Chapter 2
Towards a Target System to Incorporate Sustainability in Multi-project Management in Factories

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Abstract Shortened life cycles and increasing customer-specific mass production confront factories. The professional use of project management is necessary for a permanent adaptation under unstable conditions to retain objective attainment of the factory. Multi-project management is a proven approach to cope with the resulting complex project portfolios. Supported by a literature review, the necessity for a comprehensive and differentiated target system becomes evident, enabling factory management to deliberately position themselves and make decisions in the numerous conflicts of objectives. A predominant contradiction exists between prioritizing projects with short-term profitability while ensuring portfolio sustainability. This challenge of portfolio balancing requires an overarching target system providing guidance. In order to develop this target system, we first developed a hierarchy framework according to which suitable existing approaches are refined and implemented. Furthermore, we illustrate performance indicators to enhance this target system and make it applicable, which we conclusively demonstrate in a case study.

Keywords Multi-project management · Portfolio management · Factory planning · Sustainability · Target systems · Portfolio balancing

2.1 Introduction

Today's factories are characterized by turbulent global markets [20]. The reasons for this are numerous overlapping and mutually influencing factors, which have their origin in particular in the ever-shorter technology cycles, globalization as well as new products and processes [22, 25]. A continuous adjustment of production systems and the yielding increase in the number of projects within factories reflects this dynamic [2, 12, 31]. As a result of the constantly changing environment, factory planning is no longer a one-time task. Rather, factory planning can increasingly

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be characterized as a permanent process by which production is adapted to the continually changing circumstances [32]. Both proactive and reactive changes are realized through projects and thus affect the total number of existent projects in the factory, which are considered as project landscape. Consequently, a very high project heterogeneity characterizes this project landscape [34].

Existing project management approaches and their consecutive procedures can only insufficiently cope with the increasing complexity within the project landscape of a factory [2, 11]. In addition, little attention is paid to linking higher level company and operational project objectives when selecting projects. As a result, changes in objectives at the company level are not given enough consideration in single projects. Additionally, project sustainability is considered as central criteria for long-term success [1]. Furthermore, a lack of project transparency leads to untapped synergy effects as well as insufficient networking between different projects or possible cumulative risks in the project portfolio. Due to these deficits, systematic and target-oriented multi-project management must supplement conventional single project management in a factory in order to combine effective project selection, managing portfolio sustainability and uncertainties as well as supporting efficient project execution [1, 2, 11, 21, 33].

The hypothesis of this paper, therefore, is that multi-project management has to be enhanced by a target system incorporating all relevant criteria including sustainability, in order to make it applicable in factories. The objectives of factories as well as of multi-project management must be consolidated and coordinated in such a way as to start project initiatives in the factory, which support the collective set of objectives. In order to select, equip and implement those projects, which bring about the change and future sustainable development of the factory in the desired direction, it is necessary to create a common and comprehensive target system. With the help of such a target system, multi-project management decisions in factories can be made in a manner that enables deliberate positioning in prevailing target conflicts. As a consequence, individual projects may be stopped or taken down in priority in terms of resource supply, as long as the overriding attainment of objectives is beneficial.

2.2 Fundamentals

There are always numerous project ideas in companies, various projects are being implemented, some have been cancelled and an even larger number of projects have already been completed and documented. Today, almost all changes in a company are implemented through projects or project-like initiatives [8]. Different project types, objectives pursued, lead times and sizes of the projects characterize the resulting project landscape [15]. Examples for different projects can be long-term reorganizational projects, involving all departments of a company as well as projects to comply with upcoming legal regulations, small improvement projects of everyday workflows or even large factory expansion projects.

Projects initially pursue their individual objectives and should ideally bring about the implementation of company objectives either directly or indirectly. Due to scarce resources and existing dependencies between projects, consequently overall planning and coordination in the form of multi-project management is a reasonable approach [8].

2.2.1 Multi-project Management

Multi-project management primarily comprises the planning and control of the project landscape and provides the necessary organizational and processual framework [8]. Multi-project management therefore is understood as an important function between the strategic level of a company and the operative individual project level [29]. Figure 2.1 shows four relevant elements of multi-project management. The multi-project landscape (a) contains the single projects as well as project programmes, which by itself consist of a number of single projects. The hierarchization (b) of individual projects at the operational level is usually obtained via project programmes and a superordinated project portfolio [7].

