Chapter 2
Integration of Tools for Application Case Studies

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Abstract This chapter elaborates the bottom-up approach taken within the European R&D project HOLISHIP to flexibly integrate and utilize software tools and systems of tools for the design, analysis and optimization of maritime assets. The focus of the project HOLISHIP and its bottom-up integration platform(s) was the design of maritime assets at the early design phases in heterogeneous environments. As it is often the situation, tools and systems come from different developers, companies and research institutes. So far they have been mostly used as stand-alone applications with the design team being responsible for proper tool execution, data exchange and management. Within HOLISHIP the tools and systems were coupled to CAESES®, i.e., a cross-platform Process Integration and Design Optimization (PIDO) environment that also provides comprehensive Computer Aided Design (CAD) functionality for the parametric modelling of shapes. Any tool or system that can be run in batch-mode can be coupled to CAESES and can be set up in order to exchange data with other tools, supporting the assembly of sophisticated synthesis models. Further developments as were needed for the application cases (AC) of the HOLISHIP project will be presented, complementing the discussion given in Harries and Abt (A holistic approach to ship design, Vol. 1: optimisation of ship design and operation for life cycle. SPRINGER Publishers, 2019).

Keywords Process Integration and Design Optimization (PIDO) · Computer Aided Engineering (CAE) · Simulation-driven Design (SDD) · Synthesis model · Surrogate model · Parametric model · Tool coupling · Collaboration

Abbreviation

AC	Application Case
AI	Artificial Intelligence
ANN	Artificial Neural Networks

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ASCII	American Standard Code for Information Interchange
BRep	Boundary representation
BV	Bureau Veritas, France
B2B	Business-to-business relationship
B2C	Business-to-customer relationship
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAx	Acronym for various Computer Aided solutions for design, simulation, engineering etc.
CADMATIC	Marine design software by CADMATIC, The Netherlands
CAESES®	Computer Aided Engineering System Empowering Simulation by FRIENDSHIP SYSTEMS, Germany
CAPEX	Capital Expenditure
CFD	Computational Fluid Dynamics
COSSMOS	COmplex Ship Systems MOdelling and Simulation by DNV GL, Greece
CoP	Coefficient of Prognosis
CPU	Central Processing Unit
CSG	Constructive Solid Geometry
DE-ferry	Double-ended ferry
DoE	Design-of-Experiment
DP	Dynamic Positioning
DTD	Document Type Definition
DXF	Drawing Interchange Format (file)
EEDI	Energy-efficiency Design Index
FEA	Finite Element Analysis
FFD	Free-form Deformation
FPM	Fully-parametric Modelling / Fully-Parametric Model
FreSco$^+$	RANS solver by HSVA
GA	General Arrangement
GA	Genetic Algorithm
GUI	Graphical User Interface
HSB	Hochschule Bremen (University of Applied Sciences), Germany
HSVA	Hamburg Ship Model Basin, Germany
HPC	High-performance computing
html	Hypertext Markup Language
iges (igs)	Graphics Exchange Specification file for exchange of geometry data
m	Number of tools integration in a synthesis model
n	Number of free variables (degrees-of-freedom of the system)
LHS	Latin Hypercube Sampling
MARIN	Maritime Research Institute Netherlands
MPOV	Multi-Purpose Ocean Vessel

NAPA	Naval Architecture Package for ship design by NAPA Oy, Finland
NEWDRIFT	Non-linear potential flow code for seakeeping analysis of ships by NTUA, Greece
NSGA II	Non-sorting Genetic Algorithm (also NSGA 2)
NURBS	Non-uniform Rational B-Spline curve / surface
NTUA	National Technical University of Athens
MOGA	Multi-objective Genetic Algorithm for design space exploration and exploitation
MPOV	Multi-Purpose Ocean Vessel
OPEX	Operational Expenditures – Operating Cost
OSV	Offshore Supply Vessel
PIDO	Process Integration and Design Optimization
Platform	Assembly of disparate systems and tools that are integrated in order to work with each other
PLM	Product Life-cycle Management
png	Portable Network Graphics (file)
RBR	Radial Basis Function(s)
PPM	Partially-parametric Modelling / Partially-parametric Model
RANSE	Reynolds-averaged Navier-Stokes Equations, also RANS equations
RAPID	Non-linear potential flow code for wave resistance analysis of ships in calm water by MARIN
RBF	Radial Basis Function
RCE	Remote Component Environment by DLR (German Aerospace Center), Germany
RoPAX	Passenger ferry with roll-on/roll-off cargo (mainly trucks and cars)
RS	Response Surface, also surrogate model
RSM	Response Surface Model, also Response Surface Methodology
R&D	Research and Development
SDD	Simulation-Driven Design
ShipX	Package for hydrodynamic analysis of ships by SINTEF Ocean, Norway
Sobol Quasi-random	Design-of-Experiment, aiming at evenly populating a design space
STEP	Standard for the Exchange of Product Model Data
stl	STereoLithography (file) for exchange of geometry data by means of tri-meshes
VPN	Virtual Private Network
VTK	Visualization Toolkit
ν-Shallo	Non-linear potential flow code for wave resistance analysis of ships in calm water by HSVA

2.1 Introduction

The bottom-up approach taken within the European R&D project HOLISHIP to flexibly integrate and utilize systems for the design, analysis and optimization of maritime assets, primarily of ships, is discussed and shown by means of selected application cases. Details of these application cases are given in dedicated chapters of this book while the idea of how to integrate tools and systems and, furthermore, how to collaborate between systems, even though they stem from different (and sometimes competing) sources, are discussed here and in (Harries and Abt 2019). The two chapters, i.e., this one and (Harries and Abt 2019), should be understood as complementing material with a slight overlap to still allow for independent reading.

Implementing the HOLISHIP approach by use of the CAESES® design platform (Harries and Abt 2019) some general requirements for the set-up of an efficient ship design process and CAE procedure need to be considered:

- Explicitly state objectives, constraints and free variables and have an agreement on them between the various stakeholders,
- Generate large sets of variants by parametric models from which cause-and-effect relationships can be better understood,
- Identify most influential variables and detect governing constraints,
- Ease the burden of repeated (and error-prone) data transfer,
- Ensure that the right data are exchanged between tools (to be handled by the tool experts for quality control) and that the tools are run consistently for all variants (quality enhancement),
- Prepare decision making by formulating quantifiable objectives and decide on favourable and best designs for multiple objectives in a rational way.

For the platform(s) of HOLISHIP, a key characteristic is *flexibility*, i.e., the flexibility of incorporating additional tools as needed, of extending and/or changing tools as designs (and demands) are progressing and, furthermore, of managing evolving and growing sets of data.[1]

2.2 Approach to Application Case Studies

The main application cases (AC) that utilized CAESES® as HOLISHIP design platform were.

1. Offshore supply vessel (OSV) [responsible partner: Kongsberg]
2. Multi-purpose Ocean Vessel (MPOV) [responsible partner: The Naval Group]

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[1] A deliberate choice was made within HOLISHIP to not aim at developing and providing a strict PLM system (product life-cycle management) with access rights (possibly across legal units), design history and version control, diligent change management etc. This would simply have been adding complexity and constitute a new large R&D project in itself. See Sect. 2.5.1, too.

3. Structural design of a superstructure with composite materials [responsible partner: Meyer Werft]
4. Retrofitting of Merchant Ships, including Machinery Outfitting [responsible partners: NTUA and DNV GL]
5. Offshore platform [responsible partner: Elomatic]
6. RoPAX ferry [responsible partner: Tritec]
7. Double-ended ferry [responsible partner: Elomatic]

These application cases are elaborated in respective chapters of the present book.

The synthesis models for four of the above ACs are given in Figs. 2.1, 2.2, 2.3 and 2.4. Table 2.1 presents an overview of tools involved. The diversity of the synthesis models is obvious and corresponds to the situation encountered "on the ground" in which (i) different design environments with diverse tool sets, (ii) different design phases, and (iii) different levels of detail have to be accommodated. Not only can it be seen that many tools had to be connected but that not one synthesis model would fit all purposes. Details of several of these AC are given in Harries et al. (2019) and in Papanikolaou et al. (2019).

In addition, the ACs provided feedback for the adjustment of CAESES (*bottom-up approach*), introducing several challenges that would go even beyond standard design tasks: (i) Quite many different partners and many tools from various developers had to be brought together, and (ii) the process was spread out over several years. The latter implied that, naturally, communication was less stringent than in purely commercial design projects and that the partnership encountered changes typical of long-term projects (e.g. people leaving the project due to career changes, periods of parental leave and sabbaticals, new people being onboarded, adjustments and progress in

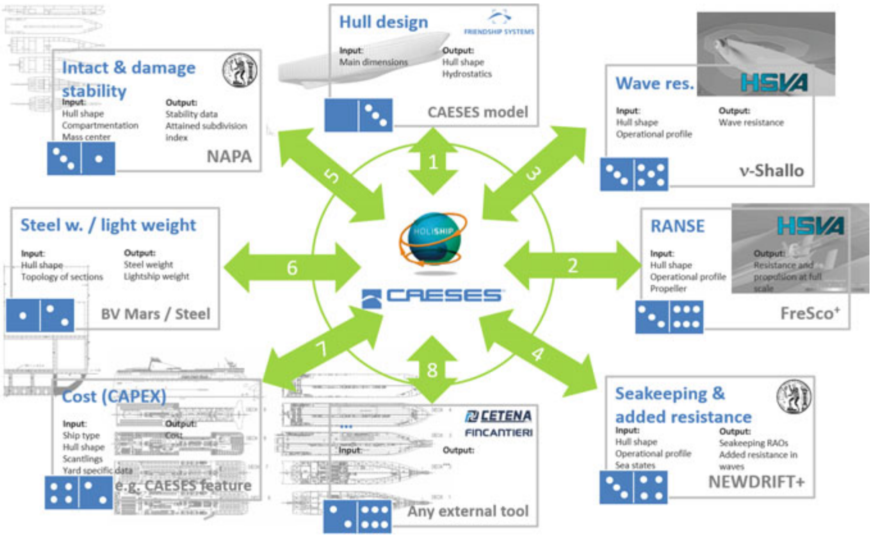

Fig. 2.1 Synthesis model for the design and optimization of a RoPAX ferry (see also Fig. 2.5)

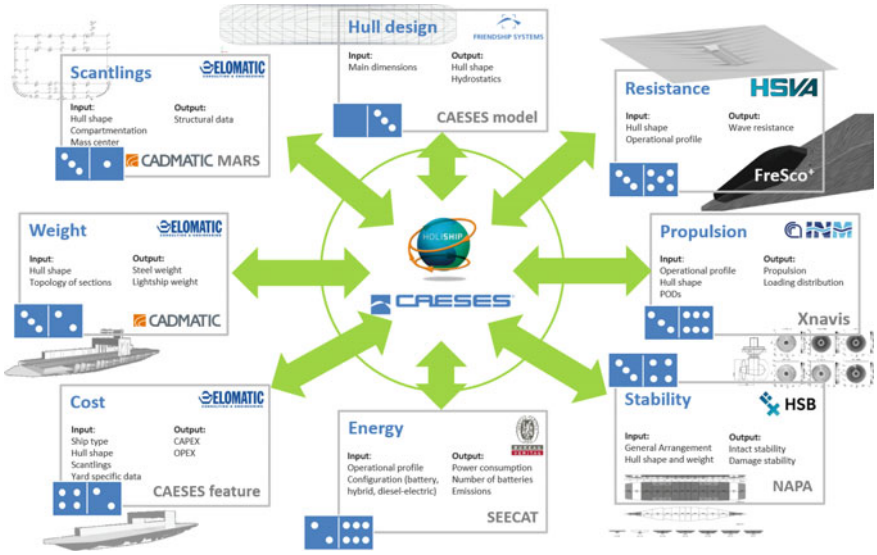

Fig. 2.2 Synthesis model for the design and optimization of a double-ended ferry (Elomatic)

