Faculty of Behavioural, Management and Social Sciences

BSc. Industrial Engineering & Management

Realigning the tactical- and operational information systems within Gietart Kaltenbach

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S2092042

Bachelor thesis Industrial Engineering and Management

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Preface

Dear reader,

In front of you lies my bachelor thesis 'Realigning the tactical- and operational information systems within Gietart Kaltenbach'. This research was conducted for Gietart Kaltenbach between September 2021 and February 2022. During this research I got support from a number of people I would like to take the opportunity in the preface to thank them.

First, I would like to thank Gietart Kaltenbach for the challenging assignment they offered me and the opportunity to come to the company during these extraordinary circumstances. Foremost, I would like to thank my supervisor Stefan Kok who guided me through this research at Gietart. Without his input and directions, the results in this report would not have been there.

In addition, I would like to thank Patricia Rogetzer, my first supervisor of the university for her engagement and the extensive feedback she provided me, which improved the quality of this thesis a lot. It was nice working with you! Next to this, I want to thank Wouter van Heeswijk, my second supervisor for his critical feedback to improve and assess the quality of this report.

Also, a special thanks to Mick van Diermen, my buddy during this research. Thanks for the support and reflection during the time we spent at Gietart.

I sincerely hope that you enjoy reading this report, and it generates new insights about planning management within project-oriented organizations.

Kind regards,

Fleur Veenman
Enschede, February 2022

Management summary
The reason behind this research is the lack of alignment between the tactical and operational information systems (MS Project, MS Excel and BaaN) which are used as support for planning within Gietart Kaltenbach. This alignment will be explained by means of illustrative examples. For an encompassed solution design on the alignment, we investigated parameters and limitations within the planning process within project-oriented organizations, which Gietart is, to prevent disturbances on the technical- and user side by adjustments in the current methodology. The impact of the 'lack' reflects on inaccurate indications on both planning levels because the information at tactical level is the input for the planning at operational level and vice versa.

The goal of this research is to provide a realigned design for planning support such that performance of projects can be better monitored and controlled, which is an aid to create an increase in organizational performance. Therefore, we redefined the objectives of tactical- and operational planning in an appropriate hierarchical framework for project-oriented organizations, to provide unambiguous expectations of the output of the planning levels and so create realistic input. This thesis answers thereby the following research question:

"How can tactical and operational information systems be better aligned within Gietart Kaltenbach to generate accurate output that can be monitored and controlled for improved production performance?"

Therefore, those conditions were important to achieve tactical- and operational objectives:

Conditions	Explanation
Transparency	The planning must be clear to all stakeholders. Their understanding is important for good steering of the whole process from engineering to expedition. Mistakes based on wrong interpretations needs to be prevented.
Progress determination	Keeping track of the progress of the modules, Production Orders (POs) and components is valuable information for the management team, operation manager, production manager and the sales department regarding the budget and new incoming orders. Those insights should be provided by the planning for evaluation and determination of (possible) follow-up actions.
Cost control	Deviations in the reported- compared to the scheduled hours must be traceable for the control process such that future schedules can be prevented from the same failure. Next to this, the ERP system should be fed with correct data to generate an independent calculation from the system in the future, this makes the planning process less dependent on human.
Structure	A standard structure should be formulated which is repeatedly usable within planning management. Next to this, due to the multiple projects which are produced in parallel with finite resources and capacity, the planner needs to be aware of interdependencies between activities within modules to be able to optimal deploy the resources.

Table 1, Conditions set by planning management

Method
We started with an analysis of the current situation within Gietart and investigating the possibilities of system alignment and qualifications of project management within project-oriented organizations. Based on literature studies we examined how we could align the information transfer between the information systems and create a stepwise approach to implement adjustments in the current planning methodology. Here a trade-off has been made between the complexity of the used systems, effort on the user- and the technical side.

Conclusion
The use of different information systems complicated the information transfer between the information systems and thereby the monitor and control phase of the planning levels. MS Project did not offer an environment in which the conditions (Table 1) could be covered or alignment with the Enterprise Resource Planning (ERP) system, but through a conversion of the used information systems, we achieved a better alignment. This conversion we created, saves costs in time and the costs of an 'extra' information system itself. To realize this conversion, we designed a repeatedly usable tactical format where the functionalities of MS Project are included in MS Excel. The designed format simplifies the process on the technical- and the user side by having all functionalities in one information system for controlling the planning process. Furthermore, we have explored additional possibilities in this thesis to make the process more transparent for stakeholders. For instance, by applying consistency and structure in the tactical planning such that visualizations of the department occupation and workload is obtained. In addition, we created a Gantt-chart model in MS Excel for a multi-project view of the active and ongoing projects that are scheduled to provide insights into the dependence and variation between projects.

Recommendations
To generate more accurate data and a better information transfer between the planning levels, we recommend excluding the information system MS Project from the planning process and to use the information system MS Excel for scheduling on tactical- and operational level, where the additive support of BaaN on operational level for the routing of the activities and material planning is required. MS Excel provides extra visualization options for transparency and additional information in the decision-making process through our redesigned planning format. The elimination from MS Project limits the information transfer between the information systems and thereby the planning levels to two systems for a decrease in motions and defects along the information transfer.

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Chapter 1
In this chapter we give a short introduction on the company where this research is conducted and will we explain why this research has been set-up. Furthermore, we will discuss why this problem has influence on the organizational performance, what our goal is and which research methodology we are going to apply to achieve the goal.

Chapter 2
In this chapter we dive deeper in the current situation of this organization, to explore their operations processes and remark important parameters within their planning environment to discover an appropriate solution design which can integrate within their current environment.

Chapter 3.
Literature studies to express principles for improved production performance within project-oriented organizations and clarify the added-value of the realigned methodology is elaborated on in this chapter. Hereby, we try to envision the complexity of the planning within this kind of organizations and explain how the solution model provides indicators for added-value to prevent defects within the planning environment.

Chapter 4
The steps made towards a new planning environment are in this chapter substantiated and reinforced by visualizations. Next to this, the overall findings and how those contributes to a better alignment between the information systems are presented.

Chapter 5
Furthermore, adjustments in the current methodology requires adjustment in the way people are working. Therefore, we present a solution for an implementation of the design, other proposals within the planning environment and an illustration of the impact on the organizational performance.

Chapter 6
The conclusions and some appropriate recommendations for the company together with the limitations of this research are presented in this chapter.

List of abbreviations and definitions

Definition	Explanation
BaaN	The ERP system used within Gietart Kaltenbach.
BOM	Bill Of Material
CAD	Computer-Aided Design, Designing 2D and 3D structures using computer programs.
CODP	Customer Order Decoupling point
CPM	Critical pad method
ERP	Enterprise Resource Planning
ETO	Engineer-to-order
FTE	Full-time equivalent
HH	High dependency, High variability
JIT	Just In Time
KPI	Key Performance Indicator
MCDA	Multi Criteria Decision Analysis
MS Excel	Microsoft Excel
MS Project	Microsoft Projects
4M	Men, Material, Machine, Method
MRP	Material Requirement Planning
MS	Microsoft
MPSM	Solving Managerial Problems Systematically
MTO	Make-to-order
MTS	Make-to-stock
OEE	Overall Equipment Effectiveness
PDCA	Plan, Do, Check Act
PERT	Program Evaluation Review Technique
PO	Production Order, Contains information about the item being produced, the quantity and the planned finish date in combination with the materials and processes required.
PRP	Project Requirement Planning
Routing	The sequence of the activities in operations.
SIC	Statistical Inventory Control (stock production)
SMART	Simple Multi Attribute Rating Technique
SWOT	Strength, Weakness, Opportunities, Threats
WBS	Work Breakdown Structure

Table 2, List of abbreviations and definitions

Chapter 1: Introduction

This chapter provides a general introduction to the research. A brief description of the company of this research, Gietart Kaltenbach, is given in Section 1.1. In Section 1.2 the investigated problem is described and will be elaborated, resulting in an all-encompassing core problem. In Section 1.3 the problem-solving approach in relation to the current environment is plotted against the aim of the research. In order to arrive at a well-founded solution, the research has been set out step-by-step by several sub questions that elaborate on the method used to answer the research question in Section 1.4. Finally, the deliverables of this research are described in Section 1.5.

1.1 Gietart Kaltenbach

Gietart Kaltenbach (in this document further referred to as Gietart) is a subsidiary of company Kaltenbach. The Kaltenbach Group consists of two production locations: Lörrach Germany and Gietart Hengelo. The production location in Hengelo has approximately 20,000 m^2 of working space and around 80 employees. At this production location, Gietart is responsible for designing, producing and engineering several types of shotblasting machines for steel service treatment (Figure 1). This treatment entails removing the unwanted corrosion and the metallic waste on finished goods (SIkka, 2021). Gietart is a project-oriented organization. A wide range of shotblasting machines is produced in Hengelo and a customer-specific solution is built upon request (Kaltenbach, 2021).

Figure 1, shotblasting machine design by Gietart (Kaltenbach, 2021)

The customer-specific shot blasting machines are produced on a project basis and therefore a project in this report can be read as producing one shotblasting machine specifically for a customer. Gietart has been in a transition phase from 80% Make To Stock (MTS) production in combination with 20% Engineer To Order (ETO) to 80% Configure To Order (CTO) in combination with 20% ETO, a transition is made to smart customization (Nonhof, 2021). Smart customization entails that every customer is free to configure a machine according to their wishes. Several options are defined by the sales department like the number of roller tracks, the number of doors and an additional brush or blower. Because each blasting machine is unique, with different options, the planning process becomes more complicated and the productivity of the operations will therefore more than before be the result of correct planning.

1.2 Problem identification

Right now, the quality of planning management within Gietart is low. The planning is only recorded at a high abstraction level (e.g., in MS Excel or MS project) and is dependent on human expertise (intuition). There is a lack of insight into the workload of a particular week and it is ambiguous how many hours are spent in the end of production. Gietart wants to improve the quality of the planning and thus a planning method which reduces system complexity on the user- and technical side, data provision which support them to react in time, to prevent the process from unnecessary delays. The planning should deliver output to monitor and control the project to increase proactive decisiveness.

