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Approach to Tactical Planning for Manufacturing Innovation Projects

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Abstract

Rapid technological developments, shortened product life cycles, and constant competitive pressure require continuous efficiency improvements in producing material goods. Innovation is necessary to achieve these efficiency gains in manufacturing. Therefore, companies generate manufacturing innovation as part of the continuous improvement process or by absorbing external stimuli. As a result, tactical planning of innovation projects in manufacturing must be carried out regularly to enable resource planning and operative project implementation. The use of planning methods helps to increase the planning quality and reduce the complexity in the planning process. However, only a few approaches methodically support this tactical planning for manufacturing innovation. Therefore, an approach is developed using literature- and expert-based methods to systematically describe an innovation project in manufacturing, to identify and specify the relevant work contents, and finally to bring them into a defined processing sequence. In addition, the possibilities of individual planning steps being supported using tools and methods are shown. Finally, an industrial application of the approach is carried out, and a critical reflection on the results is presented. In summary, the systematic structuring of the planning process and the identification of available methods and tools improve the tactical planning of innovation projects in manufacturing.

Keywords

Manufacturing; Innovation Management; Innovation Project; Tactical Planning; Project Planning

1. Introduction and motivation

Manufacturing companies face significant drivers of change, such as globalisation, climate change, technological leaps, demographic change, and increasing individualisation [1]. Therefore, changes must be identified early, and the resulting opportunities must be exploited quickly to withstand competitive pressure and continue to operate economically in the market [2]. The starting points for this include continuous and radical innovation projects to offer new product features or make manufacturing processes and services more efficient. Particularly in manufacturing, selecting suitable projects and the structured planning and implementation of innovations pose challenges for companies [3]. As the framework conditions for manufacturing innovation projects (MIPs) tend to vary widely, the planning process has hardly been structured and methodically supported. However, planning methods and tools provide the basis for a structured and collaborative approach. Project roadmaps are a promising approach to support innovation planning [4]. They transfer collected information into a project structure with a tactical planning horizon to identify dependencies between work packages (WPs) and resources [5]. To date, few scientific approaches support the development of a tactical roadmap for MIPs. Therefore, the aim of this study is to develop an approach to derive a tactical project roadmap from an MIP using methods and tools that can be tailored to specific companies and applied in industry.

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2. Related literature

A structured literature review [6] was conducted to identify relevant planning approaches from innovation management and roadmapping. First, relevant search terms were defined, and search strings were created. The databases used for the research were the Technical University of Munich library, Scopus, and WISO. Three steps were taken to limit the search results when searching the databases. In the first step, the results were limited by year of publication (1950 - today), language (German, English), search terms, and subject areas (e.g., engineering and project management). In the second step, the search results were analysed, and the first irrelevant results were excluded by examining the title and abstract. The remaining literature was subjected to a full-text analysis and a forward and backward search [6], identifying 34 relevant sources. In the following, the basics and the most important approaches identified will be presented and categorised.

2.1 Manufacturing innovation management

Invention refers to the first technical implementation of an idea [7] and becomes an innovation when there is a concrete benefit or market diffusion [8]. Accordingly, an innovation in manufacturing is implementing an idea for a new manufacturing method or process that creates or redistributes value. Manufacturing innovation management (MIM) encompasses all planning, decision-making, organisational, and control tasks for generating and implementing manufacturing ideas [9]. The MIM process starts with innovation planning and continues with innovation development. The subsequent phases are innovation realisation and innovation experience [10]. Therefore, technology and change management are considered to overlap with MIM. Technology management is focused on identifying and developing technologies [11], while change management is the organisation of changes to a manufacturing system, including organisational and human-related aspects [12]. Manufacturing innovation planning is used at the strategic, tactical, and operative levels. At the tactical level, the planning aims to support production planning, resource management, and the identification of procedures [13]. Depending on the industry and product, this tactical horizon can range from a few months to a few years. Project management approaches divide tactical planning into four general steps [14]. The first step is always to collect information and identify requirements. This information is used in the second step to select and specify work content and to allocate resources. In the third step, dependencies are identified, and sequences are created. The results are documented in the fourth step for monitoring [14].

A project is essentially characterised by a defined start and end date, an objective, the involvement of several divisions, and complexity [15]. Following, a MIP is unique, targeted, interdisciplinary, complex, and creates or redistributes value through the development of methods, technologies, or organisational forms.

Within innovation, technology, and change management, scientific approaches support the planning and implementation of MIPs. Koch et al. [16] present a general process model for manufacturing change management and systematises possible reasons for change. However, the approach characterises the change process and does not provide methodological support for tactical planning. Plinta and Radwan [17] present a method for implementing MIPs and highlight the manufacturing innovation process and the fields of action. Nevertheless, the planning procedure is not considered in enough detail to support tactical planning. Schönmann et al. [18] present a method for the proactive management of manufacturing technologies based on an analysis and modeling of manufacturing-relevant cycles. The approach supports the identification of relevant planning domains, but not the analysis of interdependencies and the planning of WPs. Riesener et al. [19] present a concept for an implementation process for MIPs based on dependencies between influencing factors, objectives, and WPs. However, only the essential phases of the concept are presented, and an applicable method is not yet available. Brandl et al. [20] present a procedure for optimising the planning of MIPs, focusing on selecting suitable agile methods. Nevertheless, the procedure does not fully support the tactical planning phase, as no methods or tools for specifying WPs or dependencies are considered. Lu [14] presents a method for the stepwise management of MIPs by characterising the process phases and proposing methodological support. However, the approach provides no holistic combination of the individual methods for industrial application.

