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Can product modularization approaches help address challenges in technical project portfolio management? – Laying the foundations for a methodology transfer

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Abstract:
Formalized Project Portfolio Management (PPM) models struggle to provide comprehensive solutions to project selection, resource allocation and adaptability to dynamic technology project environments. In this article, we introduce a vision for a novel Modular Project Portfolio Management (MPPM) approach by drawing on well-established engineering methods for designing modular product architectures. We show how systems theory can be used to enable a transfer of methods from the area of engineering design and manufacturing to the area of PPM and how the concept of product modularity could help address challenges of existing PPM approaches. This lays the groundwork for the possible development of MPPM as a new and innovative methodology for managing complex technology and engineering project landscapes.

Keywords:
project portfolio management; technology projects; modular product architecture; systems theory; method transfer; project selection.

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1. Introduction

Technology organizations operate in highly dynamic, volatile and uncertain environments. Those environments can trigger changes to their strategy and performance, and they can affect how projects are designed and executed. In this respect, VUCA (volatility, uncertainty, complexity and ambiguity) has become a common phrase in different domains such as industry and military [1]. It can be caused by external changes (e.g. politics, market), internal changes (e.g. technologies, strategies) as well as project-specific changes (e.g. customer needs, project delays) [2, 3]. The result is a high level of project uncertainty that requires flexibility, fast-paced responses and frequent adaptations of projects and project portfolios [1].

Traditional linear and rigid project and process management approaches are increasingly struggling to sufficiently address these uncertainties and the need for frequent adaptations. This has led to the ongoing rise of agile approaches like “Scrum” or “lean start-ups”, which are “able to change, or to be changed, rapidly and cost effectively“ [4, 5]. Their step-wise and iterative process structure, including an inherent reflection and learning process, allows for continuous project evaluation and course adaptations [6]. In the context of continuous planning, more recent approaches have even looked at evolving baselines for performance estimation to overcome shortcomings of traditional rigid methods [7]. However, lean, agile or “leagile” approaches also present their own challenges for companies and have a strong focus on software projects [8]. Although they allow for the sufficient management of changes within projects, they are a challenge for overarching programs because project outcomes, timelines and progress are less deterministic compared to linear approaches.

In general, existing linear and agile program and portfolio management approaches tend to consider projects as the smallest unit and focus on the strategic selection of suitable projects [2, 3, 9]. Besides these strategic considerations, some companies use project portfolio management (PPM) on a tactical level with the aim of managing short-term resource capacity as well as project dependencies and sequences [10, 11]. Challenges of PPM include efficiency gains through standardisation of work packages within and reuseability across the project boundaries [12]. Risks to the success of project portfolios have been studied and consolidated extensively in recent literature (for example [13, 14]).

We aim to contribute to the discussion on how to address those shortcomings by exploring new contributions to the strategic and tactical dimensions of PPM, considering links between project activities, and supporting the derivation of logical project modules and the reuse of interim outcomes [8, 15].

In the field of technology and engineering management, product modularization and platform approaches could be well-placed to address these shortcomings. These approaches are well-established in fields such as the automotive industry, where they are used to structure complex systems into more manageable subsystems, modules and components [16, 17, 18, 19]. Besides having modules with defined dependencies and interfaces, this enables for standardization across platforms, which in turn allows for the cost-efficient use and re-use of components and modules [20, 21].

In the past, first attempts have been made to use the idea of modularity in order to describe projects in a conceptual way [22]. More recently, the role of project modularity has been explored in the context of information systems development [23]. Nevertheless, while product modularization theories and approaches have proven to be highly successful and transferable to other contexts [24], they have not been fully adopted in a project portfolio management context to date, despite a promising degree of similarities.

Therefore, in this article, we ask how concepts for designing flexible modular product architectures in engineering design can be transferred to the realm of PPM and if they can help address current challenges.

In the next section, we provide brief backgrounds on both the management of project landscapes and product modularization as focal fields of research. This is followed by a description of the applied conceptual research methodology to explore the feasibility of a new Modular Project Portfolio Management (MPPM) approach in section three. Then, we present the findings: In section four, we introduce a taxonomy based on systems theory to analyze the characteristics of products and projects and to derive transfer criteria for modularization methods. In section five, we develop an overview of current challenges for PPM approaches and subsequently discuss how modularization could help. For this assessment, we introduce an established product modularization methodology, called METUS, as an example. In section six, we conclude with a discussion of our findings and their significance and outline potential next steps and considerations for the development of an MPPM methodology.