Gietart wants to be able to respond better to upcoming orders. Interpreting a planning schedule and benchmarking those from multiple projects is difficult with the current information provision. The in- and output of the planning should be structured for clear expectations and an independent methodology from human intuition is necessary for a reliable benchmark mechanism.

The overall planning within an organization is always constructed in three layers, see Figure 2, where the strategic level is not in scope for this research. By examining the tactical- and operational planning method of Gietart was striking that the tactical planning was already drawn in details based on human intuition to determine the lead time of a project. The operational planning was further examined based on the data in the tactical planning. The operational planning was used to assign the employees based on available resources to project components from day-to-day (instead of on measurable activities), see Appendix B for display of the operational planning format within Gietart.

The disturbance in the alignment between tactical and operational planning (information transfer) can be seen as a 'communication black box'. There is no comprehensive alignment due to the parallel running of the used information systems. An alignment between the systems could help clarifying this black box and smoothening the information transfer between the levels resulting in higher quality of planning management (Samek et al., 2019).

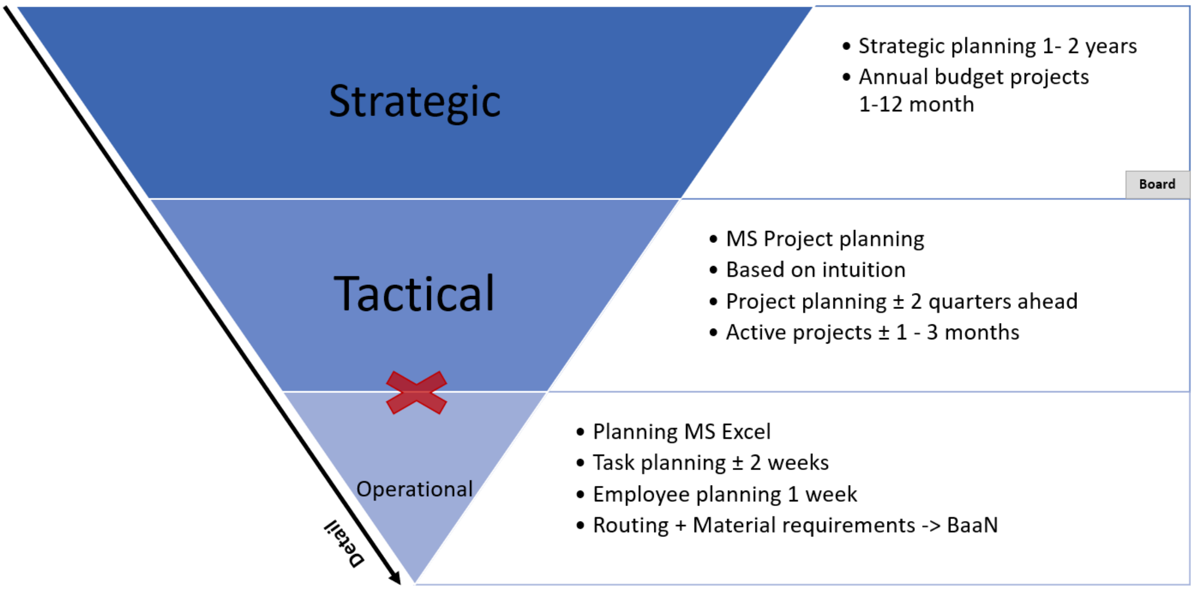

Figure 2, Composition overall planning Gietart, where X denotes the communication 'blackblox' between tactical and operational information systems.

1.2.1 Reason for research

As mentioned, Gietart has been in a reorganization, whereby processes are continuously examined, adapted and improved. Responding quickly and easily so that services match the changing technologies, and matching customers need, is important. Having a dynamic planning environment which provides correct indications contributes to a higher quality of service.

1.2.2 Problem statement.

Figure 3, shows a problem cluster to visualize the impact/consequences of the indicated problems on each other.

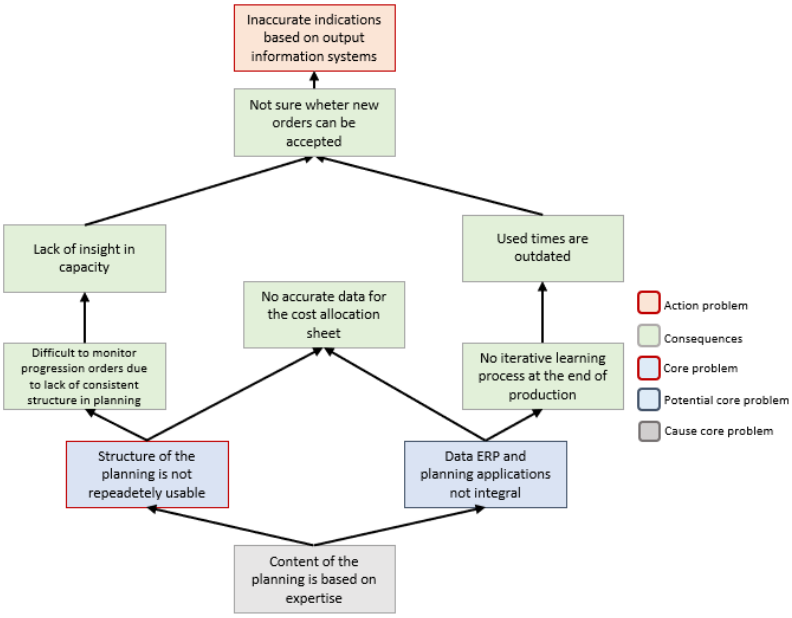

Figure 3, Problem cluster

The cause of the core problem(s) is that the content of the planning is based on expertise (intuition). This results in <u>two</u> potential core problems. The first one is that the data of the ERP system and the planning applications are not integral. The next one is that there is no clear structure between tactical- and operational planning. This research will focus on the problem to find a way to align tactical- and operation information systems which are used for the support of the planning. Thereby, a clear structure of tactical- and operational planning is the core for a repeatedly usable solution and the ability to monitor progression of the projects.

The tactical planning within Gietart does center on the determining the total throughput time of a project, where the tactical planning within Gietart is so detailed that it also serves as an operational planning as described in Section 2.1. The structure of the composition is not transparent to others than the planner himself who draws-up the planning because it is enfolded based on his intuition. In supply chain management, the planning levels need to be distinguished depending on the time horizon. Midterm decisions are related to tactical level, which includes the tactics to achieve the *strategy* set at (strategic level) and short-term decisions are done in operational level which includes the operations that needs to be executed to achieve the *tactic* at tactical level as efficiently as possible. The relative importance of these decision levels can be different from one company to another, but the vision, objectives and expectations of the <u>tactics</u> and the <u>operations</u> needs to be clear for qualitative planning management (Bender et al., 2002). The better the objectives are drawn up, the easier it is to keep an overview of what your organization actually 'must do' to achieve the goal. This raises various questions about the current planning within the organization because there are no clear objectives/indicators set for the tactical planning to provide some transparency for stakeholders and the interests of operational level are already processed in the tactical planning what reduces the decisiveness related to tactical scope. However, it is important that the quality of the information that is reinforced from the tactical planning is good because the material supply runs through the ERP system and the input for the ERP system concerning material planning is deduced from the tactical planning such that the materials can be delivered on time and inventories can be kept low.

Due to lack of structure and transparency between the tactical- and operational planning there also arises difficulties in monitoring the progress of projects, which in turn makes it is hard to indicate the available capacity over longer term (i.e. one or two months for tactical planning). Therefore, it is difficult making a good capacity planning across projects because there is a lack of validated data and consistent structure in the planning. This may result in a wrong exploitation of resources due to wrong estimations, which leads to cost increases of projects, where it is difficult to determine what the cause is in the current situation. For instance, if there is a project in the ERP system that took 1,200 hours, then the planning of the modules in the operational schedule should also add up to a total of 1,200 hours in the sub-calculation or at least the deviation must be traceable and be noted in the system such that there can be learned from (called an iterative process).

This lack of transparency also causes difficulties for the sales team. For example: The sales team got a call, a service order and they don't know exactly whether they can accept that order due to a lack of validated data and insight in the capacity occupation. The sales department must trust on the intuition of the planner and can't guarantee on what time basis the order can be processed. Therefore, is transparency an important deliverable for stakeholders of tactical planning.

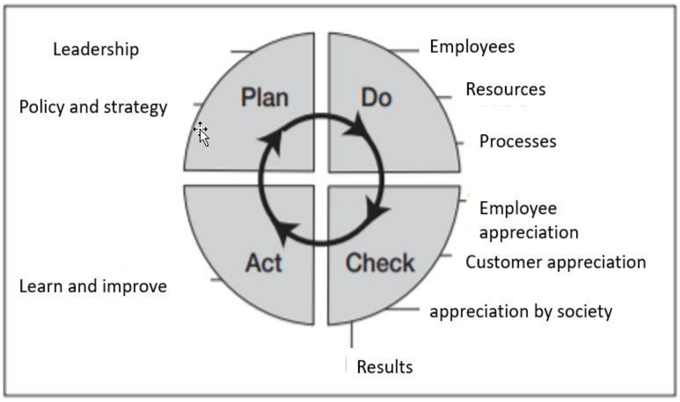

Figure 4, Plan, Do, Check, Act cycle (Gidey & Beshah, 2014)

Planning management is responsible for building, running, and monitoring the planning. As methodology: The Plan Do Check Act (PDCA) cycle (Figure 4) is used. Currently, for each project, an estimation based on intuition is made to calculate the costs and build the planning of a project, but the act step (actual costing) is skipped in the current approach. The actual costing of the project is not analysed due to the ambiguousness output caused by the lack of transparency and alignment between the used information systems, this makes it hard to track deviations between scheduled and reported hours. So, no lessons are learned from the subsequent calculation and there is no iterative process at the end of production. Therefore, the following action problem is formulated: Inaccurate indications are made based on the output of the information systems, where the underlaying cause is that the tactical and operational planning are currently 'mixed-up'. Tactical and operational planning should reinforce each other. Therefore, the expectations of both levels need to be clear to be able to analyse the performance of the project. Alignment between the information systems should improve the information transfer and improve the quality of the data output such that the act step can be accomplished for the set-up of an iterative process (Kok, 2021).

