Sustainable Management of the Navigability of Free Flow Rivers

Terms of Reference

(29 Nov. 2020)

1. Background

This WG concerns only free-flowing currents or rivers in their natural state, entirety or partially, in which the flow is not constrained by any hydraulic infrastructure. We shall refer to these as "natural rivers."
Most navigable natural rivers are "large rivers." They are alluvial rivers, with hard points (rock outcrops) in the low-flow and middle riverbed, with specific bottom morphologies. As opposed to regulated rivers, the evolutions of morphological variables (bottom slope, width, cross sections and plan view) of natural rivers makes it difficult to fix a navigation channel in a permanent alignment.
Therefore, there needs to be a change in paradigm and methodologies for navigation in natural rivers.
This WG is dedicated to the improvement of navigability natural rivers that are not intended to be regulated. The goal is finding ways to guaranty/improve navigability without conventional training structures, concrete, rock etc. inside the natural rivers.

More info about the motivations and background are given in the ANNEXE.

2. Objectives
The objectives are:

- to develop guidelines to improve and maintain the navigability in free-flowing current rivers, and to design, build and operate training river works.
- to assess the sustainability of river training works designed to improve the navigability and maintain an adequate navigation channel in large rivers subjected to morphological changes.
- to assess the sustainability of dynamic river management (monitoring and shifting of navigation aids to adapt the navigation channel to the river dynamics)
- to highlight the technical, operational, economic and environmental considerations for navigation in free-flowing current rivers compared to that in regulated rivers and canals.
- to improve the understanding of the physical processes of the flow in free-flowing current rivers, developed with or without river training works. That also includes understanding of the temporal and spatial morphological evolution of a fluvial hydrosystem and its reactions to natural effects and anthropogenic actions.

River training works typically include the following hydraulic river works: sills, bottom weirs, spur-dikes most of the time called groynes, longitudinal and transversal dikes, submerged panels, bank protection, pilot channel, deepening and bend cut-off.

WG recommendations be useful in evaluating the effectiveness of any hydraulic structures or river training works, and develop recommendations for a dynamic river considering:

- Hydrofluvial system
- Natural or large rivers
- Morphological evolution
- Navigability requirements in free flow current
- River training works
- Morphological dredging
- River survey technologies and maintenance

The benefit of this WG is to propose a new integrated methodology for "dynamic river management" and "working with nature" to analyze and improve the navigability in free flow rivers, while maintaining natural flows and ecosystem functions.

3. Earlier Reports and documentations

- Existing PIANC WG reports from InCom and EnviCom
- Given the multidisciplinary nature of the areas addressed, it is recommended to collect relevant information produced by several international associations such as:
  - IAHR - International Association for Hydro-Environment Engineering and Research
  - IAHS - International Association of Hydrological Sciences
  - ASCE - American Society of Civil Engineers
  - INBO - International Network of Basin Organization's
  - CEDA - Central Dredging Association
  - SedNet – European Sediment Network
  - USACE - U.S. Army Corps of Engineers
  - Others as identified
- Relevant books and papers

4. SCOPE

4.1 Matters to be investigated

The scope of the investigation is to:

- Improve the understanding of the current and forecast temporal and spatial morphological evolution of a river to support its sustainable management;
- Assess and formalize the technical, operational, socio-economic, and environmental considerations for navigation in free-flowing current rivers and regulated rivers;
- Inventory and review current training river works including sills, bottom weirs, groynes, dredging etc, as well as channel realignment. This shall include applicable codes and standards;
- Inventory and review existing tools, methodologies, investigations, and other research to assess morphological behavior of large rivers and to evaluate its dynamic response under the impacts of both natural and human impacts and the impact on navigation,
- Review and assess design tools including topo-bathymetry surveys, remote sensing (GIS), hydrography, hydrometry, physical and numerical modelling, trends analysis, marking, etc. to manage free-flowing current rivers, including morphological dredging methodology (smart dredging) and associated innovations (such as realignment of navigation channel).
  In many countries, mostly outside EU, the navigability problems in (large) natural rivers require:
  - a continuous knowledge of the river's situation,
  - tools to evaluate trends in the evolution of river morphology,
  - marking of the navigation channel,
  - stabilization of the banks,
  - dredging.
- Develop a better understanding of river morphology, which is a key element influencing the ecological values of the rivers. Today, numerical modeling is the preferred tool for studies but many users do not know enough about the limitations of numerical modeling of morphological and ecological effects.
- Review and assess monitoring methodologies that allow for dynamic response of the navigation channel

- In the area around many rivers, societal aspects such as poverty, population movement, economic situation, flood protection, and biodiversity have a major influence in the choice of the river training works.

