The social and environmental contributions of the increasing of gauge and capacity of Ampsin-Neuville lock site on the Meuse River

Stéphane BARLET
Waterways of Liège

Michaël BONIVERS
Engineering Office Greisch
Historical

Hydroelectric power plant

Dam

55 x 7.5 m lock

136 x 16 m lock

Ampsine-Neuville lock site
Navigable network

- London
- Dunkerque
- Zeebrugge
- Antwerpen
- Rotterdam
- Port de Liège

Durations:
- 24h
- 14h
- 48h
Main objectives

- **Modernization** - In service since 1958 - **Reliability**

- **Transfer road → waterways**

- **Reduced waiting**

- **Link between Meuse to**
  - Antwerpen (9000 T)
  - Rotterdam (4500 T)
Main objectives

1 x Va

4 x Va

or

2 x Vb

75 x

300 x
Feasibility study

Dismantling  5th opening of the dam  →  Spillway
Left bank enlargement  →  High social impact
Feasibility study

1st lock 12.5 x 225m + 2nd lock 25 x 225m → Low hydraulic impact
Right bank enlargement → Low social impact
Feasibility study – Multiple criteria decision analysis

Weighting – Main criteria

Environmental aspects ≈ 44%
Replacement of the 55x7.5m and 136x16m locks

Ampsin-Neuville lock site
With 225x12.5m lock and 225x25m lock
Nautical and hydraulic studies

Nautical study – IMDC - DST

Ampsin-Neuville lock site
Footbridge – Replacement and extension over the road
Fish pass – Artificial river - Landscaping
Fish pass – Spawning ground
Fishes passes

Ampsion-Neuville lock site

Eels pass
Environment downstream – Left bank

Ampsin-Neuville lock site
Environment downstream – Left bank – Spawning area

Diagram showing the environment downstream and the spawning area with specific details such as soil composition and bird nesting areas.
Environment downstream – Left bank – Spawning area
Typology – 225x12.5m lock – Class Vb

- Chamber sizes 225m x 12.5m; lift 4.7 m
- Filling and emptying systems: Sluices in the gates - 10 min
- Simple gate
- Floating mooring bollard on right bank
Typology – 225x25m lock – Class Vlb

- Chamber sizes 225m x 25m ; lift 4.7 m
- Filling and emptying systems: Through the heads
- 4 butterfly valves : DN 4000
- Upper flat gate
- Lower mitre gate
- Floating mooring bollard
Control unit – Electric unit
Phasing stages – Moving of the national road

Current National Road

Future National Road

Ampsain-Neuville lock site
Phasing

Currently

Navigation by 136 x 16m lock
Phasing stages – 225x12.5m lock – Low flow – Cofferdams
Phasing – Medium lock - Access - Bridge - Cofferdams

2018 → end 2021 – Construction of 225 x 12.5 lock
Phasing stages – 225x12.5m lock – Upstream cofferdam in the channel
Phasing stages – 225x12.5m lock – Coffer dam in the river

Summer 2020 – Construction of 225 x 12.5 lock
Phasing

2018 → end 2021 – Construction of 225 x 12.5 lock

Navigation by 136 x 16m lock
Phasing stages – 225x25m lock

End 2021 → End 2023 – Construction of 225 x 25 lock
Phasing

End 2021 → end 2023 – Construction 225 x 25m lock

Navigation by 225 x 12.5m lock
Phasing

2023 → Navigation by 225 x 25m lock
Planning - General

2014
TENDERING PROCESS FOR DESIGN

2015
PRELIMINARY DRAFT

2016
BUILDING DESIGN

BUILDING PERMIT
AWARDING BUILDING PERMIT 7/2016

2017
TENDERING PROCESS FOR WORKS

2018-2024
WORKS
Owner: SOFICO
Management: Wallonie service public SPW

Civil engineering studies
Electromechanical studies
Environmental impact assessment
Socio-economic study

Technical inspection and advisory services

Civil engineering works contractor: FRANKI
Electromechanical works contractor: DUCHENE

Studies Call 2013-2017 + works call 2017-2023

Co-financed by the Connecting Europe Facility of the European Union

European Investment Bank
Carbon footprint

**CO₂ emissions**
- 95% during the works
- 5% during the 75 years of operation

River transport **avoided CO₂ emissions** - 315 000 tons

**Production CO₂ avoided** 150 000 tons

Carbon footprint is positive
A FRAMEWORK FOR EARLY CONTRACTOR INVOLVEMENT IN INFRASTRUCTURE PROJECTS

Smart Rivers Conference
September 30 – October 3, 2019
Lyon, France
Cité Internationale / Centre de Congrès
What is Early Contractor Involvement?

• “Any strategy initiated by infrastructure owners towards contractors, key supply chain members and stakeholders with the purpose of optimizing values in project delivery and objectives through their participation and knowledge sharing in stages of project planning and design prior to execution contract award.”
Types of ECI approaches

Formal vs informal agreement / Single vs multiple contractors
Challenges & benefits when applying ECI

Benefits for Clients & Contractors

Main Direct Benefits
- Costs and schedules are better defined early on
- Construction methodology is better defined early on
- Construction risk is better identified and risk better allocated early on

Other Direct Benefits
- Improved design quality with increased constructability & innovative techniques
- Greater trust and understanding between client & contractor
- Increased value for money

Indirect Benefits
- Sustainability concepts included in design, construction & environmental approvals
- More reliable & accurate business cases
- Relational contracting
Challenges & benefits when applying ECI

Challenges for Clients & Contractors

**Cultural**
- Accepted practise to choose the contractor & fix price on basis of lowest price via competitive tender
- Accepted practise not pay contractors for early efforts and the contractors to divulge as little as possible
- Accepted practise to opt for a ‘control’ approach leaving little to no room for creative activities

**Client Capture**
- Procurement rules (public owners) and/or corporate governance (private owners)
- Unclear / misaligned liability concerns
- Assess the price reasonableness without the comfort of competition

**Commitment**
- Organizational commitment: transparency, investing in different skills
- Financial commitment: costs of early collaboration phase
- Offloading of all design risks down the contractual chain

**Procurement rules (public owners) and/or corporate governance (private owners)**

**Unclear / misaligned liability concerns**

**Assess the price reasonableness without the comfort of competition**

**Organizational commitment: transparency, investing in different skills**

**Financial commitment: costs of early collaboration phase**

**Offloading of all design risks down the contractual chain**
When is ECI appropriate?

Partnerships are costly, justified only when yielding substantially better results

<table>
<thead>
<tr>
<th>Type of Contract</th>
<th>Complex Contracts with Concessions (Contractual PPP)</th>
<th>Complex contracts without Concessions</th>
<th>Institutionalised PPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which procedures are ok?</td>
<td>“Negotiated procedure”</td>
<td>“Competitive dialogue”</td>
<td>“Negotiated procedure”</td>
</tr>
<tr>
<td>Is ECI possible?</td>
<td>Limited to negotiation stage</td>
<td>Yes</td>
<td>Limited to negotiation stage</td>
</tr>
</tbody>
</table>

- Complexity / uniqueness of the project
- Focus on innovative methods
- Competitors with right capabilities & attitude
- Cultural context
Review of selected ECI cases

A2 Maastricht, NL

Melbourne Port, AU

Odense Port, DK

Four Seasons, Nevis

Onagawa Fish Market, JP

PIANC MARCOM Workgroup 194
ECI Workgroup: Way forward

Complexity & assessments: modelling techniques

• **Guidelines & framework**: Code of Conduct, type of cooperation agreement, project governance, feasibility testing, defining scope,…

• **ECI community & network**: connecting ECI professionals and interested parties

• The PIANC WG consists of representatives of all relevant ECI parties:
  - **Client**: Rijkswaterstaat (NL), North Sea Port (BE-NL), Port of Odense (DK), Transnet (RSA), Ministry of Transport (Japan)
  - **Contractor**: IADC (Internat.), Besix (BE), Jan De Nul (BE)
  - **Consultant**: domain of arbitration (Barber J Consulting), design (Moffat & Nichol, HR Wallingford), contracts management (MQM Legal), risk management (Vuentica), engineering (GBA - Gahagan & Bryant, Kinlan Consulting, Garcia-Vizcaino), academics (King’s College)
PIANC MARCOM Workgroup 194

Email: kenneth.willems@vuentica.com
or info@pianc.org
Linkedin Group: www.linkedin.com/groups/12124474/
CONTRAT DE PARTENARIAT POUR LE REMPLACEMENT DE 29 BARRAGES SUR L’AISNE ET LA MEUSE. MISE EN ŒUVRE DE 4 CENTRALES HYDROÉLECTRIQUE

Authors : L. CHAPITAL – T.CHRETIEN VNF
T. ALEX – A. LOUVET BAMEO
Contrat de Partenariat pour le remplacement de 29 barrages sur l’Aisne et la Meuse. Mise en œuvre de 4 centrales hydroélectriques

Partnership Contract for the replacement of 29 manually operated dams on the river Aisne and on the river Meuse

SMART RIVERS 2019
→ Remplacer les barrages manuels par des barrages automatisés pour fiabiliser le niveau de service et améliorer les conditions de travail.

→ L’occasion de développer la production hydroélectrique.

→ Un seul projet pour répondre à des enjeux de **massification, standardisation** et **optimisation** de la gestion du bassin versant:

- 2 bassins : l’Aisne et la Meuse
- 31 barrages: 29 barrages manuels + 2 déjà reconstruits par VNF
Le Contrat de Partenariat: un partage de responsabilités

The Partnership Contract: a shared responsibility

→ Un contrat global: le titulaire doit

CONCEVOIR FINANCER CONSTRUIRE EXPLOITER ET MAINTENIR

→ VNF exprime ses besoins, les critères et les niveaux de performance à atteindre / VNF reste garant de la navigation et gère les autres ouvrages du cours d’eau

Entité de Surveillance durant la phase Travaux
Les performances relatives à la tenue de la ligne d’eau

Reaching performance to maintain the water line

→ Les contraintes d’exploitation (ICExp): traduisent les besoins des usagers de la ligne d’eau

→ Les performances eau de l’ouvrage (Ieau): traduisent la manière dont la solution technique régule le niveau d’eau en situation normale

→ La performance exploitation douce (IExpD): traduit la capacité de la solution technique à réguler le plan d’eau sans variation brusque (limiter les impacts sur le milieu naturel et berges - la variation moyenne des niveaux amont d’eau dans un pas de temps)

→ Performances à respecter 7j/7 et 24h/24 (y.c. si maintenance ou GER)
Les performances environnementales

⇒ La limitation des impacts sur les espèces et ses habitats ➔ démarche Eviter Réduire Compenser
⇒ Le rétablissement de la continuité écologique sur chaque bassin
⇒ La continuité de la grande et petite faune
⇒ L’intégration paysagère et architecturale
⇒ La non-dégradation de la qualité de l’eau de l’aval par rapport à l’amont
⇒ La réduction des déchets à la source et la non utilisation de produits phytosanitaires

PPP Barrages Aisne et Meuse
Les performances relatives au fonctionnement de l’ouvrage

Dam operating performance

→ Les bouchures peuvent être pilotées:
  - de manière automatique: la période de fonctionnement en mode automatique (IMA) est définie par le titulaire du contrat qui a fait le choix du 24h/24 pendant la période normale
  - de manière mécanisée ou manuelle par un opérateur (à distance ou sur place)