The target system (c) is the focus of this paper. It analyses the objectives of the single projects and project programmes and checks their alignment with the higher level factory objectives. Multi-project management deals with the cost-benefit relations of the projects because of the strong influence of the company management and the consideration of their objectives. Thus, it requires positioning in the potential conflict of these objectives [33]. One example of a generic conflict of objectives is the tension between short-term profitability and sustainable projects [1]. Based on the assessment by the target system, a project prioritization (d) can finally be carried out, which allows further actions to be derived, as indicated.

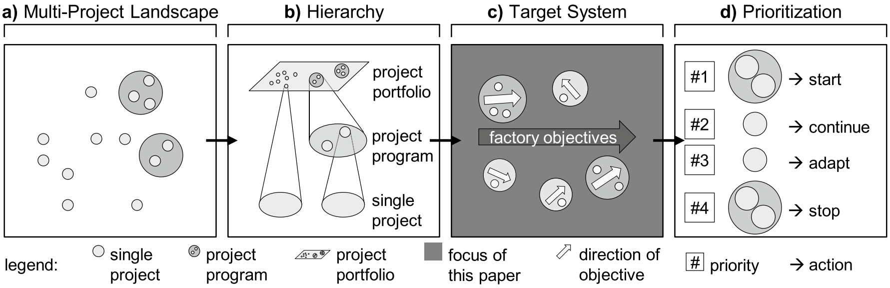

Fig. 2.1 Selection of relevant elements of multi-project management with highlighted focus of this paper, **a** Multi-project landscape, **b** Hierarchy, **c** Target system, **d** Prioritization

2.2.2 Factory Planning

According to the VDI Guideline 5200 [35], a factory is the place of value creation where industrial goods are processed using production factors. The production factors relate to operating resources, materials, personnel, information, capital and space. A factory can therefore be regarded as a socio-technical system in which production systems are formed through the interaction of social and technical subsystems [37].

Factory planning is a subfield of long-term production planning [37]. According to VDI Guideline 5200 [35], it is defined as a target-oriented, structured and systematic process with successive phases, which is carried out using the aid of tools and methods to plan a factory from the definition of factory objectives until the ramp-up of production.

2.2.3 Specificities in Multi-project Landscapes of Factories

Multitudes of different projects characterize the system of a factory. In addition to large and risky factory planning projects (such as expansion projects), equally multilayered IT projects (such as ERP-implementation projects) or smaller organizational projects take place in factories [15]. In addition, projects of the continuous improvement process (CIP) are to be mentioned. Product development projects also play an important role in a factory. Product development is one of the classic application areas of project management, which is continuously applied in research and development. The deliberate transformation of knowledge creates new, further developed or adapted products for the market, which are produced in factories [3].

Due to the strong dynamics in the environment of a factory, the production systems, in particular, have to be adapted regularly. The planning and implementation of such initiatives are usually organized and carried out through projects. Production projects are often operated for the duration of a product life cycle [3], which is why life cycle-oriented production strategies are used. Increasingly strong project planning in production can result in a cross-location project landscape. The design and control of the project landscape in a factory therefore needs methods of multi-project management to supplement the methods of single project management [2, 9].

2.2.4 Targets of Multi-project Management in Factories

By establishing a multi-project management in a company, different objectives of the company can be addressed. According to DIN 69909-1 [8], first of all, transparency is created in the project landscape, thus making connections, synergies and potential risks visible. The single projects and project programmes in the project portfolio should be aligned with the company's targets. The above-mentioned transformations, which have a permanent effect on the factory, can thereby be countered quickly and purposefully. It is therefore necessary to select those projects that should bring about a change in line with the company's objectives. Subsequently, a project prioritization must be carried out, which specifies a ranking order, e.g. for project scheduling and resource management, among the projects in the portfolio that are to be restarted or are already running. Consequently, those project ideas with the highest target conformity can be started or continued with priority and therefore be equipped with the best available resources. The identification and evaluation of opportunities and threats of the individual projects and project programmes also enable portfolio risk management. Furthermore, the projects and project programmes in the project portfolio are regularly monitored for their alignment with the company's objectives and appropriate countermeasures, such as stopping projects or amending their objectives, are initiated in the event of deviations [8].