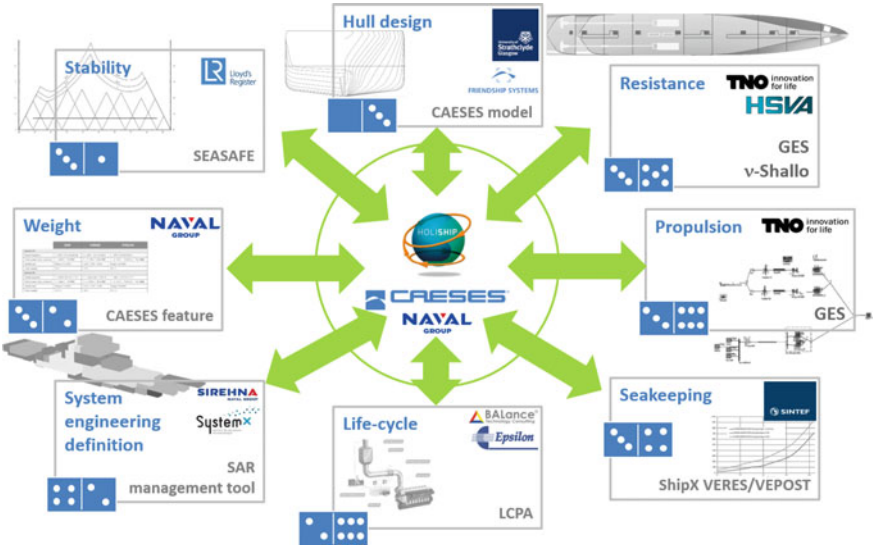

Fig. 2.3 Synthesis model for the design and optimization of a MPOV (The Naval Group)

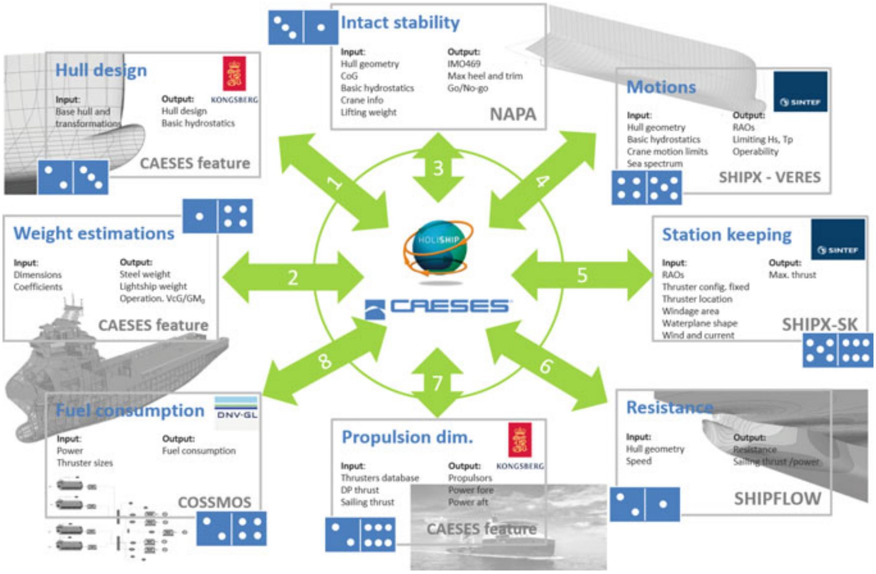

Fig. 2.4 Synthesis model for the design and optimization of an OSV (Kongsberg)

tools). In this sense the HOLISHIP platform(s) were not only tested successfully for technical diversity but also for robustness and the usage within distributed and evolving teams.

Figure 2.5 gives an abstract view of the process that involves several simulations to be executed. Important tools utilized within the HOLISHIP platform(s) and coupled to CAESES® for the ACs are summarized in Table 2.1.

2.3 Recent Improvements of CAESES

In the course of the HOLISHIP project, CAESES® itself was extended and improved. A few selected improvements shall be elaborated here.

2.3.1 Parallelization

For several years there has been a notable shift in processor technology. Today most computers, from workstations to notebooks, offer multi-core chips which strengthen computers to be effective in performing several tasks concurrently. This was different up until a few years ago when processors primarily saw a steady increase in clock speeds. CAESES was originally developed for single-core usage, its origin dating

Table 2.1 Tools utilized within HOLISHIP platform(s) and coupled to CAESES® (excerpt)

Tool coupled	Tool developer	Provider / responsible party within HOLISHIP	WP	AC	Tool's primary purpose and usage within HOLISHIP	Primary input from / via CAESES to tool	Main output from tool to CAESES and for design task
ANSYS Workbench	ANSYS	SMILE	15	Offshore platform	Structural analysis of soil	Caisson geometry, soil parameters	Deformation data for different loads
BV MARS	Bureau Veritas	Bureau Veritas	17	DE-ferry	Rule-based ship structural assessment of plating and longitudinal stiffeners	Hull shape to Cadmatic, midship with scantlings to BV MARS	Midship analysis
BV STEEL	Bureau Veritas	Bureau Veritas	17	DE-ferry	3D beam theory-based ship structural assessment of primary supporting members	Connected via Cadmatic	Connected via Cadmatic
CAESES features	FRIENDSHIP SYSTEMS	Various	7, 12 and 17	RoPAX, MPOV, DE-ferry	Compute auxiliary quantities like weight, costs	E.g. hull geometry, weight estimation and fuel consumption	E.g. CAPEX and OPEX
CAESES features	FRIENDSHIP SYSTEMS	University of Strathclyde	7	RoPAX	Holtrop and Mennen series	Hull parameters	Resistance and power estimate

(continued)

Table 2.1 (continued)

Tool coupled	Tool developer	Provider / responsible party within HOLISHIP	WP	AC	Tool's primary purpose and usage within HOLISHIP	Primary input from / via CAESES to tool	Main output from tool to CAESES and for design task
Cadmatic	Cadmatic	Elomatic	17	DE-ferry	3D modelling of General Arrangement	Hull parameters	Steel weight, position of decks and bulkheads as parameters (optional in Cadmatic Hilltop)
DNV GL COSSMOS	DNV GL	DNV GL	9	Offshore Supply Vessel	Operational analysis of machinery system's performance	Machinery design specifications (thruster nominal points), operational profile	Fuel consumption and emissions
Excel	Microsoft	Meyer Werft	10	Superstructure	Structural and fire analyses	Panels and compartmentation information	Weight and cost of FRP and/or composite panels
Excel	Microsoft	Elomatic / CMT	15	Offshore platform	Caisson geometry check and turnkey cost estimation	Caisson geometry parameters, soil parameters, site conditions	Caisson geometry validity, project cost and duration of installation
FINE/Marine	Numeca	SINTEF Ocean	14	Bulkcarrier	Bulb optimization for retrofitting	Hull geometry	Resistance, propulsion and seakeeping

(continued)

Table 2.1 (continued)

Tool coupled	Tool developer	Provider / responsible party within HOLISHIP	WP	AC	Tool's primary purpose and usage within HOLISHIP	Primary input from / via CAESES to tool	Main output from tool to CAESES and for design task
FreSco+	HSVA	HSVA	7 and 17	RoPAX and DE-ferry	Resistance and propulsion (viscous, incl. free surface)	Hull geometry	Flow field and integrated data for resistance and propulsion
FreSco +	HSVA	HSVA	14	Containership	Bulb optimization for retrofitting	Hull geometry	Resistance, propulsion and seakeeping
GES	TNO	TNO	12	MPOV	Time domain simulation of multi-physics complex systems Statistical resistance estimates (e.g. Holtrop, Harvard, Fung)	Model parameters, selection of propulsion system configuration	Resistance along with gas emissions and fuel consumption
Hexpress	Numeca	HSVA	7, 16 and 17	RoPAX, DE-ferry	Grid generation for flow analysis	Hull geometry	Grid for RANS simulation
LCPA	Balance/Epsilon	Balance/Epsilon	12	MPOV	Life cycle cost and life cycle assessment from design/build and operation to scrapping	Hull geometry, weight estimation and fuel consumption	CAPEX and OPEX

(continued)

Table 2.1 (continued)

Tool coupled	Tool developer	Provider / responsible party within HOLISHIP	WP	AC	Tool’s primary purpose and usage within HOLISHIP	Primary input from / via CAESES to tool	Main output from tool to CAESES and for design task
MPSET	Kongsberg (formerly RRM)	Kongsberg	9	OSV	Quasi static time domain simulation of marine power systems		Performance, costs and reliability data
NAPA	NAPA OY	NTUA	7	RoPAX	Design of hull form and internal layout, intact and damage stability	Hull geometry	3D model of internal layout, LS, DWT, transport capacity, stability
NAPA	NAPA OY	HSB	17	DE-ferry	Intact and damage stability	Hull geometry	Stability results
NAPA	NAPA OY	NTUA	16	RoPAX	Design of hull form and internal layout, Intact and damage stability	Hull geometry	3D model of internal layout, LS, DWT, transport capacity, stability
NAPA Steel	NAPA OY	Tritec	16	RoPAX	Weight estimates of steel structure	Hull geometry	Plates, bulkheads, decks, stiffeners
NEWDRIFT+	NTUA	NTUA	7 and 16	RoPAX	Seakeeping, added resistance in waves	Hull geometry	Seakeeping, added resistance
NEWDRIFT+	NTUA	NTUA	14	Containership and bulk carrier	Seakeeping, added resistance in waves	Hull geometry	Seakeeping, added resistance

(continued)

Table 2.1 (continued)

Tool coupled	Tool developer	Provider / responsible party within HOLISHIP	WP	AC	Tool's primary purpose and usage within HOLISHIP	Primary input from / via CAESES to tool	Main output from tool to CAESES and for design task
RCS	DLR	DLR / Marin	7 and 8		Check connectivity of platforms	Any data set from CAESES	Any data set from RCS
SAR	SIREHNA	SIREHNA	12	MPOV	Baseline definition of system architecture, preliminary layout and analysis of stakeholder's needs	CAESES script file storage in SAR management tool for connectors and design engine definition	Import of preliminary tank arrangement for baseline model (from Shipbuilder incl. in SAR tool)
SEECAT	Bureau Veritas	Bureau Veritas	17	DE-ferry	Time domain simulation of multi-physics complex systems	Operational profile and electrical load balance	Fuel consumption rate, battery load balance and emissions
SeaSafe	LR	LR	12	MPOV	Hull and tank layout geometry, and definition of loading condition	Intact stability criteria check	Hull and tank layout geometry, definition of loading condition
SHIPFLOW	Flowtech	Kongsberg	9	OSV	Resistance and propulsion	Hull geometry	Resistance and propulsion
ShipX	SINTEF Ocean	SINTEF Ocean and Kongsberg	9	OSV	Vessel responses	Geometry and parameters	Ship motions and global loads

(continued)

Table 2.1 (continued)

