WHITE PAPER

The Digital Fabric of Data-Driven Shipbuilding

– 3D CAD data exchange in shipbuilding projects

The CADMATIC approach to interoperability, data migration, and handling of legacy data in the design stage of projects.

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Executive summary

The digital fabric of shipbuilding consists of data threads that originate from various specialized applications. There are commonly numerous different software solutions involved in a shipbuilding project, hundreds of engineers and designers, several companies located in different countries and continents, and even several building sites.

The data related to the project is often based on a model-centric approach and serves all stages of the life cycle: from initial design to production, MRO, and operations. An incrementally built digital twin can be used for a wide range of purposes.

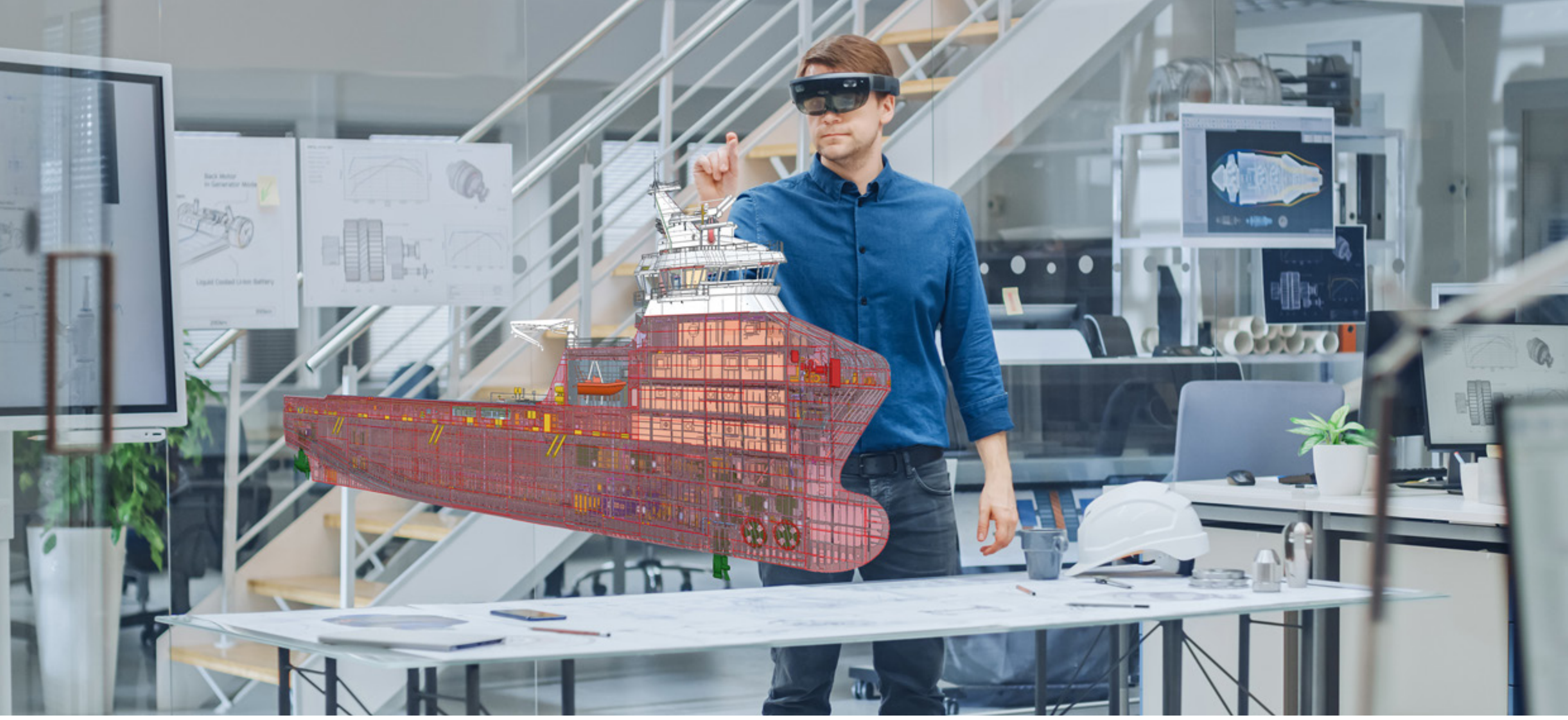
One of the most difficult questions in handling complex shipbuilding projects in the design stage concerns the CAD data format and level of interoperability. The challenges faced by shipbuilders include highly specialized data that is stored in various locations, applications, and databases that come with restricted access and a lack of universally accepted data exchange formats.

From a design perspective of possible 3D data types in shipbuilding, the CAD systems include 3D models, reference data, MCAD models, interoperability with various calculation software, simulation and other CAD systems, laser-scanned data, and data for AR/VR metaverse use. Data exchange scenarios for production, MRO, and operation fall into the category of PLM system integration.

In this white paper, we present and discuss the leading causes of data migration and outline the approach CADMATIC recommends to our customers based on our experience in the shipbuilding industry and countless customer and partner projects, as well as the possibilities offered by current technology solutions.

Contents

This white paper outlines 'CADMATIC's approach and recommendations and doesn't substitute technical documentation. All technical specifications are related to CADMATIC version 2022T1. For the latest information, please refer to the release documentation at www.docs.cadmatic.com or consult our technical support for advice about the possibilities for conversion and the use of external partners for integration at support@cadmatic.com. Any mentioned file formats or technology might be a trademark of the respective owners.



Introduction: Data migration in shipbuilding CAD projects

3D CAD data in shipbuilding projects is the most significant asset. It contains 3D geometry information, material data, the components used, and a lot of interconnected parts and information for production.

Compared to Mechanical CAD 3D models, shipbuilding-specific CAD data incorporates the model data structure or "model tree" where spatial and functional relations between parts is stored. It has extensive links with part libraries (equipment models, outfitting part catalogs and armatures, piping and steel prefabricated parts), specification sets, and standard libraries (these might include predefined class rules or yard standards for production). Additionally, production data, such as drawings and other documents, and direct numerical data for production manufacturing can be customized for building yard standards and extracted automatically from the 3D model.

In this white paper, we present and discuss the leading causes of data migration and outline the approach CADMATIC recommends to our customers based on our experience in the shipbuilding industry and countless customer and partner projects, as well as the possibilities offered by current technology solutions.