2.2 Roadmaps

Roadmaps are used in various strategic and tactical planning approaches to analyse, forecast, and visualise the future development paths of products, projects, and technologies [21]. Roadmaps can be categorised according to their planning horizon and type in product, technology, and project roadmaps focusing on operational, tactical, or strategic planning [22,13].

Several scientific approaches support roadmap development. Willyard and McClees [23] present an approach to combine information about a company's ideas, products, and technologies in a strategic roadmap. Machate [24] presents a process model for creating a product roadmap based on analysing the relevant external and internal influencing factors and provides software support for the individual steps. The approaches of Willyard and McClees [23] and Machate [24] focus on the strategic planning of products and therefore do not consider the relevant planning domains and resources required for the tactical planning of MIPs. Specht and Mieke [25] extend the scope of analysis and present a corporate network project roadmap that combines different MIPs and represents interdependencies. However, this approach does not support the planning of an individual project. Huang et al. [26] expand the scope of analysis and present an approach that considers the nation, the technology, the industry, the risks, and the impacts to derive technological developments and translate them into recommendations for action at the national level. The approaches of Specht and Mieke [25] and Huang et al. [27] also focus on strategic product and technology planning and are not applicable to the tactical planning of MIPs. Following Industry 5.0, Despeisse et al. [27] propose an approach to integrate sustainability into a roadmap by combining value analysis with product roadmaps.

2.3 Contribution beyond the state of research

The literature review identifies four fundamental shortcomings (*SCs*) in the current state of research on tactical MIP planning. Firstly, it became clear that existing planning approaches are primarily concerned with the planning of products and technologies, neglecting the relevant circumstances of MIPs, that include manufacturing planning domains and resources (*SC1*). Secondly, it emerged that most planning approaches focus on strategic planning and that tactical planning of MIPs is still insufficiently supported (*SC2*). Thirdly, the industrial application showed deficits, as either no concrete methods and tools are presented (*SC3*), or the industrial validation is insufficient (*SC4*). Table 1 shows the described approaches and summarises the deficits identified. Therefore, the contribution of the present study is to address these *SCs* and provide an industrially applicable approach to tactical planning for MIPs.

Table 1: Overview of the most relevant approaches from the state of the research and shortcomings

	Shortcoming Literature	Manufacturing and project focus (*SC1*)	Tactical point of view (*SC2*)	Methodological support (*SC3*)	Industrial applicability (*SC4*)
Innovation Management	Schönmann et al. [18]	-	✓	✓	✓
	Koch et al. [16]	-	✓	-	-
	Brandl et al. [20]	✓	-	✓	✓
	Riesener et al. [19]	✓	✓	-	-
	Plinta and Radwan [17]	-	✓	✓	-
	Lu [14]	-	✓	-	-
Roadmaps	Willyard and McClees [23]	-	-	✓	✓
	Specht and Mieke [25]	-	✓	✓	✓
	Machate [24]	-	-	-	✓
	Huang et al. [26]	-	-	✓	✓
	Despeisse et al. [27]	-	-	✓	-

3. Methodological approach

The development procedure for the approach to tactical planning for MIPs consists of three phases, as shown in Figure 1. In the first phase, the requirements for the approach were derived based on the *SCs* identified, and an initial list of applicable methods and tools was compiled through a literature search. In the second phase, the relevant methods and tools were selected according to the method of Hirsch et al. [28] and recombined using the method of Zanker [29]. In the third phase, the scientific procedure and the developed approach were verified in an expert workshop and through initial industrial application.

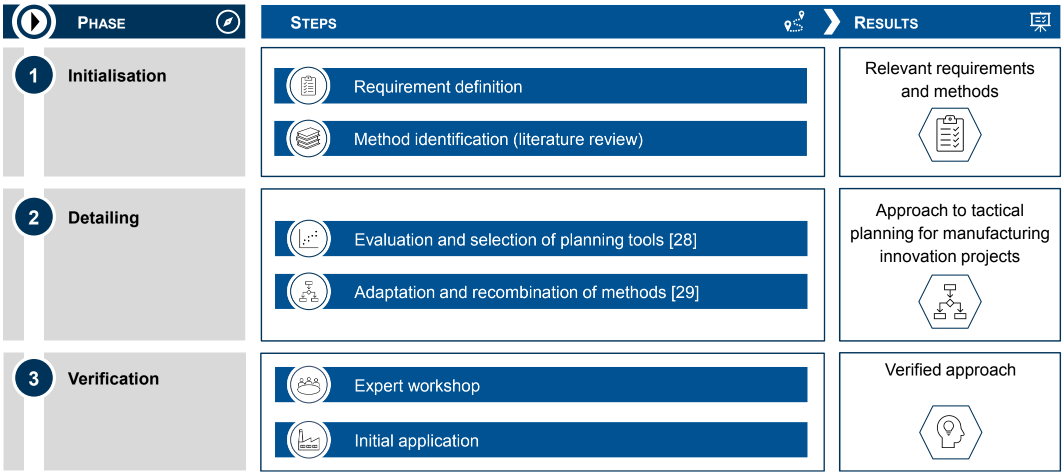

Figure 1: Scientific procedure for developing the approach to tactical planning for MIPs

