ABSTRACT

At present, less than 2% of the hinterland traffic to the harbour of Zeebrugge is carried by inland navigation, due to the insufficient capacity of the waterway connections. An alternative could be offered by estuary vessels, i.e. inland vessels strengthened and equipped for safe operation between the Belgian coastal harbours and the West Scheldt in favourable weather and wave conditions. However, the window determined by the present regulations of the Belgian Shipping Inspectorate is too restrictive, traffic being impossible for 60 days a year on average.

Accordingly, the Belgian federal authorities have recently prepared new regulations, based on probabilistic design procedures, including a risk analysis with respect to criteria which take due account of the limitations inherent to the design of inland vessels.

Measures have been proposed by the Flemish authorities to stimulate the operation of estuary inland vessels for container transport from and to the coastal harbours, implying financial support for construction and exploitation.

sommaire

A présent, moins de 2% du transport à l'arrière-pays du port de Zeebrugge sont assurés par la voie d'eau, à cause de la capacité restreinte des voies navigables. Une alternative pourrait être offerte par le transport estuaire en employant des bateaux de navigation intérieure renforcés et équipés de sorte qu'en conditions de houle favorables l'opération entre les ports côtiers belges et l'Escout Occidentale puisse se produire en sécurité. Cependant, les règles actuelles de l'inspection maritime belge sont trop restrictives, puisqu'en moyenne le transport estuaire n'est pas permis pendant 60 jours par an.

Pour tenir compte de ces restrictions, les autorités fédérales belges ont récemment préparé un nouvel Arrêté royal relatif aux bateaux qui sont aussi utilisés pour effectuer des voyages non internationaux par mer, basé sur une procédure probabiliste, incluant une analyse de risque par rapport à des critères qui tiennent compte des limitations inhérent à la conception de bateaux de navigation intérieure.

Des mesures ont été proposées par les autorités flamandes pour stimuler le transport de conteneurs par navigation intérieure et estuaire à destination et en provenance des ports côtiers, entre autre par une subvention de la construction et de l'exploitation.

keywords: estuary vessels, container traffic, risk analysis, regulations, financial support, subsidy
the hinterland for the Flemish coastal ports via inland waterway navigation will be reinforced. A pilot project has been launched to stimulate the modal shift for container traffic from road to inland waterway transport, by optimising the use of the existing capacity via the canal Ghent-Bruges-Ostend with traditional inland waterway vessels on one hand, and by stimulating the introduction of estuarine navigation on the other hand.

Table 1. Modal split of maritime traffic in Zeebrugge (local deliveries excluded) for 2005. Source: MBZ NV.

<table>
<thead>
<tr>
<th>*1.000 t</th>
<th>transhipment</th>
<th>feeder</th>
<th>estuarine</th>
<th>barge</th>
<th>rail</th>
<th>road</th>
<th>pipe</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ro/ro</td>
<td>60</td>
<td>26</td>
<td>0</td>
<td>256</td>
<td>11 435</td>
<td>0</td>
<td>11 777</td>
<td></td>
</tr>
<tr>
<td>Containers</td>
<td>2 207</td>
<td>0</td>
<td>194</td>
<td>4 904</td>
<td>8 299</td>
<td>0</td>
<td>15 604</td>
<td></td>
</tr>
<tr>
<td>general / mixed cargo</td>
<td>2</td>
<td>0</td>
<td>176</td>
<td>2</td>
<td>831</td>
<td>0</td>
<td>1 011</td>
<td></td>
</tr>
<tr>
<td>liquid bulk</td>
<td>956</td>
<td>946</td>
<td>8</td>
<td>0</td>
<td>591</td>
<td>1 979</td>
<td>4 480</td>
<td></td>
</tr>
<tr>
<td>dry bulk</td>
<td>0</td>
<td>0</td>
<td>121</td>
<td>22</td>
<td>1 576</td>
<td>0</td>
<td>1 719</td>
<td></td>
</tr>
<tr>
<td>Total (1 000 t)</td>
<td>3 225</td>
<td>972</td>
<td>499</td>
<td>5 184</td>
<td>22 732</td>
<td>1 979</td>
<td>34 591</td>
<td></td>
</tr>
<tr>
<td>Total (%)</td>
<td>9 %</td>
<td>3 %</td>
<td>1 %</td>
<td>15 %</td>
<td>66 %</td>
<td>6 %</td>
<td>100 %</td>
<td></td>
</tr>
<tr>
<td>Total inland (%)</td>
<td>– – –</td>
<td>3 %</td>
<td>2 %</td>
<td>17 %</td>
<td>72 %</td>
<td>6 %</td>
<td>100 %</td>
<td></td>
</tr>
</tbody>
</table>