The main data exchange scenarios in shipbuilding projects:

1. Use of MCAD models

- Using parts of the ship project that come from Mechanical CAD, such as 3D models of equipment or other units

2. Import and export of CAD data

- The need to extensively import and export data at various stages of the design or production process, as reference or native models or production data in the needed format

3. Data migration

- Change of CAD systems and access to legacy project data
- Conversion of CAD data between different CAD solutions: components, equipment, piping specifications, or units
- Concurrent design in a multi-CAD environment

4. Use of data from laser scanners

- Use of laser-scanned data for reference or remodeling

5. Integration with data management systems

- Interfacing with PDM/PLM/ERP systems and creating digital twin

6. Use 3D in AR/VR

- Output for a different use, such as in AR/VR/MR/XR or image rendering software

Main scenarios that require CAD data migration

Creating a 3D CAD model and utilizing it for production purposes remains the most crucial factor contributing to the success of the overall shipbuilding project. However, data migration has become one of to the top considerations in modern shipbuilding projects. It comes into the picture when several participants need to use different CAD systems, or concurrent design in two or more systems is desired. There are six main scenarios of data exchange in shipbuilding projects, which are illustrated on page 5 and discussed in the following chapters.

Use of MCAD models in CADMATIC

MCAD refers to mechanical CAD 3D data and usually contains geometry definition and meta-data, such as attributes, layers, etc. It may come in various formats and types, usually including several options for generic format exports.

Use case: Importing equipment, such as engines or heavy machinery, furniture or other accommodation items, or similar parts that need to be positioned in the overall 3D ship model.

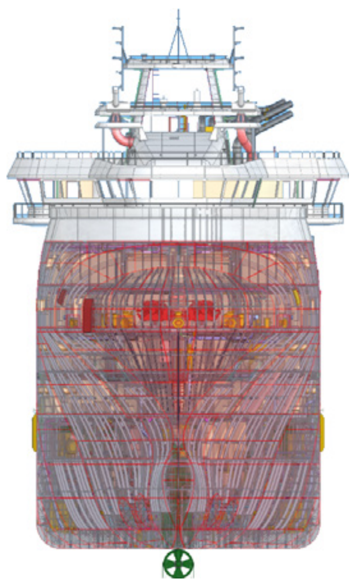
Considerations: Before selecting the format and way of importing, one should assess the needs and the use scenarios in a particular project. Typical questions to consider are:

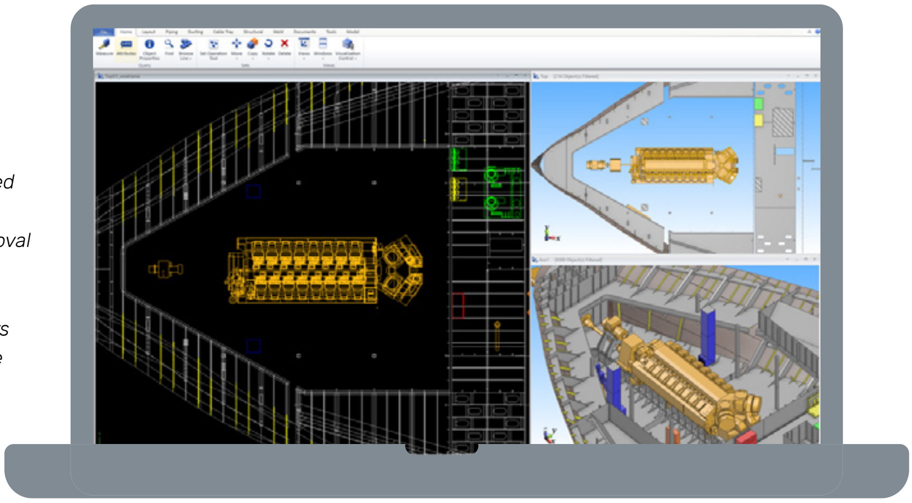
- What is the import size? Some MCAD models can be surprisingly large due to the highly detailed internal parts. In some cases, it is possible to reduce the size by removing invisible internal parts, and in others, one can consider creating a native component model using Component Modeller.
- Is it a unique part, or are there many similar parts in the 3D model? If the part is used often, it is better to make a native parametric component and store it in the library for easy reuse in other projects.
- Will it be a one-time import, or are frequent updates expected? In cases where updates are expected, one should consider the location and workflow of updating.

FURTHER READING:

» Optimization of imported objects
Removing invisible internal parts

» Component Modeller
Building instructions for components





Example of an imported 3D MCAD model of a main engine. The removal of internal parts helps to reduce the size of the import and impacts the overall project size and performance.

Solution: The optimal solution depends on the MCAD software and the importing or exporting needs and expectations. If the imported data only contains a few items, and there is no foreseeable need for frequent updates, a generic interface such as AutoCAD eXchanger, IFC, STEP, or JT formats should be used. For more file formats, it may be feasible to use PolyTrans eXchanger to benefit from its over 100 compatible formats with various MCADs.

Additional possibilities, such as the optimization of the 3D geometry, mapping of attributes, and the use of import manager can simplify and optimize the workflow for different use cases: importing and updating models, positioning equipment in the project space, mapping attributes, etc.

FURTHER READING:

» 3D eXchanger for AutoCAD
ObjectARX application for AutoCAD

» 3D Import & Export Using IFC
Open, international standard for exchanging CAD data

» STEP: Hull structures
Importing/exporting SAT/STEP

» 3D Import & Export Using JT
JT is a 3D data exchange format that is used by Siemens PLM Software

» 3D eXchanger for PolyTrans
3D translation, optimization and viewing application by Okino Computer Graphics

» 3D import manager
Tool for importing model data from various file formats

Import and export of shipbuilding CAD data

This scenario is an extended case of importing separate components. Data exchange comes into the picture when some project parts originate from or need to be transferred to other software packages or formats for production. Currently, there is no universally accepted data exchange format in the shipbuilding industry.

Use case: There are many combinations for import/export data needs in the shipbuilding design and production process. Possible situations may include importing hull shapes, exporting data for FEM or scantlings, data exchange with calculation software, simulation or CFD systems, OCX export for class approvals, importing pipes or 3D models from other disciplines, modeling using various design applications specific to some shipbuilding discipline, and exporting project parts for reference remodeling.