3.1 Initialisation

The first step of the initialisation defines the requirements for the approach. The requirements consist of formal requirements, which ensure a qualitative and user-friendly application, and content requirements, which result from the *SCs* of the current state of research. According to Patzak [30], the formal requirements include empirical and formal correctness, relevance to purpose, and manageability.

In the second step, a literature search was conducted to identify the most relevant methods and tools to support tactical MIP planning. Methods are a rule-based and targeted sequence of activities to achieve a specific goal. Tools are aids that make the implementation of an activity more effective and efficient [31]. For this purpose, the databases mentioned in Section 2 were searched for publications on methods and tools, which identified more than 680 methods and tools, including duplicates from the publications by Eversheim [32], Strasser [33], Braun [34], Lindemann [35], VDI [36,37], Andler [38], Universities of Oldenburg and Vechta [39], Kraus and Westermann [40], and REFA [41].

3.2 Detailing

The objective of the second phase is to select and combine suitable methods and tools to derive a new approach, which meets the defined requirements. Therefore, the method presented by Hirsch et al. [28] for the selection of planning methods and tools was used in the first step.

To start the method, each process step is characterised based on complexity factors (*CFs*) proposed by Hirsch et al. [28]. The *CFs* include scope, dimensions, target areas, level of detail, disciplines involved, and data volume of the planning process. Here, the four steps of tactical MIP planning are considered: project analysis (*S1*), work content specification and resource allocation (*S2*), dependency analysis and sequencing (*S3*), and visualisation and analysis (*S4*). The *CFs* are assessed using a percentage scale, subdivided into five equally sized ranges, with 0% representing the lowest and 100% representing the highest level of each *CF*. The detailed evaluation results are shown in Table 2 in the Appendix. In the second step, a lower and an upper limit are defined for each *CF* and each process step (*S1* to *S4*), using the same percentage scale. In the third step, the methods and tools identified in the initialisation phase were evaluated concerning the same *CFs* as the first. Based on the evaluation results and the defined upper and lower limits of the *CFs* for every planning phase, a pre-selection of relevant methods and tools was made by excluding those whose complexity was outside the boundaries. This way, the number of suitable methods and tools was reduced to 28. In the fourth step of the method, the effort required to apply the remaining 28 methods and tools was assessed using the evaluation criteria proposed by Hirsch et al. [28]: expertise, investment, method experience, organisational effort, and required input data quality. The evaluation was carried out using the percentage scale already presented. Detailed evaluation results are shown in Table 3 in the Appendix. In the fifth step, the final decision on using the methods and tools was prepared by plotting the relevant methods and tools on a graph with the method and tool effort on the y-axis and the complexity of the associated process steps on the x-axis. As Hirsch et al. [28] propose, three zones can be identified within the portfolio, with zones two and three being the target area. Figure 2 shows the results of the method.