1.3 Research methodology

This research consists of two parts, namely a qualitative and a quantitative study aimed at eliminating waste in the execution of the production process by creating smooth flow in the information transfer between the planning levels to generate accurate indications. Table 3, provides an overview of the research design in combination with the structure of the chapters. At the beginning a qualitative study was carried out to map the current processes and to analyse which problems are experienced in practice along the tactical- and operational planning. To this end, open and semi-structured interviews have been conducted with different types of actors (sales support, the operations manager, the production leader, production employees and specialists) to avoid the bias of a particular actor. In addition, the qualitative study consisted of observing consult sessions in which coordinating departments discussed the planning objectives during the ’day start’ to gain insights on limitations due to information provided by the tactical- and operational planning during the execution.

In the theoretical framework, literature research is done incorporating multiple elements such as the lean methodology and the effect of waste in a production process due to organizational disabilities concerning planning management. Based on literature studies and qualitative research an aligned format is designed in which the impact is evaluated by illustrated examples. The perspective of the used information systems is assessed by scoring criteria, the Simple Multi Attribute Rating Technique (SMART) is therefore used, SMART is a multi-criteria decision analysis (MCDA) method in which alternatives per attribute are assessed based on direct rating for measurable results, such that we could assess the functionalities of the information systems for the realigned methodology.

The following success factors have been used for assessment and evaluation of the new aligned planning methodology (Umble & Haft, 2003):
Success factor 1: Clear formulation of tactical and operational objectives
Success factor 2: Dedication of the management team
Success factor 3: Excellent project management
Success factor 4: Change management
Success Factor 5: Data accuracy
Success factor 6: Education and training

In the research design, as shown in Table 3, we have conducted the research along the specific questions.

Knowledge question	Type of research	Research population	Subjects	Research strategy	Method of data gathering	Method of data processing	Activities
How is the planning currently managed within Gietart?	Descriptive	Company	Production manager Operations Manager Sales support	Deep quantitative	Interviews, observations and literature studies (cross-sectional)	Visual representation and documentation. Quantitative and qualitive.	Semi-structured interviews stakeholders. Creating overview processes
What Literature on hierarchical planning alignment within project-oriented organizations is available that is applicable to this research?	Descriptive and explanatory	Literature, Company	Operations management	Broad qualitative	Literature and communication (cross-sectional)	Description of tool and methodologies. Qualitative	Literature research database.
How to create an iterative structure between the information systems that is repeatedly possible?	Explanatory	Literature Company	Production manager Manager operations	Deep qualitative	Literature, observation and communication (cross-sectional)	Explanation of the assessing criteria and possibilities. Quantitative and qualitative	Overview requirement and possibilities. User-friendly explanation and overview
How is the quality of the planning management improved using the recommended realigned planning method?	Explanatory	Company	Management team Operation manager Production manager	Deep qualitative	Interview stakeholders, evaluation of additional control information (cross-sectional)	Descriptive, qualitative	Evaluation and interview stakeholders concerning improvements and adaptions.

Table 3, Research design

1.3.1 Problem quantification

A problem is often indicated as a difference between norm and reality. The norm is that there is alignment between the tactical- and operational information systems and that the structure between the operational and tactical planning is repetitively usable. The reality is that there is no clear expectations of the tactical- and operational production planning and there is no alignment between the used information systems. After a quick analysis, the cause of the core problem, (the underlying problem) is that the content of the planning is based on human expertise (intuition). There is limited use of data during the decision process, decisions are made based on intuition, instead of on data and systematical input.

Figure 5, current situation/reality

This 'lack' in alignment is hard to measure in numbers. Given the limited time span of this study, it was decided not to quantify this 'lack' with indicators. It was more valuable to investigate the solutions and expose possible bottlenecks. This provides new insights and actual visible data for improved decisiveness.

Measuring the increase of performance when planning decisions are made based on the aligned information systems is beyond the scope of this research, to measure improvements towards the norm the following suggestion is made: To define the alignment between the information systems supported by data and creating performance indicators to (evaluate) and assess the realigned format on long term.

1.3.2 Research goal

The goal of this research is to increase the organizational performance by aligning the used information systems in which the operational and tactical planning are differentiated and defined with clear expectations to create more flexibility, insights and involvements from the stakeholders. By systematically recording historical quantitative and qualitative data from the information systems, the (planning) performance of projects can be compared. Based on this, quality standards for planning management can be formulated such that the performance delivered after a project can be assessed and improved by means of KPIs.

1.4 Research questions

For a comprehensive solution to the core problem, the following research question is formulated:

"How can tactical and operational information systems be better aligned within Gietart Kaltenbach to generate accurate output that can be monitored and controlled for improved production performance?"

To explain the coherence and structure of this research a set of sub-questions has been formulated for a stepwise approach towards the answer:

1. **How is the planning currently managed within Gietart?**

To empathize the reason of this research, an elaboration on the most important aspects within the current set-up and method of production within the organization of this research is given. Furthermore, how the structure of the current information systems is incorporated on the different planning levels, a summary of the data transfer between the systems and the overall impact of a planning schedule on planning management is explained.

2. **What Literature on hierarchical planning alignment within project-oriented organizations is available that is applicable to this research?**

An improved performance gets along with lean principles, these are researched and used as directions for this research. Next to this, background information on the recommended hierarchical planning framework is done and how the positioning of Gietart within multi-project management has impact on the performance of production is examined and taken in consideration during the construction of the alignment methodology of the planning methods. Furthermore, developments towards a successful implementation process are investigated to evaluate the impact and the application of the changes.

3. **How to create a structure between the information systems that is repeatedly usable?**

To provide a future-proof solution multiple conditions and suggestions provided by stakeholders are further examined and translated in preconditions to create a friendly design on technical- and user side. To formulate a structure which is repeatedly possible an (iterative) link is investigated for a successful implementation process. Furthermore, recommendations according to the execution of the preconditions in the realigned method are done.

4. **How is the quality of the planning management improved using the recommended realigned planning method?**

The results of this research are presented together with an elaborated view on the added value of the aligned method. Furthermore, management information about the predicted impact and additional control information is delivered. Next to this, other improvement proposals are discussed together with the effects on the overall structure of the planning and the alignment between the used information systems.

1.5 Deliverables

This report contains a detailed report describing all processes related to the execution of 'excellent' planning management in combination with a problem/data analysis of the communication gap between the used information systems within the specific organization. To start the solving process, the perspective of the used information systems is investigated to create an improvement proposal entangled with the current approach. The results of the trade-off and future perspective is evaluated by the SMART goals. Next to this, a new format including the objectives for the tactical planning is designed and tested through conversion of old projects in the 'new' format and a careful description of the steps towards a successful transition process by the success factors is given. To set norms for the improved performance KPIs are illustrated for the long-term impact. To end this research conclusions and recommendations for improving the performance for further research are drawn.

Chapter 2: Current situation

In this chapter, the current system and processes of Gietart Kaltenbach is analyzed. Interviews and observations were conducted to gain insight into the current planning environment. To indicate disabilities in current planning management, different literature studies are used as comparison mechanism for a representative norm of planning management. Gietarts' control of planning management is summarized in Section 2.1, important parameters for material planning and their market positioning is substantiated in Section 2.2. Gietarts' operations processes are presented by visual illustrations in Section 2.3 together with an elaborated view on the provision of the planning levels. Furthermore, the steps for drawing-up a project plan based on the applied Critical Path Method (CPM) is displayed in Section 2.4 and in the end Section the conclusion entailing the most important aspects of this chapter is given in Section 2.5.

2.1 Planning management

A planning should provide a visual overview of the projects, activities, tasks, and the relationships between them. (Chofreh, 2015) mentioned that the planning management is not only a tool for practitioners. It enables the experts to coordinate and manage a project within the specified schedule and budget. The essence of planning management consists of three processes:

- The planner is responsible for drawing-up the schedule and needs to be aware of limitations for constructing a realistic planning. The current planning method for constructing the tactical planning schedule is the Critical Path Method (CPM). This method is elaborated on in Section 2.4.
- Once the schedule has been drawn-up, the planner up-dates it weekly. Up-dating is keeping the planning up-to-date, displaying progress per activity and calculate if the lead time is still representative. Due to the parallel planning in the information systems of tactical and operational level, up-dates needs to be done separately in MS Excel and MS Project to keep an accurate view on both levels.
- A planning is a means to steer both the project, material requirements and the employees on the work floor. The planning provides insight into the processes, dependencies, and critical points in a project. Based on these insights, the planning serves as management information. The determined lead time and required capacity influences the financial management of a project, if more capacity is needed than estimated in advance, project costs increase.

2.2 Customer Order Decoupling Point (CODP) Gietart

Different ways of producing require different ways of planning (Vollman, Berry, Whybark, & Jacobs, 2005). CODP is used to distinguish between different production methods, see Figure 6. The CODP is 'the point in the supply chain, where the product is linked to a specific customer order' (Olhager, 2010). Here a trade-off have to be made between stock and delivery time. The CODP concept has

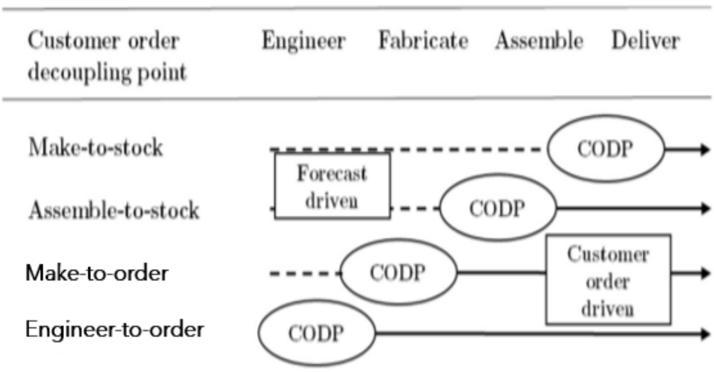

Figure 6, Customer Order Decoupling Points (Olhager, 2010) four possible decoupling points. The correct control of the CODP results in better control of the production process, a lower risk of obsolescence and a decrease in inventories. The part of the process before the CODP is not driven by a customer order. Planning and execution of this part is based on expectations of future customer demand, forecast. The part of the process that is executed after the CODP is determined by the customer order. The positioning of the decoupling point is an important step in structuring the planning of the activities. The CODP represents the method of production for planning and manufacturing. As mentioned in Section 1.1, Gietart has been in a transition phase from 80% MTS production in combination with 20% ETO to 80% MTO in combination with 20% ETO.

