design of control systems used in safety applications. He is apprentice trained and a Member of the Institute of Electrical Engineers and has European Engineer Status through Membership of FEANI. Jason is keen to promote good practice and share his knowledge by representing the UK on the PIANC WG192 - Developments in the Automation and Remote Operation of Locks and Bridges.

Royal HaskoningDHV has been making a world of difference in people’s lives since 1881. As an independent international engineering and project management consultancy, they have been working with clients to successfully deliver projects which contribute to improving living circumstances around the world for 135 years. The 6,000 colleagues, spread over 150 countries are committed to the promise to enhance society together.

United States of America

Albert Barnes
Senior Electrical Engineer at Tetra Tech

Albert Barnes is a senior electrical engineer for Tetra Tech. He has 24 years of experience in the design and commissioning of electrical and controls systems for heavy industrial projects. He has spent the last 8 years at Tetra Tech working on a variety of projects involving lock, dam, pump station, and floodgate electrical and control systems including the new locks for the Panama Canal and hurricane flood risk reduction for New Orleans.

Tetra Tech is a full-service consulting and engineering firm with offices and operational infrastructure throughout the United States, Canada, and abroad. With 16,000 associates in 400 offices in more than 110 countries on six continents, Tetra Tech’s technical knowledge and hands-on site work is broad and deep. Tetra Tech’s innovative, sustainable solutions help our clients reach their goals for water, environment, energy, infrastructure, and resource management projects. Tetra Tech has been ranked #1 in Water for 14 consecutive years by Engineering News-Record. The Global Infrastructure Design group within Tetra Tech specializes in innovative planning, engineering, and design solutions for inland navigation, waterfront, ports, dams, and levees, hydropower, and flood control.

Kathy Griffin
Deputy Chief Operations and Regulatory Division at US Army Corps of Engineers, Pittsburgh District

Kathy Griffin is an experienced technical leader with the U.S. Army Corps of Engineers. She joined the Buffalo District as an intern with the Regulatory program and currently serves as the Pittsburgh District Deputy Chief, Operations and Regulatory Division. Kathy combined her education in Biology and Regional Planning with diverse work experience in the Corps to develop skills in organizational leadership, strategic thinking, program management, collaborative problem solving, and continuous improvement.

Her experience in the Corps Regulatory program established a strong commitment to public service and ability to serve as the “honest broker” balancing the value of economic development and water resource protection. Additional experience managing the operation and maintenance of navigation infrastructure on both the Great Lakes and Inland Marine Transportation System, provided Kathy with unique skill sets that enable her to lead an enterprise approach to asset management. A key leader on the Great Lakes Navigation Team, Kathy introduced and led the implementation of numerous initiatives and business practices that enabled the Corps Great Lakes Districts and navigation stakeholders to manage individual Great Lakes harbors as a system.
The United States Army Corps of Engineers is a U.S. federal agency under the Department of Defense and a major Army command consisting of 37,000 civilian and military personnel. The corps’ mission is to “Deliver vital public and military engineering services; partnering in peace and war to strengthen our Nation’s security, energize the economy and reduce risks from disasters.” The most visible missions include:

- Planning, designing, building, and operating locks and dams. Other civil engineering projects include flood control, beach nourishment, and dredging for waterway navigation.
- Design and construction of flood protection systems through various federal mandates.
- Environmental regulation and ecosystem restoration.

As the U.S. Representative for The World Association for Waterborne Transport Infrastructure (PIANC) remote and automated lock operation working group, Kathy continues to lead continuous improvement of the nation’s waterborne transportation system.

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- Design and construction of flood protection systems through various federal mandates.
- Environmental regulation and ecosystem restoration.

Her leadership has been key to increased Federal investment on both these systems. With experience in Operations and Maintenance, Regulatory, Emergency Management, Engineering, Construction, Programs, and Project Management, Kathy has a broad knowledge of the Corps Civil Works Programs. In addition to completing two developmental assignments at the Corps Headquarters Office in Washington, D.C., she deployed to Afghanistan in 2011 where she served as the Afghan National Security Forces Program Manager.