Tool coupled	Tool developer	Provider / responsible party within HOLISHIP	WP	AC	Tool’s primary purpose and usage within HOLISHIP	Primary input from / via CAESES to tool	Main output from tool to CAESES and for design task
ShipX / VERES & VEPOST	SINTEF Ocean	SINTEF Ocean	12	MPOV	Vessel motion responses (2D strip theory)	Geometry	RAOs and check of seakeeping criteria
STAR-CCM +	Siemens PLM	Tritec	16	RoPAX	RANS solver	Geometry	Resistance and propulsion
xNavis	CNR-INSEAN	CNR-INSEAN	17	DE-ferry	RANS solver	Geometry	Propulsion data for POD
ν-Shallo	HSVA	HSVA	7 and 16	RoPAX	Potential flow solver for wave resistance in calm water	Geometry	Resistance
ν-Shallo	HSVA	HSVA	12	MPOV	Potential flow solver for wave resistance in calm water	Geometry	Resistance

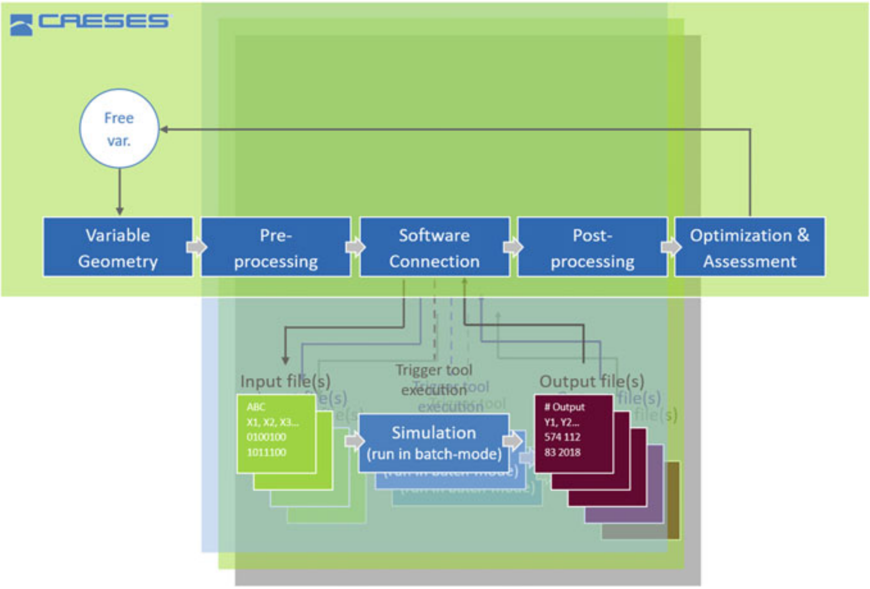

Fig. 2.5 Process of design and optimization as realized within CAESES® for a synthesis model bringing together various simulations

back to 2004 when most CPUs, even for engineering workstations, still offered only sequential task execution.

However, typical hierarchies of (even simple) parametric models feature objects that are independent from each other, and, hence, can be updated in parallel. In order to support this, CAESES had to be adapted and rearranged, leading to the parallelization of the code basis.

The most important advantage for the user can be seen from Fig. 2.6: The parallelized version of CAESES, here CAESES 5, yields a substantial speed-up when building or updating parametric models. Within the context of automated exploitation and exploration in which many CPU hours are spent for high-level computations, say RANS simulations, this speed-up from several dozens of seconds to a few seconds during an update may not be needed. However, when actually building and also when preparing a parametric model for simulation-driven design, the typical work flow requires numerous interactive steps with updates, changes and quality tests. Then, a fast update of geometry is of very high importance.

2.3.2 Complementing Algorithms

CAESES already offers a range of standard algorithms for exploration and exploitation, see (Harries and Abt 2019). In addition, the DAKOTA environment by Sandia

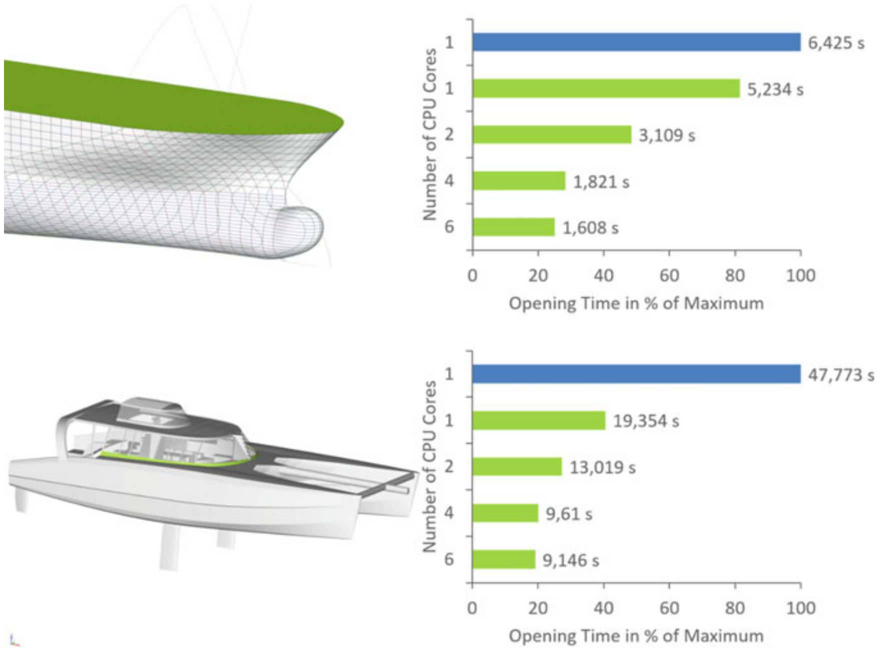

Fig. 2.6 Speed-up via parallelization for two different parametric models, depending on numbers of cores (single-core sequential update given in blue, using CAESES 4.4; parallel updates given in green, using CAESES 5.0)

National Laboratories (dakota.sandia.gov) can be utilized as a plug-in. This connection was further streamlined, making a large number of high-end optimisation algorithms available (see also Sect. 2.3.3). In addition, a new and dedicated search strategy was implemented for early design (as suggested by HSB). The method iteratively linearizes objectives and (inequality as well as equality) constrains as first proposed in (Gudenschwager 1988).

Particularly in early design phases many free variables, bounds, constraints and dependencies are present while the freedom of change and the potential for the right (and threat for an unfortunate) choice of main dimensions is still the highest. In order to support this phase, many relationships need to be formulated, setting up a non-linear and quite extensive set of equations and inequalities. This set is solved by means of a new design engine within CAESES which was called Simplexer. It is an extended implementation of the Simplex algorithm (linear programming).[2]

Figure 2.7 illustrates the Simplexer and the optima found for two-dimensional test cases with one objective (here F as function of x_1 and x_2) and several constraints (here g_j as functions of x_1 and x_2), a two-dimensional test being easier to visualize. The

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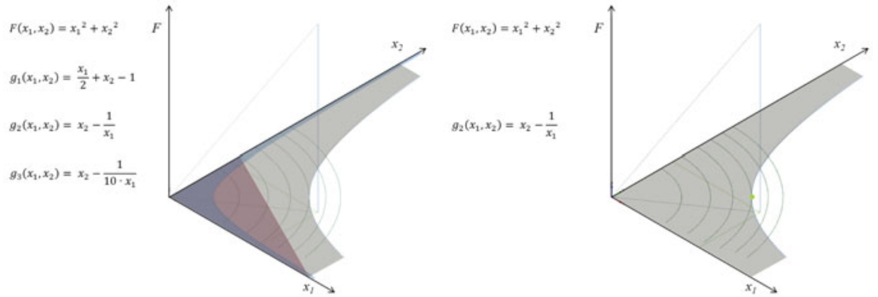
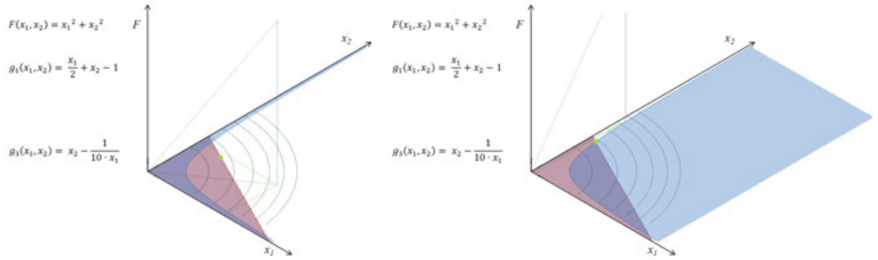
[2] In order to more easily distinguish this new algorithm from the Nelder-Mead Simplex (non-linear programming), that was already available within CAESES, the slightly different term of Simplexer was introduced.



(a) Objective and set of constraints (b) Objective, single constraint and optimum found (green dot)



(c) Objective, two constraints (set as inequalities) and optimum found (green dot) (d) Objective, two constraints (one inverted in comparison to (C)) and optimum found (green dot)

Fig. 2.7 Illustration of the Simplexer for a search in two dimensions, including constraints

constraints actually are inequality constraints for various tests but are formulated as equalities (i.e., for the situation in which the inequality constraints are active). Depending on which constraints are considered and on the starting point for the search, different optima are identified by the Simplexer. The linearization of both constraints and objectives is done internally within CAESES so that the engineer can focus on formulating the design task.

2.3.3 Extended Feature for Surrogate Modeling

2.3.3.1 Response Surface Methodology

When exploring a design space spanned by multiple design variables, often the complex interactions and correlations of the design variables with an objective are rather non-intuitive and hard to grasp. From statistics, *Response Surface Methodology (RSM)* is known as a technique that explores exactly this relationship between a set of design variables and (at least) one evaluation. See also (Harries and Abt 2019).

In simulation-driven design (SDD), often formal optimization algorithms are used to navigate through the design space and efficiently converge towards local or even global optima. But still, a more thorough understanding of how different geometric characteristics affect a solution and how this might be different for another region of the design space offers valuable insight. Such knowledge, which traditionally had to be acquired over many years of research in the field, will allow the designer to make well-educated guesses, as to how and where to modify the shape or even the underlying parametric model, in order to achieve a certain design goal. Furthermore, this capability of surrogate modeling—i.e., to predict, with a certain (known) accuracy, how a complex system will answer to a previously not yet considered set of input arguments—can be used to enhance the performance of a multitude of formal optimization methods originally developed without this technique in mind (Sánchez Castro and von Zadow 2019).

As mentioned above the open source library DAKOTA (Adams et al. 2020)is embedded within CAESES, which offers a variety of methods and tools that can be put to use in this context. The terms *Response Surface (RS), Response Surface Model (RSM)* and *surrogate* are used somewhat interchangeably. All of them follow the same basic idea, which is, to make use of an existing result pool to approximate the response of a system to a change in one or several of the free variables. Such a surrogate, if visualized in 3D space takes the shape of a surface (see Figs. 2.8 and 2.10). On two axes, a certain range of input values for two of the design variables is shown, while the remaining design variables are kept constant at any freely chosen combination of values. On the third axis the prediction of the model for any evaluation within this space can be mapped. Often all three axes will be normalized with a color-coding indicating the absolute measures of the response.

