FRAMEWORK FOR STANDARDIZATION OF LOCK AND WEIR COMPONENTS

TERMS OF REFERENCE

1. Historical Background and Definition of the Problem

Inland waterway networks serve as critical corridors for global commerce, offering an energy-efficient, high-volume alternative to road and rail transport. Historically, the infrastructure supporting these waterways—specifically navigation locks and weirs—was designed and constructed on a project-by-project basis. Spanning from the early 19th century through the late 20th century, structural, mechanical, and electrical components were custom-engineered to suit the localized physical conditions, municipal technologies, and regional design preferences of the era.

While this customized engineering approach successfully addressed immediate local constraints, it has created a highly fragmented global infrastructure asset base. Today, major inland navigation transportation systems—such as those in North America, Western Europe, and East Asia—suffer from a severe lack of interchangeable parts and unified operating standards. As nowadays assets often reach or exceed their nominal design lives (frequently 50 to 100 years), managing agencies face escalating maintenance backlogs, specialized manufacturing lead times, and prohibitive life-cycle replacement costs.

In response to these challenges, localized national efforts have emerged. For example, in US, USACE mandated the Inland Navigation Design Center (INDC) to standardise navigation lock and weir infrastructure.

Similarly, European nations have worked under various CEN (European Committee for Standardisation). In Germany (WSV and BAW) several national efforts include:

- The development of a lock standard for lift heights of up to 10 metres, with an upper head supplied with either a radial or mitre gate, and a lower head supplied with a mitre gate,
- Weir standards for various widths and heights
- A radial gate standard for weirs

In the Netherlands, the Rijkswaterstaat (RWS) has the MultiWaterWerk program to renew 52 aging locks with the goals of lower lifecycle costs and better reliability through standardizing components and parts. In France, VNF replaced more than 20 old needles weirs with standardised inflatable weirs or other technologies.

The process of deciding what components and to what level of standardisation in a network, system, or subsystem can be difficult to determine and optimize. Many organizations around the world have approached this issue from different perspectives and learning from each other would improve the overall state-of-the-practice.

The feasibility of the standardisation of equipment on a project of several locks/weirs planned on a long period (5 years or more) is limited as technology changes quickly, it is often not legal to impose component manufacturers in bidding, mechanical and electrical components pose challenges such as proprietary equipment and maintenance as well as a higher rate of technological advancement which may require more frequent updating or replacement.

This PIANC WG is established to close the above-mentioned gaps by developing the best possible global framework and implementation pathway for local or regional decision-making of IW infrastructure component's standardization.

2. Objectives

The primary objective of the WG is to produce a comprehensive, internationally applicable framework document that facilitates standardisations of navigation lock and weir components.

The specific objectives are:

- **Benchmark Current Practices:** Identify and catalogue existing regional, national, and international engineering standards, focusing on areas where standardisation has successfully reduced life-cycle costs and minimized operational downtime.
- **Selection Criteria:** How to evaluate the advantages/drawbacks of a component for a standardisation project, based on cost-benefit analysis, safety impact, or supply chain resilience.
- **Develop an Assessment & Filtering Methodology:** Create a multi-criteria decision-making (MCDM) matrix to systematically assess lock and weir components' suitability for standardisation, based on lifecycle cost, safety criticality, procurement lead times, and operational risk.
- **Formulate a Modularization Framework:** Outline the engineering process required to transition custom-engineered mechanical, structural, and electrical designs into modular, scalable, and interchangeable interfaces, ensuring the necessary flexibility.

3. Earlier Reports to be Reviewed

PIANC
- PIANC InCom WG 26: Design of Movable Weirs and Storm Surge Barriers (2006)
- PIANC InCom WG 106: Innovations in Navigation Lock Design (2009)
- PIANC InCom WG 154: Mitre Gate Design and Operation (2017)
- PIANC InCom WG 173: Movable Bridges and Rolling Gates Design, Maintenance and Operation - Lessons Learnt (2017)
- PIANC InCom WG 206: Design of Navigation Locks (2025)

Wasserstraßen und Schifffahrtsverwaltung des Bundes (WSV):
- Basic Regulations - Standardisation of Objects on Federal Waterways (2016)
- Standardisation of Inland Waterway Lock Systems up to 10m Lift (2016)
- Rules of Procedure – Standaridisation Commission (2021)

Rijkswaterstaat MultiWaterWerk reports including:
- Learning from other Administrators (2015)
- Standardisation of Lock Doors (2021)
- Wilschut (2018) System specification and design structuring methods for a lock product platform – Thesis TU Eindhoven (NL)

US Army Corp of Engineers:
- Engineer Circular 1130-2-554 "Locks and Dams Maintenance Standards" (2025)
- Engineering and Construction Bulletin No. 2026-24 "Inland Navigation Design Standards – Authority, Development, and Implementation"
- People's Republic of China Ministry of Transport (MOT):
- JTS 305-2025 "Design Code for Navigation Lock General Plan"
- JTS and JTJ standards related to component design

4. Scope of Work

The primary objective of the WG is to produce a comprehensive technical report defining the methodology, selection process, and step-by-step guidelines for a standardizing project of navigation lock and weir components. The report will mainly focus on the components that tend to be replaced due to wear, degradation, or obsolesce over the lifetime of the overall lock or weir. Examples include but are not limited to gates, bollards, operating machinery, electrical controls, and software. These components tend to be mainly of the structural, mechanical, and electrical engineering disciplines. The WG will document how components are selected, evaluated, and standardized, while assessing the cross-border and cross-waterway applicability of locally standardised components.