As the U.S. Representative for The World Association for Waterborne Transport Infrastructure (PIANC) remote and automated lock operation working group, Kathy continues to lead continuous improvement of the nation’s waterborne transportation system.

Work group 192 will deliver a final report in 2018, covering the following topics.

**Business case development for remote control**
- Value of investment vs benefit
- Traffic management
- User references

**Organisational implementation**
- Changes within the organisation
- Service model to customers
- Interaction with the public

**Operational implementation**
- Process definition
- Procedures
- Operator skills
- Control room design

**Technical implementation**
- Rules & Regulations
- System architecture
- Technical developments

**Safety**
- Reliability
- Operational safety
- Technical safety requirements
- Technical safety solutions

**Security**
- Perimeter protection
- Cyber security
- Traffic monitoring

**Business continuity**
- Redundancy
- Failure modes & support model

**Traffic management**

**Information management**
- (Big) data analysis
- Reporting and statistics

**Recurring issues regarding remote control and automation**

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Table of content of the WG192 Report
PIANC Work Group 192 relies on the wide, varied and in-depth experience of its members.

On the following pages, a selection of reference projects, that were realised by the individual members, is listed. These examples are an illustration of the rich and diverse expertise of the members of the work group.

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Automatisation of Waterways: Training and Reference Centre (AWATAR)

Name project: AWATAR (Automatisation of Waterways: Training and Reference Centre)
Client: De Vlaamse Waterweg nv
Location: Belgium

Project summary
AWATAR is a project for the design and implementation of a simulator for the remote control of bridges and locks. The goal of this simulator is fourfold:

- Aid for interaction with the operators to come to a uniform design and look of remote control rooms and procedures
- Training aid for operating installations remotely in both normal as exceptional circumstances in a safe environment
- Aid for the transition from manual/local control to remote control, since the simulator allows operators to see and test the new work situation beforehand and give feedback
- Aid for drawing up the technical standards for a uniform and standardized way of controlling

To reach these goals, the simulator must closely resemble the existing technical installations, so modifications and improvements can be tested first on the simulator. Furthermore, AWATAR is designed in a multifunctional and modular way, so it can easily evolve with the latest technological evolutions. In the design of the simulator, several workshops were held to consult the operators and ask for their feedback. Following themes were handled during these workshops:

- Design of the operator desk
- Setting of the camera’s and correct angle
- Design of the operating screen (SCADA)
- Operating procedures

Remote control of railway bridges

Name project: Remote control of movable railway bridges over the Flemish waterways
Client: De Vlaamse Waterweg nv and Infrabel
Location: Flanders, Belgium

Project summary
As part of this cooperation, remote control is introduced to improve customer service on the one hand and make the control of railway bridges more cost efficient on the other hand. Several agreements were closed between de Vlaamse Waterweg and Infrabel to reach this goal and remotely control some of the railway bridges, such as the Nijverheids bridge in Ruisbroek, Jan Bogaerts bridge in Kapelle-op-den-Bos and the Schelde bridge in Temse. In these agreements special attention is paid to maintaining the operational reliability, to ensure that operational malfunctions have no major impact on the railway and waterway traffic. One area of attention concerning operational reliability, is the data transport between the bridge and the remote control room, which needs to be fail proof. This is done by upgrading the data security and installing the necessary back-up systems.
Remote control in the Port of Antwerp

Name project  ARGUS – subproject remote control
Client          Port of Antwerp
Location        Antwerp, Belgium

Project summary
The Argus project analyses the different technical possibilities for productivity improvement of the movable bridges and locks in the Port of Antwerp. Previous studies have shown that, especially in the Netherlands, remote control rooms are gaining more and more popularity. Also in the Port of Antwerp, studies were carried out to examine if this could be implemented in the future and more importantly, how. The project was called Argus as a reference to the mythical figure of Argos Panoptes, who had hundred eyes spread across his body and who never had more than two eyes sleeping at the same time. This is a fitting metaphor for remote control on the one hand, which requires many dozens of camera’s and the business of the Port of Antwerp on the other hand, which is active 24/7.