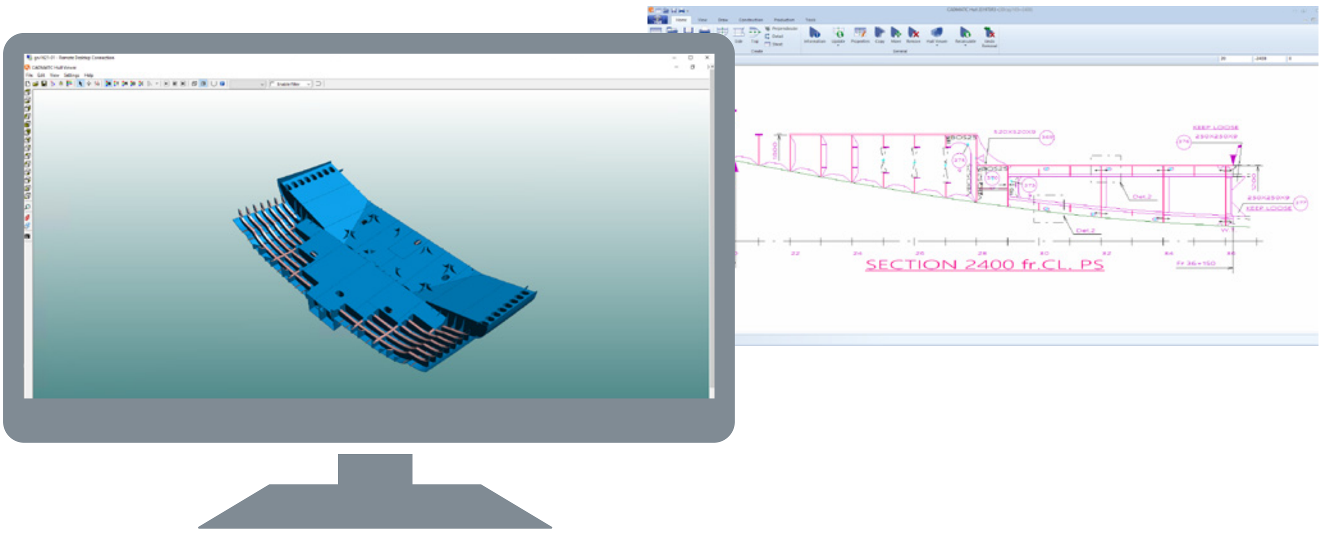
Considerations: Import and export scenarios usually imply the use of imported models as reference data. In this case, it will have a read-only status, be updated or replaced as needed, and contain meta-data. However, it will not become a native editable model. For the latter case, a data migration scenario should be considered.

Solution: While some integration scenarios have a specially developed interface, such as CADMATIC-NAPA, a Tekla direct interface, or DEXPI exchange formats, to name a few, in many cases using an intermediate neutral format such as STEP, JT, IFC or OCX is a preferred solution. The overview of existing CADMATIC Hull and Outfitting interoperability options are continuously updated as new data standards emerge and new possibilities are explored.

FURTHER READING:

» Import/Export function
About importing and exporting hull models

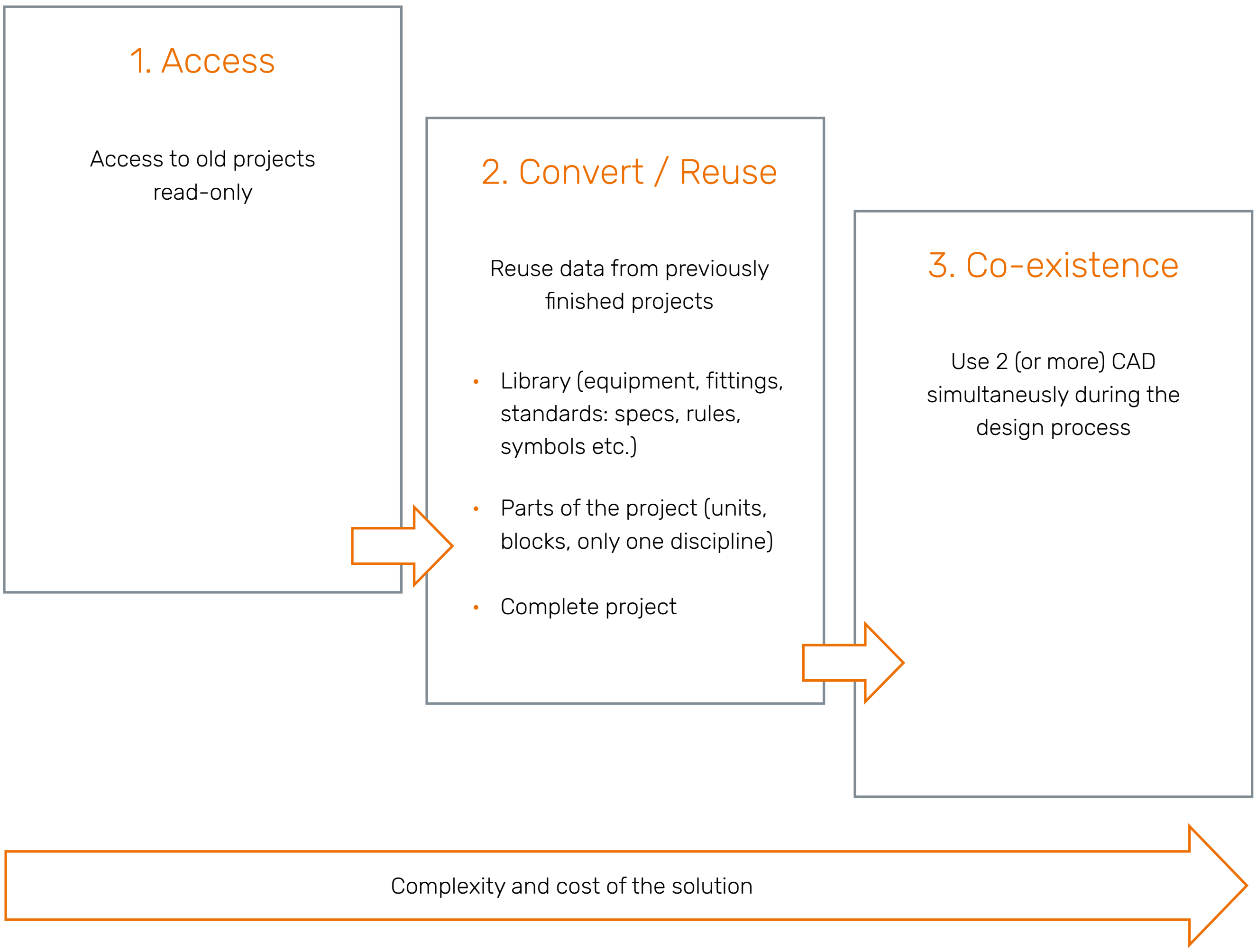
» Working with other CAD systems
Different methods of data exchange for Piping/Outfitting models



Data migration: change of CAD systems and legacy data, multi-CAD environment

Data migration scenarios have three main sub-categories: access to data, conversion or reuse of data, and a co-existence scenario. From a data handling point of view, each would require relocation and conversion of data, thus presenting a separate case in a simple import/export workflow. Each sub-category has unique considerations and solutions outlined in the following sections.

