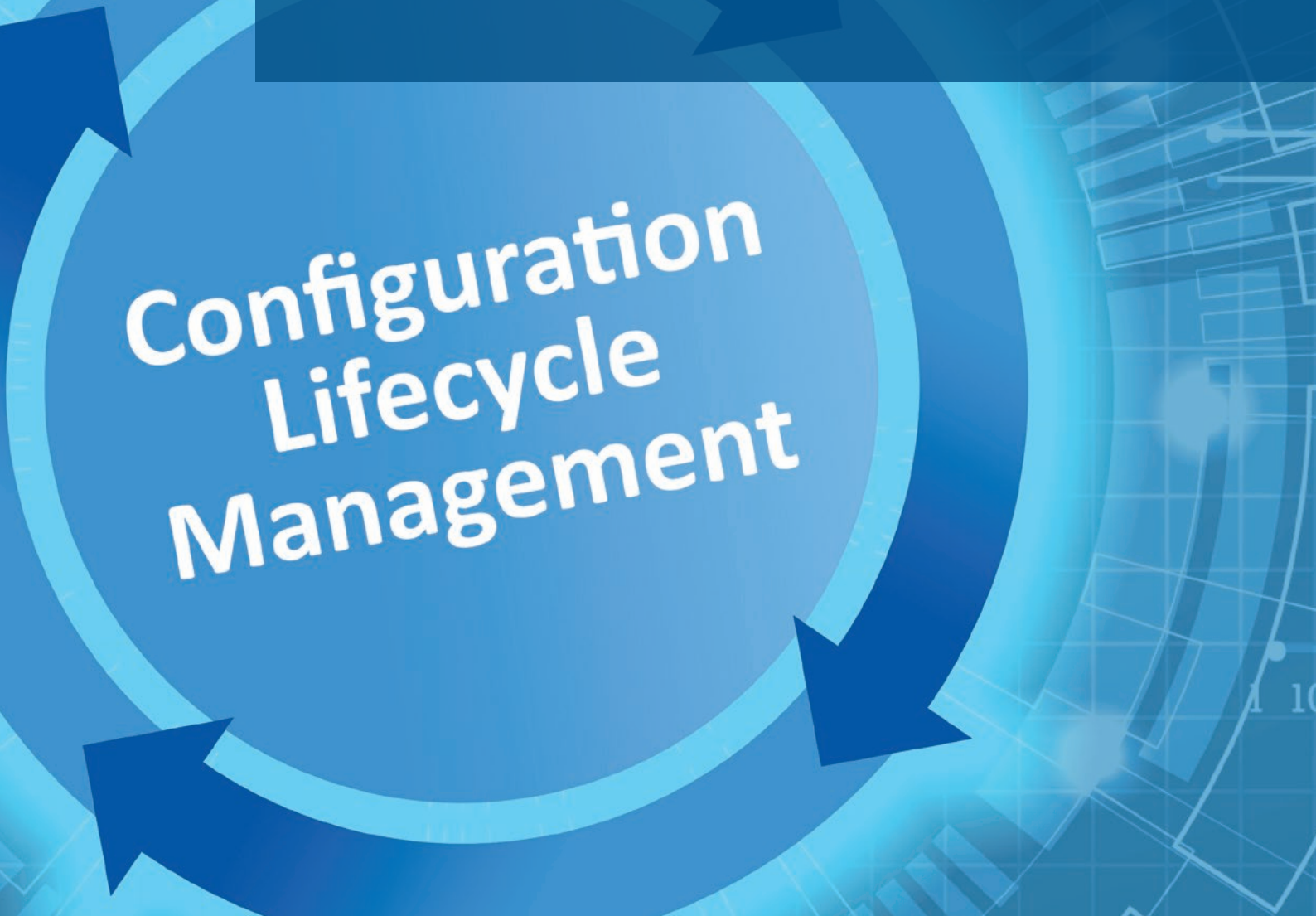
PROSTEP
integrate the future

WHITEPAPER

CONFIGURATION LIFECYCLE MANAGEMENT SOLUTION FOR **DEVELOPING AND OPERATING SMART PRODUCTS**

On the trail of product lifecycle processes



Content

Management summary

The increasing digitalization of products and services, the volatility and uncertainty of today's business environment, the need for more product and service diversification (until lot size one), the growing social and ecological demand for sustainability, and, last but not least, the ever-present requirements related to shortening innovation cycles and meeting international and market-specific regulations are among the key drivers for today's companies in a wide range of different industries. The resulting challenges in terms of an early assessment of service innovation, the mastering of the increasing complexity in product development, the tighter integration and flexibilization of the value chain, the smarter standardization of processes and products, and the realization of an end-to-end traceability of deliverables and product configurations are forcing a growing number of companies to adopt a functioning, flexible and open approach to Configuration Lifecycle Management (CLM). This type of approach helps make better decisions due to better transparency and even predictability, reduce innovation costs and compliance risks, increase operational efficiency, and competitiveness. The beneficiaries are numerous roles and functions in and outside a company – from system engineers to project, configuration, and quality managers through to service technicians and ultimately partners and customers. They all notice measurable time savings as they work because they can leverage the value of accurate and enriched data relevant to their tasks at any time and are thus more efficient and effective. Equally important from a company's perspective are aspects such as minimizing the risk of compliance violations. As the case involving the diesel scandal demonstrated, companies from different industries must assume that, in the future, the burden of proof can be reversed. They will not be able to shoulder this burden without an adequate CLM solution in place. A company's investment in this type of solution should be regarded as a kind of „life insurance policy", which also paves the way to successful digitalization.

This white paper illustrates the need for such a CLM solution, introduces basic terms and concepts, analyzes major challenges relating to implementation and, finally, puts forward an approach of its own.

Configuration lifecycle management has become a MUST

Configuration lifecycle management (CLM) is not new to companies. It is indispensable when it comes to meeting strict requirements regarding traceability and configuration management during the development of safety-critical systems and products. Relevant standards and maturity models require manufacturers to document and trace the steps and results (deliverables) involved in the development of systems, from the specification of customer requirements to verification and validation. Furthermore, digitalization, servitization and continuous innovation make it necessary to think CLM as a company and product lifecycle wide approach.

