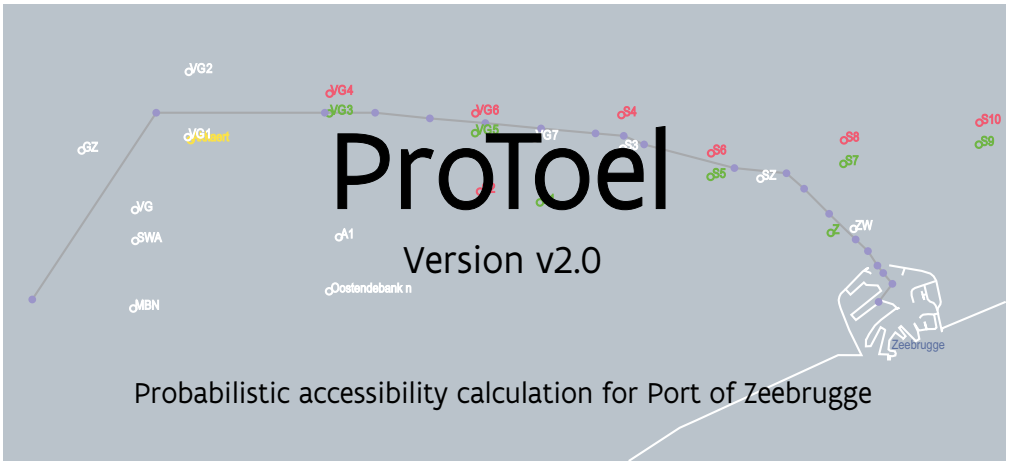

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ProToel v2.0

User manual

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ProToel v2.0

User manual

Verwilligen, J.; Defourny, D.; Vos, S.; Peeters, P.; Mostaert, F.

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This publication should be cited as follows:

Verwilligen, J.; Defourny, D.; Vos, S.; Peeters, P.; Mostaert, F. (2020). ProToel v2.0: User manual. Version 2.0. FHR Reports, 14_078_1. Flanders Hydraulics Research & ATOS: Antwerp

Document identification

Customer:	Flanders Hydraulics Research	Ref.:	WL2020R14_078_1
Keywords (3-5):	ProToel, Probabilistic, Tidal Window, User Manual		
Knowledge domains:	Harbours and Waterways > Safety > Risk analysis > Simulations Harbours and Waterways > Ship motion > Squat > Numerical calculation Harbours and Waterways > Ship motion > Seakeeping > Numerical calculation		
Text (p.):	40	Appendices (p.):	24
Confidential:	☒ No	☒ Available online	

Author(s):	Verwilligen, J. (FHR); Defourny, D. (ATOS)

Control

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Reviser(s):	Vos, S.	Getekend door: Stijn Vos (Signature) Getekend op: 2020-10-22 11:27:01 +00:00 Reden: Ik keur dit document goed
Project leader:	Verwilligen, J.	Getekend door: Jeroen Verwilligen Getekend op: 2020-10-19 12:25:02 +00:00 Reden: Ik keur dit document goed

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Abstract

In March 2017 Flanders Hydraulics Research released version 2.0 of their probabilistic accessibility tool ProToel, dedicated to the calculation of tidal windows to the port of Zeebrugge.

The major new developments in ProToel v2.0 concern:

- separation of client module and solver module allowing to perform the calculations both on a local machine (stand alonestandalone mode) or on a remote server (server mode);
- implementation of an sql-database;
- synchronization functionality with remote server;
- licensing mechanism based on different roles (user, power user, administrator);
- optimized web service processing;
- fall back functionality for environmental data;
- independent reduction point (rdp) definition for each datatype;
- independent conditions for squat and RAO calculation;
- optimized performance;
- new GUI-platform.

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1 Introduction

This document is an updated version of report [1] and is a user manual for ProToel version 2.0 released in Autumn 2016. ProToel is owned by the Flemish Government and is a common development of Flanders Hydraulics Research and the Maritime Technology Division of Ghent University.

1.1 ProToel

ProToel is a decision support tool that can be used in probabilistic admission policy for deep-drafted ships arriving at and departing from a port. Initially ProToel was tailored to the harbour of Zeebrugge. However, the tool is not limited to the port of Zeebrugge and was successfully extended to the ports of Vlissingen (Sloehaven), Terneuzen and Antwerp in several research projects ([2, 3, 4, 5]). The development and application of ProToel was published in a number of international publications regarding probabilistic accessibility [6, 7, 8, 9].

ProToel results into an advisable tidal window, based on a number of criteria that can be both deterministic and probabilistic. In a deterministic mode, the gross under keel clearance, relative to both the nautical bottom and the top of fluid mud layers, and the magnitude of current components are taken into account. In case probabilistic considerations are accounted for, a positive advise will only be given if the probability of bottom touch during the voyage due to squat and response to waves do not exceed a selected maximum value [7] and if the manoeuvring margin does not fall below a selected minimum value.

The program predicts the probability of bottom touch and the manoeuvring margin for ships of a specified type and loading condition based on current, predicted sea states and environmental data.

The following input data are taken into consideration: ship characteristics, waterway characteristics, trajectory, nautical bottom depth, top mud depth, speed over ground and through the water, tidal elevation, directional wave spectra, current, wind and departure time.

ProToel can either be used for supporting short term decisions for a particular ship, or for long term estimations for the maximum allowable draft.

Based on a specified trajectory and departure time, ProToel calculates the under keel clearances, the manoeuvring margins and bottom touch probabilities for a specific ship following the trajectory with a chosen speed along the trajectory. The trajectory is defined by a chain of waypoints. In each waypoint, the under keel clearances (and manoeuvring margin) are calculated based on bottom depth, up-to-date current and tide data and the speed dependent squat. The bottom touch probability is calculated from the directional wave spectrum for that time, location and the motion characteristics of the ship. The calculation results are stored and can be displayed after computation.

1.2 ProToel v2.0

The major new developments in ProToel v2 concern:

- separation of client module and solver module allowing to perform the calculations both on a local machine (standalone mode) or on a remote server (server mode);
- implementation of an sql-database;
- synchronization functionality with remote server;
- licensing mechanism based on different roles (user, power user, administrator);
- optimized web service processing;
- fall back functionality for environmental data;
- independent reduction point (rdp) definition for each datatype;
- independent conditions for squat and RAO calculation;
- optimized performance;
- new GUI-platform.

1.3 Overview

This manual describes the (new) functionalities of ProToel and the setup for Zeebrugge in Section 2.

Section 3 contains an installation manual in which all steps for getting started with ProToel v2 are described.

In Section 4 the graphical user interface is presented in detail, while Section 5 explains different ways of visualizing the calculation results. In case of multiple calculations, the calculations can be initiated in batch-mode (Section 6).

The user has (depending on his role) the opportunity to add data to the ProToel-database by means of excel-files. Section 7 elaborates on this functionality.

A description of the various error messages is given in Section 8. Finally, Section 9 describes the computing requirements and gives indications of the computing time required by ProToel.

2 ProToel v2 functionalities

Chapter 2 contains a general overview of the functionalities in ProToel v2. Also the standard installation and configuration for application to the port of Zeebrugge is presented.

2.1 Database

Since v2.0 ProToel is using a sql-database (PostgreSQL) to store the required data. This database consists of four schemas (see also Appendix 1: Database structure):

- Frontend: database schema containing all data required for the client module in order to define a calculation. The frontend database holds for example tables with waypoints, trajectories, criteria, ships and fall back strategies. For data defined in the frontend schema also the source of the data is defined:
    - Server: data initially added by an administrator to the server database
    - Local: data added directly to the local database
- Env: database schema containing environmental data for the five datatypes (tide, current, waves, density and wind). Except for some static tables and for the height reference table, all data are defined by:
    - Data type:
        - Tide
        - Current
        - Waves
        - Density
        - Wind
    - Reduction point name (rdp): geographical information. A reduction point is a reference station where environmental data are defined and typically corresponds to a geographical position or area.
    - Type: information regarding the content of the data:
        - Astronomical: data resulting from long term predictions
        - Predicted: data resulting from short term predictions (app. 36 h)
        - Measured: measured data.
    - Source: Information regarding the source of the data
        - Server: data initially added by an administrator to the server database
        - Local: data added directly to the local database
        - Web service: data called from web services added directly to the local database

  Env-data are clustered to the database by means of datasets (unique combination of creation date, validity period of the data and time step).

- Ship: database schema containing all the data regarding the calculation of vertical ship motions. The ship schema covers the most common dimensions of deep-drafted container ships (Table 2) and bulk carriers (Table 3) that make use of the Scheur and Pas van het Zand channels and also contains a series of LNG carriers (Table 4). The content of the ship schema is based on seakeeping tests carried out with seven ship models in the Towing tank for manoeuvres in shallow water (co-operation Flanders Hydraulics Research – Ghent University) in Antwerp and additional numerical calculations with the 2D strip method Seaway. The database covers a large number of draft – water depth combinations, and also contains data for a variation of metacentric heights.

- Calc: database schema containing calculation results. This schema is only accessible by the solver module and is emptied after each calculation.

The rights for adapting data in the different database schemas depend on the role of the ProToel user. The general rules for database access are defined in Table 1.

Table 1 – General rules for changing local database schemas based on role

		Database Schema		
		frontend	**env**	**ship**
Role	**user**	YES	NO	NO
	power user	YES	YES	NO
	administrator	YES	YES	YES

In order to separate data defined by an administrator or a (power) user, the source of the data (respectively server and local) is defined for data in the env and frontend schema. A (power) user is not allowed to adapt data with source server.

ProToel v2.0 consists of a local database installed on the same computer as the client module and of a remote database located on an external server[1] and can work in standalone mode (calculations are performed by a local solver module) or server mode (calculations are performed on a server solver module). Also a synchronisation functionality is implemented in order to synchronize the local db with the server db. Only the administrator can make changes to the server database.

More information regarding adding data to the database is defined in chapter 7.

Table 2 – Ship database Container vessels

		Length over all [m]								
		[180:200[	**[200:220[**	**[220:240[**	**[240:260[**	**[260:270[**	**[270:280[**	**[280:290[**	**[290:300[**	**[300:310[**
Beam [m]	**[30:33[**	F100		D080						
	[33:36[	F105	F110		D085					
	[36:39[		F115	F120		D090	D095			
	[39:42[				F130			D100		
	[42:44[								W075	D105
	[44:45[					F140				
	[45:46[									
	[46:47[									
	[47:48[									
	[48:50[									
	[50:51[									
	[51:53[									
	[53:57[									

[1] At present FHR is not hosting a database server. As a result ProToel v2.0 will be used in standalone mode only and synchronization functionality is not enabled.

		Length over all [m]								
		[310:318[	[318:330[	[330:340[	[340:350[	[350:360[	[360:370[	[370:380[	[380:400[	≥ 400
Beam [m]	[30:33[									
	[33:36[									
	[36:39[									
	[39:42[									
	[42:44[	W078								
	[44:45[		D110							
	[45:46[		W080							
	[46:47[			D115						
	[47:48[			W085	D118					
	[48:50[				D120					
	[50:51[					W090	D125			
	[51:53[						W092			
	[53:57[							W095	W100	

Table 3 – Ship database Bulk carriers

		Length over all [m]							
		[180:200[	[200:220[	[220:240[	[240:260[	[260:280[	[280:300[	[300:320[	[320:340[
Beam [m]	[30:33[	G100							
	[33:36[	G105							
	[36:39[	G110	G115	H115					
	[39:42[		G120	G125					
	[42:45[				E080		H125		
	[45:48[					E085	E090		
	[48:51[							E095	
	[51:54[								E100

Table 4 – Ship database LNG carriers

		Length over all [m]		
		[280:300[	[300:320[	[320:340[
B [m]	[42:45[	L075	L078	
	[45:48[		L080	L085

2.2 Waypoints

In ProToel the environment is reproduced by means of waypoints for which bathymetric and environmental data are defined. A waypoint is identified by a name and a source (local or server).

The geographical and environmental information for a waypoint are defined by means of the following parameters:

- Position
  - Easting
  - Nothing
- Reduction points for all datatypes (see §0)

The bottom profile at waypoint-level is defined by means of the following parameters:

- Depth (nautical depth)
- Top slib depth
- Reference depth.
- Channel width to port
- Channel width to starboard
- Standard deviation on the survey accuracy
- Standard deviation due to sedimentation

The waypoints defined for an installation in Zeebrugge are visualized in Figure 1 and Figure 2.

Figure 1 – Visualisation ProToel-waypoints in the coastal routes to the port of Zeebrugge

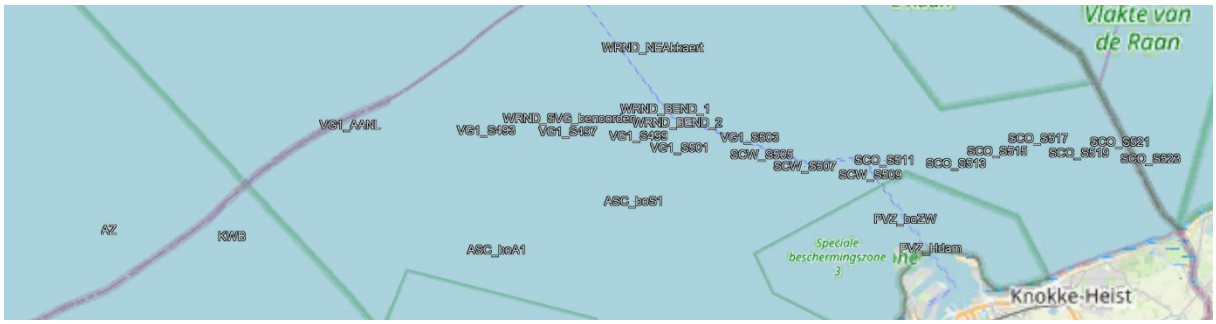


Figure 2 – Visualisation ProToel-waypoints in the port of Zeebrugge

2.2.1 Reduction points

The environmental data for different datatypes is defined at geographical reduction points. The reduction points defined for the datatypes tide, current and waves are defined in Figure 3 and Figure 4. A waypoint refers to a reduction point name for each datatype.

Figure 3 – Reduction points for datatype tide defined in ProToel v2.0

Figure 4 – Reduction points for datatypes current and waves defined in ProToel v2.0

2.2.2 Fall-back

Depending on the nature of the calculation different types and sources (see §2.1) of environmental data will be applied. For example for a historical calculation the application of measured data (type) might be most relevant, while for forecast calculations the results of long term and short term prediction models will be used. In order to define the most appropriate environmental data for a given calculation, ProToel v2 allows to define a fall back strategy for different combinations of sources and types[2]. A standard installation of ProToel comes with three types of fall back mechanisms or rdp-strategies:

- Astronomical: forecast calculation based on long term predictions for tide, current and waves (based on JONSWAP)
- Forecast: forecast calculation based on short term prediction for tide and waves (fetched from web services) with a fall back to astronomical data

[2] However the GUI is defined in such a way, the fall back mechanism is not restricted to different sources and types for one rdp. If defined accordingly in the trajectory.xml a fall back can be defined to other rdp's as well. In fact a fall back mechanism is defined for different combinations of source, type and rdp name of which only source and type (for a fixed rdp name) can be set from the GUI.

- Hindcast: historical calculation based on measured data for tide, current and waves with fall back to short term predictions and astronomical data.

In the GUI a rdp-strategy can be defined for each data type (see §4.2.3). It is advised to apply astronomical data for data type current. By default the following rdp-strategies are selected in the config-file:

- Tide: Forecast,SERVER
- Current: Astronomical,SERVER
- Waves: Forecast,SERVER

Table 5 – Rdp-strategies defined in standard installation ProToel v2

	Astronomical		Forecast		Hindcast	
rdp-strategy	source	type	source	type	Source	type
0	LOCAL	ASTRONOMICAL	WEB SERVICE	PREDICTED	WEB SERVICE	MEASURED
1	SERVER	ASTRONOMICAL	LOCAL	PREDICTED	LOCAL	MEASURED
2			SERVER	PREDICTED	SERVER	MEASURED
3			LOCAL	ASTRONOMICAL	WEB SERVICE	PREDICTED
4			SERVER	ASTRONOMICAL	LOCAL	PREDICTED
5					SERVER	PREDICTED
6					LOCAL	ASTRONOMICAL
7					SERVER	ASTRONOMICAL

2.2.3 Web services

For the rdp-strategies *Forecast* and *Hindcast* one of the sources defined concerns 'webservice'. For those waypoints and reduction points for which the source web service is defined in the rdp-strategy, the database will be updated with web service data if required. This requirement depends on the actual status of the db. Web service datasets in the db for which the creation date is older than the *wsRefreshTime* defined in *protoel.config* will be neglected. Web services will only be requested for those periods for which there are no valid web service-data defined in the database. By default the wsRefreshTime is set to 360 minutes (6 hours). If for example a first calculation was performed on March 1st 2017 08:00 AM, then (if defined in the rdp-strategy) web service data will be fetched and stored in the database for the requested calculation period. If the same day the calculation is repeated (e.g. for a different draft) at 12:00 AM then no new web service data will be called from the server. The database contains web service data that are added more recently than the wsRefreshTime (4h<6h). When the calculation would have been repeated at 04:00 PM then the web service data will be called a second time because the web service data present in the db are older than the wsRefreshTime (8h>6h). The value of wsRefreshTime can be adapted as described in §4.2.2.

If web service data are added to a local database (by a powerUser or Adminstrator) then they will be stored with source *Webservice*. In case an Administrator performs a calculation with web services in server mode, then the web service data will be stored in the server database with source *Server*.

2.3 Criteria

The accessibility calculation in ProToel can be based on a number of criteria which can be divided in local and global criteria. A local criterion applies to an individual route point while a global criterion applies to a voyage and depends on the results of all route points corresponding to this voyage.

