Strip-Theory Calculations of Motions and Loads of Ships, Barges, Catamarans and Semi-Submersibles at Infinite and Restricted Water Depths in a Seaway

S E A W A Y

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SEAWAY is a frequency domain ship motions PC program, based on both the ordinary and the modified strip theory, to calculate the wave-induced loads and motions with six degrees of freedom of mono-hull ships and barges in seaway. When not accounting for interaction effects between the two individual hulls, also these calculations can be carried out for twin-hull ships, such as semi-submersibles or catamarans. Linear springs in any arbitrary direction can be added. The program is suitable for deep and shallow water.

The program has been validated with results of other 2-D and 3-D computer programs and with experimental data. Based on these validations and on the experience, obtained during an intensive use of SEAWAY for many years by the author and industrial users and institutes, it is expected that SEAWAY is free of significant errors.

SEAWAY requires two separate input data files: a hull form data file and a variable input data file. The offsets of the cross sections of the fully loaded ship are input and have to be stored in the hull form data file. Also, this hull form data file can be output of the PIAS program of SARC. At any actual loading of the ship, new offsets will be calculated by the program from these data by the actual amidships draught and trim, given in the variable input data file. A linear transformation of this hull form can be carried out too, by an input of three independent scale factors.
For preliminary calculations, a set of hull form data files - with about 125 non-dimensional “parent hull forms” - is available for the users. Selected hull forms from this set - with acceptable waterline and block coefficients - can be scaled easily to the principal dimensions of the actual ship.
In a preliminary design stage of a ship, also a pre-processing program SEAWAY-L can be used to create a Lewis hull form data file from the sectional breadths, draughts and areas only.
A control program, named SEAWAY-H, displays the body plan of the ship, as stored in the hull form data file, on the screen. Modifications can be carried out with this control program too.
A very user's friendly input-editor, named SEAWAY-E, creates the input data file. Almost this editor takes the place of the User Manual: Manual.doc.

Always, the wave potentials are defined for the actual water depth.
Lewis or N-parameter close-fit conformal mapping methods and the potential theory of Ursell and Tasai in deep water can calculate the two-dimensional hydrodynamic coefficients. Also the 2-D diffraction pulsating source theory of Frank can be used. Shallow water coefficients can be determined with the Lewis conformal mapping method and the shallow water potential theory given by Keil. Special attention has been paid to submerge sections and to surge coefficients.
Wave loads can be calculated by either the relative motion approach or by the diffraction method.

The input data of the longitudinal mass distributions, required for calculating the vertical and horizontal shear forces and bending moments and the torsion moments are independent of the hull form input. Jumps in these distributions are permitted.
Linear and non-linear (viscous) roll damping coefficients can be determined by the empirical Miller method or by the semi-empirical Ikeda method. Damping coefficients, as derived from model tests, can be input too. If required, the program will carry out the linearisation.
Free surface anti-rolling tanks are included. External roll moments, to be defined by the user, can be input.
Linear springs (mooring) can be used too.

At choice, the uni-directional wave spectra can be defined by the ideal Neumann spectra, modified Pierson-Moskowitz, ITTC, ISSC or Bretschneider spectra or JONSWAP spectra and by an input of wave spectra. Either the spectral centre period or the zero-crossing period can define these wave spectra. The printed output data of the statistics of the responses follow this definition.

The major magnitudes of ships, barges, semi-submersibles or catamarans, which can be calculated by the program SEAWAY, are:

- Some geometrical data, such as areas and centroids of cross sections and waterlines, volume of displacement, centre of buoyancy, metacenter heights, wetted surface of underwater hull, vertical shear forces and bending moments in still water, etc.
- Two-dimensional and three-dimensional frequency-dependent hydrodynamic coefficients calculated with either one of the conformal mapping methods or the 2-D diffraction method.
- Natural heave, roll and pitch periods.
- Frequency characteristics of:
  - Wave forces and moments.
  - Centre of gravity motions: surge, sway, heave, roll, pitch and yaw.
  - At specified points: absolute motions, velocities and accelerations in the three directions and vertical relative motions, including or excluding a dynamical swell-up.
  - Mean added resistance caused by waves and ship motions, calculated with both the radiated energy method and the integrated pressure method.
  - At specified cross sections: vertical and lateral shear forces and bending moments and torsion moments.
- Energy spectra of uni-directional irregular waves defined by Neumann spectra, Bretschneider spectra, JONSWAP spectra and also measured point spectra.
- With these wave spectra: energy distributions, significant amplitudes and average periods of the responses of which the frequency characteristics have been calculated.
- Probability as well as number per hour of exceeding threshold values by the relative motions, to be used for the calculation of shipping (green) water, propeller racing, etc.
- Probability and number per hour of slamming, according to the formulation of Ochi and a pressure criterion.

With print-options, a choice can be made for the desired output.

A lot of attention has been paid to an well-ordered output of the calculated data. The ASCII output data are given in a format that can be made suitable for other programs, spreadsheets and plot routines by a usual editor, easily.
Optionally, an ASCII data file, named SEAWAY.DAT, will be filled with data in a format defined by the user. The user has to inform the author about the required data in this file. Exclusive for each individual user, these formats can be fixed into program SEAWAY. Other programs, spreadsheets or plot routines can read this Personal SEAWAY.DAT File, directly.

Standard, this SEAWAY.DAT file will be filled with LOTUS or QUATRO-PRO data.

