

PIANC WG 155 – Ship behaviour in locks and lock approaches

Carsten Thorenz¹ and PIANC WG 155

(¹Federal Waterways Engineering and Research Institute <http://www.baw.de>)



What is PIANC?



“PIANC, the World Association for Waterborne Transport Infrastructure”

- Established in 1885 as ‘Permanent International Association of Navigation Congresses’
- Non-political and non-profit organisation
- Forum for professionals around the world
- Exchange on cost-effective, reliable and sustainable infrastructures
- Partner in the design, development and maintenance of ports, waterways and coastal areas.
- Members include national governments and public authorities, corporations and interested individuals.

What does PIANC do?



PIANC will

- contribute to the integrated management of navigable water systems
- identify and disseminate world best practice
- provide access to international data
- be the international forum for analysis and discussion of all aspects of waterborne transport
- promote a network of navigation, waterway and port professionals
- co-operate closely with other associations in the field of ports, waterways, coastal zone management and related subjects.

The association can create **commissions** and **working groups**.

PIANC Commissions



Technical Commissions:

- InCom – Inland Navigation Commission
- MarCom – Maritime Navigation Commission
- RecCom – Recreational Navigation Commission
- EnviCom – Environmental Commission

... plus some more administrative commissions:

International Co-operation, Young Professional, Finance, Promotion

PIANC Working Groups



- Work on basis of „Terms of Reference“
- Should consist of international experts on the given topics, each member country is entitled to appoint two representatives
- Members must commit themselves to:
 - attend the meetings or participate through correspondence
 - execute the actions that are assigned to them
 - report on the progress of the Working Group to their National Section
- Working Groups are expected to produce a report with results/conclusions/recommendations
- Working Group activities should be accomplished within 24 months



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PIANC InCom WG 155 „Ship Behaviour in Locks and Lock Approaches“



- Successor to WG 106 „Innovation in navigation lock design“ (Chairman: Philippe Rigo), which was focused on the construction
- Originally intended to focus on the interaction between lock operation and ship behaviour, then extended to ship behaviour in approaches
- Inaugurated in September 2011 in New Orleans during the SmartRivers Conference
- WG 155 currently has 14 senior and 4 young professional members from 9 countries (with varying levels of activity)



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Meetings of PIANC InCom WG 155 „Ship Behaviour in Locks and Lock Approaches“



- Inaugural meeting and three work meetings so far
- Work meetings take roughly three days
- Work meetings were planned to combine three half day work sessions with technical tours
- Meetings in Delft (Deltares), Lyon (CNR) and Panama (ACP, IMPA)



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Group 155 in front of the hydraulic lab of CNR during the second meeting



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Last working group meeting in Panama City



WG 155 with hosts and guests at the old Panama Canal locks



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Goals of PIANC WG 155 „Ship Behaviour in Locks and Lock Approaches“



- Point out relevant physics of the interaction between lock and vessel (focusing on what is special for locks)
- Gather data from scientific studies and user experience
- Produce a comprehensible report
- Enhance interaction between experts working in the field



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Goals of PIANC WG 155 „Ship Behaviour in Locks and Lock Approaches“

Give designers of locks and organizations that operate locks an idea about the troubles they might encounter and what to do against it. It should be made clear which factors are important for safe locking. To do so, the following points should be evaluated:

- What are the relevant physical processes?
- How to evaluate the forces on the vessel?
- What is the vessels reaction?
- What does the captain/pilot think on this?
- What to do prevent misery?



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Overview on identified topics

- Sink and surge waves in approaches
- Local flow fields from lock discharge
- Density driven flows when opening the gate
- Piston effects when entering or leaving the lock
- Impact of the filling process on the vessel
- ...



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Relevant Effects: Limitation of scope



- Focus on the effects which are typical for lock operations (i.e. banking effects are nothing special for locks)
- Report will be structured based on a „timeline of events“ as observed by passing vessels (Lagrangian approach 😊)



Relevant Effects: Discharge from lock emptying

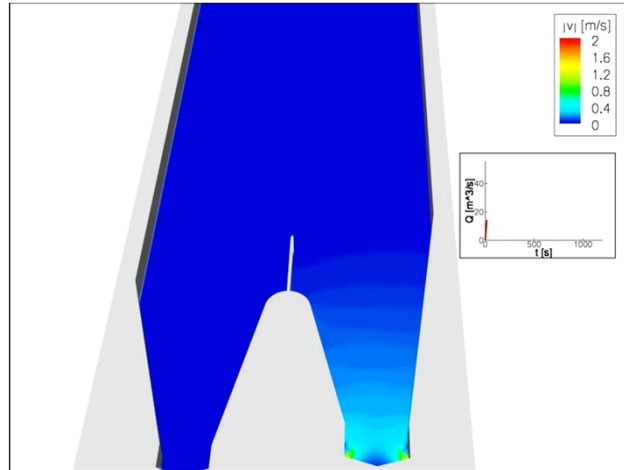


- Generates local flow fields
⇒ Bad for manoeuvring when entering a lock
- Generates long waves in adjacent reaches
⇒ Forces on moored ships
⇒ Dangerous because of hitting bridges or grounding