2.3.1 Local criteria

The local criteria defined in ProToel v2 can be defined for each waypoint individually. The following local criteria can be applied:

- Min_ukc_brut_abs
- Min_ukc_brut_rel
- Min_ukc_topmud_brut_rel
- Min_ukc_net_abs
- Min_ukc_net_rel
- Max_curr_spd
- Max_transv_curr_spd
- Max_wind_spd

Min_ukc_brut_abs

Min_ukc_brut_abs concerns a minimum absolute value for the gross under keel clearance with respect to the nautical bottom corresponding to a unit of length:

$$\mathrm{UKC}_{\mathrm{Brut\_Abs}} = \mathrm{h} - \mathrm{T}_{\max} \tag{1}$$

Min_ukc_brut_rel

Min_ukc_brut_rel concerns a minimum relative value for the gross under keel clearance with respect to the nautical bottom corresponding to a fraction of the maximum ship draft:

$$\mathrm{UKC}_{\mathrm{Brut\_Rel}} = \frac{\mathrm{h} - \mathrm{T}_{\max}}{T_{\max}} \tag{2}$$

Min_ukc_topmud_brut_rel

Min_ukc_brut_rel concerns a minimum relative value for the gross under keel clearance with respect to the top mud depth corresponding to a fraction of the maximum ship draft:

$$\mathrm{UKC}_{\mathrm{Top\_Mud\_Brut\_Rel}} = \frac{\mathrm{h}_{\mathrm{Top\_Mud}} - \mathrm{T}_{\max}}{T_{\max}} \tag{3}$$

Min_ukc_net_abs

Min_ukc_brut_rel concerns a minimum absolute value for the net under keel clearance with respect to the nautical bottom corresponding to a unit of length:

$$\mathrm{UKC}_{\mathrm{Net\_Abs}} = \mathrm{h} - \mathrm{T}_{\max} - \mathrm{Squat}_{\max} \tag{4}$$

Min_ukc_net_rel

Min_ukc_brut_rel concerns a minimum relative value for the net under keel clearance with respect to the nautical bottom corresponding to a fraction of the maximum ship draft:

$$\mathrm{UKC}_{\mathrm{Net\_Rel}} = \frac{\mathrm{h} - \mathrm{T}_{\max} - \mathrm{Squat}_{\max}}{\mathrm{T}_{\max} + \mathrm{Squat}_{\max}} \tag{5}$$

Min_ukc_net_rel is often referred to as the Manoeuvring Margin (MM)

Max_curr_spd

Max_curr_speed concerns a maximum value for the current magnitude corresponding to a unit of speed.

Max_transv_curr_spd

Max_transv_curr_speed concerns a maximum value for the current vector perpendicular to the course over ground of the vessel corresponding to a unit of speed.

Max_wind_spd

Max_wind_speed concerns a maximum value for the wind magnitude corresponding to a unit of speed.

2.3.2 Global criterion (maxBTP)

The maximum bottom touch probability (BTP) is the only global criterion that is taken into account in ProToel. It concerns the probability of the vessel to touch the nautical bottom during a voyage based on the local BTP's calculated for the individual routepoints. The theoretical calculation of BTP is presented in Appendix 2. If for one of the waypoints the max_btp criterion is defined than this criterion will be evaluated for the complete voyage.

2.3.3 Standard definition

A standard installation of ProToel will come with the combinations of criteria as defined in Table 6. In a trajectory definition (see §2.4) a criterion is assigned to each waypoint.

Table 6 – Criteria defined for a standard installation of ProToel v2

criteria	Local								Global
	min ukc brut rel	min ukc brut abs	min ukc topmud brut rel	min ukc net rel	min ukc net abs	Max curr spd	max transv curr spd	max wind spd	max btp
	[%]	[m]	[%]	[%]	[m]	[kn]	[kn]	[Bft]	[-]
BtpMm200	20			5					0.0001
BtpMm150	15			5					0.0001
BtpMm125	12.5			5					0.0001
BtpMm100_70	10		-7	5					0.0001
BtpMm150_70	15		-7	5					0.0001
BtpMm150_70_1.5kn	15		-7	5			1.5		0.0001
BtpMm125_70_1.5kn	12.5		-7	5			1.5		0.0001
BtpMm125_70_2kn	12.5		-7	5			2		0.0001
BtpMm100_0.5kn	10			5			0.5		0.0001
Det200	20								
Det150	15								
Det125	12.5								
Det100_70	10		-7						
Det150_70	15		-7						

criteria	Local								Global
	min ukc brut rel	min ukc brut abs	min ukc topmud brut rel	min ukc net rel	min ukc net abs	Max curr spd	max transv curr spd	max wind spd	max btp
	[%]	[m]	[%]	[%]	[m]	[kn]	[kn]	[Bft]	[-]
Det150_70_1.5kn	15		-7				1.5		
Det125_70_1.5kn	12.5		-7				1.5		
Det125_70_2kn	12.5		-7				2		
Det100_0.5kn	10						0.5		
DetMm200	20			5					
DetMm150	15			5					
DetMm125	12.5			5					
DetMm100_70	10		-7	5					
DetMm150_70	15		-7	5					
DetMm150_70_1.5kn	15		-7	5			1.5		
DetMm125_70_1.5kn	12.5		-7	5			1.5		
DetMm125_70_2kn	12.5		-7	5			2		
DetMm100_0.5kn	10			5			0.5		

2.4 Trajectories

A ship trajectory to be calculated is defined as a chain of waypoints for which the following information is defined:

- Ship speed over ground;
- criteria to be evaluated.

2.5 Solver

The calculation is fully defined by means of a XML-file (the trajectory.xml). When using the GUI or Batch Mode the trajectory.xml will be created automatically.

When sending the trajectory.xml to the solver module (using JMS communication) the solver will perform the calculation corresponding to the content of the trajectory.xml and will send the results (XML-format) and log-file (ascii-file) back to the client module.

Depending on the mode defined, the trajectory.xml will be send to the local solver or to an application server.

3 Installation and Getting Started

First be sure a Java Runtime Environment (at least version 1.8) is installed on your computer. You can do this by typing the command “java –version” in a command prompt. If java is not installed or the version is too old, please download it from the Internet and install it.

ProToel will be delivered as a zip file. Several versions of this zip file will be foreseen, taking into account the available RAM of the user’s PC, in order to optimize the Java and DB parameters.

A ProToel zip file contains:

- protoel.jar file, the ProToel executable file
- protoel.bat (or protoel.sh for Linux) calling protoel.jar with adapted Java parameters
- protoel_admin.bat calling protoel.jar with adapted Java parameters for an administrator starting ProToel for the first time
- protoel_batch.bat (or protoel_batch.sh for Linux) calling protoel.jar with adapted Java parameters and a batch file name as parameter
- a config subfolder containing several configuration files
- a data subfolder containing several installation files
- a doc subfolder containing the information about ProToel and a templates subfolder containing examples of Excel files to fill the different database schemas env, ship and frontend,
- an input subfolder,
    - with a data subfolder, with three subfolders env, ship and frontend where files to be loaded in ProToel can be put (see Section 7)
    - and a map subfolder where kml files can be put, that can be optionally displayed in the trajectory panel (see §4.3)
- an output subfolder that will contain the results of the calculations

This zip file has to be extracted in a folder of your choice, e.g. “C:\ProToel” (in this document referred to as <PROTOEL_HOME>).

The next part of the installation is depending on your environment: Windows or Linux.

3.1 MS Windows

The steps for installation are summarised here:

1. check java version and if necessary install JRE
2. extract installation zip-file to a folder of your choice
3. run *protoel.bat* or *protoel_admin.bat* (see §3.1.1)
    a. *licenceInfo.txt* is generated in config folder
4. send *licenceInfo.txt* to administrator
    a. Administrator provides *protoel.lic* file corresponding to the required role
5. store *protoel.lic* in config folder
6. run *protoel_admin.bat and a*ccept installation
    a. PostgreSQL installation (sql-database)
    b. database initialisation by data/server.dump
    c. GUI starts up
7. execute in GUI: File>Fill database>All (see §3.1.2)
    a. local data added to database
8. generate a shortcut of *protoel.bat* to your desktop (see §3.1.3).

3.1.1 Installation

Protoel can be started by means of the "<PROTOEL_HOME>\protoel.bat" command. Since no license file is contained in the installation zip file, by the first start of ProToel, a "licenseInfo.txt" file will be created in the <PROTOEL_HOME>\config folder. This file contains the necessary information to generate a license file. The licenseInfo.txt file should be provided to the administrator who generates a valid license file which has to be saved in the <PROTOEL_HOME>\config folder with the same name as defined in the <PROTOEL_HOME>\config\protoel.config file.

Once the license file installed, ProToel has to be started with administrator rights (via the "<PROTOEL_HOME>\protoel_admin.bat" command) in order to allow the automatic installation, tuning and initialization of the ProToel database. Potential errors during this installation are described in section 8.

3.1.2 Initialisation local DB

During the installation the local database is initialized with the data coming from a server dump. In fact at present FHR is not hosting a server, so that the synchronization functionality is not operational. In order to keep his local database up to date (for example to update the depth values of the waypoints) the user will have to actively fill the database. Because a (power) user is not allowed to update the data with source *Server*, a standard installation of ProToel v2 comes with empty tables for waypoints and trajectories. After installation of ProToel v2 the (power) user has to load the waypoints and trajectories with the fill database functionality for frontend (see §4.2.1). In this way the waypoints and trajectories are defined with source *Local*, and the (power) user can update them with the same procedure.

3.1.3 Starting GUI

After an installation, the GUI can be started by means of *protoel.bat* in the PROTOEL_HOME folder. It is advised to define a shortcut on your desktop in order to launch ProToel easily.

3.2 Linux

The procedure to get a license file remains valid, but since several versions of Linux exist, with several installers, an automatic installation is not possible.

The installation of PostgreSQL should take place as described in the "ProToel_Installation and Exploitation Guide" and the database should be initialized via the File > Restore menu item.

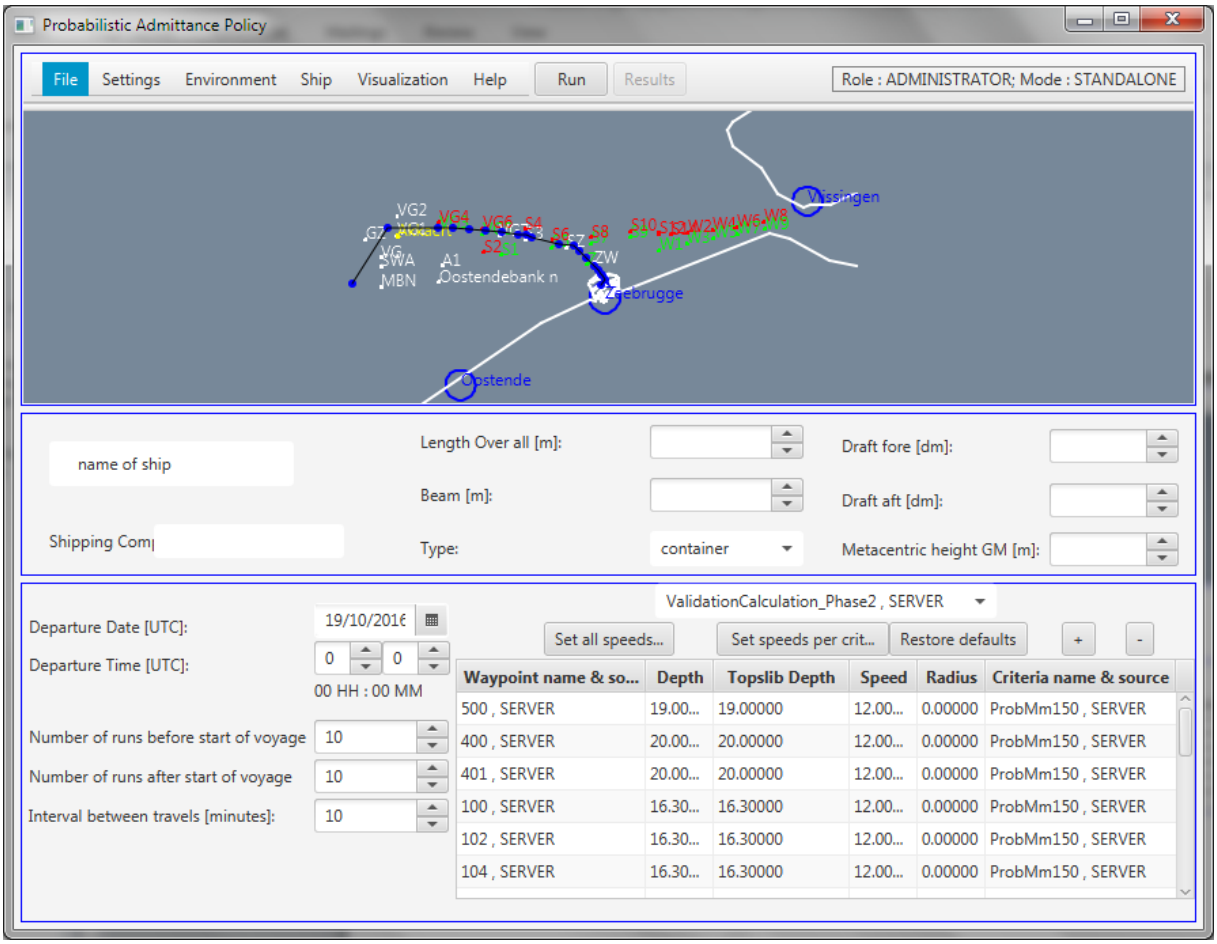
4 Graphical User Interface

4.1 Running in GUI Mode

The graphical user interface (GUI) of ProToel (see Figure 5) can be started by double clicking the batch file protoel.bat (Windows) or protoel.sh (Linux) and consists of a:

- Menu bar
- Trajectory visualization panel
- Ship data panel
- Trajectory data panel
- Voyage data panel

Figure 5 – ProToel GUI

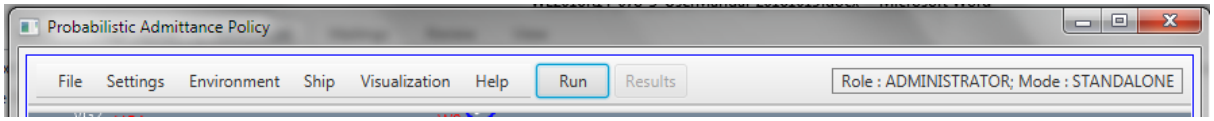


4.2 Menu bar

The ProToel menu bar (see Figure 6) consists of 6 menus and 2 buttons. The functionality of the buttons is also included in the first menu "File".

The role of the logged in user (depending on the license) and the calculation mode are also displayed in this bar.

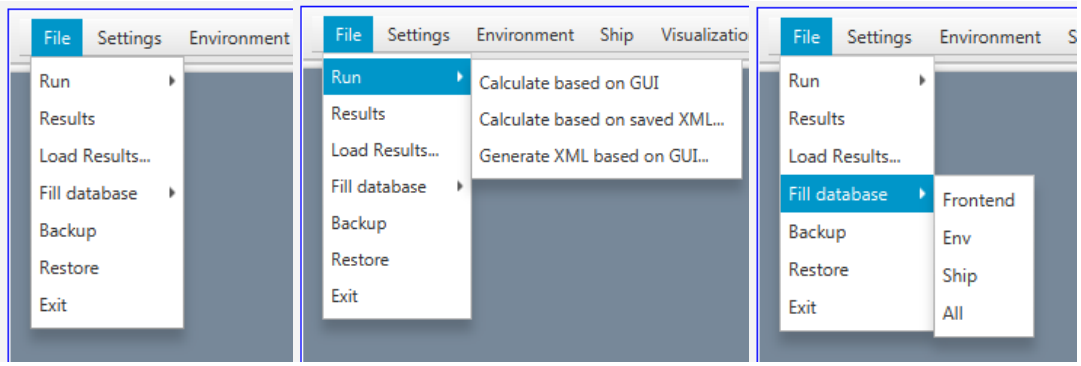
Figure 6 – Menu bar



4.2.1 File Menu

The "**File**" menu contains the menu entries displayed in Figure 7.

Figure 7 – File menu



- **"Run"**
  - "**Calculate based on GUI**" will perform a calculation based on the input defined in the GUI. This action is also available through the button "**Run**" on the menu bar. This calculation saves an XML file (trajectory.xml in output folder) that can be adapted and used for other calculations.
  - "**Calculate based on saved XML…**" will perform a calculation based on a saved XML file (format of trajectory.xml). When selecting this option, you will be able to browse the file structure to select the input file. Before that the user has to specify whether he wants to perform the calculation based on an updated status of the database or based on the historical status corresponding to the calculation date defined in the XML. In case the user decides to perform the calculation on an updated database then also web services will be updated (if applicable).
  - "**Generate XML based on GUI…**" will create a calculation input XML file (format of trajectory.xml) based on the input defined in the GUI. When selecting this option, you will be able to browse the file structure to select the place to store the file. No calculation will be performed.
- **"Results",** which can also be called by the button "**Results**" in the menu bar, is only available if a valid computation has been performed. On click, a table of the calculated results is shown which will be explained in detail in the section 5.1.
- **"Load results…"** will ask for a ProToel computation folder and opens the results xml files in a table in the same way newly calculated results are displayed.

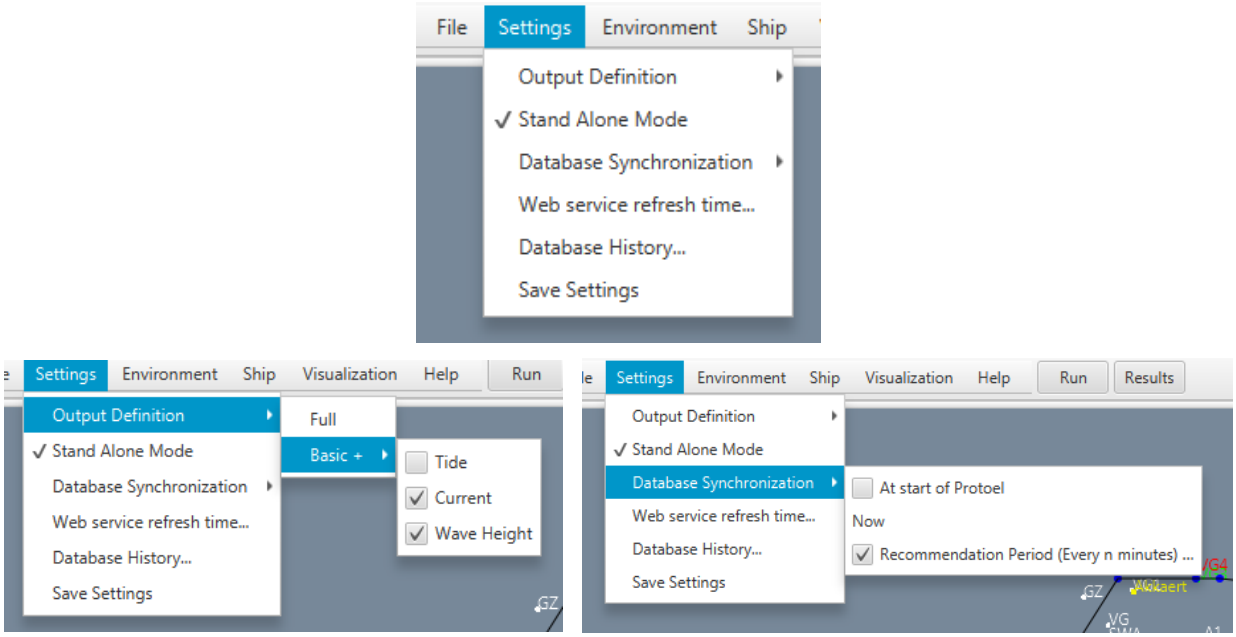
Figure 8 – Load results

- "**Fill database**" permits, according to the user's role (Administrator, PowerUser or User, see Table 1) to load data from Excel files in the different ProToel schemas in the local or server database (depending on the calculation mode defined, see section 4.2.2). How to add local data to a database is explained in §7. The Excel files are processed in alphabetical order and have to be located:
  - For "**Frontend**" in the folder <PROTOEL_HOME>\input\data\frontend
  - For "**Env**" in the folder <PROTOEL_HOME>\input\data\env
  - For "**Ship**" in the folder <PROTOEL_HOME>\input\data\ship
  - The "**All**" item will load all data above, in the order Env, Ship, Frontend.
- "**Backup**" saves the contents of your local database in the file <PROTOEL_HOME>\data\protoel_local_<yyyy_mm_dd hhmmss>.dump.zip
- "**Restore**" restores a backup stored as <PROTOEL_HOME>\data\protoel.dump.zip to your local database. This dump file can come from your local database or from a database backed up on the server or another client
- "**Exit**" exits ProToel. If some changes have been made to the settings, ProToel will propose you to first save them before exiting.