1.2. Estuary vessels: existing regulations

A service rule from 1962 of the Belgian Shipping Inspectorate stipulates that estuary ships have to fulfil in the first place all the regulations concerning inland waterway vessels, together with additional requirements as enumerated in the service rule. If all requirements are met, then BSI can allow such vessels to operate between the West Scheldt and Zeebrugge with qualified Manning and when weather conditions are favourable, which means in practice that significant wave height should be 1.2 m at most.

The additional requirements concern, among others, life saving appliances, radio equipment, nautical instruments, Colreg, freeboard and strength. The minimum freeboard rules prescribe minimum values depending on length and type of vessel, including minimum values for depth and flare. For strength requirements reference is made to the classification society rules for vessels with a maximum of 1.2m significant wave height.

The existing fleet built according to these regulations is not large – about 20 vessels – and consists mostly of smaller tankers (length 70-80m), for which it is easy to fulfill the additional strength and safety requirements.

1.3. Limitations of estuary traffic

Based on observations taken with a 30 minutes interval during the period 1997-2002 by a Wavec type directional wave measuring buoy at the location Bol van Heist near Zeebrugge, belonging to the Hydro Meteo System of the Ministry of Flanders (Dumon, 2002), a cumulative distribution of the significant wave height has been derived, see figure...
2 (upper curve). It is clear that the present limitation of 1.2 m for the significant wave height is insufficient to guarantee a reliable hinterland connection, as traffic is not allowed during 16% of the time. In order to obtain acceptable percentages of non-activity, the limiting value should be increased to at least 1.60 m, reducing the exceedance frequency to 7%.

The upper curve of figure 2 gives an indication about availability, but provides an incomplete view, as the transit time between Zeebrugge and the West Scheldt is not accounted for. In order to provide more insight in the consequences of the selection of an operational limit expressed as a maximum allowable significant wave height on the downtime of extended estuary vessels, the mentioned wave data have been analysed by Ghent University in several ways.

- Figure 2 displays the percentage of time slots with n hours duration during which the significant wave height in abscissa is not exceeded. Taking account of the transit time, the n = 2 curve is of particular interest: as an example, a maximum allowable Hs of 1.70 m results into an availability percentage of 93.5%.
- In figure 3 the percentage of six hour time blocks where a n hour time slot can be found during which the significant wave height in abscissa is not exceeded is plotted.
- The average duration of an interruption due to excessive wave height and the average yearly number of interruptions is shown in figure 4.
- Seasonal fluctuations are illustrated in figure 5.

2. ESTUARY VESSELS FOR EXTENDED SERVICE

2.1. First stage of extension

The Belgian Shipping Inspectorate received several requests from ship owners to consider an extension of the limiting conditions for estuary traffic, e.g. up to significant wave heights of 1.6 to 1.8 m. The Inspectorate was willing to take these requests into consideration and decided that the problem could be tackled in a first stage by applying modern probabilistic design procedures to each separate project. This decision was made after contacts with the classification society involved, being Lloyd’s Register of Shipping (LR – Antwerp office), as the flag state authority and the classification society have roles in safety at sea which are complementary. The flag state is committed to the safety of people on board of ships and the protection of the marine environment by means of internationally agreed and national regulations; typical aspects are stability, freeboard, fire safety. The classification society is taking care of the safety of the ship and its cargo through class rules, prescribing minimum requirements for the ship’s structure and the major systems on board.