→ Une bouchure est considérée disponible dès lors qu’elle répond à tout ordre de mouvement quel que soit son mode de pilotage et que cette réponse intervient dans le délai de réaction prévu à la conception (hors interventions programmées)
  - On comptabilise le temps d’indisponibilité d’une bouchure (IndBi)
  - et le temps d’indisponibilité de l’ensemble des bouchures du barrage (IndBB)
Les performances relatives à l’état des ouvrages (niveau équipements)

Operational state performance

<table>
<thead>
<tr>
<th>Etendue</th>
<th>Niveaux</th>
<th>4</th>
<th>4'</th>
<th>3</th>
<th>3'</th>
<th>2</th>
<th>2'</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>[91%;100%]</td>
<td></td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
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<tr>
<td>[67%;90%]</td>
<td></td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>[34%;66%]</td>
<td></td>
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<td>3</td>
<td>2</td>
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<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>[0%;10%]</td>
<td></td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

→ Tout au long de la durée du contrat est suivi:
  - l’état fonctionnel défini sur la probabilité de défaillance des équipements définit par la combinaison du niveau et de l’étendue des dégradations
  - Et la durée de vie des équipements (calcul tenant compte de la durée de vie utilisée pour la conception et de la durée du contrat)
Un Ouvrage Type
Standardization and typical structure

PPP Barrages Aisne et Meuse
Un projet conduit avec une approche par bassin

A watershed orientated project management

→ Procédures administratives : deux arrêtés inter préfectoraux par bassin versant (Loi sur l’Eau + Espèces protégées)

→ Préservation du milieu
  - Evitement / réduction durant la conception
  - Evitement / réduction pendant la réalisation des travaux avec notamment diffusion à tous les personnels de manuels dédiés à la biodiversité, délimitation et protection de zones sensibles, surveillance continue de la qualité de l’eau,
  - Dette environnementale globale de 42 ha
  - Ripisylves et désartificialisation de berges : 8’000 ml sur l’ensemble du Projet

→ Mise en place d’un comité de suivi permettant la validation des différentes étapes du processus : identification des sites, diagnostic, rédaction des plans de gestion, sécurisation foncière, réalisation des travaux, gestion pendant toute la durée du Contrat.
Les contrôles pendant la réalisation des travaux

Contrôle externe COREBAM réalisé par une cellule dédiée pilotée par la Direction Technique en charge de la validation des documents d’exécution et du contrôle de conformité des travaux (y compris levée des PA).

Contrôle extérieur réalisé par le Contrôleur Technique des Travaux mandaté par BAMEO.

À chaque étape de la conception et de la réalisation, SeMAO peut émettre des Observations relatives à l’atteinte des performances. Ces Observations peuvent être réitérées sous forme de réserves à la Réception des Ouvrages.

Si défaut majeur alors les mises en eau / Mise en service ne peuvent pas avoir lieu sans éléments de résolution et nouvelle inspection.

BAMEO

Monitoring the works

contrôle des travaux au moyen d’une Entité de surveillance (ES) qui réalise :

- le suivi de la conception avec des avis spécifiques par échantillonnage
- le suivi de la construction avec la possibilité de réaliser des inspections
- l’analyse des documents transmis par BAMEO (plans, procédures, contrôles, rapport essais)
- les inspections avant mise en eau et mise en service

VNF
Une construction à un rythme soutenu  
A fast pace achievement of works

→ Délai de mise en service de l’ensemble des ouvrages inférieur à 7 ans

→ Une organisation par Groupe d’Ouvrages (barrage et ensemble de ses équipements dont la passe à poissons et l’éventuelle microcentrale)

<table>
<thead>
<tr>
<th>GROUPE</th>
<th>NOMBRE D’OUVRAGES</th>
<th>Dates de mise en service du Groupe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 Meuse (Givet)</td>
<td>Mars 2016</td>
</tr>
<tr>
<td>1</td>
<td>1 Meuse (Monthermé)</td>
<td>Mars 2016</td>
</tr>
<tr>
<td>2</td>
<td>5 Meuse + 2 Aisne = 7</td>
<td>Mars 2017</td>
</tr>
<tr>
<td>3</td>
<td>3 Meuse + 3 Aisne= 6</td>
<td>Décembre 2017</td>
</tr>
<tr>
<td>4</td>
<td>6 Meuse + 1 Aisne= 7</td>
<td>Décembre 2018</td>
</tr>
<tr>
<td>5</td>
<td>9 Meuse = 9</td>
<td><strong>Au plus tard Mars 2020</strong></td>
</tr>
<tr>
<td></td>
<td>29 +2</td>
<td></td>
</tr>
</tbody>
</table>

Une construction à un rythme soutenu  
A fast pace achievement of works
Une exploitation bénéficiant aussi d’une approche par bassin
Differentiated operation by watershed
Une application de surveillance hébergée chez BAMEO: disponibilité d’une vision en temps réel du respect de la gestion de la ligne d’eau (avec un historique limité)

Une ou des base de données transmises régulièrement à VNF pour conserver l’historique du fonctionnement et des indicateurs de performance
<table>
<thead>
<tr>
<th>BAMEO</th>
<th>VNF – suivi contrat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modifications d’ouvrages / solution technique</td>
<td>Demande de modifications</td>
</tr>
<tr>
<td>Foncier</td>
<td>Définition des besoins: acquisition ou occupation du domaine VNF</td>
</tr>
<tr>
<td>Suivi de trésorerie / suivi des tirages - jalons</td>
<td>Suivi mensuel des 6 000 jalons + justificatifs Relations avec les prêteurs</td>
</tr>
<tr>
<td>Vente d’électricité</td>
<td>Préparation des contrats, facturation, encaissement, reversement à VNF</td>
</tr>
<tr>
<td>Rapports d’avancement études et travaux</td>
<td>Rédacteur</td>
</tr>
<tr>
<td>Rapport exploitation</td>
<td>Présentation des événements clés, des interventions programmées et des éventuels écarts aux performances</td>
</tr>
</tbody>
</table>
DBFM NEW FLOOD BARRIER LIMMEL, WHY INTEGRATED CONTRACTS LEAD TO BETTER PERFORMANCE

Ken Watzeels
BESIX
Nieuwe Keersluis Limmel
Old vs. new
Nieuwe Keersluis Limmel

Functionality
Facts and Figures

- Client: Rijkswaterstaat
- Contract type: DBFM
  - 4 y construction CAPEX 30 MIO EUR
  - 30 y exploitation OPEX 6 MIO EUR
- First “wet” PPP
- Start 2015, end 2018
Scope

- CEMT Vb
- 47 m wide, 4 m deep, 9 m high
- Flood barrier
- Culvert
- Bridge
- Demolition
Financial model

How performance is paid

- Payments on “pay-back scheme”
- Deductions on availabilities and performance
Construction phase
Lifting mechanism

Keep It Simple and Stupid

- \( R = \frac{1}{3.875} \)
- Hydraulics
- Connected vessels
- Gravity
- Low # components
- Low maintenance
- High availability
- High reliability
Working collaboratively
Investing in collaboration

Golden Rules Limmel
• We make the first wet DBFM a success
• We act in the project’s interest
• We solve problems together and at once
• We recognize each others’ interests and do not surprise the other
• We discuss effectively and efficiently
• We address issues straight away and do not throw the ball towards the other
• We go for the edge
• We laugh a lot and celebrate our successes
Working collaboratively

When it pays off
Nieuwe Keersluis Limmel
The end result

- On time
- Within (tight) budget
- A satisfied client
- 30 yr exploitation
Thank You
Ken Watzeels
OPTIMISATION DES INVESTISSEMENTS DANS LES INFRASTRUCTURES DE NAVIGATION GRÂCE À UNE CHAINE COMPLÈTE DE MODÉLISATION.

Author: Nerincx, Constantinescu, Pircalabu, Sixdenier
DN&T, ISL
Optimisation des investissements dans les infrastructures de navigation grâce à une chaine complète de modélisation.

Navigation infrastructure investment optimisation thanks to a comprehensive modelling loop.
INTRODUCTION

• BACKGROUND

✓ Increasing investment in waterways for navigation and non navigation use
  ▪ Traffic increase
  ▪ Ship size increase
  ▪ Safety reasons
  ▪ Recreationnal use of waterways (especially in urban environement)

✓ High cost and relatively complex funding

✓ Non financial constraints
  ▪ Environment
  ▪ Land use
  ▪ Various waterway use

⇒ Need for detailed assessment of the needs and definition of corresponding solutions
  ✓ The traffic and its evolution
  ✓ The traffic conditions at global scale (network) and navigation conditions at local scale (stretch, bridge, lock, narrowing...)
  ✓ Solutions implementation:
    ✓ Design and engineering of proper structural solutions;
    ✓ Definition and update of rules and regulations;
    ✓ Innovations and re-assessment of norms and usual practices
• GENERAL INTEREST OF NUMERICAL MODELS

✓ Strengthen the analysis of the current situation
✓ Help giving an objective analysis of the real needs
✓ Allow testing several solutions and their validity conditions
✓ Support and justify gaps between proposed solutions and usual practice and norms

• MODELS PRESENTED

✓ **Network traffic model**: simplified model of a complete network (meshed or not), including locks, parking and waiting places, one way traffic zones, limited speed zones

✓ **Local ship manoeuvring analyses**: safety assessment of the ship passage / manoeuvre at a particular place of the network given various environmental and infrastructure scenarios, including transit time analysis
  • Needs an *usual* 2D hydraulic modelling as an input
A GLOBAL VIEW OF THE SYSTEM

✔ Goals
  - Assess the traffic flow
  - Identify bottlenecks
  - Compute global transit time
  - Compute water consumption (for canals)
  - Consider various scenarios
    - Infrastructure
    - Ship size and ships repartition
    - Rules / regulations

✔ Our solution: ITS – Inland Traffic Simulation\textsubscript{DN&T}

✔ Some theoretical fundamentals
  - Discrete – asynchronous simulation
    - The system evolves over time as a discreet sequence of events
    - Each event occurs at a given moment and changes the state of the system
    - No changes in the system is expected to occur between two consecutive events
    - The simulation jumps rapidly from one event to the next, thus allowing rapid analysis of large and complex systems.
A GLOBAL VIEW OF THE SYSTEM

- Minimum inputs
  - Reaches description
    - Geometry
    - Speed regulations
    - Unavailability times (determinist, periodic or random)
    - Including specific local restrictions: one way, meander/curve, bridges...
  - Lock description
    - Geometry
    - Filling and emptying time
    - Unavailability times (determinist, periodic or random)
• A GLOBAL VIEW OF THE SYSTEM

✓ Minimum inputs
  ▪ Fleet characteristics
    ▪ Type of ships and ship repartition, number of ships
    ▪ Entrance and exit time in locks
    ▪ Priority level at locks
    ▪ Ship speeds
  ▪ Trip setup: for each ship lot, departure and arrival nodes, generation law (determinist, periodic or random) and number of trips
  ▪ Navigation rules
  ▪ Scenarios to be tested

⇒ Inputs generally available without extra measurements / data acquisition
• A GLOBAL VIEW OF THE SYSTEM

✓ Typical Outputs
  ▪ Global traffic smoothness assessment
  ▪ Identification of preliminary solutions to bottlenecks (via scenario analysis)
  ▪ Detailed waiting time analysis
    ▪ At locks
    ▪ At one way stretches
    ▪ By ship type
    ▪ ...
  ▪ Detailed full transit time analysis (from Origin to Destination)
  ▪ Water consumption computation
  ▪ Locks garage dimension calculation
  ▪ Usage rate of locks

✓ Primary tool for diagnosis of current network
✓ Major decision making tool
✓ Moderately time-consuming for set up
✓ Fast for execution
SHIP MANOEUVRING ANALYSIS

