

Ship design process using life cycle integrated independent software of SHIPLYS platform

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Abstract

SHIPLYS is a three-year project that started in September 2016 with funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 690770. The project aims to provide a software system that will implement rapid virtual prototyping, risk-based design, environmental aspects, end-of-life considerations and life cycle cost assessment into the concept phase of the ship design. The system will increase the competitiveness of SME design offices and shipyards by enabling them to generate cost-efficient concepts in short time. This paper presents the utilisation of independent software packages through the SHIPLYS platform with the aim to develop an early ship design for bidding purposes. The paper starts with importing the design requirements from a typical tender document and then presents how specific software tools can be used through the SHIPLYS platform to develop or check some of the critical design features, such as the compartment arrangement, weight assessment, stability evaluation etc.

The paper will interest a variety of industry stakeholders such as designers at shipyards, ship owners, classification societies, researchers and technology providers in the shipping sector.

Keywords: early ship design, virtual prototyping, life cycle analysis, risk assessment, environmental impact

Uvid u ranu fazu projektiranja broda upotrebom SHIPLYS platforme (Softverska rješenja za životni ciklus broda) koja integrira neovisne softverske pakete

Sažetak

SHIPLYS je trogodišnji projekt koji je započeo u studenom 2016. godine uz potporu istraživačkog i inovacijskog programa Obzor 2020 Europske komisije pod ugovorom o dodjeli bespovratnih sredstava br. 690770. Cilj projekta je pružiti softverski sustav koji će implementirati metodu brze izrade virtualnih prototipova, dizajn na temelju rizika, aspekte utjecaja na okoliš, razmatranje kraja životnog ciklusa te procjenu troškova kroz cijeli životni vijek u konceptualnu fazu projektiranja broda. Sustav će povećati konkurentnost malih i srednjih projektnih ureda i brodogradilišta tako što će im omogućiti da u kratkom vremenu generiraju profitabilne koncepte brodova. Ovaj članak daje uvid u upotrebu softverskih paketa na SHIPLYS platformi s ciljem razvoja koncepta broda za potrebe cijenovnog nadmetanja. Članak u početku daje prikaz projektnih zahtjeva sadržanih u uobičajenom dokumentu o upitu za nadmetanje. Kasnije, članak opisuje kako se upotrebom specifičnim softverskim alata SHIPLYS platforme mogu definirati ili provjeriti neke od ključnih značajki projekta, kao što su razmještaj prostora, procjena težine, evaluacija stabiliteta itd.

Članak je interesantan raznim stručnjacima iz industrije kao npr. projektantima u brodogradilištima, brodovlasnicima, klasifikacijskim društvima, istraživačima i pružateljima tehnologije u brodarskom sektoru.

Ključne riječi: rana faza projektiranja, izrada virtualnih prototipova, analiza životnog ciklusa, analiza rizika, utjecaj na okoliš

Introduction

The SHIPLYS project [1] is driven by the requirements of small and medium enterprise (SME) shipyards that need to very quickly come up with the reliable cost estimates in response to tenders for new building or retrofitting jobs. SMEs are in need of early ship design solutions that provide approximate, but reliable assessments of design features without going into detailed analyses. Such solutions also need to be customised to operators' requirements to find optimum ship performance from the perspectives of life cycle costs (LCC), environmental impact and risk management. Thus, the ambition of the SHIPLYS project is not just to help shipyards in making rapid and reliable estimates in response to tenders, but also to enable them to add value to the services that they provide by giving them the ability to assess and provide costing for different design alternatives with their respective LCC, environmental impact and risk profiles [1]. The central objective of the SHIPLYS project is to develop a software platform of integrated software solutions for SME shipyards to support them in the bidding stage. The platform will enable them to make quick cost estimates based on the scope of work required to fulfil the design requirements and to provide them with the decision support system that evaluates LCC, environmental impact and risk management criteria; see Figure 1 for SHIPLYS platform software concept.

