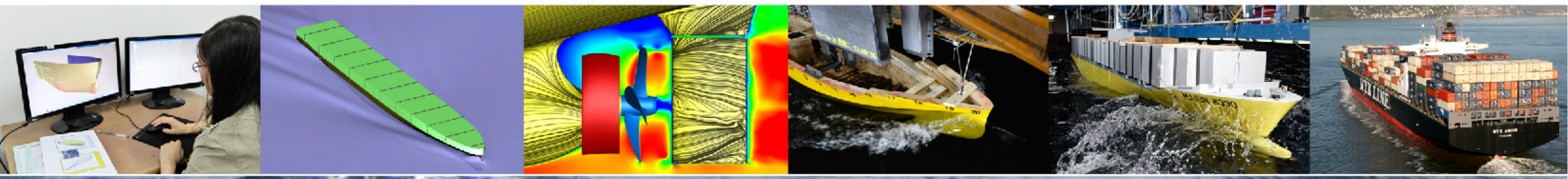


Building a leading hydrodynamic consultancy base in Asia

创建亚洲领先的水动力学咨询基地

Calculation of wave resistance and potential flow 兴波阻力和势流计算

RAPID

The computer program RAPID calculates the steady inviscid flow around a ship hull, the wave pattern and the wave resistance. It solves the exact, fully non-linear potential flow problem by an iterative procedure, based on a raised-panel method.

Since its initial development, RAPID has been routinely applied in practical ship hull design. Continuous further development has extended the applicability and improved the efficiency and accuracy. Today it is one of the best known codes worldwide in the field of resistance and flow. RAPID forms an integral part of MARIN's consultancy services related to hull form improvements.

计算机软件 RAPID 计算船体周围的稳定非粘性流体，波形和兴波阻力。基于高阶面元法，它用迭代法解决了准确的完全非线性的势流问题。

自它最初被开发以来，RAPID 已经被惯例地应用到实际的船型设计中。持续的进一步开发扩大了它的适用范围，提高了效率和准确度。现在，它是世界上在阻力和流体领域内最知名的程序之一。RAPID 是 MARIN 涉及船体线型改进咨询服务的一个整体的组成部分。

Applications 应用范围

RAPID is used for the minimisation of wave making and wave resistance, primarily. All features of the wave pattern, hull pressure distribution and streamline direction over the hull can be visualised.

RAPID is applicable to the great majority of vessels, varying from tankers and frigates to sailing yachts, and ferries; ships in deep or shallow water, or even in channels. Extensions have been developed for ships with lifting surfaces (e.g. keel or rudder), and asymmetric cases.

RAPID 主要是用于减少兴波和兴波阻力。还能够显示波形、船体压力分布和全船流线方向的所有特征。

RAPID 适用于绝大多数船型，从油轮和舰艇到游艇和渡船；深水或浅水里的船，甚至是河道里的。已开发的拓展版本可用于带有附体的船（例如龙骨或舵）以及不对称船型。

Accuracy 准确度

RAPID has been validated extensively against test results from MARIN's model test basins. The predicted flow and wave pattern have been found to be accurate, and to indicate consistently the quality of a design and possible improvements. Compared to linearised methods, RAPID predicts the bow wave height and diverging waves far more accurately. The predicted wave resistance is generally used in a relative way for the comparison of two hull forms in a hull form optimisation process.

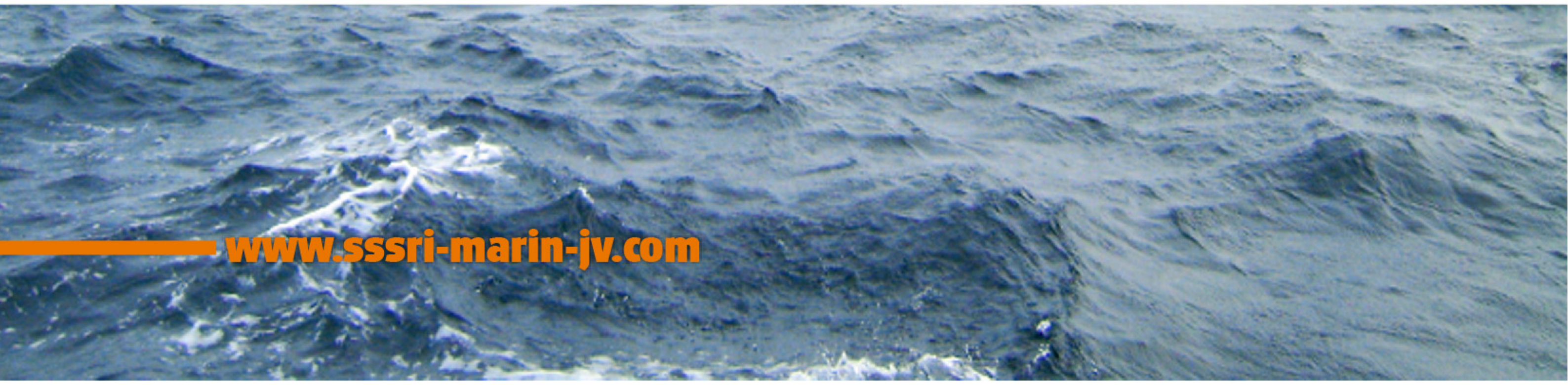
RAPID 已经被来自 MARIN 船模试验水池的试验结果所广泛验证。预报的流场和波形都是准确的，并且可以指出设计的质量和可能的改进。相比线性法，RAPID 预报的船首波高和散波要准确的多。兴波阻力的预报一般用于船型优化过程中作为比较两种船型的一种相对的方法。

