PIANC Workshop
13-14th September 2011

Maneuverability in Lock Access Channels

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BELGIUM

PIANC
Setting the course

Maneuverability in lock access channels

- Introduction
- Hydrodynamics of lock access
- Practice of lock approach
- Research tools
- Conclusions

Introduction

- **Sea-going ⇔ inland vessels**
- **Important to be aware of all phenomena that affect the behavior of a ship during lock approach**

Hydrodynamics of lock access

- **Effect of lock approach configurations**
- Currents during lock approach
- Lock chamber entry
- Lock chamber exit
- Other effects

Hydrodynamics of lock access

- Effect of lock approach configurations
  - ➢Geometry of approach channel / structures

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Hydrodynamics of lock access

- Effect of lock approach configurations
  - ➢Geometry of approach channel: asymmetry

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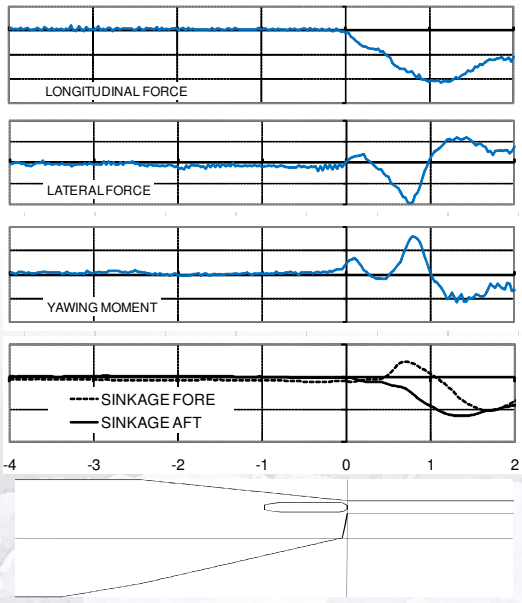
Hydrodynamics of lock access

- **Effect of lock approach configurations**
  - ➢**Geometry of approach channel: asymmetry**



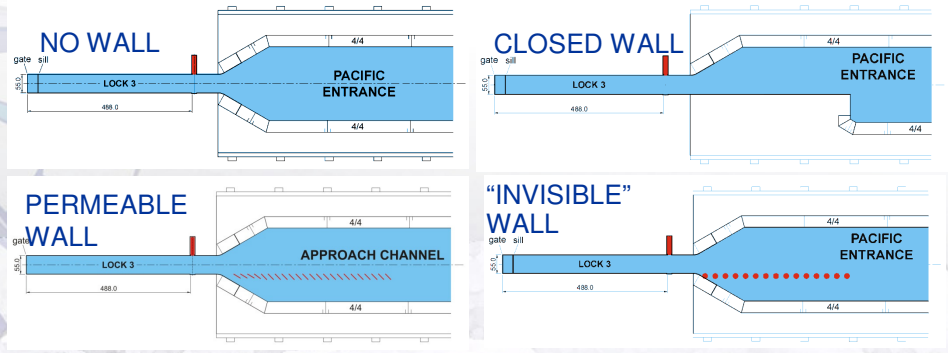
Source: Flanders Hydraulics Research

Hydrodynamics of lock access

- Effect of lock approach configurations
  - ➢Geometry of approach structures

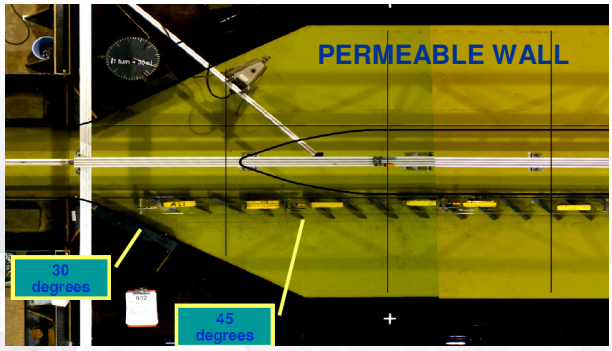
Hydrodynamics of lock access

- Effect of lock approach configurations
  - ➢Geometry of approach structures



Hydrodynamics of lock access

- Effect of lock approach configurations
  - ➢Geometry of approach structures



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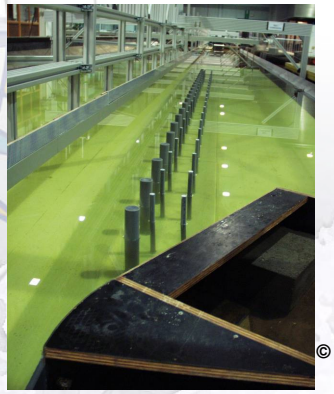
Hydrodynamics of lock access