To study remote control in the Port of Antwerp, a proof of concept on real-scale and realistic circumstances was designed in order to study how the control room of the future should look like. This proof of concept consisted out of 4 parts:

1. Controlling aspect and ergonomics
What needs to be controlled from the control room? How do we want to work? How does this differ from the current work structure and organisation? Which information and installations are needed? How can we present information in the best way? How do we deal with break-downs and glitches? How should an operator desk be designed?

2. Realization of a (training) simulator
To evaluate the new way of working and the design of the operator desks, a simulator was build. This was designed to have the same look and feel as a real operator desk. The simulator was used to test and try-out the best camera positions for remote control.

3. Realization of a full scale proof of concept (PoC)
Once the look and functionalities of the operator desk were tested and approved, Port of Antwerp started with the actual construction of a temporary control room on the Noordkasteel bridges and the Boudewijn and Van Cauwelaert lock.

4. Roll-out
The PoC showed that remote controlling for the bridges and locks in the Port of Antwerp is possible. Hence, a medium-sized control room with five operator desks was built. Here the technical concepts are being refined and further tested and the organisational design of the remote control room is designed. At the same time, the preparations for remote control have started for the Kallolock. The Kieldrechtlock and Zandvliet- en Berendrecht lock complex are next in line.
Port of Antwerp & Tractebel

Full automatic control for Port of Antwerp

Name project Full automatic surveillance of movable bridges and locks
Client Port of Antwerp
Location Antwerp (Belgium)

Project summary
Tractebel assisted and advised the Port of Antwerp on the full automatic surveillance of movable bridges and locks. This included the following tasks and deliverables:

Risk analysis for automatic control
• Analysis of safety risks according to the machine directive
• Analysis of operational reliability
• Analysis of reputational damage
• Risk reduction following ISO 12100

Availability vs reliability

Analysis for movable bridges and locks, using different risk areas
• Road Traffic
• Waterway traffic

Testing of different detection systems
• Laser scanner
• Radar detector and scanner
• Microwave through-beam detector
• 3D time of flight camera
• Video Content Analysis
• Thermal camera
• Electrostatic sensors
Consultancy remote control for Waterwegen en Zeekanaal NV (De Vlaamse Waterweg nv)

Name project Consultancy remote control of all movable bridges, locks and waterbound infrastructure of Waterwegen en Zeekanaal NV

Client Waterwegen en Zeekanaal NV (De Vlaamse Waterweg nv)

Location Western and central part of Flanders (Belgium)

Project summary
Tractebel assisted and advised Waterwegen en Zeekanaal NV on the remote control of movable bridges, locks and waterbound infrastructure of W&Z. This included the following tasks and deliverables:

Determination of scenarios according to:
- Corridor management
- Ship navigation guidance
- Water management

Design of remote control rooms
- Work load of operators
- Ergonomic factor (communication, camera images, desk, SCADA, etc…)

Risk analysis: local operation to remote control
- Analysis of safety risks according to the machine directive
- Analysis of operational reliability
- Risk reduction following ISO 12100
- Reliability of infrastructure equipment
- Clear overview of all risk areas with camera images
- Clear and reliable communication
- Optical fiber network for reliable operation and safe emergency stop devices
- Protocol for remote access control, technical interventions and maintenance
- Relocation of extra jobs from the local operator
- Training and guidance for new and current operators
- Proper distribution of work load
- Work post for efficient remote control of all infrastructure on the corridor/waterway

Risk analysis: Local operation to remote control for tidal locks
St. Lawrence Seaway Management Corporation

Self-Mooring System

Name project  Self-Mooring System
Client          Canadian Government (Transport Canada)
Location       Canada

Project summary
The Remote Operation project currently undertaken by the St. Lawrence Seaway Management Corporation intends to add remote operation of lock structures to the existing Operation Control Centers.