Restrictions 局限性

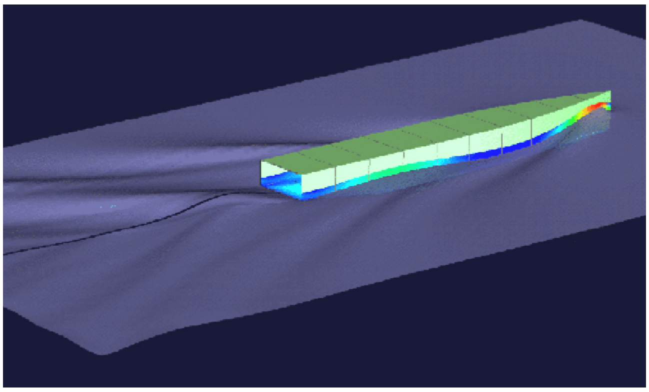
The method is based on inviscid flow theory, which excludes the effect of boundary layers, dead water zones behind a transom, or flow separation. Consequently, the amplitude of the stern wave system is usually overestimated; very little for slender transom stern vessels, more for fuller hull forms. The wave resistance prediction is affected by this, and therefore, not fully accurate for the fuller hull forms. However, the wave resistance is good for ranking different hull form designs in an optimisation process. Wave breaking or spray are not modelled.

V. 2017/08/28_SSSRI

SSSRI/MARIN
JOINT VENTURE 合资公司
Minsheng Rd. 600 民生路 600 号
Shanghai 200135, China 上海
T 电话 +86-21-58852760
F 传真 +86-21-58212824
E 电邮 info@sssri-marin-jv.com
I 网页 www.sssri-marin-jv.com



该方法是基于非粘性流场理论，没有考虑边界层效应，船尾死水区域和流场分离。因此，船尾波系的振幅通常被过高的估计了；细长艉封板船很小，肥大型船很大。兴波阻力的预报也受这个影响，所以，对于肥大型船不完全准确。但是，在优化过程中兴波阻力有益于对不同的船型设计来分级。碎波或者飞溅都没有模拟。



Input 输入

RAPID comes standard with a Graphical User Interface which helps the user preparing the input, running the code and analysing the results. Calculations are made for the speeds, displacements, LCG positions, water depths, and channel widths specified by the user.

The input consists of a hull panel distribution and a free surface panelling. The hull panel distribution can be generated from a digitised body plan or from a hull surface representation in a CAD system. Interfaces exist for generating RAPID input files directly from e.g. NAPA, TID and GMS. A free-surface panelling is generated automatically.

RAPID 拥有标准的图形用户界面，帮助用户完成输入，运行程序和分析结果。在用户指定航速、排水量、重心纵向位置、水深和航道宽度下进行计算。

输入包括船体网格划分和自由面网格。船体网格划分可以由数字化线型图或者由 CAD 系统中描述的船体表面生产。可以由界面直接从例如 NAPA、TID 和 GMS 中得到 RAPID 的输入文件。自由面网格是自动生成的。

Output 输出

The output consists of the velocity and pressure distribution on the hull, the wave pattern, wave profile along the hull, wave resistance, dynamic sinkage and trim, actual wetted surface area at speed, far-field wave spectrum, etc. A visualisation tool gives detailed insight in the character of the flow, the origin of dominant wave components and possible hull form improvements.