Three sub-categories of data migration scenarios in shipbuilding:



Access to legacy project data using CADMATIC Information Management

In most cases, access to legacy project data can be facilitated in two ways: keeping the data in the native system or storing it in the CADMATIC Information Management platform.

Use case: Access legacy projects for references and centralized storage of all the company's projects. Keeping the data in a legacy system might be the preferred solution in the short and mid-range time frame. Uploading legacy projects, including 3D data and project documentation to the Information Management platform would provide a central storage archive with easy access.

Considerations: It needs to be accessed what the intended use of the legacy data is: to store and access the data, possible reuse, and need for conversions of parts of complete projects. Keeping the data in the original format and original application may also be the preferred solution.

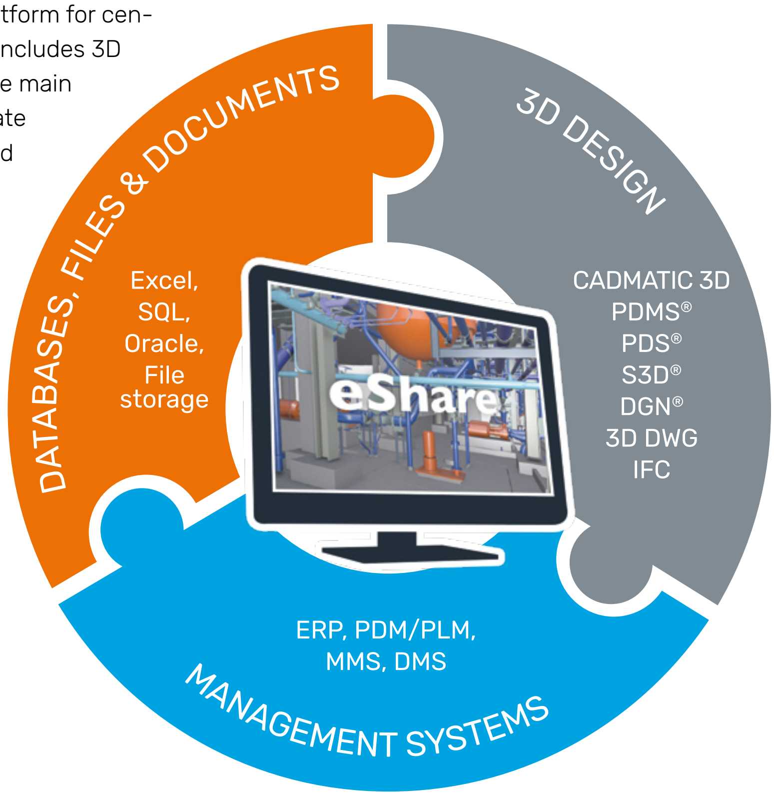
Solution: In cases where no data reuse is expected, it is advisable to use the CADMATIC Information Management platform for central access to legacy data and ongoing projects. It includes 3D CAD data with inbuilt conversion possibilities for the main CAD formats, 2D documentation, options to integrate with external file storage or DMS/PDM systems, and laser-scanned data upload.

Supported 3D formats: EBM, EBMX, 3DD, DGN, DWG, DXF, DWF, IFC, IFCzip, JT, NWC, NWD, PDMS, PDS, and SmartPlant. Supported formats for 2D documents: PDF, DWG, DXF, DGN, JPEG, PNG. It is possible to upload laser scan data in the following formats: E57, CPD, CPE, PTX, CPX. Several APIs and adapters provide extensive integration possibilities with external storage systems for document management and other project related data.

FURTHER READING:

» Adapters and Data sources
Integrating eShare with various relational database management systems

Integration of numerous sources of data and a model-centric approach in shipbuilding CAD using CADMATIC Information Management solutions



Conversion of CAD data

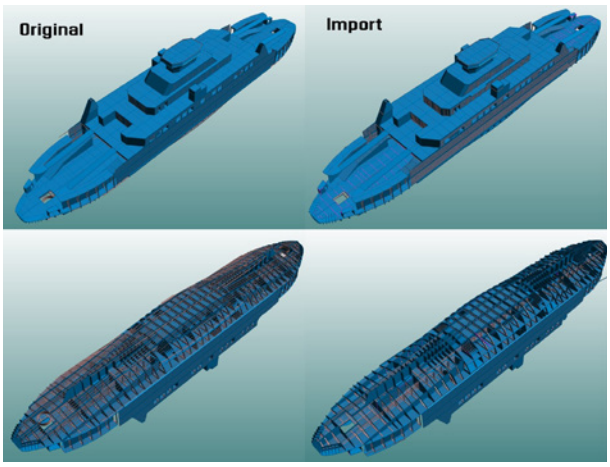
Shipbuilding CAD software distinguishes itself from other industrial CAD and MCAD in the high number of 3D parts in the models, the level of interconnectivity, the automated output of documents, and the direct interfaces to production systems at shipyards. Additionally, the system setup and use can differ significantly in every case. Customizations and customer-specific attribute data might effectively optimize use within the organization but prevent universal data conversions.