- Effect of lock approach configurations
  - ➢Geometry of approach structures



INVISIBLE WALL

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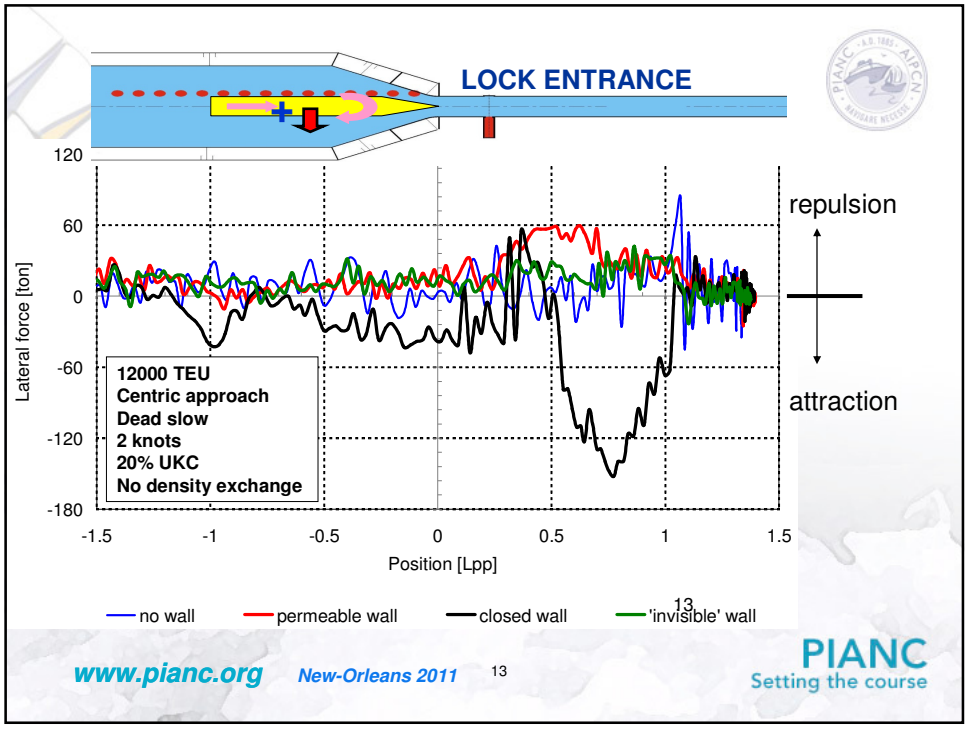
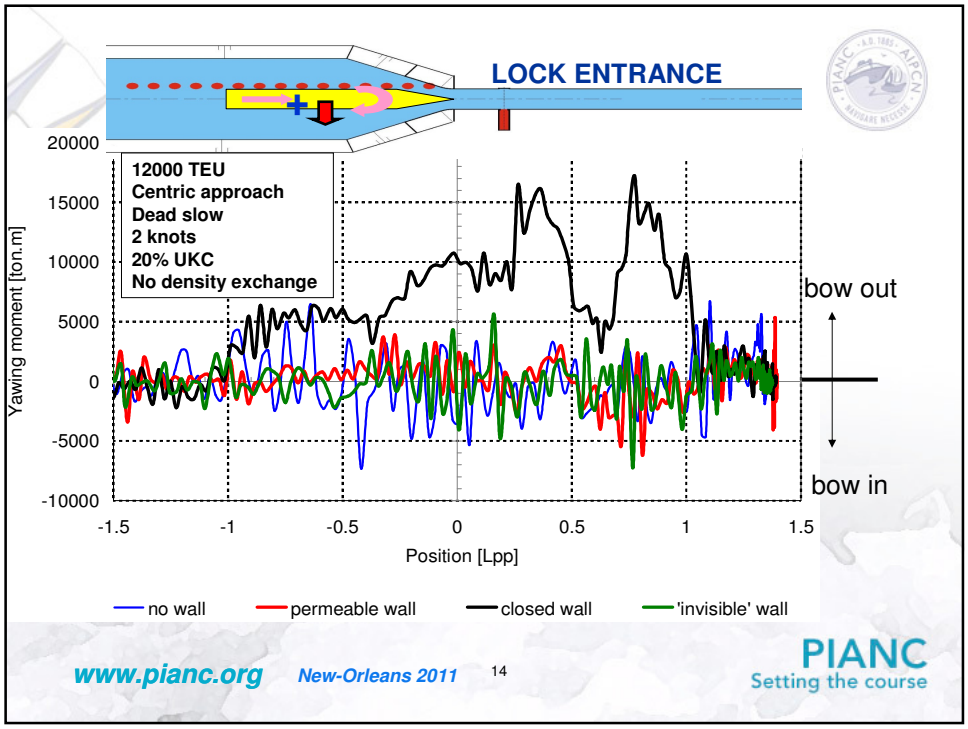