4.2.2 Settings Menu

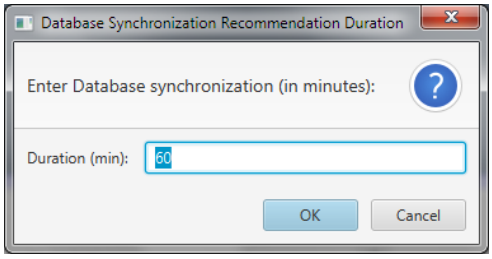
The "**Settings**" menu contains the menu entries displayed in Figure 9.

Figure 9 – Settings menu



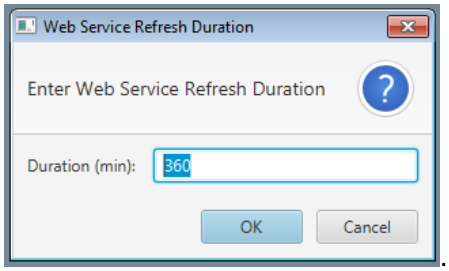
- **“Output Definition”** (see §5 for results)
  - **"Full"** means that all possible result XML’s have to be returned by the calculation.
  - **"Basic +"** means that the basic results (VOYAGE_SUMMARY, CRITERIA_SUMMARY, WAYPOINTS_SUMMARY and LOCAL_BTP_TIME) have to be returned. Additionally the following check boxes can add results to be returned:
    - “**Tide**”
    - “**Current**”
    - “**Wave height**”
- **“Stand Alone Mode”** specifies if the GUI is working in stand alone mode (checked) of server mode[3] (unchecked)
- “**Database Synchronization**[3]” contains
  - A check box “**At the start of ProToel**” that will enable the synchronization of the local DB with the server DB each time ProToel starts
  - A item “**Now**” that forces this synchronization immediately
  - A check box “**Recommendation period (Every n minutes)…**” that prompts a popup (see Figure 10) window allowing the user to define this period. If the latest synchronization dates longer than the recommended period, then the user will be asked if he wants to synchronize. By default synchronization is disabled[3].

Figure 10 – Database synchronization recommendation period



- “**Web service refresh time…**” prompts a popup window allowing the user to define the refresh time for web services (wsRefreshTime). If for a requested calculation the active DB holds web service data that are not older than the refresh time, then no new web service data will be called. By default the wsRefreshTime is set to 360 minutes.

Figure 11 – Web service refresh time

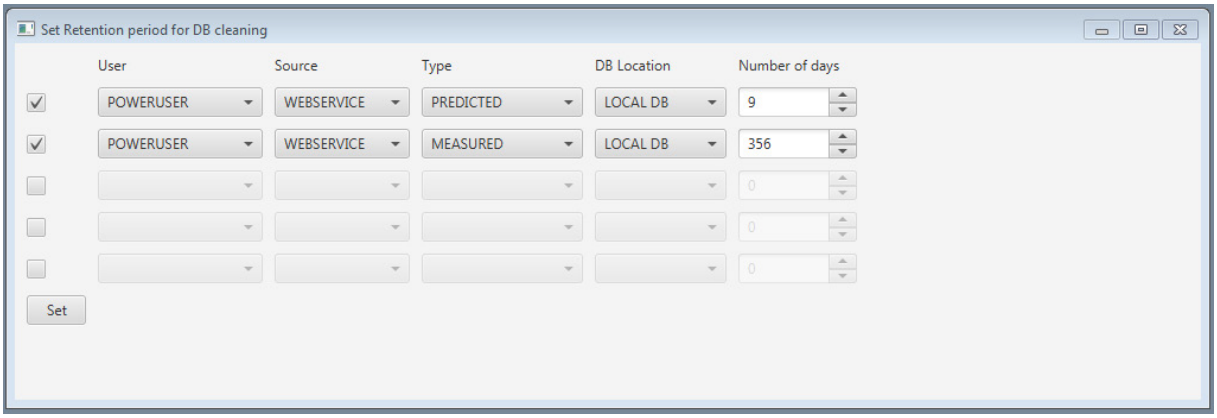


- “**Database History…**” prompts a popup allowing the user to define the data retention in days, in function of the user’s role, the source and type of data and the DB location. At start-up of

[3] At present FHR is not hosting a server for synchronization.

the GUI the Env-schema of the active DB will be checked. Datasets for which the last timestamp (valid_to_date) is older than the retention period and corresponding the other retention parameters will be deleted from the DB. The default settings for Database History are presented in Figure 12.

Figure 12 – Database History

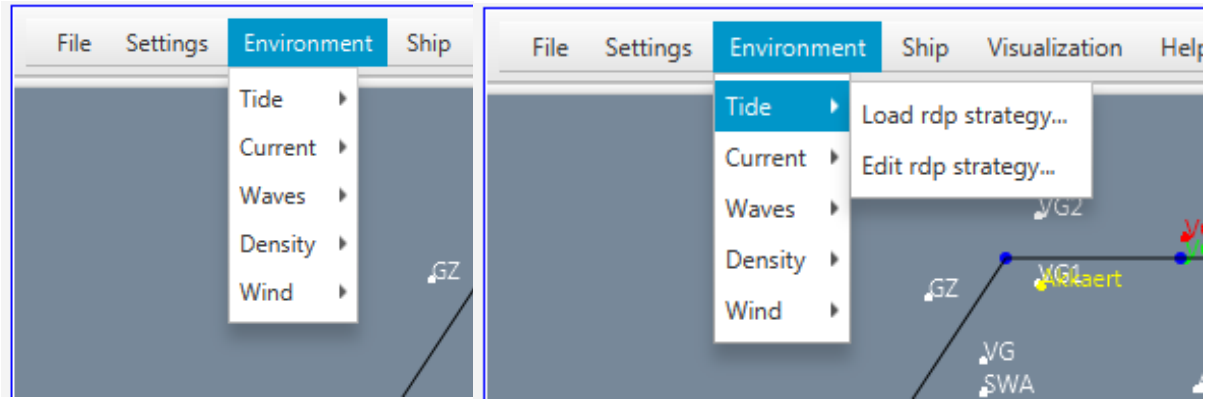


- "**Save settings**" saves all the changed settings in the ProToel config file, for the next start.

4.2.3 Environment Menu

The "**Environment**" menu contains the menu entries displayed in Figure 13.

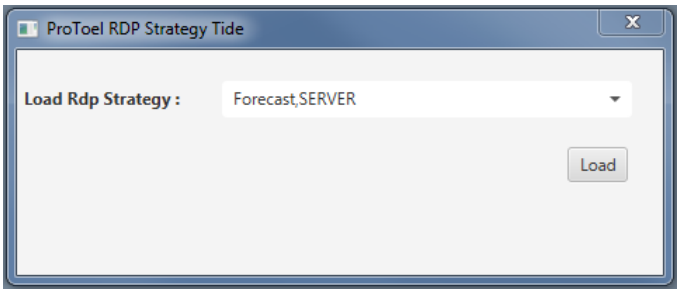
Figure 13 – Environment menu



- **"Tide"** contains the following options:
  - **"Load rdp strategy…"** prompts a popup allowing the user to select the rdp strategy name and source, for the given data type. The rdp strategy defines a fallback mechanism for env-data based on source, type and interpolation method[4].

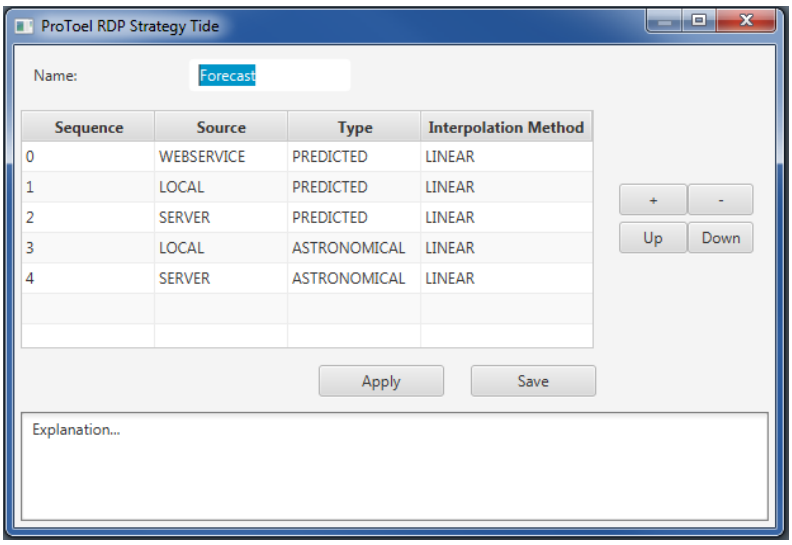
[4] The input XML also allows to use other reductionpoints as fallback. However this is not implemented for the automated XML generation from the GUI.

Figure 14 – Load rdp strategy



- **"Edit rdp strategy"** prompts a popup allowing the user to edit the rdp strategy, basis rdp and fallbacks based on source and type, for the given data type.

Figure 15 – Edit rdp strategy



This form contains:

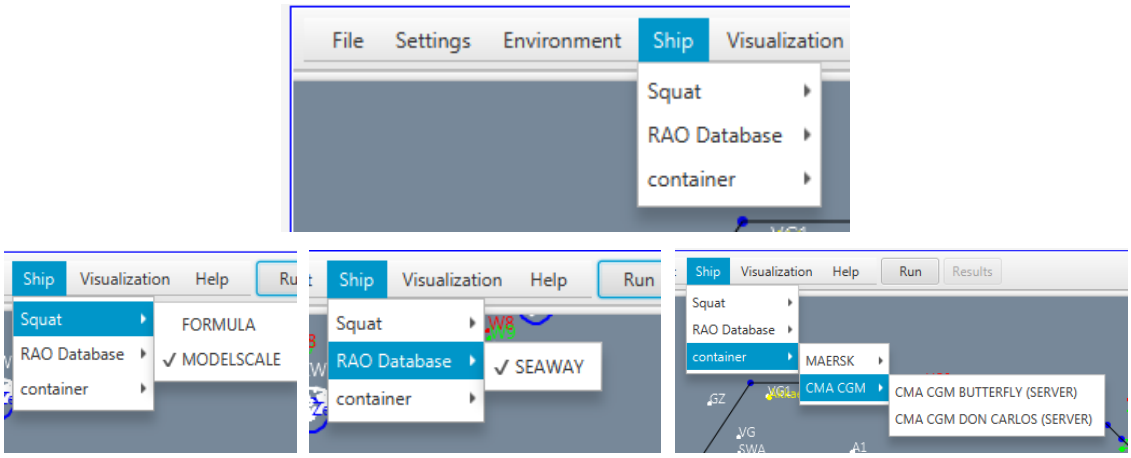
- The name of the rdp strategy
- A table with the sequences, names, sources, types and interpolation methods of the rdp's. The sequence is generated automatically
- A "**+**" button to add a rdp
- A "**-**" button to delete the selected rdp
- Up and down buttons to change the sequence of the selected rdp
- An "**Apply**" button to set the rdp strategy as active strategy
- A "**Save**" button to save to the local DB with source LOCAL and name from form, and set this rdp strategy as active strategy
- An explanation of the way to define a rdp strategy.

- **"Current", "Waves", "Density"** and **"Wind"** contain the same options as in the case of tide.

4.2.4 Ship Menu

The "**Ship**" menu contains the menu entries displayed in Figure 16.

Figure 16 – Ship menu



- **"Squat"** contains the following options:
  - With **"FORMULA"** the squat will be calculated, based on a formula
  - With "**MODELSCALE**" the squat will be interpolated based on draft, under keel clearance and speed for the MODELSCALE conditions defined in the database
  - "**…**". The possible squat options are defined in the frontend.field_possible_values table and can be adapted by the administrator.
- **"RAO Database"** contains the following options:
  - With "**SEAWAY**" the corresponding RAO database will be used. The response of the ship to waves is calculated by means of a database based on numerical calculations with the 2D strip theory software "Seaway" (integrated into "Octopus"). Although only a two dimensional approach, the motion characteristic is well represented by Seaway
  - "**…**". The possible RAO databases are defined in the frontend.field_possible_values table and can be adapted by the administrator.

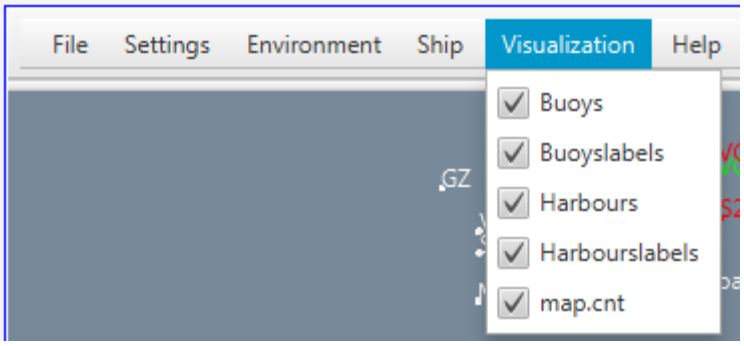
  For a limited number of ships in the database, the ship's roll response to waves is available for different values of the metacentric height; the program will select the nearest GM value in the database.

- **"container"; "bulk carrier"; "LNG"** contains the ships (name and source) of this type,
  - presented per shipping company.
  - **"…".** If other ship types are added to the frontend database (frontend.ship), they will be automatically added to the menu.

4.2.5 Visualization Menu

The "**Visualization**" menu (see Figure 17) offers the possibility to select the textual and graphical elements that will be displayed in the trajectory panel. The possible elements are defined in kml files located in the <PROTOEL_HOME>\input\map folder. The geographical reference system applied is WGS84 UTM31.

Figure 17 – Visualization menu



4.2.6 Help Menu

The "**Help**" menu contains the menu entries displayed in Figure 18.

- **"Help"**: opens this document
- **"About"**: shows some legal notes about the program which are also shown on program start up. A mouse click on the notice closes it again.

Figure 18 – Help menu

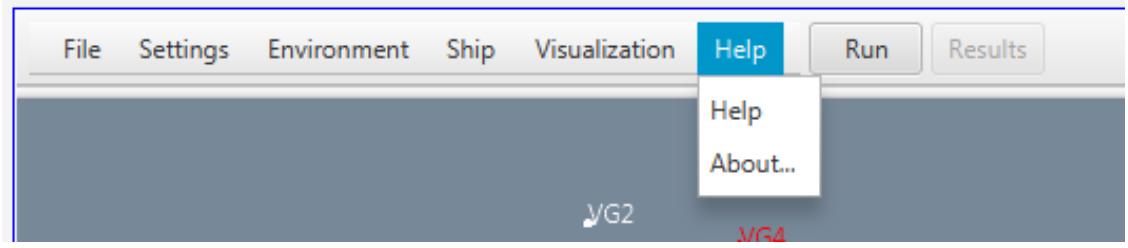
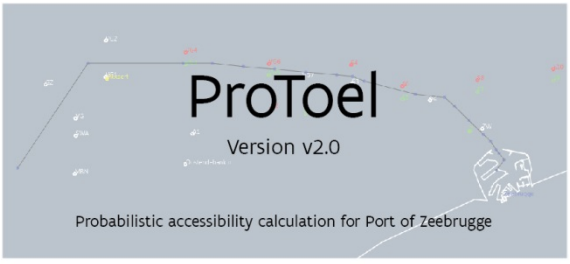


Figure 19 – About ProToel



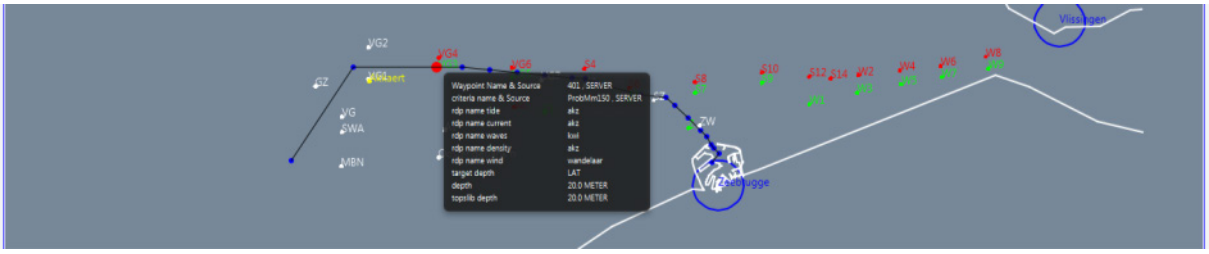
4.3 Trajectory Visualization Panel

The "**Trajectory Visualization**" panel (see Figure 20) displays the textual and graphical elements selected in the visualization menu with the trajectory selected in the trajectory data panel. The trajectory itself can be changed in the "trajectory data" panel which is described in Section 4.5. The changes will be reflected immediately in this panel.