Thereby, Gietart made a transition to smart customization, project-oriented production, which entails that production adapts more to customer order. This transition resulted in an **upstream** CODP position. This repositioning is well considered because it is an aid for a decrease in material costs: Materials are not unnecessary spilled (for stock production) and inventories are minimized due to the purchase of material is attached to the customer order, which decreases the inventory costs and a better focus on the customers delivery date is thereby achieved due to the project specific focus on customer orders and not on unnecessary production 'to utilize capacity'.

A limitation of the project-oriented production is that a disruption in the supply chain immediately affects the 'smooth' of the processes due to dependencies of components within a project because buffers have been eliminated from the process with this upstream positioning. The aim of this research, alignment between the used information systems for planning management should result in a more controlled process, where the logistics flows can respond faster to the needs of a sub-process through better monitoring of the production phases such that the planning can be used as a preventive steering tool. Where planning helps answer the question, "What should I do?" while scheduling helps with the question "How should I do it?" (Barták, 2000) Planning is a complement for an optimal schedule, where Gietart uses the pull planning approach to determine the schedule. The pull method entails that the planner starts with the end goal (the finish date) and works backwards toward the start date.

2.3 Operations processes

The flow-chart from the pre-liminary process to the expedition process is presented in Figure 7. It is essential that the timeline of the phases, tasks and additional steps within a project are clear for a good understanding of this research.

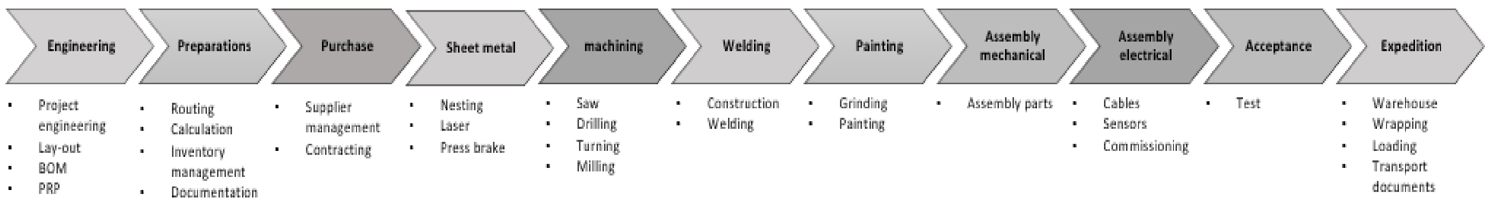

Figure 7, Operations process & activities (Kok, 2021)

An visual illustration of the production of a module is given in Figure 8:

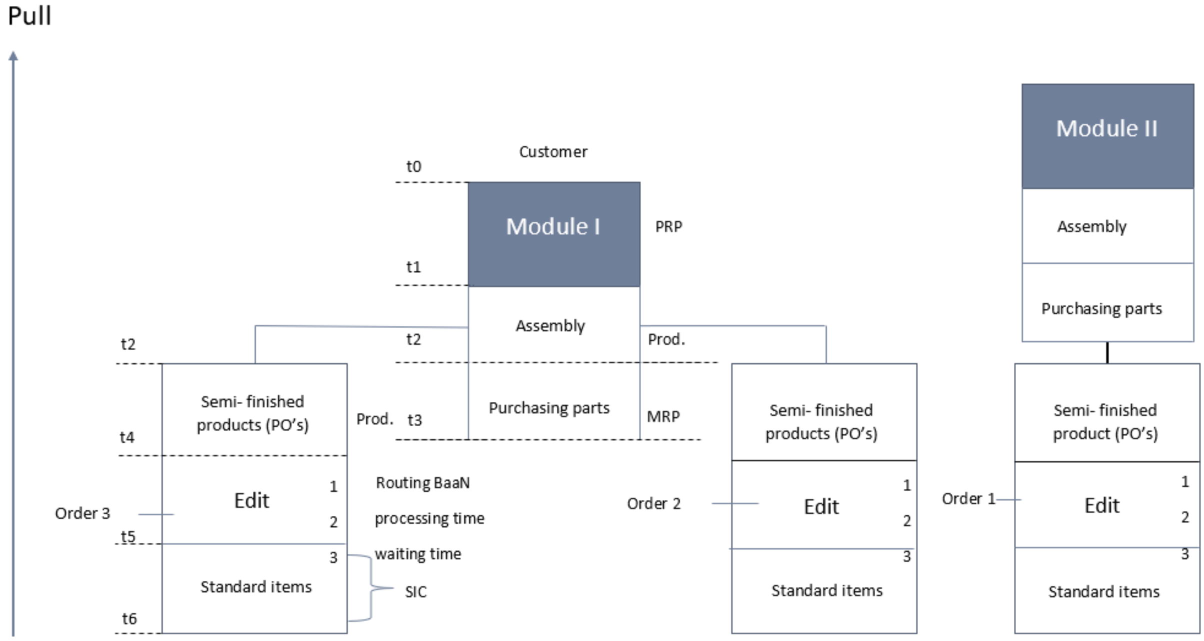

Figure 8, intermediate steps production module

The end time, when the semi-finished product (POs) must be ready, is the start date for the assembly of all parts to create the product (module). The start time (t0) is calculated back (pull). T0 equals t1 minus the lead time, the lead time is calculated by the ERP system: processing + waiting time of the module. Due to limitations in the capacity and parallel routing of processes this process must be monitored by the operational planner to control the connection between the sub-processes and departments.

The difficulties of a total setup of a new project is to plan the start dates within t0 and t1 of the POs. The ERP system gives suggestions but is not incorporated for 'changements'. Sometimes dates shift within a project, those changes are difficult to implement and control in BaaN. Therefore, the control of the operational planner is essential.

Furthermore, for the understanding: T0 is the same for every product, but the period in which the subcomponents are produced differ. Good planning and alignment between the systems should distribute to more flexibility in the execution process. In addition, the standard items in (t6) are stock items which are independent and should be 'present' in stock. Those are edited and combined with the purchasing parts (t3) to complete the production of the POs. After the completion of the POs those are assembled (t2) for completion of the module (t0).

2.3.1 Planning hierarchy

This section first examines a deeper elaboration on the applied planning hierarchy within Gietart. Furthermore, an introduction of the added value of the alignment between the information systems and the steps for drawing-up the project planning are described. The hierarchical planning framework consist of three levels as earlier described: (1) Strategic, (2) tactical and (3) operational level.

Strategic planning centres on desired future long-term goals with strategic objectives, annual budgets and visions which are monthly discussed during the management team (MT) meetings. Currently, there is no real planning in this area, but more of an approach to achieve the budget and what that requires in terms of hours, projects etc. The bridge between strategic and tactical planning is very limited.

On the **tactical level** medium-term project planning is done, where strategic objectives are translated into actions. The time-horizon of the tactical planning is set-out over two quarters and includes upcoming projects and active projects substantiated by all modules and underlaying departments in the information system MS Project, see Appendix A for display. Table 4 provides an overview of what is presented in the tactical planning. To give a better idea of what the tactical planning serves for, the in- and output is described in Table 5.

TACTICAL PLANNING	
LAYOUT	Project
	Production Order (PO)
RESTRICTIONS	Number of orders
	Connection operational planning
GANTT-CHART	One-week blocks
	Overview several months
DATA	Start and end date, expression in hours Project/PO/(task)
	Result: % completed work, actual/planned work
	Determine progress based on input operational planning

Table 4, Overview tactical planning

Input tactical schedule	Output tactical schedule
Customer deadline of the project	Throughput time per project
Number of budgeted hours per project	End time per department
Milestones	Milestones for engineering and assembly department

Table 5, In- and output tactical planning

On the most detailed level, **operational planning**, all parts that must be produced in combination with the material supply delivered by the Engineering department are translated in POs for the routing of the activities which is determined by BaaN. The ERP system reads the computer-Aided Design (CAD) drawings and makes different parts/modules of a project transparent. Furthermore, specific actions, edges and processing steps are included by the manufacturing engineer. Next to this, the execution of the activities is scheduled on daily, operational basis, where the people and resources are allocated to the activities on the POs manually in the information system MS Excel, see Appendix B for an example of an operational schedule. In Table 6 an overview of the operational planning is presented to give an idea of what it entails and an elaboration on the in- and output of the operational schedule is given in Table 7.

OPERATIONAL PLANNING	
LAYOUT	PO
	Task
	Employee
RESTRICTIONS	Resources
	Connection tactical planning
GANTT-CHART	Two-hour blocks
	Overview per week
DATA	Start and end date, expression in PO/task/employee hours
	Result: % completed work, actual/planned work
	Evaluate and adjust daily progress

Table 6, Overview operational planning

Input operational schedule	Output operational schedule
Release date per project	Assigned employees per resource group per activity
Activities per project and routing (PO)	Start, - and end date per activity
Required resources per activity	Applied resources
Budgeted hours per activity	Booked hours registered in ERP

Table 7, In- and output operational planning

To insert a view on the overall methodology, execution and dependency between the information systems, is the current set-up of the organization summarized: Currently a rough tactical planning is created in MS Project, in which the entire project is plotted containing all critical modules within the project and underlaying departments. From an operational point of view, planning is created for all parts that must be produced. Due to dependencies between activities a specific routing of the activities is determined by BaaN and translated in POs for the execution. BaaN determines when to start based on the estimated enddate of the module in the tactical planning (pull principle). Therefore, BaaN is dependent on the input of the tactical planning. Based on this information the operational schedule is generated manually, dependent on the available resources. The information flow between the different levels in the structure is visualized in Figure 9.