4.2 Proposed Methodology

- Establish a detailed work program, further detailing the scope, tasks and responsibilities, approach, and deliverables
- Conduct desk research to collect, analyze, and consolidate the current available information concerning river training works and maintenance in large rivers
- Due to the multidisciplinary nature of the WG, it would be advisable to create privileged links with the IAHR and INBO communities, as well as other PIANC sister associations. Certain InCom members, already members of these communities, could act as liaison between these bodies and the WG. The WG can use IAHR works/publications to summarize and provide guidelines (support) for the understanding of non-highly specialized hydraulic engineers, as is the case of most of IW managers.
- Evaluation of the monitoring, mitigation, modeling systems and approaches used for operational engineering, financial and policy decision-making in actual free-flowing current rivers. This will include listing of metrological technologies, methods of equipment deployment and data analysis, methods of mitigation, desktop, physical and numerical models as well as analytical models, which are used to address navigability improvement (Dynamic river management)
- Development of a method of systematically mapping the hydromorphological effects of all training river works. This could concern both local effects and cumulative effects of the various measures that can move downstream and upstream
- Project reviews and cases studies to analyze the feasibility of existing practices and the possible innovations
- Presentations and workshops to share knowledge and spread awareness. The results of the WG may also be presented in various conferences.

The WG will avoid duplication of existing research performed by other scientific communities. Existing scientific literature may only need to be "rephrased" to provide it in a manner useful to IW managers and stakeholders.

5. Intended product

The intended product is a set of guidelines to improve navigability and develop navigation in free-flowing current rivers. It will deliver an understanding of the specificities of navigation in natural rivers.
The WG report will highlight the needs, requirements, and strategies to design a navigable channel in free-flowing current rivers.
Practical insight will be provided through the use of case-studies.
An essential part of the report will be development of a guiding analytical framework to be used as an outline for future management.

6. Recommended Members

The WG should ideally include managers of inland navigation systems in natural rivers, fluvial hydraulics and morphological engineers, waterways designers/development; river training works engineers, navigation and navigation aids experts, hydrographical experts, dredging operators, researches, and national and international environmental offices/authorities.
Members should represent areas with large rivers, including North and South America, Asia and South Asia, and Africa.
Support of international associations as ECLAC (South America) and the Mekong River Commission would be helpful.
The membership should include a good balance of members representing all stakeholders and from navigation companies, IW organizations, and members with an expertise in:

- navigation in free-flowing current rivers including hydrographic techniques and marking,
- fluvial hydraulics, sediment transport and morphodynamics,
- physical and numerical modelling including navigation simulations,
- dredging,
- environmental impacts.

This joint WG (INCOM and ENVICOM) will work in close collaboration in order to promote the "Working with Nature" concept.

7. Relevance for Countries in Transition

This report is intended to support the growth of inland navigation with reduced investment in river regulation and sustained protection of ecosystem functions of natural rivers.
The report will be of value in protecting the interests of developed countries and countries in transition. The report will be of particularly use to decision makers in the assessment of navigation improvement of free-flow rivers and also prepare technical terms of reference to aid in development and presentation of a tender.
This report will enable these countries to quantify the support of Inland Waterway use in the context of the development of their hydrofluvial systems.

8. Climate Change, Working with Nature, Sustainable Goal (SDG)

Climate change is increasingly leading to extreme conditions and may drastically affect navigability of rivers with natural flow discharge, due to stronger dry seasons. It is expected that an approach based on following the natural river dynamics will be more resilient than a rigid regulation approach.