LOCK ENTRANCE
120
60
0
-60
-120
-180
Lateral force [ton]
-1.5
-1
-0.5
0
0.5
1
1.5
Position [Lpp]
12000 TEU
Centric approach
Dead slow
2 knots
20% UKC
No density exchange
repulsion
attraction
no wall
permeable wall
closed wall
'invisible' wall

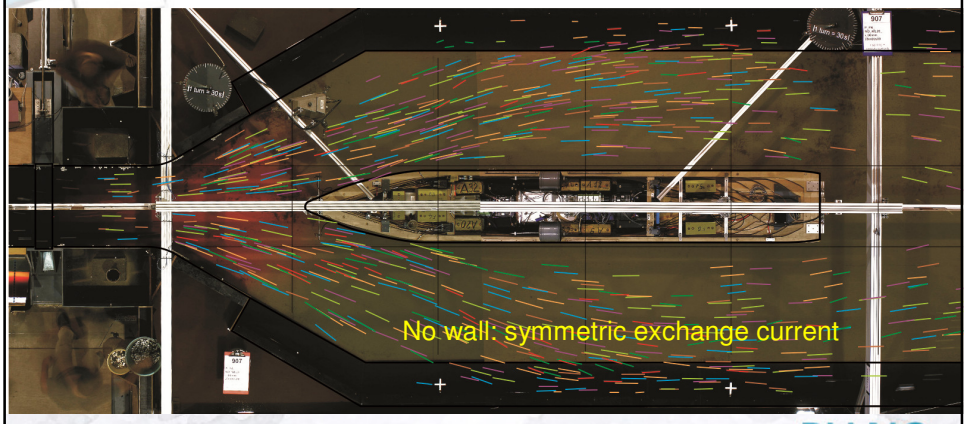

LOCK ENTRANCE
20000
15000
10000
5000
0
-5000
-10000
Yawing moment [ton.m]
-1.5
-1
-0.5
0
0.5
1
1.5
Position [Lpp]
12000 TEU
Centric approach
Dead slow
2 knots
20% UKC
No density exchange
bow out
bow in
no wall
permeable wall
closed wall
'invisible' wall

Hydrodynamics of lock access

- Effect of lock approach configurations
- **Currents during lock approach**
  - Tidal currents, river, …
  - Density currents
- Lock chamber entry
- Lock chamber exit
- Other effects