The programs are written in FORTRAN/77, suitable for any MS-DOS Personal Computer. Easily, the programs SEAWAY and SEAWAY-L can be made suitable for other computer systems, because all system-related parts have been assembled in one subroutine.
The SEAWAY program has been protected against an unauthorised use by a Sentinel-C software protection key, which will be delivered together with the programs. An International Licence Agreement has to be signed by both parties.

The programs in the SEAWAY-package are described in documents on the Internet:

- **BrochureSEAWAY.doc**, with short general information about the program (4 pages)
- **UserManualSEAWAY.doc**, the user manual (140 pages), including 123 transformable hull form files
- **TheoreticalManualSEAWAY.pdf**, the theoretical manual (286 pages)
- **ValidationSEAWAY.pdf**, a report (102 pages) in progress with verifications and validations SEAWAY with 3-D computational data and numerous experimental data.

Further information:

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The present licensees of the ship motions program SEAWAY are listed below.

000	S/Sd	Author and Students of DUT, HTO and HNO
001	S	IHC Gusto Engineering, Schiedam, The Netherlands
002	S	Royal Dutch Navy, Ship Design Office, Den Haag, The Netherlands
003	S/Sd	Royal Institute for the Dutch Navy, Den Helder, The Netherlands
004	S	Allseas Engineering, Delft, The Netherlands
005	S	Kupras Computer Systems, Zoetermeer, The Netherlands
006	S	Hoger Technisch Onderwijs Rotterdam, Rotterdam, The Netherlands
007	S	Technische Hogeschool Haarlem, Haarlem, The Netherlands
008	S/Sd	Delft University of Technology, Dredging Lab., Delft, The Netherlands
009	S	Wijsmuller Engineering, IJmuiden, The Netherlands
010	S	Hollandse Signaalapparaten, Hengelo, The Netherlands
011	S/Sd	Delft Shiphydromechanics Laboratory, Delft, The Netherlands
012	S	Kahn Shipping, Rotterdam, The Netherlands
013	S	University of Twente, Enschede, The Netherlands
014	S	Norwegian Contractors, Stabekk, Norway
015	Sd	Delft Hydraulics, Delft, The Netherlands
016	S	Directorate General of Transport, Den Haag, The Netherlands
017	S	Nevesbu, Den Haag, The Netherlands
018	S/Sd	Delft University of Technology, Ship Design, Delft, The Netherlands

019	Sd	TNO-CMC, Delft, The Netherlands
020	S	Meteo Consult, Wageningen, The Netherlands
021	S	Shipyard YVC, Capelle aan den IJssel, The Netherlands
022	S	Directorate General of Transport, Den Haag, The Netherlands
023	S	Bureau voor Scheepsbouw de Groot, Bloemendaal, The Netherlands
024	S	Hoger Nautisch Onderwijs, Rotterdam, The Netherlands
025	S	Damen Shipyards, Gorinchem, The Netherlands
026	Sd	HAM, Capelle aan den IJssel, The Netherlands
027	Sd	Boskalis-Westminster, Papendrecht, The Netherlands
028	Sd	Ballast-Nedam, Zeist, The Netherlands
029	S/Sd	SAM Consult, Delft, The Netherlands
030	S	University of Ghent, Ghent, Belgium
031	S	University of Izmir, Izmir, Turkey
032	S	University of Trondheim, Trondheim, Norway
033	S	Geomatic, Dordrecht, The Netherlands
034	S	University of California, Berkeley, USA
035	S	Vestfold College, Horten, Norway
036	S/Sd	MTI Holland, Kinderdijk, The Netherlands
037	S	Technical University of Berlin, Berlin, Germany
038	S	Flanders Hydraulics, Antwerp, Belgium
039	S	Bluewater Engineering, Hoofddorp, The Netherlands
040	S	Pattimura University, Ambon, Indonesia
041	Sd	JBR, Pijnacker, The Netherlands
042	S	Shipyard de Hoop Lobith, Lobith, The Netherlands
043	S	Bureau Veritas, Rotterdam, The Netherlands
044	S	Marine Structure Consultants, Schiedam, The Netherlands
045	S	Dockwise, Meer, Belgium
046	S	Marine Treasure, Rotterdam, The Netherlands
047	S	Boskalis, Papendrecht, The Netherlands
048	S	Seaway Heavy Lifting, Zoetermeer, The Netherlands
049	S	Alkyon, Marknesse, The Netherlands
050	S	Oceanco Shipyards, Alblasserdam, The Netherlands
051	S	Cochin University of Science and Technology, Cochin, India
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054	S	Isfahan University of Technology, Isfahan, Iran
055	S	Baar Maritime Cons. Int., Burgh-Haamstede, The Netherlands
056	S	Sea of Solutions, Vlaardingen, The Netherlands
057	S	University of Newcastle, United Kingdom
058	S	University of Rijeka, Croatia.
059	S	Polytechnics of Dubrovnik, Croatia.
060	S	Yildiz Technical University, Istanbul, Turkey.
061	S	Hochschule Bremen, Germany.
062	S	Queen's University, Canada.
063	S	University of La Coruna, Spain.

Note: S = Licensee of the parent program SEAWAY.
Sd = Licensee of a derivative version of program SEAWAY, for instance a hydromechanic Pre-processing Program for time domain calculations.

Apart of these licensees, the SEAWAY programs are and have been used temporarily by and for a large number of other (mostly small) companies.