For the lock **filling**, the local effects are much less pronounced (potential flow); large scale effects are comparable



Discharge from lock emptying: Local influence



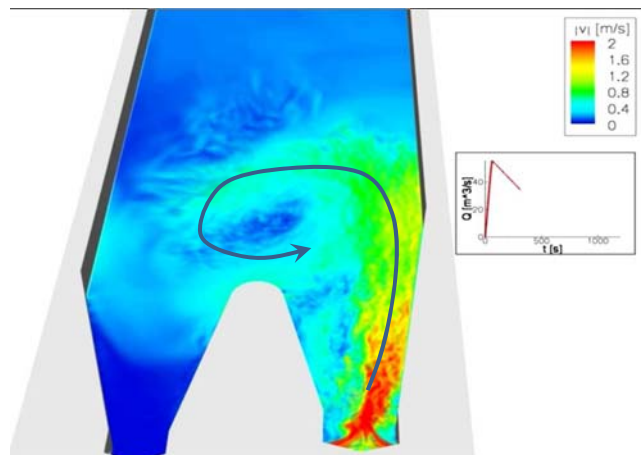
Computed flow field for the double lock Kostheim (River Main)



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Relevant Effects: Discharge from lock emptying



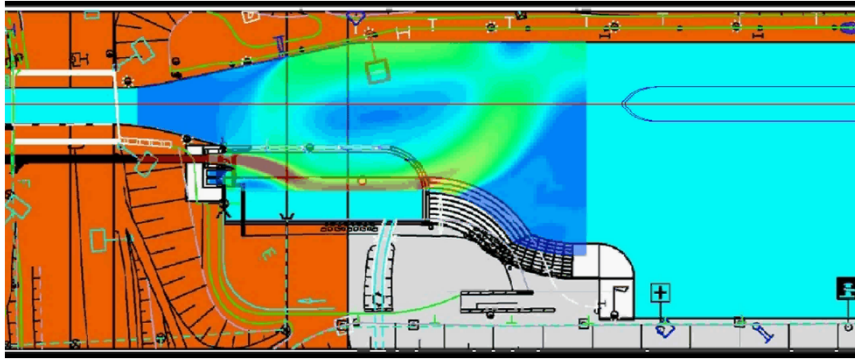
Flow field locally disturbed by discharge



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Relevant Effects: Impact on navigation



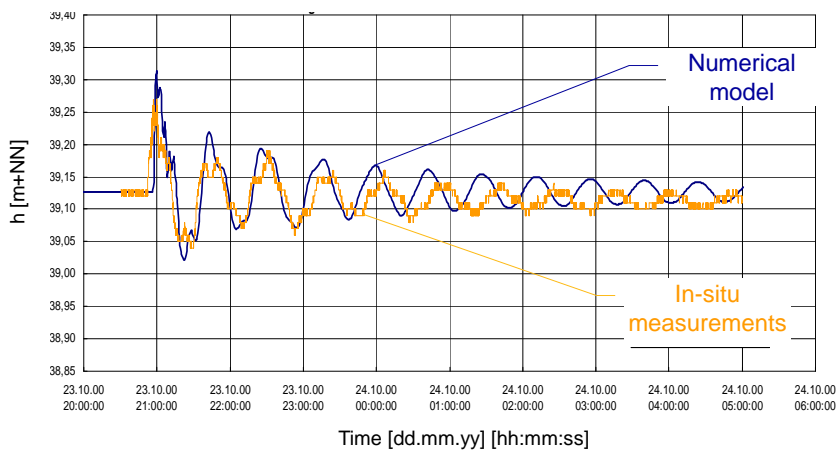
Local currents can make it impossible to enter a lock (here: Manoeuvring simulation, *Dettmann 2005*)



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Discharge from lock emptying: Large scale influence



Computed and measured water table downstream the lock Rothensee



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Relevant Effects: Density driven flows



- Occur in locks of the coastal regions
- Difficult for manoeuvring because „what you see is not always what you feel“
- Can be mitigated by technical devices (bubble screens, flushing, pumping), but this is expensive



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Relevant Effects: Density driven flows



Observed salt exchange in IJmuiden



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Relevant Effects: Density driven flows



Observed salt exchange in IJmuiden



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Relevant Effects: Density driven flows