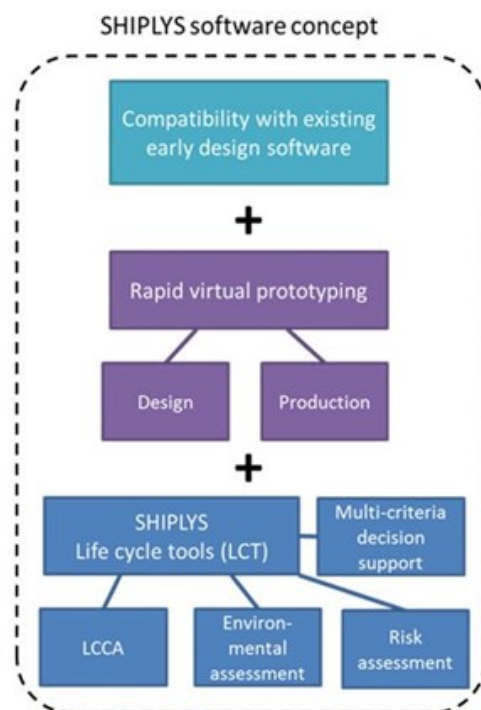


Figure 1: SHIPLYS software concept

The platform functionalities being developed are, in the first place, rapid design and production simulation that is obtained by integrating the existing software packages to the SHIPLYS software platform. These functionalities are being further combined with SHIPLYS 'life cycle tools' (LCT), where LCT is the solution module that enables LCC analyses (LCCA),

environmental impact estimates, risk assessments, and multi-criteria decision analyses (MCDA). MCDA will enable end-user specified criteria to be used in the assessment of aspects such as operational costs, disposal costs, risk tolerance etc. [2] describes an MCDA framework that includes the provision of conducting sensitivity analyses and uncertainty in input data to be considered. Another key aspect of SHIPLYS solutions is providing shipyards with the ability to exchange data between existing software using ISO 10303 protocols [3] and a REST-based platform. ISO 10303 is a standard for computer-interpretable representation and exchange of product manufacturing information. This standard is also known as STEP (Standard for the Exchange of Product model data) and can represent 3D objects in Computer-aided design (CAD) and corresponding product model information. REST (Representational state transfer) web services are a way of providing interoperability between computer systems and are already being successfully implemented in the SHIPLYS platform.

To properly test the SHIPLYS platform, three end-user design cases are considered, and these are called 'Scenarios' that indicate the types of problems for which the SHIPLYS platform should be able to provide solutions. A first such scenario is a hybrid ferry that utilises diesel-electric propulsion in combination with batteries on a short-route voyage. The idea is to optimise the power consumption and to enable silent operations while the ferry is in a port [4]. The second scenario focuses on ship structure of a multi-purpose vessel (MPV), being able to carry oil, bulk and container cargo. The idea here is to have a ship that is easily adaptable to the shipping market, but the scenario also considers the implications of building such MPV [5]. The third scenario is about retrofitting a scrubber unit onto an existing ship. The idea is to test how the software will estimate the retrofitting costs and perform the LCCA of the ship after the retrofitting [6].

The following sections describe the current SHIPLYS platform capabilities shown in the example of the design of MPV. Furthermore, current and future software development within SHIPLYS project are briefly elaborated.

Overview of the design process using SHIPLYS platform

Graphical User Interface

The graphical user interface (GUI), shown in Figure 2, allows the user to track progress through the design process and to verify if the tender requirements are met, but also to identify and resolve the design issues if any.