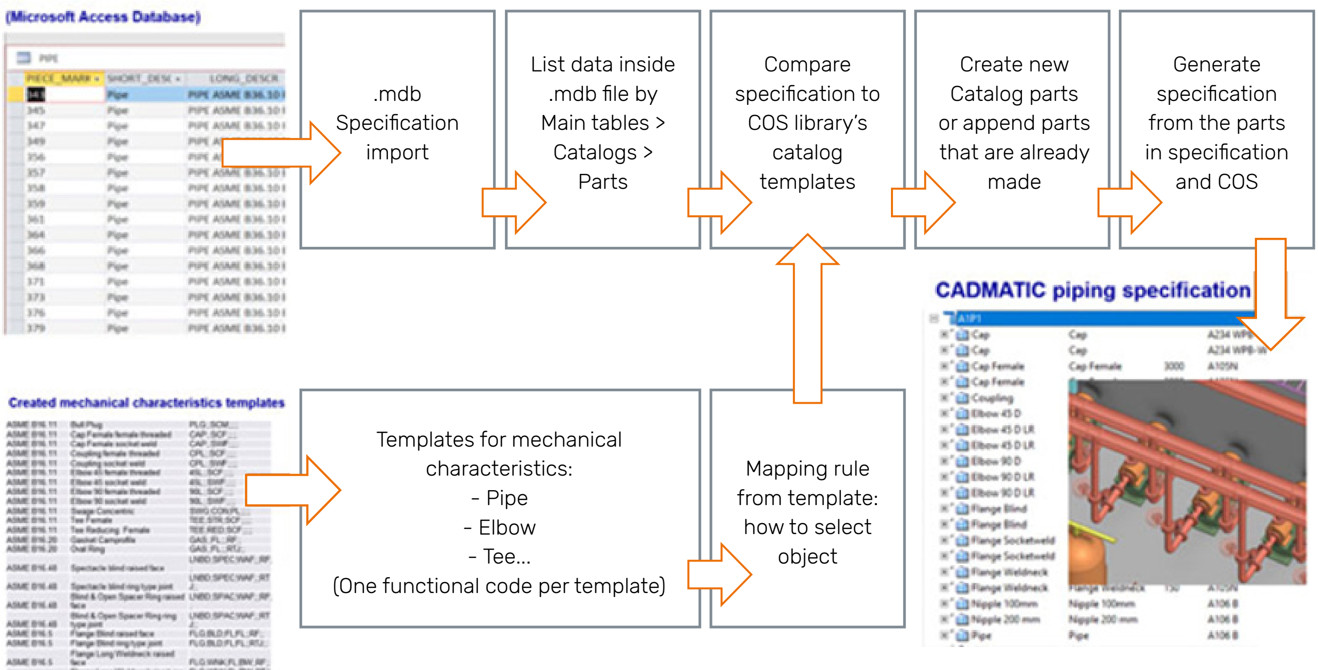
Use case: Changing a shipbuilding CAD system is a significant step. There may be several reasons for the need to change: mergers and consortiums of shipyards or design companies, intended modernization of IT infrastructure, CAD format requirements in the networks of design-production-operation, or others. A clear definition of the scope for CAD conversions would help define the optimal solution: conversion of equipment library, piping components, and specifications, mapping of attributes, or conversion of the 3D CAD model itself. Using legacy data as a read-only reference might significantly simplify the workflows and save resources, allowing them to focus on the essential design processes.

Considerations: When converting a 3D CAD model from one format to another in shipbuilding-specific solutions, one must consider the data structure, geometrical shape, and possible topological linkage between parts and between 3D model – 2D documents if there are any in the origin and target systems. Typically, most CAD models contain high amounts of data referenced to a library of components and piping specifications, which require conversion and respective mapping. The conversion type and execution scenario depend on the origin and target CAD systems, their versions, the scope of transformation, and intended workflow (bi-directional, one-time conversion, using neutral format files as intermediary steps, and IT setup for shared locations and services).

Solution: Depending on the scope of conversion, the solution would consist of all or only some parts: conversion of equipment library, piping components, and specifications, mapping of attributes, and conversion of the 3D CAD model itself.

There are many options for transferring a reference 3D model using intermediate formats, such as 3D DXF, DWG, IFC, JT. In this case, the geometry transfer will be ensured, while most part attributes will not be transferred. However, it may be a fast and easy solution in most cases when only access to the data is needed, as presented in the import/export scenario.





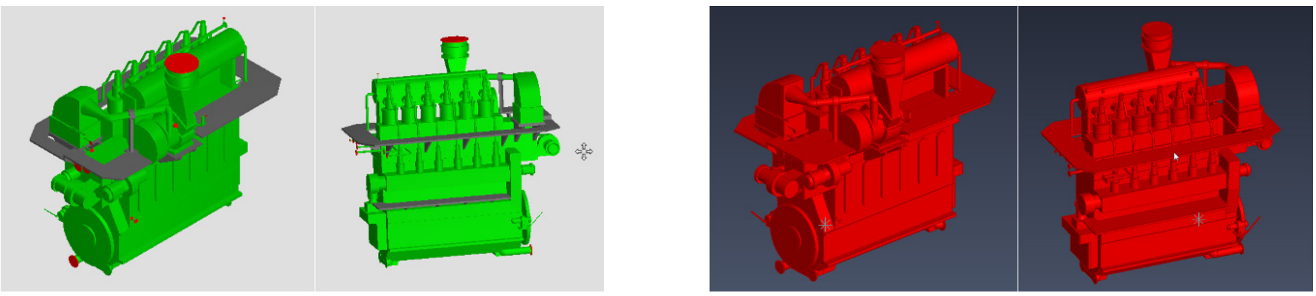
Example of a workflow to convert piping specifications and catalog parts.

Conversion of equipment

The equipment library is an important asset, and it may be considered one of the first items for conversion in the legacy data handling process. However, new projects often use the unique technologies of equipment and different suppliers. Therefore, a critical evaluation of the existing library and tools for creating a new equipment library is beneficial before deciding on a conversion project. In the case of such a conversion, a library containing geometrical volume definition and attributes is converted and stored as a library in the target system.

Conversion of piping parts and specifications or catalogs

CADMATIC has an inbuilt tool for converting piping specifications from various systems and formats to facilitate data exchange between CAD systems and material management applications. It requires fine-tuning and setup for every set of systems in conversion projects. It provides a foundation for 3D model conversions by referencing piping components and parts in the library.