• A DETAILED VIEW ON A SPECIFIC LOCATION

✓ Goals
  ▪ Detailed knowledge of navigation conditions on a defined stretch
    ▪ Duration
    ▪ Safety
    ▪ Complexity – indirectly related to duration and fuel consumption
  ▪ Impact assessment of
    ▪ Environmental conditions – wind and currents
    ▪ Loading condition of the vessel
    ▪ Direction (upstream/downstream)
    ▪ Rules – speed limitations; parking; overtaking; crossing
    ▪ Various obstacles - corbelled construction, bridge piles ...
  ▪ For several ship types
  ▪ Detailed lay-out definition of infrastructure
    ▪ Navigation channel
    ▪ Curve
    ▪ Widening
    ▪ Quay / turning basin
    ▪ Entrance / exit of locks
  ▪ Definition of manoeuvres to be carried out by the pilot (ex: for turning basin)
SHIP MANOEUVRING ANALYSIS

• A DETAILED VIEW ON A SPECIFIC LOCATION

✓ **Our solution**: *Trajectonav*$_{\text{DN&T}}$ — *other solutions exist on the market*

✓ **Fundamental input** — *for waterways with current*:
  - 2D hydraulic model of the waterways for several hydrological conditions

✓ **Theoretical model**
  - Computation core based on MMG (Maneuvering Modeling Group) method
  - 4 DOF for the ship (6 DOF end of 2019)
  - Deep and shallow water particularities
  - Impact of banks — limited width
  - Pilote orders from real equipment
SHIP MANOEUVRING ANALYSIS

• A DETAILED VIEW ON A SPECIFIC LOCATION

✓ Main features

- Features
  - Wind and hydraulic conditions
  - Bow and stent thrusters
  - Tugs module
- Semi automatic calibration process, a.o. based on numerical models and scaled models tests at the towing tank.
- Increasing 3D visualisation capacities for more realistic simulation
SHIP MANOEUVRING ANALYSIS

• CASES – MEUDON (SEINE, DOWNSTREAM PARIS - VNF)
  ✓ Impact assessment of residential boats parked on Meudon curve (where parking is prohibited) on the navigation safety given several environmental and navigation scenarios

⇒ Relevance evaluation of possible regulation update

• CASES – MAIRIE DE PARIS (SEINE)

✓ Definition of suitable parking locations for new floating establishment with respect to safety and traffic flow

⇒ Advise for regulation evolution for further development of diverse activities on waterways
SHIP MANOEUVRING ANALYSIS

• CASES – TURNING BASIN ARQUES - VNF
  ✓ Collaboration with Flanders Hydraulic Research (FHR – LARA simulator)
  ✓ Optimisation of turning basin initially designed according to standard practice (Dutch and German recommendations for design of turning basin) in order to reduce earthworks and civil works (hence the costs).
    ✓ Layout – circle, trapezium, triangle
    ✓ Dimension

⇒ Infrastructure optimisation and costs reduction
⇒ Support gaps between design and standard practice

Smart Rivers 2019 - LYON
SHIP MANOEUVRING ANALYSIS

• CASES – PETITE SEINE NAVIGABLE FOR LARGER VESSELS - VNF

✓ Control and optimisation of new (future) channel designed with standard practice, for transit of Va vessels

✓ Assessment of navigation limits for transit of Va, Va+ and Vb vessels on existing channel (limiting wind and currents, loading and acceptable direction)

⇒ Control and optimisation in design phase of a waterway upgrade project

⇒ Definition of safe navigation conditions in order to update the current navigation rules – less arbitrary rules; more adapted to real and varying site conditions
• LESSONS LEARNED

✓ Navigation studies must be fed by high quality and reliable data regarding site conditions and traffic studies – current and future traffic

✓ Ship type and loading conditions of utmost importance; right project vessel(s) must be defined depending on current and forecasted traffic

✓ Wind conditions must be properly assessed; including local effect (vegetation, screens...)

✓ Ships power and specific equipment (such as bow thrusters) must be realistically taken into account – given current and future fleet. Ship database must be extensive.

✓ Ships crossings or overtaking, interaction with moving or stationary ships might be decisive, depending on site conditions
LESSONS LEARNED

✓ 2D models are sufficient for various situations; (relatively) easy to implement, transportable to Client’s office.
✓ 3D models (realistic view from the ship bridge) especially relevant for high fidelity results, as the pilot will work in an environment close to the reality. His reaction will be more effectively influenced by various factors e.g. other vessels, environmental conditions – rain, fog, high currents

✓ Pilots with experience on the project ship and/or the site must be called for manoeuvring studies

✓ The calibration of the vessels before the simulations is a very important step

✓ Frequent stepwise studies as first level knowledge is often necessary followed by further detailed investigation and sensitivity analysis to environmental conditions
• WATERWAY PROJECT MANAGEMENT

✓ In case traffic increase is anticipated or current traffic jammed, network traffic model is highly recommended
  ▪ Identification of bottlenecks
  ▪ Gives an objective view and quantify impact of obstacles / bottlenecks identified by pilots
  ▪ Prioritisation of investment
  ▪ Allows considering management / regulations solutions instead of structural solutions and quantify benefit of those solutions
+ Water consumption management in the frame of Climate Change!

✓ Once obstacle to deal with and needs are identified, manoeuvring studies must be performed
  ▪ Fast and “cheap” with respect to investment budgets for structural works
  ▪ Significant savings possible with design optimisation
  ▪ Allows gaps between design and usual practice, as the latter are of very general scope and not site specific
  ▪ Helps defining in details management / regulation solutions

✓ Regulation must be regularly assessed and revised if any, given evolution of vessels types, with help of manoeuvring studies.

✓ In the future...Dynamic regulations may further investigated and detailed for investment rationalization

Smart Rivers 2019 - LYON
THANK YOU FOR YOUR ATTENTION
FULL MISSION SIMULATOR FOR RIVER NAVIGATION ON RHÔNE-SAÔNE BASIN

Author: Philippe MIROUDOT
CEREMA Eau, mer et Fleuves
Context

- A first approach in 2006
- 2009 new specifications for an efficient simulator
- A group of experts
Objective of the project

• To make a realistic simulator of training
• Accelerated training programs
• Training to react to extreme situations (weather, flood)
• Enhancement Program for rhodanian Pilots
• Training for beginners or pilots from other basins
• Suite à l’accident de la Voulte
• Et aux recommandations du bureau enquête accident
The site

- A new dedicated training Center
- Managed by the FLUVIA Institut
Architecture of the simulator

- 1 principale pilot cabin
- 1 instructor station
- 5 secondary posts
The pilot Cabin

Full mission simulator for river navigation on Rhône-Saône basin
Life on board

Full mission simulator for river navigation on Rhône-Saône basin
The pilot cabin equipments

- A large stretched canvas (240° and 1m70 high)
- 5 projectors ultra short focus optical mirror
- 65-inch HD TV screen projecting rear view
- 75 advanced instruments (twin disc, al pharu dudder, speedometers, alphatrio pilot, ...)

Full mission simulator for river navigation on Rhône-Saône basin
wheelhouse

- Userfriendly interface to support easy installation and configuration.
- Exchangeable wheelhouse by means of drawers
The Instructor station

- Total control and view on the cabin
- Create the scenario and launch the simulation
The student station

- Four independant secondary posts
- Lighter equipments
- Interaction with the pilot cabin
The back office

- 22 computers
- 31 screens
- 75 interfaces and control
- 1km of cables
- 1 audio system
The architecture

Navmer
- Leverage of Flow, current
- Wind
- Collision

Numeric datas
- Modelling currents
- Technical characteristics of boats
- Position of the obstacles

Simulator

man-machine interface
- Water rendering
- Weather
- Virtual traffic
- 3D modelling of sites

Materials interfaces
- Switches and drawbar
- Navigation instruments
- Dials and light
Navmer

- Calculate the ship's position and movement
  - mechanical forces (rudder, thrusters, towing, ...)
  - environmental conditions (current, wind)
  - collision
5 modelled boats

- Two auto-engines (110 m and 120 m);
- A pusher barge and one barge;
- A pusher barge and two barges;
- And a liner to passengers.
The sites of simulation

9 sites on the Rhône
- Arles
- Avignon
- Donzère
- La Voulte
- Montfaucon
- Tarascon
- Terrin
- Tournon
- Vienne
The sites of simulation

6 sites on the Saone
Zone of alternating traffic of Lyon
Passage of Barbe island
Lock of couzon
Crossing of Chalon
Verdun sur le Doubs
Charnay les Chalon
Thank you

Philippe MIROUDOT
Chef du service Données Logiciels
Direction Eau, mer et fleuves

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philippe.miroudot@cerema.fr
Full mission simulator for river navigation on Rhône-Saône basin
A COMPREHENSIVE CHARACTERIZATION OF THE NAUTICAL ACCESSIBILITY AND TRAFFIC FLOW OF THE ECMT CLASS VA INLAND WATERWAY NETWORK OF NORD-PAS-DE-CALAIS, FRANCE

Authors: Adams R. ¹, Page S. ¹, Mansuy M. ², Candries M. ², Eloot K. ³, Doorme S. ¹, Thorel X. ⁴, Labourie Cl. ⁴

¹ IMDC, ² FHR, ³ UGent, ⁴ VNF
Team

• IMDC
  • Coordination
  • Desktop study
  • Simulation protocol
  • Traffic study
  • Feasibility study

• Flanders Hydraulics Research
  • Simulation environment

• University of Ghent
  • Simulations
Why and what

- Construction of the Canal Seine Nord Europe
- Connection of Seine with Scheldt/Meuse Basins – potential for increase of traffic: more ships, larger size
- The ECMT Va network of Nord-Pas-de-Calais is the link between this new canal and the rivers in Belgium, that are currently being upgraded
Why and what

• Is this network fit to accommodate the traffic between these waterways?
  • Is it everywhere capable of handling ECMT class Va and larger vessels (in two directions), or even class Vb in one direction. Where are the eventual restrictions?
  • Will the increased number and size of ships lead to traffic jams, where. Will they lead to economic losses, that justify investments to improve the capacity of the waterway infrastructure?
This presentation

• Nautical assessment of the network
• Traffic flow analysis
• Interaction between nautical and traffic study
• Conclusions & next steps
Nautical assessment

• Two-fold approach
  • desktop analysis: identify bottlenecks
  • worth to investigate with (real time) nautical simulations

• Why:
  • Optimise budget
  • Desktop study is much more efficient, dedicate budget for more effective nautical simulations only for situations where needed
Nautical assessment

• Desktop study
  • Geometrical rules: two sets of designs
    • Ease criteria met: no navigation simulations required
    • Safety criteria are met
      • dedicate budget for nautical simulations
      • To confirm status
        • Where there is a reasonable chance that navigation is possible without additional measures
  • Safety criteria are not met
    • chance to be accessible is poor: no need for detailed investigation
Nautical assessment

• Desktop study
  • Check network accessibility for all possible combinations (encounters) or individual (large) vessels (eg. Vb)
  • Step 1. bathymetric data > bathymetric model
  • Step 2. establish check points related to vessel length (most narrow section)
  • Step 3. apply geometric rules defined for navigation with ease and safety
    • This includes width additions in function of bend radius, etc.
  • Step 4. break down waterway in sections defined by accessibility level
  • Step 5. identify and categorize in sections liable for higher functionality
  • Step 6. select sections for real time navigation simulations
Nautical assessment

• Real time navigation simulations
  • What
    • Simulation environment FHR
    • With pilots
  • Why
    • More time consuming, but more effective than fast time
    • Feedback from skippers
Nautical assessment