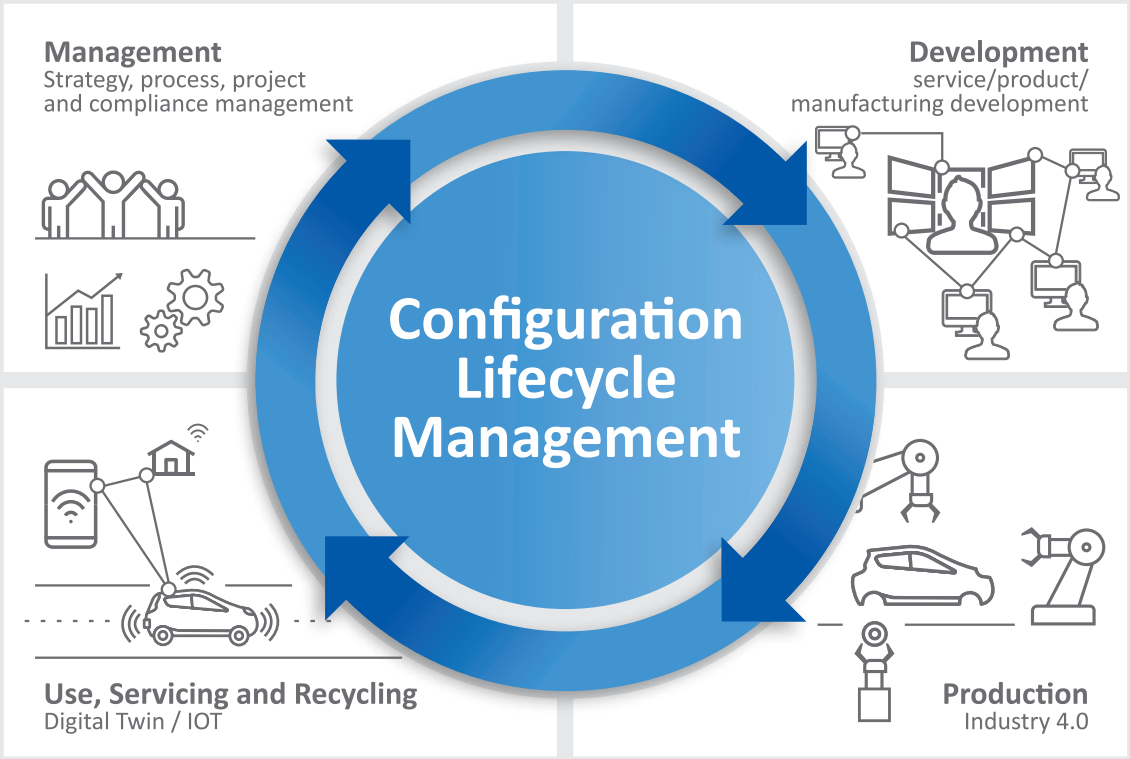


Figure 1: Configuration Lifecycle Management throughout the entire lifecycle of systems / products

In context of the development of complex systems, CLM plays a major role, particularly, integrating process, project, task, maturity, configuration, change and release management. If they do not know the status of the development steps and the maturity of and dependencies between deliverables, the roles involved in development (e.g., project manager, product manager and product developer) often have to spend a great deal of time and effort on coordination or laborious fact-finding before they can make informed statements about the progress of a project and the maturity of the product, assess the impact of changes and implement changes efficiently. The transparency and even predictability improvement through an accurate CLM solution help making better decision, increasing operational efficiency and competitiveness, and reducing costs as well as compliance risks. Software engineering studies, for example, show that developers do their jobs 24 percent faster and 50 percent more correctly with CLM support.

When applied throughout the entire lifecycle, a CLM solution contributes to continuous product, service, process improvement and innovation by tracing all the lifecycle data (e.g. customer requirements, design assumptions, manufacturing signature, operating conditions, defects, customer feedback, etc.) and supporting advanced analytics to provide valuable insights and so generate new knowledge.

Companies have long regarded ensuring CLM as tiresome obligations. Today, among others due to the volatility, fast changing business environments and, even not to be neglected, the impact of COVID, many manufacturers are introducing cost saving and operational efficiency improvement measures. Since costs are determined to a large degree in the early stages of the product life cycle, CLM means that the product condition but also the costs can be tracked and readjusted earlier and easier. Therefore, an integrative solution that firmly anchors CLM in the entire company strategy and overall product lifecycle management processes is required. Key characteristics for this type of integrative solution are resilience, openness, and IT system independence. It must function reliably in heterogeneous process and IT system landscapes, even if the processes and IT systems in the individual domains involved change, which is likely to happen more often in the future.

Fundamentals and challenges posed by CLM in product development

CLM aims at the management of product configurations including all related traceability information. Traceability and configuration management are therefore the foundation for CLM.

Configuration management is a management activity that applies technical and administrative direction over the life cycle of a product and service, its configuration identification and status, and related product and service configuration information [ISO 10007]. Traceability on the other hand is the ability to link with each other specific configuration of system data or product development deliverables, such as system requirements, system architecture, system functions, FMEA, DVP/test plans or test cases, so that their dependencies can be traced at any time.

When it comes to service innovation, thought must also be given to the support and optimization of systems in the field. Focus here is placed on verification of where a particular system comes from, how it is configured, operated, maintained (digital logbook) and even disposed. CLM is closely related to the digital master and to the digital thread. It is a prerequisite for the digital thread and all the concepts based on it, including the digital twin. While the digital master represents the overall result of product development in the context of a 150% product structure that includes all preliminary product ideas, requirements, functional data, simulation data, test results, etc., the digital twin is the digital representative of the product that is delivered and connected with the physical product. CLM is the glue that establishes and manages the relationships between the two throughout the product lifecycle in the context of the digital thread. For example, it not only makes it possible for manufacturers to gather all the data relating to operation of the delivered system and provide it to the system operator but also to establish relationships between data from the field and the system's digital master. The latter is particularly useful when searching for the causes of errors.