2. Background

2.1 Strategic and tactical PPM

In organizational planning and management, PPM is defined as “the management of a multi-project organization and its projects in a manner that enables the linking of the projects to business objectives” [25]. Program management refers to “the integration and management of a group of related projects with the intent of achieving benefits that would not be realized if they were managed independently”. In contrast, PPM – on a more aggregated level – does not only include related projects, but also deals with the challenges of achieving strategic advantage by coordinating and aligning several projects that draw from the same resources [26]. Therefore, program management focusses on “doing projects right”, while project portfolio management focusses on “doing the right projects” [27]. Different key elements are [27]:

- Interdependencies: the identification and reduction of competition for resources among projects (also [28]);
- Prioritization, alignment and selection: the composition of a project portfolio, its scope and importance in line with business strategic goals (also [29]); and
- Dynamic re-assessment of the portfolio: the possibility to abandon projects after initiation (also [30]).

In recent years, many efforts have been made to formalize programs and portfolios by generating standards, frameworks, formal evaluation criteria and guidelines [31]. Integration of methods into technology and product development have shown to be able to align business and technology innovation goals [32]. However, formalized models are still struggling to provide comprehensive solutions for project selection, resource allocation and dealing with dynamic project environments [33]. In this context, coaction and dynamics are key complexity drivers in the configuration of projects.

Besides the focus of strategic PPM on aligning projects with the strategic objectives of the organization and determining whether the organization should invest in the project, tactical PPM focusses on efficient product selection and implementation [34]. On this level, areas of concern are a loss of interim results when projects are stopped, negative side effects for other projects when focal projects are changed or stopped due to dependencies between projects, and the neglect of synergy and learning effects when planning new projects [15]. Recent investigations have produced comprehensive sets of risks to the success of a project portfolio, including sharing resources across and interdependencies between projects, affecting smooth communication flow as well as portfolio fragmentation [14, 13, 11]. These sources of complexity and interdependency present a particular challenge in tactical PPM. Managing project interdependencies in technical project portfolios tends to be a complex task [11]. Hence, there is a need for improved methods to understand and manage project interdependencies since they form the foundation of project identification and scoping [35]. We will build on this initial overview by creating a more detailed set of PPM challenges and requirements as part of our analysis in section 5.1.

2.2 Product modularization – a source of inspiration to tackle PPM challenges?

In the field of engineering design and manufacturing, the challenge of managing complexity and interdependency of physical modules has been successfully addressed by the introduction of modular product architectures [36]. In 1999, Volkswagen saved US$1.7 billion on costs for product development and manufacturing using modular product architectures [37].

Product modularization and platform approaches analyze dependencies between components and group them into suitable modules, considering different module drivers across the entire product lifecycle [38]. Reducing dependencies between modules and the standardization of components and interfaces decreases uncontrolled side effects and allows for flexible architectural changes. The use of standardized components across product platforms also allows the use and/or reuse of existing component kits, which leads to cost savings through economies of scale and the division of labour, an effective coordination of processes and the avoidance of bottlenecks [20, 21].

In order to address the specific demands of customers, product variants need to become increasingly individual. However, this is in conflict with increased cost pressures in a globalized competitive environment [39]. Modular product architectures address this conflict by allowing the creation of a broad variety of products (so called external variance) using a limited number of interchangeable modules with standardized interfaces (so called internal variance) as shown in Figure 1 [40].

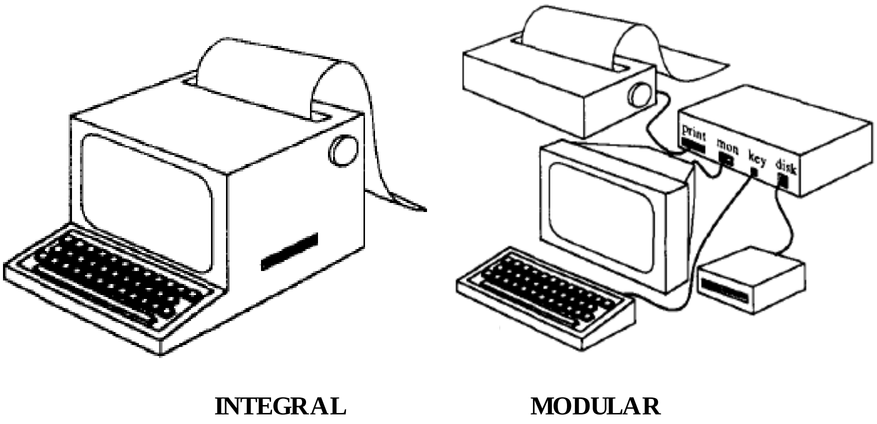

Fig. 1. Integral and modular product architectures [36]