- 1\textsuperscript{st} rounds
  - Confirm navigability
  - Feedback to desktop study
    - Test assumptions for identifying ease and safety levels at desktop study
      - Review rules
      - Select additional situations for study with navigation simulations
      - Discard previously selected situations
      - Select additional simulations to further refine the rules of selection
        - to allow evaluation of more/less severe situations without need of simulation
Nautical assessment

- Identify accessibility for
  - Va/Va
  - Va/IV
  - Vb
  - Va/Va+(+)

- Define sections
  - Two way traffic
  - Max. velocity
  - Alternating traffic
  - Required interventions
Traffic flow analysis

• There have been network models/studies of individual branches to study traffic, but no comprehensive model to study the flow

• Need to check whether network is capable of handling the expected increase in traffic, identify bottlenecks, impact of (and solution of) bottlenecks on the flow
Traffic flow analysis

• Traffic flow model
  • IMDC\textsuperscript{1} Waterways
    • Event driven model – time based
    • Object oriented and declarative programming allows packaging of events
    • Capable of modelling branched networks
    • In-house: flexibility in pre- and postprocessing as desired by client
    • Process both ships and network structures at individual level

\textsuperscript{1} Integrated Model for Design and Capacity analysis
Traffic flow analysis

• First step
  • Traffic analysis
  • Generation of traffic for scenario conditions
  • Reproduce current traffic with generated traffic time series

• Second step
  • Build network
    • As requested by ToR: first individual branches
    • Consecutively the entire network at once
  • Simulate current situation: model validation
  • Simulate increased traffic: investigate capacity limits of the network

• Third step
  • Study scenarios
Traffic flow analysis

- Challenges
  - not possible to match data from different sources required to build a sound image of the traffic (displacement of individual ships)
    - some assumptions on:
      - lack of data on empty vessels: not included in OD matrices, and not systematically registered at locks
      - lack of precise timing of lock passages (non automated registration)
      - OD sectors do not necessarily include lock passages
    - Allows nevertheless, near perfect reproduction of traffic
Traffic flow analysis

• Challenges
  • individual behaviour of skippers
    • when and where do they stop sailing?
    • affects distribution of arrival at locks > important as it determines peaks, hence waiting
  • Despite this: fair and representative reproduction of arrival distribution

Douai: Observed ships  Modelled ships
Traffic flow analysis

• Challenges
  • match of traffic and individual branches with entire network
    • Fair match

Cuinchy: Observed ships Modelled ships

![Pie charts showing Observed and Modelled ships for Cuinchy]
Results

• Trajectory
  • Result visualisation
    • Dynamic visualisation of swept paths
    • Time series of kinematic parameters
  • Feedback from skippers
  • Success indicators evaluation matrix
    • UKC
    • Distance to isobaths
    • Reserves (engine, bow thruster, rudder)
Results

• Trajectory
  • Result visualisation: time series
    • Engine rate
    • Use of bow thruster
    • Long. and transv. speed
    • Distance to isobaths, ships
Results

• Trajectory
  • Success indicators evaluation matrix
    • UKC
    • Distance to isobaths, to encountered ships
    • Reserves (thruster, bow thruster, rudder)

<table>
<thead>
<tr>
<th>Evaluation expert</th>
<th>Signification</th>
<th>Condition(s) suffisante(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Croisement impossible.</td>
<td>Si l’un des indicateurs est rouge.</td>
</tr>
<tr>
<td>2</td>
<td>Manoeuvre difficile, requiert une attention particulière des pilotes et une réduction de vitesse.</td>
<td>Si la variation du gouvernail est jaune et/ou la réserve du propulsor d’étrave est jaune et/ou la distance à l’isobathe à 3m est nulle.</td>
</tr>
<tr>
<td>1</td>
<td>Croisement sans contrainte.</td>
<td>Si tous les indicateurs sont verts.</td>
</tr>
</tbody>
</table>
Results

• Trajectory
  • Overview sheets
## Results

- **Trajectory**
  - **Characterisation of accessibility**

<table>
<thead>
<tr>
<th>#</th>
<th>Bief</th>
<th>Commune(s)</th>
<th>PK début</th>
<th>PK fin</th>
<th>Linéaire [m]</th>
<th>Tirant d'eau max</th>
<th>Tirant d'air max</th>
<th>Acc. à étudier</th>
<th>Cause du point dur</th>
<th>Acc. retenue</th>
<th>Type de contrainte</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Pont-Malin-Goulzin</td>
<td>Bouchain, Wavrechain-sous-Faulx</td>
<td>0,5</td>
<td>1,8</td>
<td>1300</td>
<td>2,5 m</td>
<td>3,4 m</td>
<td>Va - IV</td>
<td>Rétrécissement local sous eau</td>
<td>Va</td>
<td>Sans objet</td>
</tr>
<tr>
<td>18</td>
<td>Pont-Malin-Goulzin</td>
<td>Hem-Lenglet</td>
<td>5,4</td>
<td>5,6</td>
<td>200</td>
<td>2,5 m</td>
<td>3,4 m</td>
<td>Va - Va</td>
<td>Absence de surlargeur</td>
<td>Va - Va</td>
<td>Attention particulière et vitesse adaptée</td>
</tr>
<tr>
<td>22</td>
<td>Pont-Malin-Goulzin</td>
<td>Fressies, Hem-Lenglet</td>
<td>6,7</td>
<td>7,3</td>
<td>600</td>
<td>2,5m</td>
<td>3,4 m</td>
<td>Va - Va</td>
<td>Absence de surlargeur</td>
<td>Va - Va</td>
<td>Attention particulière et vitesse adaptée</td>
</tr>
<tr>
<td>32</td>
<td>Pont-Malin-Goulzin</td>
<td>Arleux</td>
<td>15,7</td>
<td>16,0</td>
<td>300</td>
<td>2,5 m</td>
<td>3,4 m</td>
<td>Va - IV</td>
<td>Absence de surlargeur</td>
<td>Va - IV</td>
<td>Attention particulière et vitesse adaptée</td>
</tr>
<tr>
<td>34</td>
<td>Pont-Malin-Goulzin</td>
<td>Cantin, Arleux</td>
<td>16,9</td>
<td>17,4</td>
<td>500</td>
<td>2,5m</td>
<td>3,4 m</td>
<td>Va - Va</td>
<td>Profil en travers asymétrique</td>
<td>Va</td>
<td>Sans objet</td>
</tr>
<tr>
<td>41</td>
<td>Goulzin-Courchelettes</td>
<td>Corbehem, Courchelettes</td>
<td>23,5</td>
<td>23,8</td>
<td>300</td>
<td>2,5 m</td>
<td>3,4 m</td>
<td>Va - Va</td>
<td>Absence de surlargeur</td>
<td>Va - Va</td>
<td>Attention particulière et vitesse adaptée</td>
</tr>
<tr>
<td>49</td>
<td>Courchelettes-Douai</td>
<td>Douai</td>
<td>22,2</td>
<td>27,5</td>
<td>300</td>
<td>2,5 m</td>
<td>3,4 m</td>
<td>Va - Va</td>
<td>Rétrécissement local sous eau</td>
<td>Va - IV</td>
<td>Sans objet</td>
</tr>
<tr>
<td>64</td>
<td>Douai-Cuinchy</td>
<td>Leforest</td>
<td>34,7</td>
<td>34,9</td>
<td>200</td>
<td>2,5 m</td>
<td>3,4 m</td>
<td>Va - Va</td>
<td>Rétrécissement local sous eau</td>
<td>Va - Va</td>
<td>Attention particulière, signalisation adaptée et vitesse adaptée</td>
</tr>
</tbody>
</table>
Results

• Traffic flow
  • Reported results
  • Travel and waiting time for each node
  • Fleet structure
  • Transported volume
  • Number of passages
  • Lock occupation
  • Number of lock operations
  • Water use
  • Number of waiting ships

Frequency of waiting ships: traffic x1, x3
Results

• Traffic flow
  • Locks are the limiting factors
    • delays on the waterway sections negligible compared to locks
    • Most restraining locks are:
      • Cuinchy
      • Fontinettes
      • Flandres
      • Fresnes
      • Don
      • Grand Carré
      • Quesnoy
    • these are today near “comfort capacity”: 10% of ships need to wait longer than a full lock cycle

Waiting time compared to lock cycle ex. Cuinchy
Results

• Traffic flow
  • Impact on travel time
Interaction

• Accessibility
  • Defined by desktop study
    • Va/Va: green
    • Va/IV: kaki
    • Va: red
  • Next step
    • Result of RT simulations
Interaction

• Ship velocity
  • Critical velocity Schijf
  • Capped by RPP\textsuperscript{1} max. authorized
• Next step
  • Velocity from RT simulations:
    • Encounters
    • Bends

\textsuperscript{1} règlements particuliers de police
Conclusions & next steps

• The ongoing comprehensive trajectory and traffic analysis of the Nord Pas de Calais class Va Waterway network allows to characterise it’s accessibility level and identify major bottlenecks for increased traffic

• Semi-automated desktop analysis of section geometry allows to focus real time navigation simulations to sections where it is really needed, this is more efficient and effective

• The analysis provides the necessary elements to allow VNF to decide on either soft (speed limits, alternating traffic sections), or structural measures to improve safety and ease of navigation, and travel time
Conclusions & next steps

• Complete navigation simulations
• Define accessibility of all sections
• Feedback of RT simulations to traffic model
• Propose and investigate potential measures
  • calculate cost
  • study effects on traffic flow, time benefits
  • reiterate (optimise)
• Decide on measures/investments
Questions ?
MODELLING THE TRAFFIC CAPACITY OF THE NARROW CANAL ROESELARE-LYS, FLANDERS (BELGIUM)

Authors: Goormans T. ¹, Doorme S. ¹, Paeleman S. ², Eloot K. ³, Adams R. ¹

¹ IMDC, ² DVW, ³ FHR
Team

• IMDC
  • Nautical design
  • Traffic capacity model
  • (Dredging works)

• Flanders Hydraulics Research
  • Nautical Simulations

• De Vlaamse Waterweg
  • Flemish Waterway manager
Context of the study

• Future Seine-Scheldt connection via Lys River
• Canal Roeselare-Lys directly connected
• Upgrade of canal to meet expected economic development

(Aadapted from: De Vlaamse Waterweg)
Aim of the study

• Current situation:
  • In theory: canal calibrated up to CEMT class IV, draught ≤ 2.8 m
  • In practice: CEMT class Va (L ≤ 110 m, B ≤ 11.5 m) allowed
  • Past Bruane bridge (Roeselare port area): L ≤ 86 m, B ≤ 9.6 m

• Upgraded situation:
  • Improve navigability for class Va ships, draught ≤ 3.2 m
  → Deepening and enlargement as much as possible between existing banks
  → Narrow channel
  → Limited space for meeting // three turning circles in-line with canal
    ▪ Detailed nautical study based on real-time sims
    ▪ Traffic capacity model to assess impacts of certain manoeuvring cases on travel time [this presentation]
IMDC Waterways: concept

• Traffic flow model
  • IMDC\(^1\) Waterways
    • Event driven model – time based
    • Object oriented and declarative programming allows packaging of events
    • Capable of modelling branched networks
    • In-house: flexibility in pre- and postprocessing as desired by client
    • Process both ships and network structures at individual level

\(^1\) Integrated Model for Design and Capacity analysis
IMDC Waterways: model set-up

- 15-km long canal: 40 nodes connected with 39 links
- 6 (reduced speed if width requires so)
- 12 bridges (reduced width)
- 3 turning basins
- 1 lock (Ooigem)
- Mooring at intermediate locations (quay walls)
- **Bruane bridge**
Traffic generation