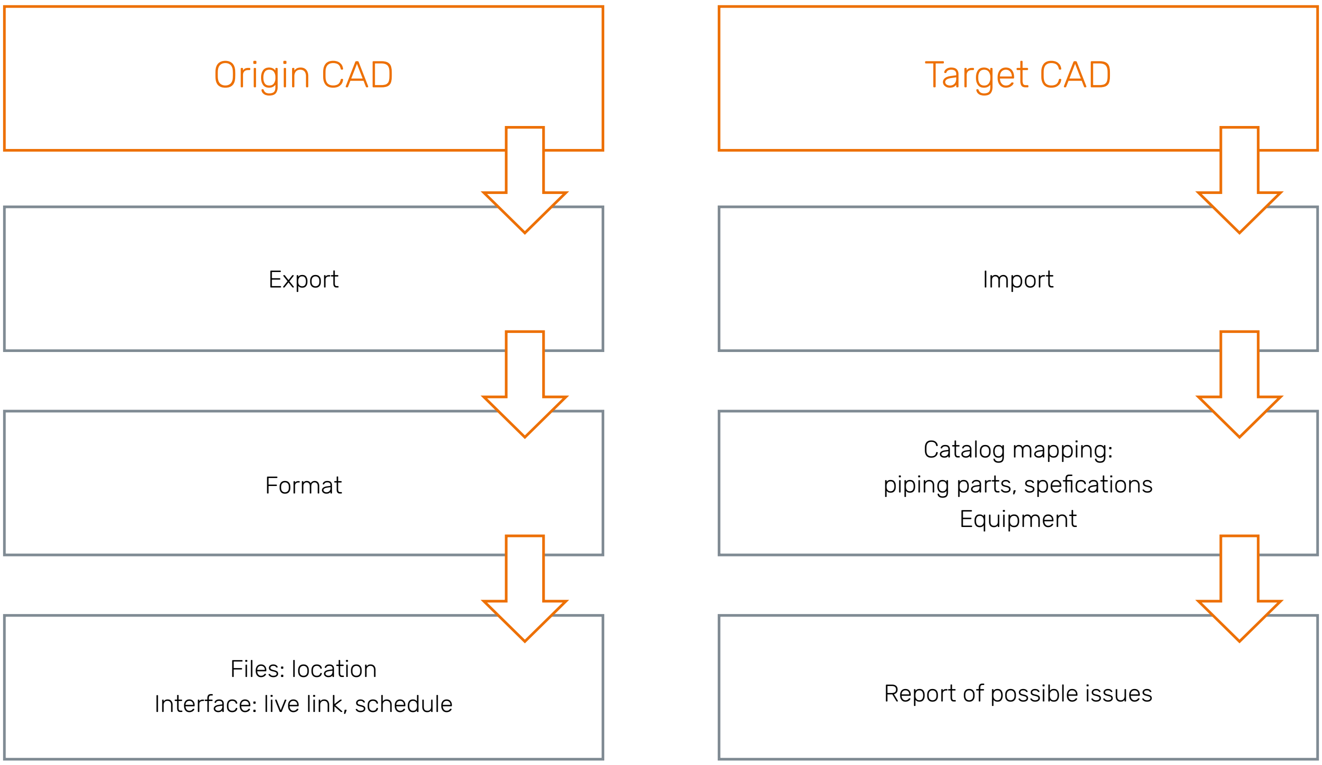
An example of the conversion of a shape in Tribon (left) format to equipment in the CADMATIC library (right).

Conversion of 3D CAD models

The conversion of the 3D CAD model starts with the previous step of converting the equipment library (or a required part), and then continues to the piping catalog, and specifications and intends to convert native 3D objects between the CAD systems. Realized projects to date include native data transfer and conversion to CADMATIC from the following systems: Aveva Marine Outfitting, PDMS, Tribon, NAPA, and Nestix.

While the original CAD system needs to provide only export with the selected format and location, the target system has significantly more complexity to handle the conversion of the data. A middleware integrator often needs to be involved as proprietary CAD databases are highly specialized and their structures are often not shared between major market players in shipbuilding.

CAD conversion process between origin CAD and target CAD system, primary considerations:



Concurrent design in a multi-CAD environment

The case of concurrent design emphasizes the simultaneous design process in different CAD systems and the use of native editable models in both systems simultaneously. It is different from the import/export scenario. The intention is to have an automated process of CAD data transfer between the systems during a significant part of the design process.

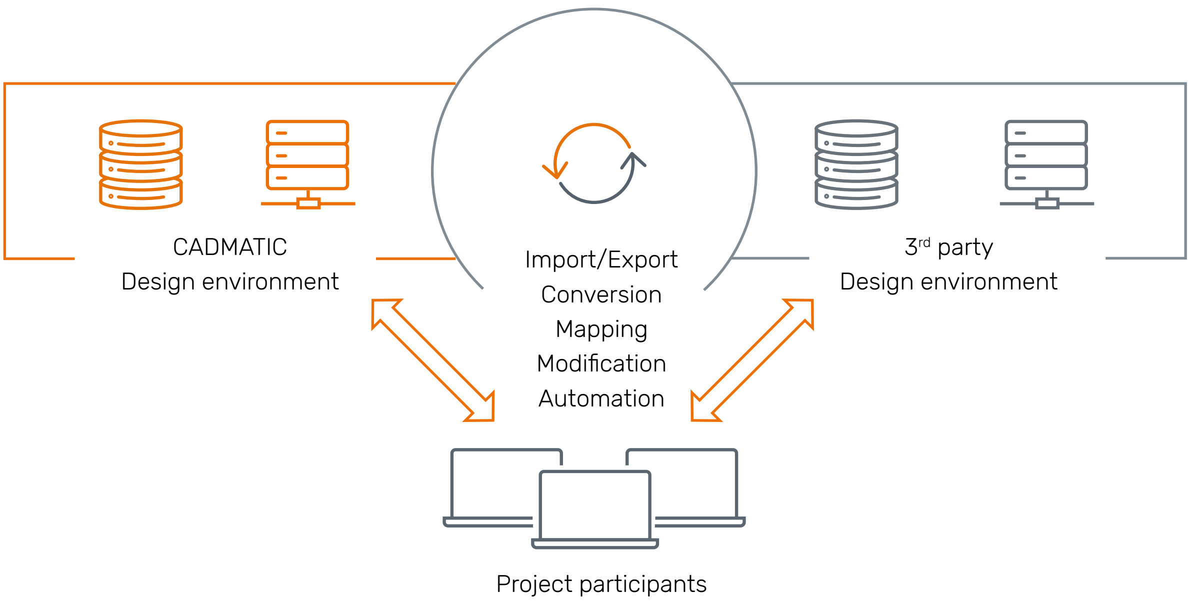
Use case: Parallel design in two or more CAD systems, with bi-directional automated export-conversion-import and use of native editable data in each system.

Considerations: This is the most complex scenario for shipbuilding software, and it should preferably be avoided due to the high complexity and administration and infra-structure support costs of the overall solution. Clarifying the intended workflow is essential to set up the digital thread in this scenario. Some of the questions to address are:

- Should both systems have an overall consolidated model?
- What is the most suitable intermediate format?
- What is the optimal synchronization interval, and how many sites will be incorporated in the design network?