In factories, the objectives described above also apply but are supplemented by factory specific characteristics. For example, the concrete design of factory objectives is strongly dependent on the type of factory [30]. A low-cost factory, for instance, would place less emphasis on a changeable shop floor with a sustainable air-conditioning concept than an exemplary high-tech factory. In general, factory targets can be divided into formal and factual objectives [10]. Formal objectives are overriding objectives, such as cost-effectiveness and profitability. According to Heger [10], factual objectives contain performance targets, such as quality, logistics performance and changeability.

Linking the various objectives of multi-project management and factory planning in a single model represents a previously unaddressed challenge.

2.3 Factory Requirements for Multi-project Management

The individual conditions of a factory result in different requirements for the most efficient and effective applicability of a target system for multi-project management. This paper only brings forward such requirements, which are particularly important to achieve this purpose.

Planning from rough to detailed results in a hierarchy of objectives that can be used to structure a target system for multi-project management in a meaningful way. Usually, a factory is given overriding corporate objectives, which then have to be broken down into more concrete factory objectives [5, 32]. The project portfolio subsequently is aligned to achieve these factory objectives through approved single project programmes or single projects [11]. A cascading of planning from rough to detailed is therefore necessary since the far-reaching company or factory objectives usually cannot be achieved by singular actions [4, 16, 36].

Promoting portfolio transparency must be aspired by a target system for multi-project management in a factory, in order to systematically plan and control the project landscape. A frequent point of criticism, for example, in factory planning projects, is the lack of interlinking between planning disciplines [27]. Greater transparency allows more interdependencies to be detected and the effects of changes to be represented in a better way [14]. Transparent handling of factory planning projects means that the overall benefit can be maximized, as the individual planning projects can benefit from each other and promote an interaction [24]. Accordingly, an increase in transparency leads to a holistic and targeted cooperation of all projects as well as to an efficient coordination of all members involved [27].

Compliance with project heterogeneity can be derived as requirement originating from the high project variety in a factory. A target system for multi-project management must take this heterogeneity into account and be applicable to all existing types of projects, so that a comprehensive control of the project landscape is possible [8]. Especially the heterogeneity of project clients or sponsors is particularly high [33], whereas the resources involved in the portfolio differ significantly [9].

Compliance with portfolio sustainability in a factory also is an important point that must be considered and represents the focus of this paper. Through their production processes and their considerable influence on the population, factories play a central role in shaping the sustainable development of societies [6]. This requirement therefore addresses a project portfolio in a factory that is ecologically, economically and socially beneficial today and in the future [18]. In order to fulfil this requirement, single project sustainability is important, but has already been discussed extensively [1]. Portfolio sustainability goes beyond taking care of single project sustainability. The sustainability of individual projects is of no gain if the portfolio as a whole is not following the overarching objective of sustainability. A sustainable project portfolio specifically includes the features of 'portfolio balancing' and 'strategic fit', which are described as vital [8, 26]. In the context of the factory, however, there is a particular need for them [2], for example, to start strategically relevant projects that are not profitable in the short term. To consider systematically a certain share of such projects in the portfolio prevents an excessive procrastination in adjustments, which later on would result in enormous correction costs [19].

For a future-oriented factory, *compliance with factory changeability* must also be taken into consideration. A changeable factory can implement structural changes at all levels quickly, with little effort and comparatively low investment expenditures [40]. New products, technologies and markets, as well as fluctuating demand, create a volatile environment to which the factory must adapt quickly and with little effort for a successful existence on the global market [18, 28]. In order to avoid cost-intensive restructuring measures or uneconomical production processes, a target system for multi-project management must meet these requirements and continue to be able to act under rapidly changing conditions.

Compliance with (factory) standards is not to be understood as compliance with legal or other binding requirements, as these are usually covered by existing approaches. Rather, it is intended to comply with voluntary or self-imposed standards or overfulfilment of current regulations for the purpose of expected compliance with future (possibly mandatory) requirements [5].

2.4 Literature Review and Identification of Research Gap

Figure 2.2 compares existing process models with reference to a target system as well as dedicated target systems with the previously mentioned requirements of a target system for multi-project management in a factory.

Although the existing models cover a number of requirements, only a selection of these aspects are in the respective focus of the various approaches. It is also not possible to reach a complete consideration of all requirements by solely combining existing approaches.

Larger deficits can be found in the analysis of existing research with regard to promoting portfolio transparency, compliance with project heterogeneity, as well as compliance with portfolio sustainability. While the first two mentioned are partly covered by some existing approaches, portfolio sustainability is not addressed by any of the assessed models. As a result, no approach currently exists that enables the holistic assessment of the objective attainment of multi-project management decisions in factories with special consideration of portfolio sustainability. Linking the various objectives of multi-project management and factory planning in a coherent model represents a hitherto unsolved challenge. In particular, existing approaches fail to provide a consistent hierarchy of objectives across the different levels to create a coherent target system under inclusion of portfolio sustainability.