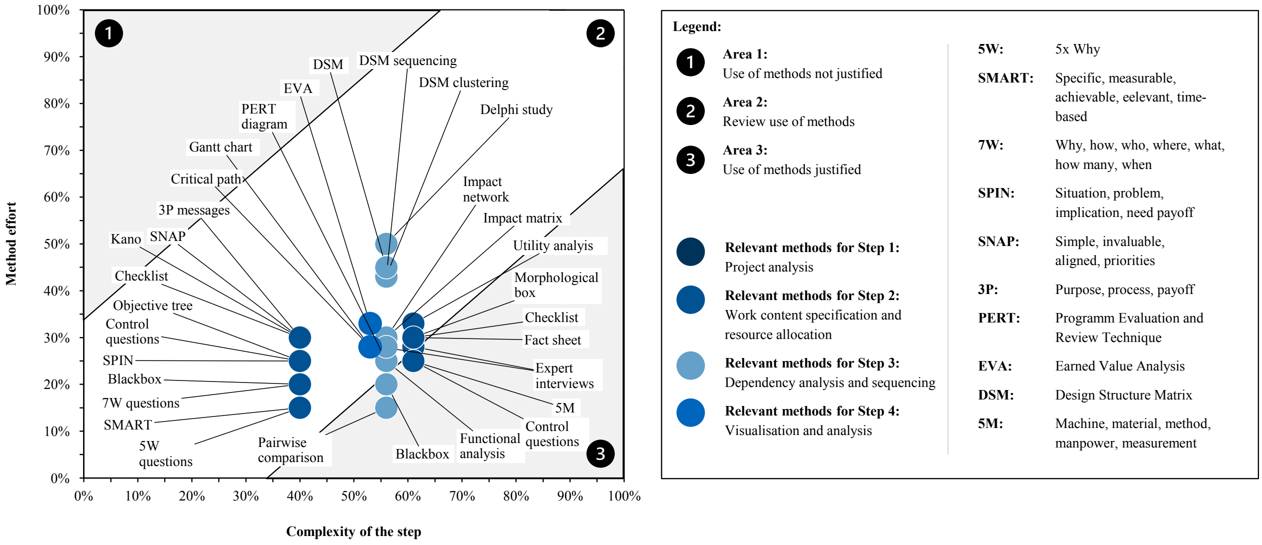

Figure 2: Results of the method from Hirsch et al. [28] for the selection of planning methods and tools

After the structured identification and evaluation of the relevant methods and tools, the approach from Zanker [29] was used to combine these. In the first step, the suitable methods and tools are assigned to the primary activities defined by Zanker [29]. The desired primary activities are then assigned to the individual process steps of the planning approach (*S1* to *S4*). For example, the first step of the planning approach (*S1*) requires the following basic activities defined by Zanker [29]: identify, collect, structure, break down, describe, and document. An allocation of the primary activities to the process steps *S1* to *S4* is shown in Table 4 in the Appendix. Subsequently, it is thus possible to cover the desired primary activities of the new approach by combining methods and tools and their primary activities. Various possible combinations of methods and tools were analysed according to the trial-and-error principle.

Consequently, the methods and tools that successfully fulfilled the primary activities in their combination were selected. For *S1*, the methods SPIN [38], 7W questions [42], SMART [43], control questions [44], and the tool checklist [35] were combined. To support *S2*, the methods of semi-structured expert interviews [45], control questions, and 5M [36] and the tools checklist and fact sheet [46] were combined. The methods Design Structure Matrix (DSM) [47], semi-structured expert interviews, DSM sequencing [48], and DSM clustering [48] and the tool Program Evaluation and Review Technique (PERT) diagram [49] were combined to support *S3*. For *S4*, the critical path method [50] and the tools Gantt chart [51] and Earned Value Analysis (EVA) [52] were combined. A short description of the selected methods and tools can be found in Table 5 in the Appendix.

4. Approach to tactical planning for manufacturing innovation projects

The tactical planning approach of MIPs combines the identified methods and tools into an overall methodology. The approach is illustrated in Figure 3 using Business Process Model and Notation (BPMN).

4.1 Step 1: Project analysis

The situation questions of the SPIN method are combined with control questions and the checklists tool to gather general information, like the company size, location, type of production, and the production principle. For the analysis of the initial situation, the SPIN method's problem questions are combined with the 7W questions. With this, only five questions are utilised to identify the problem and when, how, why, and where it arose. Additionally, the SMART method is used to analyse project objectives according to the seven potential categories presented by Gärtner et al. [53]. This way, project objectives regarding cost, quality, time, changeability, social, environment, and strategy are captured according to the SMART method.