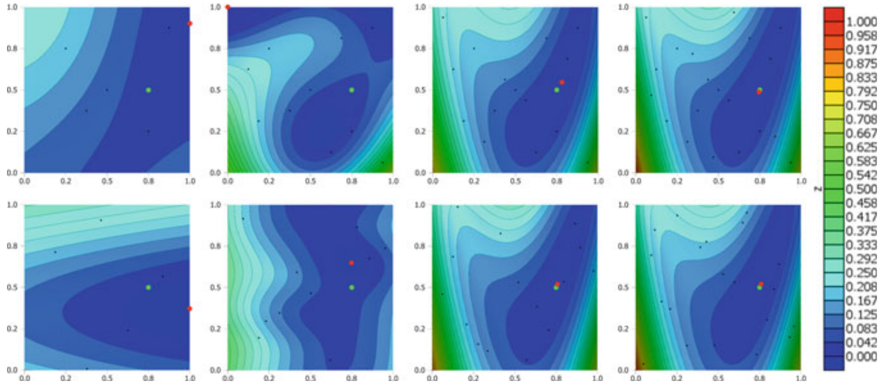


Fig. 2.8 Different surrogates based on a *Sobol* (top row) and *LHS* sampling (bottom row) for 5, 10, 15 and 20 samples; the predicted and the correct optima are indicated via red and green points, respectively

2.3.3.2 Sampling

As a prerequisite for any surrogate, a result pool is needed. This data set is often referred to as training data—especially in the context of *Artificial Neural Networks (ANN)*. It should consist of a sufficient number of designs that are conveniently spread throughout the design space. For most simulation-driven design applications, having more designs within the pool will lead to a model of higher accuracy. However, the chosen method of sampling does not only significantly affect the accuracy of a prediction itself but where in the design space the highest accuracy, i.e., the best match to the actual function value, can be found.

From the perspective of an engineer who is already searching for a final, locally optimal design, this region of high accuracy should preferably lie in the vicinity of this design point. However, in an earlier phase of the design process it might still be the objective to just detect potentially interesting regions or simply to acquire a greater understanding of correlations and cause-and-effect relationships. Without being able to look at different surrogates one might not even be able to tell if the problem under consideration is single- or multi-modal, or how well the objective behaves with respect to a certain change in input variables, after all. In such cases, where a prediction of similar accuracy across a design space is targeted, a *Design-of-Experiments (DoE)* method such as *Latin Hypercube Sampling (LHS)* or a *Sobol* sequence is often the most suitable.

2.3.3.3 Illustrating Example

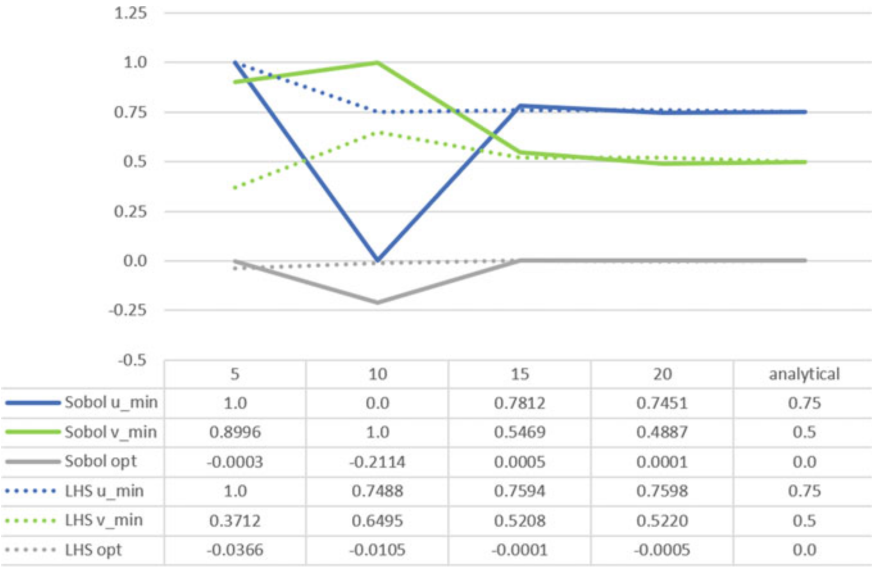
The Rosenbrock function

$$f(x, y) = (a - x)^2 + b\big(y - x^2\big)^2 \tag{2.1}$$

with $a = 1$ and $b = 1$ is a popular test function and shall be used to illustrate a single-objective optimization problem with x and y being the design variables and $f(x,y)$ being the objective. When restricting the range of the input variables $x \in [-2, 2]$ and $y \in [-1, 3]$ and normalizing the function to its maximum value within this range, i.e., $f(-2, -1) = 34$, it can be written in normalized form with $u \in [0, 1]$ and $v \in [0, 1]$

$$g(u, v) = \frac{1}{34}\Big[(3 - 4u)^2 + \big((4v - 1) - (4u - 2)^2\big)^2\Big] \tag{2.2}$$

Figure 2.8 shows multiple surrogates with the analytically determined global minimum at $g(0.75, 0.5) = 0$, indicated by a green point. The global minimum associated with each surrogate is marked by a red point. For both sampling methods a good approximation can be observed for 15 and more samples. The actual positions u_{min} and v_{min} for the predicted global optima are given in Fig. 2.9. Comparing the



	5	10	15	20	analytical
▬ Sobol u_min	1.0	0.0	0.7812	0.7451	0.75
▬ Sobol v_min	0.8996	1.0	0.5469	0.4887	0.5
▬ Sobol opt	-0.0003	-0.2114	0.0005	0.0001	0.0
•••••• LHS u_min	1.0	0.7488	0.7594	0.7598	0.75
•••••• LHS v_min	0.3712	0.6495	0.5208	0.5220	0.5
•••••• LHS opt	-0.0366	-0.0105	-0.0001	-0.0005	0.0

Fig. 2.9 Predicted optima and their positions based on *Sobol* and *LHS* sampling for different sample sizes. (Note, that LHS, as opposed to Sobol sampling does not offer the added benefit of repeatability and hence, the outcome for another run might differ slightly)

obtained optima for 15 and 20 LHS samples, one can observe that more samples do not necessarily result in a more accurate approximation.

Considering the low gradient of the chosen benchmark function in the optimal region, both data sets yield rather satisfactory approximations. (For comparison, to determine the positions u_{min} and v_{min} as well as the functional value of the optimum found by running a T-Search algorithm starting from $u = 0$ and $v = 0$ would require more than 120 designs until a similarly good solution is obtained. In addition, the knowledge derived from a data set stemming from an exploitation will be clustered near the optimal design point and, hence, will not allow for a reasonable approximation in the remaining design space).

2.3.3.4 Model Generation

Within CAESES and the present implementation, the generation of a surrogate always refers to a model that will predict just one evaluation based on a set of at least two design variables. Therefore, all the necessary input needed to trigger a model generation via *Surfpack*, which is part of the DAKOTA software toolkit, is available in CAESES in the form of a results table containing the sampling designs. All it takes is a custom export that writes out these data in the appropriate file format. Next, a template file is written to specify the type of model that shall be generated along with the previously prepared data set. It is then merely a matter of triggering an external executable that performs the necessary calculations in batch-mode and returns a model file.

As can be seen from Fig. 2.10, all of these steps were conveniently wrapped into a CAESES feature (here in CAESES 4.4), enabling the design engineer to apply the technique with just a few clicks. The only input arguments that need to be given by the user are the type of model one wishes to generate, the design variables and evaluation of interest ("Response Index") as well as the table containing the corresponding training data. Out of the different model types that are offered within *Surfpack*, the current implementation offers *Kriging, ANN* and second as well as third order polynomials.

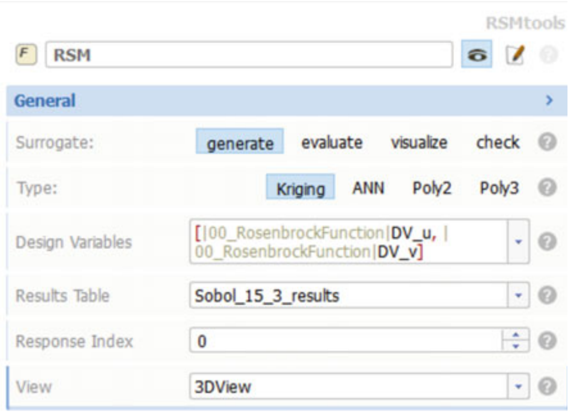
2.3.3.5 Evaluation and Visualization

Similar to the generation of various models, the evaluation of an existing model file can be conveniently wrapped within a CAESES feature. To improve usability both feature definitions were packaged as sub-features and, hence, their in- and outputs are automatically linked; this means that a previously generated model file will be directly available for evaluation within the project (see input argument *"Surrogate"* in Fig. 2.10).

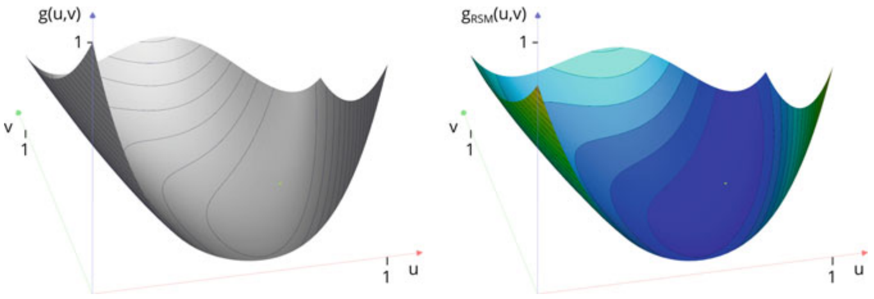
For the evaluation of one or multiple designs a data file is written, too. Furthermore, a template file pointing to the data as well as to the model which shall be used for prediction needs to be created. Again, from within the same feature, DAKOTA's *Surfpack* is called in batch-mode. The obtained response is subsequently written into an additional file.

For only one evaluation at a time, all it takes for CAESES is to wait for this file to appear and read in the predicted response. For multiple simultaneous evaluations, an array of responses can be read in from a single *Surfpack* computation. By evaluating two series of design variables with all their permutations of interest, keeping the remaining design variables constant, this procedure allows to conveniently visualize

Fig. 2.10 Input arguments of the CAESES feature for generation, evaluation, visualization and cross-validation of the surrogate



Surrogate: generate evaluate visualize check
Type: Kriging ANN Poly2 Poly3
Design Variables [|00_RosenbrockFunction|DV_u, |00_RosenbrockFunction|DV_v]
Results Table Sobol_15_3_results
Response Index 0
View 3DView



(a) Original Rosenbrock function

(b) Approximation of the Rosenbrock function based on a Sobol with 15 samples using a Kriging model (same perspective as (A))

Fig. 2.11 Comparison of original Rosenbrock function and an associated surrogate

the surrogate in three-dimensions via the use of an interpolation surface. This is illustrated for the Rosenbrock function in Fig. 2.11.

2.3.3.6 Cross Validation

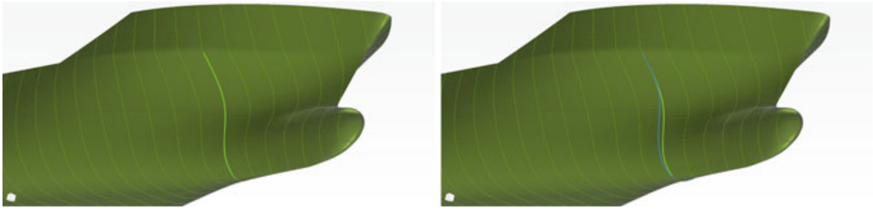
To judge the quality of a surrogate, a *k*-fold cross-validation (Fushiki 2011) has been implemented. The available result pool containing *n* designs is hereby split into *k* subsets, each of which contain *n*-*k* designs. For each subset, a model of the desired type is generated and evaluated at the remaining *k* design points. The coefficient of prognosis (CoP) is then calculated as

$$CoP = 1 - \frac{\sum_{i=1}^{n} (g - g_{RSM})^2}{\sum_{i=1}^{n} \left(g - \frac{\sum_{i=1}^{n} g}{n}\right)^2} \tag{2.3}$$

For the surrogate shown in Fig. 2.11, the maximum coefficient of prognosis of a threefold cross validation equals $CoP_{max} = 0.9506$. For a Kriging model it follows, that the actual CoP when using the entire result pool of 15 will be even higher. However, it should be noted that a higher CoP does not necessarily mean that any point within the design space will be predicted with a higher accuracy. Also the CoP is not necessarily higher for larger sample sizes as could be seen from Fig. 2.9.