The objective is to develop guidelines to improve and maintain the navigability of free-flowing current rivers and to design, build and operate navigation, in line with the "Working with Nature" concept. This should be included in river management methodology to improve navigation as measures to guarantee navigability in free-flow rivers

This WG is intended to support primarily the following "Sustainable Development Goals (UN's SDG)":

- Goal 8 "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all";
- Goal 9 ""Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation".

ANNEX: Additional details about the motivations and background of the proposal

Inland Waterway Transport (IWT) can be classified as utilizing three kinds of waterways: rivers, lakes and canals. For rivers, there are two possible situations: natural rivers (or free-flowing current) and rivers regulated by hydraulic infrastructure.

The scope of this WG concerns only free-flowing currents or rivers in their natural state, entirety or partially, in which the flow is not constrained by any hydraulic infrastructure. We shall refer to these as "natural rivers."

Natural rivers can naturally provide an adequate depth for navigation, especially in the downstream reaches of these rivers.

Most navigable natural rivers are "large rivers."[1] They are alluvial rivers, with hard points (rock outcrops) in the low-flow and middle riverbed, with specific bottom morphologies such as meandering, braided, multi-branched, anastomotic configurations. As opposed to regulated rivers, the temporal and spatial evolutions of the morphological variables (bottom slope, width, cross sections and plan view) makes it difficult to fix, in the long term, a navigation channel.

The hydrofluvial system of a river relates to the territory used by the river, consisting of the entire riverbed, its tributaries and wetlands forming an integrated part of its environment. Rivers flow through two natural elements, water and sediment, coupled by temporal and spatial physical and environmental relationships.

If a river is in a morphological equilibrium, any changes in one of the geometric variables (width, depth, bottom slope, etc.) due to natural events (e.g. climate changes) or anthropogenic actions (e.g. river training works) can result in more or less significant evolutions in the short, medium, and long term.

Many rivers around the world provide striking examples of such adaptations generated by both natural and human effects, for example, Congo and Kasai, Senegal, Niger (inner delta), Mississippi, Ichilo--Mamore, Mekong (upper delta), Brahmaputra, and others.

The majority of European navigable rivers are pseudo-free-flowing rivers because river training works have usually been established (Rhine, Danube, Volga, Meuse, etc.).

The river training works and maintenance usually consist of hydraulic structures and/or dredging works. The goal of river training works is to provide a desired channel dimension and alignment.

However, in many river configurations, it is not technically possible nor environmentally desirable to improve river training works. The only solution is to "help" the river maintain a navigable channel through specific actions such as morphological dredging.

Recurring problems of navigability are typically solved by maintenance dredging. The need for dredging is due to the appearance of bed deformations, sills and shoals due to the morphological configuration of the river. Dredging as a permanent measure is not sustainable and must be replaced by morphological dredging or "smart dredging" taking into account the evolutionary trends of the river. To achieve this, it is first necessary to understand the physical functioning of the river and not to act against it, but with it.

In the past, these hydrofluvial responses were not always well understood.

A solid understanding of the actual and forecast temporal and spatial morphologic evolutions are required to develop sustainable management of a river. Any project to maintain river navigation must start with a fluvio-morphological diagnosis explaining why and how geometrical variables have evolved in the past and will evolve in the future.

It is also necessary to differentiate the methodology to evaluate the impact of river training works, either for a significant part of the river (global model) or for small part of the river (local model). Physical models can only be made to local scale, primarily because of the expense of these models. Numerical models are more appropriate for the study larger parts of a river. In order to validate the results of modeling, the use of hybrid models by combining the two types of modelling is preferred. Field studies are also necessary no matter what model or combinations of models are used.

[1] A "large river" is based on its basic characteristics, the most objective and quantitative criteria: length, watershed area, median discharge (modulo), specific discharge and annual sediment load (UNESCO, IAHR).

Therefore, there needs to be a change in paradigm and methodologies and development of a set of methods (a "toolkit") such as physical and numerical modelling, field studies, specific measurements, data collection and improved interpretation of these methods based on experience.

Based on analysis of InCom WG reports it has been observed that no WG has investigated specific navigability aspects of the hydrofluvial system of (large) free-flow rivers.

In order to conduct such investigation, it is recommended that a WG dedicated to the improvement of navigability with river training works in free-flowing current rivers while ensuring the stability of the navigation channel be established.