A uniform, end-to-end data model that provides a system-neutral description of all the relevant data flows and data objects, together with their relationships, provides the basis for traceability and configuration management in both contexts. Building on this data model, systems, and system families, including all components and variants, can be mapped in a cross-disciplinary product model that connects the partial models from the domains using a network of logical relationships. Because this product model consolidates all the product-relevant information, configuration management can be used, for example, to generate specific views and/or document the period for which they are valid and their levels of maturity (baselines).

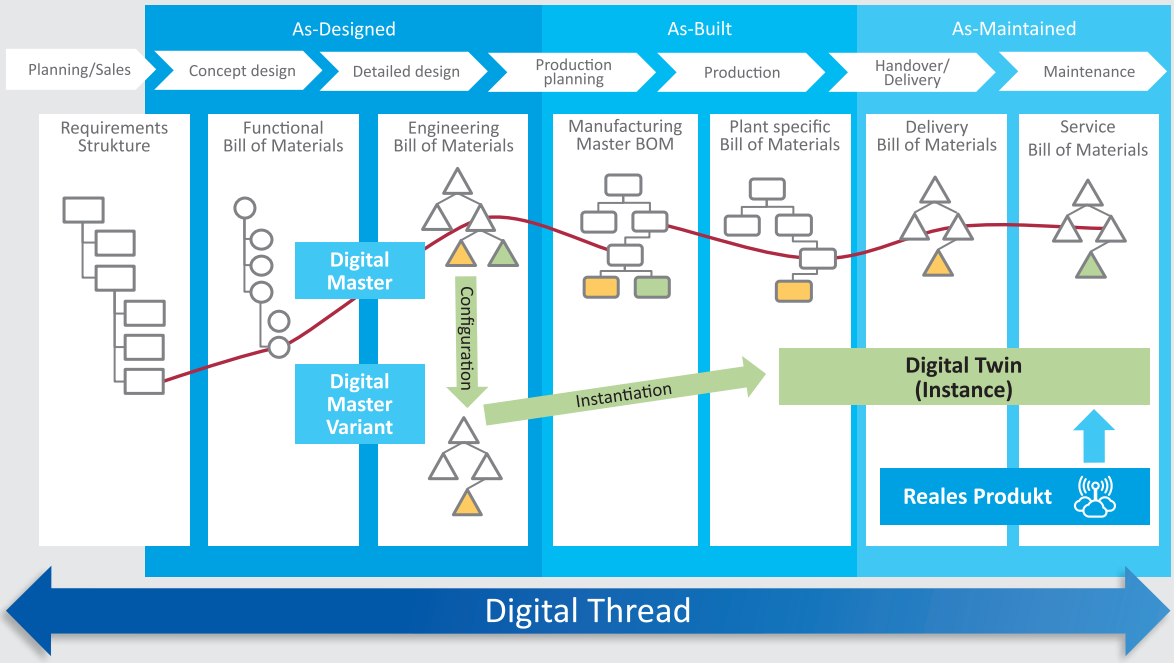


Figure 2: Configuration Lifefycle Management enables the digital thread

Today, the configuration and consistency of data flows are made more difficult by the heterogeneous IT system landscapes in companies and the growing flood of digital data that are created during product development and product usage. The disciplines and domains involved create their development deliverables using hundreds of different IT systems and store them in separate data silos, which are often only integrated in a rudimentary form. A lot of data is still stored in Excel spreadsheets and can only be accessed by a limited number of users. Eliminating these isolated solutions is a major challenge. An even greater challenge is reducing the number of different IT systems. The technologies used for development and production are evolving dynamically, and users want to be able to replace existing IT systems in a flexible manner. At the same time, the trend towards smart products, which include increasing amounts electronics and software, means that new IT systems for MBSE, application lifecycle management (ALM) and the Internet of Things (IoT) need to be integrated or connected.

Another challenge when it comes to implementing CLM is cross-domain/cross-enterprise collaboration in globally distributed value chains. Certain data stemming from model-based system development and hardware/software development have to be exchanged and continuously synchronized between the domains. This is not easy even within a single company; it is however even more difficult when multiple companies are collaborating in an ecosystem due to a lack of standards and the need to protect intellectual property. When exchanging the digital twin that an operator uses to monitor and optimize the physical product during operation, it is also necessary to ensure that the relationships with the digital master remain unchanged.

PROSTEP approach to Configuration Lifecycle Management

With OpenCLM, PROSTEP has developed a lightweight, user-friendly and easy-to-configure and integrate web application for CLM. It eases the management of complex system development projects and allows to link data and documents from different source IT systems instead of replicating them in their entirety. It is a kind of meta-level whose core functions include integration in process and project management, the planning of the deliverables for milestones (tasks), the integration of IT systems for the domains, the generation and management of trace links and configurations, the data-driven maturity assessment, the coordination of cross-domain changes, and the synchronous and asynchronous integration of partners.

