

ARROW – Software for Avoidance of Roll Resonance Or Wave Impact

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, specifically potential danger caused by synchronous or parametric resonance. 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 results in the Result Display Area (right hand side):

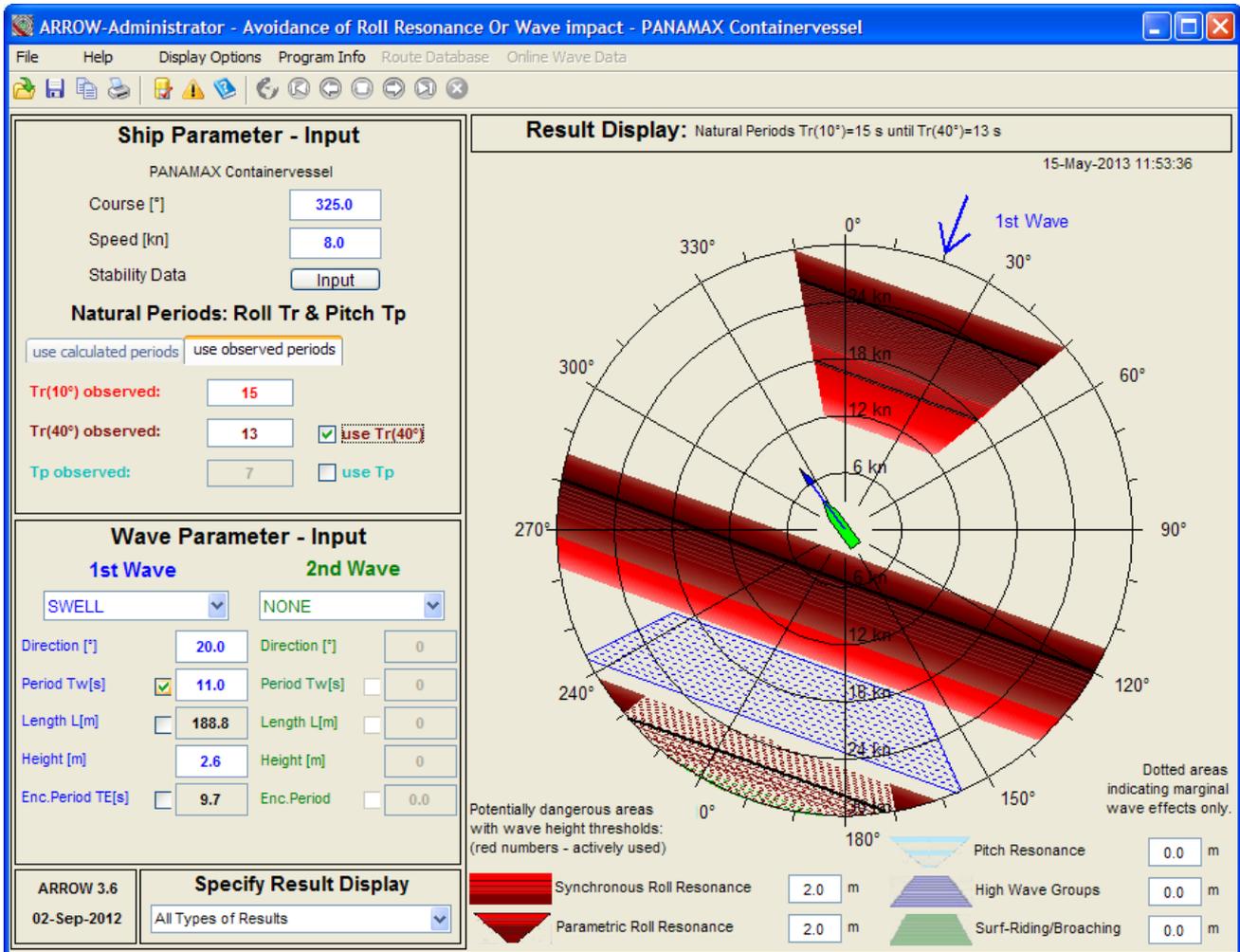


Fig. 1 ARROW program window – overview

2 Parameter Input

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.

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

(a) Direct Input of Natural roll period 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.