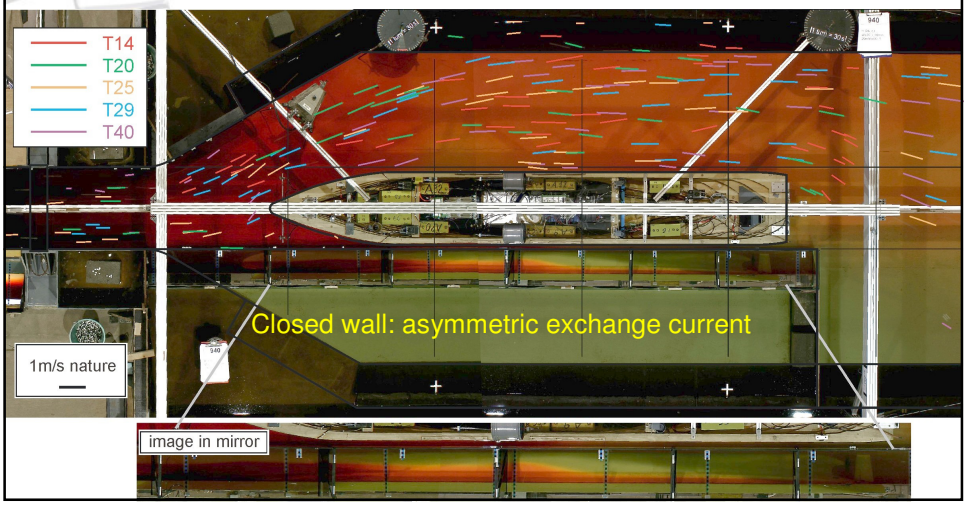
Hydrodynamics of lock access

- **Currents during lock approach**



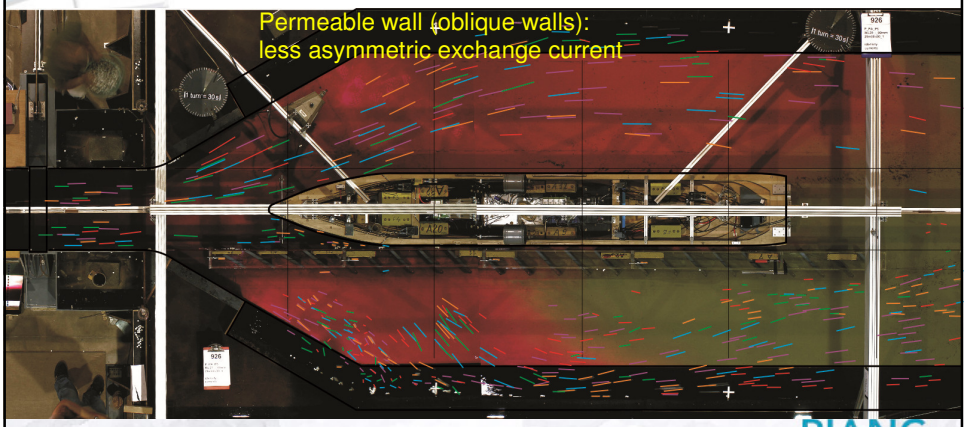
Hydrodynamics of lock access

- Currents during lock approach



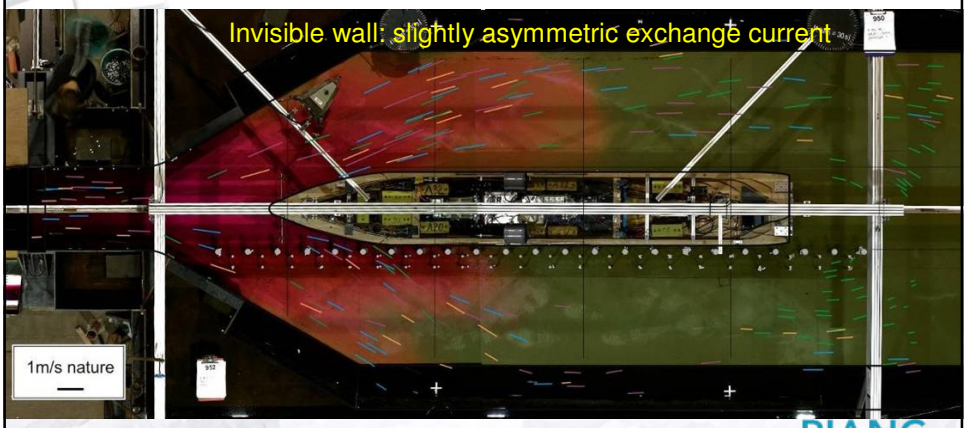
Hydrodynamics of lock access

- Currents during lock approach



Hydrodynamics of lock access

- **Currents during lock approach**

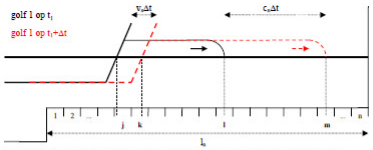


Hydrodynamics of lock access

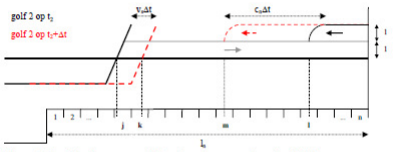
- Effect of lock approach configurations
- Currents during lock approach
- **Lock chamber entry**
- Lock chamber exit
- Other effects