As part of the Remote Operation project, different modernization programs are considered key in the achievement of the corporate business plan. One of the main modernization program projects is the installation of a Self-Mooring System. The mooring system was designed to replace the steel cables used to moor vessels during the lockage process for many decades. Primary to the design were the safety aspects of protecting workers and users from the danger of cable breaks. Additionally, the physical effort required to handle the steel cables was an increasing source of injury to the staff. Lastly, the elimination of the requirement for vessels to be outfitted with steel cables allows a greater percentage of the world fleet to successfully transit the system.

The automated mooring robots employ vacuum pads to hold the vessel in position during the lockage process. The system was designed to provide 20 tons of holding force per suction pad and there are three double pad systems installed at each lock. Two mooring machines (four pads) were deemed to be sufficient to replace the steel cables previously required to moor full size vessels. A third mooring machine was added to provide spare capacity for maintenance cycles and to accommodate vessels with hulls that make it difficult to achieve a proper vacuum seal.

The automated mooring system is being integrated into the lock automation system to make it more effective. Data from the Traffic Management System will automatically be sent to the mooring system as the vessel approaches the lock. This data will indicate how many vacuum pads are required to achieve the minimum system capacity to safely process this specific vessel. Also, the data will include the initial vacuum pad position (height above the water) where the mooring system can have the best chance to successfully attach to the vessel.
Remote terminal for the small locks operation

**Name project**  Remote terminal for the small locks operation

**Client**  Voies navigables de France (VNF)

**Location**  French waterways

**Project summary**
The french waterway network is 8500 km long. More than three quarters of this network was built during the 18th century. The (approximately 1500) locks of these canals are 40 meter-long and 5 meter-wide, and are mostly used by leisure navigation. The locks are automated, to keep a good amplitude of operating hours, even in winter when only few boats are on the canals.

The users are generally equipped with a remote terminal to ask for lockage.

Different remote terminals have been built since the end of the 1900’s, and Cerema and VNF decided to design a new ‘smart’ remote terminal.

*The main goals are:*  
- to be compatible with the old systems for a progressive deployment,
- to implement a certified safety stop,
- to be easily adaptable to other uses (operating moveable bridges, provide information for big data, give traffic information, perform tourism information,...),
- to use standards, and when it’s not possible, to be the property of the network manager, both hardware and software.

The remote terminal is called SCUO – (Communication System between the User and the Infrastructures), and is a concentrate of technology; 433 MHz and 866 MHz radio systems, GPS, GSM, safety buttons, submersion detection, updating software,...

The terminal was designed under the control of a national expert group, led by VNF and Cerema. After two iterations and many tests, the design of a final compact version is in progress.
Rhône Traffic Center

Design and construction of the Rhône Traffic Management Centre

Name project: Design and construction of the Rhône Traffic Management Centre
Client: Compagnie Nationale du Rhône (CNR)
Location: Châteauneuf-du-Rhône, France

Project summary
The Compagnie Nationale du Rhône has designed the Rhône Traffic Management Centre, which allows them to operate and remotely control 14 wide gauge locks from one central location in Châteauneuf-du-Rhône. Furthermore, CNR put in place an AIS (Automatic Identification System) on the Rhône. This system is based on an automatic geolocation system allowing boats fitted with it to find out the identity, status, position and route of the units in the navigation zone, by automatic exchanges of VHF radio messages. The AIS system is composed of three main parts, namely:

- VHF antennas over the length of the waterway
- VHF transponder + GPS equipment on board of the boats
- IT platform for collecting and managing data

To implement AIS, CNR placed the appropriate reception equipment in all 14 locks along the Rhône. The transmitted AIS data is used in the Rhône traffic management application (GTR) and allows the Management Centre to have the exact positioning of the traffic on the Rhône and estimated arrival of boats at the locks. Hence, CNR is able to improve the navigation management thanks to AIS by a perfect knowledge of the traffic on the Rhône.