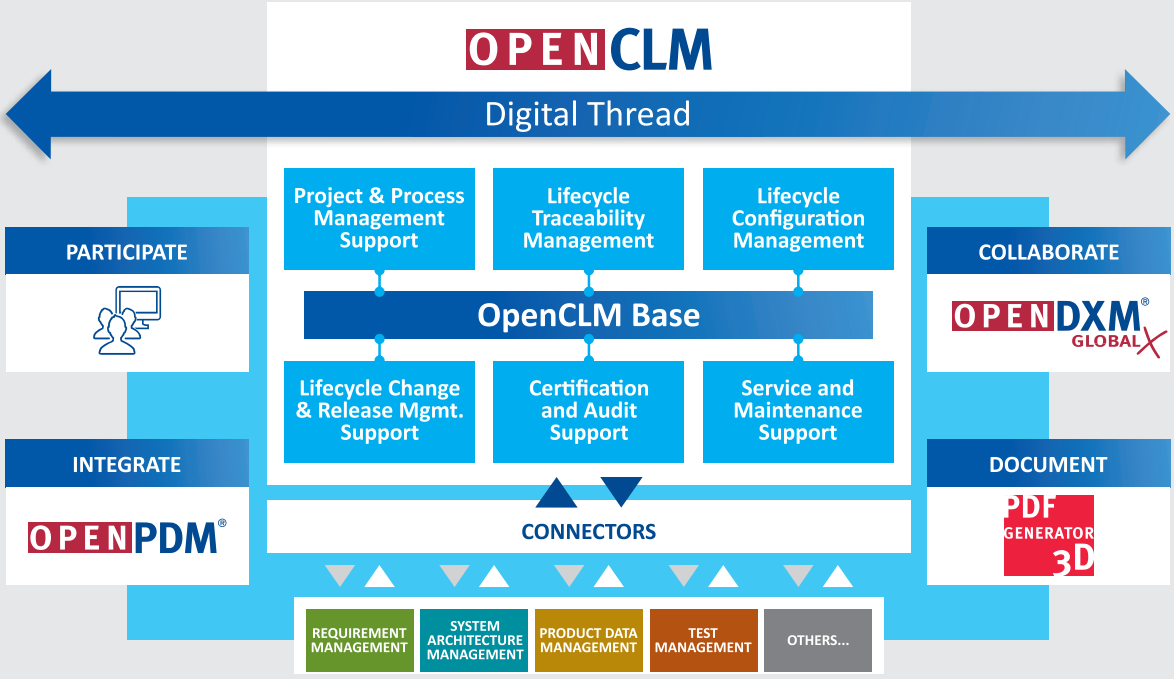


Figure 3: OpenCLM orchestrates many PROSTEP products for a holistic CLM Solution

OpenCLM used per Default OpenPDM, which is used to integrate not only all leading TDM, PDM/PLM and ERP systems but also simulation data management systems, ALM systems and other enterprise applications via product-specific connectors or standards such as OSLC. OpenCLM can also be implemented on top of other ESB Technologies. From the source systems, OpenCLM transfers only the metadata and attributes belonging to the linked data objects that are required to define and manage cross-domain configuration management and trace links between them. What is crucial here is that the trace links between the data objects are mapped independently of the IT systems used. This allows them to remain unchanged even if one of the source IT systems are replaced.

While other linking concepts aim to automatically establish semantic references between the data at database level with the aid of intelligent search algorithms, PROSTEP focuses on targeted linking of the original data based on the concrete process requirements while considering their status information in the respective source systems. This has, among other things, the advantage that the linked data can not only be displayed but also edited directly if necessary, provided that the user has appropriate authorization in the source IT system.

The creation of a consistent data model in OpenCLM provides the basis for integrating the domains and their source IT systems. OpenCLM comes with a library of predefined data objects. They serve as placeholders for the deliverables typically generated during product development process, which are also referred to as “configuration items” (CI). This data model maps the most important industry-specific standards and maturity models.

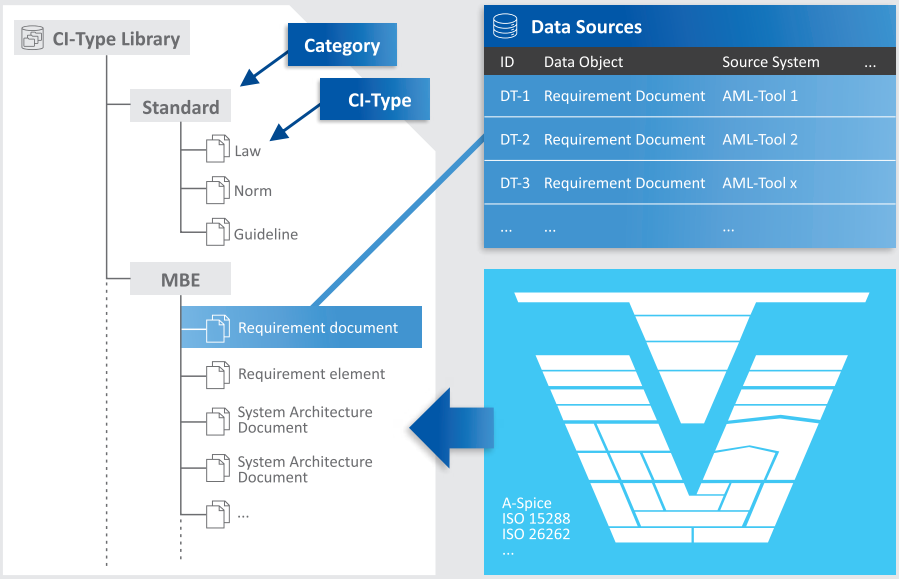


Figure 4: Standards-compliant data model as the foundation in OpenCLM

In addition to these predefined data objects, there are also predefined link types with permissible start and end data objects for meeting traceability requirements. Data objects and link types can be extended and configured to meet company specific needs.

Once the data model has been established, process and project templates can be created and managed. A process template maps a business process that has been defined according to the Stage Gate Model and is made up of milestone and phase definitions. Each phase involves tasks, which in turn are linked to data objects from the data model to establish a link between the tasks in the individual domains and the deliverables to be provided. Milestone definitions include a list (CI list) of the data objects or CIs that must be verified when the respective milestone is achieved.

Another element in OpenCLM, which complements the process template, is the project template. Project templates are the link between project and process management. They can reference one or more process templates and can include additional milestones and tasks for a project. This makes it possible to instantiate and edit a process template independently. If a project reference is required, the project template can be linked to one or more processes. This allows all the changes belonging to a development project to be linked to the project. The same applies to the integration of all the sub-development steps in a development project that are carried out in parallel, e.g., for components or sub-systems that are developed internally or externally.