In this context, an important characteristic of a system is its degree of modularity. The degree of modularity is located within the gradual spectrum between a completely integral and a completely modular architecture [19, 41, 42, 43, 44, 45]. Modularization refers to the activity of rearranging a system in a way that an optimal (not maximal) level of modularity for a certain purpose is achieved. In the modularization process, subsystems are created that are relatively independent from each other [16]. By creating modules with standardized interfaces, manifold benefits in development and production can be realized [36]. A degree of modularity that is too high, can however lead to numerous interfaces between individual building blocks. The alignment among these building blocks becomes conspicuous and thus would increase transaction costs.

The process of modularization generally follows a common workflow [46]:

- Decomposition of existing product structure and identification of product components as smallest unit of analysis – depending on the desired granularity, a component could be a single part (e.g. a screw) or an assembly group (e.g. a gear box);
- Analysis of components and their interdependencies (e.g. mechanical links, electrical links or information exchange);
- Arrangement of components into modules as new smallest unit of analysis considering specific module drivers (e.g. better functional alignment, improved mechanical interfaces etc.).

There is a range of different modularization methodologies that is used in engineering design and manufacturing (e.g. [18, 41]). Several of those methodologies have been developed and implemented with the aim of identifying and shaping modules according to specific purposes and to assess the related costs. While following the broadly similar workflow outlined above, different methodologies put emphasis on different aspects, such as functions, suppliers and logistics [47], the strength of the coupling between components [48], and heuristic methods [40]. Mathematical models to assess the level of modularity have also been developed [49]. More recent research initiatives are further investigating the cost and complexity effects of modular product architectures and their impact on the design of effective supply chains, and are creating a common language around the manifold approaches [20, 44, 50].

Product modularization approaches have already been used to successfully enhance management in other fields such as logistics [51], supply chains and production systems [52], business modelling [53] and business services [54].

3. Method

Before transferring a methodology into a new research context, it makes sense to gather directional input on its potential success [55, 56]. In order to gain this directional input and to provide a basis for eventually initiating the development of an MPPM theory, we follow a conceptual approach in this article [57]. To enable the theory building, we aim to create a theoretical framework that enables relationships between two distinct areas of research – product modularization and the management of project portfolios [58]. To connect those two areas, we will first develop a taxonomy for the transfer of parameters from modular product architectures to modular project portfolios, systematically arranging those parameters in relevant categories [59]. For this, systems theory is introduced as the bridging theory. From a methodological standpoint, systems theory will serve as a nomological network to enable the identification of linkages and to explore new connections between the two constructs of modular products and PPM [60, 61]. This builds the foundation for transferring a modularization methodology from the domain of engineering design to the domain of project management.

Next, we will review challenges of existing project management approaches from literature. Then, we refer back to them and use the example of the “Management Engineering Tool for Unified Systems” (METUS) as an established methodology for product modularization, to conceptualize the merit of a potential MPPM methodology towards addressing those challenges [59]. Methodologically speaking, the set of challenges will help us to determine to what extent, a new MPPM approach can provide supplementary value by bridging the observed gaps of the focal theory [58]. Figure 2 provides an overview of the applied research method.