Thanks to the Rhone Traffic Management Centre and implementation of AIS, CNR was able to improve the services towards the skippers, for example by extending the operating hours from 5am-9pm to a 24/7 service. This enables CNR to provide a permanent surveillance and monitoring along the navigable section of the Rhône and hence increase the safety of lock operators. The Traffic Management Centre makes it possible for CNR to quickly respond to crises (accidents, floods, …) and manage them in the appropriate way. Furthermore, CNR is able to give better information to the users of the Rhône by providing full information on traffic in real-time and optimizing the lock passages (less than 20 min).
German Federal Waterways and Shipping Administration

Development of the guideline “Automation and Remote Control”

Name project Development of the guideline “Automation and Remote Control”
Client German Federal Waterways and Shipping Administration
Location Germany

Project summary
The experience of the German Waterways and Shipping Administration with the remote operation of locks goes back to the middle of the nineties. In order to ensure high quality levels of service to shipping, the Waterways and Shipping Administration decided to introduce appropriate standard solutions for the renewal of existing lock operation centres and for implementing future centres. Within this standardisation process the guideline “Automation and Remote Control” was developed. The guideline document deals with major technical, operational and legal aspects of automation and remote control systems while paying special attention to safety and ergonomics.

In order to deal with issues arising in the area of ergonomics, the Waterways and Shipping Administration initiated a study which was carried out by the Institute for Applied Work Science (IAW) at the University of Aachen and Fraunhofer - Institute for Communication, Information Processing and Ergonomics (FKIE). The study was supported by the Federal Institute for Occupational Safety and Health (BAuA) and began with an examination of existing operation centres. Over a period of 18 months, 45 individual workstations in 15 operational centres were assessed with regard to important ergonomic aspects such as indoor climate, lighting, acoustics, mental stress, workload and accessibility. Interviews with shift supervisors were also conducted in order to take their experiences into consideration.

This resulted in an optimised design proposal for future operation centres, comprising the entire process system and including the elements of staffing, design and arrangement of workstations and components, as well as the graphical user interface for operation and visualization. As an example, a standard operating desk is now being introduced. The desk enables ergonomic standing and sitting postures with optimum space within reach, fields of vision, viewing distances and motion sequences. The reduction of the number of devices to be installed in the desk was consistently implemented as recommended by the ergonomic study.

The guideline was introduced in 2015. 11 operation centres serving more than 110 lock chambers are currently being implemented or planned on the basis of the guideline. The guideline document will be updated according to new developments and demands.
Rijkswaterstaat

3B Building block

Name project 3B Building block
Client Rijkswaterstaat
Location The Netherlands

Project summary
Rijkswaterstaat will start working with standard systems when operating (Bedienen), managing (Besturen) and monitoring (Bewaken) bridges. This 3B Building block will be used to operate, manage and monitor bridges in a uniform manner.

The development of the 3B Building block stems from a refinement of the I-Strategy of Rijkswaterstaat which mainly focuses on the standardisation of information services and the standardisation of industrial automation as well as implementing this in a sustainable way in the organisation and processes.

The first step in standardizing the operation, management and monitoring of bridges is defining building blocks which encompass the entire chain, ranging from operating moveable components to the signaling of locks and bridges. The development of the 3B Building block must result in a standardized system, consisting of different modules. As a result the Building block becomes exchangeable and configurable and thus applicable for the complete Rijkswaterstaat.

The 3B Building block presents numerous advantages to Rijkswaterstaat such as:

• Cost-saving measures on Industrial Automation - design, realization and testing processes;
• Efficient approach towards generic problems in projects;
• Cost-saving measures on management and maintenance;
• Less disturbance for waterway users;
• Increased agility of Rijkswaterstaat in implementing changes in the future.

A first pilot program will be established for the renovation of the Wantijbrug (Dordrecht) and Van Brienenoordbrug (Rotterdam). If it turns out the Building block is reusable, it will be applied for the remaining bridges of Rijkswaterstaat.
Operation centre for movable bridges and navigation locks in Lelystad

Name project: Operation Centre for movable bridges and navigation locks
Client: Rijkswaterstaat
Location: Lelystad, Flevoland (The Netherlands)

Project summary
Witteveen+Bos carried out a project where an operation center was installed in the Flevoland province office building. From this operation center, five bridges and ten locks in Flevoland are remotely controlled. There are eight operator desks available, but the number of operators depends on the season and number of expected ships.