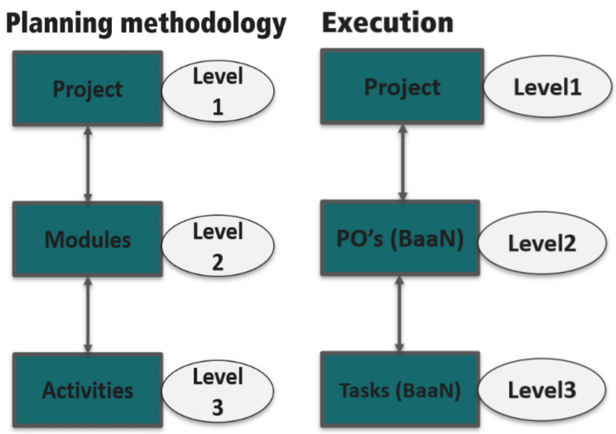

Figure 9, Planning methodology and execution

2.3.2 Bottlenecks

When generating the schedule, the planner must be aware of multiple bottlenecks for the smooth flow of the sub-processes. The total lead time will extend due to impact of bottlenecks within the production process. Tackling waste and bottlenecks is an effective way to achieve a reduction in lead time. The most leading bottlenecks over all levels are summarized:

1) The available budget.
2) Market demand (the number of sales orders coming in).
3) The mix of the different projects that have to be produced.
4) The machines and areas used for the production of the projects.
5) The number of available FTEs.
6) Sheet metal working, programming the laser

Where the first two points are strategic burdens, (3) influences the tactical objectives where multiple aspects need to be taken in consideration due to variance and parallel processes. Furthermore, number (4), (5) and (6) have impact on operational schedule due to finite capacity and exploitation of resources.

That tactical and operational schedule are connected can also be illustrated by the bottlenecks. For example, a deeper elaboration on **point six**: Programming the laser is noted as a bottleneck in sheet metal processing. This bottleneck affects the calculated lead time because there is no infinite capacity due to burdens in the programming process. This is difficult to display but to provide reliable lead times at tactical level, it is necessary to be aware of the occupation of the laser on operational level. The occupation of the laser does not have to be presented in the tactical planning, but the awareness needs to be there that there is a bottleneck on operational level by determination of the lead time on tactical scale to create a realistic picture (Anupindi et al., 2013).

3.3 Resource-based view

Situations may change in this highly dynamic business environment. Collaboration between departments and dependencies between projects and activities should be exerted and resources must continuously be reassessed to be optimal deployed. It is also indicated that higher level of competition augments the values of resources (Teng & Cummings, 2002).

The 4M method creates awareness of all important aspects associated with manufacturing resources: Man, Machine, Material and Method. The goal is to provide a means for the simultaneous improvement of product design, workplace ergonomics and assembly tasks.

Man: Both tactical and operational planning are created by the production manager. Due to the operational experience, the planning is constructed in such a way that all risks which have occurred in the past or things that went wrong are included on tactical level, this reflects in the productivity. There is a capacity of 420 hours available (weekly) and only 350 is used (Kok, 2021). The planner is too conscious of specifications on the work floor (operational level) and includes this in the tactical planning (Kok, 2021). Clear differentiation between tactical and operational planning in combination with segregation of responsibilities over the distinct levels would increase the decisiveness of what belongs to a specific scope: Tactical or operational. This should result in more adequate decision-making in the long term and a better utilized capacity.

Machine(s): The used information systems for planning are MS Project, MS Excel and the ERP system BaaN. MS Project remains leading for both tactical and operational planning. In addition, the ERP system is 'the power supply' for MS Project. The hours established in BaaN determine the routing and the start date of the activities for the operational planning. In MS Excel, a block schedule is designed for assigning employees on the production floor based on the information provided by MS Project.

Material: Materials are mainly related to the number of man-hours/machinery/parts available. Currently this is not transparent in the planning and the distribution is done in good faith.
The standard items are produced from stock (SIC) and other supplements are ordered on a project basis, but due to delayed delivery times of the suppliers (<500 days), this is difficult to monitor.

Method: Operational/tactical planning is prepared in MS Project based on expertise. Routing of the activities (POs) and material supply are retrieved from the ERP system. BaaN is also the reporting stage for the hour calculation. As can be seen in Figure 10 and Figure 11 there is a large deviation between the scheduled and 'reported' hours according to the current available data in the ERP system. Alignment between the systems should contribute to a renewed benchmark mechanism for cost control because correct reporting in the ERP system is therefore a prerequisite.

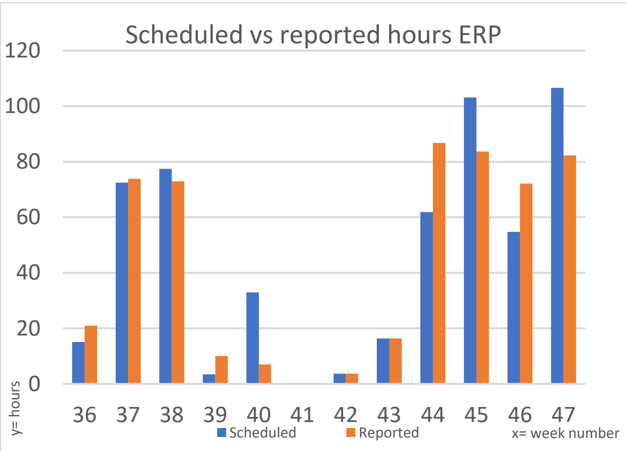

Figure 11, Hour distribution machine Sprint (build in 2021)

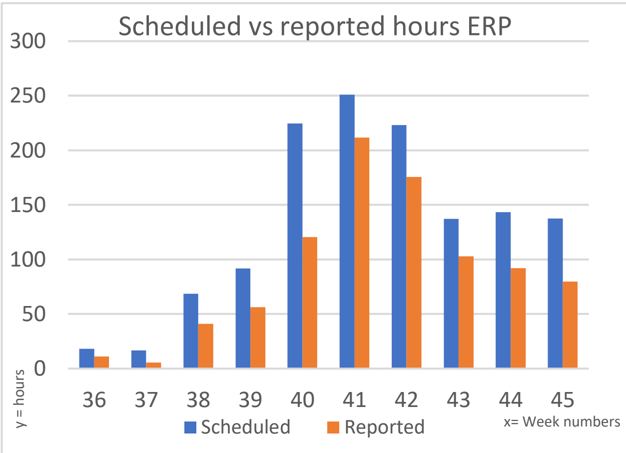

Figure 10, Hour distribution machine Eco (build in 2021)

2.4 Set-up project planning

2.4.1 Critical Path Method

The CPM is used throughout planning management to visualize the path towards the project goal, to identify from the preliminary process to expedition where the critical points are, to determine task dependencies and calculate task durations. To determine the most effective path the Work Breakdown Structure (WBS) is applied, where the project is broken down into individual tasks to facilitate more effective resource management and create awareness of bottlenecks. (Asana, 2021)

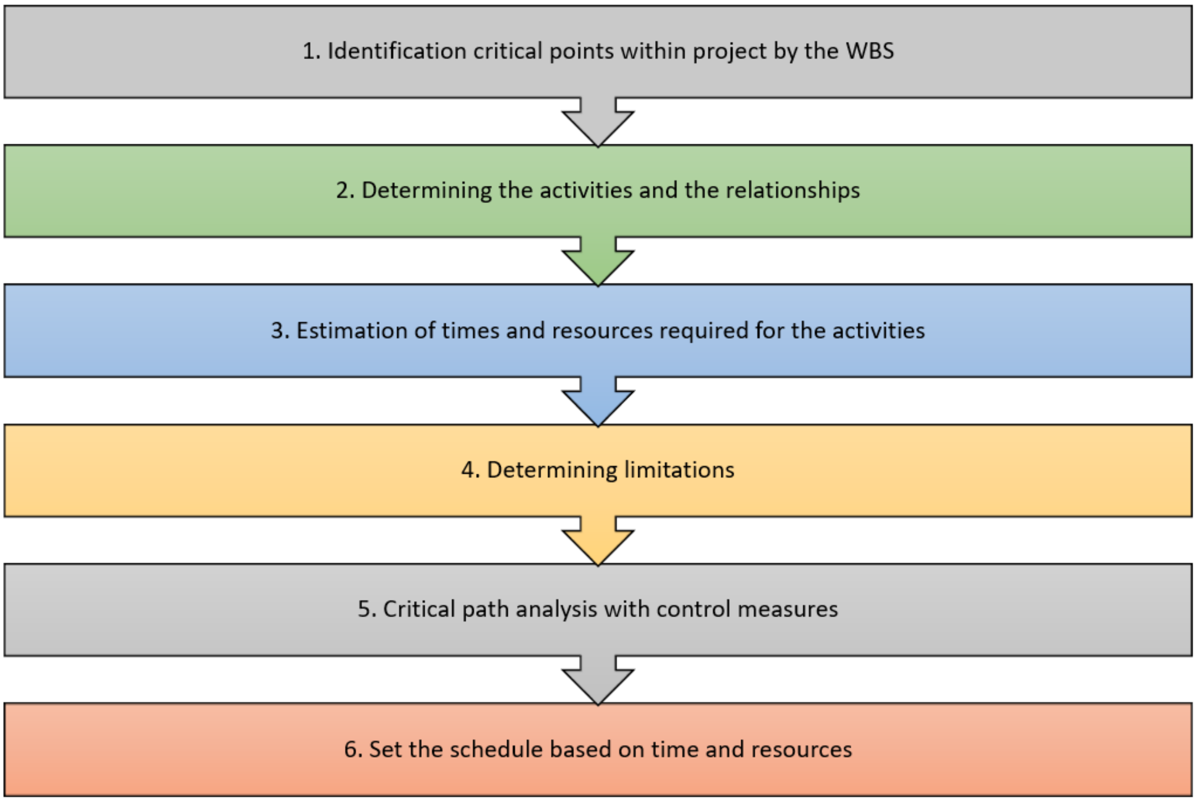

Figure 12, Steps drawing-up production planning

Based on literature studies (Heizer et al., 2016) concerning multi-project organizations in combination with qualitative research, we have sketched the applied planning method of Gietart in six steps (Figure 12) with their disabilities. These steps are substantiated in this section.

1. Identify critical points within project by using the WBS

Due to the complex structure and dependencies within projects, projects are broken down into modules, departments and activities/tasks to create a manageable overview. These modules are further 'broken down' in the phases they are going through from engineering- to the assembly department to identify the critical points. Thereafter the modules are further defined until a manageable set of activities (tasks) for the routing, a work package is composed: a (PO). This work structure is called the WBS: It brings clarity and definition to the project planning process. It is a visual, hierarchical and result-oriented deconstruction of a project component. Currently the 'three-layer structure' as described: Module, department and activity division is not the same everywhere in the planning, the WBS structure isn't consistent. In Appendix A, the tactical planning of the eco is displayed in MS Project, where the 'rolbokken' module is unfolded with the 7 departments underneath according to the WBS (WBS, 2021).