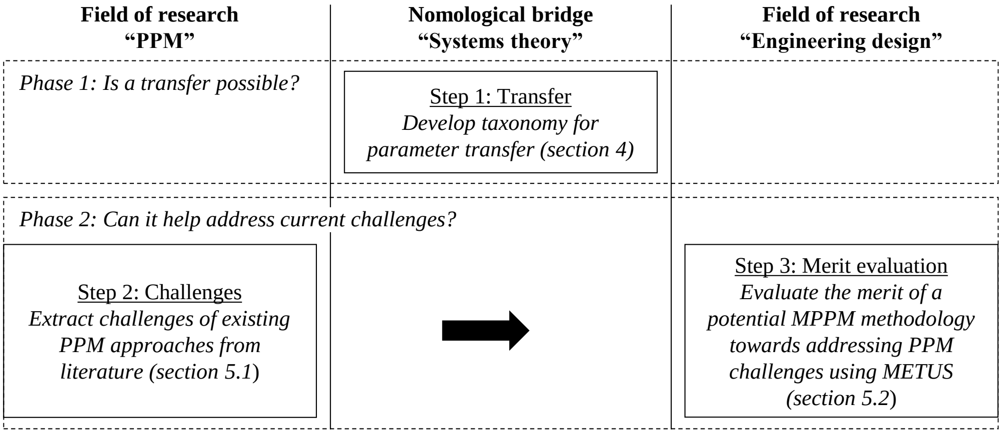

Fig. 2. Research design

4. Developing a taxonomy for parameter transfer

In this section, we identify key parameters used in methodologies for product modularization and demonstrate how they can be linked to equivalent parameters in the context of PPM. On a high level, product and project landscapes show a certain degree of structural similarity, such as a high number of different elements (e.g. components and modules vs. tasks and work packages) and a high number of different interdependencies (e.g. physical interfaces vs. information flows), which form a complex and dynamic system. However, a direct adoption of existing modularization approaches from products or technical systems to projects is not feasible due to the different nature of time dependencies and the increased role of human interaction in project environments [62].

To establish such a link, systems theory is identified as a theoretical bridge between the two domains. To establish these links, four aggregation levels are introduced to cluster the parameters. In systems theory, a system is made up of elements, which are linked via connections and system boundaries, which separate the system from its environment [63]. Systems consist of different modules, which are a kind of subsystem. They are defined by strong connections between its comprised elements, but only few and often standardized connections to external elements and modules. Systems are often part of overarching systems of systems [64].

Applying this systems theory lens to both product architectures and PPM, we see some general similarities between both domains (Figure 3).

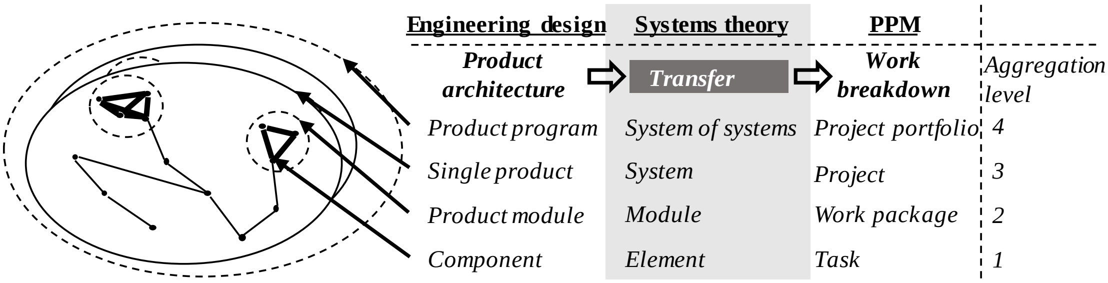

Fig. 3. Transfer of modularization approach to PPM

These are explored in more detail below. Using this neutral systems theory layer allows us to identify key characteristics of each domain and map them onto their equivalents in the other domain.

Aggregation level 1 – "Element":

The element, as a component or constituent of a whole, is the lowest building block of a system and is not further subdivided [65]. In the context of this research, the element is represented by a physical component in engineering design and manufacturing (e.g. a screw). In the context of PPM, we consider a single task/activity within a project as an element.

Aggregation level 2 – "Module":

The module is a set of standardized or independent elements, which can be used to build a more complex structure [66]. It ideally contains elements with strong interactions between them. To the outside, there are only few and standardized interactions. In engineering design and manufacturing, components are merged into product modules based on their individual contributions towards fulfilling the same functionality (e.g. the keyboard as a module of the system "computer" fulfilling the function of a user interface). From a PPM perspective, a work package is the equivalent of a module comprising different tasks that attribute to the same objective.

Aggregation level 3 – "System":

A system consists of interrelated and interdependent elements and modules, which are systematically organized and structured [65]. In engineering design and manufacturing, this is represented by a single product consisting of elements and/or product modules. The PPM equivalent is a single project.

Aggregation level 4 – "System of systems":

The highest aggregation level considered in this research is the system of systems, defined as "an interoperating collection of component systems that produce results unachievable by the individual systems alone", including resources and capabilities of the component systems [64]. This level allows for modules with standardized interfaces and clearly defined functionalities to be replaced and/or shared across different systems. In engineering design and manufacturing, this is represented by a product program comprising a set of related products. For PM, system of systems corresponds to project portfolios consisting of individual projects.