	Process models and target systems		Requirements: Planning from rough to detailed	Promoting portfolio transparency	Compliance with project heterogeneity	Compliance with portfolio sustainability	Compliance with factory changeability	Compliance with (factory) standards
Process models	process model multi-project management	[33]	◐	◐	◐	○	○	○
Process models	process model factory planning	[35]	◐	○	○	○	○	◐
Process models	reference model production projects	[3]	◐	○	○	○	◐	◐
Target systems	magic triangle project management	[17]	○	○	◐	○	○	○
Target systems	target system production logistics	[39]	○	○	○	○	○	○
Target systems	target pyramid of company	[36]	●	○	○	○	○	○
Target systems	target system factory planning	[5]	○	○	○	○	●	●

legend: ● focused ◐ partly covered ○ not covered ▇ focus of this paper

Fig. 2.2 Revealing the research gap by comparing the factory's requirements for multi-project management with existing process models and target systems

2.5 Target System for Sustainable Multi-project Management in Factories

To close the previously mentioned research gap, a corresponding target system, especially for sustainable multi-project management in factories, is presented. It builds upon the findings of the existing approaches already presented. The model is structured according to the hierarchy levels in multi-project management introduced earlier (Fig. 2.1b), supplemented by the levels factory and company [23].

The target system therefore consists of company objectives, factory objectives, project portfolio objectives, project programme objectives and single project objectives. Each of these objectives is to be operationalized by further sub-objectives and KPIs in order to enable a deliberate, target-compliant positioning between the alternatives for action, some of which are conflicting. The classification of objectives, sub-objectives and KPIs in a holistic target hierarchy allows the clear identification of local optimum that could lead to a failure to achieve targets at the higher levels. On the other hand, a local suboptimum can be overcompensated and thus legitimized by a transparent, comprehensible and sustainable global improvement in target achievement. The developed target system for sustainable multi-project management in factories is shown in Fig. 2.3.

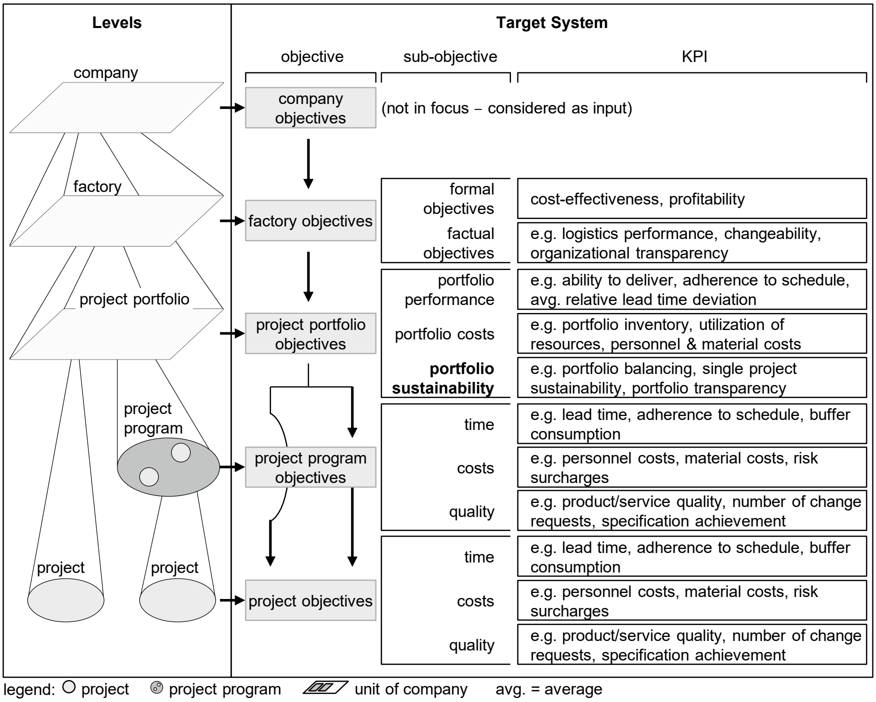

Fig. 2.3 Target system for sustainable multi-project management in Factories

Since all objectives and sub-objectives of the target system can and must be operationalized by various, partly company-specific key indicators, exemplary key indicators are displayed and elaborated in Fig. 2.3 and the following sections. Further information on the applicability of the target system can be found in the corresponding section.