- Starting from existing traffic image
  - Lock registration data 2015-2017 (3 years)
  - About 80% of lockages for 30% of the fleet (on an annual average of 4000 lockage)
  - Account for in stochastic generation by increased inter-arrival time, to obtain realistic spread in time of larger classes
Traffic generation

- Destinations: current situation
  - Questionnaire launched among 51 companies along canal (response rate 26%)
    - Up to Bruange bridge: almost only CEMT class IV and Va is used
    - Past Bruane bridge: CEMT class I to IV
    - A destination could be attributed for up to 61% of ships
  - Remaining 39% based on
    - Data from past economic study (Technum-IMDC, 2014)
    - Fleet distribution registered at Ooigem lock
    - Assumptions regarding remaining amount of ships berthing at certain quays (‘close’ the balance)

- Resulting average amount of ships per class per day:

<table>
<thead>
<tr>
<th>CEMT class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Va</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counts at Ooigem</td>
<td>2.65</td>
<td>1.58</td>
<td>3.69</td>
<td>3.01</td>
<td>3.05</td>
</tr>
<tr>
<td>Sum over all quays, after attributing destination</td>
<td>2.44</td>
<td>1.47</td>
<td>3.84</td>
<td>2.76</td>
<td>2.85</td>
</tr>
</tbody>
</table>
Traffic generation

- Destinations: projected situation (2040)
  - Projected fleet distribution in past economic study

- Planned developments (two container terminals) with projected tonnage
- Resulting average amount of ships per class per day:

<table>
<thead>
<tr>
<th>CEMT class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Va</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on projections economic study</td>
<td>0.48</td>
<td>0.84</td>
<td>3.70</td>
<td>3.82</td>
<td>3.11</td>
</tr>
<tr>
<td>Sum over all quays, after attributing destination</td>
<td>0.48</td>
<td>0.84</td>
<td>3.70</td>
<td>3.81</td>
<td>3.11</td>
</tr>
</tbody>
</table>
Nautical simulations

- Two steps
  - First: main bottlenecks
    → Possible to stay within current water boundary at most locations
  - Next: updated nautical design
- Performed by FHR
  - Eloot et al. (2018a; b)
- Input to nautical design, but also to capacity model
  - Inaccessibility of area due to turning ship: 10 min when class Va
  - IV and I-III: 8 min and 5 min resp. (assumption)
Model assumptions vs. reality

• **Assumption:**
  Ship entering canal, first sails to destination, (waits,) unloads (2 hours), continues to the next turning circle, and returns.

• **Reality:**
  • Sometimes first turning, then unloading
  • Unloading times vary

• **Assumption:**
  No backwards sailing to nearest turning circle is assumed

• **Reality:**
  When turning circle is near (e.g. < 1 km), some skippers sail backwards (based on interviews with skippers)
Some results

- One year of traffic generated with traffic generator

<table>
<thead>
<tr>
<th>No. of meetings [-]</th>
<th>Meeting with Va</th>
<th>Meeting with IV</th>
<th>Meeting with Va or IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount [-]</td>
<td>Amount [%]</td>
<td>Amount [-]</td>
</tr>
<tr>
<td>0</td>
<td>497</td>
<td>54.0</td>
<td>527</td>
</tr>
<tr>
<td>1</td>
<td>316</td>
<td>34.3</td>
<td>288</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>9.8</td>
<td>73</td>
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<td>1.4</td>
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</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>
Some results

• One year or traffic generated with traffic generator

*Number of times a CEMT class Va ship has to wait due to another ship turning in a turning basin*

<table>
<thead>
<tr>
<th>No. of times waiting due to turning</th>
<th>Turning of Va</th>
<th>Turning of IV</th>
<th>Turning of Va or IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount [-]</td>
<td>Amount [%]</td>
<td>Amount [-]</td>
</tr>
<tr>
<td>0</td>
<td>880</td>
<td>95.7</td>
<td>886</td>
</tr>
<tr>
<td>1</td>
<td>39</td>
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<td>34</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
</tr>
</tbody>
</table>
Conclusions

• To benefit from expected economic development along the canal Roeselare-Lys, upgrade of canal necessary
• From nautical simulations: upgrade possible within (most locations) current water boundaries (limited spatial impact)
• Capacity modelling can benefit from real-time simulations output
• Probability of meeting class IV or Va ship can be estimated (none: 35%, once: 32%, twice: 21%, etc.)
• Probability of waiting due to turning vessels can be estimated (none: 92%, once: 7%, twice: 0.5% etc.)
• **To be continued:** impact on travel times
Recommendations

• The more data on traffic you can collect, the better!

• Questionnaires and interviews with companies and skippers provide valuable additional insights (if and how to model them is something else...)

• Make maximum use of real-time simulation output
Questions?

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roeland.adams@imdc.be
ETA COMPUTATION
ESTIMATED TIME OF ARRIVAL

Authors: Jean-Matthieu FARENC
Florian LINDE
Thomas SERE

CEREMA
Seine River Information Services
## Estimated Time of Arrival (ETA)

<table>
<thead>
<tr>
<th>Goal</th>
<th>Determine ETA of river ship operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits</td>
<td>Improve reception of boat accommodation in ports</td>
</tr>
<tr>
<td></td>
<td>Improve integration of river navigation in international supply chains</td>
</tr>
<tr>
<td>Specificity of the project</td>
<td>Improve prediction considering several parameters like tide</td>
</tr>
</tbody>
</table>
Method

Data acquisition

Database development

Data processing

Data analysis
Data acquisition

AIS Data
- Geographical coordinates
- Date
- Boat ID

Ships Data
- Length
- Width
- Deadweight
- Boat ID

Flow Data
- Flow
- Date
## Data acquisition

### Tide Data
- Water level
- Tidal range
- Date

### VELI Data
- Tonnage transported
- Nature of the goods
- Date
- Boat ID

### AvisBat Data
- Section concerned
- Date
# AIS data

**Automatic Identification System**  
- Data exchange system between vessels rules by IMO and also used for inland navigation

**Data**  
- Yearly AIS data in NMEA format
- 53GB of compressed data in bz2
- 500GB of decompressed data

**Database**  
- Only one AIS signal kept per boat per minute
- Data extraction limited to the Seine
Tide data

Tide gauges
Constitution of the Travels base

Reliability of AIS signals 100%
Constitution of the Travels base

Le Havre

Rouen

Paris

Lock

Node
Constitution of the Travels base

First step

Second step

Third step

<table>
<thead>
<tr>
<th>id</th>
<th>start_node</th>
<th>end_node</th>
<th>Mmsi</th>
<th>start_date</th>
<th>end_date</th>
<th>time</th>
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<td>1</td>
<td>18</td>
<td>19</td>
<td>227043520</td>
<td>2017-06-01 00:14:18</td>
<td>2017-06-01 01:50:17</td>
<td>1:35:59</td>
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</table>
Constitution of the Travels base

Section [7-8]  
Duration

Section [8-7]  
Duration

June 2017  
68 ships
Database development

- Travels
  - MMSI
    - Ships
      - Date, Start_node, End_node
        - AvisBat
          - Date
            - Flows
              - Date, Start_node, End_node
                - Tide
                  - Date, Start_node, End_node, Nom
                    - VELI
                      - Database
Data processing

Database → ETA calculation

Averages → Probabilistic methods

Results → Machine Learning
Learning

Parameter 1
Parameter 2
Parameter N
Arrival time: 20h34

Parameter 1
Parameter 2
Parameter N
Arrival time: J+1 7h15

Parameter 1
Parameter 2
Parameter N
Arrival time: 15h48

Linear regression
Machine learning:

Found a function $f$ such that $f(X) \approx H$ with $H = \text{Travel time}$.

Data

Solutions
Machine Learning

Departure

Arrival

Parameters of the trip

\( (X_1, \ldots, X_x) \)

Hd

Departure time

\[ \text{ETA} = \text{Hd} + f_{13-14} (X_1, \ldots, X_x) + \ldots + f_{22-23} (X_1, \ldots, X_x) \]
Results and Perspectives

Data processing and Machine Learning

Comparison with the Seine RIS calculator

Expend dataset

Implementation in the Seine RIS if results are significant
PASSING SHIP EFFECTS ON INLAND VESSELS MOORED IN A SIDE HARBOR NEXT TO A FAIRWAY

Lutz Schweter, Wojciech Misiag, Peter van den Bosch
Arcadis
Jean-Pierre Dubbelman
Aquater
Content

• Introduction and objectives
• Passing ship effects
• Methodology (“model train”)
• Boundary conditions and evaluation criteria
• Scenarios and results
• Conclusions
Introduction

• Re-development of industrial area.

• Optimization of adjacent (small scale) inland harbor.

• Located along major transport corridor with an annual traffic intensity of over 65,000 passages of inland AND seagoing ships.

• Legislation (BPR): Ships must adapt their sailing speed to not cause hinder for ships moored along the waterway or in adjacent harbors.

Artikel 6.20. Hinderlijke waterbeweging

1 Een schip moet zijn snelheid zodanig regelen, dat hinderlijke waterbeweging waardoor schade aan een varend of een stilliggend schip of drijvend voorwerp of aan een werk zou kunnen worden veroorzaakt wordt vermeden. Het moet daartoe tijdig zijn snelheid verminderen, echter niet beneden de snelheid die nodig is voor veilig sturen:

Reducing the sailing speed is unwanted
Objectives

• Assess effect of passing ships on ships moored in the harbor.

• Assess effect of structural and operational factors on the ship motions and resulting mooring loads:
  • Berth position
  • Bottom depth
  • Passing ship scenarios
  • Number of ships moored next to each other
  • Arrangement, number and strength of mooring lines

• Assess effect of using the innovative high-performance mooring device ShoreTension®.

(Nautical) feasibility of planned harbor optimization

© Arcadis 2019
Passing ship effects

• Sailing ships cause a dynamic pressure field moving with them (primary flow) resulting in forces acting on moored ships.

• These hydrodynamic interaction forces (“suction forces”) induce motions of the moored ships and resulting loads in the mooring system.

• Additional forces due to free-surface effects caused by ship wave propagation and reflections in the harbor basin.

• Reference is made to Pinkster papers.
Methodology

1. 3D time domain double body flow model
2. 3D frequency domain diffraction model
3. 3D time domain model for the analysis of the behavior of moored ships

Boundary conditions (passing/moored ship scenarios, geometry, environment)

Frequency dependent free surface elevations and resulting forces and moments on the moored ship

Time series of potentials and velocities of ship induced waves

Moored ship motions and mooring system loads

Primary flow around the passing ship + free surface effects
Model 1: 3D time domain double body flow model

- Passing ship and fairway are modelled with a panel schematization
- Conservative but realistic passing ship scenarios are simulated

Inland ship (CEMT class VIc, 270 x 22.8 x 4.0 m)  
Seagoing ship (tanker, 175 x 25.0 x 8.5 m)
Model 2: 3D frequency domain diffraction model

- Moored ship(s) and harbor are modelled with a panel schematization
- Potentials and velocities from Model 1 are applied on the panels

- Free surface elevations and reflections in the basin
- Forces and moments on moored ships
Model 3: 3D time domain mooring analysis model

- Moored ship(s) and harbor are modelled with a panel schematization
- Mooring system is modelled as non-linear springs (fenders, lines) or fixed points (bollards)
- Driving force: time series of passing ship forces and moments on the moored ship from Model 2
Boundary conditions

Harbor geometry
- East (present harbor): waiting places (dolphins)
- West (new): 250 m long quay wall
- 2 basin depths (minimum water depth 5 m and 6.5 m)

Waterway bathymetry
- Fairway inland ships: 210 m wide, minimum water depth about 5 m, adjacent to harbor entrance
- Fairway seagoing ships: 100 m wide, minimum water depth about 10 m, distance 60 m to harbor entrance
Boundary conditions

Environmental conditions:
• Low water level (exceeded 99% of the time)
• Flow velocities and wind waves negligible
• Wind neglected (ships sheltered at low water levels)

Passing ships:
• Different passing distances and speeds
• Inland ships:
  • Class VIc, 6 barges pushed convoy, long formation (L x B x T): 270 x 22,8 x 4,0 m
• Seagoing ships:
  • Handysize tanker, 25.000 dwt (L x B x T): 175 x 25 x 8,5 m

Source: Google Earth
Boundary conditions

Berths

• West: North and South; East

Moored ships

• Inland class Va (single ship and side-by-side or Vb uncoupled).