The following actions can be performed:

- Move the mouse on a waypoint displays information about this waypoint
- Scrolling of mouse wheel allows basic zooming functionality
- Press right mouse button and move mouse to drag the map

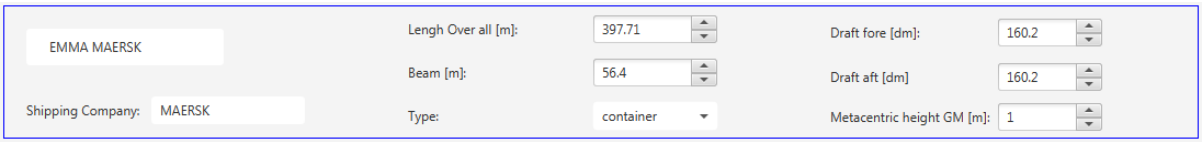
Figure 20 – Trajectory Visualization panel



4.4 Ship Data Panel

In the "**ship data**" panel (see Figure 21), the user can define the ship characteristics and the loading conditions.

Figure 21 – Ship data panel



- The ship characteristics consist of:
  - The ship's name
  - The ship's shipping company
  - The ship's length
  - The ship's beam
  - The ship type (possibilities based on the frontend.ship table).

  When performing a calculation, ProToel selects the best fitting ship from the selected database (see Table 2, Table 3 and Table 4).

  The characteristics can also be entered automatically by selecting a ship in the ship menu.

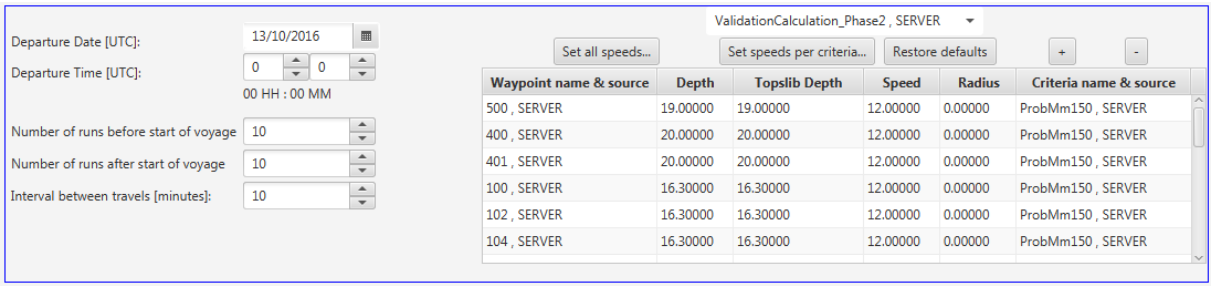
- The loading conditions consist of:
  - The draft at the fore perpendicular
  - The draft at the aft perpendicular
  - The metacentric height (GM)

4.5 Trajectory Data Panel

In the "**trajectory data**" panel the trajectory can be loaded and adapted (see Figure 22):

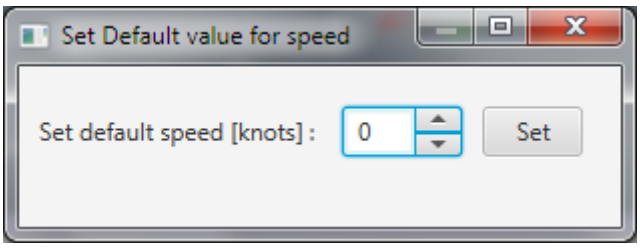
- To load a trajectory the combo box can be used. A trajectory is defined by consecutive waypoints that define the trajectory to be calculated. For each waypoint the following parameters should be defined and can be adapted in the trajectory-table
  - Waypoint (name & source)
  - Depth
    - Nautical depth (=depth)
    - Topslib depth
  - Speed over Ground (= speed)
  - Criteria (see §2.3)

Figure 22 – Voyage data panel (left) and Trajectory data panel (right)



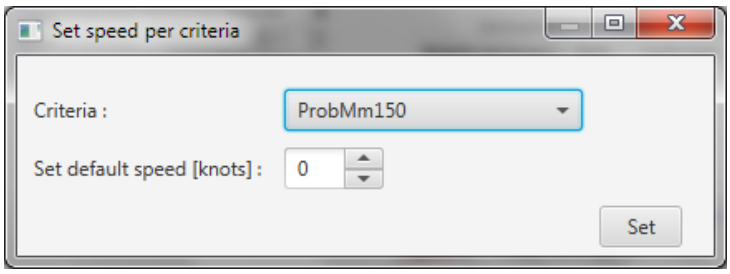
- The ship's speed along the trajectory can be adapted directly in the trajectory table. On the other hand there are some buttons to adapt speeds for a combination of waypoints:
  - "**Set all speeds…**" allows to set a fixed speed over the complete trajectory

Figure 23 – Set all speeds



  - "**Set speed per criteria…**"

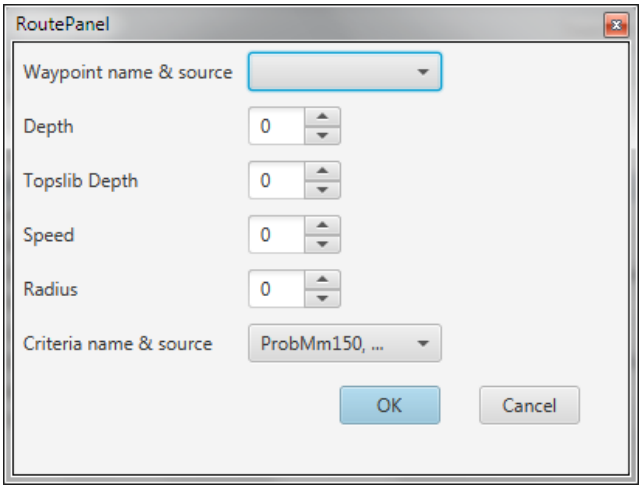
Figure 24 – Set speed per criteria



  - "**Restore default**" restores the speed settings to the initial values in the trajectory

- Adapt waypoints in trajectory
    - You can add a waypoint to the row below the selected row in the trajectory table with the "**+**" button that prompts a popup where you can define the waypoint characteristic (see Figure 25):
        - Waypoint name and source
        - depth (always in meters)
        - topslib depth (always in meters)
        - speed (always in knots)
        - radius (always in meters)
        - criteria name and criteria source

Figure 25 – Add waypoint



- You can remove the waypoint selected in the trajectory table with the "**-**" button
- You can also change the existing waypoint characteristics in the trajectory table

4.6 Voyage Data Panel

In the "**voyage data**" panel (see Figure 22), the following selections have to be made with respect to the planned voyage:

- The date and time of departure (timezone defined in <PROTOEL_HOME>\config\protoel.config and visualized in GUI);
- The number of voyages before and after the given time of departure to be calculated and the time span between each voyage in minutes.

5 Results

After a calculation, results are generated in xml format and saved in a subfolder of the <PROTOEL_HOME>\output folder.

The possible result files are:

- Summary:
  - result_voyage_summary.xml: summary xml with the acceptance of the calculated voyages;
  - result_criteria_summary.xml: summary xml with the acceptance of local and global criteria for the calculated voyages;
  - result_waypoints_summary.xml: summary xml with values and acceptance of all requested local criterion at waypoint level and the criteria set for all waypoints (local) and voyages (global);
  - result_btp_data.xml: summary xml with bottom touch probability for all voyages and local bottom touch probability at route point level

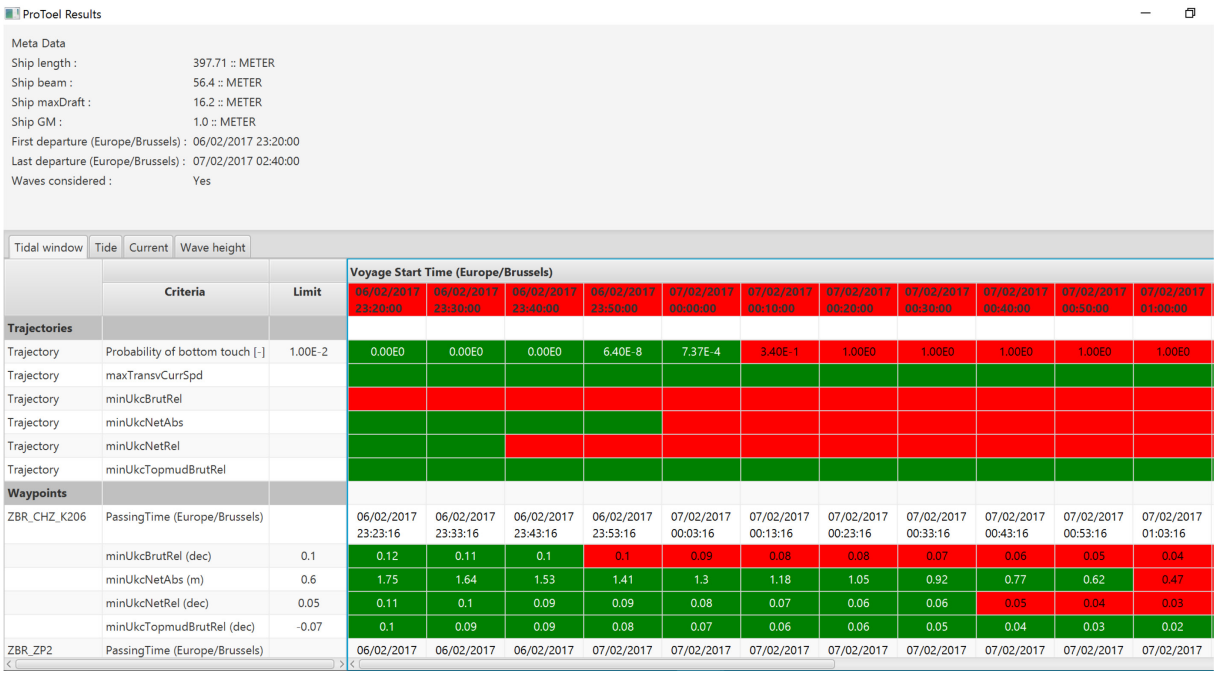
- Environmental data: xml-files with environmental data fetched from the database and metadata regarding the id's of the data
  - result_tide_data.xml: tide value [m LAT]
  - result_globalcurr_data.xml: current magnitude [m/s] and direction [°]
  - result_heightsigwav_data.xml: significant wave height [m]
  - result_zeroupcrossperiod_data.xml [s]
  - result_wind_data.xml: wind magnitude [m/s] and direction [°]
  - result_density_data.xml: density [kg/m³]
- Basic calculation:
  - result_waterdepth_data.xml: bottom depth and tide [m]
  - result_shipspeed_data.xml: speed over ground and speed through water [m/s]
  - result_longcurr_data.xml: longitudinal current [m/s]
  - result_transvcurr_data.xml: lateral current [m/s]
- Squat calculation:
  - result_maxsquat_data.xml
  - result_meansquat_data.xml
- Dynamic ship motions calculation:
  - result_shipmotion_data.xml: significant ship motion at most critical point
  - result_encounterperiod_data.xml
  - result_criticalpoints_summary.xml: most critical point
- Local criteria:
  - result_ukcbrutabs_data.xml
  - result_ukcbrutrel_data.xml
  - result_ukcnetabs_data.xml
  - result_ukcnetrel_data.xml
  - result_ukctopmudbrutrel_data.xml
- Performance:
  - result_calculation_performance.xml: calculation time at different levels: calculation, voyage, route point.

5.1 Results form

Via the menu "**File**" item "**Results**" or "**Load results…**", you will display a form (see Figure 26) containing the following results of the last calculation or of a selected saved calculation, respectively:

- trajectory.xml
- result_voyage_summary.xml
- result_criteria_summary.xml
- result_waypoints_summary.xml
- result_btp_data.xml

Figure 26 – Results with meta data and tabs with tidal window, tide, current and wave height

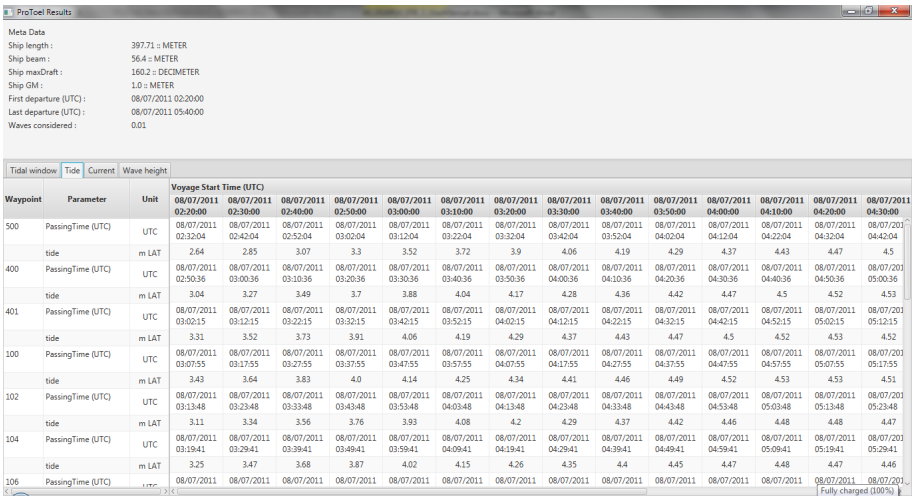


	Criteria	Limit	Voyage Start Time (Europe/Brussels) 06/02/2017 23:20:00	06/02/2017 23:30:00	06/02/2017 23:40:00	06/02/2017 23:50:00	07/02/2017 00:00:00	07/02/2017 00:10:00	07/02/2017 00:20:00	07/02/2017 00:30:00	07/02/2017 00:40:00	07/02/2017 00:50:00	07/02/2017 01:00:00
Trajectories													
Trajectory	Probability of bottom touch [-]	1.00E-2	0.00E0	0.00E0	0.00E0	6.40E-8	7.37E-4	3.40E-1	1.00E0	1.00E0	1.00E0	1.00E0	1.00E0
Trajectory	maxTransvCurrSpd												
Trajectory	minUkcBrutRel												
Trajectory	minUkcNetAbs												
Trajectory	minUkcNetRel												
Trajectory	minUkcTopmudBrutRel												
Waypoints													
ZBR_CHZ_K206	PassingTime (Europe/Brussels)		06/02/2017 23:23:16	06/02/2017 23:33:16	06/02/2017 23:43:16	06/02/2017 23:53:16	07/02/2017 00:03:16	07/02/2017 00:13:16	07/02/2017 00:23:16	07/02/2017 00:33:16	07/02/2017 00:43:16	07/02/2017 00:53:16	07/02/2017 01:03:16
	minUkcBrutRel (dec)	0.1	0.12	0.11	0.1	0.1	0.09	0.08	0.08	0.07	0.06	0.05	0.04
	minUkcNetAbs (m)	0.6	1.75	1.64	1.53	1.41	1.3	1.18	1.05	0.92	0.77	0.62	0.47
	minUkcNetRel (dec)	0.05	0.11	0.1	0.09	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.03
	minUkcTopmudBrutRel (dec)	-0.07	0.1	0.09	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.03	0.02
ZBR_ZP2	PassingTime (Europe/Brussels)		06/02/2017	06/02/2017	06/02/2017	07/02/2017	07/02/2017	07/02/2017	07/02/2017	07/02/2017	07/02/2017	07/02/2017	07/02/2017

The form contains:

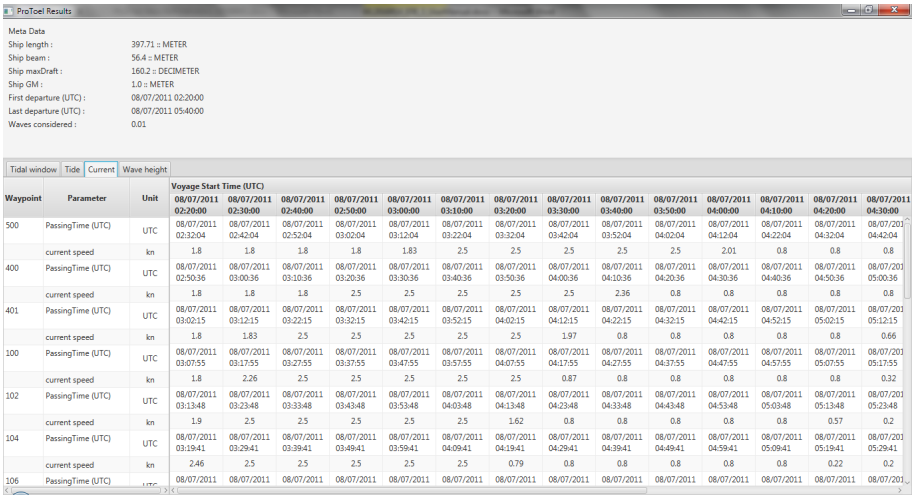
- Meta data (see Figure 26)
  - Ship length = trajectory.ship.lengthOverall trajectory.ship.lengthOverall.<unit>
  - Ship beam = trajectory.ship.beam trajectory.ship.beam.<unit>
  - Ship maxDraft = maximum of trajectory.ship.draftForward and trajectory.ship.draftAft trajectory.ship.draftForward.<unit>
  - Ship GM = trajectory.ship.metacentricHeight trajectory.ship. metacentricHeight.<unit>
  - First departure = minimum of trajectory.travels.startTime
  - Last departure = maximum of trajectory.travels.startTime
  - Waves considered = trajectory.maxBottomTouchProbability defined
- A tab with the tidal window (see Figure 26), containing, at trajectory level first and waypoint level secondly, the criteria, their limits and for each voyage (one per column) the calculated values of the criteria. The colors correspond to the success (green) or failure (red) at trajectory, trajectory criteria and waypoint criteria level.
- A tab with the tide data, if available in the results (see Figure 27), containing, at waypoint level, for the passing time and the tide, their unit and for each voyage (one per column) their calculated values

Figure 27 – Results, tide



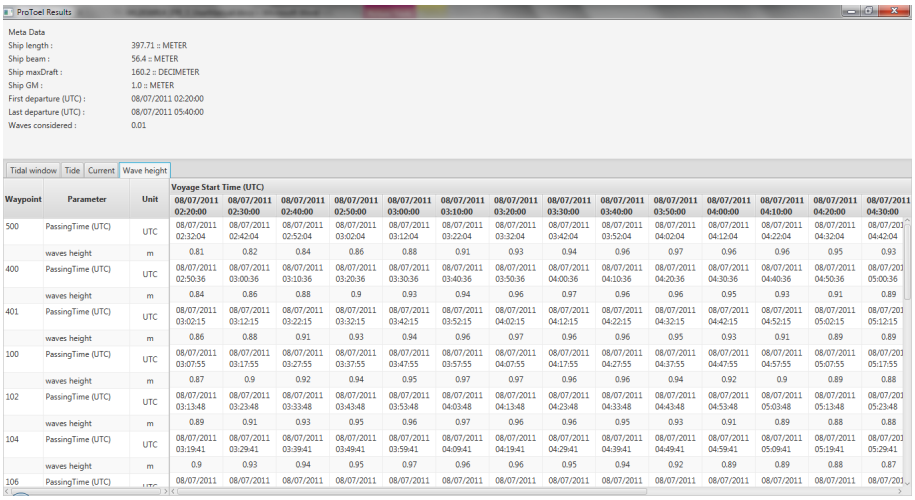
- A tab with the current data if available in the results (see Figure 28), containing, at waypoint level, for the passing time and the current speed, their unit and for each voyage (one per column) their calculated values

Figure 28 – Results, current



- A tab with the wave data, if available in the results (see Figure 29), containing, at waypoint level, for the passing time and the waves height, their unit and for each voyage (one per column) their calculated values

Figure 29 – Results, wave height



5.2 Summary pdf file

A pdf file with the same name as the ship, saved in the same folder as the xml files, contains similar results. It's based on the following xml files:

- trajectory.xml
- result_voyage_summary.xml
- result_criteria_summary.xml
- result_waypoints_summary.xml
- result_btp_data.xml

and contains the following sections:

- "**Calculation settings**"
  - description
  - calculation time (time zone as defined in config file)
  - deterministic or probabilistic
- "**Ship**"
  - name
  - type
  - length (incl. unit)
  - beam (incl. unit)
  - draft at aft (incl. unit)
  - draft at fore (incl. unit)
  - metacentric height (incl. unit)
  - motion characteristics database
  - squat database
- "**Route**"
  - trajectory name
  - first start time (time zone as defined in config file)
  - last start time (time zone as defined in config file)
  - tide data: rdp strategy of first waypoint for which tide is defined
  - current data: rdp strategy of first waypoint for which current is defined

  - wave data: rdp strategy of first waypoint for which wave is defined
  - density data: rdp strategy of first waypoint for which density is defined
  - wind data: rdp strategy of first waypoint for which wind is defined
  - table with:
    - waypoint number
    - waypoint name
    - waypoint depth (incl. unit and height reference)
    - waypoint topslib depth (incl. unit and height reference)
    - waypoint speed (incl. unit and speed type)
    - waypoint radius (incl. unit)
- "**Tidal window**"
  - Calculation of acceptable time slots (= tidal window) displayed under the form of a table containing:
    - starts at
    - duration
    - before: 'not calculated' or names of the criteria that are not fulfilled one voyage before the start of tidal window
    - after: 'not calculated' or names of the criteria that are not fulfilled one voyage after the end of tidal window
  - Table containing the same data as the tab "Tidal window" of the Results form described in section 5.1
- "**Env data**" **contains** the same data as the tabs "Tide", "Current" and "Wave height" of the Results form described in section 5.1.