2.5.1 Factory Objectives

The factory objectives are influenced by the superordinate company objectives. However, these are outside the focus of this paper and are therefore only considered as a given input. According to Heger [10], factory objectives can be distinguished between formal and factual objectives. The formal objectives include the cost-effectiveness and profitability of a factory. Factory planning must create the framework conditions for an economic and profitable factory operation in order to enable a lasting existence of the factory on the market. The factual objectives are of a rather operational nature and are composed, for example, of logistics performance or changeability. Other factual objectives for example include organizational transparency and organizational interconnectivity [10].

The factory objectives described are used to derive the subordinate project portfolio objectives. In return, the achievement of inferior levels directly influences the achievement of objectives of superior levels.

2.5.2 Project Portfolio Objectives

The sub-objectives allocated to the project portfolio objectives consist of portfolio performance, portfolio costs as well as portfolio sustainability. This clustering ensures that the above-mentioned requirements for multi-project management in the factory are taken into account at this level of consideration. It is important to mention explicitly the equal importance and legitimacy of portfolio sustainability as long-term objective alongside performance and cost objectives. Portfolio sustainability therefore is representing the antipole to performance and costs, which together form the magic triangle on portfolio level.

Portfolio performance can be operationalized through several KPIs, including ability to deliver, adherence to schedule and average relative lead time deviation of the project portfolio. These KPIs are used to identify and avoid systematic misplannings or avoidable blockages caused by interdependencies between individual projects that would have a negative impact on project portfolio performance.

The portfolio costs can be determined, for example, by the portfolio inventory or the utilization of resources. Similar to a high inventory level in a warehouse, which results in tied-up capital and other warehousing costs, a high portfolio inventory level of single projects represents a cost driver. These costs are created through a high number of simultaneously running projects with distracting multitasking for all resources. The portfolio inventory should be reduced, which also leads to a positive influence on the average relative lead time deviation (portfolio performance). The utilization of resources should be maximized in order to make the best possible use of available capacities. These KPIs stand in a fundamental conflict of objectives, as utilization of resources and low portfolio inventories are logically contradictory. In addition, other direct costs, such as personnel or material costs should also be considered in portfolio cost observations.

Portfolio sustainability also consists of a number of KPIs. For a comprehensive control of multi-project management, a portfolio balancing between strategic and profitable projects must be considered by compliance with project heterogeneity [13]. A sustainable project portfolio can only be realized persistently through compliance with single project sustainability in the ecological, economic and social areas. In today's turbulent environment, compliance with factory changeability also has a major impact on the sustainability of the project portfolio. Without the project portfolio's ability to adapt quickly to changing conditions, its continued existence is at stake. This changeability is generally described as being facilitated through five changeability enablers [38]. They represent generic approaches to address changeability via modularity, scalability, universality, compatibility and mobility. By emphasizing these five approaches, sustainability can be promoted [40]. The aim should be a balance between efficiency enhancing and changeability supporting projects for the portfolio to be sustainable. Furthermore, a project portfolio requires a maximum of portfolio transparency. Synergies, interdependencies and risks in the project portfolio can only be identified and exploited or overcome through a high degree of openness in single projects, project programmes and the portfolio as a whole.

2.5.3 Project Programme and Single Project Objectives

The objectives of the project programmes, as well as single projects, are derived from the project portfolio objectives. Due to the similar character of project programmes and single projects [8], the same sub-objectives and KPIs can be assumed, which is why this paragraph only refers to the term projects. According to Lock and Wagner [17] a project is subject to three basic target criteria (also called *triple constraint*): time, cost and quality. This *magic triangle* of objectives in project management is an established approach for single projects. The time dimension in a project determines the requirements for set deadlines, measured, for example, through lead time, adherence to schedule and buffer consumption. Another dimension represents costs. All resources used in connection with the project, such as the resulting personnel costs, material costs as well as necessary risk surcharges influence the resulting project costs and need to be considered. The third dimension is the quality of the resulting product, service or subject of a project. This criterion is intentionally very broad and includes all KPIs that are not of a time-based or monetary nature. These include, for example, the product/service quality, the number of change requests or the specification achievements of a project. The objectives contained in the magic triangle are in a permanent conflict so that the improvement of one of the objectives leads to an inevitable deterioration of the other two objectives. This contradiction requires deliberate positioning in the conflict of objectives [17].