The structure of corresponding system layers is the basis for a detailed analysis and mapping of system characteristics on all four levels. In addition to the structure of four system layers, the identification of parameters was guided by the definition of systemic properties (see Figure 3). In systems theory, systemic properties (such as complexity, flexibility and robustness) can be described by types and number of elements and connections and their development over time [67]. This structure allows us to search for context-specific representations of elements, connections and dynamics in the areas of both engineering design and PM.

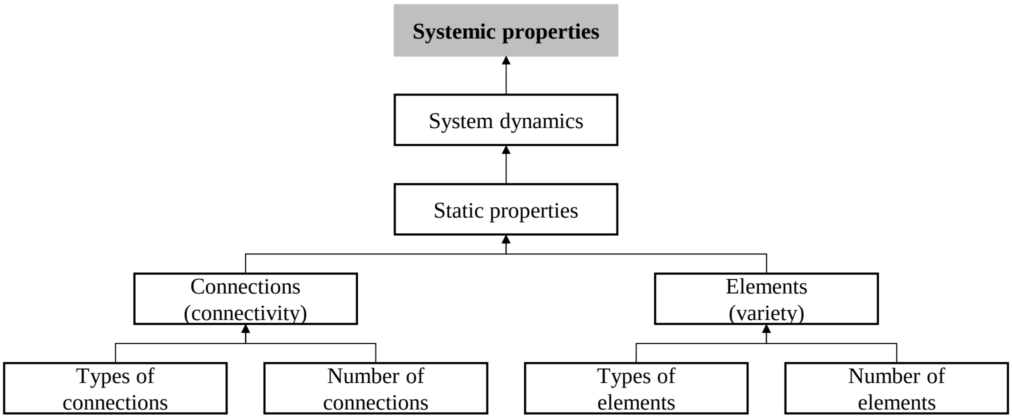

Fig. 3. Description of system properties (based on: [68, 69]])

The results and insights are consolidated in the Systems Transfer Taxonomy, illustrated in Table 1. Using the system properties and building blocks as a framework, we can identify contextual specifications in both areas and on all four aggregation levels, supporting a general transferability of methods based on the underlying structure and terminology. Some of those specifications are very similar in both areas (such as the simple number of products vs projects in a portfolio) and therefore might allow for a direct transfer of unchanged modularization methods. Others are different in that they represent physical properties (such as product dimensions or material interfaces between components) in engineering and intangible properties (such as project scope or information flows between tasks/work packages) in the realm of PPM. These differences, together with the heightened importance of the human factor in PPM environments, will necessitate a close examination of methods and appropriate changes in the process of adapting to the new context of PPM [62].

Table 1. Systems Transfer Taxonomy

	Engineering design ***(Contextual specification)***	**Systems theory layer** ***(General characteristic)***	**PM** ***(Contextual specification)***
Aggregation Level 4 **(strategic)**	***"Product program"***	***"System of systems"***	***"Program"***
	Number of products	*Number of systems*	*Number of projects*
	Usability of modules across products in product program	*Degree of system standardisation*	*Usability of work packages across projects in portfolio*
	Criteria for product modularisation (e.g. functional, supplier/department involvement, ability for concurrent engineering)	*Criteria for modularisation*	*Criteria for project modularisation (e.g. alignment of responsibilities, project objectives, resources, timeframes)*
	Contribution of products to business objectives	*Contribution to overarching objectives*	*Contribution of projects to strategic objectives*
	E.g. adaptivity, complexity, maintainability	*Emergent system properties*	*E.g. agility, complexity, flexibility*
Aggregation Level 3 **(tactical)**	***"Product"***	***"System"***	***"Project"***
	Number of product modules	*Number of modules*	*Number of work packages*
	Types of product modules	*Types of modules*	*Types of work packages*
	Number of connections between product modules	*Number of connections between modules*	*Number of work package dependencies*
	Types of connections between product modules	*Types of connections between modules*	*Types of work package dependencies*
	Product innovation cycles	*System dynamics*	*Evolving project scopes and priorities*
	Value-oriented alignment of customer priorities with module costs (target costing)	*Importance of modules*	*Prioritisation of work packages according to their contribution to project success*
	Definition of product dimensions	*Definition of system boundaries*	*Definition of project scope, objectives and timeframes*
	Degree of product modularity	*Degree of modularity*	*Degree of project modularity*
Aggregation Level 2 **(operational)**	***"Product module"***	***"Module"***	***"Work package"***
	Number of components	*Number of elements (extent)*	*Number of tasks*
	Types of components	*Types of elements (diversity)*	*Types of tasks*
	Number of connections (e.g. interfaces)	*Number of connections (density)*	*Number of task dependencies*
	Types of connections (e.g. energy, data, material)	*Types of connections (content)*	*Types of task dependencies (e.g. reporting structures, prerequisites*
	Product module innovation cycles	*Module dynamics (change of above system properties over time)*	*Evolving work package scopes and priorities*
Aggregation Level 1 **(fundamental)**	***"Component"***	***"Element"***	***"Task"***
	Physical properties (e.g. size, weight)	*Inherent system properties*	*Required labour (e.g. man-hours)*
	Functionality	*Justification of existence*	*Scope/objective*
	Number and type of interfaces: Capability to interact with other components	*Number and type of interfaces: Capability to interact with other elements (information, material, energy, spatial) (what can generally be exchanged?)*	*Type and number of interfaces (especially communication interfaces): Capability to interact with other tasks*
	Development, manufacturing efforts	*Resource requirements*	*Planning, execution efforts*