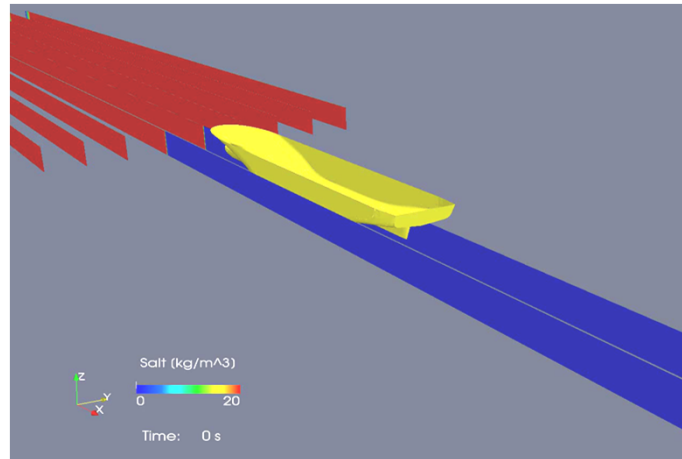
Observed salt exchange in IJmuiden



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Relevant Effects: Density driven flows



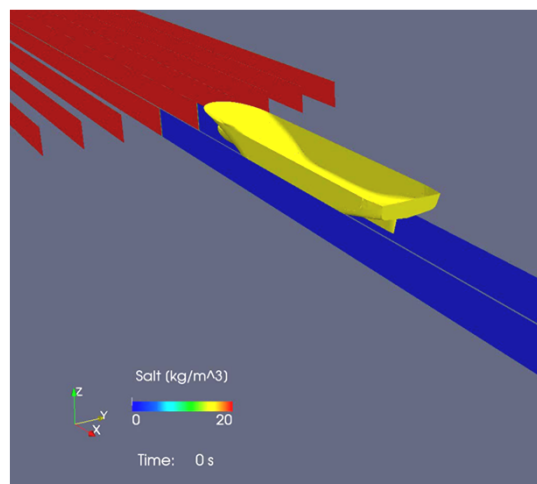
Computed salt intrusion in sea lock (instantaneous gate opening)



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Relevant Effects: Density driven flows



Computed salt intrusion in a sea lock (instantaneous gate opening)



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Relevant Effects: Density driven flows



Gallery of valves along the chamber in Volkerak (ecological reasons)



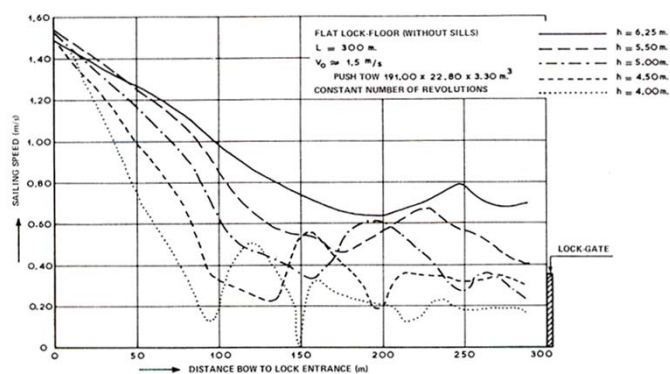
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Relevant Effects: Piston effects



- When entering, vessels observe sudden strong deceleration
- When exiting, the vessel is in danger to hit the sill



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Relevant Effects: Impact of valve operation on forces on the vessel



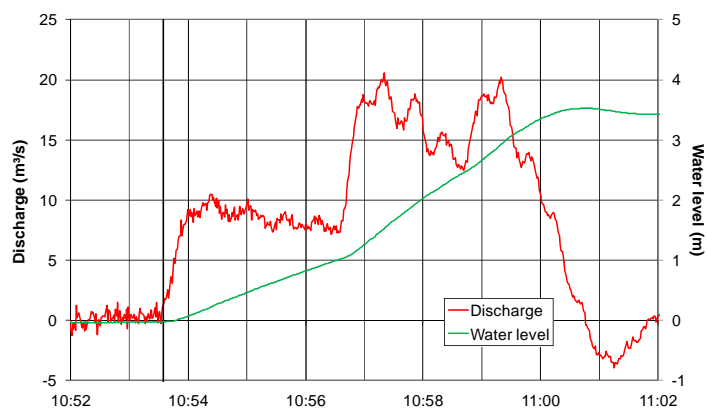
- The operation of the lock valves rules the balance between smoothness and speed
- Allowable speed strongly depends on chosen filling system
- Speed changes should be carefully evaluated



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Relevant Effects: Impact of valve operation on forces on the vessel