Hydrodynamics of lock access

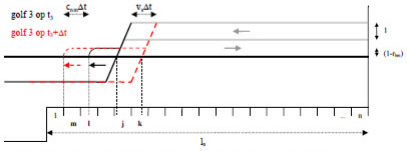
- Lock chamber entry
  - ➢Translation waves
  - ➢Return flow
  - ➢Cushion effects
  - ➢Retardation forces (memory effects)



Figuur 2.3: Verloop van golf 1 op twee opeenvolgende tijdstippen.

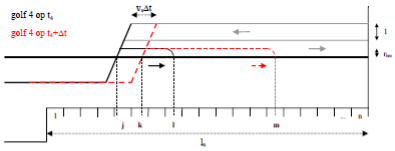


Figuur 2.4: Verloop van golf 2 op twee opeenvolgende tijdstippen.

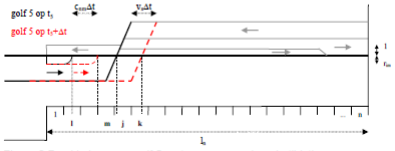


Figuur 2.5: Verloop van golf 3 op twee opeenvolgende tijdstippen.

➢Translation waves



Figuur 2.6: Verloop van golf 4 op twee opeenvolgende tijdstippen.



Figuur 2.7: Verloop van golf 5 op twee opeenvolgende tijdstippen.

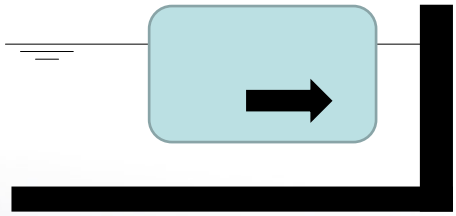
Hydrodynamics of lock access

- Lock chamber entry
  - ➢Return flow
    - ➢Increased resistance
    - ➢Flow on rudder(s) and propeller(s) affected
    - ➢Vertical motions

Hydrodynamics of lock access

- Lock chamber entry
  - ➢Return flow
    - ➢Increased resistance
    - ➢Flow on rudder(s) and propeller(s) affected
    - ➢Vertical motions

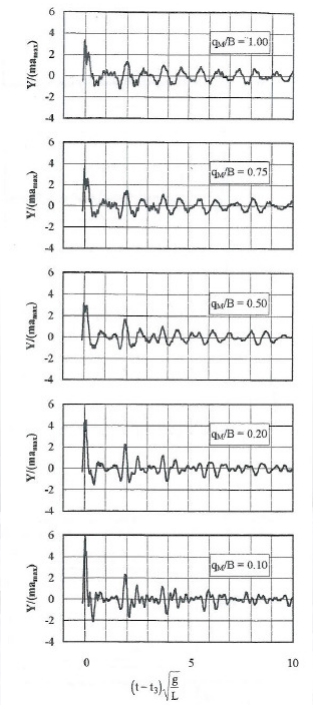
Hydrodynamics of lock access



- **Lock chamber entry**
  - Translation waves
  - Return flow
  - **Cushion effects**
  - Retardation forces (memory effects)

Hydrodynamics of lock access

- **Lock chamber entry**
  - Translation waves
  - Return flow
  - Cushion effects
  - **Retardation forces (memory effects)**
    - High accelerations / decelerations
    - Wave effect
    - Depends on boundaries of waterway, water depth, …
    - Non-stationary effect

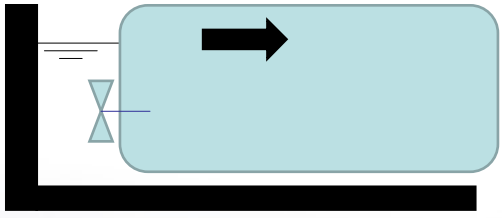


Sudden lateral deceleration of a ship near a vertical wall

Source: Vantorre & Laforce (1998), MAN98, Val de Reuil.