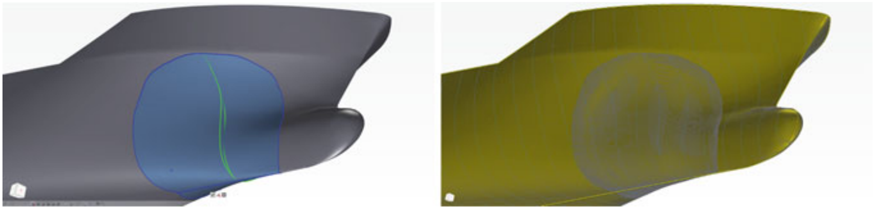
2.3.4 Further Partially-Parametric Modeling

In order to enable less experienced engineers to more easily and quickly introduce high-quality changes in geometry, in particular to hull forms, the broad range of partially-parametric modeling approaches already available within CAESES was



(a) Baseline

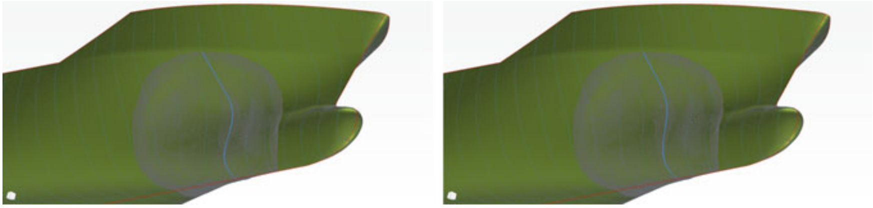
(b) Baseline (source shown in green) and desired new geometry (target shown in blue)



(c) Selection of region within which modifications are applied

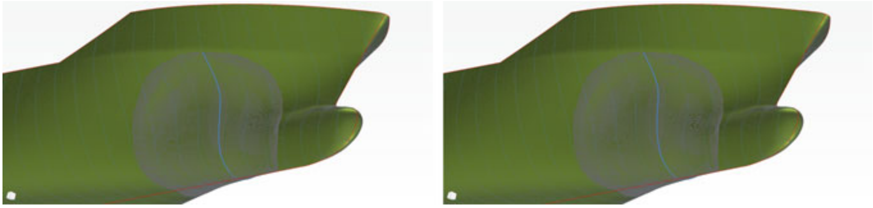
(d) Tessellation and refinement for subsequent modification

Fig. 2.12 Set-up of a partially-parametric modeling approach using RBF



(a) Variation with free variable set to –2

(b) Variation with free variable set to 0 (no change)



(c) Variation with free variable set to +2

(d) Variation with free variable set to +3

Fig. 2.13 Application of a partially-parametric modeling approach using RBF

further extended. A new Radial Basis Function (RBF) approach was developed which allows the selection of regions to be modified interactively and to evoke changes to a baseline by means of source and target geometry. Figures 2.12 and 2.13 illustrate the set-up and the modification for a representative hull form given as a tessellated geometry (here by importing an stl-file to CAESES). Details of the RBF approach, following (Botsch and Kobbelt 2005), are elaborated in Table 2.2.

Table 2.2 Radial Basis Function approach

CAESES supports both discrete (trimeshes) and continuous (NURBS) geometries as baselines for RBF based deformations. The set-up for both kinds of geometries differs in the details but the underlying principle is the same and the usage is quite similar. In principle, a geometry can undergo more than one transformation. One such transformation is called an "RBF region"
First, the user needs to define an area of the geometry that may be freely deformed by the algorithm. (In the case of discrete geometry this can be done within CAESES using a newly created paint tool that allows for painting areas onto the geometry, while in the case of continuous geometry the user may select faces from the Boundary Representation that will be subject to the freeform deformation.) The area that was marked in this manner is treated (and called) the "support region", while the rest of the geometry is regarded as the "fixed region" as it will not be a part of the deformation
Once the support region is marked, the user needs to select a shape characteristic, the so-called "source", inside that region and specify what that shape should look like, i.e., how it should be transformed, establishing the so-called "target". Both the source and the target need to be supplied by the user, forming the creative part of the partially-parametric model. The support region will then be deformed by the algorithm in a way that ensures a tangent-continuous transition to the fixed region
Features (shape characteristics) that may be selected as source and target geometries are: • a point inside the support region that will be translated to a target location; • a collection of triangles that may be translated, rotated and scaled to a new location (discrete geometry only); • a curve on the geometry that is mapped to a target curve somewhere in space; • a sub-surface of the geometry that is mapped to a target surface in space (NUBRS geometry only)
To calculate the space deformation that governs the deformation of the support region, Radial Basis Functions (RBF) of the form $\phi_i(\boldsymbol{x}) = \lvert(\boldsymbol{x}\text{-}\boldsymbol{c}_i)^3\rvert$ are used. Here $\boldsymbol{x}$ is any point for which a deformation is to be calculated and the $\boldsymbol{c}_i$ are the centres of the RBF-points that are sampled from the boundary area of the fixed region and points sampled from the sources and targets defined by the user. For each centre $\boldsymbol{c}_i$ a basis function ϕ_i is assigned for which the algorithm needs to calculate an associated weight w_i. The space deformation to determine the new position of a point $\boldsymbol{x}$ can then be calculated as $\boldsymbol{d}(\boldsymbol{x}) = \sum \boldsymbol{w}_i \phi_i(\boldsymbol{x}) + \boldsymbol{p}(\boldsymbol{x})$ (summed over all centres $\boldsymbol{c}_i$), with $\boldsymbol{p}(\boldsymbol{x})$ being a trivariate quadratic polynomial.
To calculate the weights, a symmetric system of linear equations needs to be solved. Depending on how dense the point sampling from the "fixed region" and from the desired features is, the system of equations can become very large and, consequently, is computationally expensive to solve. To remedy this an incremental version of the QR factorization using Householder reflections was implemented to solve the system. Once the weights are known, the support region can be transformed.

(continued)

Table 2.2 (continued)

CAESES supports both discrete (trimeshes) and continuous (NURBS) geometries as baselines for RBF based deformations. The set-up for both kinds of geometries differs in the details but the underlying principle is the same and the usage is quite similar. In principle, a geometry can undergo more than one transformation. One such transformation is called an “RBF region”
This is where the major differences in the transformation of discrete geometry and continuous geometry come into play: For discrete geometry (trimeshes) the deformation can be directly applied to all vertices in the support region. In addition, the transformation can be used to refine the given input mesh so as to realize smoother modifications. Also, since a space deformation is defined, the changes are not limited to points that lie on the actual surface. Furthermore, within CAESES the application of “RBF regions” on discrete geometry was realized as an additive transformation, which means that a point to be modified may be part of different, possibly overlapping RBF regions. Its new position is then determined by the sum of all transformations, enabling very complex modifications. For continuous geometry (NURBS) the transformations are applied to the vertices of the affected surface(s). A surface’s control polyhedron is refined until a very close NURBS approximation is reached. Then the transformation is applied. Afterwards the polyhedron is reduced again without deviating beyond a user defined tolerance.

2.4 Additional Means of Integration

2.4.1 Integration via COM

The standard connection between CAESES and any external simulation tool via template files was discussed in (Harries and Abt 2019). This type of connection is very flexible and independent of the operating system and, hence, is available for both Windows® or Linux™. Quite frequently, however, statistical data, auxiliary computations, estimates and quick checks (e.g. on the basis of previous design work or literature surveys) are compiled and run within Microsoft Excel. To support data exchange with Excel there is an integration mechanism within CAESES built on the COM-interface under Windows®, allowing to utilize Excel as an additional simulation tool.

In principle, any cell within an Excel-file can be addressed either to write data to or to extract data from (bidirectional data exchange). This allows a design team to formulate analyses, built parametric models (e.g. for costs and weight) and formulate company-specific relationships between data (e.g. from heuristics) within a spreadsheet—as is often done already—and still include this “knowledge” in a complex synthesis model. Maintenance of the data within the spreadsheet can then be done outside the synthesis model (and does not require an update of the integration unless the cells for data exchange, as identified via their row and column numbers, are modified).

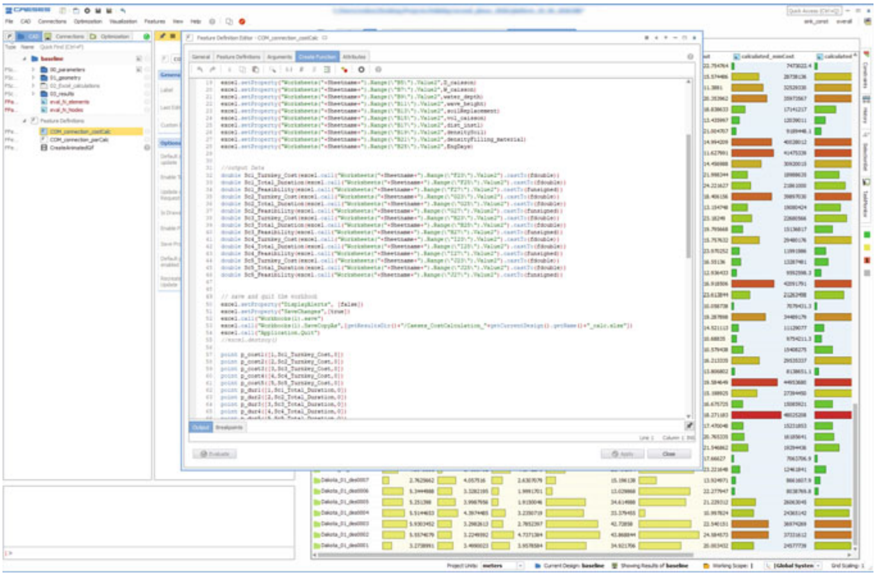


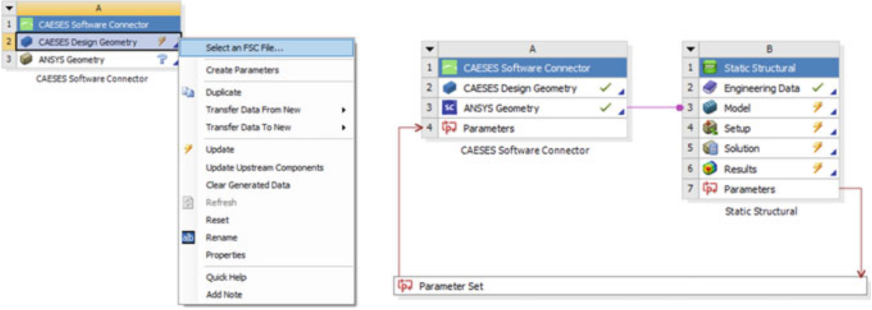
Fig. 2.14 Excerpt of CAESES feature for the connection to Excel (AC Offshore Platform)

Figure 2.14 shows an excerpt of a feature within CAESES with which to connect to Excel in the context of the application case of the design of an offshore platform. Within this AC, an Excel spreadsheet was developed that determines project costs (as an objective), the estimated duration for platform installation and an overall feasibility (as a constraint).