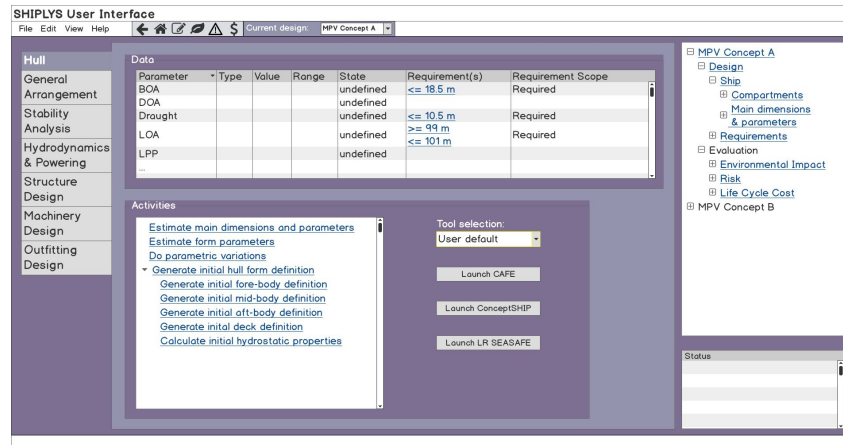


Figure 2: Graphical User Interface

On the GUI-top, there are buttons used to start a new project, start a risk analysis, environmental analysis or LCCA. The window below, called “Data” shows design parameters related to the project and their current and required values. On the right side of the GUI, there is a database structure in the form of a data tree related to the current project with a short description of the items contained in the tree. On the left side, there are subcategories of design, starting with the hull and general arrangement, then stability, hydrodynamics, machinery, etc. In the middle of the GUI, there are “Tool selection” drop-down menu and “Activities” window. When a user selects a design tool from the drop-down list of the SHIPLYS-integrated tools, the activity window gets populated with the possible design activities that the selected tool can perform. Depending on the activity that a user needs, he will execute the most favourable design tool. Once the activity is completed in a design tool, the newly obtained data is stored to the SHIPLYS database, and the “Data” table is refreshed with parameter definitions and values. If there are any issues with the data transfer part, the list of errors and warnings will be shown in the “Status” window in the lower right corner in Figure 2.

It is worth noting that the selection and the sequence of the design tools in SHIPLYS platform are flexible and that for different projects, a user can choose different tools for the same design activity. In the following sections, one possible alternative of the design tool sequence will be presented, and it is schematically shown in Figure 3.

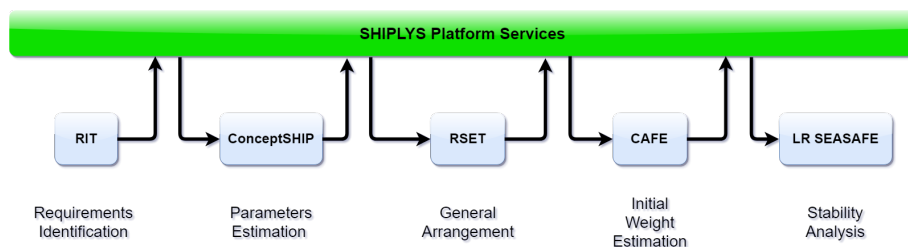


Figure 3: One possible design tool sequence using SHIPLYS platform

Requirement Identification Tool

At the beginning of the bidding process, it is necessary to identify the design requirements. SHIPLYS utilises a Requirement Identification Tool (RIT) developed for the project. The requirements can be very general in the beginning of the bidding process referring only to the overall parameters, such as ship speed, vessel range, loading capacity etc.. However, as time progresses through the bidding phase, these requirements can become very specific, such as the manufacturer and the model of radar or auxiliary pumps etc. To make RIT user friendly, the tender document is imported into the SHIPLYS platform, and all the design requests are shown in plain text within the GUI. A user reads through the text and easily identifies the requirements, such as the ship speed, range deadweight etc. A user can highlight the text that is giving the value of some required parameter, and the RIT will store the parameter description and its value to the SHIPLYS database and in the “Data” table in Figure 4 and “Requirements” table in Figure xx within the column titled “Requirements”. After storing all the design requirements, a user is ready to start designing a ship.

[illegible]

Figure 4: Requirements table

ConceptSHIP

Within this design tool sequence, a user will start the design work using the ConceptSHIP tool in which the user will define the main ship characteristics. This tool is a powerful MS Excel program that does the optimisation of the major parameters of ship design, and its biggest strength is in the fact that it utilises some regression formulas that are based on a large number of built ships. A small insight into the ConceptSHIP's software is shown in Figure 5.