When defining process and project templates, existing task management solutions such as Jira or IBM RTC (Rational Team Concert) can be connected to OpenCLM and the tasks in OpenCLM can be linked to those in other applications, or project plans from existing project management solutions can be included when project templates are defined.

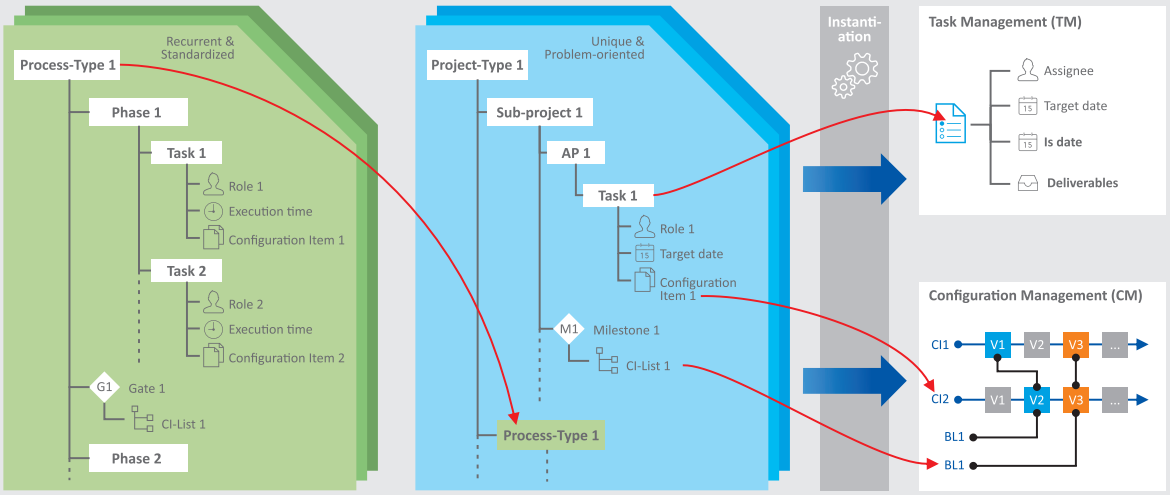


Figure 5: Templates for projects and processes in OpenCLM

Once the data model and process/project templates have been defined, the actual operational work with OpenCLM can begin. First, the generic process or project templates have to be instantiated. Tasks and milestones can then be scheduled and the deliverables to be provided can be linked manually to the data objects from the respective source systems. This is where an easy search in the linked source systems is helpful. Once the deliverables have been linked with data from the source systems, the OpenPDM connectors automatically monitor changes to the original data and display them in OpenCLM. This makes it possible to see at a glance how far a process has advanced, where there is still a need for action, and where completed deliverables are already available. Links to the referenced data objects can be used to branch directly to the source systems.

In OpenCLM, cross-domain configuration management is implemented using what are referred to as baselines. The concept of baselining comes from the software development field and makes it possible to "freeze" a given development status that can be rolled back to if necessary. The basis for creating a baseline is the existence of a list of deliverables (also referred to here as a CI list) with data from the source systems that has been linked accordingly. CI lists of this kind have usually already been linked to milestones, and additional milestones can be created as needed. A baseline corresponds to a cross-section of the versions of deliverables in a CI list and thus documents a status together with its validity periods.

Trace links can be created between the deliverables or trace links that already exist in the source systems can be imported into OpenCLM. These trace links are also part of the baselines. Baselines can be serialized and exported, exchanged, or archived in various standardized formats (3D PDF, STEP, etc.) to provide support for verification, asynchronous collaboration with suppliers, or for any collaboration-related purpose.

Not only configuration management but also the coordination of distributed, cross-domain changes is an important core function of OpenCLM. An existing baseline in OpenCLM can serve as the starting point for a distributed change process. This type of change process is characterized by the fact that it can trigger subordinate domain-specific change processes in the connected source systems, or, if these already exist, it can be linked to them to form an overarching change context. If the change process refers to a baseline, OpenCLM provides optimal support for impact analysis and definition of the scope of the change. Much like deliverables, the OpenPDM connectors take over synchronization of the information in the source systems with the linked, domain-specific change objects in OpenCLM.

OpenCLM displays the linked data objects with metadata such as status, change date, owner, etc. in a clear and concise cockpit, so that they can be compared with other data statuses. The cockpit makes it possible to navigate the network of data objects and their relationships and to search for and filter the information based on certain criteria. Predefined templates for specific views or reports are used to automatically merge and visualize the information needed for a specific context. This could, for example, be an overview of all the tasks and deliverables belonging to a certain milestone or an Automotive SPICE-compliant report for an upcoming audit.

Benefits: Primarily supported use-cases

Managing complex, distributed development contexts

The challenge when planning and structuring complex and often distributed development projects is, on the one hand, breaking down the overall system into its individual parts (sub-systems, modules, and components) and, on the other hand, creating an overarching context for (internal and external) collaboration, traceability and configuration management. To do this, OpenCLM makes it possible to create a higher-level development project context for the overall system, which can then be extended to include additional subproject contexts for the individual system components. This can also be done by instantiating project templates previously defined based on best practices. Each project or subproject context can include one or more instances of process templates (e.g., PEP templates that include gateway systems or ECM templates for ongoing changes). This allows decentralized data spaces to be integrated to create an overarching data space for the overall system that can be used for both domain-specific and cross-domain traceability and CLM. This provides the basis for making complex projects manageable, even if individual sub-projects are distributed across different organizations.