5. Can a new MPPM approach address challenges of existing PPM approaches?

5.1 An overview of PPM challenges

Resolving paradoxical tensions (such as between rigid or flexible approaches, control and autonomy, or individual and team-based rewarding) has been identified as a crucial factor for success on a project level [70]. However, due to the interplay of different projects with individual and interdependent uncertainties, dynamics and complexity, PPM cannot rely on upscaled project management approaches [35]. It requires specific and structured approaches that can be tailored to the specific application context [5, 35, 71]. It remains to be seen to what extent those challenges remain critical for success. Traditional PPM approaches tend to focus on selecting projects on a strategic level to optimize the value of the entire project portfolio [9]. However, this might not be sufficient for a more agile PPM [72]. There is a necessity for a more detailed consideration of projects based on activity level, even though that means greater effort required as a result [15]. A PPM approach should combine a strategic and an operational perspective. The strategic perspective includes the alignment of portfolios with company strategies, adaptability to internal and external changes, and the insurance of value proposition. The operational perspective includes project visibility to stakeholders, transparency in decision-making and predictability of outcomes [73]. It is important to align PPM with organizational structures and processes along with the company strategy [72]. From a decision-making perspective, multiple factors need to be considered for a systematic ranking of projects such as project costs, timelines and necessary resources [35, 71, 72].

A key requirement of a successful agile PPM is the consideration of project dependencies [35, 74, 75]. This is specifically true for high tech R&D environments [76]. Dependencies can be clustered into financial dependencies (shared funding sources), resource dependencies (shared infrastructure and resources), market or benefit dependencies (complementary or competitive effects), outcome dependencies (projects’ use of other project outputs), and learning dependencies (projects’ use of the learnings from other projects) [35, 76]. These dependencies and interactions need to be monitored in all phases of a project’s lifecycle to allow for performance to be controlled and risks to be managed [5, 71]. Along with dependencies between ongoing projects, it is also crucial to consider dependencies between ongoing and potential projects in the project pipeline [71, 75]. For technology projects, a quantification of those interdependencies can help to optimize project selection and evaluate changes to the portfolio [77]. In addition, it is important to consider and involve different key stakeholders, such as project managers and middle and senior management sponsors [78].

Table 2 takes into consideration the project portfolio risks (component, structural and general) shown in Hofman and Grela [13] as a basis and consolidates them into a set of high-level challenges, clustered along different perspectives, in order to initiate the assessment of a potential MPPM method.

Table 2. Challenges of PPM approaches

Perspective	**Challenge**	**Additional source**
Agility	*Tailorable approach concerning different application contexts*	[35]
	Adaptability to internal and external changes	[72, 73]
	Continuous consideration of all project phases across the entire project lifecycle	[5, 71]
	Involvement of different key stakeholders	[78]
Complexity	*Size of portfolio and consideration of multiple project criteria, such as costs, timeframes and necessary resources*	[71, 72]
	Consideration of project dependencies (financial, resources, market/benefit, outcomes, learnings)	[35, 74, 76]
	Consideration of dependencies between ongoing projects and potential ones in the project pipeline	[71, 75, 77]
Structural alignment	*Hierarchical structure of portfolio*	[5, 71]
	Alignment to company strategy and value proposition	[72, 73]
	Alignment with organisational structures and processes	[72]
Transparency	*Consideration of project activities and methodical standards for portfolio element management*	[15]
	Project visibility to key stakeholders and transparent decision-making process and information flow	[73]
	Predictability of project deliverables and information transfer between portfolio elements	[73]

5.2 Assessing the merit of a modularization approach in addressing the PPM requirements

We now introduce an existing product modularization methodology as an example and assess its potential to address those current challenges of PPM. This allows us to determine whether an MPPM method could be used as a desirable alternative to fill the gap in current PPM approaches.