6 Batch Mode

The batch mode can be used to progressively calculate several configurations.

ProToel can be called from the command line with a batch file name as parameter. To do this, execute the following commands from a command prompt:

- cd <PROTOEL_HOME>
- protoel_batch.bat <batch file name>

The batch file name is an XLSX-file for which every line corresponds to one calculation. An example of a batch-file is available in <PROTOEL_HOME>\exampleBatch.xlsx.

Per calculation, the batch mode will

- define the time zone
- define the mode
- create trajectory.xml based on xlsx and store it in output folder
  <PROTOEL_HOME>\output\<Calculation name>_<YYYYMMDD_HHMMSS>
  If Calculation.Name ends with '.xml' then
  copy this xml-file and store it as trajectory.xml in the output folder
  else
  create trajectory.xml based on cells in xlsx
  read data from Excel and perform time conversion
  save the result xml's to the output folder
- start the calculation
- save the result xml's to the output folder
- generate the summary pdf file to the output folder

Each line of the XLSX-file contains the information of Table 7

Table 7 – Batch mode key words

Category	Parameter	Mapping to trajectory.xml	Comment
Calculation	Name	trajectory.name	
	Description	trajectory.description	add "Generated by BATCH to perform " + stand alone or server mode + ": " before description
	Date	trajectory.calculationDate	convert Time zone to UTC
	Time zone		see Date
	Update DB		used for run
	Mode		see description

Category	Parameter	Mapping to trajectory.xml	Comment
Travels	Departure date	travels.startTime	convert Time zone to UTC
	Time zone		see Departure date
	# Runs before departure	travels.startTime	see GUI
	# Runs after departure	travels.startTime	see GUI
	Interval	travels.startTime	see GUI
Ship	Type	ship.type	
	LOA	ship.lengthOverall	
	B	ship.beam	
	TF	ship.draftForward	
	TA	ship.draftAft	
	GM	ship.metacentricHeight	
	Squat method	ship.squatMethod	
	RAO Database	ship.raoDatabase	
Trajectory	Name	waypoint	see GUI
	Source	waypoint	see GUI
Rdp strategy	Tide name	waypoint.reductionPoint	see GUI
	Tide source	waypoint.reductionPoint	see GUI
	Current name	waypoint.reductionPoint	see GUI
	Current source	waypoint.reductionPoint	see GUI
	Waves name	waypoint.reductionPoint	see GUI
	Waves source	waypoint.reductionPoint	see GUI
	Wind name	waypoint.reductionPoint	see GUI
	Wind source	waypoint.reductionPoint	see GUI
	Density name	waypoint.reductionPoint	see GUI
	Density source	waypoint.reductionPoint	see GUI
Output	All files	outputDefinition.resultType	1 means all files, 0 only VOYAGE_SUMMARY, CRITERIA_SUMMARY, WAYPOINTS_SUMMARY and LOCAL_BTP_TIME

7 Adding data to Database

The ProToel database contains information about several domains:

- Environment data: tide, current, waves, density and wind
- Ship data: types, RAO's and squat values
- Frontend data: trajectories, rdp strategies and criteria

According to his role and to the mode (standalone or server), the user can add information into the database, on the basis of structured Excel files.

These rights are summarized in Table 8 and examples of these structured files are referred to in Table 9 to Table 11.

Table 8 – Database access

INPUT			OUTPUT		SCHEMA			
USER	MODE	SOURCE	DB	SOURCE	Frontend	env		ship
							height_reference	
User	stand alone	LOCAL	local DB	LOCAL	Enable			
User	server	LOCAL	local DB	LOCAL	Enable			
User	stand alone	SERVER	local DB	LOCAL	Enable			
User	server	SERVER	local DB	LOCAL	Enable			
PowerUser	stand alone	LOCAL	local DB	LOCAL	Enable	Enable	Disable + WARNING MESSAGE*	
PowerUser	server	LOCAL	local DB	LOCAL	Enable	Enable	Disable + WARNING MESSAGE*	
PowerUser	stand alone	SERVER	local DB	LOCAL	Enable	Enable	Disable + WARNING MESSAGE*	
PowerUser	server	SERVER	local DB	LOCAL	Enable	Enable	Disable + WARNING MESSAGE*	
Administrator	stand alone	LOCAL	local DB	LOCAL	Enable	Enable		Enable
Administrator	server	LOCAL	ERROR MESSAGE**					
Administrator	stand alone	SERVER	local DB		SERVER	Enable	Enable	Enable	Enable
Administrator	server	SERVER	server DB		SERVER	Enable	Enable	Enable	Enable

* WARNING MESSAGE: Only administrator can make changes to env.height_reference
** ERROR MESSAGE: <xlsx-filename>: source *LOCAL* cannot be defined on server DB

The following xlsx templates (see Table 9, Table 10 and Table 11) explain the format of the different files required to load the tables of the ProToel database.

Template folder "<PROTOEL_HOME>\doc\templates\env\", Database schema "env"

Table 9 – XSLX-templates for adding env data to database

Template	Target tables
_heightReference.xlsx	height_reference
Tide.xlsx	dataset, rdp_tide, tide_data, rdp_dataset
Current.xlsx	dataset, rdp_current, current_data, rdp_dataset
Wind.xlsx	dataset, rdp_wind, wind_data, rdp_dataset
Density.xlsx	dataset, rdp_density, density_data, rdp_dataset
Waves.xlsx WavesJonswap.xlsx	dataset, rdp_wave, wave_data, rdp_dataset
WaveSpectra\ bvhSpectrumInput_20111114_1.xlsx	wave_spectra

The tables unit and rdp_measure have to be fed manually by the administrator.

Template folder "<PROTOEL_HOME>\doc\templates\ship\", Database schema "ship"[5]

Table 10 – XSLX-templates for adding ship data to database

Template	Target tables
_registeredShips.xlsx	reg_ship_type
shipCriticalPoint.xlsx	ship_critical_point
Seaway_D100_DA8.xlsx	condition_rao, roll_ampl, rel_roll_ampl_cond, roll_phase, rel_roll_phase_cond, pitch_ampl, pitch_phase, heave_ampl, heave_phase
SquatD100.xlsx	condition_squat, squat

The table unit has to be fed manually by the administrator.

Template folder "<PROTOEL_HOME>\doc\templates\frontend\", Database schema "frontend"

Table 11 – XSLX-templates for adding frontend data to database

Template	Target tables
_criteria.xlsx	criteria
_waypoint.xlsx	waypoint
trajectory.xlsx	trajectory, trajectory_definition
ship.xlsx	ship
rdp_strategy.xlsx	rdp_strategy rdp_strategy_sequence

[5] This folder is not defined in a standard installation, as only an administrator is allowed to make changes to the ship-schema.

The tables rdp_strategy_condition, criteria_datatype and rdp_ field_possible_value have to be fed manually by the administrator.

In these XLSX-files the field ‘update method’ defines how the data are inserted in the database. The update method can be:

- UPDATE_OR_INSERT means updating existing rows and inserting unexisting rows
- CLEAR_AND_INSERT means clearing the table and inserting all rows. In some specific case, like, _registeredShips.xlsx, it means clearing all the tables of the schema and should be used carefully.

8 Pop-up messages and Problem Handling

Table 12 – Pop-up messages and problem handling

Message	Context
ProToel could not find a valid license file at <lic-file>. In order to obtain a Protoel license, please supply the administrator with the following file: <inf-file>.	Invalid License File or Incorrect Role
No valid installation of PostGres could be found. A new installation requires to start ProToel as a windows-administrator and might take long. Do you want to continue?	PG standalone installation
Please check the consistency of your <PROTOEL_HOME>\config\hibernate.cfg.local.xml with your PostgreSQL installation or contact your system administrator.	PG standalone installation
Please uninstall current version of PostgreSQL or install another one, by changing postgreSQLInstaller in <PROTOEL_HOME>\config\protoel.config and copying this installer in <PROTOEL_HOME>\data\ or contact your system administrator.	PG standalone installation
Port <port>, defined <PROTOEL_HOME>\config\protoel.config, PostgreSQL port is already in use. Please either select a free port and update - <PROTOEL_HOME>\config\protoel.config, postgreSQLPort, - <PROTOEL_HOME>\config\hibernate.cfg.local.xml, in hibernate.connection.url, - <PROTOEL_HOME>\data\postgresql.windows.conf, port or contact your system administrator. The first free port after the one from the config file is <first free port>.	PG standalone installation
Error while executing the sequences. Please check the log file at: <PROTOEL_HOME>\data\PGLogs\pgCreateSequence.log.	PG standalone installation
Error while taking back up of PostgreSQL database. Please check the log file at: <PROTOEL_HOME>\data\PGLogs\pgBackupProcess.log.	PG standalone installation
Windows has to be restarted in order to finish the PostgreSQL installation process. Would you like to restart now?	PG standalone installation
Unable to connect to Database. Incorrect database configuration file.	Database Connection Error
RDP strategy defined in protoel.config file (<RDP Strategy>) is not present in the database. Please load other RDP strategies before generating a trajectory.xml based on GUI to avoid further issues.	Rdp Not Present in DB
No ship data available in frontend schema.	Ship Data not present in frontend schema

Message	Context
No trajectories available in frontend schema.	Trajectory Data not present in frontend schema
RDP Strategy defined for tide data is missing in the database.	Data not present for currently loaded RDP for Tide
RDP Strategy defined for current data is missing in the database.	Data not present for currently loaded RDP for Current
RDP Strategy defined for wave data is missing in the database.	Data not present for currently loaded RDP for Waves
RDP Strategy defined for wind data is missing in the database.	Data not present for currently loaded RDP for Wind
RDP Strategy defined for density data is missing in the database.	Data not present for currently loaded RDP for Density
Error while editing rdp strategy <RDP Name>.	Edit RDP Strategy
Name field can not be blank.	Saving RDP without entering name
RDP Strategy for <RDP Name> has been saved and applied successfully.	Saving RDP
No data to save.	Saving RDP without entering data
Error while saving rdp strategy.	Saving RDP Error message
Please select a row to delete.	Edit RDP Strategy (deleting row without selecting any row)
Error while loading RDP Strategy for <RDP Name>.	Load RDP Strategy error while loading
RDP Strategy for <RDP Name> has been loaded successfully.	Load RDP Strategy success
Last synchronization of the local database was performed on <time> . Do you want to synchronize now?	Calculate based on GUI
File created and saved at path :: <directory path>.	Generation XML based on GUI
Please define a ship.	Generation XML based on GUI (ship type not selected)
Please define at least one waypoint in the trajectory.	Generation XML based on GUI (trajectory not selected)
Please select an xml-file defining the calculation.	Calculate based on saved XML (run clicked without selecting a file)
XmlParsingException: <error>.	Error while parsing trajectory.xml - Missing or incorrect tag(s)
XmlValueOutOfRangeException: <error>.	Error while parsing trajectory.xml - Invalid value(s)
The unit <unit> could not be found in the unit table of the <schema> schema.	Error while parsing trajectory.xml input file - Missing unit
No web service entries defined for datatype: <dataType>; rdp name: <reductionPoint.name> and type: <reductionPoint.type>.	Web services
Web service did not contain data for datatype: <dataType>; rdp name: <reductionPoint.name> and type: <reductionPoint.type> from <startTime missing data> to <endTime missing data>.	Web services

Message	Context
No valid data was received from web services for id <id> for the requested period: <starttijd> to <eindtijd> (<timezone corresponding to <Web serviceRdp.xml>)	Web services
Calculation completed successfully. Output files generated at path: <output result directory path including <PROTOEL_HOME>>.	Calculation Success
The calculation was aborted. No valid env-data / ship-data could be found. Please check the logfile at path: <output result directory path <PROTOEL_HOME>>.	Calculation failure
Calculation performed succesfully, but failed to summarize results from output	Summary PDF
<Schema Name> schema synchronized successfully.	Synchronization Success Message
No data to synchronize. All tables are up to date.	Synchronization (up to date schema)
Error in database cleaning definition: user cannot delete any table in env schema.	DB History Cleaning Error for Role USER
Error in database cleaning definition: server data can never be deleted on the local db.	DB History Cleaning (cleaning server data on local db)
Error in database cleaning definition: server data on the remote db can only be deleted by an administrator.	DB History Cleaning (deleting server data on remote db)
Processing of <filename>.xlsx requires more memory than assigned to ProToel. Please either increase the Java heap size (in <PROTOEL_HOME>\protoel.bat) if sufficient memory is available on your machine, or reduce the size of the xlsx file.	Fill database - Out of memory error
<FileName> ::: Failed to process.	Fill database - Loading env schema
<FileName>; row: <row> ::: Failed to process.	Fill database - Loading env-waves schema
<FileName> ::: Failed to process.	Fill database - Loading ship schema
<FileName> ::: Failed to process.	Fill database - Loading frontend schema
No unit table available in env and ship schema.	Unit table not loaded in ENV and SHIP schema
Database restore completed successfully.	Database Restore
Backup creation Successfull.	Database Restore
Settings saved in the configuration file.	Save Settings
Do you want to save settings for Protoel? Yes/No/Cancel	Exit Protoel Application

9 Computing requirements and performance

ProToel requires important computer resources for normal and especially long term calculations.

When running calculations in standalone mode, only the local resources of the local computer will be required.

On a quite standard Intel i5 4 cores CPU computer, depending on the available memory, the following calculations could be run:

- 4 GB: up to 1 day trajectory, with 20 way points and a time span of 10 minutes between voyages
- 8 GB: up to 1 month trajectory, with 20 way points and a time span of 10 minutes between voyages
- 16 GB: up to ??? trajectory, with 20 way points and a time span of 10 minutes between voyages

Table 13 gives, for a trajectory with 20 waypoints and voyages every 10 minutes during a given period, the execution times in standalone mode, on several configurations with tuned parameters. These figures are indicative and also depend on others factors, like CPU, disk access,…

Table 13 – Performance figures

	Execution time		
	Standalone mode - Client RAM		
	4 GB	8 GB	16 GB
	Java Heap Size (defined in <PROTOEL_HOME>\protoel.bat)		
	? GB	? GB	? GB
	Split Factor (defined in <PROTOEL_HOME>\config\protoel.config)		
	?	?	?
	PostgreSQL Shared Buffers (defined in postgresql.conf)		
Trajectory period	? GB	? GB	? GB
2 hours			
6 hours			
1 day			
1 month			
3 months			
6 months			
1 year			

10 References

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[9] **Vantorre, M.; Candries, M.; Verwilligen, J.** (2013) Optimization of Tidal Windows for Deep-Drafted Vessels by Means of ProToel. International Workshop on Next Genereation Nautical Traffic Models 2013, Delft, The Netherlands.

[10] **Richter J., Vantorre M., Laforce E., Eloot K., Mostaert F.** (2008). Support of a probabilistic access policy for the Flemish harbours: Implementation of the software ProToel for the harbour of Zeebrugge: ProToel User Manual. WL Rapporten, Mod 801/3. Flanders Hydraulics Research & Ghent University: Antwerp, Belgium.

