

# ARROW – Quick-Start Guide

## 1 Overview

The ARROW program is a software tool to estimate and display the potential conditions and countermeasures to Avoid Rolling Resonances Or Wave impacts on ships due to specific wave encounter situations. By means of the Main user interfaces (Fig. 1) the input of a small amount of data are needed to be entered into the areas of the Ship Parameter Input (top left side) and Wave Parameter Input (lower left side) to provide the qualitative results in the Result Display Area (right hand side):

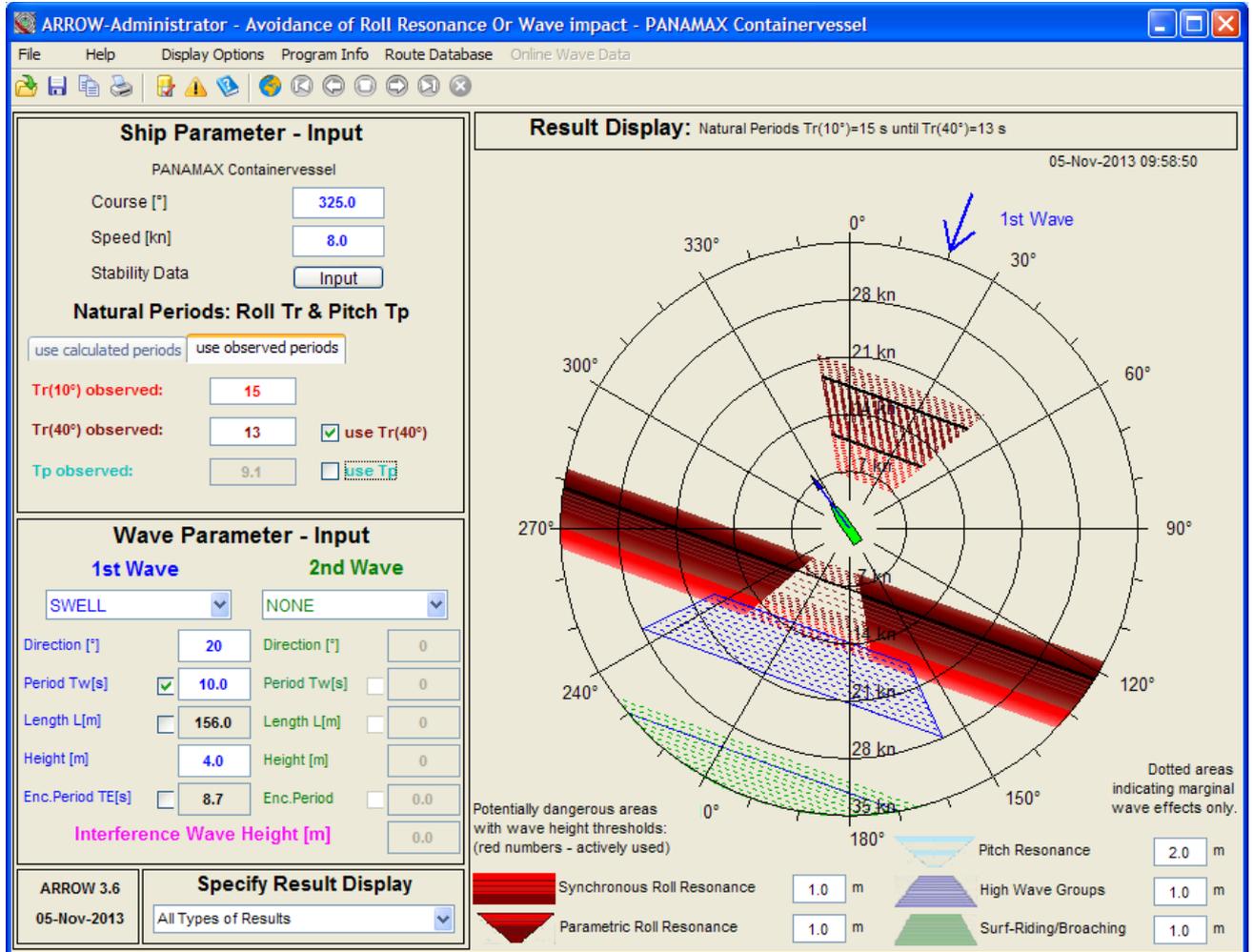


Fig. 1 ARROW program window – overview

## 2 Parameter Input

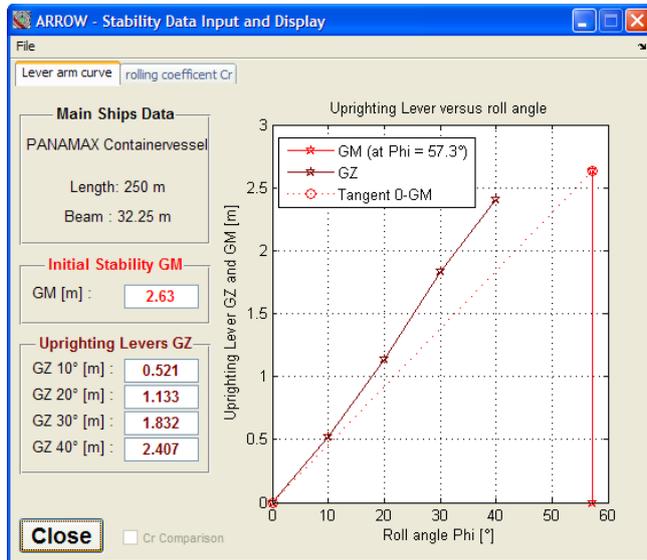
**2.1. Ships course and speed** can be entered in the respective data fields. The heading direction of the ships contour and speed vector in the Result Display will immediately change according to changes in the data fields. Alternatively these values can be set by mouse click (right button) into the ARROW - Result Display Area. Then any desired speed and course can be selected according to the position of the mouse indicator in the polar diagram and using the “Change Course and Speed” menu option afterwards.

**2.2. Natural Roll periods of the ship** can be either calculated by using stability data or alternatively by entering observed periods directly. Both options will be described below:

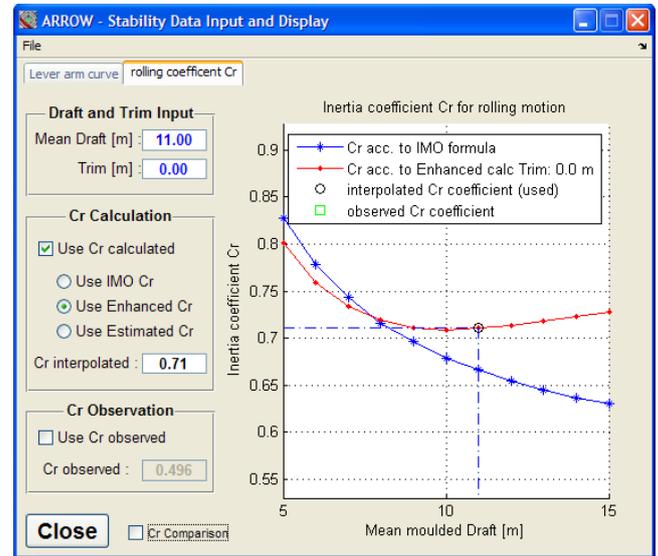
(a) **Stability Data Input:** Open the ARROW - Stability Data Window by clicking onto the 'Input'-Button. Enter the following data (in metres) into the respective input fields: Mean ships draft, Metacentric height GM (including free surface effects) and Up-righting Levers GZ<sub>10</sub> to GZ<sub>40</sub> for roll angles 10° to 40°. The input of these Stability Data can be checked in the plot of the GM and GZ<sub>10</sub> values versus roll angle (s. Fig. 2). To compare the GZ<sub>10</sub> values with the initial stability GM a tangent is drawn from 0 to the GM value at roll angle Phi = 57.3°. The ships' natural roll periods Tr will be immediately calculated and shown in the left side of the ship parameter input area (s. Fig. 1) parallel to the stability data input. The Tr values for small (up to 10°) and large (up to 40°) roll angles are displayed.

(b) **Direct Natural roll period Input from Observations:** Alternatively it is possible to use observed ships roll periods instead - for this purpose a checkbox is available to change between “calculated” and “observed” roll periods. In this case the respective Cr value is highlighted according to the GM value.