METUS is an established modularization tool that uses a solution-neutral modelling approach, is available as a software for data handling and visualization, and is adaptable to different use cases. METUS originates from the German automotive industry [79]. It structures and systematically enhances system development processes with a focus on creating modules based on their functional alignment. Figure 4 illustrates the underlying principle.

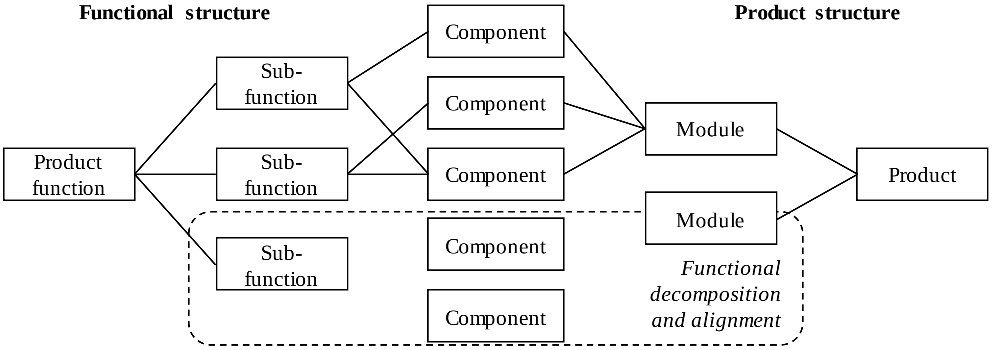

Fig. 4. Product architecture for METUS [79]

Due to the modular and adaptable structure of the METUS methodology and software, they can be easily tailored to different application contexts, companies, user needs and products. The ability to replace product structures with project portfolios makes METUS a promising candidate for exploring its applicability in a PPM context.

METUS substantiates the generic modularization workflow for product modularization outlined earlier [80]. Table 3 summarizes this workflow and shows, how it could be translated to the PPM context.

Table 3. High-level workflow of METUS-based MPPM

Step	METUS	METUS-based MPPM
1	*Clarify objectives of a modularization project and identify the product requirements that reflect customer needs and market dynamics*	*Clarify objectives of technology project portfolio and identify the project requirements that reflect stakeholder needs and alignment with company strategy*
2	*Create a solution-neutral functional structure that hierarchically decomposes the main function of the product into sub-functions (without mental constraints of an existing physical system)*	*Create a functional structure, free from organizational limitations, that decomposes the overall strategic goal of the technology portfolio into appropriate sub-goals based on previously identified requirements*
3	*Create an existing product structure by identifying components, interfaces and assembly groups of the product (only if existing product is modularized; can be skipped if new product is being developed)*	*Create an existing project structure by identifying tasks, activities, organizational dependencies and information flows of the projects (only if current project landscape exists; can be skipped if new portfolio is being developed)*
4	*Map sub-functions to components and create new modules that group components based on their functional alignment*	*Map sub-objectives to tasks and create new modules that group tasks based on their strategic alignment*
5	*Optimize new product architecture based on product-specific variant drivers and alignment with company objectives (e. g. optimise for supplier network, logistics, packaging, re-useability of modules etc.)*	*Optimize new project structure based on project-specific variant drivers and alignment with company objectives (e. g. optimise for resource allocation, budget constraints,project independence, re-useability of project results etc.)*

We can now assess METUS and its high-level workflow against the previously established challenge perspectives of agility, complexity, structural alignment and transparency in the following sections.