(b) Stability Data Input: the stability data can be entered into the respective input fields of ARROW - Stability Data Window. The input of these Stability Data can be checked in the plot of the GM and GZ_ values versus roll angle (s.Fig. 2). To compare the GZ_-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. 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 from the ships hydrostatic tables.

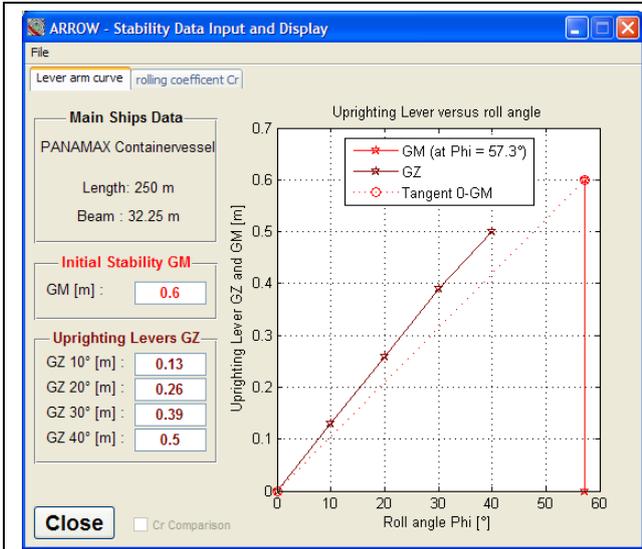


Fig. 2 Stability Data Window – Graph of up righting lever versus roll angle Phi and GM tangent

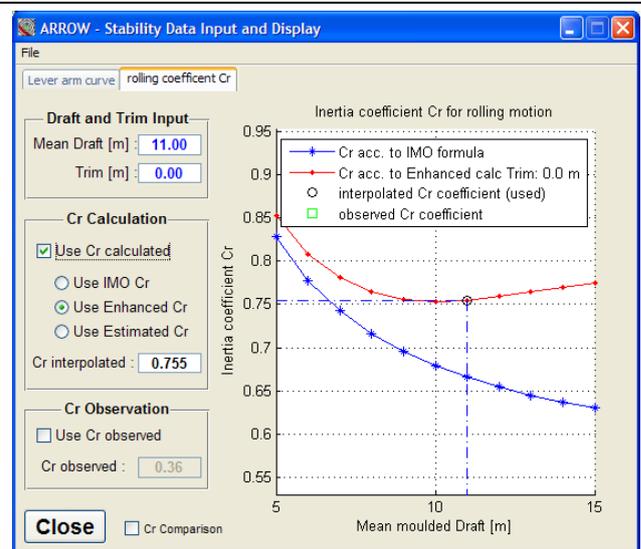


Fig. 3 Stability Data Window – Graph of Inertia coefficient Cr and respective Cr value due to draft

Wave Parameter Input: The ARROW program accepts the input of two different wave systems. The 1st Wave area (blue, left side) is designated for the input of the dominant wave system interacting with the ship. Only a few wave input parameters, taken either from observations on the ship or from weather reports and forecasts, have to be entered in the respective fields. The input for the 2nd Wave system is identical to the 1st 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.

3 Result Display Area and Measures to avoid problems due to wave effects

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 instead of the full overview for "All Results"!