This tool can:

- do the estimation of main hull dimensions,
- generate the hull form
- estimate resistance & propulsion
- define hull compartments
- calculate capacities
- calculate building and operating costs
- determine the energy efficiency and polluting gas emissions

Once we determine the optimum main design parameters, a user stores them in the SHIPLYS platform database on the server. The next step a user would need to do is to define the general arrangement of the ship. For that purpose, a user can use the Rapid ship evaluation tool (RSET) tool.

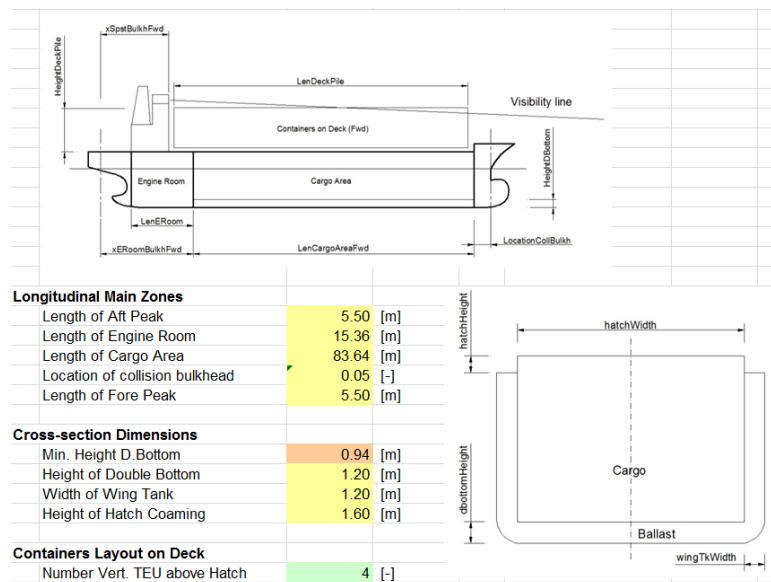


Figure 5: Evaluation of main ship characteristics using ConceptSHIP

Rapid ship evaluation tool (RSET)

RSET utilises the semi-automated procedure to get the optimum arrangement of ship spaces. The work in RSET starts from the hull form defined previously in ConceptSHIP. At first, a user has to define decks and significant transverse and longitudinal bulkheads. After that, the definition of spaces can be made, and that includes, for example, cargo spaces, different kind of storages, cabins, meeting rooms, bridge etc.. Once the initial arrangement is established, constraints need to be defined. The constraints are design preferences expressed in the form of the adjacent spaces, for example, a user can define that captain's quarters are below the bridge or, for another example, a food storage is next to the galley. Once the initial arrangement is determined along with the constraints, the optimisation algorithm finds an improved version of the general arrangement. A user has to check the newly developed arrangement that everything is according to the design preferences as set previously using the constraints. In the case that the optimised arrangement is not acceptable, for example, there is food storage too far from the galley, then a user can either modify the constraints and run the optimisation again or rearrange the spaces manually. Figure 6 shows the example of the arranged spaces on board a vessel, where these spaces are defined by their volume size and the position within a ship coordinate system.

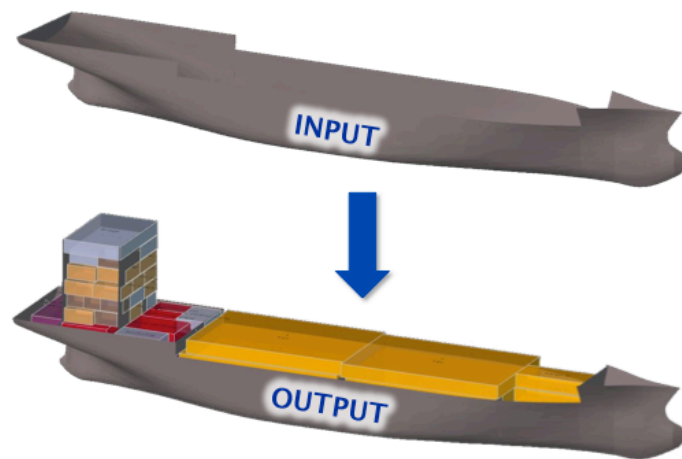


Figure 6: General arrangement of ship spaces using RSET

The next activity in the design process would be to check the lightship weight of the ship (i.e. a hull and equipment weight without cargo and provisions). Very good initial weight estimation can be done in CAFE tool, in which a user can quickly model the preliminary ship structure.