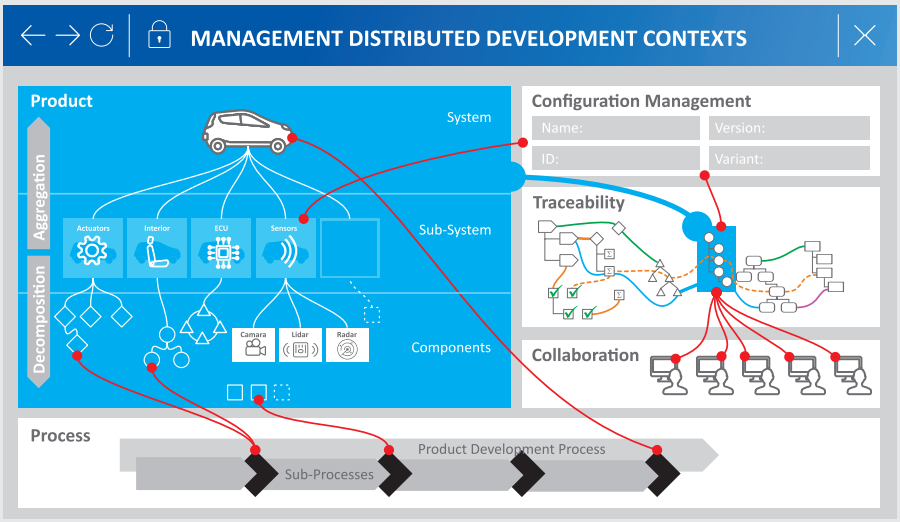


Figure 6: Managing complex, distributed development projects in OpenCLM

Project status monitoring and reporting

With regards to IT, project management in many companies is isolated from task management in the various domains and from deliverables that are being or have been created. Establishing a connection between project management and the process deliverables enables project managers and team members to monitor the project status and work progress across the domains.

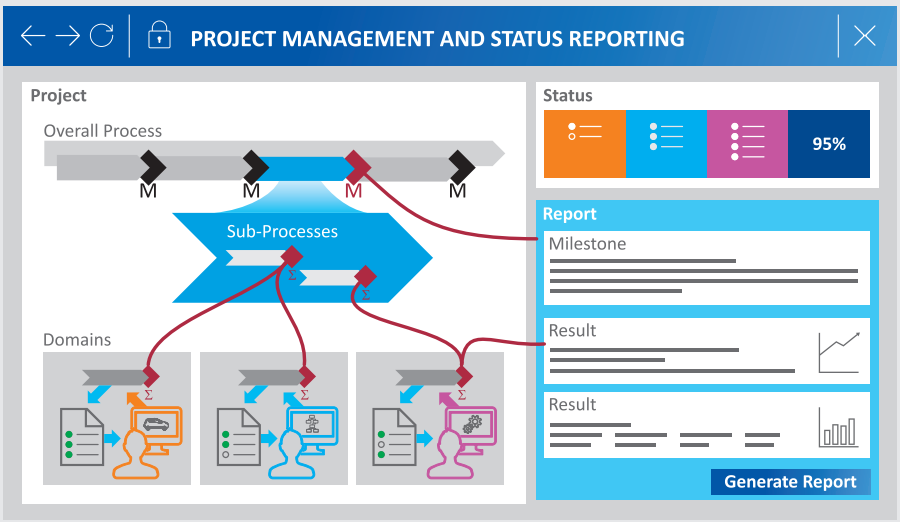


Figure 7: Managing projects and status reporting in OpenCLM

Trace links can be used to automatically identify open issues and deliverables that are still missing. In addition, project managers receive visual feedback on problems encountered, e.g., if a simulation task was carried using an obsolete model status. Traceability, which is anchored in the process from the very beginning, reduces the effort required for reporting the status of milestones and makes it possible to respond promptly to deviations from the project plan, which in turn significantly improves adherence to project deadlines.

Cross-domain change and release management (incl. Impact analysis)

Systems and the associated deliverables (requirements, materials, etc.) change during development and even during operation. When the need for a change arises, companies need to understand which deliverables are involved to assess the impact of the change on costs, delivery times, etc. The cross-system linking of development data with the help of traceability ensures that all data affected by a change can be identified at the click of a button and that the persons responsible in the respective domains are involved in the impact analysis. This makes it possible for companies to respond to changes faster and more efficiently.

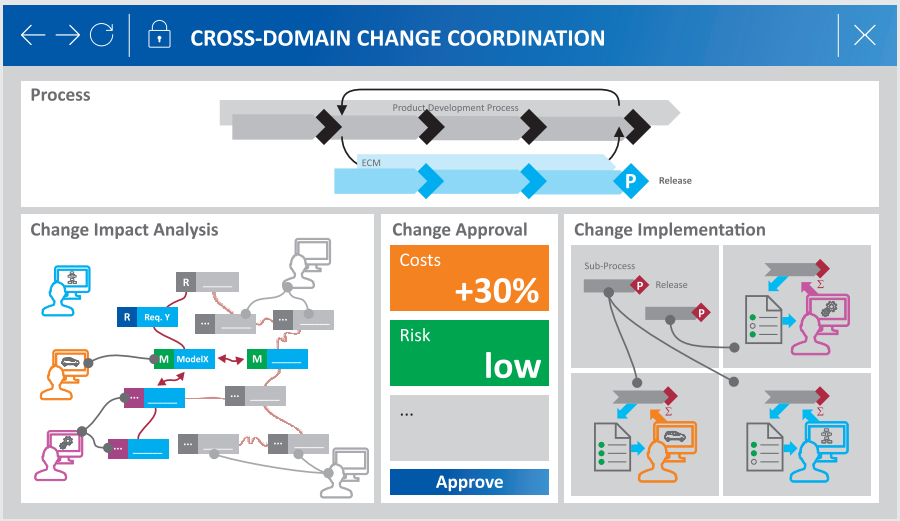


Figure 8: Coordinating cross-domain changes in OpenCLM

Alongside mechanical components, smart products include an increasing number of electronic and software components that are related to each other. If an electronic component is replaced, the software usually also must be adapted or at least tested again; changes to the housing may also be necessary. Traceability and configuration management make the dependencies between the mechanical, electrical/electronic and software components in the products transparent and are therefore essential prerequisites for the cross-domain coordination of change processes. They also ensure cross-system coordination of release processes, so that, for example, production release for a component in the ERP system cannot take place until the corresponding request has also been approved. Cross-domain change and release management helps reduce the cost of errors in development and production.