A more elaborate explanation about integration via COM can be found in (Abt et al. 2009). Further adaptations, maintenance and improvements were realized within the scope of the HOLISHIP project.

2.4.2 *CAESES and ANSYS Workbench*

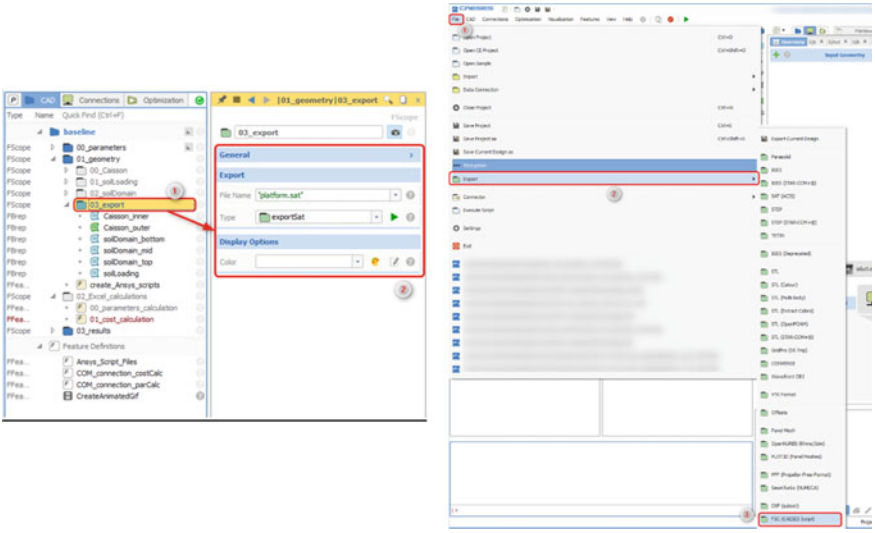
For the same AC of an offshore platform, an additional type of connection was needed, namely a smooth connection between CAESES and the ANSYS Workbench, with ANSYS Finite Element Analysis (FEA) being one of the market leaders in structural design. Building on the existing collaboration between ANSYS and FRIENDSHIP SYSTEMS, two interfaces could be established to support data exchange between CAESES and the ANSYS Workbench: (i) The ANSYS Workbench is run from CAESES as the controlling entity (i.e., the PIDO) and (ii) CAESES becomes available within the ANSYS workbench. While the former regards the ANSYS Workbench as yet another tool run in batch-mode, the latter offers CAESES parametrics



(a) Selection of a CAESES FSC file (for batch-mode execution)

(b) Link between an "ANSYS Geometry" and a component that processes geometry

Fig. 2.15 Integration of CAESES® within the ANSYS Workbench (AC Offshore Platform)



(a) Selection of objects to be exported

(b) Creation of a CAESES script file for the Workbench

Fig. 2.16 Integration of CAESES within the ANSYS Workbench (AC Offshore Platform)

and geometry generation for the Workbench as a plug-in (or component), further increasing the scope of multi-lateral integration.[3]

Figures 2.15 and 2.16 illustrate the integration within the ANSYS Workbench. Here, CAESES itself is executed in batch-mode (on the basis of an FSC file, i.e., a CAESES script file, see Fig. 2.15a). Within the AC Offshore Platform this approach

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[3] In this context it should be noted that the ANSYS Workbench is a very flexible integration platform in its own right and hence, similar to what has been discussed, this additional connection increases the scope of applicability.

was utilized to compute with ANSYS FEA the maximum deformation under gravitational loads, under ice loads and under wave loads for a set of platform geometries (caisson) and seabed configurations (soil), see Fig. 2.15b.

2.4.3 Integration via XML

Within CAESES, tools can also be integrated on the basis of data exchange via XML files. This type of integration is typically used (and favoured) by tool developers that can freely decide on the format of their input and output files and that opt for XML syntax to combine human readability with easy maintenance.[4]

The XML integration in CAESES is based on a custom document type definition (DTD) provided by FRIENDSHIP SYSTEMS. This DTD defines all usable datatypes for both input and output, enabling the tool developer to complement (or, alternatively, even to replace) the existing input and output files by file formats following standard XML syntax. As soon as this has been done—which represents the major work load encountered—the tool provider sets up a so-called CAESES Definition which contains all possible input data. This can be readily done by using the GUI of CAESES itself.

Figure 2.17 shows parts of the so-called XFFL file for MARIN's flow code RAPID for illustration, RAPID being a nonlinear potential flow code for wave resistance computation. Figure 2.18 illustrates the definition for RAPID in the object tree of CAESES along with one of the entries, here the Froude number, in the object editor. Entries can be added or deleted and all necessary attributes like name, type, default value, number of occurrences etc. can be set interactively. Furthermore, CAESES Definitions can be structured in groups and sub-groups.

A CAESES Definition is saved in an XML file by the tool developer and then directly supplied to the users. This means that tailored versions of a tool, new features and changes can be distributed throughout a tool's user community without any need of involvement of FRIENDSHIP SYSTEMS. See also (Abt et al. 2009) for details. As with the COM interface, further adaptations, maintenance and improvements were realized within the scope of the HOLISHIP project.

2.4.4 Cross-Platform Integration of Tools

Tool integration as needed to build synthesis models does not only face the challenge of having to bring together separate tools from different providers with non-homogeneous inputs and outputs, disparate data storage, non-harmonized nomenclature etc. but also that not all tools can be made available on a single computer

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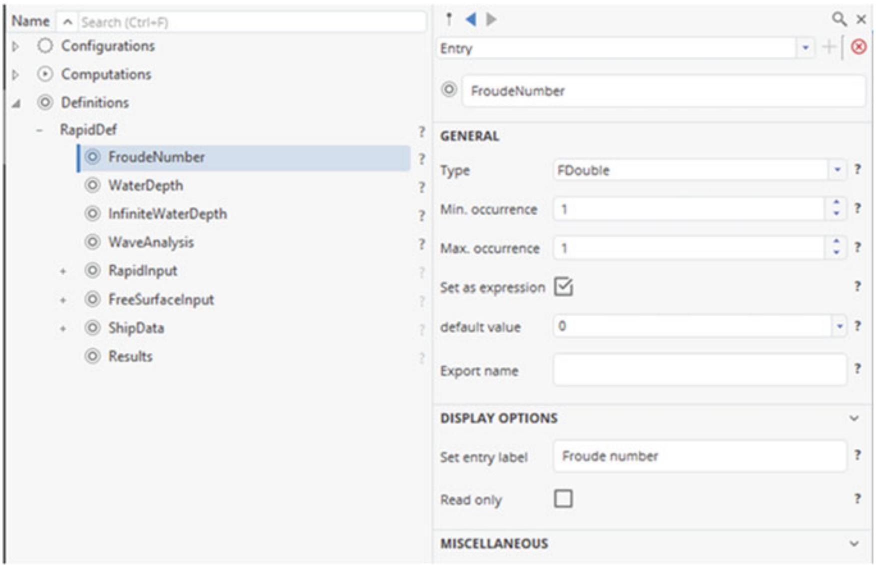
[4] This situation is different to that of a pure software user who, commonly, has neither influence on any of the file formats nor on their syntax and semantics.

```
<?xml version="1.0" encoding="UTF-8" ?>
<!DOCTYPE xffl>
<xffl name="caseRapidDef01" >
  <FDouble name="FroudeNumber" >
    <value>0.3</value>
  </FDouble>
  <FDouble name="WaterDepth" >
    <value>50</value>
  </FDouble>
  <FInteger name="NumberOfStrips" >
    <value>37</value>
  </FInteger>
  <Group name="RapidInput" >
    <FDouble name="InitialSinkage" >
      <value>0</value>
    </FDouble>
    <FDouble name="InitialTrim" >
      <value>0</value>
    </FDouble>
    <FBool name="FixSinkageAndTrim" >
      <value>true</value>
    </FBool>
  </Group>
  <Group name="FreeSurfaceInput" >
    <FDouble name="ExtendAhead" >
      <value>1</value>
    </FDouble>
    <FDouble name="ExtendAstern" >
```

Fig. 2.17 Excerpt of XFFL file for MARIN's RAPID code



FroudeNumber

GENERAL

Type: FDouble

Min. occurrence: 1

Max. occurrence: 1

Set as expression ☑

default value: 0

Export name:

DISPLAY OPTIONS

Set entry label: Froude number

Read only ☐

MISCELLANEOUS

Fig. 2.18 Definition within CAESES®

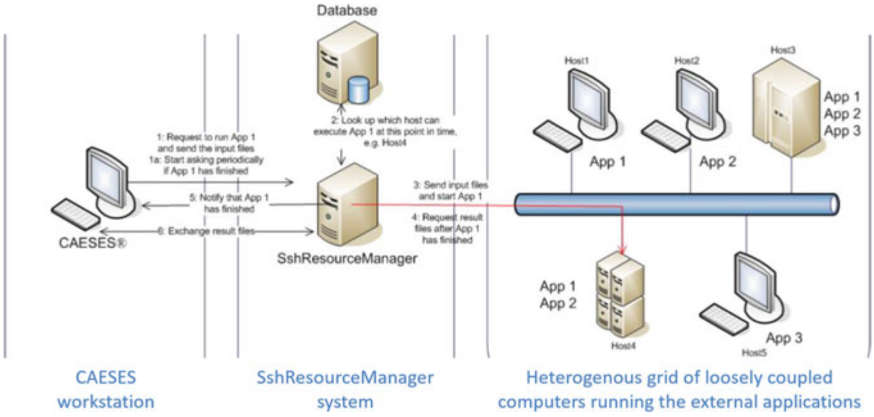


Fig. 2.19 CAESES resource manager for usage of tools across platforms and on different computers

or even within the same operating system. One way to circumvent this problem is to utilize surrogates as discussed in Sect. 2.3.3. An additional means of bridging the gap between computers and/or operating systems is to use CAESES' resource management capabilities.

As shown in Fig. 2.19 different apps—i.e., applications, meaning simulation tools and/or other integration platforms—can be accessed by a CAESES instance via the so-called SshResourceManager that can trigger and communicate with computers, may they run under Windows® or under Linux™, which are administered within one (local) network or within a virtual private network (VPN). This then enables, for instance, a design engineer to run CAESES on his or her personal computer, say under Windows®, and make use of a simulation tool that was installed and for which a license was provided on a more powerful Linux™ workstation (or on an HPC). It also supports the utilization of various computers for resource-intensive simulations overnight and over weekends when these computers would usually not be needed for interactive work. Furthermore, it can be put to use to run a tool remotely that is only installed on a colleague's computer and to which concurrent access cannot be provided easily.

2.5 Selected Connections and Collaboration

The main strategy behind the development of CAESES® and of HOLISHIP in general was not to attempt to introduce yet another monolithic system. Rather, the approach was to flexibly connect tools as they are needed for solving challenging design tasks. CAESES allows communication with stand-alone simulation tools either in a one-to-one relationship or in a one-to-*m* synthesis model (see again Figs. 2.1, 2.2, 2.3 and 2.4) with m being the number of tools connected. In addition, CAESES as the chosen integration platform can collaborate with Computer Aided Engineering systems that represent platforms themselves.