The current class rules for inland waterways vessels only cover operations in zones with limited significant wave height (e.g. 0.5 m according to the LR Rules, 2002). Scantlings and arrangements for ships intended to operate in zones with higher sea states have to be specially considered; for instance, they have to be determined by direct calculation procedures. In sea states characterised by Hs exceeding 1.6 m, not only the additional wave bending moments have to be considered for determining the longitudinal strength of the vessel, but also other phenomena are identified as being critical. Slamming and the shipping of massive amounts of water (“green seas”) in the more severe conditions (Hs > 1.60 m) could cause excessive additional transient loads, leading to (fatigue) loads the structure of typical inland waterway vessels are not designed for.

The uncertainty on the magnitude and the nature of these additional loads made Lloyd’s Register decide that both slamming and shipping of “green seas”, especially over the bow, should practically not occur during the ship’s lifetime. BSI has extended this line of thought to include the determination of other basic design parameters affecting the behaviour and the safety of estuary ships while crossing the sea zone between the West Scheldt and Zeebrugge. Stability criteria are similar to the IMO intact stability criteria for sea going general dry cargo vessels. Also the amount of water allowed on the deck was limited to safeguard the dynamic stability range.

In order to operate in estuary service beyond service rule 8, the owner has to prove that his particular design meets criteria concerning various safety aspects in seaways up to a maximum significant wave height. The imposed methodology includes a risk analysis with respect to these criteria, which take due account of the limitations inherent to inland vessel design. The ship could then be designed and built respecting proven inland waterway arrangements, while at the same time incorporating design features and construction details derived from sea-going practice.

Two sets of criteria can be distinguished. In the first place, strict basic criteria which have to be met by the geometry (hull form, fore castle height and length, bulwark height, etc.) or the loading condition of the ship (minimum and maximum draft): no slamming, no “green seas”, intact stability requirements, deck wetness limitations. A second set of criteria need to be assessed as a consequence of the behaviour of the vessel in the sea conditions anticipated during its lifetime: e.g. wave bending and torsional moments, rolling angle, accelerations.

Several vessels have been approved for extended estuary traffic according to these principles:

- Since 2004, BSI has approved three inland tankers for estuary traffic between Antwerp and Zeebrugge, in sea states with a significant wave height up to 1.60 m. For these tankers, Tanzanite (Wiljo nv, Antwerp), Texas (Verbeke Bunkering nv, Sint-Job in’t Goor) and Breitling (R. Verstraeten, Schilde), the risk analysis was carried out by the UGent Division of Maritime Technology. The three tankers have approximately the same overall dimensions (length over all 110 m, beam 13.5 m).
- Three estuary car carriers Waterways 1/2/3, the first of which was put into service in January 2004, are operated by Cobelfret nv, Antwerp (Guns, 2004). The ships have been designed for operation in Hs values up to 1.75 m. For more details on this extended estuary service reference is made to Truijens et al (2006).
Figure 2. Bol van Heist (Wavec, 1997-2002): Percentage of \( n \) hours time blocks during which the significant wave height is not exceeded.

Figure 3. Bol van Heist (Wavec, 1997-2002): Percentage of 6 hours time blocks containing a slot of at least \( n \) hours during which the significant wave height is not exceeded.

Figure 4. Bol van Heist (Wavec, 1997-2002): Average duration of an interruption due to excessive wave height, average yearly number of interruptions and downtime percentage as a function of maximum allowable significant wave height.

Figure 5. Bol van Heist (Wavec, 1997-2002). Cumulative frequency of occurrence of significant wave height: seasonal fluctuations.
2.2 New regulations

As mentioned in chapter 1.2, the existing regulations for estuary vessels date back to 1962 and are not adapted to cater for new developments in the shipping sector. Rather than to continue to develop or adapt these restrictive regulations, the choice was made to develop a completely new set of regulations partly based on the principle of risk analysis and experience gained over many years with seagoing inland waterway vessels. This approach could be seen as a simplified form of the idea of “goal based standards” which is currently under discussion at the IMO.

The scope of the new regulation is restricted to fully certified inland waterway vessels transporting cargo on non-international voyages and going out to sea in a restricted area between the Scheldt estuary and Belgian coastal harbours under verifiable restricted weather, sea state and load line conditions. These restrictions are annotated in the Supplementary Community inland navigation certificate of the vessel. This annotated certificate, delivered by the Belgian inspection body for inland navigation, has a validity of 5 years and is subject to a yearly survey. It is mandatory to class the vessel with a recognised organisation in its highest class. The vessel needs full ADNR certification and the competence of the crew will have to be supplemented with specific STCW-certification.