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**Fig. 2 Stability Data Window – Graph of uprighing lever versus roll angle Phi and GM tangent**



**Fig. 3 Stability Data Window – Graph of Inertia coefficient Cr and respective Cr value due to draft input**

Note: Corresponding to the draft input the inertia coefficient Cr for rolling motion is shown (s. Fig. 3) in the field below the draft input field. When the draft is changed a new Cr coefficient is interpolated from the programs internal ships data base which was specifically tailored to this ship by means of the ships hydrostatic tables! If a more precise Cr coefficient is known (e.g. from latest on-board measurements resulting from inclining test and roll period test) then the interpolated data can be overwritten by entering a new Cr observed value in the respective data field. To use this observed data the checkbox on the right side can be enabled by mouse click. New values for Tr(10°) and Tr(40°) rolling periods are automatically calculated from the observed Cr and put into the corresponding fields.

### 3 Wave Parameter Input

The ARROW program accepts the input of two different wave systems. The 1<sup>st</sup> Wave area (blue, left side) is designated for the input of the dominant wave system interacting with the ship. Following wave input parameters, taken either from observations on the ship or from weather reports and forecasts, have to be entered in the respective fields:

Selection of type of wave: WIND SEA (short crested, typical wave period up to 10 seconds) or INTERMEDIATE (intermediate type of sea state) or SWELL (long crested, fully developed, typical wave period 10 ... 20 seconds) respectively; Wave Direction (0-360°); Period of Wave Tw (1-30s) or Wave length Lw (1-1400m) respectively (Tw directly corresponds to the wavelength, therefore Tw or Lw can only be entered alternatively by clicking into the respective checkboxes to the left of the parameter fields); Alternatively the Period of Encounter Te can be entered instead of Tw. Height of Wave (0-30m).

The input for the 2<sup>nd</sup> Wave system is identical to the 1<sup>st</sup> Wave. The direction of the first wave system is drawn as a **blue arrow** outside of the polar diagram in the ARROW - Display Area (s. Fig. 1), the second system as **green arrow**. The **magenta arrow** shows the transmission direction of the interference wave.

### 4 Result Display Area

The **blue arrow** attached to the ship and coming out of the centre of the diagram shows the course and the current speed - the point of the arrow - of the vessel according to the ship parameter input data.

The polar diagram provides the critical course and speed ranges resulting in resonance areas by stripes and sectors of high wave impact according to IMO guidelines. All types of resonance and wave impacts are drawn with different colours and shapes to distinguish between them. Beneath the polar diagram a legend is drawn to clarify the relation of the different colours and shapes with respect to the different types of resonance and wave impacts. The speed range and other options can be changed in the top menu "Display options". With a pop-up-menu **Specify Result Display** on the bottom of the left half of the program window the user can choose which results to be shown separately. It is recommended to use "All Types of Results" first to get the full overview!

The ships conditions are potentially unsafe, if the point of the arrow is within one (or even more) of the dangerous areas. In this case the ships speed and course have to be changed. In order to avoid resonances the ships rolling period could be varied by changing the stability parameters (GM or GZ\_values). All of these countermeasures can be checked by trial variations using the ARROW program modules. For a detailed explanation see manual chapter 4.

### 5 Use of ARROW together with ships routing program BON VOYAGE (AWT)

When using the onboard routing system Bon Voyage the most recently edited route can be imported (top menu: "Route Database/Load Route Database") and viewed in the ARROW route list table. ARROW will instantly analyse the route points of this route in terms of the formerly described risks. The status of a route point can be viewed (see Fig. 4) in both, the Result Display and Wave Parameter-Input section by clicking on the corresponding line in the ARROW route list table (blue row). If any line has been highlighted red then there is a potential risk, if orange then a marginal risk may have been left.

Due to any changes in the route or weather conditions in the Bon Voyage system the new data will be transferred automatically to ARROW and an updated ARROW route List will be displayed.

In order to avoid potential resonance conditions either the route can be changed in the Bon Voyage system (course or speed respectively) or the ships natural rolling period could be adjusted by GM corrections in the ARROW interface. Both options can be used to find suitable conditions by simple trial and error methods.