2.6 Applicability of the Target System and Case Study

The use of the target system for multi-project management in factories allows a target-oriented alignment of single projects, project programmes as well as project portfolios in order to achieve a high degree of target conformity with the factory and finally the company goals. The presented target system is to be understood as an initial target system to start with following [5]. Based on this universal foundation, it is intended that the factory management supplements or reduces the sub-objectives or KPIs for the individual application case. In addition, a specific weighting of the individual target system components should be carried out during application. In concrete decision-making situations within the project landscape, action alternatives can be analysed and evaluated on the basis of their effects on the KPIs, the sub-objectives and ultimately the objectives.

In our case study, we utilize the situation of German automobile OEMs (Original Equipment Manufacturers) as a unit of analysis. We use an explanatory case (according to [42]) to elucidate the strategic positioning of German automotive OEMs regarding their portfolio balance as a project mix for conventional internal combustion and fully electrical vehicles in their factories. Consequently, we express the overarching research question: How can the strategic decision-making process for project portfolio selection be changed to incorporate sustainability in multi-project management? Furthermore, we formulate the follow-up question: How can the hierarchy framework presented in this paper support the strategic positioning of above-mentioned companies in order to reach higher attainment for sustainability objectives, which are in conflict with performance and cost objectives? The data used for the case study was publically available statements in annual reports.

The current challenge at hand for German automotive OEMs is the uncertain product mixture of conventional internal combustion and fully electrical vehicles in the upcoming years. Drastically diverting scopes of assembly and new regulations, as well as the digitalization of the whole branch, represent various parallel issues for managers [41]. In order to best equip their factories for a hitherto unknown mix of both technologies, the right projects need to be selected for execution. There is a risk that today's automobile manufacturers will prefer the supposedly more profitable short-term improvement projects for increasing the output of conventional combustion vehicles. This would result in shortcomings of the strategically relevant, but very capital-intensive and partly less efficient assembly systems, which offer a high degree of changeability with regard to the combustion/electrical mix to be expected in the future. Conventional portfolio management would select projects according to the individual project objectives (time, cost, quality). Possibly they also consider performance and cost objectives on a portfolio level, but certainly do not take sufficient account of project portfolio sustainability. Due to the equal positioning of portfolio sustainability alongside the performance and cost targets as suggested in this paper, a deliberate decision against a sustainable project at least requires elaborated justification or legitimation. This enables appropriate portfolio balancing in accordance with all relevant criteria.

The main findings of the case study consequently are the following. German automotive OEMs would normally favour projects in their prioritization, which solely support vehicles with internal combustion engines. However, through the utilization of the target system presented in this paper, the project selection process would increase the importance of sustainability by placing it on the same level as performance and cost indicators. The research question therefore can be answered with this explanatory case. Nevertheless, further research with regard to a broad empirical study is recommended to substantiate the results determined in this case.

2.7 Conclusion

In today's factories, the professional use of multi-project management is unavoidable due to rapidly changing conditions. It has been shown that planning and controlling the project landscape in a factory requires a comprehensive and factory-specific target system. The special requirements of a factory for such a target system for sustainable multi-project management in factories were presented in detail. A literature review showed that the existing approaches from the fields of process models or target systems only insufficiently take into account the identified requirements. Thus, a research gap could be identified in the form of a target system for sustainable multi-project management in factories.

This paper therefore contributes to the creation of such a target system addressing the specific requirements of a sustainable multi-project landscape in factories. In order to derive the objectives of the project portfolio and consequently the project programmes and single projects from the factory and company objectives, the target system is first hierarchically structured into five levels. Subsequently, sub-objectives were assigned, which allow a breakdown and thus a more differentiated view. Finally, exemplary KPIs were assigned to each sub-objective that build upon the existing approaches and take into account the identified special requirements of the factory as well as making their achievement measurable at each level. Finally, the necessary steps for the applicability of the target system were explained.

To conclude, it can be stated that with the target system for sustainable multi-project management in factories an essential building block for the consideration of the special requirements of a factory was developed. Future research work and publications of the Institute of Production Systems and Logistics will work towards the development of a comprehensive and integrated process model for multi-project management in the factory. This will enable managers in the factory to carry out the numerous tasks and associated decisions within the multi-project management of a factory effectively and efficiently.

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