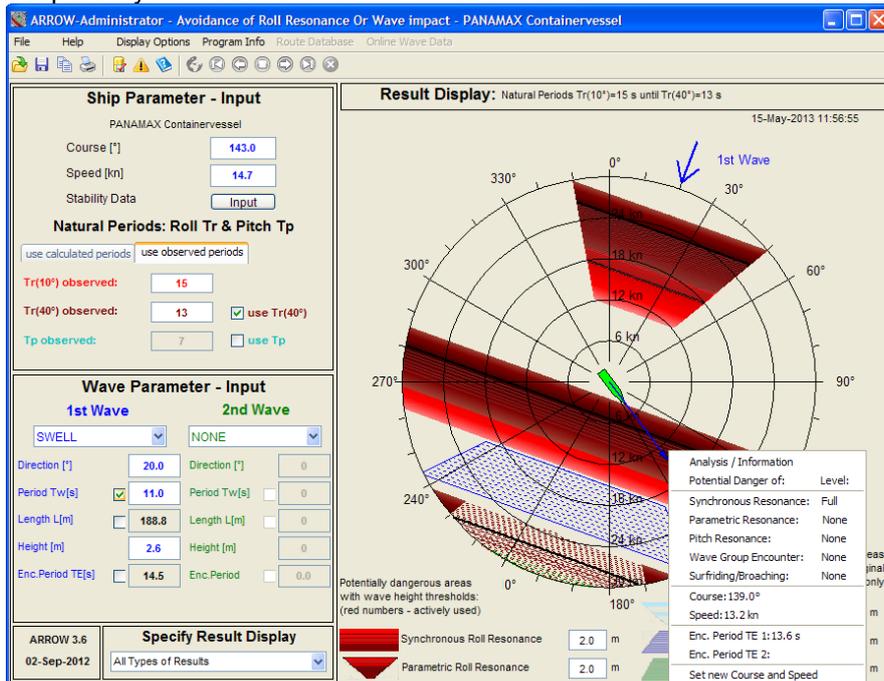


Fig. 4: ship in potentially dangerous situation due to synchronous resonance

If the point of the arrow is within one (or even more) of the dangerous areas the ships conditions are potentially unsafe. In this case the ships speed and course have to be changed to bring the arrow top out of those areas. Alternatively the ships rolling period could be varied by changing the stability parameters (GM or GZ_values) in order to avoid resonances as shown in Fig. 5. All of these countermeasures can be checked by trial variations using the ARROW program modules.

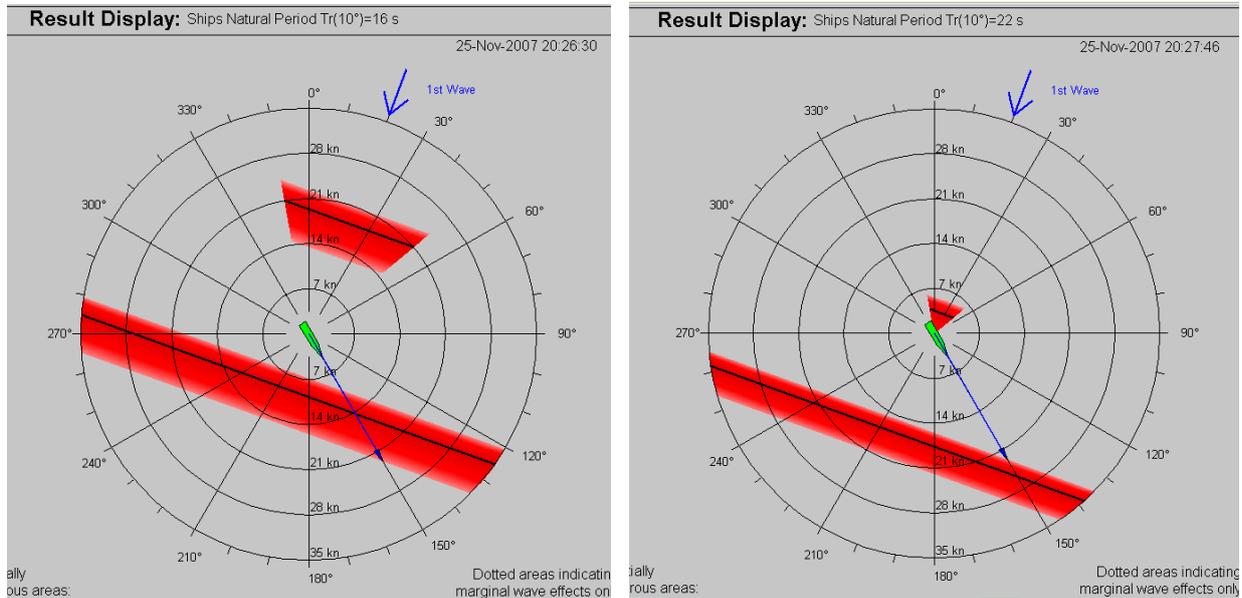


Fig. 5: Shifted resonance areas after changes of rolling period due to change of GM:

a) Results for $T(10^\circ)=16.0$ GM= 1.752m

b) Results for $T(10^\circ)=22s$ at GM= 0.92 m.

4 Use of ARROW Software together with ships routing programs

When using the onboard weather routing system “Bon Voyage” from Applied Weather Technology AWT 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 with respect to the different types of resonance and wave impacts. If any line has been highlighted red then there is a potential risk, if orange then a marginal risk may have been left.