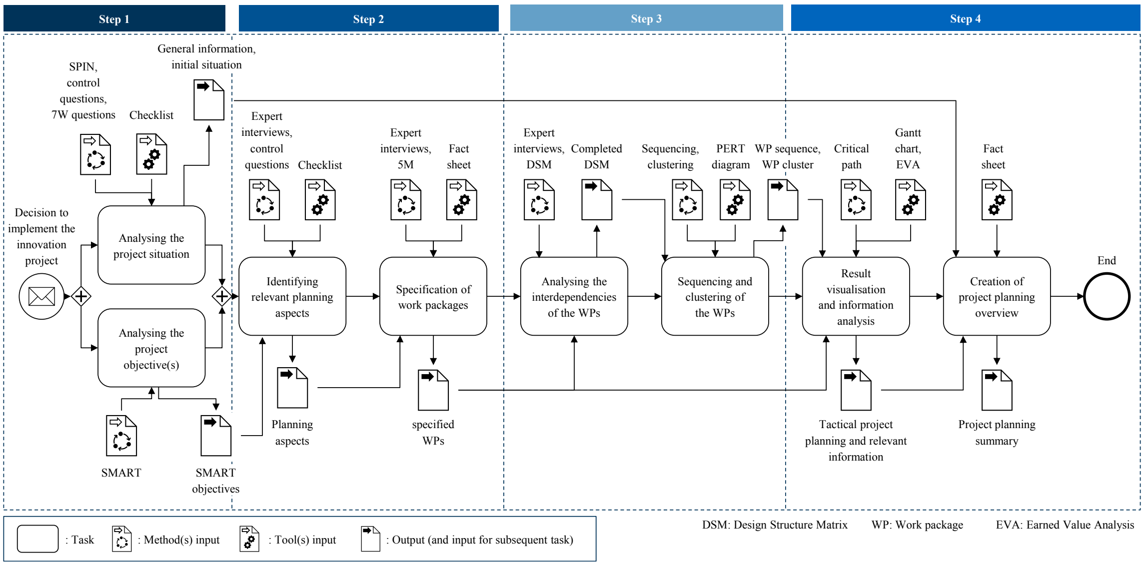

Figure 3: Overview of the approach to tactical planning for MIPs in BPMN

4.2 Step 2: Work content specification and resource allocation

The second step begins with selecting planning dimensions for each previously defined objective. The selection is done in three steps. First, the relevant planning dimensions are assigned to the objectives identified in the first step using control questions in combination with semi-structured expert interviews. In the second step, the relevant planning areas are determined using the checklist tool in combination with semi-structured expert interviews. In the third step, these planning areas are detailed using the same procedure to derive the relevant planning aspects. This approach utilises the systematisation of planning dimensions for MIPs by Gärtner et al. [54]. However, other company- or industry-specific systematisations can be utilised. Then, the identified planning aspects are specified using fact sheets as tools and the semi-structured expert interview method. First, in expert interviews, the required WPs are derived from the fact sheets for the planning aspects provided by Gärtner et al. [54]. Subsequently, the necessary information to describe a WP is systematically collected through semi-structured expert interviews and documented in the WP fact sheet. The description includes the tasks, the objectives, the activities, and the resources required. Here, the 5M method is applied to specify the necessary resources. Figure 4 shows a schematic illustration of the WP specification.

4.3 Step 3: Dependency analysis and sequencing

At the beginning of the third step, the DSM is applied in combination with semi-structured expert interviews. In the DSM, the WPs identified in the second step are entered symmetrically to the main diagonal. By placing crosses, the dependencies between the WPs are systematically identified within semi-structured expert interviews. The reading direction is from column to row, i.e., the required input for a WP in a row is in the column where the cross is placed. The rules presented by Eppinger & Bowning [48] must be followed to avoid loops. Once all dependencies between WPs have been marked, WPs that do not have any dependencies are removed from the DSM to focus on the dependent WPs first. Subsequently, the DSM Sequencing method is used, which brings the crosses as close as possible to the main diagonal by swapping rows and columns. The resulting matrix can then be analysed [48] to obtain a PERT diagram showing the interdependencies between the WPs. Subsequently, the previously excluded WPs are added to the DSM matrix again, and all previously identified dependencies are removed. The remaining WPs are then analysed for content-wise relationships to other WPs using the same methods as explained previously. Following this, the DSM Clustering method is applied [48]. Areas of high correspondence are formed, and these WPs are placed as close as possible to their corresponding WPs in the previously created PERT diagram. Figure 4 shows an exemplary DSM and PERT diagram.

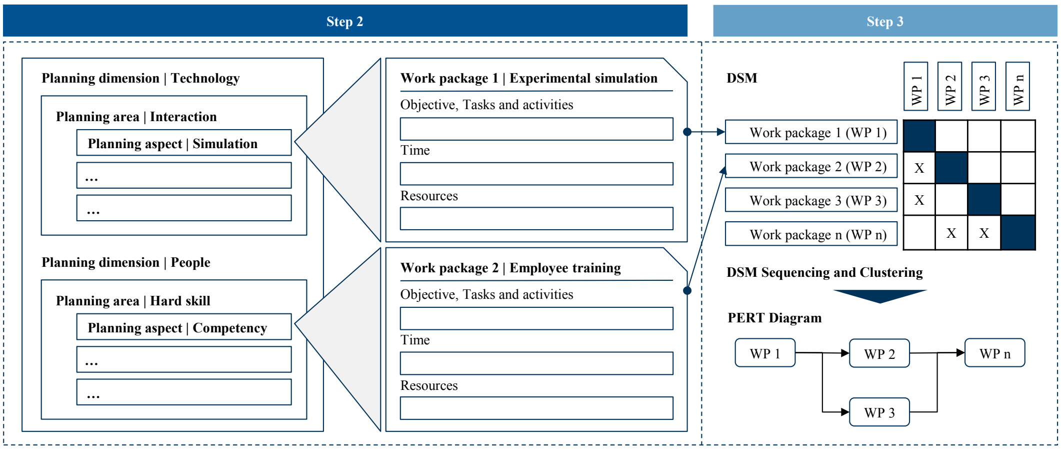

Figure 4: Schematic specification of the WPs and the derivation of the PERT diagram

4.4 Step 4: Visualisation and analysis

The fourth step is supported by the Gantt chart tool, which transfers the elaborated PERT diagram to a bar chart. The duration of the WPs can be taken from the WPs' fact sheets. Subsequently, the critical path method is applied, identifying the WP sequence with the shortest buffer times between the individual WPs that influence the total duration of the MIP. The project cost or actual cost (AC) calculation from the EVA tool can be used in parallel with creating the Gantt chart. The costs for personnel, machinery, materials and energy, knowledge, and other costs from the WP fact sheets are considered. The AC can be estimated based on an accumulation of the WP costs throughout the project. Finally, a fact sheet summarises the essential information generated while applying the planning approach, including a project description, the project objectives, the Gantt chart, information on resources, and the relevant planning aspects. The project fact sheet can be handed over to operational planning and utilised for MIP controlling.