Agility perspective

A METUS-based MPPM approach could be tailored to different contexts. It offers the freedom to adjust the structure of the model and the Key Performance Indicators (KPIs) and is very flexible in terms of which data are fed into it. The tool is built in a modular way and consists of solution modules that allow flexible adaption to different application scenarios, such as project portfolios. Variant drivers define alternative customer-relevant product characteristics to address the needs of different customers (such as different colors, engine performances or bodyworks of a car). In combination with the product structure, the variant drivers help identify structural standard or platform elements (common in every product variant), variant elements (different for each product variant) and optional elements (not in every product variant, these elements may be standard or variant). Similar to modules and products, requirements are different between projects and portfolios and depend on the needs of stakeholders. These changing requirements can be mapped into variant drivers in METUS. Stakeholder alignment is also a core concept of METUS. A potential loss of agility can arise however from the fact that METUS is often used sequentially in a project’s context. However, the methodology allows for parallel processing, which would benefit overall agility.

Complexity perspective

A key weakness of METUS is its ability to consider dependencies between ongoing and upcoming projects. However, the tool generally allows for mapping of inter-project dependencies. It also allows for the consideration of multiple project success criteria such as cost, quality and time, which are widely similar to criteria from product modularization. Addressing complexity requirements such as cost and effect relationships is a core feature of METUS, but successful implementation requires a software to ensure correct application and visibility of dependencies. The new product architecture concept is then assessed on its interface optimization, make-or-buy analysis and an enhancement of the supplier structure, which would also become a step in the MPPM workflow (see Table 3). Overall, the METUS approach comprises 18 steps, so called “solution modules”, which form a generic workflow that guides product developers through the modularization process.

Structural alignment perspective

METUS has the ability to address requirements related to structural alignment of project portfolios. It can easily be aligned with organizational structures and processes as projects need to fulfil a structure’s set of functions like products. Instead of mapping this functional structure to a product structure, METUS can be adapted to PPM to map functional structures onto project structures instead. Alignment to strategy and processes is possible as well in that way.

Transparency perspective

Visibility to key stakeholders is enforced within the tool, which has the effect of increased transparency. This requirement also reiterates the necessity of using a software tool to provide transparency and highlights the need to communicate deliverables clearly as this is not an integral part of the METUS workflow. METUS is generally implemented through a dedicated software to allow for good usability, easy data manipulation and handling, testing of different settings, transparency and the visualization of complex structures and dependencies. The software also enables interdisciplinary experts to collaborate and consolidate their knowledge in one data model as well as capture the lessons learnt.

6. Conclusion and outlook

Efficient PPM will be highly relevant to prepare new and existing industries in an era of digital transformation and ever-increasing complexity for the challenges of increasing global competition and limited resources. In this article, we explore the possibility and merit of transferring established modularization methodologies from the context of engineering design and manufacturing to the context of PPM. To demonstrate that a transfer is possible, we develop a taxonomy based on systems theory to establish correlations between the central parameters of products and project. After that, an exploratory analysis of an established product modularization methodology (in this case METUS) is performed in order to assess its capacity to address PPM requirements for technology projects.

This research contributes to closing an open research gap around agile PPM approaches, which goes beyond approaches focusing on single projects like Scrum. The Systems Transfer Taxonomy provides new insights into a systematic transfer of approaches and methods between different disciplines and domains, which can also inform other research fields such as cross-industry innovations. Therefore, MPPM also contributes to a better understanding of transdisciplinary research initiatives.

The practical implications of a newly developed MPPM approach would be that companies could react more flexibly and quickly to project changes and changing boundary conditions. This could support companies in better dealing with known and unknown project uncertainties. In addition, the modular and standardized project setup with self-contained work packages would increase the reusability of intermediate outcomes. In the medium-term, this allows for a better exploitation of experience and knowledge and enhances the value from limited resources across multiple portfolios.

However, certain limitations have to be considered and can inform future studies on this topic. We have used one well-established product modularization methodology (METUS) as an example to show how the concept of modularity can help address PPM challenges. Other methodologies might be just as or even more appropriate for future works on developing an MPPM methodology. Other approaches that could be considered include Modular Function Deployment (MFD) [81] and Modular Engineering [82]. Further modularization methods (without a corresponding software tool) to be taken into consideration are the ones by Baldwin and Clark [16], Pimmler and Eppinger [83] or Ulrich [36].

The next step will be to develop an executable MPPM methodology that effectively and efficiently addresses current PPM challenges. In the process of developing this methodology, a set of empirical data should be collected to ensure it includes and correctly prioritizes all relevant (potentially industry-specific) steps towards designing modular project portfolios. In the context of developing the methodology, its viability will have to be considered to create a sustainable business model for implementation and produce positive financial outcomes. Therefore, direct evaluations in different organizations are suggested to ensure the applicability and benefits of this new MPPM methodology.

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