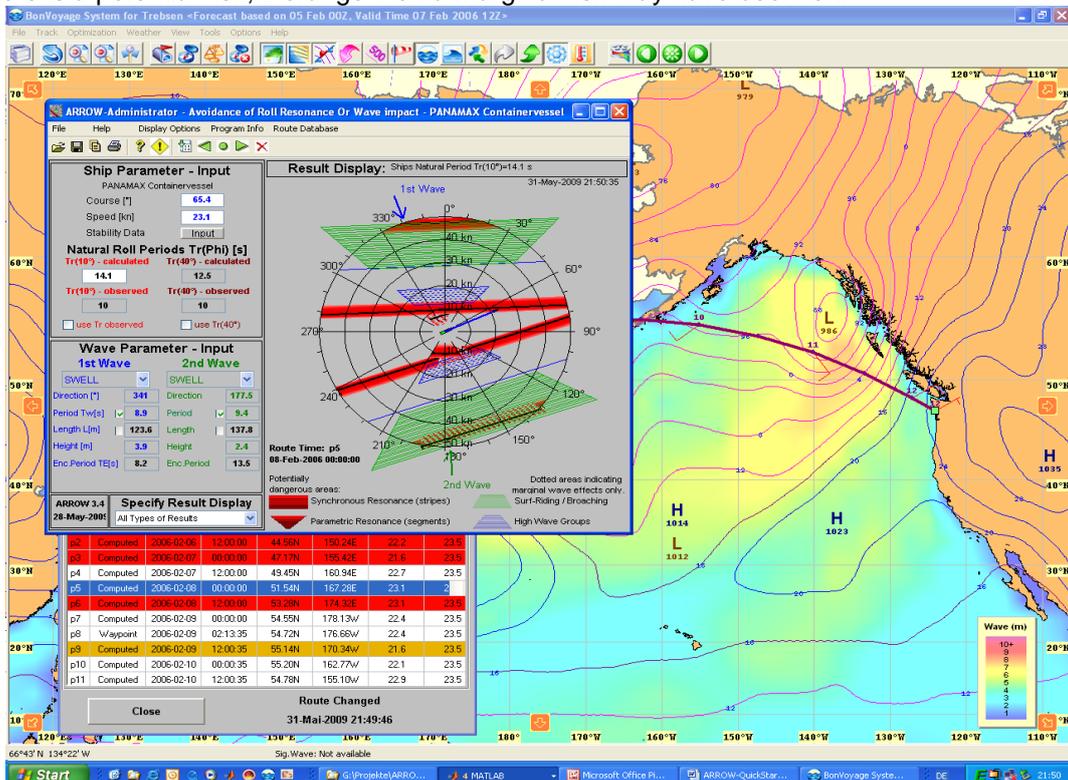


Fig. 6 Use of ARROW program together with onboard routing system Bon Voyage

By simply clicking on the corresponding line in the ARROW route list table (see Fig. 6: left corner bottom; blue line) the status of a route point can be viewed in both the Result Display and Wave Parameter-Input section (top left). In this case even two wave systems were existing (swell from 117° and from 268°)

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 (to be checked by GM corrections in the ARROW interface). Both options can be used to find suitable conditions by simple trial and error methods in the phase of voyage planning or for the actual condition at sea.

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. This immediate update will also take place, if the stability data respectively the roll period are being changed.

5 Versions of ARROW Software

There are several versions of ARROW available:

Training Institute Version: For Education and lecturing of Wave Effects at Seafaring Training Institutions or training in their computer labs. For this reason several different vessels and encounter situations can be prepared and loaded according to the specific training needs.

On Board Versions: Used for decision making on ships of any type

Basic Version: specifically designed and data base adjusted to quickly calculate and display all wave effects for that one specific vessel. Manual input of route segments and wave data is available for voyage planning and decision making for avoidance measures.

Routing Version: Specific Interface allows for interoperation with AWT ships routing software "Bon Voyage". Planned routes files from "Bon Voyage" can be screened for potential danger of wave impact and decision making for avoidance measures can be taken.

Office Versions for Shipping Companies: Comprising software and databases for all ships of a company carrying ARROW to be monitored on shore by the persons in charge (inspectors) or in case of distress. Situation files generated on board and sent to shore can be displayed and discussed for decision making.

6 ARROW Contact Details:

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