Annex I to the regulations gives a list of requirements supplementing the requirements under the existing regulations for inland waterway vessels further ensuring the vessels ‘restricted seaworthiness’:

- Chapter 1 requires full compliance with the European marine equipment directive as well as with Marpol and Colreg regulations.
- Chapter 2 requires compliance with restrictions of a statistical type, on slamming, water intake, roll of vessel, bending moment, torsion and accelerations, which has to be demonstrated through a risk analyses for certain types of ships (see further). The methodology of the analysis is described in the appendix to annex 1. The restrictions annotated in the Supplementary Community inland navigation certificate of the vessel stem from the results of this analyses endorsed by the Belgian maritime inspectorate.
- Chapters 3 to 10 give supplementary requirements on the different aspects of the ship’s construction, stability and equipment.

Annex II lays down the minimum standards of the assessment procedures for the captain to decide whether or not to start the voyage. On the basis of weather and wave height actual measurements and predictions from an approved information provider, the procedure will provide the captain with a ‘go / no go’ answer subject to the annotated restrictions. The procedure needs basic approval by the Belgian Shipping Inspectorate.

The new regulations are expected to enter into force by the beginning of 2007. Certificates for existing ships under the service rule from 1962 will cease to be valid on a fixed date in the future.

2.3 Risk analysis

Concerning the behaviour of the vessel in a seaway, the new regulations require a number of probabilistic conditions to be fulfilled. For all probability calculations, it is assumed that the vessel performs 300 round trips per year during a 20 years’ lifetime.

- The probability that the most forward point of the ship’s keel emerges from the water must not be more than once a year.
- The probability that the water reaches the fore deck or the top of closed bulwarks on the forecastle must not exceed once in a lifetime. In determining the relative vertical motion at the bow, the height of the bow wave and dynamic piling-up as a result of diffraction and radiation must be taken into account. If no reliable empirical data from model or full-scale tests are available, the new regulations provide a formula to calculate this allowance.
- The probability that the water level exceeds a reference level at the sides must not be greater than once in a lifetime. This reference level is defined as follows:
  - in case of vessels with watertight steel hatch covers: at the top of the hatch coamings;
  - in case of vessels with open hatches, two levels are considered:
    - at a safety distance under the top of the hatch covers, being 20% of the vertical distance between the waterline and the top of the hatch covers, 0.90 m above the deck at side;
    - 0.35 m above the deck at other sections.
- The probability that the water reaches the aft deck or the top of closed bulwarks on the forecastle must not exceed once in a lifetime.
- The probability that the roll angle exceeds 67% of either the angle of flooding or the angle corresponding with the maximum of the stability curve must not be greater than once in a lifetime; the roll angle must never exceed 15 degrees.
- With respect to strength conditions to be fulfilled, the values occurring once in a lifetime of following phenomena due to wave action must be calculated as well: the vertical longitudinal bending moment, the torsional moment, the lateral accelerations of cargo on deck and of the movable wheelhouse.

For the risk analysis, the vessel’s response to all directional spectra measured at location Bol van Heist during one year has to be calculated. Therefore, the following ship response functions for each loading condition have to be determined for all relevant wave frequencies and wave incidence angles (see figure 6):
• the relative vertical motion of a number of selected points: the most forward point of the ship's keel, one or more points on the bulwark of the forecastle, a number of points on the main deck or on the rim of the hatch side coamings, port and starboard, one or more points on the bulwark on the aft deck;
• the roll motion;
• internal loads (vertical bending moment, hydrodynamic torque,…);
• acceleration components at a number of selected points (wheelhouse, cargo,…).