Several CAE systems were utilized within the scope of HOLISHIP's application cases, e.g. the ANSYS Workbench (see above) from ANSYS, CADMATIC from Elomatic, NAPA Ship Design and NAPA Steel from NAPA OY and the Remote Component Environment (RCE) from DLR. The primary motivation for this was and continues to be that the engineering environments found in industry are rather diverse and that, depending on experience, available soft- and hardware, partners involved, the design task to undertake etc. a number of tools, be it for the reason of utilizing best-of-class or just the tools at hand, need to be brought together. If a CAE system then already has connections to other tools the key advantage of collaboration between platforms is obvious, i.e., an integration need not be replicated but integrating systems and/or frameworks can cascade and exchange data from one system to the other.[5]

Some of the connections and collaborations shall be highlighted here with reference for further reading.

2.5.1 CAESES and CADMATIC

Figures 2.20 and 2.21 are taken from the application case of the design of a double-ended ferry. As discussed in detail in Harries et al. (2019) CAESES and CADMATIC exchange data that relate to the hull form and the inner structure. CADMATIC utilizes the current hull geometry to map a parametric model for decks, bulkheads etc. to generate an estimate of steel weight. When changing the hull form the inner structure is automatically adapted so that a considerable range of design variants can be taken into account.

The full elaboration of the design task, the optimization, including hydrodynamics and considerations for batteries, a hybrid and a conventional drive system, along with results are given by the task leader, Elomatic, in (Jokinen et al. 2020, and Chap. 12 of this book).

2.5.2 CAESES and NAPA Steel

Figure 2.22 is taken from the application case of the design of a RoPAX ferry (AC RoPAX). It shows the imported data of the steel structure set up for the RoPAX ferry (design Alpha). Here, CAESES allows filtering of data for viewing and examination.

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[5] Moreover, the direct connection of tools that CAESES communicates with is not prohibited. In other words, if two tools that are integrated in a synthesis model require direct data exchange that can be accommodated, too.

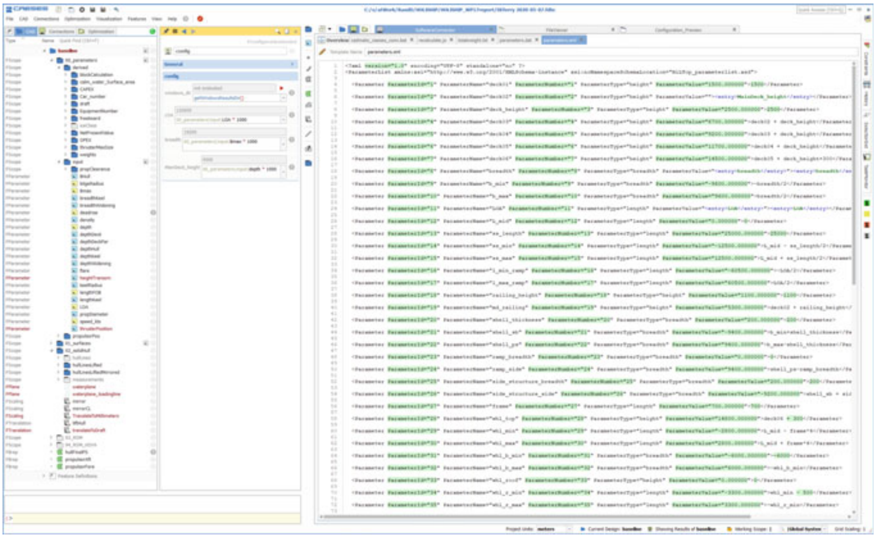


Fig. 2.20 Coupling of CAESES and CADMATIC (AC Double-Ended Ferry)

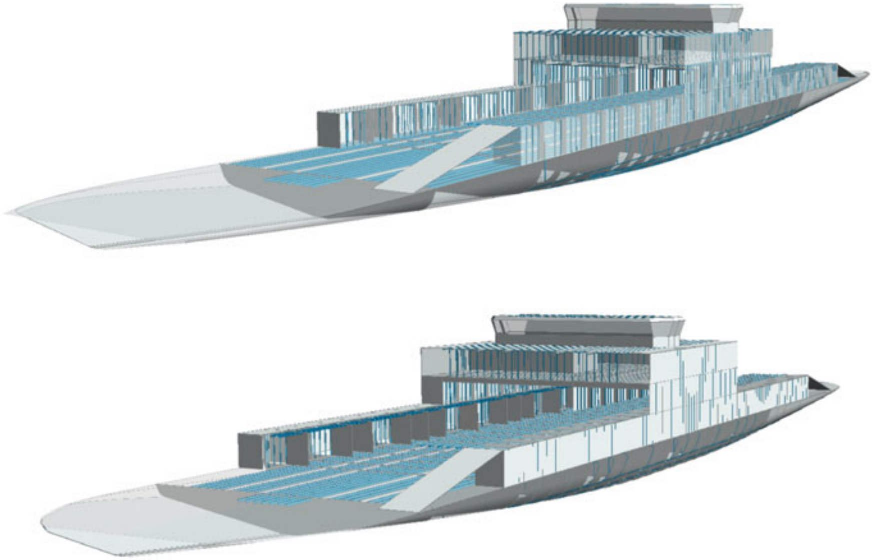
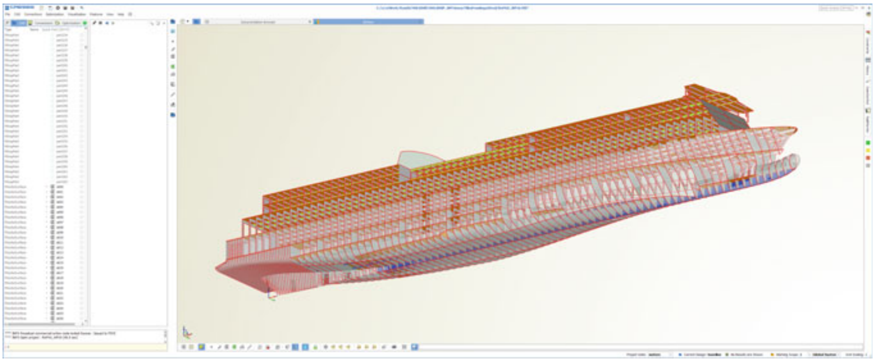
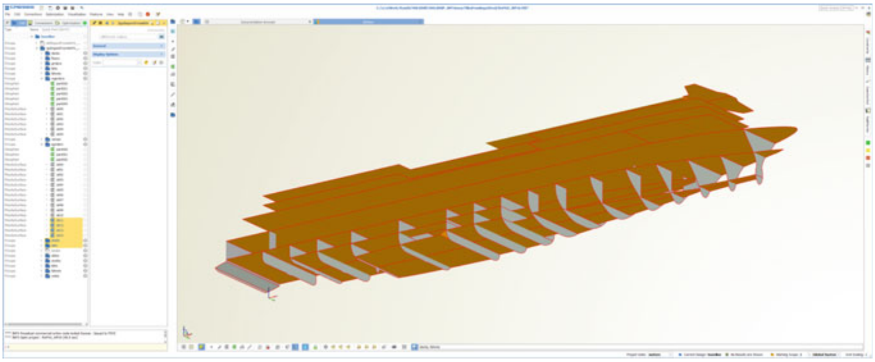


Fig. 2.21 Two variants of a parametric model for steel weight analysis within CADMATIC as triggered via CAESES (AC Double-Ended Ferry)



(a) Import from NAPA Steel (with plates of outer shell set as non-visible)



(b) Filters set to visualize decks and bulkheads

Fig. 2.22 Import from NAPA Steel (AC RoPAX)

2.5.3 CAESES and Shipbuilder

Figure 2.23 is taken from the application case of the design of a Multi-purpose Ocean Vessel (MPOV) (AC MPOV by the Naval Group, see Chap. 6 of this book). It displays the data imported from a general arrangement (GA) of blocks, representing rooms, compartments and important functional areas and volumes as defined within Shipbuilder by Sirehna. Details are described in (Le Néna et al. 2020). The data imported from the GA helps to adjust the hull shape or, alternatively, to check if the blocks fit the geometry and to identify which blocks may need adjustments (e.g. cut-aways, tapering, resizing, relocation etc.).

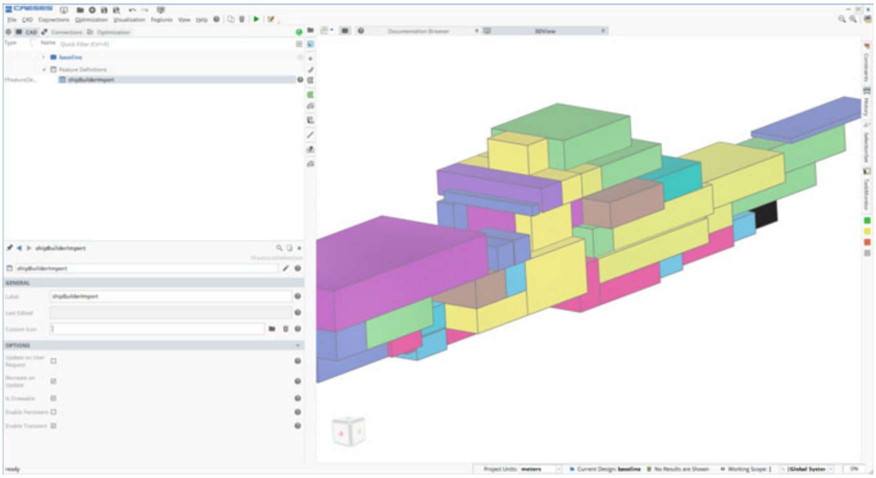


Fig. 2.23 Import of blocks in CAESES (AC MPOV)

2.6 Outlook

2.6.1 Version Control

It needs to be noted that CAESES even though versatile and flexible as a parametric modelling system (CAD) and as a process integration and design optimization environment (PIDO), respectively, has the inherent limitation of not being a product life-cycle management system (PLM). A PLM system would offer roles, access rights, version control, check-out and check-in of data, unified and long-term data storage etc. This is not the purpose of CAESES and, when developments started in 2004, was not part of its roadmap. Consequently, in order to elevate integration, coworking, concurrent engineering, collaboration between team members and also across company boundaries to another level, an additional PLM layer would be required. This was beyond the purpose of the HOLISHIP activities. Nonetheless, it would be worthwhile to pursue this topic, even though it has to be addressed with considerable effort within a yet to be defined new R&D project.

2.6.2 Marketplace

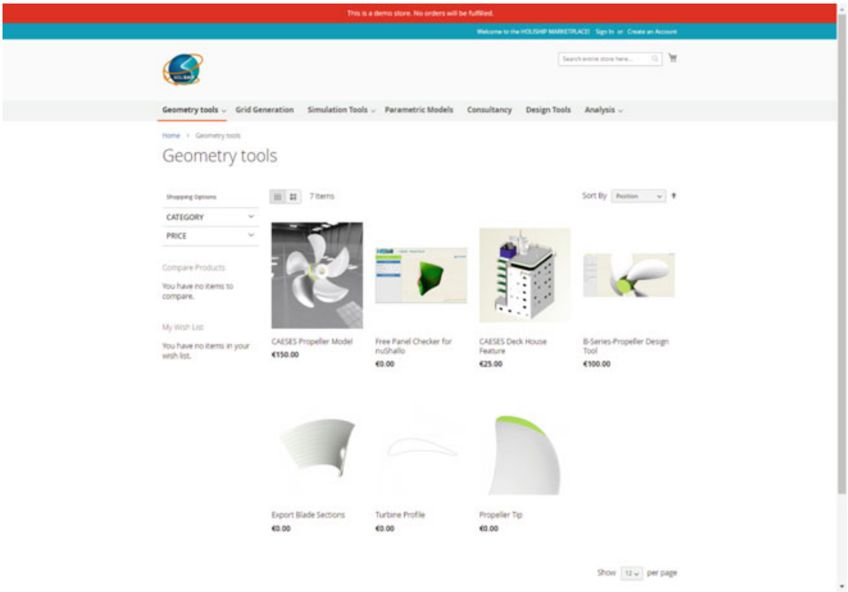
Complementing the holistic approach to ship design and the development of integration platform(s) within HOLISHIP, further ideas were proposed and studied, namely how to enable access to tools of various origin at a wider range, not only for partners of HOLISHIP but for the broader maritime community.