Mooring system (conform PIANC and RVW 2017)

• East: 4 dolphins with bollards and wooden fendering
• West: 30 t bollards and cylindrical fenders at different heights and spacings
• Mooring lines: minimum required (ROSR) and common
• Mooring line arrangement: common (green) and optimized (cyan)
• ShoreTension®
Boundary conditions

ShoreTension®

- Portable hydraulic cylinder connected to a bollard
- Piston connected to a very stiff and strong Dyneema® mooring line
- Dyneema® line running via a second bollard to the ship’s fairlead and to the bitt on-board
- Activated once via a hydraulic system than stand-alone without the need for external energy
- Provides constant high-tension coping with e.g. peak (passing ship) loads without exceeding the minimum breaking load of the line
  - Significantly dampens the ship’s motions and absorbs the energy of the moving ship
  - Prevents lines from becoming slack

Source: www.shoretension.com
Evaluation criteria

Bollard loads
• Safe Working Load SWL = 300 kN

Mooring line loads
• Minimum Breaking Load MBL = 200 kN (or 400 kN)
• Incidental load (e.g. passing ships): 75% MBL = 150 kN (or 300 kN)
• Repeated load (e.g. wind or wind waves): 50% MBL = 100 kN (or 200 kN)

Also evaluating ship motions

© Arcadis 2019
Output

- Water surface elevations
- Passing ship loads
- Moored ship motions
- Mooring system loads
General observations

- Free surface effects can be significant (reflections and peak loads)
- Surge force dominant resulting in large motions (long lines to allow for water level variations)
- Surge motions and therefore spring line loads are critical
Scenarios

• Base case (worst case): side-by-side, closest passing distance at highest speed.
• Scenario A: berth location within the harbor
• Scenario B: bottom depth in the basin
• Scenario C: passing ship type, speed and distance
• Scenario D: mooring system variations
• Scenario E: single moored ship vs. side-by-side moored ships
Base case

- Inland ship (50m, 15.0 km/h): okay
- Seagoing ship (60m, 18.5 km/h): forces in lines and bollards are (far) too high
  - Worst-case passing ship conditions in combination with side-by-side mooring not feasible

<table>
<thead>
<tr>
<th>Base case</th>
<th>Line no.</th>
<th>Passing ship:</th>
<th>Seagoing (60m, 10kn)</th>
<th>Inland (50m, 8kn)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NW berth</td>
<td>East berth</td>
</tr>
<tr>
<td>50% MBL Criterium [kN]:</td>
<td>1</td>
<td>677</td>
<td>359</td>
<td>128</td>
</tr>
<tr>
<td>75% MBL Criterium [kN]:</td>
<td>2</td>
<td>493</td>
<td>323</td>
<td>98</td>
</tr>
<tr>
<td>100% MBL Criterium [kN]:</td>
<td>3</td>
<td>698</td>
<td>360</td>
<td>141</td>
</tr>
<tr>
<td>Minimum line force [kN]:</td>
<td>4</td>
<td>454</td>
<td>338</td>
<td>80</td>
</tr>
<tr>
<td>150</td>
<td>5</td>
<td>513</td>
<td>211</td>
<td>151</td>
</tr>
<tr>
<td>200</td>
<td>6</td>
<td>400</td>
<td>219</td>
<td>97</td>
</tr>
</tbody>
</table>

Side-by-side, closest passing distance at highest speed
Scenario A

- NW berth (closest to fairway) is worst case
- At the SW berth, peak surge forces are about 30-35% smaller compared to the NW berth
- At the E berth, peak surge forces are about 20-30% smaller compared to the NW berth

Berth location within the harbor
Scenario B

- Deepening the harbor decreases passing ship loads.
- Increase of water depth by 30% (h/T from 1.4 to 1.9) results in reduction of the peak surge forces of 13%.
- Between 6-12% lower mooring line loads (depending on the line).

![Diagram of Bottom depth in the basin]

Passing ship loads (surge) on the single body moored ship for different bottom depths:
- North-west; 5m water depth
- North-west; 6.5m water depth
- East; 5m water depth
- East; 6.5m water depth
Scenario C

- Reducing passing speed (by 20%) results in lower passing ship loads (50%). Note: when using a double body flow model, a reduction of about 35% can be expected, as here the relation between passing speed and resulting load is quadratic.

- Increasing passing distance (by 75%) results in lower passing ship loads (40%).

- Seagoing ship causes higher loads compared to the inland ship because of a larger beam (25 m vs. 22.8 m) and especially draught (8.5 m vs. 4 m) and related smaller under keel clearance of the seagoing ship.

![Graphs](Passing ship loads (surge) on the side-by-side moored (inner) ship for different passing ship cases)
Scenario D

- All investigated variations result in significant improvements regarding the ship’s surge motion and resulting maximum line loads.

- Stronger lines or the optimized mooring line arrangement results in 30-40% lower maximum mooring line loads.

- Applying ShoreTension® results in 45% (line 1 and 2) and 80% (line 3 –working in the same direction as the ShoreTension®) reduction of the maximum mooring line loads.

- Applying two units reduces the loads in all lines by 80-90%.
**Scenario E**

- Maximum line loads single ship are 60% smaller.
- Loads on inner ship in side-by-side configuration are higher than loads on outer ship.
- The inner ship experiences higher surge forces (+15-20% compared to the single moored ship) than the outer ship (+10-15% compared to the single moored ship).

<table>
<thead>
<tr>
<th>Case</th>
<th>single ship line 1</th>
<th>single ship line 3</th>
<th>side-by-side line 1</th>
<th>side-by-side line 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>175 m tanker passing at 60 m distance with 10 knots 5 m water depth in the basin</td>
<td>235 kN</td>
<td>155 kN</td>
<td>675 kN</td>
<td>700 kN</td>
</tr>
<tr>
<td>175 m tanker passing at 60 m distance with 8 knots 5 m water depth in the basin</td>
<td>105 kN (-55%)</td>
<td>75 kN (-50%)</td>
<td>290 kN (-55%)</td>
<td>305 kN (-55%)</td>
</tr>
<tr>
<td>175 m tanker passing at 60 m distance with 10 knots 6.5 m water depth in the basin</td>
<td>220 kN (-10%)</td>
<td>145 kN (-5%)</td>
<td>625 kN (-10%)</td>
<td>635 kN (-10%)</td>
</tr>
</tbody>
</table>

**Single moored ship vs. side-by-side moored ships**
Conclusions

- Ships can be moored safely in the new harbor even under the worst-case passing ship conditions, but only under certain conditions (e.g. no side-by-side mooring).

- Free surface effects are important considering passing ship effects in side harbors (reflections, higher peak loads).

- The following measures caused as expected lower passing ship loads:
  - Decreasing the passing speed and distance: difficult to influence/control in real life / unwanted.
  - Deepening the harbor basin: expensive measure.

- Optimizing the mooring system: promising and controllable (line arrangement/no. of lines). Some aspects difficult to influence/control in real life (line strength, pretension).

- Applying the ShoreTension® device(s) is a promising alternative:
  - Significant reduction of peak loads.
  - Control of loads.
  - No slack lines.
THANKS FOR YOUR ATTENTION!

PASSING SHIP EFFECTS ON INLAND VESSELS MOORED IN A SIDE HARBOR NEXT TO A FAIRWAY

Lutz Schweter, Wojciech Misiag, Peter van den Bosch
Arcadis
Jean-Pierre Dubbelman
Aquater
MARIN
Author: Anke Cottelein, Hyoje Raven, Arno Bons
VESSELS
VALIDATION OF SQUARE FORMULAS FOR INLAND

Smart Rivers
PIANC
Conferences
// Lyon France
Cité Internationale / Centre de congrès
September 30 – October 3, 2019
// Lyon 2019
CoVadem – Shipping made smarter

- More information about CoVadem
  - refer to presentation Meeuwis van Wirdum
Introduction - squat

• CoVadem:
  • Deliver a real time water depth based on cooperative measurements of inland ships

• “Squat is the reduction in underkeel clearance between a vessel at-rest and underway due to the increased flow of water past the moving hull (Briggs).
Introduction - squat

• Initial and dynamic trim have to be taken into account.

• Average operational conditions:
  • 10 cm midship sinkage, some centimeters trim

• Extreme conditions:
  • high ship speed, small underkeel clearance, narrow waterway
  • 40 cm midship sinkage, 10 centimeter trim
Introduction – Objective of presentation

• Question:
  • Which squat formula compares best with model tests?
    • Formulas include:
      • Dynamic trim
      • Restricted fairway width

• Barrass (2006)
• Ankudinov (Briggs 2009)
• Römisch (1989)
• Empirical method
• Give a quick estimate of the order of magnitude
• Based on 600 results measured on ships and ship models

\[
Z_{bow} = \frac{c_B S^{0.81} V_e^{2.08}}{20}
\]
\[
trim = K_t Z_{bow}
\]

• Version for open water conditions,
  • width of influence (used to calculate blockage S) is very small

Blockage (S) = As/Ac

Pianc (2014)
• Semi-empirical method
• Coefficients deduced using
  • hydrodynamic methods and
  • systematic model tests of Panamax and Post-Panamax containerships
  • in range of waterway configurations

\[ Z_{mid} = (1 + K_p P_{Hu} P_{F_{nh}} P_{+h/T} P_{Ch1}) \]
\[ trim = 1.7 P_{Hu} P_{F_{nh}} P_{h/T} K_T P_{Ch2} \]

• Full scale validations in Panama Canal with containerships, bulk carriers and tankers
  • Bow squat overpredictions of factor 1.25 to 2.2
  • Stern squat factor 0.95 to 1.4
Formulas - Tuck, Hooft, Huuska, Guliev, Stocks

- **Tuck**: Slender-body potential theory
  - Shallow water of infinite width
- **Hooft**: simplification \( 1.46 \frac{\nabla}{L_{pp}^2} \frac{F_{nh}^2}{\sqrt{1 - F_{nh}^2}} \)
- **Huuska/Guliev**: restricted width \( (K_s) \)
- **Stocks**: trim component
  \[
  Z_{bow} = 1.46 \frac{\nabla}{L_{pp}^2} \frac{F_{nh}^2}{\sqrt{1 - F_{nh}^2}} K_s + 0.5L_{pp}\sin^2\left(\frac{\nabla}{L_{pp}^3}\right) \frac{F_{nh}^2}{\sqrt{1 - F_{nh}^2}} K_s
  \]
- **Theoretical basis**
- **Ks** probably based on model tests
• Semi-empirical method
  • including different fairway configurations

\[ Z_{\text{bow}} = C_V C_F K_{\Delta T} T \]

\[ Z_{\text{stern}} = C_V K_{\Delta T} T \]
Discussion – restricted fairway

- Restricted fairway by speed independent factor:
  - Ankudinov, Barrass, Tuck/.../Stocks