For the two heading angles corresponding with the passages West Scheldt – Zeebrugge and vice versa, all required response spectra are calculated for each directional wave spectrum. From each response spectrum, the significant response magnitude and the average time between zero-crossings of the response are computed. For each directional wave spectrum, the number of times the critical value(s) for each of the ship responses considered is expected to be exceeded during a crossing can be calculated. The spectra are then grouped in significant wave height classes with an interval of 0.05 m or less. For each interval, the conditional average number of times the critical value is expected to be exceeded during a crossing is determined as a function of the significant wave height. From this function, the cumulative average number of events can be calculated, i.e. the average number of times the critical value is expected to be exceeded during any crossing, if a particular value of the significant wave height is considered as a maximum allowable value and is therefore never exceeded. Figure 7 shows an example.

Assuming that 300 crossings per year are carried out, and a ship's lifetime is 20 years, the critical value is expected to be exceeded once a year or in a lifetime if the cumulative average number of events equals 1/300 or 1/6000, respectively.

Depending on the criterion which is applicable, the value of \( H_s \) corresponding with one of the above probabilities according to the cumulative average curves determines the limiting conditions in which the ship can be allowed to operate.

Figure 6. Typical selection of points for calculation of the relative vertical motion or lateral acceleration.

Figure 7. Example of a plot showing the relation between the actual significant wave height and the (conditional) minimum, maximum and average number of times a given critical level is expected to be exceeded during a crossing, as well as the relation between the maximum allowable significant wave height and the (cumulative) average number of times the critical value is expected to be exceeded during any crossing.
3. ESTUARY CONTAINER TRAFFIC AS AN ALTERNATIVE HINTERLAND CONNECTION

3.1 Measures to stimulate inland traffic as an alternative hinterland connection for container transport

In July 2005 measures for a total estimated budget of 6.24 million EUR have been proposed by the Flemish government to stimulate the operation of estuary inland vessels for container transport between the Flemish coastal harbours and the hinterland (Flanders and the Rhine). As mentioned in chapter 1.1, nowadays container transport to and from Zeebrugge/Ostend almost exclusively occurs via the road.

The pilot project consists in using the existing capacity of the canal Ghent-Bruges-Ostend in the most optimal way for hinterland traffic with traditional container inland waterway vessels. Therefore the project provides a limited financial support for operational use of these inland waterway vessels during a start-up period of three years. Furthermore, the project aims at the introduction of estuarine (container) navigation whereby adjusted or specifically designed container vessels are used on the short sea route between the two coastal ports (temporarily only Zeebrugge) and the estuary of the river Scheldt. In this case, the project provides for a limited financial support for the (re)construction and operational use of these estuarine vessels, equally during a three years start-up period.

During a start-up period of three years the service provider(s) can enjoy a variable financial subsidy per TEU, in addition to a fee for the (re)construction of the inland waterway vessels to make them suitable for estuarine navigation. The service provider has to process an increasing volume of container traffic during this start-up period (3 years). During the following seven years, he equally has to process a minimal volume of container transport via inland waterway navigation or estuarine navigation. In case the service provider does not achieve these minimal requirements concerning container transport a penalty regime can be imposed.

As stated in the decision of the Flemish government concerning the principal validation of the project of estuarine navigation a prime condition for the actual implementation of the project is the notification and positive evaluation of the project and the financial support proposed by the services of the European Commission. At this moment the notification procedure is still ongoing.

A more detailed description of the proposed measures is given in Appendix 1.

3.2 Feasibility study for open hatch container vessels

In the frame of the measures taken by the Flemish authorities to stimulate the operation of estuary vessels as an alternative hinterland connection for container traffic, a limited risk analysis has been performed by Ghent University in co-operation with Lloyd’s Register EMEA to investigate the feasibility of four types of open hatch container vessels for operation in sea states up to significant wave heights between 1.7 and 2.0 m. The results of this study served as a tool for the Flemish Authorities to evaluate candidate service providers, and were also consulted by the Federal Public Services Mobility & Transport during the development of the new regulations.