A first prototype of a web-based marketplace was realized on the basis of MAGENTO, a platform for B2B (and possibly also B2C) commerce. Figure 2.24 gives an impression. In principle, such a marketplace can offer tools, services, consultancy for design and simulation, quality assurance and can bring together teams beyond traditional company and academic boundaries. Two examples tasks are described in Table 2.3.

2.7 Conclusions

The purpose of integration and collaboration is to create synthesis models that comprise the most important drivers, i.e., the key aspects, when working on a specific design task. Since key aspects and the way they are determined differ depending on the design stage, the actual design task and the available resources an ad-hoc assembly of tools and systems as well as of dedicated parametric models and surrogates are proposed. The approach showed its validity and versatility when brought to life and put to use for challenging applications, namely the design of twin-screw passenger ferries of different size (RoPAX), the development of an Offshore Supply Vessel (OSV) for safe crane operations under dynamic positioning, the concept and contract design of a Multi-Purpose Ocean Vessel (MPOV) for safety and security as well as search-and-rescue in European waters, the design of a double-ended ferry (DE-ferry) with electric (alternatively hybrid and conventional) propulsion, the design and installation of a gravity-based offshore platform for shallow waters and, moreover, the retrofitting of a bulk-carrier and a container ship already in operation. As can be readily appreciated neither the design challenges nor the synthesis models for these application cases are the same nor are the parties involved or the interests they pursue.

Setting up suitable synthesis models takes time as well as the expertise and cooperation of several partners. Presently, this may still call for too much effort and may yet take too much time for daily practise when working on standard designs. Nevertheless, once synthesis models are available they can be employed to run sophisticated optimisation campaigns in order to generate valuable and new insight. This then leads to cutting-edge and even to rather ingenious designs which yields a competitive advantage in a commercially challenging economy. In particular if non-standard solutions are required the potential gain merits the effort. Furthermore, with each new integration and with more experience gained, the speed of setting-up synthesis models and the benefit of utilizing them for simulation-driven design increases.



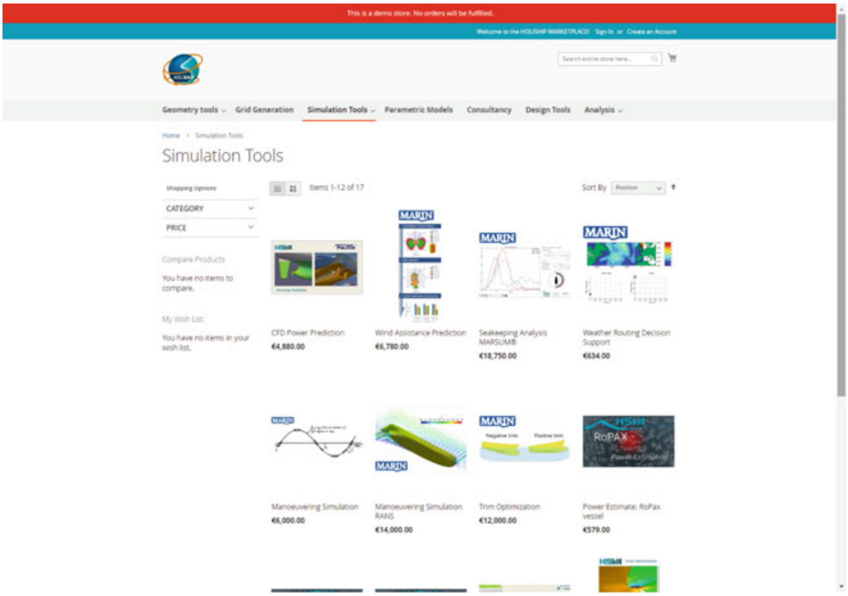
This is a demo store. No orders will be fulfilled.

Welcome to the HOLISHIP MARKETPLACE! Sign In or Create an Account

You have no items to compare.

You have no items in your wish list.

(a) Possible way to offer geometry tools
(N.B. Prices are not consolidated; they are purely given for illustration purposes)



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(b) Possible way to offer simulation tools
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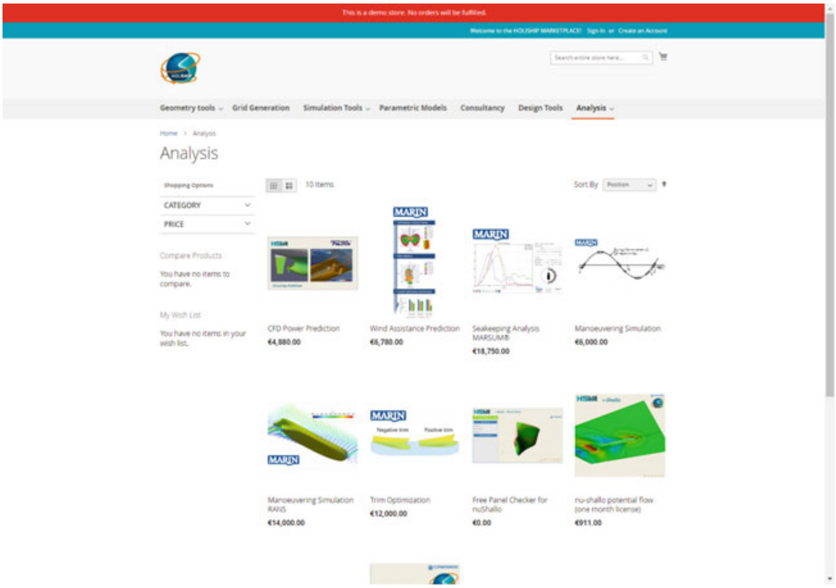
Fig. 2.24 Screen shots from a first mock-up of a potential HOLISHIP marketplace (note that this is an outlook and all prices shown are purely fictitious and are given just for illustration)



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Analysis

10 Items

Compare Products

You have no items to compare.

My Wish List

You have no items in your wish list.

CFD Power Prediction
€4,880.00

Wind Assistance Prediction
€6,780.00

Seakeeping Analysis MARSUM®
€18,750.00

Manoeuvering Simulation
€6,000.00

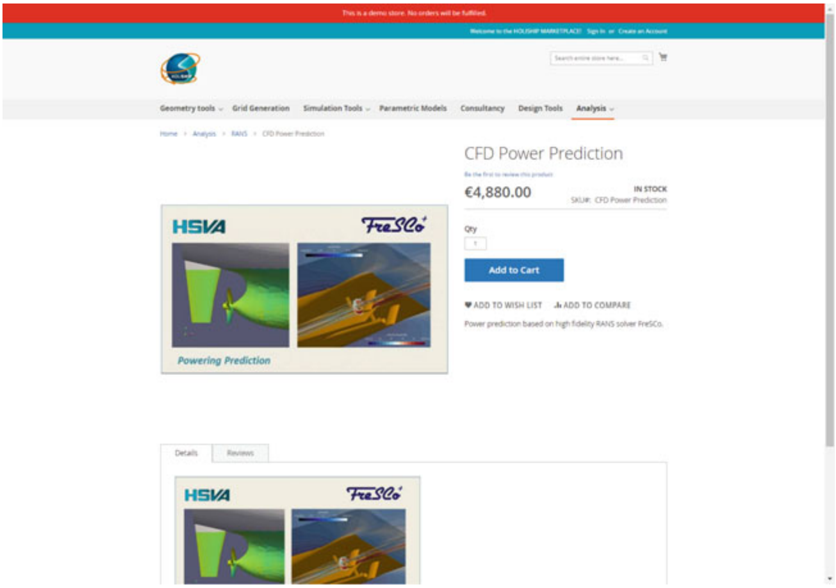
Manoeuvering Simulation RANS
€14,000.00

Trim Optimization
€12,000.00

Free Panel Checker for nuShallo
€0.00

nu-shallo potential flow (one month license)
€911.00

(C) Possible way to offer analysis tools
(N.B. Prices are not consolidated; they are purely given for illustration purposes)



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CFD Power Prediction

Be the first to review this product

€4,880.00

IN STOCK

SKU#: CFD Power Prediction

Qty: 1

Power prediction based on high fidelity RANS solver FreSCo.

(D) Possible way to offer specialized CFD power prediction
(N.B. Prices are not consolidated; they are purely given for illustration purposes)

Fig. 2.24 (continued)

Table 2.3 Exemplary description of tasks and solution approaches for a possible marketplace on the basis of HOLISHIP (outlook)

Description: "My current design still requires an improved bulbous bow for a given operational profile. The lines are established. However, the bulb region just aft of the forward perpendicular, the lengths and volume of the bulb can still be changed We would need the improved design within the next five days in order to decide on the engine and freeze the lines" (a) Task description: Bulbous bow optimization	Solution via the HOLISHIP marketplace 1. The ordering company uploads several perspective views of its hull form along with a task definition and the description of the operational profile 2. It invites users of the marketplace to make an offer (price and time of delivery) within a certain time frame 3. It then selects its favorite offer and uploads the hull geometry to a secure area of the marketplace (e.g. STL-file, iges-file, CAESES project) 4. The service provider that runs the project starts the optimization work 5. While work is in progress certain data such as optimization history can already be accessed by the ordering company; selected variants can be downloaded for further investigations 6. The service provider and the ordering company discuss results in a virtual meeting (e.g. GoToMeeting) offered via the marketplace 7. Upon finishing the project invoicing is done automatically via the marketplace (e.g. PayPal, standard invoicing by automatically sending documents to all parties involved) (b) Solution approach for (a)
Description: "As a design team we are working on a new design which is supposed to be a SWATH. We have not yet worked on any SWATH of similar size nor can we find or access reliable data for resistance and propulsion We would need data for resistance at the design speed and one lower speed by the end of next week. So far we only have preliminary lines and estimates of the main dimensions" (c) Task description: Numerical hull series	Solution via the HOLISHIP marketplace 1. The ordering company uploads a sketch of its design along with a definition of the task 2. It invites users of the marketplace to make an offer (price and time of delivery) within a certain time frame 3. It then selects the service provider(s) • The fastest and most economic solution is a service by two partners that work together • One partner will provide a parametric SWATH model while the second partner will run the CFD analyses to build a surrogate model 4. The first service provider develops a parametric model in CAESES® within three days. The parametric model is made available to the ordering company via a WebApp 5. The ordering company uses the WebApp to study the model and give feedback 6. The CFD provider already uses a baseline geometry from the parametric model for setting up the CFD computations 7. Based on a slightly modified parametric model all three partners discuss the details for the numerical series in a virtual meeting (e.g. GoToMeeting) offered via the marketplace 8. The CFD provider runs the Design-of-Experiment over several days and provides the data for the surrogate model 9. While work is in progress certain data such as wave heights, pressure distribution, streamlines can already be accessed by the ordering company; selected variants can be downloaded for further investigations 10. Service providers and ordering company discuss final results in a virtual meeting 11. Upon finishing the project invoicing is done automatically via the marketplace (e.g. PayPal, standard invoicing by automatically sending documents to all parties involved) (d) Solution approach for (c)

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