Support for certification / audits

The traceability of the development steps and deliverables is mandatory for the certification of safety-critical systems. Regular audits are used to check whether requirements regarding traceability are being met. Manufacturers of safety-critical control systems must, for example, prove which legal regulations applied in the respective country at the time of delivery, which simulations, and physical tests they used to verify compliance with these requirements, which tools were used to do this, and which results did the tests lead to. Thanks to traceability, they can use a serial number or batch to work their way back through the development process, pull all this information together at the click of a button and present it to the customer or the authorities. This reduces the search effort required and saves quality and project managers an enormous amount of time.

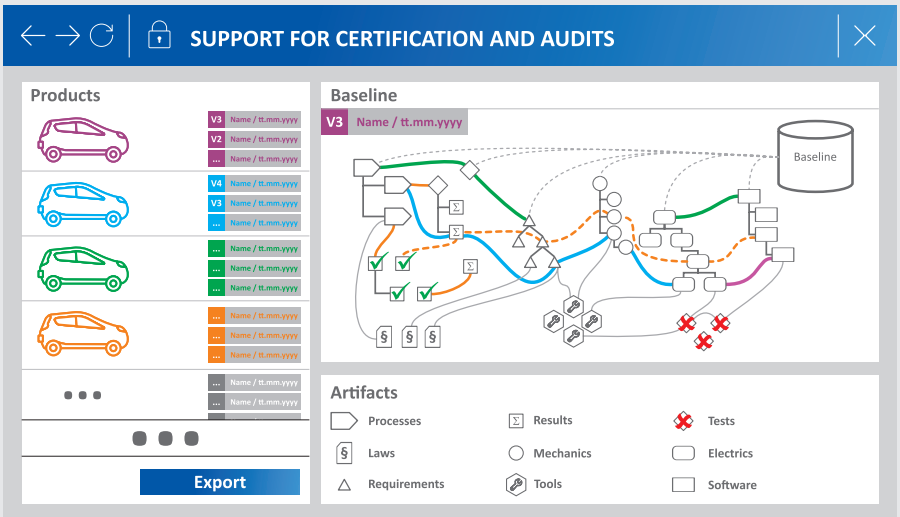


Figure 9: Supporting certification and audits in OpenCLM

Improvement of product quality / defect management

The ability to quickly correct errors and improve products during operation is a prerequisite for new service-oriented business models. If a defect occurs during operation, the people responsible need quick access to all development data required to analyze the cause of the error and to assess whether it can be eliminated by a software update or whether further measures need to be taken. They need to know, for example, which simulation models belong to the product to be able to reproduce the error with the help of a simulation. Traceability proves all domains with structured access to the digital twin of the delivered product. All the data can be made available in neutral formats such as 3D PDF and visualized independently of the authoring systems used. Linking operating and development data allows for more efficient defect management and supports the continuous improvement of products.

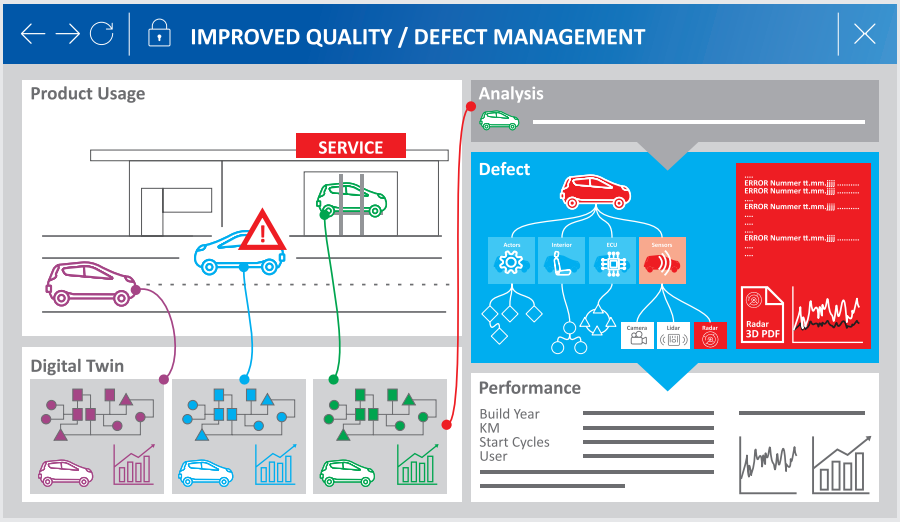


Figure 10: Improving Quality and Defect Management with OpenCLM

Replacing tools and methods in a flexible manner

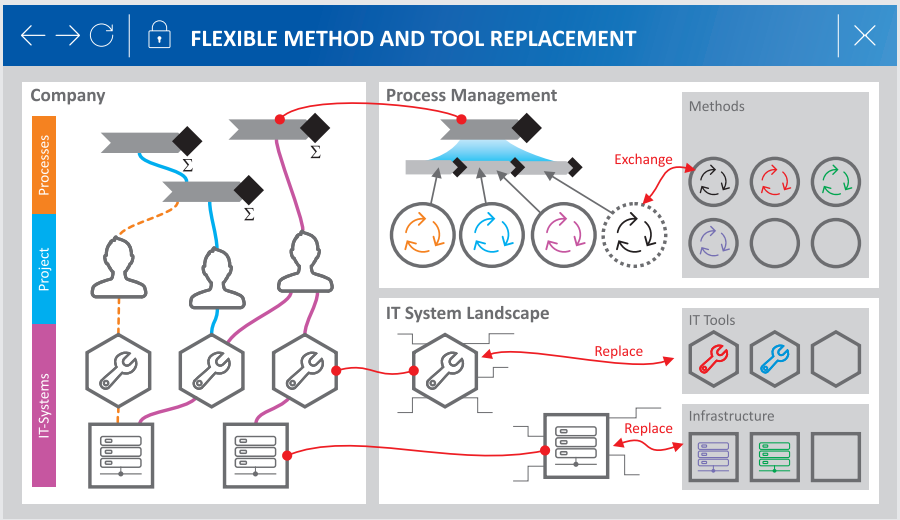


Figure 11: Implementing an open, flexible and resilient IT system architecture with OpenCLM