<table>
<thead>
<tr>
<th>Length over all (m)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam (m)</td>
<td>11.4</td>
<td>17.1</td>
<td>17.1</td>
<td>22.8</td>
</tr>
<tr>
<td>Draft (m)</td>
<td>2.5 – 4.0</td>
<td>3.0 – 5.0</td>
<td>3.5 – 5.0</td>
<td>3.5 – 5.0</td>
</tr>
<tr>
<td>Freeboard (m)</td>
<td>2.5 – 3.0</td>
<td>2.5 – 3.5</td>
<td>2.5 – 3.5</td>
<td>3.0 – 4.0</td>
</tr>
<tr>
<td># TEU in length</td>
<td>13</td>
<td>13</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td># TEU in beam</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td># TEU in height</td>
<td>3 – 4</td>
<td>4 – 5</td>
<td>4 – 5</td>
<td>4 – 5</td>
</tr>
<tr>
<td>Totaal # TEU</td>
<td>156 – 208</td>
<td>312 – 390</td>
<td>408 – 510</td>
<td>544 – 680</td>
</tr>
<tr>
<td>Height of centre of gravity above keel (m)</td>
<td>3.0 – 5.0</td>
<td>4.0 – 6.5</td>
<td>4.5 – 6.5</td>
<td>4.5 – 7.0</td>
</tr>
<tr>
<td>Metacentric height GM (m)</td>
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<td>1.0 – 5.0</td>
<td>1.0 – 4.5</td>
<td>4.5 – 10.0</td>
</tr>
</tbody>
</table>

Table 3. Feasibility study for estuarine container traffic: Loading configurations.

<table>
<thead>
<tr>
<th>Draft (m)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>KG (m)</td>
<td>3.00</td>
<td>3.50</td>
<td>4.00</td>
<td>3.50</td>
</tr>
<tr>
<td>KG (m)</td>
<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
<td>5.50</td>
</tr>
<tr>
<td>KG (m)</td>
<td>4.00</td>
<td>5.00</td>
<td>6.50</td>
<td>6.50</td>
</tr>
<tr>
<td>KG (m)</td>
<td>2.38</td>
<td>2.38</td>
<td>3.05</td>
<td>3.05</td>
</tr>
<tr>
<td>KG (m)</td>
<td>2.36</td>
<td>2.38</td>
<td>3.05</td>
<td>3.46</td>
</tr>
</tbody>
</table>
The main dimensions of the four vessels are summarised in Table 2. For each vessel, five loading conditions – of which one in ballast – have been examined, as indicated in Table 3. For each configuration, the following data have been determined:

- the minimum level of the forecastle deck and aft deck bulwarks, the main deck and the top of the hatch coamings required for meeting the new regulations from the point of view of shipping of water (see example in Figure 8);
- the minimum draft fore required to avoid slamming (see Figure 9);
- the roll angle reached once in a lifetime;
- the lateral acceleration of selected points (upper container, wheelhouse) occurring once in a lifetime;
- the vertical wave bending moment occurring once in a lifetime; based on these results, the total vertical bending moment has been determined (see Figure 10), and an estimation was made for the additional steel weight required compared to a conventional inland vessel with the same dimensions (Figure 11);
- the wave induced torsional moment occurring once in a lifetime.

4. CONCLUSIONS

Estuary vessels, i.e. inland vessels strengthened and equipped for safe operation between the Belgian coastal harbours and the West Scheldt in favourable weather and wave conditions, are expected to offer an alternative hinterland connection for the Belgian coastal harbours, especially for container traffic. Although the concept exists for more than 40 years, important opportunities have recently been created by new regulation, restricted to fully certified inland waterway vessels transporting cargo on non-international voyages and going out to sea in a restricted area between the Scheldt estuary and Belgian coastal harbours under verifiable restricted weather, sea state and load line conditions. The new regulations are based on probabilistic design procedures, including a risk analysis with respect to criteria which take due account of the limitations inherent to the design of inland vessels.

In order to avoid road congestion as a result of the increasing container traffic to the harbour of Zeebrugge, financial measures have been proposed by the Flemish authorities to stimulate the operation of estuary inland vessels for container transport from and to the coastal harbours, implying financial support for construction and exploitation. In the frame of these measures, a limited risk analysis has been performed to investigate the feasibility of four types of open hatch container vessels (length 110-135 m, beam 11.4-22.8 m) for operation up to significant wave heights between 1.7 and 2.0 m.