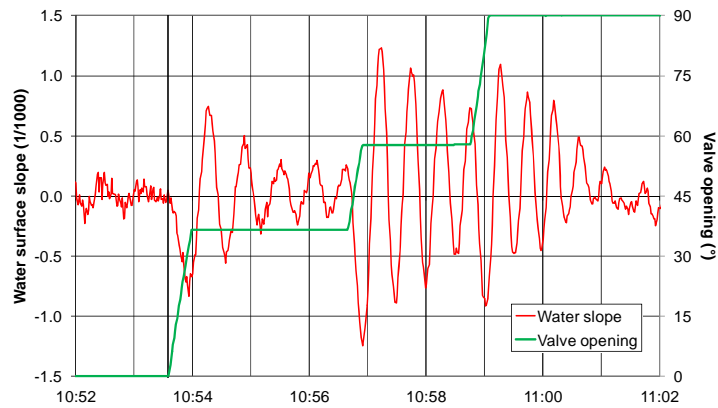
Lock Roselies, River Sambre, Belgium: Impact of a discontinuous valve opening schedule on the water surface (from PIANC 155 report draft)



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Relevant Effects: Impact of filling systems on forces on the vessel



- Ideal filling-emptying system spreads flow equally over the whole length of the chamber
- Real filling-emptying systems are more or less imbalanced
- More complex filling systems enable faster lock operation, but are more expensive to build and more expensive to operate



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Relevant Effects: Impact of filling systems on forces on the vessel



Most simple:
Filling through the gate



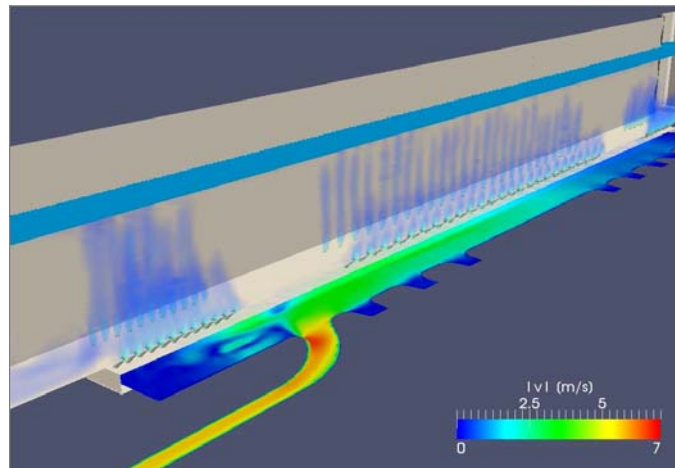
More complex:
Filling through the bottom



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Relevant Effects: Impact of filling systems on forces



Numerical results for a partially balanced „through the sill“ system



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Ship forces, hawser forces and mooring forces



Definition:

- Ship forces are hydrodynamic (aerodynamic, external) forces acting on the vessel
- Hawser forces are the forces in the mooring lines
- Mooring forces are the forces exerted on the mooring equipment (bollards, ...)



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Methods to evaluate „mooring forces“ for vessels in the lock chamber



- Evaluate water slopes and estimate ship forces, hawser force and mooring forces from them or
- Measure forces on the hull and compute hawser force and mooring forces from them or
- Measure forces in the hawsers or bollards directly
 - Sounds best, but introduces many uncertainties:
Hawser types, pretension, orientation, handling
 - Hard to reproduce
⇒ not feasible



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Future report structure: „Scientific“ variant



Based on a chain of consequences:

- ways to compute / estimate forces on the vessel
- reactions of the vessel
- handling of vessel, mooring, etc. by the crew
- evaluation of safety levels based on vessel behaviour and equipment
- definition of guidelines (if possible)



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Future report structure: Point of view of the user



Based on a timeline of events for the vessel that transits through a lock (Lagrangian approach ☺):

- leaving normal navigation
- waiting in front of the entrance
- entering the lock
- the locking process
- leaving the lock
- returning to normal navigation

It should give basic information for operators and designers, which are no experts on the topic



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Chosen approach for the report



- Report structure based on a „timeline of events“ as observed by passing vessels (Lagrangian approach ☺)
- It should give basic information for operators and designers, which are no experts on the topic
- Focus mainly on the effects which are typical for lock operations (i.e. ship-ship interaction is nothing special for ships leaving locks)



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SmartRivers Conference in Maastricht and Liege



- PIANC WG 155 organizes a workshop on September 24th
- Attached to SmartRivers Conference 2013
- Covers main points of the report and further lock related topics

Join the discussions in Maastricht and Liege!



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Summary and conclusions



- Many aspects govern the interaction between vessel and lock
- WG 155 tries to pick out the most relevant ones and put them in a report
- Join a PIANC WG if you want to meet interesting people in interesting places
- Did I mention Maastricht/Liege in September?