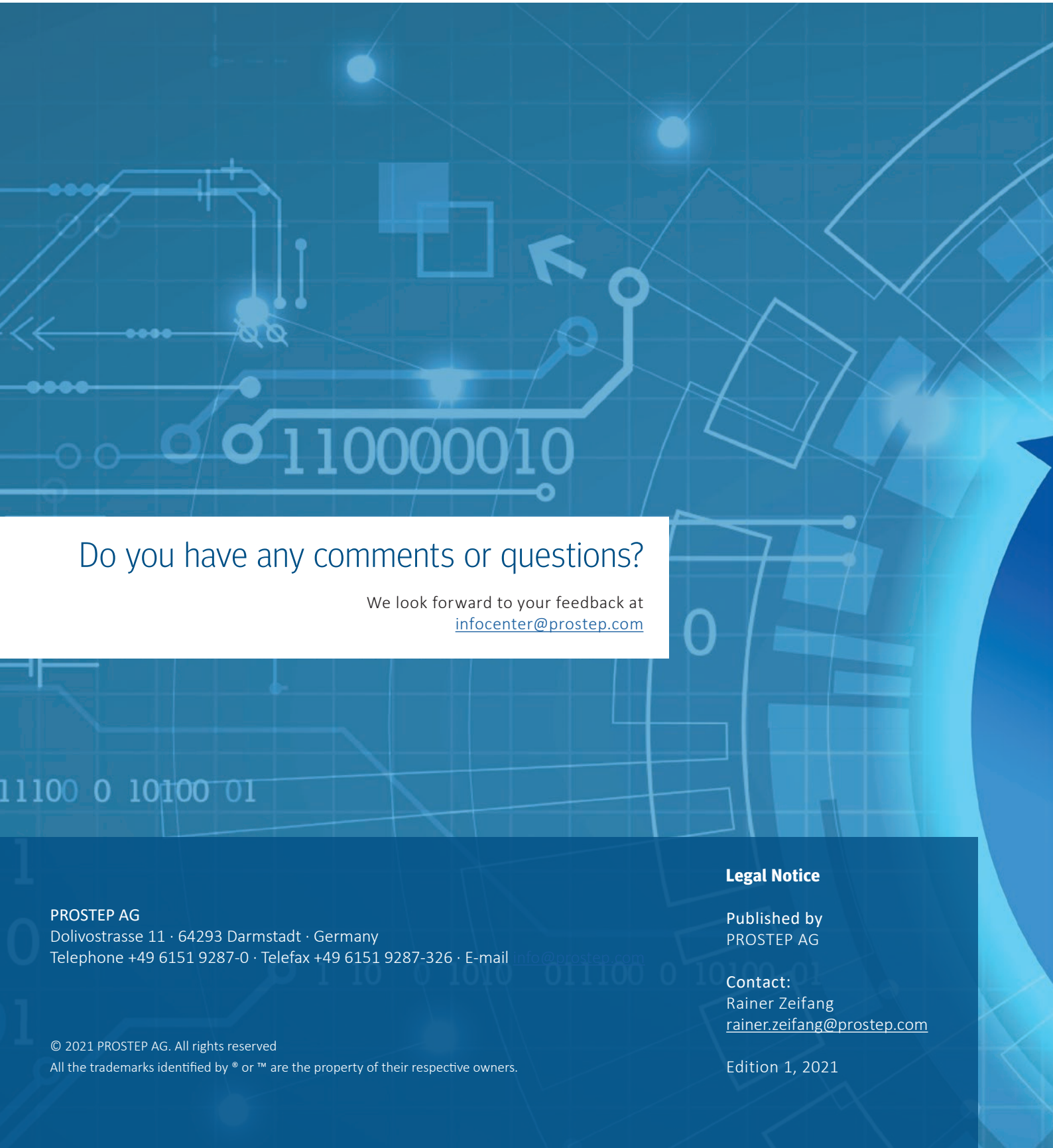
Not only the products but also the technologies used for their development are changing dynamically. Departments want to take an agile approach to integrating new tools and methods in their system landscapes and replacing existing ones without a loss of cross-domain transparency and traceability in the product development process. Mapping the relationships between the development objects and linking them via a system-neutral layer has the advantage that they remain unchanged even if individual IT systems are replaced. In OpenCLM, the deliverables that the domains need to provide and when is defined in the baselines, which ensures stable processes and minimizes the administrative overhead required to ensure traceability.

Summary

This white paper illustrates the need for a holistic approach CLM and the benefits it would bring and describes key concepts for achieving this. With OpenCLM, PROSTEP offers a flexible and user-friendly solution that firmly anchors CLM in the product development process and provides appropriate support throughout all phases of the product lifecycle. This not only reduces the amount of time and effort required to gather information and structure product documentation, but also improves the consistency and quality of information and increases the efficiency of core processes. OpenCLM also makes it possible for companies to be agile in their response to new requirements and to replace their tools and methods as and when required, thus allowing for additional productivity gains. For companies, investing in OpenCLM means faster innovation cycles and a shorter time-to-market, which has a positive impact on competitiveness. Equally important from a business perspective are aspects such as minimizing the risk of compliance violations in the context of traceability requirements and the ability to meet increasingly strict product liability requirements.

PDF version of the white paper:
www.prostep.com/whitepapers
or scan the QR Code

PROSTEP
integrate the future



Do you have any comments or questions?

We look forward to your feedback at
infocenter@prostep.com

PROSTEP AG
Dolivostrasse 11 · 64293 Darmstadt · Germany
Telephone +49 6151 9287-0 · Telefax +49 6151 9287-326 · E-mail info@prostep.com

Legal Notice

Published by
PROSTEP AG

Contact:
Rainer Zeifang
rainer.zeifang@prostep.com

Edition 1, 2021