Although the present approach is focused on the trajectory between Zeebrugge and the West Scheldt estuary, the concept can be extended to other coastal areas with limited access to the inland waterways network. In order to provide a reliable alternative to other transport modes, the weather/wave limitations should be not too restrictive so that an acceptable downtime is obtained. However, a safe operation requires reliable wave climate monitoring and forecast and an assessment procedures for the captain to decide whether or not to start the voyage taking account of the present and expected wave conditions.

REFERENCES

Dumon, G., Marine meteorological support optimizing shipping traffic in a coastal zone and river estuary, 30th PIANC-AIPCN Congress, Sydney, paper S3D2 P46, September 2002.
**Figure 8.** Ship configuration C1A: required water levels according to new regulations for several values of the maximum allowable significant wave height.

**Figure 9.** Required minimum draft fore to restrict the occurrence of loss of contact between the ship’s keel and the water to less than once a year, as a function of the maximum allowable significant wave height.

**Figure 10.** Total vertical wave bending moment for all ship configurations as a function of the maximum allowable significant wave height.

**Figure 11.** Estimated additional steel weight compared to a conventional inland vessel with the same dimensions as a function of the maximum allowable significant wave height.
APPENDIX 1.
Scope of application
The subsidy will be granted to (a) service provider(s) of – existing or new – container transport services via estuarine navigation or inland waterway navigation from the Flemish coastal ports to inland terminals located in Flanders (possibly also the Walloon Region) or the Rhine area. This subsidy will therefore not be granted to shipbuilding yards, portal authorities, ship-owners (as far as they do not provide such regular transport services) or inland terminals. The aid scheme is open and accessible for any private or public party, regardless of its nationality and activity.

The traffic type eligible is exclusively container traffic. Other categories (cars, roll on roll off, bulk, etc.) do not fall within the aid scheme. The measure only applies to the transport of containers from and to the Flemish coastal ports (Zeebrugge and Ostend) and the North-West European hinterland; pure maritime transport, e.g. connections between Zeebrugge/Ostend and Rotterdam or other European seaports, is excluded.

Selection of the service providers
In principle the selection of service providers is not subject to the legislation on public procurement. Nevertheless, the procedures laid down in this legislation on public procurement are an appropriate instrument to ensure transparency and equal treatment of the candidates. Therefore the service provider(s) will be chosen in accordance with this legislation on public procurement by means of a negotiation procedure with advance notice.

Through a public call for tenders market opportunities will be found for private parties to undertake this kind of container transport. The Agency W&Z NV consequently enters into an agreement with the service providers. The public authority can award the project to several candidate-service providers, each with a specific limited number of vessels.

Calculation of the subsidy
A calculation is made of the difference in operational costs for inland waterway transport via the current canal Ostend-Bruges-Ghent (vessel type 60 and 90 TEU) and inland waterway transport via estuarine navigation to Zeebrugge. Furthermore, a comparison is made with the operational costs for inland waterway transport to Zeebrugge in the event a new canal with large moulding (vessel type 220 TEU) would be available.

Two areas are identified as destinations for hinterland traffic: the area of Flanders including the inland terminals of Willebroek and Meerhout, and the Rhine area including the inland terminals in the range of Duisburg – Koblenz.

In comparison to a 220 TEU vessel via a new canal, the additional costs for a 90 or 60 TEU vessel via the existing canal Ostend-Bruges-Ghent amount, respectively:
- 5.71 to 7.49 EUR per container (on average 4.4 EUR per TEU) for a destination in Flanders,
- 22.53 to 25.88 EUR per container (on average 16.14 EUR per TEU) on the route Zeebrugge – Rhine, to be divided by 1.5 for the additional costs per TEU. These extra costs are the basis for the subsidy granted to the service provider(s) per loaded or unloaded TEU.

Research by Ghent University has shown that the costs for constructing and operating estuarine vessels are 25 to 30% higher compared to traditional inland waterway vessels of equal size. Furthermore, the calculations show that only estuarine vessels with sufficient loading capacity will become economically viable.

Besides estuarine navigation with new or specifically designed vessels also traditional inland waterway transport is subsidized. In this case, no construction fee will be allowed.