Solution: Usually, middleware integration and a conversion layer are necessary to facilitate the pro-cess. Depending on the intended workflow, setting up scheduled exports and imports might be possible and using a shared location for data transfer. While exporting, mapping, converting, and importing data represent a straightforward workflow, an additional business logic might be applied by the middleware. The IT infrastructure would be governed by business needs, while users have the advantage of focusing on creating and using data.

Below is an example of the architecture in a concurrent design scenario between CADMATIC Design applications and third-party design applications:



Use of laser-scanned data in CADMATIC

Laser scanners can capture as-is situations of physical assets to digitize them. Laser scans can facilitate retrofit projects by eliminating the need for trips on board, help identity inconsistencies between design and construction, and provide a digital model when the original design model is unavailable.

Use case: Import point clouds from laser scans, recognize and convert shapes into native objects, use parts of projects from point clouds to consolidate the design model.

Considerations: Raw data from laser scanners might need to be processed in software recommended by laser scanner producers and converted to a suitable format before use. The intended use of the point cloud defines whether it needs to be imported in design applications for reference, converted into 3D model objects, or whether it suffices to have it in an eBrowser or eShare review environment.

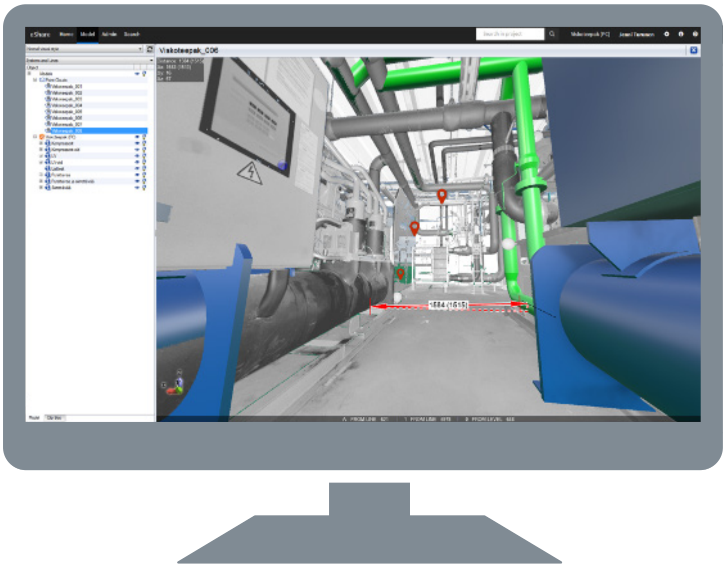
Solution: Importing point clouds in the design application provides a consolidated model approach where users can manipulate and refer to native 3D objects in the model, point clouds, and use point cloud data for remodeling. Review point cloud data can be added to the project model in project review tools: eBrowser or eShare, which can be enriched with markups, dimensions, links to additional data, and more. The performance is automatically optimized for the user by switching between the scanner views and converting point cloud to 3D photo images as needed during navigation. The supported formats are text-based formats: .ASC, .PTS, .XYZ, .PTX and binary formats: E57, CPD, CPE, PTX, CPX.

Third-party applications can extract pipes and steel geometry shapes from point clouds. In CADMATIC, point cloud-based pipes can be converted into intelligent CADMATIC models with the Piping Component Files (.PCF) import, and steel parts can be imported. Other types of model objects such as equipment can be obtained using the STEP model import of Component Modeller or CADMATIC eXchangers.

FURTHER READING:

» Importing PCF
Importing Piping Component File (.pcf), a text file that contains component and routing information

» Working with other CAD systems
Different methods for data exchange



An example of using a point cloud as a reference and for dimensioning in CADMATIC eShare

Integration with PDM/PLM/ERP systems

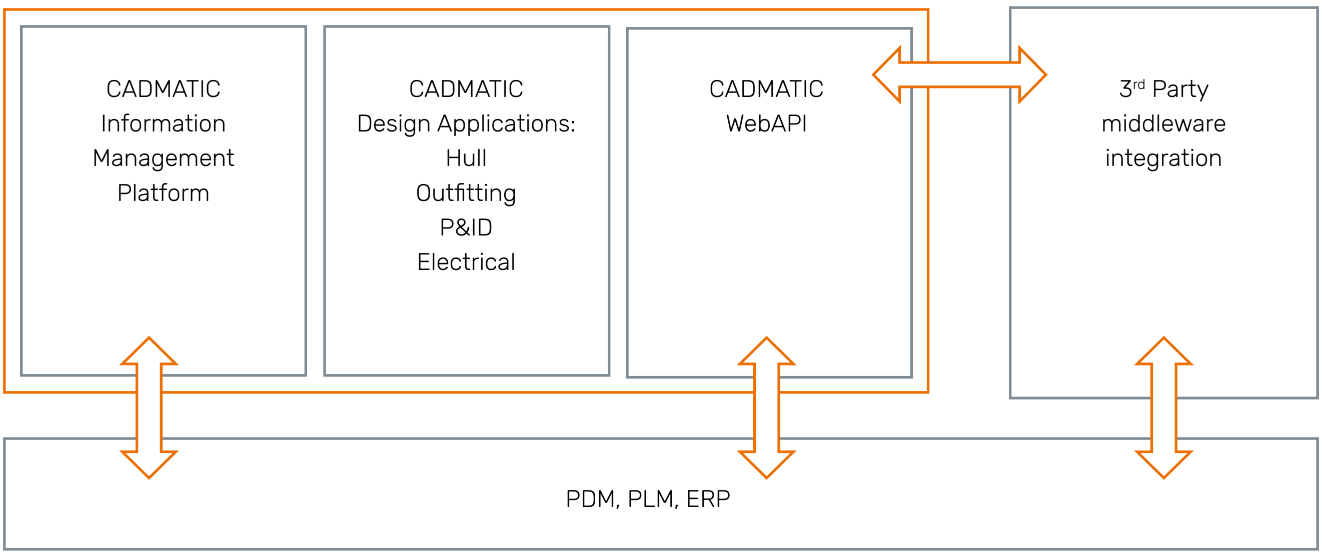
External data management systems, such as PDM/PLM or ERP solutions for shipbuilding-specific digital environments require extensive data transfer to and from the CAD system. The integration is always tailor-made for specific business processes and operations and integrates a specified system and scope of use cases.