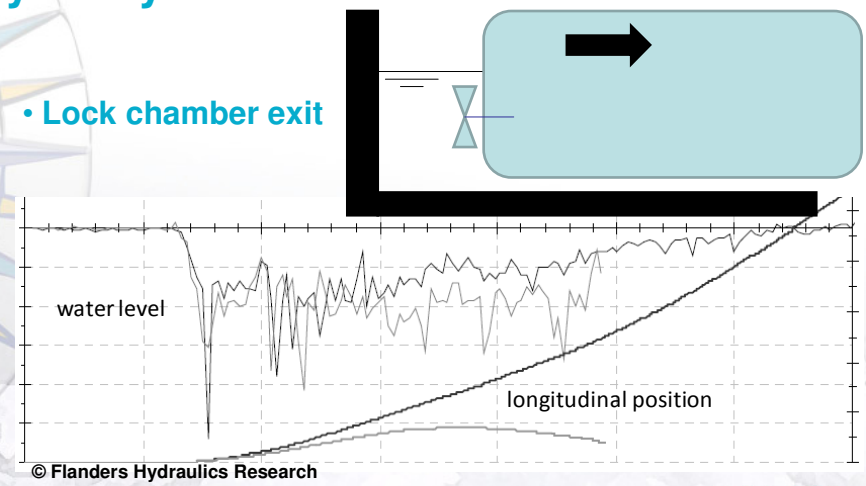
Hydrodynamics of lock access

- Lock chamber exit



Hydrodynamics of lock access

- **Lock chamber exit**



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Hydrodynamics of lock access

- Effect of lock approach configurations
- Currents during lock approach
- Lock chamber entry
- Lock chamber exit
- **Other effects:**
  - Wind
  - Contact forces (e.g. with fenders)

Practice of lock approach

- **Panama: present locks**
- Terneuzen: West Lock
- Antwerp: Berendrecht Lock

Practice of lock approach

- **Panama: present locks**

Practice of lock approach

- Panama: present locks

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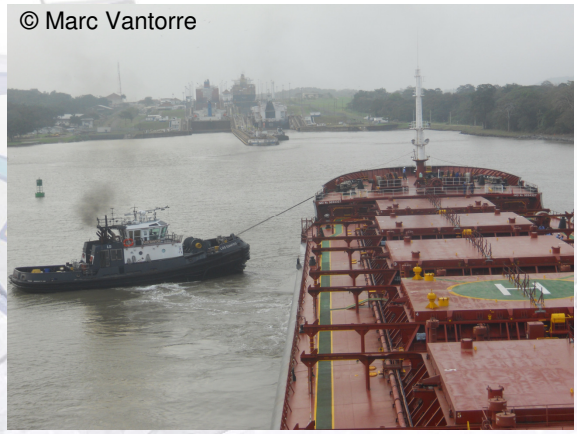

Practice of lock approach

- Panama: present locks

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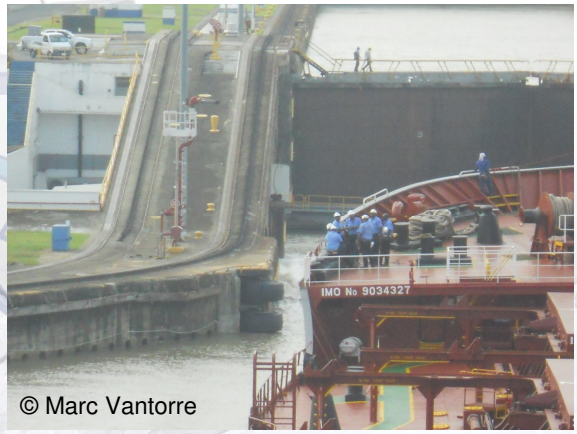
Practice of lock approach

- Panama: present locks



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Practice of lock approach

- Panama: present locks

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Practice of lock approach

- **Panama: present locks**

Practice of lock approach

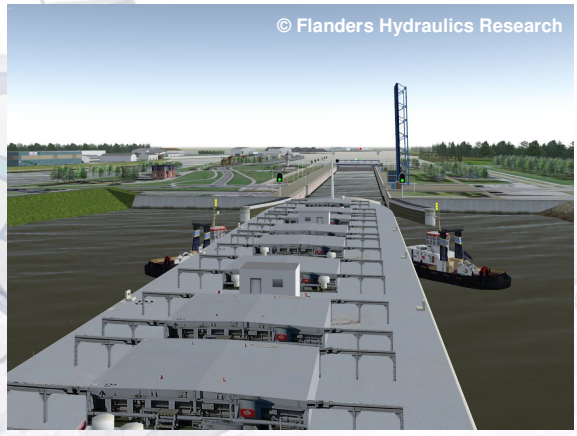
- Panama: present locks
- **Terneuzen: West Lock**
- Antwerp: Berendrecht Lock