- Hydrodynamic approach for restricted waterways
  - Critical speed of Schijf’s theory based on continuity and Bernoulli equations
    \[ v_{cr} = \sqrt{gh_M \left[ 2\sin\left(\frac{\arcsin\left(\frac{3}{S} - 1\right)}{3}\right)\right]}^{3/2} \]
    \[ S = \frac{A_s}{A_c} \]

- Römisch
Discussion - trim

• Barrass:
  • Trim depends on \( C_B \),
  • inland ships always trim bow down

• For situations in this study
  • bow down trim for
    • Ankudinov
    • Stocks

• Römisch:
  • Trim depends on block coefficient, ship length and breadth
  • 110 m x 11.45 meter inland ships always give trim stern down
  • Wider or shorter ships will trim bow down.
Discussion – restrictions of formulas

- Large block coefficients of inland ships
  - Only Römisch is officially suited for them
- $h/T$ should be small (below 2.25).
  - For Ankudinov it should be below 1.3, which only very rarely occurs in the case of inland ships.
Comparison with model tests

- Three inland ships
  - 110 m x 11.4 m
  - Twin-screw
    - Tanker
    - Cargo ship
  - Triple-screw passenger ship
- Midship sinkage
- Dynamic trim
- Tank width used as waterway width
Comparison with model tests – midship sinkage

- Computed squat by Römisch is closest to model test results
Comparison with model tests – dynamic trim

(None of methods gives correct direction of dynamic trim)

Model test results of three 110 x 11.45 m ships

Container ships: Eloot (2008)
Conclusions and future work

• Midship sinkage
  • Römisch gives best correspondence with model tests
  • Pompée and PIANC 2019 correctly select Römisch

• Dynamic trim
  • Generally
    • bow down,
    • Small draughts
    • Stern down

• None of equations matches this
• More model tests for dynamic trim are being performed
BUILDING A STRATEGIC SCHEME FOR MANAGEMENT AND INVESTMENTS ON THE WALLOON WATERWAYS NETWORK

Didier Bousmar, Nicolas Dubois, Christophe Vanmuysen
Service Public de Wallonie Mobilité et Infrastructures
Walloon waterways network

- TEN-T corridors
  - North Sea-Mediterranean
  - Rhine-Alpine
- Total freight:
  - $40 \times 10^6$ t/yr
  - $1.7 \times 10^9$ t.km/yr
Walloon waterways network

450 kms, 88 locks and ship lifts, 45 weirs, 6 reservoirs
Context: Mobility Vision FAST 2030

• Improved mobility in Wallonia:
  – Fluid, Safe, Sustainable
  – Persons and goods

• Wallonia: efficient and sustainable region
  for transport and logistics

• Waterways: modal shift for freight transport
  14 % in 2017 → 18 % in 2030
  (Total freight x 2)
## Context

<table>
<thead>
<tr>
<th>Category</th>
<th>Key Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility Vision FAST 2030</td>
<td>• Global objectives</td>
</tr>
<tr>
<td>Regional Mobility Scheme</td>
<td>• New policies and instruments</td>
</tr>
<tr>
<td>Strategic Scheme Manag. &amp; Invest.</td>
<td>• Infrastructures: service level</td>
</tr>
<tr>
<td>Investments plans</td>
<td>• Existing or news</td>
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</table>
Strategic Scheme Management Investment 2050

- Objectives
- Network diagnosis
- Actions
- Priorities & planning
- Indicators

Stakeholders consultation
Main themes

1. Freight transport
2. Water management
3. Mobility
4. Environment
5. Other functions
6. Asset management
Main themes

1. Freight transport
   - Waterway dimensions
   - Waterway capacity
   - Services to traffic
   - Port infrastructures
Main themes

1. Freight transport
2. Water management
   - Flood and drought
   - Daily management
   - Reservoir management
Main themes

1. Freight transport
2. Water management
3. Mobility
   - Soft mobility
Main themes

1. Freight transport
2. Water management
3. Mobility
4. Environment
   – Sediments
   – Ecological continuity
   – Habitats
Main themes

1. Freight transport
2. Water management
3. Mobility
4. Environment
5. Other functions
   – Recreational navigation
   – Tourism, bathing, heritage
   – Hydropower
Main themes

1. Freight transport
2. Water management
3. Mobility
4. Environment
5. Other functions
6. Asset management
   – Inspection and maintenance
Strategic Scheme Management Investment 2050

Objectives → Network diagnosis → Indicators → Actions → Priorities & planning

Stakeholders consultation
Objectives

• Global traffic growth objectives fixed by government
• International rules (EU TEN-T, AGN, …)
• Technical constraints

• Long-term perspective:
  – Climate change
  – Emerging technologies
  – …
Objectives

• Focus on service, not on results
• SMART
  Specific, Measurable, Achievable, Realistic, Timed

Example:
Provide enough public berthing places, with adequate land accessibility and equipment. Berthing number is equal or larger than half the number of vessel loading/unloading per day in the considered reach (or 10 km sector). Berthing places close to urbanized area are fitted with electrical power supply.
Strategic Scheme Management Investment 2050

Objectives

Network diagnosis

Actions

Priorities & planning

Indicators

Stakeholders consultation
Indicators

• Defined from objectives
• Target values, with intermediate steps
• Estimated from network diagnosis
## Indicators: example

<table>
<thead>
<tr>
<th>#</th>
<th>Indicator 1.2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Network availability</td>
</tr>
<tr>
<td>Data</td>
<td>Navigation stops: reason, duration, preliminary notification delay</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Identify stops for which expected notification delay was not respected</td>
</tr>
<tr>
<td></td>
<td>Compute cumulated duration on each sector</td>
</tr>
<tr>
<td></td>
<td>Compute cumulated duration on whole network</td>
</tr>
<tr>
<td>Target value</td>
<td>Cumulated duration of stops no properly notified &lt; 24 h/3 year</td>
</tr>
<tr>
<td>Threshold values</td>
<td>Red: one sector &gt; 2 x target value</td>
</tr>
<tr>
<td></td>
<td>Orange: all sector &lt; 2 x target value</td>
</tr>
<tr>
<td></td>
<td>Green: all network &lt; target value</td>
</tr>
</tbody>
</table>
### Indicators: example

<table>
<thead>
<tr>
<th>#</th>
<th>Indicator 2.1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>System capacity for low-flow management</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>Effective capacity of pumping stations, reservoirs and equipments. Required capacity to maintain all water supplies at 25- and 100-year horizons, accounting for climate change, estimation updated since less than 10 years.</td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td>Proportion of equipment OK in 100 years</td>
</tr>
<tr>
<td><strong>Target value</strong></td>
<td>100 %</td>
</tr>
</tbody>
</table>
| **Threshold values** | Red: Required capacity not updated, capacity KO at 25 years  
Orange: 100% capacity OK at 25 years  
Green: 100% capacity OK at 100 years |
Strategic Scheme Management Investment 2050

- Objectives
- Network diagnosis
- Actions
- Priorities & planning

Indicators

Stakeholders consultation

Service public de Wallonie mobilité infrastructures SPW
Actions

- To achieve objectives:
  - New infrastructures
  - Maintenance or improvement works
  - Improvement of procedures, rules
  - Detailed diagnosis
- Associated resources (budget, workforce)
- Maturity
Priorities and planning

• Weighting/ordering of indicators
• Benefit of each action related to indicators
• Planning according to available resources, maturity, expected benefit
• Groups of actions:
  – Diagnosis
  – Already planned in existing plans
  – New suggestions
Strategic Scheme Management Investment 2050

- Objectives
- Network diagnosis
- Indicators
- Actions
- Priorities & planning
- Stakeholders consultation
Stakeholder involvement

• One pilot group in waterways administration
• All parties in waterways administration
  – Validation of objectives, indicators
  – Support to diagnosis
  – Identification of actions
• Other stakeholders:
  – Boatmen, shippers, industry, local communities, …
  – Feedback on objectives and actions
Lessons learnt

• Lack of data:
  Preliminary actions = additional diagnosis
  E.g.: berthing equipment, effective lock availability, asset inspection, …

• Main requirement from stakeholders
  = Reliability, prior to increased capacity
    → Increased attractiveness for new freight
    → Pre-requisite for remote control

• Required actions on improved maintenance
Thanks for your attention
Merci pour votre attention
GUIDELINES FOR INLAND WATERWAYS IN RIVERS

Author: Dick ten Hove, MSc – MARIN
Co-author: Otto Koedijk, MSc – Rijkswaterstaat WVL/TU Delft
Background

• The Dutch Rijkswaterstaat is among others responsible for the design, construction, management and maintenance of the main inland waterway network and water systems.

• To support the design from a traffic point of view Rijkswaterstaat developed the Waterways Guidelines (RVW) in 1996, which evolved into the latest 2017 edition. The RVW2017 are restricted to waterways with a limited longitudinal flow velocity (less than 0.5 m/s).

• In almost all free-flowing rivers this flow velocity is exceeded. That is why Rijkswaterstaat decided to develop integral guidelines for inland waterways, including rivers. Preferably these guidelines consist of design guidelines, tables and rules of thumb for dimensioning the waterway in a free-flowing river.
Flowdiagram designcycle
Assumptions and conditions

- Guidelines will include CEMT Class I to Vlc waterways.
- A minimum aim for rivers is to achieve a profile for undisturbed two-lane traffic. With this “normal” profile, the width-average depth of a cross section of the waterway must be at least 1.4 times the loaded draft of the design ship with respect to the reference water level.
- In case of a traffic density of more than 30,000 commercial vessels each year, a “high intensity profile” is required, which facilitates multi-lane traffic. This is achieved by a density increment on the width of the “normal” profile.
Reference levels

- In the case of rivers it is necessary to determine the waterway dimensions at several reference water levels.
- From a nautical point of view for the river Rhine branches the agreed low water level (OLR) and the median water level (MW) are the most decisive reference water levels to define the waterway dimensions. The first because it indicates the minimum water level that is available for about 95% of the year, but may force larger vessels to limit the draft. The second because it allows to sail with maximum draft.
- For the river Maas -when free flowing- these levels are the median water level and the low water level with a 1-year frequency. In the canalised part the reservoir level is the most decisive reference level.
**Straight river sections**

• BAW processed experiments of the US Army Corps of Engineers with pushed convoys on the Mississippi and supplemented it with its own experiments with motor vessels to get an impression of the extra path width due to longitudinal current. The study came up with a regression formula for the additional path width due to current:

\[
\Delta b = \frac{1.12 \times T \times V_c + 0.023 \times L \times v_g}{v_r}
\]

with:
- \(\Delta b\) the extra path width
- \(T\) the loaded draft of the vessel
- \(h\) the water depth
- \(V_c\) the longitudinal flow velocity
- \(v_r\) the sailing speed relative to the water
- \(v_g\) the sailing speed relative to the ground
Straight river sections

- For most inland vessels with a sailing speed of 13 km/h through the water and a flow velocity of 0.5 m/s, the extra path width ($\Delta b$) is about 0.3B. Upstream slightly larger than 0.3B, downstream slightly smaller. This is in line with the 1.3B basic path width for good manoeuvrable vessels that is used in other guidelines, e.g. PIANC guidelines for approach channels.