CAFE

The preliminary ship structure is generated based on the full ship geometry, meaning a hull form, all internal hull spaces and superstructure that were defined in RSET; see Figure 7. The geometry is given in two-dimensional and three-dimensional surfaces that are converted in CAFE into plating of appropriate material and thicknesses. Therefore, in this way, the geometry gets the density and the weight. Apart from the plating, a user adds transverse framing, strong longitudinal girders, creates the openings and adds stiffening members. Another tool from the SHIPLYS platform called LR RulesCalc is used to check if everything is according to class society requirements and seeing if these thicknesses and beam section properties are in agreement with the classification requirements for a particular ship. Then, any major equipment like cranes, engines, mooring equipment etc. can be added into the model in their respective locations to estimate the mass and the centre of gravity of a lightship as accurate as possible in the early design phase. The mass and the location of the centre of gravity are essential for the stability calculations that can be done in LR SEASAFE.

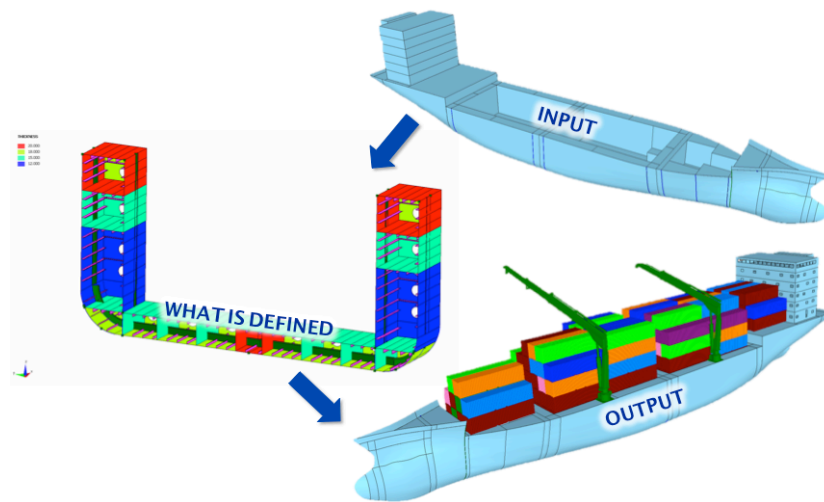


Figure 7: Structural modelling in CAFE

LR SEASAFE

The next step of the design process would be to check the intact and damaged stability to confirm that the ship is seaworthy and safe from capsizing. The task in LR SEASAFE starts from hull form and hull compartments. In fact, the starting point in LR SEASAFE is almost the same as it is in CAFE, except LR SEASAFE also possesses the information about the lightship weight and the location of the centre of gravity. There are usually some loading conditions to be investigated to determine if the ship is safe, especially for a multi-purpose vessel of the type designed in this paper. For the definition of each loading condition, a user needs to make an input about the amount and location of containers, bulk or other cargo, amount of supplies, levels of fluids in tanks (ballast, fuel, water, etc.). The stability calculations are stored in a report called a stability booklet presented in Figure 8.