Witteveen+Bos connected the different objects with a glass fiber network to the control center in Lelystad and added remote control to the existing locks and bridges, without carrying out major changes in the local existing installation.

This project brought up some major discussion points about remote control, which Witteveen+Bos had to take into account in the design and installation of the operation center:

- **CCTV Camera positions:** The wishes and needs of the operators in the operation center differed heavily with the theoretical design. This was especially the case with navigation locks where there was a movable bridge across the lock chamber. This point was resolved by performing local onsite sight measurements to determine the exact position of the cameras.

- **Privacy of nearby residents:** This point was resolved by using cameras with built-in privacy masking software and to involve residents during commissioning of the cameras.

- **Responsibility over the safety of the installation:** The contractor is responsible for the changes on the existing installation that are related to remote control. However, the contractor cannot be be taken fully responsible for the existing installation connected to the remote control. Therefore an interface was designed by the contractor to solve the responsibility issue. On every installation a safety PLC was installed, that serves as an interface between the emergency stop button on the operator desk and the emergency circuit of the local object.
**Lock Centralisation Consultancy Services**

Name project  Lock Centralisation Consultancy Services  
Client  Peel ports  
Location  Liverpool (UK)

**Project summary**
Mersey Docks & Harbour Co is a subsidiary of Peel Holdings Group. The Group owns and operates the second largest port group in the UK. The Port of Liverpool is one of the busiest ports in the UK; it is a gateway to trade from North America and more than 100 other non-EU destinations. In addition, the Port of Liverpool sees nearly three quarters of a million people per year travelling on Irish Sea Ferry services and cruise ships.

The Lock Centralisation Project is a control system that is designed on a SCADA network, utilising radio microwave uplinks and fibre optic networks. The SCADA network allows for large amounts of data to be transmitted back to the central Dock Master’s control room in the form of positional sensor arrays, pressure and level readings and live CCTV images. The live CCTV images ensure that a safe and controlled environment is maintained whilst the bridge or lock is operated remotely.

The operator is able to control the bridge or lock from several miles away through an operator PC interface. To minimise the risk of an operator error, there are software interlocks within the programming software that ensure the operator is looking at the assigned lock or bridge and that the operator is not trying to operate the lock or bridge outside of the agreed operational parameters.

After the initial design concepts had been finalised, the system integration was then staged to ensure the Port’s operations remained largely unaffected. Royal HaskoningDHV provided technical expertise and independently verified the system conformed to the Port’s initial outlined design, whilst ensuring everyone involved had clarity of the design and operational philosophy.

**Automated lock system for Rijkswaterstaat**

Name project  RWS ZN Lock Weurt – Automated lock system  
Client  Rijkswaterstaat PPO Zuid  
Location  Nijmegen (The Netherlands)

**Project summary**
The risk of ship collisions on the lock gates of the shipping locks at Nijmegen is considered to be too high. Royal HaskoningDHV was assigned to develop a conceptual design for protective measures to reduce this risk. Hence, we have designed a movable beam, which is able to stop incoming ships moving towards the gates.
Kolenhaven bridge for Gemeente Delft

Name project Design of the new movable Kolenhaven Bridge
Client Gemeente Delft
Location Delft (The Netherlands)

Project summary
The movable Kolenhaven bridge is a modern and iconic replacement of the former typical Dutch drawbridge which was in urgent need of replacement. The streamlined design fits fluently into the winding track of the new bus lane alongside the Schie Canal. The extremely light spoked balancing plate is a contemporary addition to the industrial character of the site.

Since the bridge is visible both from the train as well as from the turnoff of the motorway, the bridge has become a beacon for Delft, city of the University of Technology.