Total estimated budget
The project is proposed during the period 2006-2008. The total estimated budget amounts to 6,240,776 EUR for the three years of the start-up period. As far as estuarine navigation is concerned, the budget of year 1, being 4,530,443 EUR, relates to the construction and the operational use of these vessels. Construction of estuarine vessels amounts to 2,250,000 EUR. The figures of years 2 and 3, being 1,140,222 EUR and 570,111 EUR, respectively, only relate to the variable support for operational use of estuarine and traditional inland waterway vessels.

State aid scheme
The service provider receives aid under the form of financial support for the (re)construction of specifically adjusted or designed vessels which can navigate between Zeebrugge (later also Ostend) and the estuary of the river Scheldt, and/or the operational use of these or traditional inland waterway vessels.

The state aid scheme consists thus out of three elements: a construction fee relating to the investment costs, a variable subsidy per TEU relating to the operational costs and a penalty regime.

Prior and in addition to the (variable) subsidy per TEU, financial support is granted for the construction of estuarine vessels, or the reconstruction of traditional inland waterway vessels into estuarine vessels. The construction fee relating to the investment costs is limited to 20% of the total construction costs of the estuarine vessel, with a maximum of 375,000 EUR for a 220 TEU vessel. The private partner is thus responsible for at least 80% of the investment. Furthermore, this (re)construction support will only be granted when the estuarine vessel(s) are into operation. The construction of traditional inland waterway vessels will not benefit from this financial support for investments costs.

The maximum financial support for operational costs to be granted for each TEU which can be loaded or unloaded from an inland waterway vessel between the Flemish coastal ports and the terminals in Flanders (possible extended to the Region of Wallonia) will be 4.40 EUR, to be increased to 16.14 EUR for vessels serving terminals in the Rhine area.
This amount will be halved each year over the first three years. The average subsidy per equivalent TEU granted over three years amounts thus to 2.57 EUR for Flanders and 9.42 EUR for the Rhine area.

To be eligible for aid, the service provider must:
- Transmit one or more precise navigation schemes in both directions which apply for the whole year;
- Process supply in the seaports, irrespective of destination and origin;
- Ensure a non-discriminating access for all potential users to these services;
- Respect the fixed services schemes and frequencies;
- Transmit a financial plan which states the costs and the expected profitability (the projects must be viable after a period of maximum three years).

The service provider has to process a minimal volume of equivalent TEU during the start-up period of three years: 40, 60 and 80% of the available (subsidised) capacity during years 1, 2 and 3, respectively. In the event these minimal volumes per destination Flanders and Rhine are not met, the subsidy will be lowered in accordance to these minimal obligations (40%, 60% and 80%) and the subsidy per TEU in the year concerned. Furthermore, the service provider has to guarantee that (estuarine) inland waterway navigation remains possible during a period of seven years following the start-up period. To that extent, the service provider will have to process a minimal traffic volume each year of 80% of the available (subsidised) capacity.

During these seven years, the service provider will be penalised if he does not meet minimal traffic volumes. This penalty equals (1) the difference between the actual volume of equivalent TEU processed and the minimal traffic volume (80% of the available capacity) multiplied by the subsidy per TEU in the third year of the start-up period and (2) the reimbursement of the construction fee. This reimbursement equals to one seventh of the construction fee (i.e. investment support), and is brought to one third of the construction fee in the event the amount of equivalent TEU processed is lower than 50% of the required traffic volumes.

In the event the required traffic volumes will not be reached – which would imply that the project fails - service provider will lose in the years 2 and 3 some subsidy obtained and will be penalised in the years 4 to 10 in relation to the received construction fee and the actually handled volumes. In the worst case, the service provider will have to reimburse all financial support received. The aid scheme thus includes a strong ‘incentive’ to encourage the service provider and to effectively promote hinterland traffic via the waterway.

Control mechanisms

The aid scheme does not make a distinction between empty and full containers. The first aim is to avoid the transport of (full or empty) trucks by road. Therefore a focus can preferably be given to the number of TEU regardless if they are full or empty. The scheme however has to avoid that empty containers are transported back and forth in order to obtain the financial support provided in this scheme. The tenders of the service providers will be evaluated according to the guarantees given to avoid such situations. Such guarantees can for example be given via computer follow-up.