2. Determining the activities and the relationships.
All relationships between POs must be identified because often there are dependencies between activities, therefore these needs to be performed in a certain order. Contrary there are also activities that can be performed independently. It is also important to classify those activities such that these can run in parallel to reduce the overall lead time. As stated in Section 2.1 project planning is a tool to provide techniques that help to deal with time, resources and complex relationships.

3. Estimate the times and resources required for the activities.
A prerequisite for good planning is knowledge of the relationships between time, resources and the activities. Without a correct estimation or 'value identification' of entangled modules, POs and activities it is hard to steer at any point during the production. Valid indication of start- and enddates are important. When data is incorrect, the roots for the process are distorted what will result in an accumulation of indirect decisions. The format for tactical planning is based on obscure data translated by the intuition of the human planner. Due to inaccuracy in the capacity estimation a lot of ad-hoc revisions needs to be done during the operational execution.

4. Determining limitations.
Once a sketch of the schedule has been set-up, where patterns and dependencies are identified, limitations need to be indicated, for example:

- Availability of materials
- Time-bound: Productions steps must be executed before the due date in a specific order.
- Limited resources: (machines, workplaces, employees) cannot be exceeded.
- Capacity driven schedule: The point in the process where the biggest bottleneck occurs is executed right now **first**, which mostly result in a longer lead time for a project.

To give an idea: The sheet metal working in the preliminary process is a bottleneck which often disturbs the process flow. Thus, the laser is identified as a capacitance driver. This is familiar with the **First Come First Serve (FCFS)** principle. FCFS is an operating system scheduling algorithm that automatically executes queued requests and processes by order of their arrival, which is not an ideal technique for time sharing projects because it results in a long average waiting time due to short processes that are at the back of the queue must wait for the long process at the front to finish. (Lawrence, 2022). This crosses because processes after sheet metal working have to wait till sheet metal working is finished, where the sheet metal working takes longest due to the bottleneck by the programming of the laser. This causes delays in all follow-up step due to all processes which must wait till sheet metal working, the bottleneck, is finished.

5. Critical path analysis with control measures
After the composition of the planning the planner checks whether the requested lead time can be arranged and if the available capacity is evenly distributed. If the critical path turns out to be longer than expected, it can be examined whether more activities can be planned in parallel. If this is not possible other control measures should be considered, for example deploying more capacity or hiring additional staff during a periodical. These control measures can be incorporated in the planning.

6. Set the schedule based on time and resources

The concept planning based on time and resources will be introduced in a consultation between production and sales to discuss final treatment and delivery time. The order card/form (the order card contains the customer specific options, delivery time, transport and destination.) will be checked to control if everything is included in the project planning. Thereafter a kick-off meeting with all department heads will be introduced and the last adjustments (if necessary) will be processed. As soon as there are no more changes, the schedule can be determined (Schoorlemmer, 2021).

2.4.2 Substantiate planning

To make a qualitative planning, the planner must ensure that the information is complete, correct and unambiguous. The planner must ensure that the content and the way in which the information is presented meets the information needs of the people for whom the information is intended. For Gietart it is important that the quality of the planning is good, because the costs of the project are determined by the time that the team is developing the machine for the customer. This has a direct effect on the profitability of the project. If the organization completes the project under invested costs (used resources), then the organization makes additional profits from the project and other way around it will reduce profits when the project isn't completed within the agreed fixed cost set with the customer. (Amado et al., 2009)

The quality of the planning depends on two aspects:

The quality of the information; A planning without complete, well-founded correct and unambiguous information leads to an unreliable project planning and ambiguous lead times. Therefor the planning should be updated weekly for a correct information provision.

The quality of the information transfer: Are the people for whom the information is intended able to understand the information and does the information meet their information needs? A planning that does not contain the desired information will not provide unambiguous guidelines, which in turn leads to a low reliability of the project planning.

2.4.3. Steering on the schedule

Within Gietart, time is controlled in various ways by means of planning.
This is done in both proactive and reactive ways.

- Reactive steering: The progress of the active projects is discussed during the midweek project sessions, where actors from different departments come together to discuss what measures needs to be taken for achieving the objectives.
- Proactive steering: In the day starts, the progress of the active and on-going projects is discussed with the responsible department leaders every morning for the current day. Project milestones are discussed in combination with the planning abilities. Due to this meeting the team is aware of the common interests and interdependencies. It is important to incorporate interests of others in the independent decision-making process in a project organization.

2.5 Conclusion chapter Two

This chapter provides an answer to the sub question one: *How is the planning currently managed within Gietart?*

Along with the used methods to construct the planning can the most important aspects of planning be entailed in four processes: Drafting, steering, updating and reporting. These processes are described as:

- A planning is a means to steer both the ongoing- and scheduled projects and the project-team on the management aspect of time. A planning is drafted by the planner to provide insight into the processes, dependencies, and critical points in a project. The time, resources and limitations should be incorporated for a correct information transfer. Based on these insights, the planning can serve as management information.
- Once the schedule has been drawn up. The planner updates it frequently to preserve the quality of the information. For a correct update, alignment between the information systems and thereby tactical- and operational level would simplify and improve the accuracy of the data.
- BaaN is the reporting stage where the hour calculation and the material supply are generated, the supply chain.

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Chapter 3: Literature on hierarchical planning within project-organizations

In this chapter, literature study to illustrate the impact of entangled factors within the planning environment of project-oriented organizations are described to generate understanding of the complexity within this kind of organizations. In Section 3.1 we are focusing on principles to picture important parameters within internal processes based on lean management. Thereafter, a short description of the function of an ERP system is given in Section 3.2 for understanding of the material supply within the planning process. In Section 3.3 is described what multi-project management is and how this goes along with project-oriented organizations together with the importance of controlled project management. Since we are focussing on the tactical- and operational planning it is an aim to have a clear understanding of the tactical and operational objectives for clear expectations as substantiated in Section 3.4. Finally, in Section 3.5 a trade-off is made to remark the added value of the alignment and a summary of the discussed theory along the goal of this chapter is given in Section 3.6.

3.1 Lean management and principles

Sustainability has become a major concern of the academic and the business world (Chofreh, 2015). The term “lean” means a series of activities or solutions to minimize waste and non-value-added operations towards the end product. The term “lean process” in the literature has many definitions (Rother & Shook, 1999). (Abdulmaleka & Rajgopal, 2007): “lean production means identification of all types of waste in the value stream of supply chain and implementation of necessary tools to eliminate them for minimizing lead time and prevent the exploitation of resources.” Whereas waste could be related to the lack of alignment between the systems which resulted in unused capacity, spill of resources and duplication of actions towards the end product which together increases the cost of the project and the inaccuracy of the approximated lead time. The three core lean principles are identified and elaborated on within this research:

(1) Identification of value

Different functions are identified as value indicators in controlling the project process within a project-oriented organization, in Figure 13 six identificators are displayed together with a legend to illustrate how their value can be measured. The smoothen of the process starts by a good information transfer from the pre-process plan near the execution of the project start. Thereafter, the organization of the project controlling process, determination of the project status and definition of project objectives provides as ‘success’ value identificators for stakeholders. Visual support is considered as an appropriate way to identify value for defined project controlling- and coordination, which provides value for planning efficiency and results in additional information for decision making, as for instance the impact of releasing a project over a larger interval can be visualized, it provides a direct view on discontinuities in the scheduled workload against the capacity over tactical time interval and identificates if adjustments should be made in the design of the Project

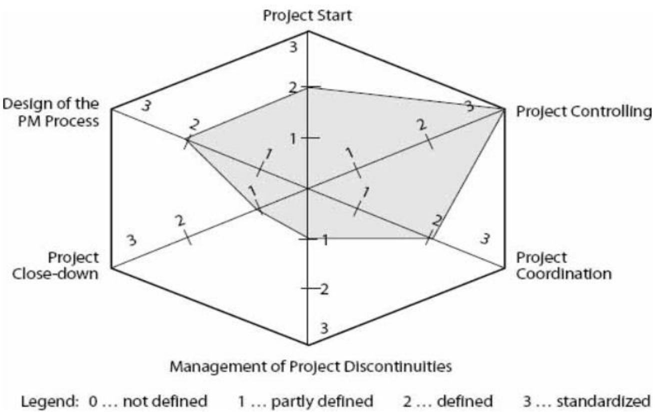

Figure 13, Value identificators of PM in project-oriented organizations and their measurement (Gareis, 2000).

Management (PM) planning process of what the effect is of the close-down of a project and the release of a new project against the capacity (Gareis, 2000). This workload is unpredictable and differs every week.

(2) Elimination of waste

The steps from engineering up to expedition are examined in the planning process to find-out where value can be created in the eyes of the customer (value creating). Any process step that does not add value for the customer is seen as a waste. Waste must be eliminated to shorten the lead time and steps in the value stream process to effectively achieve the goal. Concrete and better insights in the progression and capacity occupation can be generated by consistency and structure in the planning. Other forms of waste which have effect on planning management are waiting times, motions and defects: Fixing mistakes due to human failure in the planning costs a lot of money just like motions, unnecessary movements which exists if a process is not organized in a convenient and orderly manner. The alignment between the tactical and operational information systems is an intermediate step to achieve the overall goal of the organization more effectively: *An increase in revenue*. A better alignment between the planning levels is a tool to eliminate waste within the operations processes & activities such that less resources are spilled during the production process, which in turn leads to a decrease in project costs and so more revenue can be generated, an increase in organizational performance.

3) The generation of a smooth flow

(Womack J.P. et al., 1990) The alignment of the tactical and operational information systems can be encompassed as a generation of smooth flow between the systems. This can be used to iteratively improve the performance due to better control of data within organization in combination with lower costs and a better impression of the scheduled and executed hours. A continuous flow of many small, (periodic) large improvements. (Soltero & Waldrip, 2002).