Appendix 1: Database structure

The database consists of four schemas:

- **The “Env” schema**

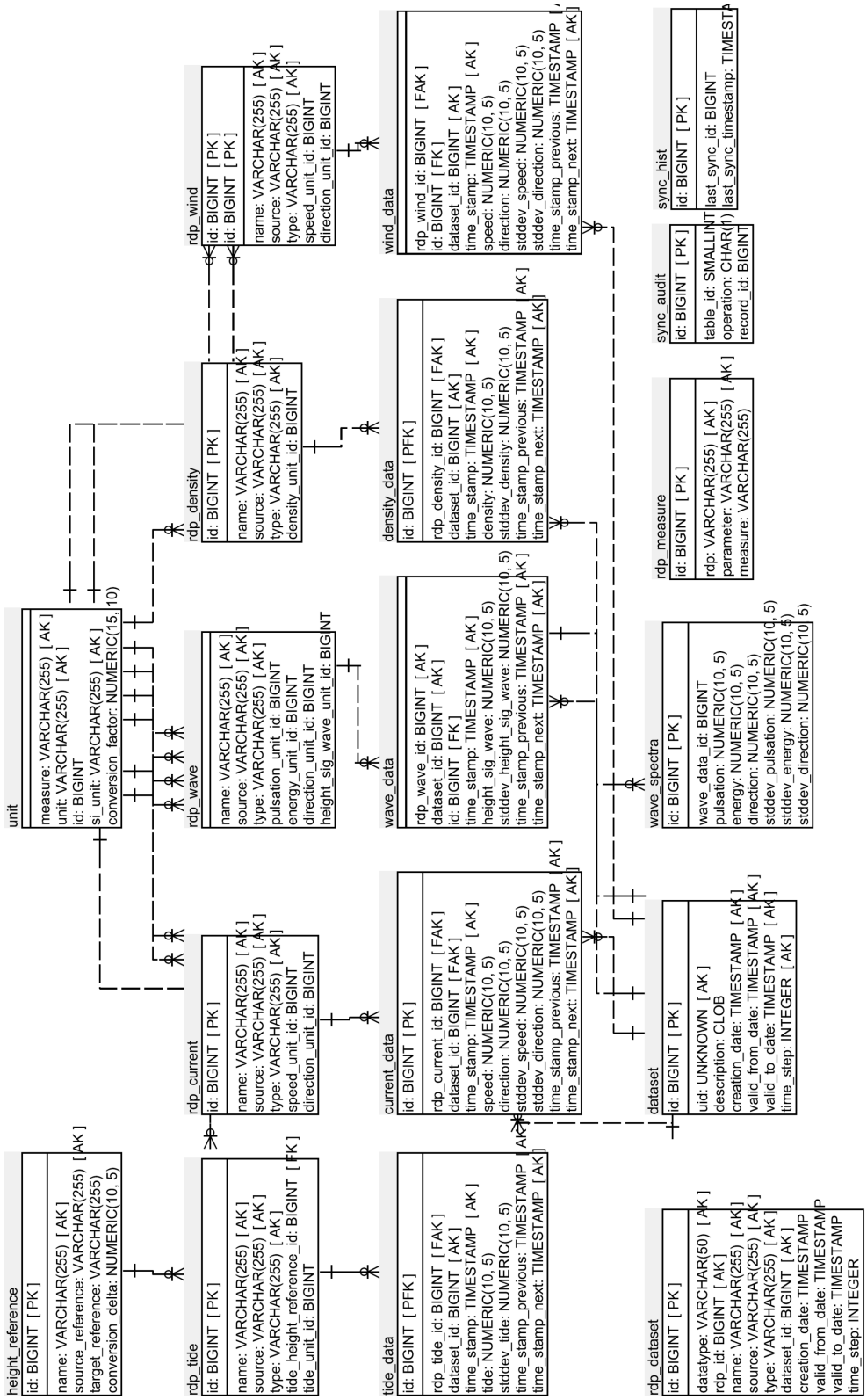


Table	Content
unit	Holds all units and there relation to the SI-unit applied in the calculation
height_reference	Holds the vertical distance between the vertical reference levels LAT, GLLWS, TAW, NAP and MSL for all reduction points for which tide is defined. Adding reduction points for tide requires to add the corresponding information in env.height_reference (this is restricted to an administrator)
rdp_measure	Holds information about the dimension or measure of different inputs in the env-schema
dataset	Holds all the datasets that were added to the db
rdp_tide	Holds the reductionpoints for datatype tide
tide_data	Holds the tide data
rdp_current	Holds the reductionpoints for datatype current
current_data	Holds the current data
rdp_wave	Holds the reductionpoints for datatype waves
wave_data	Holds the wave data (1D)
wave_spectra	Holds the wave spectra
rdp_density	Holds the reductionpoints for datatype density
density_data	Holds the tide density
rdp_wind	Holds the reductionpoints for datatype wind
wind_data	Holds the wind data
rdp_dataset	Summarizes the available data for different combination of datatype, rdp, source, type and dataset. The rdp_dataset is automatically generated from the dataset-table, rdp-tables and data-tables.
Sync_hist	Holds the latest sync-date and the latest synchronization id (only relevant for client (stand alone)
Sync_audit	Holds all db-changes made within the schema (only defined for server db) in order to allow synchronization of clients.

- **The “Ship” schema**

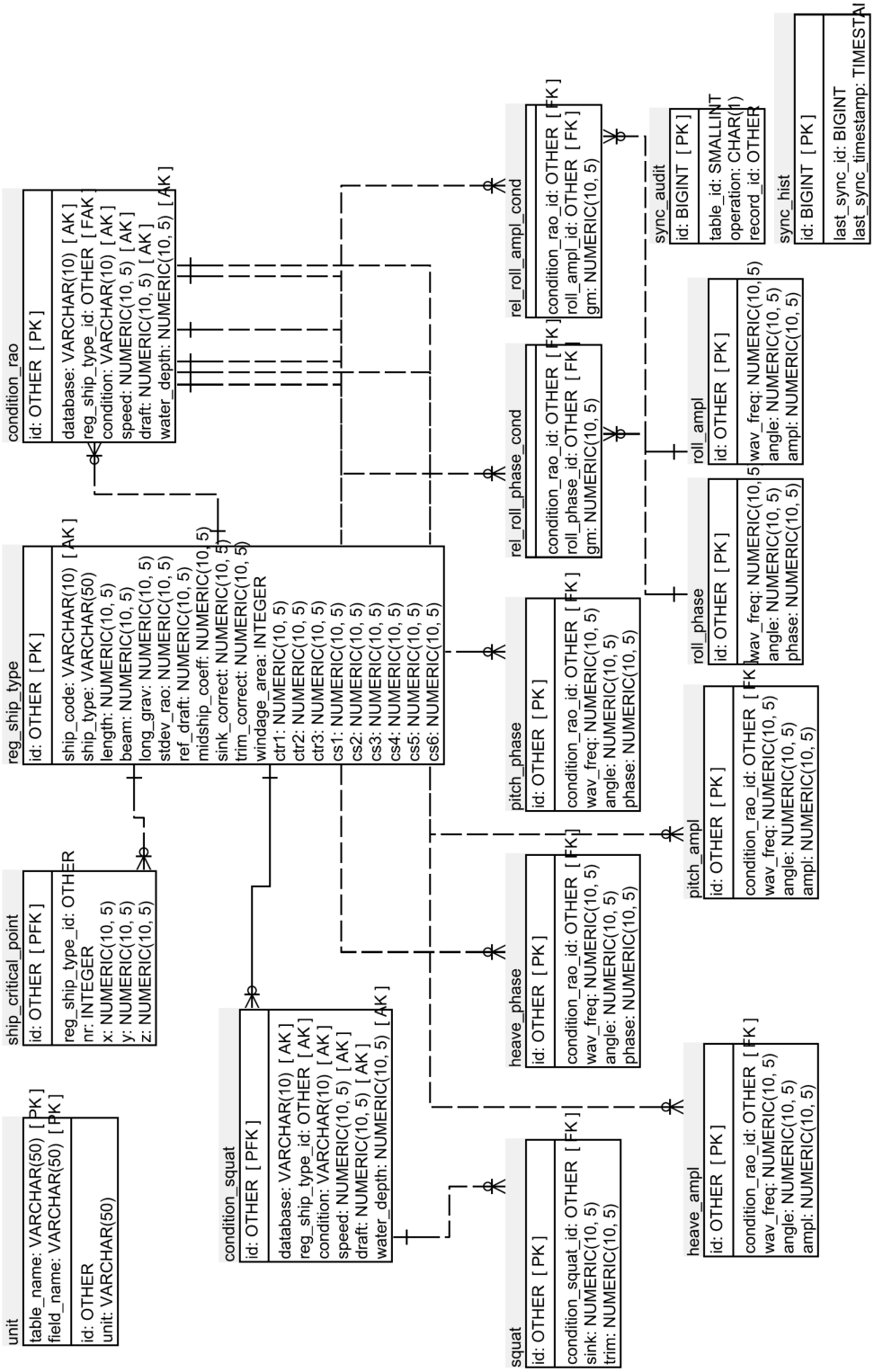


Table	Content
unit	Holds the unit defined for all parameters in ship-schema
reg_ship_type	Holds the main particulars of the vessels in the ship database of ProToel
ship_critical_point	Holds the positions of critical points on the ship keel for all vessels in the ship database of ProToel
condition_rao	Holds the available conditions (for each ship combination of draft, water depth and speed over ground) for which RAO-data are available
roll_ampl	Holds the RAO-data for amplitude of roll motion
rel_roll_ampl_cond	Holds the relation between GM and roll_ampl
roll_phase	Holds the RAO-data for phase of roll motion
rel_roll_phase_cond	Holds the relation between GM and roll_phase
pitch_ampl	Holds the RAO-data for amplitude of pitch motion
pitch_phase	Holds the RAO-data for phase of pitch motion
heave_ampl	Holds the RAO-data for amplitude of heave motion
heave_phase	Holds the RAO-data for phase of heave motion
condition_squat	Holds the available conditions (for each ship combination of draft, water depth and speed over ground) for which squat-data are available
squat	Holds the squat data (sinkage midship and trim)
Sync_hist	Holds the latest sync-date and the latest synchronization id (only relevant for client (stand alone)
Sync_audit	Holds all db-changes made within the schema (only defined for server db) in order to allow synchronization of clients.

- **The “Frontend” schema**

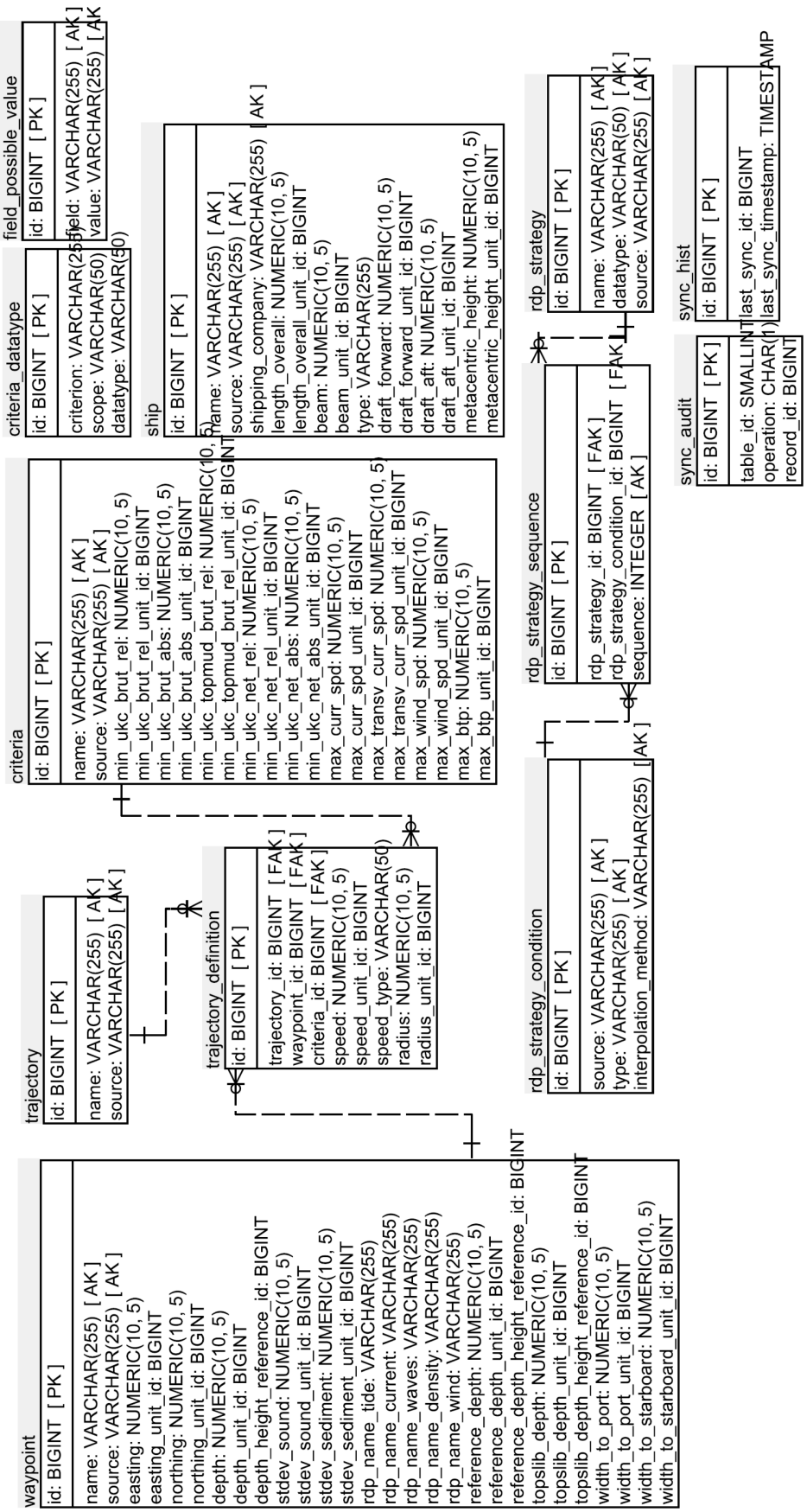


Table	Content
criteria	Holds the available criteria to be selected in GUI
waypoint	Holds all available waypoints, including position and depth-information
trajectory	Holds the names of the trajectories defined
trajectory_definition	Holds the definition of the trajectories. This involves an ordered list of waypoints to which criteria ad ship speeds are assigned.
ship	Holds a list with vessels that can be selected in the GUI
rdp_strategy	Holds the names of different strategies that can be defined as fall back mechanism for env-data
rdp_strategy_condition	Holds all possible combinations of source, type and interpolation method
rdp_strategy_sequence	Holds the definition or the rdp-strategies by defining the order of different rdp-strategy-conditions
criteria_datatype	Holds information regarding the required env-data in order to assess a certain criteria
field_possible_value	Holds information regarding the available options used in the GUI-menus for the parameters: datatype, source, type, interpolation_method, condition_rao_database, condition_squat_database and db.
Sync_hist	Holds the latest sync-date and the latest synchronization id (only relevant for client (stand alone)
Sync_audit	Holds all db-changes made within the schema (only defined for server db) in order to allow synchronization of clients.

- **The "Calc" schema**

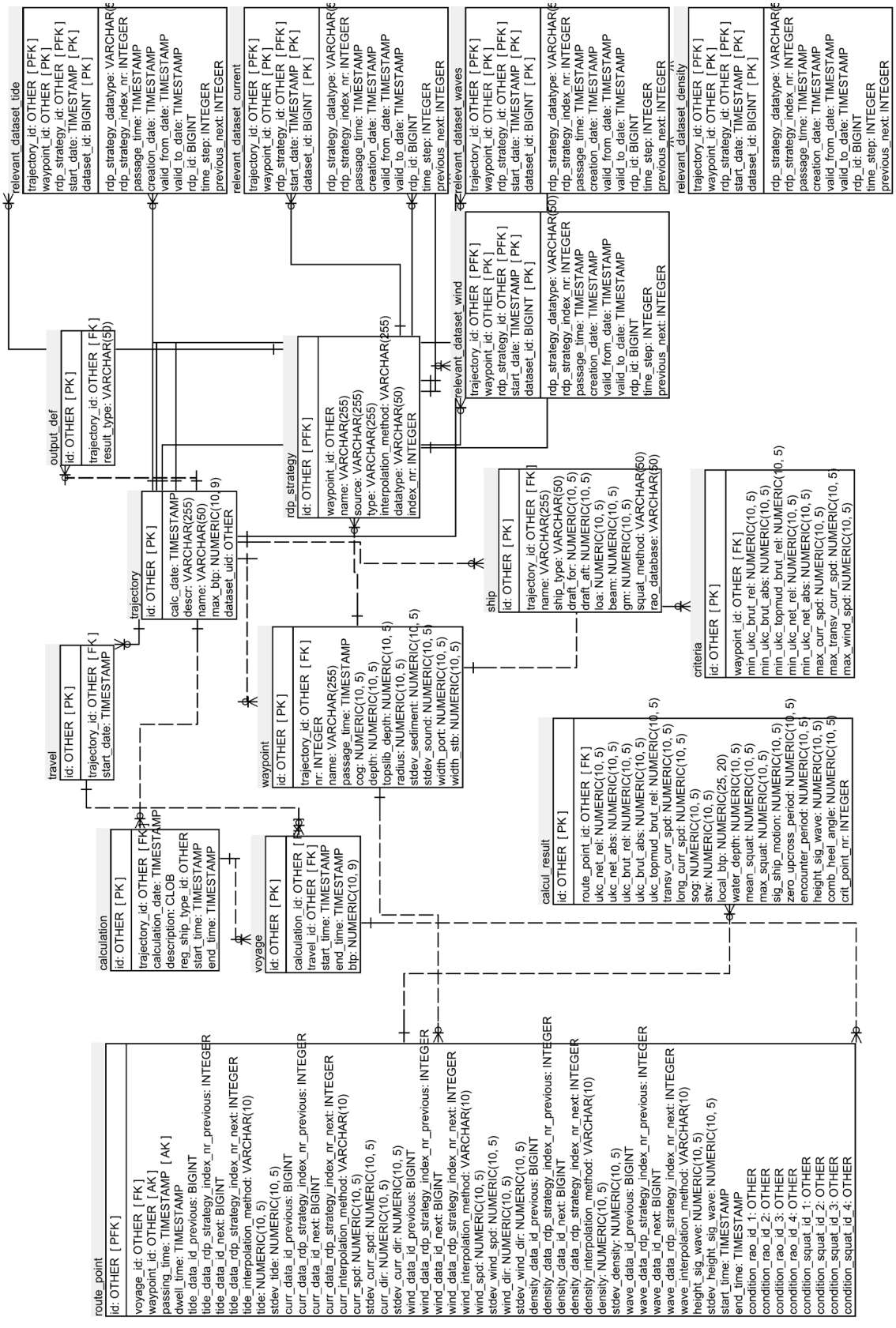


Table	Content
trajectory	Holds the basic information for the calculation fetched from the trajectory.xml
ship	Holds the ship information fetched from the trajectory.xml
travel	Holds the start dates for the different voyages to be calculated (fetched from the trajectory.xml)
output_def	Holds the results-xml's that have to be generated (fetched from the trajectory.xml)
waypoint	Holds the waypoint data (fetched from the trajectory.xml)
criteria	Holds the criteria data (fetched from the trajectory.xml)
rdp_strategy	Holds the rdp_strategy for all waypoints and datatypes (fetched from the trajectory.xml)
calculation	Holds the calculation results at calculation level
voyage	Holds the calculation results at voyage level
route_point	Holds the calculation results at routepoint level
calcul_result	Holds the calculation and criteria results at routepoint level
relevant_dataset_tide	Holds the datasets for datatype tide that correspond to the rdp_strategy and calculation_date
relevant_dataset_current	Holds the datasets for datatype current that correspond to the rdp_strategy and calculation_date
relevant_dataset_waves	Holds the datasets for datatype waves that correspond to the rdp_strategy and calculation_date
relevant_dataset_density	Holds the datasets for datatype density that correspond to the rdp_strategy and calculation_date
relevant_dataset_wind	Holds the datasets for datatype wind that correspond to the rdp_strategy and calculation_date

Appendix 2: Bottom Touch Probability

ProToel facilitates the probabilistic calculation of bottom touch along a voyage. The determining criterion (max BTP) is the bottom touch probability over the entire voyage. For calculation of BTP the following parameters are taken into account for every routepoint:

- values and standard deviation of tide, bottom depth and draft;
- directional wave spectrum with standard deviation on significant wave height;
- density;
- wind;
- speed over ground, speed through the water and course over ground;
- dwell time;
- vertical ship motions based on §12.1.