- It is recommended to take into account an surcharge on width of the lane of 0.1B for flow velocities from 0.5 m/s to 1 m/s and a surcharge of 0.2B for flow velocities higher than 1 m/s. Below 0.5 m/s no surcharge is required. The surcharge must be applied per lane and must be available at the draft of the loaded vessel.
Intensity surcharge

- In case of more than 30,000 passing vessels each year a density surcharge is required for the fairway width.
- The intensity surcharge is independent of the flow velocity.
- The following formula can be used to derive the required additional fairway width:

\[
\Delta b = c_i*(l_v-2050)^2+c_i*(\text{in-30.000})
\]

with:
- \(\Delta b\) the recommended additional channel width
- \(l_v\) the average load capacity of the passing fleet
- \(\text{in}\) the number of passages on an annual basis
- \(c_i = 3.6*10^{-5}\)
- \(c_i = 0.00053\)
Additional width in bends

• In bends an additional width for the current must be taken into account.
• The additional width can be calculated by $\Delta b \approx C*\frac{L^2}{R}$, in which an empirical model derived by Fisher can be used to determine the factor C. L is the length of the design vessel; R is the radius of the bend.
• In the empirical model, the factor C depends on the local water depth, the ship's dimensions (length, width and draft), the speed of the vessel relative to the water and the flow velocity. This way a distinction can be made between a deep outer bend and a shallow inner bend when calculating the additional fairway width.
Additional width in bends

- The empirical model can only be used if there is no interaction between the bends in a river. If there is interaction, such as in short consecutive opposite turns, additional research is necessary.

- For smaller bend radii (R<4L), additional research is necessary.
The minimum line of sight (LOS) in a bend is based on the requirement that vessels can anticipate to one another in time when meeting. From the relative speed principle it is concluded that for meeting vessels the relative speed of approaching each other does not change as a result of the current. So there is no reason to adjust the LOS for a waterway with current.

It is recommended to use 5L for the LOS in a bend, with a maximum of 600 m, but with an absolute minimum of 3L.
CEREMA Eau, Mer et Fleuves
Fabrice Dalix
Consultant
Authors: Jean Marc Depalax

Evolution du Dimensionnement
- Waterway Dimensions in Perspective

Lyon / France
Cité Internationale / Centre de Congrès
September 30 - October 3, 2019 / Lyon 2019

Conference
SMART RIVERS
InCom Working Group Report 141 on Design Guidelines for Inland Waterway Dimensions was published in 2019. In order impacts on the environment, the socio-economic aspects or the politico-economics of waterway improvement be acceptable for the Society, the design should be as narrow as necessary, but not more than that.
On the other side, looking on the aspects of Safety and Ease of navigation (later abbreviated ‘S&E’), of the level of traffic and of the operational economy of shipping, the design should be generally as generous as possible. The working group attempted this balancing job, in... 300 pages.
The methodology: Define 3 groups of S&E

<table>
<thead>
<tr>
<th>Score</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1.0</td>
<td>A</td>
<td>restrictions: moderate to strong</td>
<td>presqu'aucune</td>
</tr>
<tr>
<td>+0.8</td>
<td>easy sailing</td>
<td>légères à notables</td>
<td>A</td>
</tr>
<tr>
<td>+0.6</td>
<td>not really easy</td>
<td>facilite de navigation</td>
<td>A</td>
</tr>
<tr>
<td>+0.4</td>
<td>easiness</td>
<td>pas vraiment facile</td>
<td>B</td>
</tr>
<tr>
<td>+0.2</td>
<td>Score</td>
<td>Note</td>
<td>+0.34</td>
</tr>
<tr>
<td>0.0</td>
<td>tricky drive</td>
<td>0,0</td>
<td>+0.2</td>
</tr>
<tr>
<td>-0.2</td>
<td></td>
<td>-0.2</td>
<td>-0.33</td>
</tr>
<tr>
<td>-0.4</td>
<td></td>
<td>-0.6</td>
<td>-0.33</td>
</tr>
<tr>
<td>-0.6</td>
<td></td>
<td>-0.8</td>
<td>-0.6</td>
</tr>
<tr>
<td>-0.8</td>
<td></td>
<td>-1.0</td>
<td>-0.8</td>
</tr>
</tbody>
</table>

representing the easiness to navigate a waterway
How to evaluate this score?
2 tables:
one to evaluate the present state, like in a classification, and calibrate the weighting,
The other to take stock of what has to be done to reach the desired level of S&E, so as to prepare the terms of reference of the design.
The structure of these 2 tables looks similar, but one is the mirror of the other: in particular for waterway related criteria,

<table>
<thead>
<tr>
<th>Criterion</th>
<th>The ease quality is high if the following arguments hold true</th>
<th>In the following cases the ease quality is low</th>
<th>Score</th>
<th>Single factor</th>
<th>Group factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st rating group:</td>
<td></td>
<td></td>
<td></td>
<td>7/20</td>
<td>35%</td>
</tr>
<tr>
<td>Waterway related criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Depth exploitation of waterway and type of load</td>
<td>Empty or ballasted vessels, no dangerous goods, sufficient water depth</td>
<td>Deep draught vessels, especially with dangerous goods in very shallow water</td>
<td>1/7</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Level of training, personnel skills and experience</td>
<td>Optimally qualified and experienced helmsman</td>
<td>Poorly trained pilots, low knowledge on waterway features and infrastructure</td>
<td>1/7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Attention level, distraction and stress of the pilot</td>
<td>Short manoeuvre situation, e.g. during a meeting or by passing a bridge opening</td>
<td>Long time or boring drive, permanent manoeuvring conditions</td>
<td>1/7</td>
<td></td>
</tr>
</tbody>
</table>
What was a hindrance to navigation, and giving a poor S&E figure in the present state, red column on the right,

<table>
<thead>
<tr>
<th>Criterion</th>
<th>The ease quality is high if the following arguments hold true</th>
<th>In the following cases the ease quality is low</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scoring rules for waterway related criteria:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The score is +1, if the argument in the green coloured left column is true, it is -1, if the argument in the right red coloured column is true. If neither the left or right argument is true or if both are true, the score is 0.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Depth exploitation of waterway and type of load</td>
<td>Empty or ballasted vessels, no dangerous goods, sufficient water depth</td>
<td>1/7</td>
</tr>
<tr>
<td></td>
<td>Level of training, personnel skills, and experience</td>
<td>Optimally qualified and experienced helmsman</td>
<td>1/7</td>
</tr>
<tr>
<td>3</td>
<td>Attention level, distraction and stress of the pilot</td>
<td>Short manoeuvre situation, e.g. during a meeting or by passing a bridge opening</td>
<td>1/7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep draught vessels, especially with dangerous goods in very shallow water</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poorly trained pilots, low knowledge on waterway features and infrastructure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long time or boring drive, permanent manoeuvring conditions</td>
<td></td>
</tr>
</tbody>
</table>

7/20 = 35%
...is the reason to aim at a high S&E figure in the **REQUESTED** design, red column on the left of the second table, for design

<table>
<thead>
<tr>
<th>SmartRivers, river pools for design / Criterion</th>
<th>Arguments speaking for a higher necessary ease score for design</th>
<th>Cases where a lower ease quality may be acceptable for design</th>
<th>Score</th>
<th>Single factor</th>
<th>Group factor</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st rating group:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Depth exploitation of waterway and type of load</td>
<td>Deep draught vessels, especially with dangerous goods in very shallow water</td>
<td>Empty or ballasted vessels, no dangerous goods, sufficient water depth</td>
<td>0,5</td>
<td>1/7</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Channel to be deepened few dangerous goods</td>
</tr>
<tr>
<td>2</td>
<td>Level of training, personnel skills and experience</td>
<td>Poorly trained pilots, low knowledge on waterway features and infrastructure</td>
<td>Optimally qualified and experienced helmsman</td>
<td>0,5</td>
<td>1/7</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Qualified pilots, but foreign boats likely</td>
</tr>
<tr>
<td>3</td>
<td>Attention level, distraction and stress of the pilot</td>
<td>Long time or boring drive, permanent manoeuvring conditions</td>
<td>Short maneuvre situation, e.g. during a meeting or by passing a bridge opening</td>
<td>0,5</td>
<td>1/7</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rather difficult driving, many structures</td>
</tr>
</tbody>
</table>
3 groups of criteria:

one on waterway conditions, with 7 criteria to grade
second on speed, with 2 criteria
third on traffic, also with 2 criteria

Respective weights to be tested

More details in Deplaix Panama Paper, during the 34th PIANC Congress, 2018, on Bray-Nogent improvement works
For each of these 11 criteria, we evaluate the proper figure (score), multiply by the coefficient (single factor) then by the group factor, to obtain a total on 20, itself divided by 20 to obtain a figure between +1 and -1, enabling to place the waterway in A, B or C.
Next, depending on whether it is a canal, a river or a canalised river, we use tables giving the dimensions to follow, in straight course. The terms of reference are then fixed, we pass to studies of specific places.
Here is such a table, for canals, the more complete. Then, if there are difficult points we turn to another method, detailed design,

Table 5.2: Concept Design Method for canals ("basic dimensions" for straight sections)

<table>
<thead>
<tr>
<th>Waterway</th>
<th>Fairway width for alternate single-lane</th>
<th>Fairway width for two-way (approximately also for two-lane, including overtaking manoeuvres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ease quality</td>
<td>Remarks</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>min W_length (straight canal sections)</td>
<td>2.3 B</td>
<td>2.2 B</td>
</tr>
<tr>
<td>min n</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td>min h (over bottom width)</td>
<td>1.3 T</td>
<td>1.4 T</td>
</tr>
<tr>
<td>min R (ΔF needed for R ≠ ∞)</td>
<td>4 L</td>
<td>7 L</td>
</tr>
<tr>
<td>max V_flow (longitudinal)</td>
<td>0.5 m/s</td>
<td>0.5 m/s</td>
</tr>
<tr>
<td>max V_cross (averaged over L, ΔF needed for V_cross ≠ 0)</td>
<td>0.3 m/s</td>
<td>0.3 m/s</td>
</tr>
<tr>
<td>design V_w (inland) (ΔF needed for empty/ballasted or container vessels at V_w ≠ 0)</td>
<td>5-6 BF (8.0 – 13.9 m/s; 10.5 m/s according to Dutch Guidelines)</td>
<td>5-6 BF (8.0 – 13.9 m/s; 10.5 m/s according to Dutch Guidelines)</td>
</tr>
<tr>
<td>design V_w (costal) (ΔF needed for empty/ballasted or container vessels at V_w ≠ 0)</td>
<td>6-7 BF (10.8 – 17.2 m/s; 13.5 m/s according to Dutch Guidelines)</td>
<td>6-7 BF (10.8 – 17.2 m/s; 13.5 m/s according to Dutch Guidelines)</td>
</tr>
</tbody>
</table>
... entailing the use of simulators or detailed studies.

Figure 4.2: Contribution of the present guidelines to the planning process of waterway
In France, other methods were used: applying the standards set by Circular 76-38 (concept design), then analysis of difficult places, with trajectography
Analysis of a difficult passage
Analysis of a difficult passage

<table>
<thead>
<tr>
<th>Excess or Gap (m)</th>
<th>1 Way</th>
<th>2 Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>+3</td>
<td>1 Way</td>
<td>2 Way</td>
</tr>
<tr>
<td>+10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Theoretical Required Width without Corridor (m)

<table>
<thead>
<tr>
<th>Channel</th>
<th>Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>47</td>
</tr>
<tr>
<td>42</td>
<td>63</td>
</tr>
<tr>
<td>75</td>
<td>90</td>
</tr>
</tbody>
</table>

All Measures in Metres