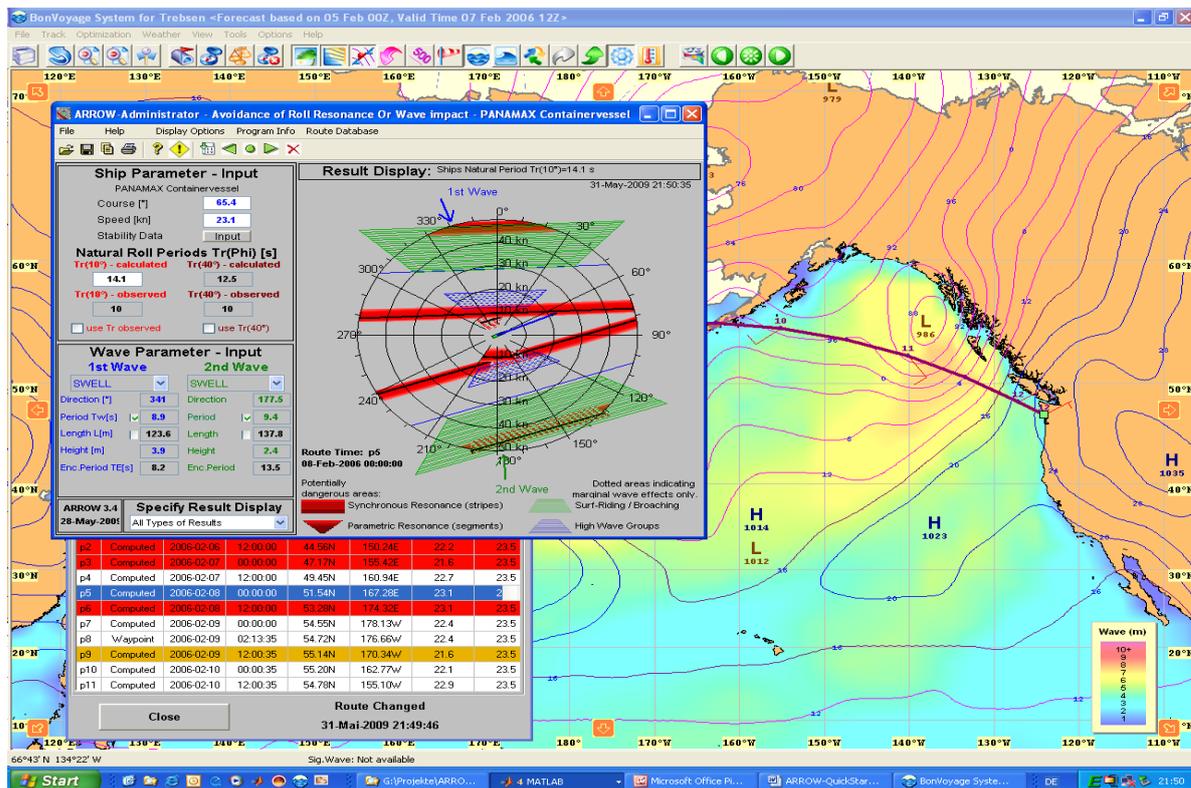


Fig. 4 Use of ARROW program together with onboard routing system Bon Voyage (Fig is taken with ARROW 3.4)

### 6 Use of ARROW with manual route input

Optionally the ARROW software can be delivered with a manual route input (see Fig. 5). Weather routing information arriving onboard on fax or email can be manually edited into a list and thus a complete route can be created. For each point of the route the resonance and wave effects will be calculated and displayed.

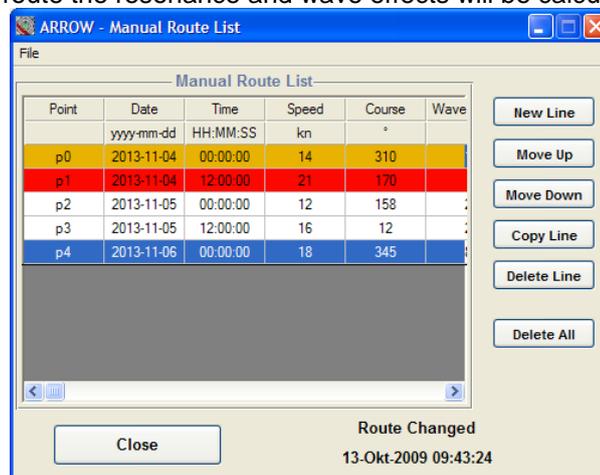


Fig. 5 ARROW manual route input list