The BTP for the trajectory can be calculated from the local BTP at every waypoint. The local BTP however cannot readily be used as a local criterion as it depends on the dwell time a vessel is present in the routepoint. This implies that the local BTP is strongly affected by the number of waypoints that compose the trajectory, while the global BTP is not.

1. Vertical ship motions

For calculations of both manoeuvring margin and BTP the vertical ship motions of a vessel should be accounted for. A distinction is made between:

- changes to the static draft as a result of wind and density;
- stationary vertical sinkage (squat) independent of wind and waves;
- dynamic vertical ship motions corresponding to the wave climate.

At present ProToel does not take into account the effects of wind and density on the static draft and roll of the vessel. For the BTP calculation both squat and dynamic motions are taken into account.

Below the calculation of the vertical motions as a result of squat and waves are presented, based on [14].

1.1 Ship database

1.1.1 Overview

In order to calculate the probability of bottom touch during a particular voyage, the program requires information about the vertical motion of the ships in the database:

- Squat data: average sinkage and trim;
- Dynamic response characteristics (motion amplitude relative to wave amplitude and phase lag as a function of wave pulsation and angle of incidence of wave) for the vertical motions (heave, pitch, roll) due to waves;
- Correction factors for response in irregular seaways.

The database is based on results of model experiments and numerical calculations.

The model tests were carried out in 1996-2009 in the Towing tank for manoeuvres in shallow water (co-operation Flanders Hydraulics Research – Ghent University) in Antwerp, Belgium, with five ship models: three normative ships (D, E, W) and two critical ships (F, G), see Table 14. The normative ships, two slender ship types (model D and W, container carrier) and a full one (model E, tanker / bulk carrier) were expected to be the largest ones in their category to frequent the harbours of Antwerp, Ghent and Zeebrugge in the near future. Taking into account the wave characteristics in the southern part of the North Sea, it can be expected that these normative ships will not be subject to the largest motions; deep-drafted ships with smaller horizontal dimensions may have a larger probability of bottom touch. For this critical category, two ship models – a slender (model F, panamax container carrier) and a full ship (model G, panamax bulk carrier) – were selected.

By adapting the scale factor, a series of ships can be derived from each of the five parent scale models. In this way, the complete range of interest of length-beam combinations is covered by the investigated ship models, see Table 2, Table 3 and Table 4 on p.4 to p.5.

Table 14 – Ship models: main dimensions, [14].

Model		D	E	F	G	W
Scale	(-)	1/75	1/85	1/50	1/50	1/90
Length over all	(m)	300.0	343.0	200.0	190.0	398.0
Length between perpendiculars	(m)	291.1	325.0	190.0	180.0	376.0
Breadth, moulded	(m)	40.25	53.00	32.00	33.00	56.40
Maximum draft	(m)	15.00	21.79	11.60	13.00	16.00
Block coefficient at max. draft	(-)	0.6	0.85	0.6	0.85	

1.1.2 Squat

The actual time-averaged vertical distance between the bottom and the ship's keel is smaller than the gross under keel clearance due to the squat phenomenon.

Due to a ship's forward speed, the pressure and, hence, the water level around the ship is lowered, causing a sinkage and a change of trim. This phenomenon is especially significant in restricted waters, where the influence of squat increases.

Initially, the database contained a tabular relationship of mean sinkage and dynamic trim as a function of the speed through the water for each of the combinations ship type – scale factor – water depth – draft. Taking account of the bathymetry of the dredged channels in the North Sea, the effect of the lateral boundaries of the waterways due to blockage could be neglected. In order to be able to extend the calculation tool with trajectories in more confined waters such as rivers and canals, where blockage may be of interest, an alternative calculation method for squat of container vessels has been developed, based on various series of model tests.

Principally, the calculation method for squat of container vessels is based on the widely used Tuck parameter T_{nh}:

$$T_{nh} = \frac{F_{nh}^2}{\sqrt{1 - F_{nh}^2}} \qquad (1)$$

with

$$F_{nh} = \frac{u}{\sqrt{g \cdot h}} \tag{2}$$

- T_{NH} Tuck parameter [-];
- F_{NH} depth based Froude number [-];
- u ship's forward speed component [m/s];
- g acceleration of gravity [ms^{-2}];
- h water depth [m]

However, the present method makes use of an alternative Tuck parameter that takes account of the effect induced by the lateral boundaries of the waterway. (1) is replaced by:

$$T'_{nh} = \frac{F'^{2}_{nh}}{\sqrt{1 - F'^{2}_{nh}}} \tag{3}$$

with

$$F'_{nh} = \frac{u}{\sqrt{k_m k_s g h}} \tag{4}$$

k_m is a blockage dependent factor:

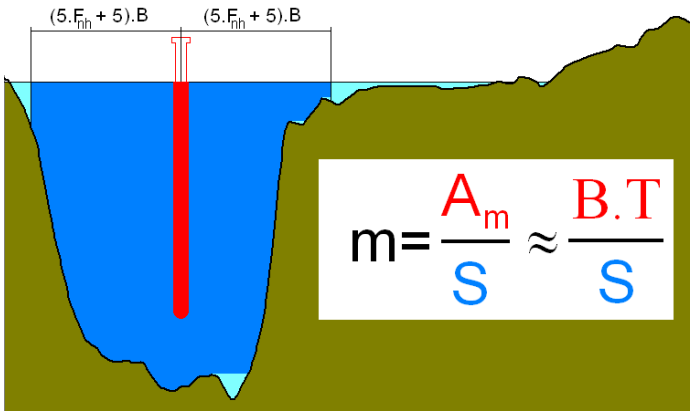
$$k_m = \left[2 \cdot \sin\left(\frac{\mathrm{Arc}\sin(1-m)}{3} \right) \right]^3 \tag{5}$$

m denotes an equivalent blockage factor, defined in Figure 30. It should be noted that Schijf's limiting Froude Number [11] equals $k_m F_{nh}$. k_s is a ship dependent factor that increases with the draft.

with

- A_m midship section [m^2];
- S cross section waterway [m^2];
- B ship's beam [m];
- T ship's draft [m].

Figure 30 – Blockage definition for squat calculation



The importance of squat and its dependence on ship characteristics is illustrated in Figure 31 and Figure 32. In particular, Figure 31 shows that an increase of draft may lead to a decrease of squat, for equal values of the under keel clearance expressed as a fraction of the draft. This can be explained by the fact that, under these circumstances, an increased draft implies an increased water depth and, therefore, a reduced Froude depth number F_{nh} for the same speed. In addition, a variation of the dynamic trim (bow- or stern-heavy) is noticed during the experiments depending on the load condition or draft.

The squat model applied in ProToel was applied for several studies to determine the probabilistic tidal windows to Zeebrugge, Antwerp en Vlissingen. These studies also revealed that the squat has a major impact on the results of a probabilistic calculation combined with a manoeuvring margin.

Figure 31 – Ship model D: maximum squat [12]

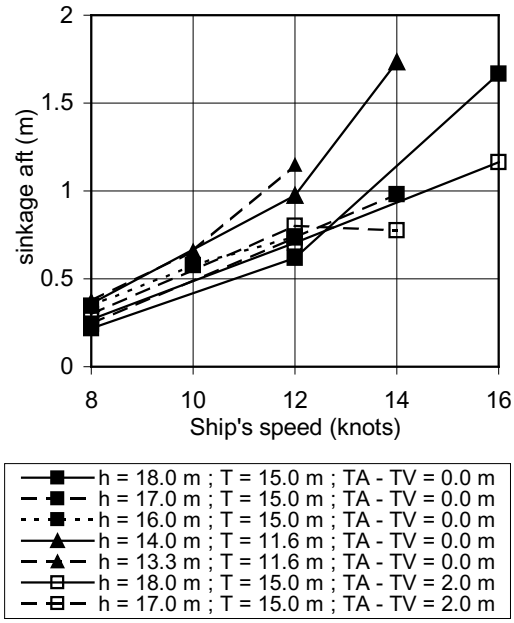
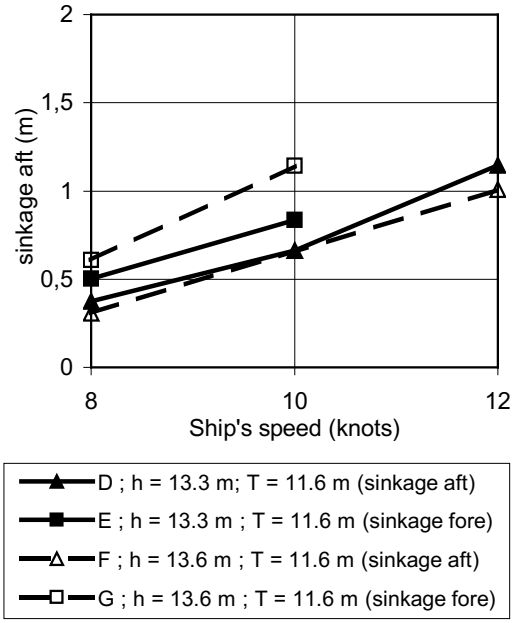


Figure 32 – Squat: comparison between ship models [12]



1.1.3 Vertical Ship Response to Waves

The vertical ship response to waves is calculated based on:

- Dynamic response characteristics (motion amplitude relative to wave amplitude and phase lag as a function of wave pulsation and angle of incidence of wave) for the vertical motions (heave, pitch, roll) due to waves;
- Correction factors for response in irregular seaways.

These data for the ships available in the database (ship schema) are a part of the ProToel Back End.

Dynamic response characteristics

For a number of draft – water depth combinations for each ship from the ProToel Database, the response functions for heave, pitch and roll are stored in the ship database for a range of forward ship speeds; the roll characteristics are defined for a number of metacentric heights. The response functions are formulated under tabular form as a function of wave frequency and wave angle of incidence.

The response functions are derived partly from the results of tests in regular waves, partly from numerical calculations. The dimensions of the Towing tank for manoeuvres in shallow water only allows the execution of model tests with angles of incidence in the ranges [-10 deg ; 10 deg] (following waves) and [170 deg ; 190 deg] (head waves). Tests with higher angles of incidence can only be carried out at zero speed.

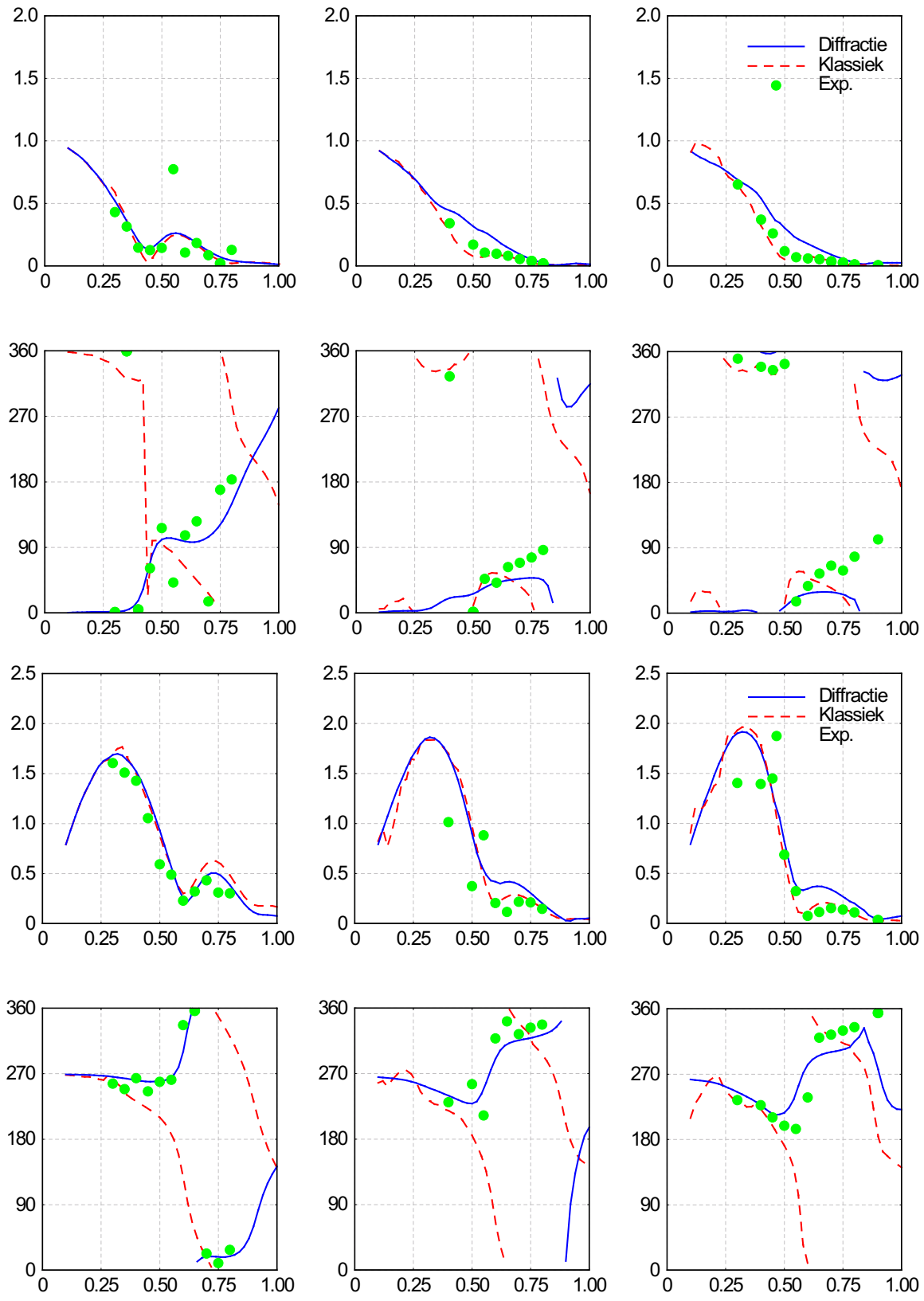
Therefore, computer computations have been used to increase the database by including motions for larger wave angles. Seaway, a strip-theory based seakeeping program developed by Journée [15], appeared to generate results with acceptable accuracy in comparison with experimental data. As an illustration, Figure 33 compares the frequency characteristics for heave and pitch of ship model F in head waves.

Precalculation of the response functions for different ship classes results in a datasets of response functions that were verified and validated based on towing tank tests. During calculation of the response functions the calculation options were optimized for shallow water conditions. This method is considered to be more reliable than an on line calculation of response functions for every vessel separately and applying the results from the numerical codes directly in the BTP calculation.

Correction factors for irregular waves

The response functions for heave, pitch and roll were partly validated by model tests in regular and irregular waves. Deviations between results in regular and irregular waves can be accounted for by introducing correction factors.

Figure 33 – Panamax container vessel F, condition FA. Heave and pitch motions in head waves:
comparison between model tests (•) and SEAWAY results computed with 2D diffraction method (——) and classical strip theory (- - -), [13].



2. Probabilistic Considerations

2.1 Calculation scheme for probability of bottom touch (BTP)

The following steps are executed consecutively to calculate the probability of bottom touch during a particular voyage defined by the Front End.

- Based on the ship definition a ship is selected in the database.
- Based on the passage time of the consecutive waypoints (j = 1,….,n) the tide and current along the trajectory are time interpolated from the data base. The water depth is calculated based on bottom depth and tide with a standard deviation taking into account:
  - standard deviation on the tide prediction;
  - standard deviation on the survey;
  - standard deviation as a result of sedimentation between two surveys.
- For each waypoint, four combinations water depth – draft – speed are selected in the database which give the best approximations for the actual condition. A weight factor is attributed to each selected combination.
- Sinkage and trim are calculated for each waypoint, taking into account the ship's speed through the water. This allows computation of the stationary sinkage of a number of so-called critical points on the ship hull. These points are predefined as the positions on the hull that are most likely to experience bottom touch, see Figure 34.
- For each waypoint, the wave data (spectral density $S_\zeta(\omega)$, average angle of propagation, standard deviation of this angle) for the reference location are introduced and transformed into a table $S_\zeta(\omega,\mu)$ of the spectral density of the irregular seaway as a function of angle of incidence and frequency.
- Based on the motion characteristics for the four selected combinations (T_k, h_k, V_k), the spectral density table $S_\zeta(\omega,\mu)$ and the experimentally determined correction factors for response in irregular seaways, weighted average amplitude and phase characteristics for heave, pitch and roll are computed. This allows the computation of the amplitude characteristic of the vertical motion of each critical point $Y_{Z_\ell\zeta}(\omega;\mu)$ (ℓ = 1,…,N).
- The spectral density function of the vertical response of critical point ℓ can be computed as

$$S_{Z_\ell}(\omega;\mu) = S_\zeta(\omega;\mu)\cdot Y^2_{Z_\ell\zeta}(\omega;\mu) \tag{6}$$

with

- ω wave frequency [rad s^{-1}]
- μ incident wave angle [deg]
- ζ wave elevation [m]

which allows computation of:

$$m_{0,Z_\ell} = \int_0^{2\pi}\int_0^{+\infty} S_{Z_\ell}(\omega;\mu)\,d\omega\,d\mu = 16Z^2_{s,\ell} \tag{7}$$

$$m_{2,Z_\ell} = \int_0^{2\pi} \int_0^{+\infty} S_{Z_\ell}(\omega;\mu)\omega^2 d\omega d\mu \tag{8}$$

with

- m_{0,Z_ℓ} 0th moment of response spectrum of vertical motion of critical point ℓ [m²]
- m_{2,Z_ℓ} 2nd moment of response spectrum of vertical motion of critical point ℓ [m²s⁻²]

$Z_{s,\ell}$ being the significant value of the vertical wave-induced peak-to-peak motion of critical point ℓ, comparable to the significant wave height.

