Estuary Traffic: an Alternative Hinterland Connection for Coastal Ports

PORT INFRASTRUCTURE SEMINAR
Delft, June 2010

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Overview

Introduction

Principles of estuary navigation

Present regulations: RD of 8 March 2007

Practical approach

Important parameters

Further research

Concluding remark
Introduction

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## Introduction

### Table 1.
**Port of Zeebrugge (2008): modal split in 10³ ton.**

<table>
<thead>
<tr>
<th>Cargo Type</th>
<th>Transhipment Feeder</th>
<th>Estuary Traffic</th>
<th>Inland Navigation</th>
<th>Rail</th>
<th>Road</th>
<th>Pipeline</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roro</td>
<td>744</td>
<td>75</td>
<td>0</td>
<td>377</td>
<td>10,618</td>
<td>0</td>
<td>11,814</td>
</tr>
<tr>
<td>Containers</td>
<td>4,908</td>
<td>453</td>
<td>32</td>
<td>6,749</td>
<td>9,061</td>
<td>0</td>
<td>21,203</td>
</tr>
<tr>
<td>General Cargo</td>
<td>5</td>
<td>0</td>
<td>260</td>
<td>422</td>
<td>165</td>
<td>0</td>
<td>852</td>
</tr>
<tr>
<td>Liquid Bulk</td>
<td>1,491</td>
<td>1,409</td>
<td>0</td>
<td>0</td>
<td>775</td>
<td>2,527</td>
<td>6,202</td>
</tr>
<tr>
<td>Dry Bulk</td>
<td>0</td>
<td>0</td>
<td>46</td>
<td>0</td>
<td>1,907</td>
<td>0</td>
<td>1,953</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7,148</strong></td>
<td><strong>1,937</strong></td>
<td><strong>338</strong></td>
<td><strong>7,548</strong></td>
<td><strong>22,526</strong></td>
<td><strong>2,527</strong></td>
<td><strong>42,024</strong></td>
</tr>
<tr>
<td><strong>% Total</strong></td>
<td>17.01%</td>
<td>4.61%</td>
<td>0.80%</td>
<td>17.96%</td>
<td>53.60%</td>
<td>6.01%</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>% Inland Traffic</strong></td>
<td>-</td>
<td>5.55%</td>
<td>0.97%</td>
<td>21.64%</td>
<td>64.59%</td>
<td>7.25%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Introduction
Introduction

1962: Service Rule on estuary traffic (BSI)

Class: range of navigation – suitable scantlings

Additional requirements:

- Freeboard
- Strength

...

- \( H_s < 1.2 \text{ m} \) or wind < 5 Bf
- Mostly (bunkering) tankers
Introduction

Hydro Meteo System (Coastal Division):
Monitoring Network Flemish Banks

Bol van Heist:
directional wave buoy (WAVEC)
collected data 1997 – 2002
Introduction

![Graph showing significant wave height vs percentage time blocks]

- $n = 0.5$
- $n = 2$
- $n = 4$
- $n = 6$
- $n = 12$
- $n = 24$

84% corresponds to a significant wave height $H_s = 1.20$ m.
Introduction

93 - 97%

% time blocks

n = 0.5
n = 2
n = 4
n = 6
n = 12
n = 24

significant wave height Hs (m)

1.60 – 1.95 m

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Overview

- Introduction
- **Principles of estuary navigation**
- Present regulations: RD of 8 March 2007
- Practical approach
- Important parameters
- Further research
- Concluding remark
Principles of Estuary Navigation

Inland ships at sea??

Flag state authority
- Safety of people on board
- Protection of marine environment
- e.g. stability, freeboard, fire safety

Classification society
- Safety of ship and cargo
- Requirements for ship’s structure and major systems
Principles of Estuary Navigation

Class: Rules and regulations

Lloyd’s Register of Shipping:

- Zone 3: $H_s \leq 0.5 \text{ m}$ ➔ neglect wave loads
- Zone 2: $H_s \leq 1.0 \text{ m}$ ➔ additional wave bending moment and shear force
- Zone 1: $H_s \leq 1.6 \text{ m}$

Bureau Veritas:

- NI1: $H_s \leq 1.20 \text{ m}$
- NI1 (X m): $H_s \leq X \text{ m} (1.20 \leq X \leq 2.00)$
Principles of Estuary Navigation

**Waves ⇔ Still water?**

- Additional wave loads
  - (bending moments / shear forces / torsional moments)

- Impact loadings:
  - Slamming
  - Water on deck (green seas)
Principles of Estuary Navigation

**Estuary vessels:**

- **Inland** ships – **No** sea-going vessels!
- **Strength:** adapted to
  - Wave loads
  - Accelerations
- **Structure not suited for impact loadings**
  - Avoid slamming
  - Avoid green seas
- **Additional requirements for**
  - Deck wetness – Shipping of water in cargo holds
  - Stability: based on IMO for sea-going vessels
Principles of Estuary Navigation

Estuary vessels:

2004 – 2007:
- individual studies
- $H_s \leq 1.60 – 1.75$ m

2007: Royal Decree
- Base = risk analysis
Overview

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Present Regulations: Royal Decree

Royal Decree concerning inland waterways vessels also used for non-international sea voyages

Vu la loi du 5 juin 1972 sur la sécurité des bâtiments de navigation, notamment l’article 17ter, § 1er, inséré par la loi du 22 janvier 2007;