Practice of lock approach

- Terneuzen West Lock

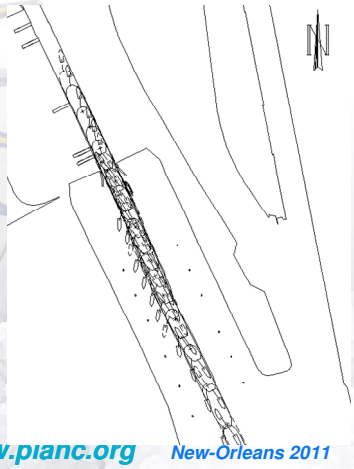
Practice of lock approach

- Terneuzen West Lock



Practice of lock approach

- **Terneuzen West Lock**



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Practice of lock approach

- Panama: present locks
- Terneuzen: West Lock
- **Antwerp: Berendrecht Lock**

Practice of lock approach

- Antwerp: Berendrecht Lock

Practice of lock approach

- Antwerp: Berendrecht Lock

Practice of lock approach

- Antwerp: Berendrecht Lock

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Practice of lock approach

- Antwerp: Berendrecht Lock

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Practice of lock approach

- Antwerp: Berendrecht Lock

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Practice of lock approach

- Antwerp: Berendrecht Lock

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SNMS:

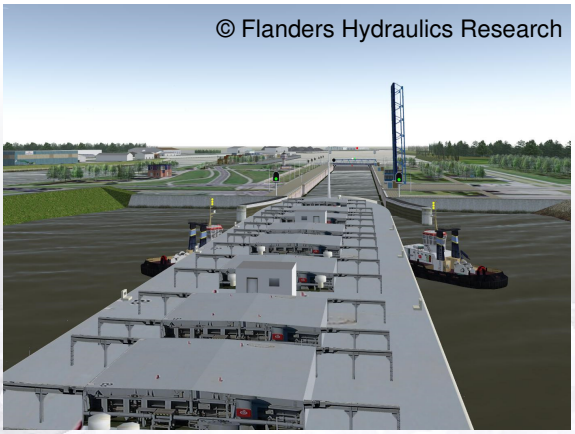
Scheldt
Navigator
for
Marginal
Ships

Research tools

- Maneuvering simulation
- Model tests
- Full scale measurements

Research tools

- **Maneuvering simulation**

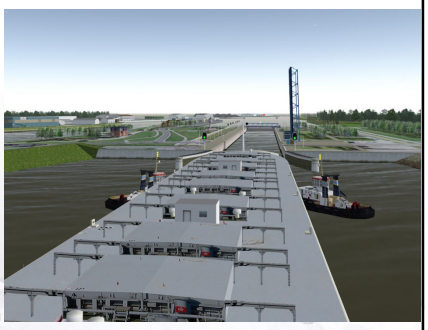


Research tools

- **Maneuvering simulation**
  - Realism
  - Reliability

Research tools

- Maneuvering simulation



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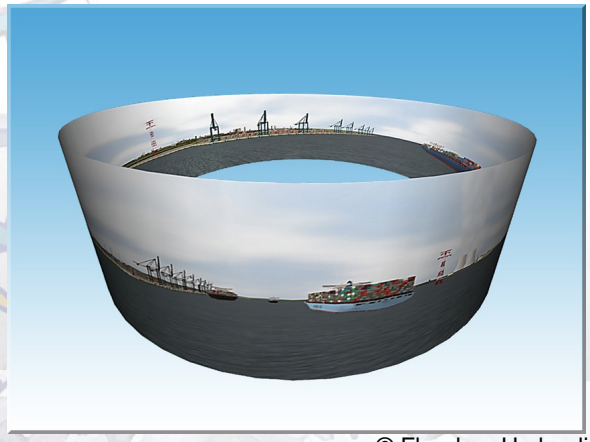
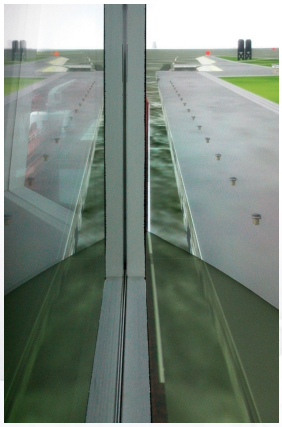
Research tools