3.2 ERP system

An ERP system is a software program with which data and processes from different departments, Finance, Human Resources, Production, Supply Chain Management, Project Management and Customer Relationship Management, can be integrated within the organization. (Mayeh et al., 2016). ERP emphasizes resource planning from a business perspective (Chang et al., 2008). If the drawing for the project is made in CAD, the Bill Of Material (BOM) structure from CAD is transferred to BaaN (BaaN IV is the ERP system which is used by Gietart). The BOM from CAD is leading in this and the engineering BOM is converted into a manufacturing BOM, taking into account the assembly sequence and limitations according to (Chang et al., 2010). In BaaN it is indicated whether the item is produced on a customer-specific basis or whether it is produced as a standard item, whereby it is possible to produce the item from stock. The structure of the POs within a project is not in line with the way in which production takes place due to the dependencies. (Veuger, 2021)

3.3 Multi-project management

Multi-project management entails the integration, prioritisation and continuous control of multiple projects and operational schedules in an enterprise-wide operating environment (Boznak, 1996). Individual project goals and deliverables need to be translated towards operational and tactical decisions on capacity allocation and scheduling in the overall needs of the organisations. Multi-project management generally treats the case of multiple (in)dependent goals (Wysocki et al., 2002). Gietart generally produces four projects (machines) parallel in the factory. The lead times of the individual projects depend on a good distribution of the available resources at the aggregate capacity level over the projects which requires good planning towards operational and tactical level. A nominal division of manhours is distributed from the initial phase to the final phase in production. For an optimal distribution, good insights and awareness of the operations and the dependency between projects is essential. An aggregated, combined project plan provides good management support for optimal resource and order acceptance over multi-projects so that there are no 'gaps' over tactical time interval in the planning. General objectives of multi-project management principles include optimal timing of operations for the operational level, optimal resource management for the tactical level and robustness of stability of plans for all levels. (Leus et al., 2007)

Gietart is a multi-project organisation what comprehends that multiple projects, that are independent from each other have to be managed, planned and monitored at the same time. Due to the appropriate organization structure, methods, processes and incentive systems, is a good information provision (alignment) between the tactical and operation planning valuable. The separate processes must provide input to each other and be mutually consistent as this provides optimal planning. (Leus et al., 2007). To realize a successful alignment several control aspects must be enhanced for critical points such as dependency and variability in multi-project organizations, where clear objectives for tactical and operational planning must be drawn-up.

3.3.1 Positioning framework

Variability and complexity are intertwined in project driven organizations. (Leus et al., 2007) describes a framework to position project-planning methods, in which they distinguish the degrees of general variability in the work environment and the degree of dependency between the projects. The 'variability' is an aggregated measure for the uncertainty because of, on the one hand, the lack of information in the tactical stage and/or, on the other hand, operational uncertainties on the production floor. 'Dependency' measures to what extent a particular project is dependent on influences of other internal projects. For instance, shared resources with other projects. Dependency forms part of the complexity of the planning of a project-based organization. It will strongly determine the organizational structure. The resulting framework is depicted in Table 8. For this research is only elaborated on the case of High variability and High dependency (HH) position.

Dependency / Variability	LOW →	HIGH
LOW ↓	LL	LH
HIGH	HL	HH

Table 8, Positioning framework for multi-project organisations (De Boer, 1998)

3.3.2 (HH) position in an ETO environment

Every machine is designed for a specific new customer. Therefore, every machine requires an engineering process. The customer may require modifications of the design combined with the complexity of the machine results in a project environment that has a high degree of variability. Furthermore, multiple products are produced simultaneously, which results in dependency between the projects. Projects in the HH-category requires planning and control approaches that can deal with both the organisational complexity and the variability as well as with the complexity of the planning problem. Gantt-charts are considered as an appropriate way to monitor and control HH in the aligned methodology to monitor and control the HH between projects.

3.4 Hierarchical planning framework

A complete multi-project scheduling system uses: (1) a method for assigning due dates to incoming projects, and (2) a priority rule for sequencing individual jobs such that total costs are minimised (heuristically) (Fendley, 1968).

A structured quantitative approach that addresses the issue of alignment between the tactical and operational stages of the project planning process is desirable. Therefore, the distinction between tactical and an operational level should be clear with different planning objectives at each level. (Speranza & Vercellis, 1993)

At the tactical level, due dates are set. At the operational (service) level, the timing of the activities needs to be determined and resources needs to be allocated to achieve the due dates. Thereby the assumption is made that a set of aggregated activities at the tactical level constitutes a macro-activity. The aggregated activities are seen as the POs which belong to the activities (the macro activity) within Gietart.

(De Boer, 1998) proposes a hierarchical planning framework (Figure 14) for project-driven organizations. He argues that a hierarchical decomposition is necessary to arrive at a more manageable planning process. He also mentions how, especially in project environments, uncertainties play an important role and proposes some strategies to deal with them: (A) creating slack by lowering output targets; (B) Creating stand-alone activities, i.e. large tasks that can be performed by multidisciplinary teams; (C) and investments in vertical information systems. Whereas the application of strategy (C) is investigated during this research.

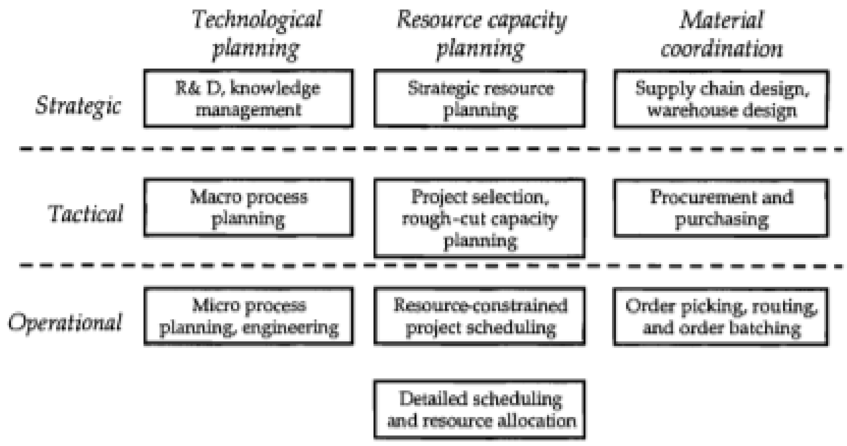

Figure 14, Hierarchical planning framework (De Boer, 1998)

In Figure 14 three planning areas are distinguished: (a) technological planning (b) capacity planning, and (c) material coordination.

Identification of value from the distinct planning levels within the hierarchy is necessary because it aims to repeat an identical process during consecutive periods. According to (Rewers et al., 2017)

planning levelling aims to maximize utilization of the resources which automatically reflects in increasing sustainability and minimizing waste.

3.5 Trade-off 'value' alignment

The alignment between the systems will generate a smoother flow between the planning processes which ties together lean concepts and techniques. See the Table 9 for the advantages and disadvantages of the proposed alignment based on (slack et al. (2010)).

Advantage	Disadvantage
Integrated system	Costs: Current software must be adapted to business processes
Delivers accurate information	Change management: Employees must be willing to work in a new system
Better alignment between planning and execution	Training: Employees must learn to go with the new way of planning

Table 9, Advantages and disadvantages based on slack et al. (2010)

One of the disadvantages described in Table 9 is *change management.* However, the employees who must work with the new approach do not need to develop the talent to understand the alignment. The understanding of the information system alignment lays outside the skills and proceedings of the employees, they only need to understand the purpose and new working method for a success. Therefore, the advantages of the alignment like the efficiency and productivity improvements needs to be clear for a shift in mindset and possible *training* in the work processes for some employees (Waller & Fawcett, 2013). Therefore, support and training to create understanding towards the adoption of the new method in the system is designed. (Caldwell, 2020)

3.6 summary chapter three

In this chapter we answer the research question: *What Literature on hierarchical planning alignment within project-organizations is available that is applicable to this research?*

Alignment between the information systems and thereby the planning levels is a step to eliminate waste and thereby non-value adding steps within the production process to achieve the overall organizational goal: Improved production performance where more value can be generated with less resources to increase the revenue. Eliminating waste within the process starts in this case by vertical alignment between the information systems, therefore the lay-out of the hierarchical planning framework needs to be designed to generate a clear structure and expectations of both planning levels. Moreover, project-oriented organizations must deal with some complications along the alignment due to dependencies and variances between projects where the system and stakeholders needs to be aware of for good steering on the schedule. Also, resistance to change from human perspective is a formidable roadblock against changements within organizations, where it is important to make the improvements clear from employee perspective.
These were important parameters during this research on information system alignment along planning management within project-oriented organizations.

Chapter 4: Roadmap towards alignment within the planning environment.

The core principles for a successful alignment are the guidelines for this chapter: Unambiguity, efficiency, realism and cooperation (Umble et al., 2003) to go along with the objective of this research: Incorporating alignment between the information systems used for planning at tactical and operational level at Gietart. In this chapter the most important features of tactical- and operational planning are differentiated in Section 4.1. A methodology to improve the alignment and control process between the current tactical and operational planning is proposed in Section 4.2. In Section 4.3 improvements for the quality of the data are investigated to cover the conditions. A foundation for the assessment of the used planning applications in combination with opportunities are provided in Section 4.4. At least, the goal of this chapter is summarized in Section 4.5, to formulate a clear vision, objectives and expectations of the aligned information systems.

As we described Gietart uses the information system MS project, which is used to determine the lead time of a total project and their components in combination with the ERP system BaaN and MS Excel which are used for the daily, operational planning, hour registration, material requirements and routing of the activities.

4.1 Provision tactical and operational level:

Together with the operations manager we made a clear distinction in the provision of the planning levels to make clear what output should be generated by the tactical and operation planning to create unambiguity in the structure and output of the levels. The distinction is derived top-down based on the planning hierarchy and framework described in Section 3.3 for realistic expectations. In Table 10, the needs of both levels are described together with an explanation on how those translates back to the system.