Vu la communication à la Commission européenne du 23 novembre 2006, en application de l’article 8, paragraphe 1er, de la Directive 2000/75/CE concernant les sites et zones naturelles d’importance communautaire;
Present Regulations: Royal Decree

Requirements:

- Full ADNR certification
- Crew: specific STCW certification
- “Restricted seaworthiness”
  - Equipment, MARPOL, COLREG
  - Fire safety, stability, freeboard, container stowage, structural strength
  - Draft scales, manoeuvrability, navigation aids, communication equipment, propulsion, bilge pumps, electrical installations, fire fighting, anchor, personal life saving, bulwarks, railings

RISK ANALYSIS

- Not required for Hs ≤ 1.20 m ➔ minimum freeboard
- Required for Hs > 1.20 m
Present Regulations: Royal Decree

Requirements:

- Full ADNR certification
- Crew: specific STCW certification
- “Restricted seaworthiness”
- Assessment procedures for captain:
  - “go – no go”
  - Based on actual measurements and predictions of weather and wave height
Present Regulations: Royal Decree

Risk Analysis: Criteria

Probability calculations:

- Ship’s lifetime: 20 years
- 300 round trips / year
Present Regulations: Royal Decree

Risk Analysis: Criteria

Green water (foredeck):
\[ \leq 1 \text{ / lifetime} \]

slamming (bow emergence):
\[ \leq 1 \text{ / year} \]
Present Regulations: Royal Decree

Risk Analysis: Criteria

Cargo holds/tanks:
Exceedance of reference level
≤ 1 / lifetime

Reference level fore/aft
Reference level midships

1.35 m
0.9 m
0.2 Z
0.9 m
Z

0.9 m
1.35 m
Reference level midships
Reference level fore/aft

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Present Regulations: Royal Decree

Risk Analysis: Criteria

Exceedance of aft deck / bulwark level
≤ 1 / lifetime
Present Regulations: Royal Decree

Risk Analysis: Criteria

- Roll angle: limitations 1/lifetime
- Wave bending moment
- Wave torsional moment 1/lifetime
- Lateral acceleration

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Practical Approach

Directional spectra for representative period (1 year)
Practice Approach

- Directional spectra for representative period (1 year)
- RAO's: response as a function of wave frequency and direction for given ship speed
- Response spectrum of ship to each individual spectrum
- Probability of exceedance of a critical value during round trip
  - Zeebrugge → West Scheldt → Zeebrugge
  - Zeebrugge → Nieuwpoort → Zeebrugge
- Sort spectra by significant wave height
Practical Approach

**Graph:**
- **Title:** Average probability of exceedance if $H_s = 1.60$ m
- **Legend:**
  - Conditional minimum
  - Conditional maximum
  - Conditional average
  - Cumulative average

**Axes:**
- 'significant wave height (m)'
- 'number of exceedances per trajectory (-)'

**Note:**
- **Estuarine Tanker - Ballast Condition**
- **Scheldt - Zeebrugge**
- **Motion Point 1 - Bow Slamming**
- **Directional Spectra Bol Van Heist 1998**

**Text:**
- Estuary Traffic: an Alternative Hinterland Connection for Coastal Ports
- Port Infrastructure Seminar, Delft, June 2010
Practical Approach

Average probability of exceedance if $H_s = 1.60$ m

Average probability of exceedance if $H_s \leq 1.60$ m

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Practical Approach

![Graph showing significant wave height (m) vs. number of exceedances per trajectory with various lines indicating conditional minimum, conditional maximum, conditional average, and cumulative average.]

**ESTUARINE TANKER - BALLAST CONDITION**
**SCHELDT - ZEEBRUGGE**
**MOTION POINT 1 - BOW SLAMMING**
**DIRECTIONAL SPECTRA BOL VAN HEIST 1998**

**1 / 300 = 1 / year**

**1 / 6000 = 1 / lifetime**
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Important Parameters

Loading Condition

Draft

GM

![Graph showing loading condition for Draft and GM, with key points and labels for different conditions.]

Draft = Tref
Draft = Tref + 0.2 m

GM = 1.75 m
GM = 3.00 m
Important Parameters

Loading Condition

- Draft
- GM
- Inertia radius

[Graphs showing the relationship between roll amplitude, wave amplitude, and pulsation for different draft and GM values.]

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Important Parameters

Bilge keels

- Reduction of roll resonance peak (25 – 75%)
- Typical increase of allowable Hs: 0.10 m
- Typical draft increase / required freeboard decrease: 0.13 m
Important Parameters

- Trajectory
- Direction
- Spatial variation
Important Parameters

- Trajectory
- Direction
- Spatial variation

Diagram showing trajectories and percentages:
- Zeebrugge
- Bol van Heist
- Western Scheldt
- Breskens
- Percentages: 100%, 95%, 87%, 80%, 77%, 72%, 67%
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Further Research

Topics

Flexible admittance policy
- “stepped” approach: e.g.
  - draft 4.40 m for $H_s \leq 1.30$ m
  - draft 3.80 m for $H_s \leq 1.80$ m

Continuous relationship $H_s$ – draft

Wind induced loads (steady + gustiness):
  adequate margins?

Local wave climate

Ship response: RAOs, bow wave, margins
Further Research

Methods

- Model testing
- Simulator
- Full scale monitoring
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