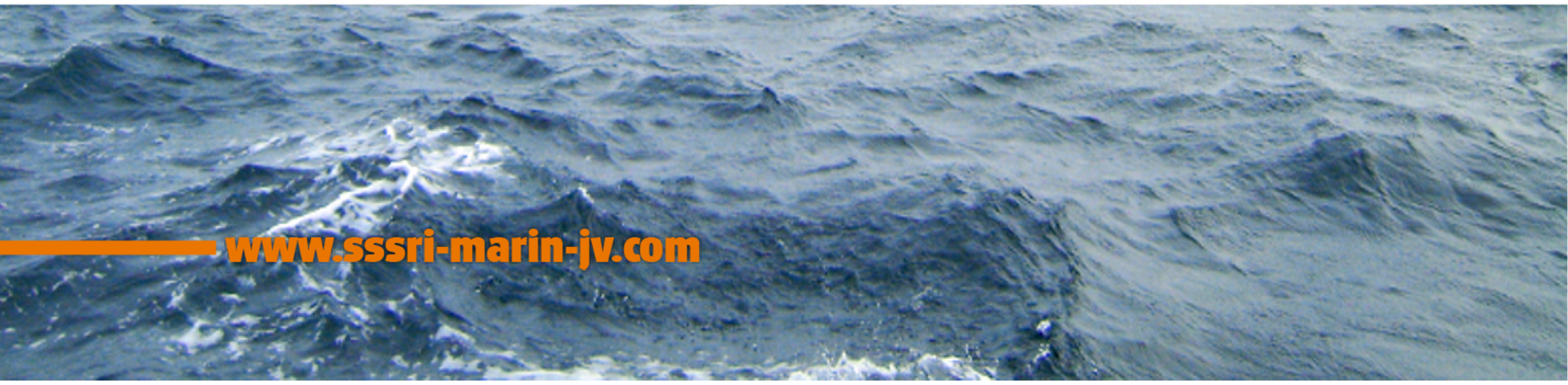
Expert judgement of the results will indicate which hull form modifications will reduce the wave making. Hereafter, RAPID can be used again to verify the modified design. In a few steps a hull form can efficiently and quickly be optimised, and thus model testing can be limited.

Additionally, the pressure distribution may indicate possible improvements of the viscous flow (e.g. reducing flow separation). Flow directions on the hull are used for aligning bilge keels or knuckle lines with the local flow. Predicted far-field wave heights are relevant for wash.

输出包括速度和船体压力分布、波形、波切图、兴波阻力、深沉和纵倾、实际航速下的湿表面积、远场波谱等。可视化工具给出了详细的信息，包括流场的特征，主要的波成分和可能的船型改进方向。

专家对结果判断可以指导船型的修改，以减少兴波。此后，RAPID 可再次使用以验证改进的设计。经过几轮，船型就能够被快速且有效地优化，从而可以减少船模试验次数。

此外，压力分布可表明粘性流体可能改进的地方（例如减少流分离）。船体上的流线方向可用于校准舭龙骨或者局部流的折角线。借助尾流预测远场波高。



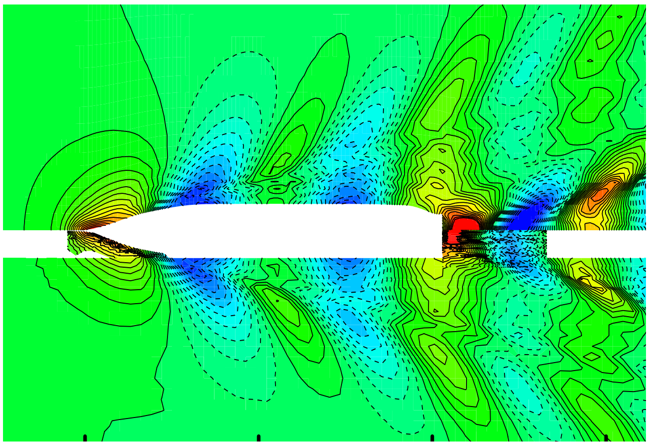
Computational approach 计算方法

The solution of the non-linear free-surface problem is found in an iterative procedure. The flow field and wave surface are repeatedly updated until all boundary conditions are met. The dynamic trim and sinkage of the hull are adapted to balance the hydrodnamic forces and moments.

Each iteration solves a linearised intermediate problem using a panel method. Source panels are distributed over the hull and at a small distance above the wave surface. The hull and free-surface boundary conditions lead to a large system of equations that is solved using an efficient iterative algorithm.

非线性自由液面问题的解决方法是用迭代法。流场和波面不停地被更新直到所有边界条件都满足。船体的纵倾和深沉适用于平衡水动力和力矩。

每一步迭代用网格法解决了一个线性中间问题。源面分布全船和波面上一个很小的距离。船体和自由边界条件导出了一个很大的等式系统，使用有效的迭代法则得以解决。



Wave pattern of a container ship.一艘集装箱船的波型

Top half: RAPID prediction. Bottom half: experiment (KRISO)上半：计算结果。下半：试验结果

References 参考文献

- Raven, H.C. and Valkhof, H.H.; "Application of Non-linear Ship Wave Calculations In Design", 6th PRADS Symposium, Seoul 1995.
- Raven, H.C.; "A Solution Method for the Non-linear Ship Wave Resistance Problem", PhD. Thesis, Delft Univ. Technology, June 1996.
- Raven, H.C.; "Inviscid Calculations of Ship Wavemaking Capabilities, Limitations and Prospect", 22nd Symp. on Naval Hydrodynamics, Washington DC, 1998.

For more information please contact the department Maritime Simulation & Software Group;

更多信息请联系海事模拟及软件组；

T +31 317 49 32 37

E msg@marin.nl

Follow us on WeChat !

欢迎关注我们的微信公众号！