Lock Gates for Sentosa Cove

Name project Design of lock gates for Sentosa Cove
Client Sentosa Cove Development Corporation
Location Sentosa (Singapore)

Project summary
Sentosa Cove is a residential and leisure yachting facility in Singapore. To protect the inner developments against the sea and to maintain a constant water level in the canal system within the development, two parallel locks were required. Each lock barrel is 30 m long x 7 m wide.

Royal HaskoningDHV was commissioned to design the lock gates, associated bridges for light vehicles and pedestrians, lock pontoons and the hydraulic and electrical control systems. The client requested very fast lock operation times and in order to achieve this, the gates were designed as pairs of sector gates with intelligent sluicing and sluicing troughs. The bridges across the lock are integral with the gates to reduce both the cost of the civil works and prevent the requirement for additional operating equipment. The lock can be operated either by a lock keeper or by remote control from vessels using the lock. It is the first installation of this type to have a user remote controlled facility. The actuation of the gates is by electro-hydraulic power which is doubly backed up by a standby generator and mobile diesel hydraulic power packs.
## Remote operation of mechanised bridges

**Name project**  Remote operation of mechanised bridges  
**Client**  Canal & River Trust  
**Location**  Gloucester & Sharpness canal (United Kingdom)  

### Project summary

The Trust currently has 14 mechanised bridges on the Gloucester & Sharpness canal that are operated by staff for the use of boaters. Manning of these bridges is not only costly but has a number of negative impacts on customer service. This project has looked at new technologies that will improve both customer experience alongside reducing costs to the Trust.

A solution has been developed that will transform the navigation experience through an innovative design which offers a primary method of ‘Self Service’ remote operation to boaters. As a boater approaches a bridge, a previously downloaded software App on their ‘smart device’ will automatically detect they are within a Trust ‘Self Service Zone’ for a particular bridge. The App will ask if they wish to operate the structure ahead. A simple one touch request on their ‘smart device’ will operate the structure giving updates on the sequence of operation and instructions to wait and proceed as appropriate.

There will be no requirement for the boaters to leave their boat. The App will be secure and boaters will need to register with specified details before downloading it. A number of lasers installed strategically on the bridge deck and canal within the bridge operating zone together with existing safety systems and interlocks will ensure safe and reliable operation.

A bridge control room will have oversight of all bridge status and activity through SCADA (Supervisory Control & Data Acquisition) and CCTV systems. The control room will also act as a single point of contact for boaters and bridge users.
**Design of the Panama Canal Lock Number 3**

**Name project**   Design of the Panama Canal Lock Number 3  
**Client**   Panama Canal Authority  
**Location**   Panama  

**Project summary**  
Tetra Tech was appointed together with MWH and IV Group as the engineering contractors for the design and development of the third lock in the Panama Canal, which later will be operated by the Panama Canal Authority. During this project, Tetra Tech was responsible for lock valves, lock chambers, water saving basins, and approach walls.

**Control Upgrades at the Bonneville Dam Navigation Lock**

**Name project**   Control Upgrades at the Bonneville Dam Navigation Lock  
**Client**   US Army Corps of Engineers, Portland District  
**Location**   Portland, Oregon (United States of America)  

**Project summary**  
The Bonneville Lock and Dam is a navigation lock, which is situated approximately 80km east of Portland, Oregon and is operated by the Portland District of the USACE. The dam is controlled from the lock, where there is remote viewing at the Dam. Tetra Tech was hired to upgrade the PLC controls and control screens for the lock.
Upper Saint Anthony Falls
Tainter Gate Update

Name project: Upper Saint Anthony Falls Tainter Gate Update
Client: Terrebonne Levee District
Location: Minneapolis, Minnesota (United States of America)

Project summary
The Upper Saint Anthony Falls Lock is the most upstream lock on the Mississippi River and is located in downtown Minneapolis. The lock is normally operated by USACE St. Paul District, but is now closed to navigation traffic by act of US Congress. Tetra Tech is asked to update the hoist machinery on the Tainter Gate including new electrical and PLC controls.
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COLOPHON

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