The actual (time-averaged) under keel clearance[6] for critical point ℓ in waypoint j is denoted $UKC_{j,\ell}$:

$$UKC_{j,\ell} = h_j - T_\ell - \overline{Z_\ell} \tag{9}$$

with:

- h_j water depth in waypoint j [m]
- T_ℓ vertical distance between waterline static position critical point ℓ [m]
- $\overline{Z_\ell}$ sinkage due to squat (sink and trim) of critical point ℓ [m]

As the peak-to-peak values of the vertical wave-induced motion of critical point ℓ are assumed to follow a Rayleigh distribution:

$$p_R(Z_\ell; Z_{s,\ell}) = \frac{16}{Z_{s,\ell}^2} Z_\ell \, e^{-8\left(\frac{Z_\ell}{Z_{s,\ell}}\right)^2} \tag{10}$$

the probability of bottom touch of critical point ℓ for one oscillatory cycle is given by:

$$P_{j,\ell}^{(1)} = P\left[Z_\ell > UKC_{j,\ell}\right] = e^{-\frac{UKC_{j,\ell}^2}{2m_{0,Z_\ell}}} = e^{-8\left(\frac{UKC_{j,\ell}}{Z_{s,\ell}}\right)^2} \tag{11}$$

The probability of bottom touch of critical point ℓ during the passage of the ship in waypoint j with dwell time t_j can be expressed by:

$$P_{j,\ell} = \frac{1}{2\pi}\sqrt{\frac{m_{2,Z_\ell}}{m_{0,Z_\ell}}} t_j P_{j,\ell}^{(1)} \tag{12}$$

$P_j \equiv \max(P_j, \ell)$ can be considered as the probability of bottom touch in waypoint j. The probability P of bottom touch in full trajectory can be computed as:

$$P = 1 - \prod_{j=1}^{N}\left(1 - P_j\right) \tag{13}$$

[6] In this document the actual under keel clearance is considered the actual time-averaged under keel clearance. It corresponds to the net under keel clearance without taking into account wave response.

Effect of uncertainty of the actual under keel clearance

The calculation above is valid if the actual under keel clearance $UKC_{j,\ell}$ is exactly known. In reality, this value is subject to uncertainty, due to uncertainty of the bottom level, the still water draft, the tidal level, the squat estimation. If a normal distribution of this actual under keel clearance is assumed with standard deviation $\sigma_{Z\ell}$, than (10) can be calculated as follows:

$$P_1 = \int_0^{\infty} p_R\left(z; Z_{s,\ell}\right) P_G\left(z; UKC_{j,\ell}; \sigma_{Z_\ell}\right) dz = \int_0^{\infty} \frac{16}{Z_{s,\ell}^2} z\, e^{-8\frac{z^2}{Z_{S,\ell}^2}} dz \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}\sigma_{Z_\ell}} e^{-\frac{\left(x-UKC_{j,\ell}\right)^2}{2\sigma_{Z_\ell}^2}} dx \qquad (14)$$

The importance of a reliable tide forecast is illustrated in Figure 35. For a container carrier with 15.0 m draft, the window based on a 10^{-4} probability of bottom touch appears to decrease with 1.5 hours if the standard deviation on the tide prediction increases from 0.01 m to 0.19 m.

Effect of uncertainty of wave forecast

The calculation scheme described above is valid for a given wave climate. If the wave input is based on forecasts, however, the uncertainty on the prediction should be taken into account.

If the significant wave height H_s is predicted with an uncertainty expressed by a standard deviation σ_{Hs}, it can be assumed that the significant wave-induced motion $Z_{s,\ell}$ has a normal distribution with standard deviation $\sigma_{Zs,\ell}$:

$$\sigma_{Zs,\ell} = \frac{Z_{S,\ell}}{H_S} \cdot \sigma_{Hs} \qquad (15)$$

The peak-to-peak values of the vertical wave-induced motion of a critical point ℓ no longer follows a Rayleigh distribution (10), but a Rayleigh based distribution with a Gaussian distribution of the variance:

$$p_{RG}\left(Z_\ell; Z_{s,\ell}; \sigma_{Zs,\ell}\right) = \int_{-\infty}^{+\infty} p_G\left(Z_S; Z_{s,\ell}; \sigma_{Zs,\ell}\right) \frac{16}{Z_S^2} Z_\ell\, e^{-8\frac{Z_\ell^2}{Z_S^2}} dZ_S \approx \frac{\int_0^{+\infty} p_G\left(Z_S; Z_{s,\ell}; \sigma_{Zs,\ell}\right) \frac{16}{Z_S^2} Z_\ell\, e^{-8\frac{Z_\ell^2}{Z_S^2}} dZ_S}{\int_0^{+\infty} p_G\left(Z_S; Z_{s,\ell}; \sigma_{Zs,\ell}\right) dZ_S} \qquad (16)$$

taking account of the fact that negative values for the significant value of the vertical motion are physically meaningless.

By calculating the probability of bottom touch in this way, not only account can be taken of the quality of the wave forecasts, but also uncertainties of ship characteristics can be dealt with. As a matter of fact, the RAO's for heave, pitch and roll not only depend on the main dimensions of the ship, but also on parameters that depend on the weight distribution, such as the moments of inertia and the metacentric height. A spreading of 5% appears to be sufficient to take account of variations of the longitudinal moment of inertia, but the effect of GM variations may be 10 to 20%, so that this value should be correctly defined.

Figure 34 – Illustration of critical point positions corresponding to the positions on the hull that are most likely to experience bottom touch, [14].

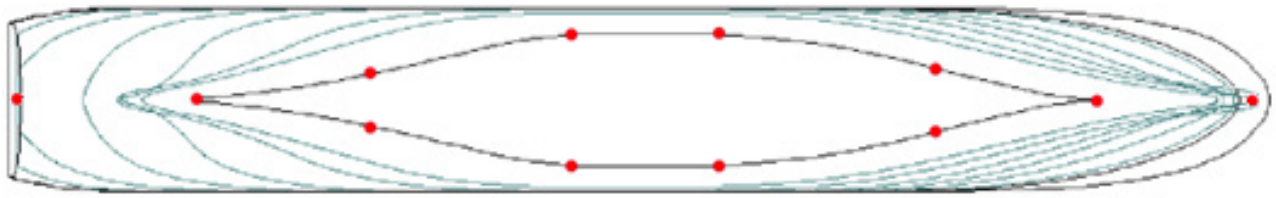
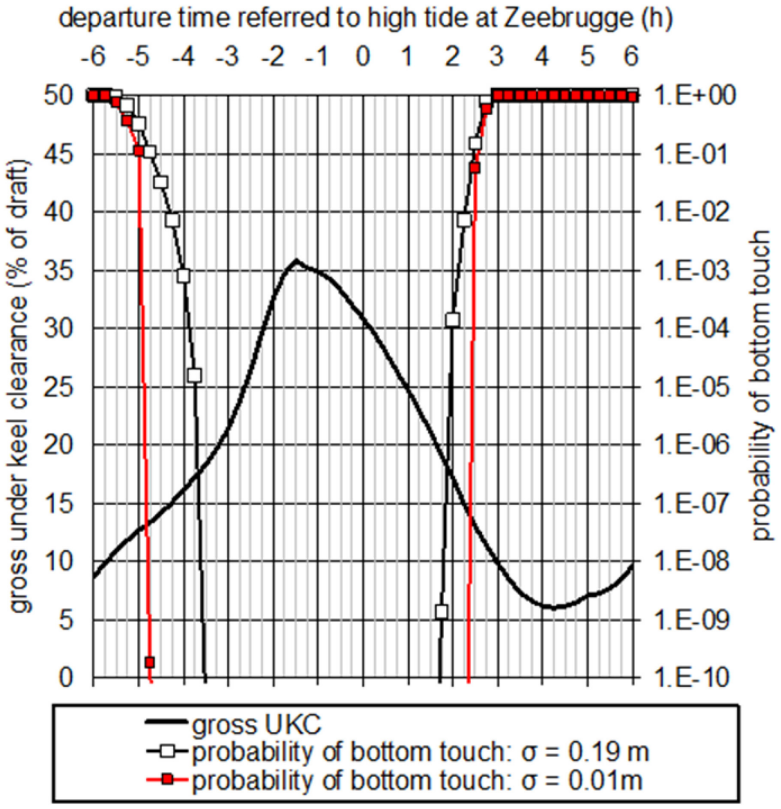


Figure 35 – Arrival of a 15 m draft container vessel at Zeebrugge (fictitious example): influence of standard deviation of tide prediction, [14].



3. References

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Appendix 3: Log Messages

Message	Context	Used In
ProToel could not find a valid license file at <lic-file>. In order to obtain a Protoel license, please supply the administrator with the following file: <inf-file>.	Invalid License File or Incorrect Role	Pop-up
No valid installation of PostGres could be found. A new installation requires to start ProToel as a windows-administrator and might take long. Do you want to continue?	PG standalone installation	Pop-up
Please check the consistency of your <PROTOEL_HOME>\config\hibernate.cfg.local.xml with your PostgreSQL installation or contact your system administrator.	PG standalone installation	Pop-up
Please uninstall current version of PostgreSQL or install another one, by changing postgreSQLInstaller in <PROTOEL_HOME>\config\protoel.config and copying this installer in <PROTOEL_HOME>\data\ or contact your system administrator.	PG standalone installation	Pop-up
Port <port>, defined <PROTOEL_HOME>\config\protoel.config, PostgreSQL port is already in use. Please either select a free port and update - <PROTOEL_HOME>\config\protoel.config, postgreSQLPort, - <PROTOEL_HOME>\config\hibernate.cfg.local.xml, in hibernate.connection.url, - <PROTOEL_HOME>\data\postgresql.windows.conf, port or contact your system administrator. The first free port after the one from the config file is <first free port>.	PG standalone installation	Pop-up
Error while executing the sequences. Please check the log file at: <PROTOEL_HOME>\data\PGLogs\pgCreateSequence.log.	PG standalone installation	Pop-up
Error while taking back up of PostgreSQL database. Please check the log file at: <PROTOEL_HOME>\data\PGLogs\pgBackupProcess.log.	PG standalone installation	Pop-up

Windows has to be restarted in order to finish the PostgreSQL installation process. Would you like to restart now?	PG standalone installation	Pop-up
Unable to connect to Database. Incorrect database configuration file.	Database Connection Error	Pop-up
RDP strategy defined in protoel.config file (<RDP Strategy>) is not present in the database. Please load other RDP strategies before generating a trajectory.xml based on GUI to avoid further issues.	Rdp Not Present in DB	Pop-up
No ship data available in frontend schema.	Ship Data not present in frontend schema	Pop-up
No trajectories available in frontend schema.	Trajectory Data not present in frontend schema	Pop-up
RDP Strategy defined for tide data is missing in the database.	Data not present for currently loaded RDP for Tide	Pop-up
RDP Strategy defined for current data is missing in the database.	Data not present for currently loaded RDP for Current	Pop-up
RDP Strategy defined for wave data is missing in the database.	Data not present for currently loaded RDP for Waves	Pop-up
RDP Strategy defined for wind data is missing in the database.	Data not present for currently loaded RDP for Wind	Pop-up
RDP Strategy defined for density data is missing in the database.	Data not present for currently loaded RDP for Density	Pop-up
Error while editing rdp strategy <RDP Name>.	Edit RDP Strategy	Pop-up
Name field can not be blank.	Saving RDP without entering name	Pop-up
RDP Strategy for <RDP Name> has been saved and applied successfully.	Saving RDP	Pop-up
No data to save.	Saving RDP without entering data	Pop-up
Error while saving rdp strategy.	Saving RDP Error message	Pop-up
Please select a row to delete.	Edit RDP Strategy (deleting row without selecting any row)	Pop-up
Error while loading RDP Strategy for <RDP Name>.	Load RDP Strategy error while loading	Pop-up
RDP Strategy for <RDP Name> has been loaded successfully.	Load RDP Strategy success	Pop-up
Last synchronization of the local database was performed on <time> . Do you want to synchronize now?	Calculate based on GUI	Pop-up
File created and saved at path :: <directory path>.	Generation XML based on GUI	Pop-up
Please define a ship.	Generation XML based on GUI (ship type not selected)	Pop-up
Please define at least one waypoint in the trajectory.	Generation XML based on GUI (trajectory not selected)	Pop-up
Please select an xml-file defining the calculation.	Calculate based on saved XML (run clicked without selecting a file)	Pop-up
XmlParsingException: <error>.	Error while parsing trajectory.xml - Missing or incorrect tag(s)	Pop-up
XmlValueOutOfRangeException: <error>.	Error while parsing trajectory.xml - Invalid value(s)	Pop-up
The unit <unit> could not be found in the unit table of the <schema> schema.	Error while parsing trajectory.xml input file - Missing unit	Pop-up

No web service entries defined for datatype: <dataType>; rdp name: <reductionPoint.name> and type: <reductionPoint.type>.	Web services	Pop-up
Web service did not contain data for datatype: <dataType>; rdp name: <reductionPoint.name> and type: <reductionPoint.type> from <startTime missing data> to <endTime missing data>.	Web services	Pop-up
No valid data was received from web services for id <id> for the requested period: <starttijd> to <eindtijd> (<timezone corresponding to <Web serviceRdp.xml>)	Web services	Pop-Up
Calculation completed successfully. Output files generated at path: <output result directory path including <PROTOEL_HOME>>.	Calculation Success	Pop-up
The calculation was aborted. No valid env-data / ship-data could be found. Please check the logfile at path: <output result directory path <PROTOEL_HOME>>.	Calculation failure	Pop-up
Calculation performed succesfully, but failed to summarize results from output	Summary PDF	Pop-up
<Schema Name> schema synchronized successfully.	Synchronization Success Message	Pop-up
No data to synchronize. All tables are up to date.	Synchronization (up to date schema)	Pop-up
Error in database cleaning definition: user cannot delete any table in env schema.	DB History Cleaning Error for Role USER	Pop-up
Error in database cleaning definition: server data can never be deleted on the local db.	DB History Cleaning (cleaning server data on local db)	Pop-up
Error in database cleaning definition: server data on the remote db can only be deleted by an administrator.	DB History Cleaning (deleting server data on remote db)	Pop-up
Processing of <filename>.xlsx requires more memory than assigned to ProToel. Please either increase the Java heap size (in <PROTOEL_HOME>\protoel.bat) if sufficient memory is available on your machine, or reduce the size of the xlsx file.	Fill database - Out of memory error	Pop-up
<FileName> ::: Failed to process.	Fill database - Loading env schema	Pop-up
<FileName>; row: <row> ::: Failed to process.	Fill database - Loading env-waves schema	Pop-up
<FileName> ::: Failed to process.	Fill database - Loading ship schema	Pop-up
<FileName> ::: Failed to process.	Fill database - Loading frontend schema	Pop-up
No unit table available in env and ship schema.	Unit table not loaded in ENV and SHIP schema	Pop-up

Database restore completed successfully.	Database Restore	Pop-up
Backup creation Successfull.	Database Restore	Pop-up
Settings saved in the configuration file.	Save Settings	Pop-up
Do you want to save settings for Protoel? Yes/No	Exit Protoel Application	Pop-up
Database cleaning in progress. Please wait.	DB History	Progress Bar
Calculation in progress. Please wait.	Start calculation	Progress Bar
Web services in progress Please wait.	Web services	Progress Bar
Loading env schema data. Please wait.	Fill database - Loading env schema	Progress Bar
Loading ship schema data. Please wait.	Fill database - Loading ship schema	Progress Bar
Loading frontend schema data. Please wait.	Fill database - Loading frontend schema	Progress Bar
Synchronizing ship schema. Please wait.	Synchronize Ship Schema	Progress Bar
Synchronizing env schema. Please wait.	Synchronize Env Schema	Progress Bar
Synchronizing front end schema. Please wait.	Synchronize Frontend Schema	Progress Bar
Database backup in progress. Please wait.	DB backup	Progress Bar
Database restore in progress. Please wait.	DB restore	Progress Bar
Data is clearing from database older than the date : <now date> UTC.	DB cleaning validation	Log file
Computation starts at <now>.	Computation start	Log file
Computation ends at <now>.	Computation end	Log file
Calculation starts at <now>.	Calculation start	Log file
Calculation ends at <now>.	Calculation end	Log file
Retrieve entries from <config.web serviceRdpFile>.	Web services	Log file
No web service entries defined for datatype: <dataType>; rdp name: <reductionPoint.name> and type: <reductionPoint.type>.	Web services	Log file
Connecting to web services at url: <config.wsdlfile> with user: <config.username> .	Web services	Log file
Connection to web services succeeded.	Web services	Log file
Web service did not contain data for datatype: <dataType>; rdp name: <reductionPoint.name> and type: <reductionPoint.type> from <startTime missing data> to <endTime missing data>.	Web services	Log file
Connection to web services closed.	Web services	Log file
Connection to web services failed.	Web services	Log file
Web service data stored in <local/server> database.	Web services	Log file
endtime for sending web service tide inside connection	Web services	Log file
starttime for sending web service tide inside connection	Web services	Log file

Processing of all access methods starts at <now>.	Start of processing of all access methods	Log file
Processing of all access methods ends at <now>.	Process completed for all access methods	Log file
Processing time of all access methods: <time duration>.	Processing time of all access methods	Log file
Fetching <access method> data starts at <now>.	Fetching of <access method> data start	Log file
Fetching <access method> data ends at <now>.	Fetching of <access method> data end	Log file
Fetching ConditionSquat data starts at <now>.	Fetching of condition squat data start	Log file
Fetching ConditionSquat data ends at <now>.	Fetching of condition squat data end	Log file
Fetching Squat data starts at <now>.	Fetching of squat data start	Log file
Fetching Squat data ends at <now>.	Fetching of squat data end	Log file
No wave spectra were found.	Fetching of spectra data during calculation	Log file
Filling calc schema starts at <now>.	Update of calculation result in calc schema start	Log file
Filling calc schema ends at <now>.	Update of calculation result in calc schema end	Log file
No Env Data found for waypoint <waypointName>, passageTime <passageTime>, datatype <datatype>.	Env Data not found	Log file
Error:GC overhead limit exceeded	OutOfMemory Error	Log file

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