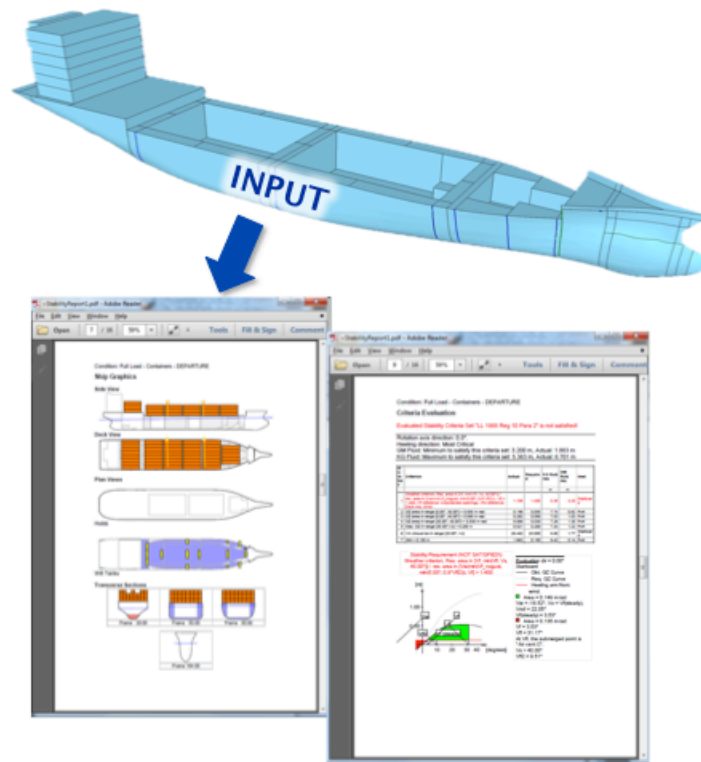


Figure 8: Stability booklet in LR SEASAFE

The outcome of the design steps presented in this paper is mostly traditional ship design. However, the added value of SHIPLYS project is in combining and enhancing the traditional design using the new developments in risk assessment and life cycle analysis.

Current development

At present, the consortium is investing a significant effort in the development of codes for risk assessment, life cycle analysis and decision making support. These codes will be integrated into the SHIPLYS platform in the near future. The idea is to quantify risks, environmental impact indicators and end-of-life considerations as measurable attributes, which are expressed in EUR; see Figure 9 for more details. Once a user generates multiple design alternatives, the SHIPLYS platform will be able to serve as the decision support system, enabling the user to choose a cost-efficient design solution in a short time.

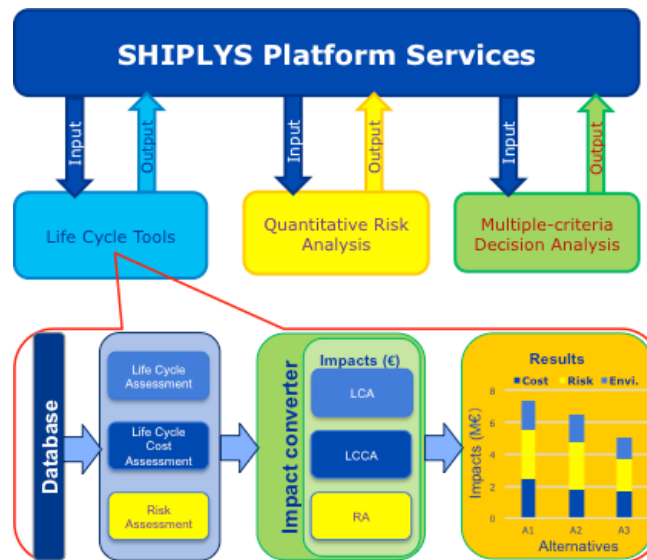


Figure 9: Integration of LCA tools into the SHIPLYS platform

Conclusions

The SHIPLYS project aims to provide the software system that will implement rapid virtual prototyping, risk-based design, environmental aspects, end-of-life considerations and life cycle cost assessment into the concept phase of the ship design. As shown, the virtual prototyping is mostly developed by integrating existing design tools into the SHIPLYS platform achieving a ship design in the traditional manor. However, the full potential of the SHIPLYS platform will be realised after the new efforts in the development of life cycle analysis and multi-criteria decision-making are integrated into the platform [1]. The system will increase the competitiveness of SME design offices and shipyards by enabling them to generate cost-efficient concepts in a short time, thus increasing their competitiveness in the market

Acknowledgement

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Note: The authors, their respective organisations and the European Commission assume no responsibility and shall not be liable to any person for any loss, damage or expense caused by reliance on the information or advice in this document or howsoever provided.

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