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Research tools

- **Maneuvering simulation**

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Research tools

- **Maneuvering simulation**
  - Visuals
  - Bridge mock-up
  - Mathematical model:
    - Include all relevant effects
    - May require introduction of non-stationary effects (memory effects, return flow, translation waves, …)

Research tools

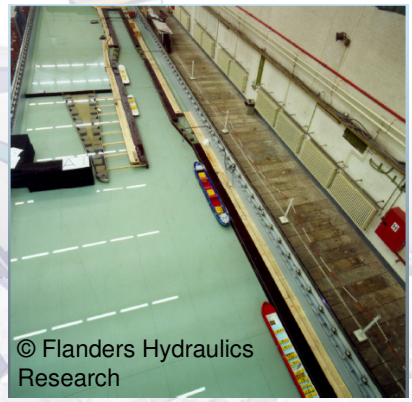
- **Maneuvering simulation**
  - Visuals
  - Bridge mock-up
  - Mathematical model
  - Human control: pilot(s), tug masters, wheelmen

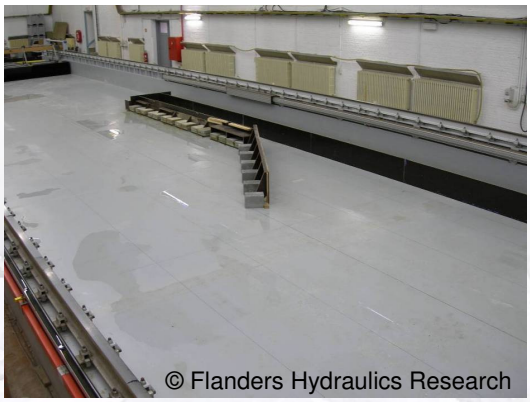
Research tools

- **Model tests**
  - Captive


Research tools

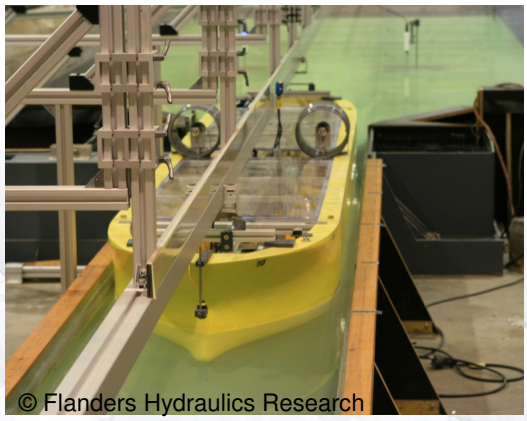
- **Model tests**





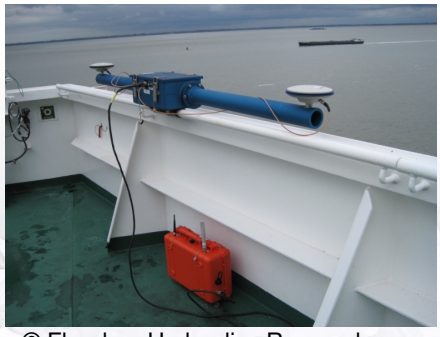
Research tools

- **Model tests**
  - Captive
  - Self-propelled



Research tools

- Maneuvering simulation
- Model tests
- **Full-scale measurements**
  - Horizontal
  - Vertical



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Conclusions

- Safe and efficient use of locks requires approach strategy depending on:
  - Ship characteristics,
  - Lock approach and lock chamber geometry
  - Tug assistance
  - Aids to navigation
  - Environmental conditions
- Maneuvering simulation offers useful tool for
  - Optimising lock design
  - Assessing accessibility of existing lock for new traffic
  - Training

Conclusions

- Maneuvering simulation offers useful tool, BUT:
  All phenomena affecting/dominating ship behavior of a ship entering a lock should be represented in a realistic and reliable way in the mathematical simulator model

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