Use case: Integration for CAD and PDM/PLM/ERP solution for company-wide project management - requirement and variant management, change management, project scheduling, eBOM/mBOM/xBOM, and other use cases.

Considerations: While most primary use cases are similar, the integration will always require customization and setup. The integration is not an out-of-the-box product. CAD+PDM integration requires the mapping of the desired business process logic reflected in software solution workflows. The shipbuilding-specific process is distinctively different from other industries. It covers the full scope of shipyard activities. The significant size of 3D models, the large number of people with various functions involved, complex procurement process, and production design all need to be considered to ensure the designed project can be built in a particular shipyard with its specific infrastructure.

Solution: CADMATIC provides the needed flexibility and expertise in shipbuilding to identify business processes and implement them in a CAD+PDM workflow. CADMATIC currently offers many PDM functionalities as part of its CADMATIC Information Management solutions and supports "best-in-class" scenarios of direct or third-party integrations with the CADMATIC WebAPI.

The figure below depicts the interfacing of CADMATIC applications with PDM/PLM/ERP systems, using the CADMATIC Information Management platform to consolidate and access information. The WebAPI is used for direct integration or third-party middleware to facilitate additional business logic.



The use of CAD data in AR/VR/MR/XR or image rendering software

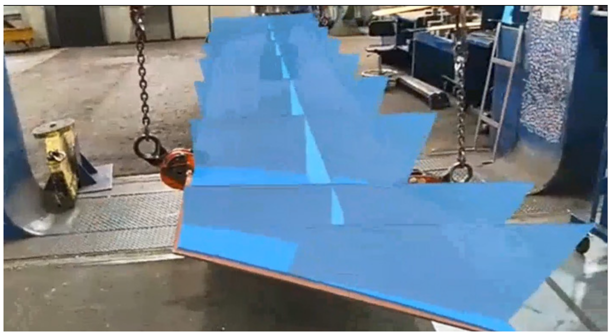
The metaverse paradigm and new technologies in 3D data handling often imply the use of AR/VR/MR/XR hardware equipment and the provision of a completely new user experience for design and review in CAD environments.

Use case: Transfer the 3D model to an AR/VR compatible format and use with wearable devices for virtual review or as a hologram augmented with the physical surroundings or exiting parts of the project.

Considerations: There are hardware limitations for the memory of wearable devices that prevent complete model loading. The maturing technology will unlock numerous possibilities for VR, such as design outside of the screen boundaries or AR with digital assets residing in their natural surroundings. It is the most fluid area of development where a new way of working with design data can be expected in the future.

Solution: CADMATIC Outfitting inspection view offers an inbuilt interface to VR that doesn't require data transfer or conversion. It allows users to view the 3D design data in VR, check object meta-data, or measure distances. The HoloLens AR interface in eBrowser or eShare provides hologram rendering and alignment with physical objects.

An example of a VR view in the eBrowser project review tool.



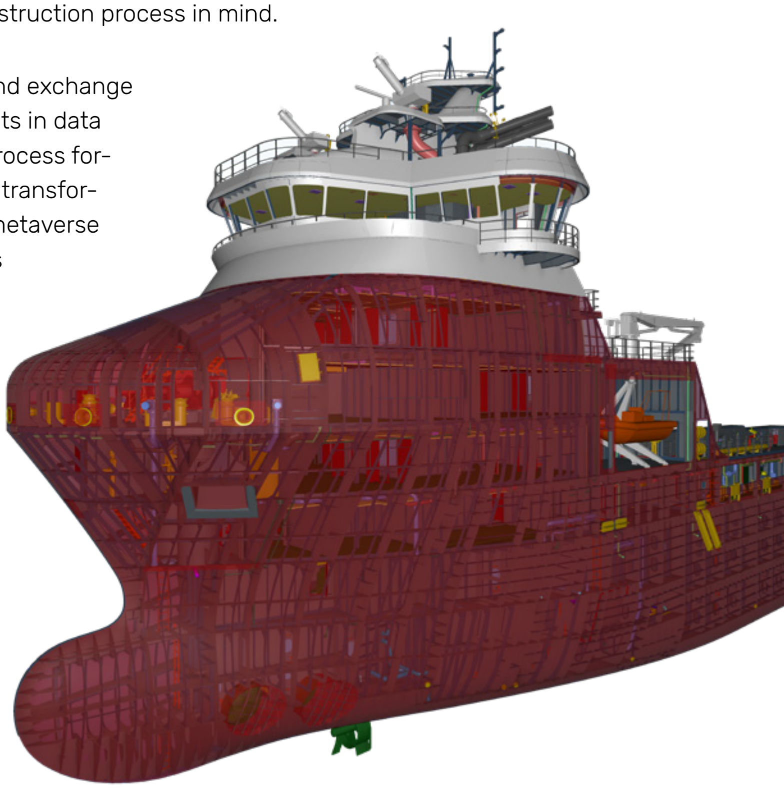
HoloLens view of a 3D shell plate design model aligned with the production plate.

Conclusions

The scenarios presented in this paper refer to the CADMATIC approach to the data-driven shipbuilding process. They were presented based on experience accumulated at CADMATIC and primarily referred to projects where we solved the needs of our customers.

While data formats and conversion technologies evolve, several tested approaches can help in data migration scenarios. The practical goals of data usage should not be obscured by complex data handling methodology or format compatibility. At present, there is no universal data exchange format in the shipbuilding industry. One must always keep the complexity of linking design data with the production and construction process in mind.

The emergence of new methodologies and exchange formats and the continuous improvements in data handling capacity will keep driving this process forward. Open discussions about the digital transformation, facilitation of digital treads and metaverse applications merged with practical needs of industry are a continuous effort at CADMATIC.



About the author

Ludmila Seppälä holds an M.Sc. in Shipbuilding and Ocean Engineering from St. Petersburg Marine Technical University as well as an MBA from the Turku University of Applied Sciences. She has over 20 years' experience in the marine and CAD software fields with a strong know-how in digital transformation and data-driven shipbuilding.

Seppälä is a shipbuilding and software solutions field professional with extensive experience in software implementation and project management. She has also traveled to over 1/3 of the world to meet with shipbuilders and CAD users. Her previous experience includes marine engineering, basic, detailed, and production outfitting design, project management, international business development, and marketing.

She currently holds the position of Director, Business Development, Marine Industry at CADMATIC in Turku, Finland.

CADMATIC

CADMATIC is a leading 3D design and information management solution developer and supplier for the marine, process, energy and construction industries.

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