The WG will focus on establishing a repeatable, two-stage framework for identifying and standardizing infrastructure assets. First, the group will develop a systematic process to evaluate, categorize, and prioritize components for standardisation. This phase will deliver a quantitative multi-criteria decision framework that assesses candidate components (including structural, safety, mechanical, and electrical subsystems) against critical metrics such as manufacturing lead times, failure rates, safety risks, and potential lifecycle cost savings. By defining clear entry thresholds for standardisation, the framework will enable asset managers to distinguish between high-priority, system-wide candidate components and those that must remain custom-engineered for site-specific conditions, maintaining a necessary amount of flexibility. The group should investigate if and where the functions of locks and weirs overlap.

Second, the group will detail the procedural steps required to transition a prioritized component from a custom design to a local or regional standard. This work will define the exact workflow for cross-jurisdictional alignment, detailing how to compile divergent technical specifications and resolve regulatory mismatches.

Additionally, the group may formulate a methodology for designing modular physical and digital interfaces (such as mounting configurations, fluid compatibility, and open communication protocols). This ensures that standardising components does not limit future design innovation due to technology changes, allowing new technologies to seamlessly integrate into installed physical frameworks.

5. Intended Product

The intent will be to provide a report of the current best practices and guidance of navigation lock and weir components standardisation.

The report will include:

- **The Standardisation Decision Framework:** A step-by-step evaluation guide and scoring matrix designed to help waterway authorities identify and prioritize high-value components for standardisation.
- **Process Guidelines for Technical Alignment:** The collaborative engineering processes needed to reconcile regional codes and practices into standardised yet flexible physical, mechanical, and digital interfaces.
- **Reference Previous Pilot Projects:** Provide examples of how existing methodologies have been applied to representative components (e.g., evaluating safety ladders, mooring bollards, or hydraulic cylinders) to demonstrate practical application.
- **Strategic Implementation:** A transition guide outlining how agencies can integrate standardised components into their existing capital improvement plans and routine maintenance schedules.

6. Working Group Membership

To ensure the framework is robust and globally applicable, the WG seeks an interdisciplinary coalition of experts representing:

Waterway and Navigation Authorities: System engineers, asset managers, and policy makers from agencies actively pursuing modernization programs.

Systems Engineers & Decision Scientists: Specialists in asset management, operations research, multi-criteria decision-making, and lifecycle assessment.

Equipment Manufacturers and Suppliers: Industrial suppliers of marine bollards, ladders, control systems, and heavy hydraulic machinery.

Design Engineers & Consultants: Structural, mechanical, electrical, and hydraulic specialists with experience in both bespoke and standardised marine infrastructure design.

Academics: Representatives from research institutions specializing in industrial standardisation and modular design.

7. Target Audience

The deliverables of this WG are engineered to support a diverse set of international stakeholders:

Waterway Operators and Infrastructure Authorities: Executive asset managers, procurement officers, and engineering directors who need a rigorous, defensible process to justify standardisation investments and shape future capital improvements.

Engineering Consultants and Design Firms: Structural, mechanical, electrical, and hydraulic designers tasked with planning rehabilitation projects or new lock and weir constructions.

Equipment Manufacturers and Suppliers: Officers tasked with aligning product roadmaps with future national, regional or international interface standards.

Standards and Regulatory Bodies: Organizations responsible for maintaining national or regional codes, providing them with a template to coordinate requirements within or across borders.

8. Relevance

a. Relevance to Countries in Transition, etc.

Developing nations and countries in transition face acute financial and logistical challenges when procuring specialized, custom-engineered marine parts. By establishing a clear methodology for modularization and interface standardisation, the WG enables these countries to transition away from expensive, proprietary, sole-source designs. It empowers local industries to fabricate, install, and maintain standard components, boosting domestic capacity, reducing reliance on long overseas supply chains, and driving down lifecycle costs.

b. Climate Change and Adaptation

Climate change introduces severe hydrological volatility, resulting in more frequent, extreme flood and drought events that stress lock and weir systems. A standardised approach allows managing agencies to rapidly deploy resilient, sensor-enabled, and adaptable components (such as automated gates, variable-speed drives, and real-time structural health monitoring systems). Additionally, standardizing component interfaces reduces the carbon footprint associated with the custom casting, heavy machining, and long-distance transport of bespoke industrial machinery.

c. Working with Nature

In alignment with PIANC's Working with Nature philosophy, the process of standardizing lock and weir components will integrate ecological criteria directly into the decision-making matrix. For instance, the selection framework will prioritize standardizing modular fish-passage control gates, low-vibration and low-noise hydraulic designs, and component interfaces that support eco-friendly, bio-lubricated operating systems. This ensures that standardised infrastructure works in harmony with local riverine ecosystems rather than disrupting them.

d. UN Sustainable Development Goals

This WG directly supports several UN SDGs:

- SDG 6 (Clean Water and Sanitation): Supporting sustainable water management and eco-friendly mechanical operations in trans-boundary inland navigation.
- SDG 9 (Industry, Innovation, and Infrastructure): Facilitating resilient, high-performing, and inclusive trans-national transport infrastructure.
- SDG 12 (Responsible Consumption and Production): Minimizing waste through modular components, extended asset lifecycles, and circular procurement practices.
- SDG 13 (Climate Action): Promoting low-carbon logistics, adaptive water infrastructure, and sustainable heavy industrial processes.