5. Verification and initial application

The approach was verified in two steps. In the first step, a workshop was held with scientific employees from a production engineering research institute to verify the scientific approach and the results obtained. In the second step, the developed approach was applied industrially.

The workshop was held with ten scientific employees from the research areas of data analytics, lean manufacturing, human in manufacturing, remanufacturing, and change management and was structured into three sections. In the first section, the relevant terms were defined, and the objectives of the research work and workshop objectives were clarified. The second section presented the individual phases of the scientific approach and the results, as explained in detail in Section 3. The third section was used to discuss the procedure and the results. The general scientific approach was reviewed, and the *CF*'s assessment of individual methods and tools was discussed again. It was suggested that unique methods and tools should be presented in the portfolio rather than in groups. Subsequently, the feedback from the workshop was summarised and incorporated into the results.

The industrial application was carried out in collaboration with a large aerospace manufacturing company. The MIP tactical planning approach was applied throughout two expert interviews with one project manager. The project aims to implement a multi-product assembly flowline to reduce costs by 10%, tied-up capital by 25%, and lead times by 30%. Data, interaction, process capability, assistance systems, process organisation and methodological competence were considered within the planning areas, and 35 individual WPs were derived. The software tool Cambridge Advance Modeller II was utilised for dependency analysis and evaluation of the derived DSM. Based on the expert interviews and the evaluation results, a project fact sheet was created (see Appendix, Figure 5), which was then discussed with the project manager to review the fulfillment of the requirements. According to the expert, the formal requirements of empirical and formal correctness are met because the approach structure contains no contradictions. The requirement for purposefulness is also met by the goal-oriented structure of the approach and the further processing of the results of each step. Manageability is also considered to be met as the approach utilises understandable methods and tools and provides guidance through a BPMN model. Regarding the content requirements, the expert stated that the proposed approach was tailored to manufacturing and focused on MIPs by considering planning domains and resources relevant to manufacturing, thus fulfilling *SC1*. In addition, the fact sheet provided all the necessary information for tactical planning, including dependencies, relevant resources, and a timeline, thus satisfying *SC2*. Concerning *SC3* and *SC4*, the expert stated that the industrial applicability of the approach could be improved by individualising the process and further exploring available digital tools, and by applying the approach in other industries, so that *SC3* and *SC4* were not fully met.

6. Conclusion and future research

Manufacturing companies face various challenges and must adapt their products and processes in ever shorter cycles to remain successful in the marketplace. As a result, MIPs need to be planned and implemented at ever shorter intervals. Structured and systematic MIP planning is essential for efficient and successful project implementation. However, no adequate approaches support tactical MIP planning methodically. In this study, suitable methods for the relevant planning steps were identified, evaluated, and combined into an overall approach. The comprehensive approach was then verified and applied industrially. In this way, the main objective of the research work was achieved by developing methodological support for tactical project planning that is tailored to the manufacturing context and the selected planning horizon and can be applied industrially. The formal and content requirements were challenged during the verification process.

However, three starting points for further research were identified throughout the study. First, an extension of the planning approach should allow for a company-specific adaptation of the planning process. This could be done by further detailing the four work steps and identifying other applicable methods and tools so that companies can tailor the level of detail and tools applied. Secondly, external influencing factors could be incorporated into the tactical MIP through additional process steps or methods to gather specific information relevant to the MIP planning. In a third step, the industrial application could be extended to other companies and sectors to demonstrate its full applicability and identify additional starting points for further research opportunities.

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Appendix

Table 2: Determination of complexity factors for the process steps *S1* to *S4*

Process step Complexity factors	*S1*: Project analysis	*S2*: Work content specification	*S3*: Dependency analysis	*S4*: Visualisation and analysis
Scope	60%	60%	60%	40%
Dimensions	20%	60%	40%	40%
Target areas	80%	100%	100%	60%
Level of detail	20%	50%	80%	80%
Disciplines involved	40%	40%	40%	40%
Processed data volume	20%	60%	20%	60%
Avg. complexity	40%	62%	57%	53%

Table 3: Evaluation results of the relevant tools and methods according to the approach of Hirsch et al. [28]

Criteria Tools and methods	Expertise	Invest-ment	Method experience	Organisational effort	Input data quality	Avg. complexity
SMART	25%	0%	0%	0%	50%	15%
5W	25%	0%	25%	0%	25%	15%
7W questions	50%	0%	25%	0%	25%	20%
Kano	50%	0%	25%	25%	50%	30%
SPIN	50%	0%	25%	0%	50%	25%
Control questions	75%	0%	25%	0%	25%	25%
Expert interviews	50%	15%	50%	25%	0%	28%
5M	50%	0%	25%	0%	50%	25%
Morpholog. box	75%	0%	25%	0%	50%	30%
Utility analysis	50%	15%	25%	25%	50%	28%
Fact sheet	25%	0%	25%	25%	75%	30%
Pairwise comp.	25%	0%	25%	25%	0%	15%
PERT diagram	25%	0%	25%	25%	50%	25%
Funct. analysis	50%	0%	25%	25%	25%	25%
Impact matrix	75%	0%	25%	25%	25%	30%
Impact network	75%	0%	25%	25%	25%	30%
DSM	75%	0%	50%	25%	75%	45%
Sequencing	50%	15%	50%	25%	75%	43%
Clustering	50%	15%	50%	25%	75%	43%
Delphi study	75%	0%	50%	75%	50%	50%
Critical path	50%	15%	0%	25%	50%	28%
Gantt chart	25%	15%	25%	25%	50%	28%
EVA	50%	15%	25%	25%	50%	33%
Blackbox	50%	0%	0%	25%	25%	20%
Checklist	75%	0%	25%	0%	50%	30%
Objective tree	50%	0%	25%	0%	50%	25%

Table 3 cont.

Criteria Tools and methods	Expertise	Investment	Method experience	Organisational effort	Input data quality	Avg. complexity
3P messages	50%	0%	25%	0%	75%	30%
SNAP	50%	0%	25%	25%	50%	30%

Table 4: Assignment of the basic activities according to Zanker [29] to the process steps *S1* to *S4*

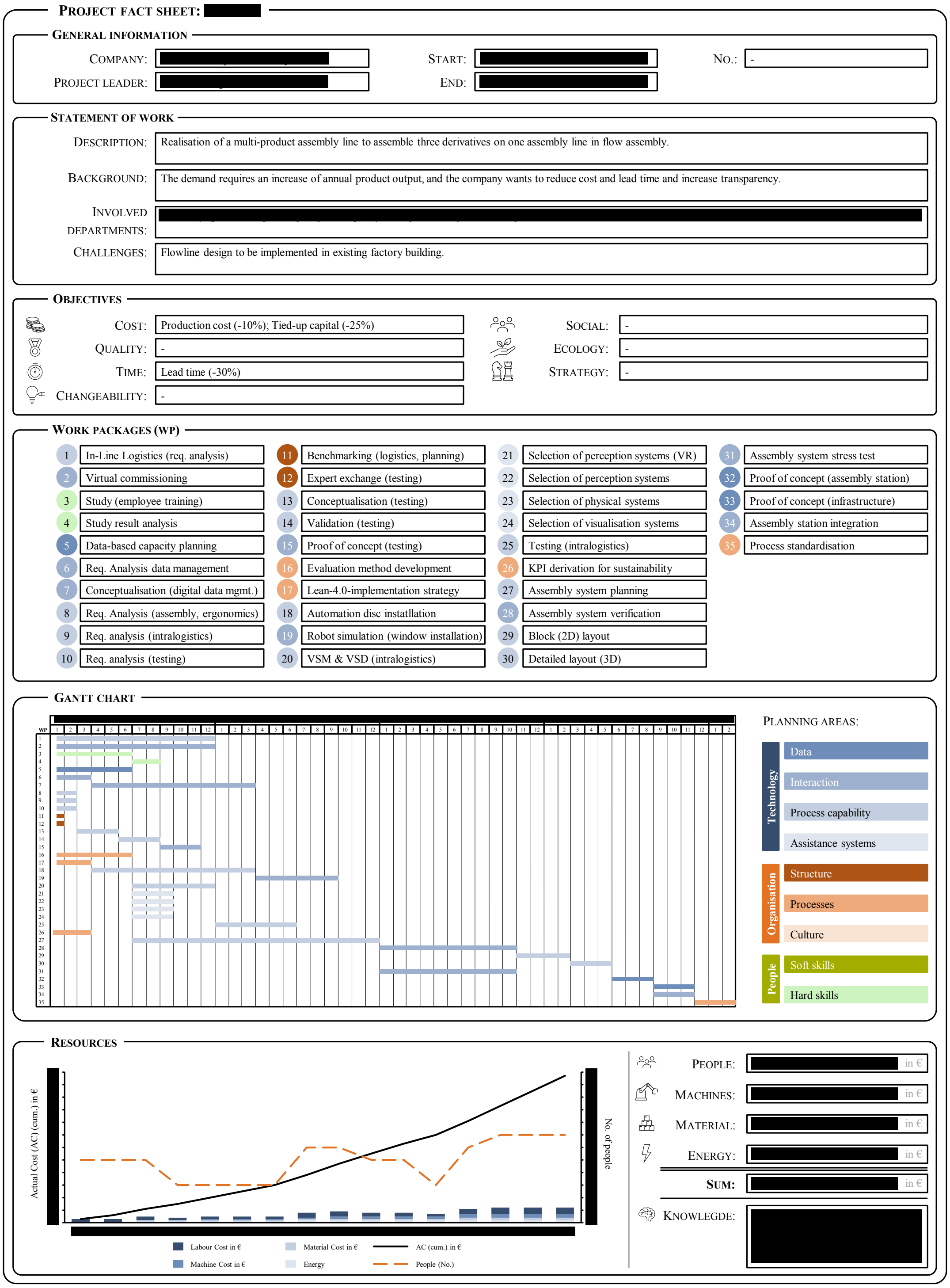
Steps Basic activities	*S1*: Project analysis	*S2*: Work content specification	*S3*: Dependency analysis	*S4*: Visualisation and analysis
Identify	✓	✓	✓	-
Search		✓	-	-
Collect	✓	✓	-	-
Structure	✓	✓	✓	✓
Break down	✓	✓	-	
Put into relation	-	-	✓	✓
Calculate	-	-	-	✓
Create	-	-	-	✓
Combine	-	-	✓	-
Evaluate	-	-	-	✓
Set	-	-	✓	-
Inform	-	-	-	✓
Display	-	-	✓	✓
Describe	✓	✓	-	-
Document	✓	✓	-	-

Table 5: Short description of selected methods and tools

Method	Short description
SPIN	The method aims to elicit specific information by asking questions about the situation, the problem, the impact, and the benefit. [38]
7W questions	The method aims to get understanding of a situation by asking questions about the why, the how, the who, the where, the what, the how much and the when. [42]
SMART	The method makes it possible to formulate goals in such a way that they are specific, measurable, attractive, realistic, and time-based. [43]
Control questions	Control questions are specific open-ended questions that cannot be answered with yes or no to obtain specific information from a particular source. [44]
Checklist	Checklists allow questions to be asked in a specific order and structured information to be obtained through pre-defined response options. [35]
Semi-structured expert interviews	Semi-structured expert interviews are systematised interviews with experts that aim to gather comprehensive expert knowledge using a guideline. However, the interviewer has the flexibility to improvise follow-up questions based on the interviewee's answers. [45]

Table 5 cont.

Method	Short description
5M	The 5M method helps to find the cause of a problem by structuring the relevant resources into machine, material, method, manpower and measurement. [36]
Fact sheet	Fact sheets help to present information in a structured way by providing a standardised format and a structured arrangement of information. [46]
Design Structure Matrix	The DSM helps to structure complex systems by representing all relevant elements of a system in a matrix and identifying and analysing their relationships. [47]
DSM clustering	DSM clustering is a method for analysing the relationships between system elements in a DSM. The aim is to group system elements that have many interdependencies. [48]
DSM sequencing	DSM sequencing is a method for analysing the dependencies between system elements in a DSM. It attempts to create a linear process flow based on the dependencies of the system elements. [48]
PERT diagram	A PERT diagram shows the content dependencies of activities and specifies individual content, such as the resources required. [49]
Critical path	The critical path represents the longest sequence of activities that must be completed on time for the overall project to be completed successfully. [50]
Gantt chart	In a Gantt chart, the sequence of activities is plotted on a time axis and the content dependencies are shown. [51]
Earned Value Analysis	EVA shows the planned and actual value of a project against the actual costs incurred over time. [52]



PROJECT FACT SHEET: [redacted]

GENERAL INFORMATION

COMPANY: [redacted]
PROJECT LEADER: [redacted]
START: [redacted]
END: [redacted]
NO.: -

STATEMENT OF WORK

DESCRIPTION: Realisation of a multi-product assembly line to assemble three derivatives on one assembly line in flow assembly.
BACKGROUND: The demand requires an increase of annual product output, and the company wants to reduce cost and lead time and increase transparency.
INVOLVED DEPARTMENTS: [redacted]
CHALLENGES: Flowline design to be implemented in existing factory building.

OBJECTIVES

COST: Production cost (-10%); Tied-up capital (-25%)
QUALITY: -
TIME: Lead time (-30%)
CHANGEABILITY: -
SOCIAL: -
ECOLOGY: -
STRATEGY: -

WORK PACKAGES (WP)

1 In-Line Logistics (req. analysis)
2 Virtual commissioning
3 Study (employee training)
4 Study result analysis
5 Data-based capacity planning
6 Req. Analysis data management
7 Conceptualisation (digital data mgmt.)
8 Req. Analysis (assembly, ergonomics)
9 Req. analysis (intralogistics)
10 Req. analysis (testing)
11 Benchmarking (logistics, planning)
12 Expert exchange (testing)
13 Conceptualisation (testing)
14 Validation (testing)
15 Proof of concept (testing)
16 Evaluation method development
17 Lean-4.0-implementation strategy
18 Automation disc installation
19 Robot simulation (window installation)
20 VSM & VSD (intralogistics)
21 Selection of perception systems (VR)
22 Selection of perception systems
23 Selection of physical systems
24 Selection of visualisation systems
25 Testing (intralogistics)
26 KPI derivation for sustainability
27 Assembly system planning
28 Assembly system verification
29 Block (2D) layout
30 Detailed layout (3D)
31 Assembly system stress test
32 Proof of concept (assembly station)
33 Proof of concept (infrastructure)
34 Assembly station integration
35 Process standardisation

GANTT CHART

PLANNING AREAS:

Technology: Data; Interaction; Process capability; Assistance systems
Organisation: Structure; Processes; Culture
People: Soft skills; Hard skills

RESOURCES

PEOPLE: [redacted] in €
MACHINES: [redacted] in €
MATERIAL: [redacted] in €
ENERGY: [redacted] in €
SUM: [redacted] in €
KNOWLEGDE: [redacted]

Figure 5: Anonymised fact sheet of the industrial application of the approach to tactical planning for MIPs

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