Strategic/Tactical → Tactical	Tactical/Operational → Operationeel

• **Status componenten**:
  • Project + Assembly parts (according to layers production scheme)
	• **Status componenten**
	  • Project + Modules based on production orders) + departments

• **Workload**:
  • Connection departments under projects to estimated hours/lead time → visualization over time in graph.
$\frac{Project\ specific\ hours}{\left(\frac{available\ hours\ for\ projects\ (capacity)}{\#ongoing\ projects}\right)}$ = estimation number of weeks project
	• **Workload:**
	  • Connecting departments under projects to estimated hours/leadtime → visualization over time in graph.
	  • Day-to-day planning based on available resources

• **Leadtime:**
Rule of thumb for entire project:
	• **Leadtime**
	  • Own determination of leadtimes for modules based on tactical planning.
	  • Possibly later destilled from ERP system

• **Inclusion project status:**
  • Active, planned and on hold.
	• **Inclusion project status:**
	  • Active

• **Purpose:**
  • Set-up lead times unique projects
  • To create decision support for accepting new orders, insight when these can be scheduled
	• **Purpose**
	  • Set-up day-to-day management
	  • To create insight in the deviation between scheduled and reported hours

Common goals: • Creating an iterative process • Flexibility: Visualizing consequences of changes, delays etc. faster	

Table 10, Provision tactical and operational level

In Figure 15, an example of how we conversed an active project from MS Project to MS Excel according to the new tactical structure based on the four main (assembly) components: Substructure, superstructure, additional parts and transport. The 4 main (assembly) components with the 7 departments underneath are used as indicators on tactical scale as described in Table 10. Such that all modules will no longer have to be entered entirely manually by the CAD structure on tactical scale.

Project Structure	Name	Duration (WD)	Start Date	End Date	Project_Status	Working hours	Working hours completed	Remaining working hours
110306	110306 HMV sprint A 3008	76 days	22 November 2021	3 March 2022	Active	1.825u	249u	1.576u
110306.1	Substructure	64 days	22-11-2021	17-2-2022		693u	97u	596u
110306.1.A	Engineering	10 days	22-11-2021	3-12-2021		20u	20u	0u
110306.1.B	Work preparation	3 days	1-12-2021	3-12-2021		20u	20u	0u
110306.1.C	Sheet metal Machining	5 days	6-12-2021	10-12-2021		110u	56u	54u
110306.1.D	Mechanical Machining	7 days	4-1-2022	12-1-2022		11u	1u	10u
110306.1.E	Welding	19 days	3-1-2022	27-1-2022		350u	0u	350u
110306.1.F	Surface Treatment Area	11 days	27-1-2022	10-2-2022		32u	0u	32u
110306.1.G	Assembly	12 days	2-2-2022	17-2-2022		150u	0u	150u
110306.2	Superstructure	54 days	1-12-2021	11-2-2022		374u	36u	338u
110306.2.A	Engineering	16 days	1-12-2021	22-12-2021		18u	18u	0u
110306.2.B	Work preparation	7 days	13-12-2021	21-12-2021		18u	18u	0u
110306.2.C	Sheet metal Machining	4 days	5-1-2022	10-1-2022		39u	0u	39u
110306.2.D	Mechanical Machining	3 days	5-1-2022	7-1-2022		33u	0u	33u
110306.2.E	Welding	17 days	10-1-2022	1-2-2022		196u	0u	196u
110306.2.F	Surface Treatment Area	4 days	1-2-2022	4-2-2022		24u	0u	24u
110306.2.G	Assembly	6 days	4-2-2022	11-2-2022		46u	0u	46u
110306.3	Additional Parts	58 days	29-11-2021	16-2-2022		332u	48u	284u
110306.3.A	Engineering	12 days	29-11-2021	14-12-2021		20u	20u	0u
110306.3.B	Work preparation	15 days	30-11-2021	20-12-2021		24u	16u	8u
110306.3.C	Sheet metal Machining	5 days	2-12-2021	8-12-2021		43u	10u	33u
110306.3.D	Mechanical Machining	14 days	6-12-2021	23-12-2021		4u	2u	2u
110306.3.E	Welding	20 days	13-12-2021	7-1-2022		169u	0u	169u
110306.3.F	Surface Treatment Area	3 days	7-2-2022	9-2-2022		32u	0u	32u
110306.3.G	Assembly	6 days	9-2-2022	16-2-2022		40u	0u	40u
110306.4	Transport	39 days	10-1-2022	3-3-2022		426u	68u	358u
110306.4.A	Engineering	12 days	10-1-2022	25-1-2022		40u	40u	0u
110306.4.B	Work preparation	13 days	12-1-2022	28-1-2022		44u	28u	16u
110306.4.C	Sheet metal Machining	17 days	14-1-2022	7-2-2022		30u	0u	30u
110306.4.D	Mechanical Machining	17 days	14-1-2022	7-2-2022		42u	0u	42u
110306.4.E	Welding	19 days	19-1-2022	14-2-2022		100u	0u	100u
110306.4.F	Surface Treatment Area	15 days	27-1-2022	16-2-2022		48u	0u	48u
110306.4.G	Assembly	21 days	3-2-2022	3-3-2022		122u	0u	122u

Figure 15, New tactical format designed in MS Excel

From this set-up (Figure 15) we derived visual support in MS Excel as displayed in Figure 16, which delivers added value as we described in Section 3.1. MS Excel can make changes immediately visible in the workload graph through the applied consistency in the WBS, see Appendix C for the method behind the consistency, to compare the scheduled project hours against the workload (capacity), this offers more flexibility than MS Project because there the planner had to switch continuously between the applications to create a workload view (first an data export from MS Project to MS Excel had to be made to create visual support) and then adjustments had to be made in MS Project

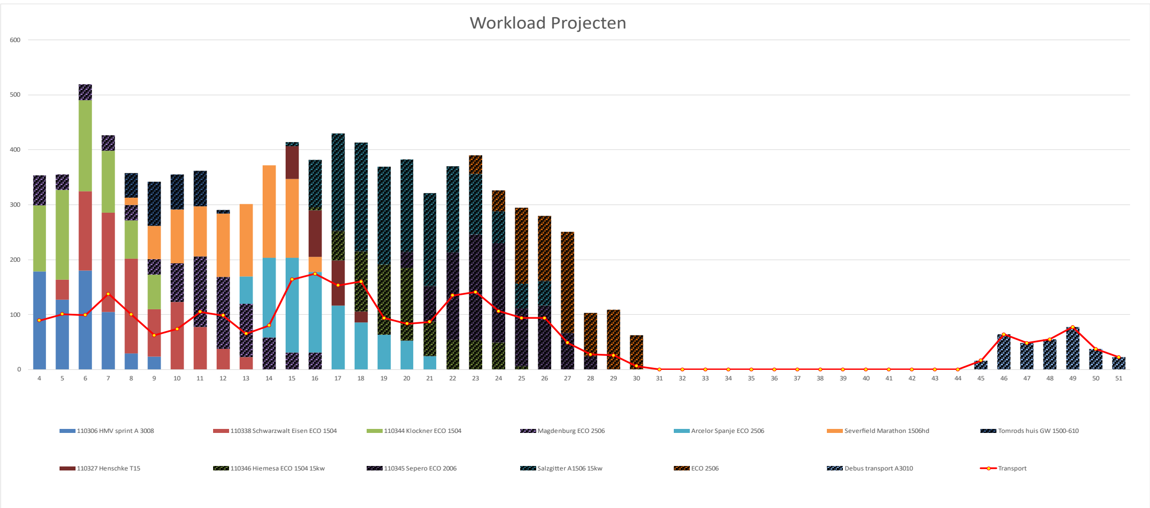

Figure 16, Workload deduced from new structure in MS Excel, where the x-as presents the week nr. and the y-as the workload in hours.

again if necessary, which was time-consuming. Next to this, through the repeatedly usable structure for tactical planning as described in Section 4.1, the tactical planning can be drawn - up by others than the (intuition of) the production manager because the structure at the assembly level is the same for every project, only the project specific hours attached to the components are different due to the customer-specific options. This makes the planning process less complex, because at the tactical level, the hours of the 'extra' options can be attached to the assembly components by the help of an option list. Such that an order card can be constructed where the machine options are presented, and an automatic tactical planning can be extracted to determine the lead time for the customer. The condition 'structure' as we described in Table 1 is thereby covered.

By the introduction of the new tactical format, we already improved the alignment between the used information systems (Figure 17). The information provision between the applications is limited to two applications. By visualizing everything in MS Excel, the 'smooth flow' of the information transfer aligns already better.

Figure 17, Alignment between systems.

This will present a better overview and storage of data. Furthermore, for involvement of stakeholders concerning the tactical planning is recommended to set-up a 'tactical planner' meeting. In Appendix F, an example is given where the duties are segregated over the involved stakeholders for more adequate decision-making and involvement on the tactical process. Together with the extra functionalities described in Section 4.4.1 and 4.4.2 a simplified planning methodology is created in MS Excel. In figures 18, 19, 20 and 21 an elaboration of the information flow in Figure 17 is presented.

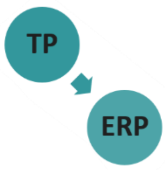

Figure 21, Enddate main components for material planning.

Figure 20, Startdates modules and related POs for determination routing activities.

Figure 19, Reporting hours

Figure 18, Adjustments based on most recent reporting and analyses, for future improvements planning.

4.2 Control plan

In Section 2.1 we described that tactical and operational planning should be updated frequently. There are four basic steps according to the control cycle which provide guidelines to control the tactical and operational planning: (1) routing, (2) planning, (3) monitoring and (4) control, where routing of activities and planning are principles to build the operational planning and the monitoring and control steps are in coordination with the tactical planning. These are taken into consideration in the 'aligned approach'.

4.2.1 Routing, creating structure

Routing, the primary purpose of routing is to determine and record the best sequence of activities/tasks for a smooth flow of the follow-up of activities. Routing is an important step in the production planning and control phase due to the dependencies and bottlenecks within the process.

At Gietart, the routing is dependent on the activities which belong to the PO, where the routing of the PO is still determined by the ERP system.

4.2.2 Control and efficiency

Planning should ensure that time and resources are optimally used by identifying the amount of work that needs to be done and arrange the operations in order of priority and dependency for Overall Equipment Effectiveness (OEE).

Modules that were not on the critical path were in the old situation not included in the tactical planning. Which meant that not all project modules were included in the planning. (About 80% of a project was incorporated in the tactical planning due to the time-consuming approach by having to enter all modules manually by the CAD structure (Weegen, 2021).) In the new designed tactical format, all belonging modules are included in the hour calculation such that the best estimation of the customers lead time can be generated. In addition, reported hours can be compared with the scheduled hours to trace the deviations in the hour calculation and to track if the correct hours are reported on a project. When the deviation between the scheduled and reported hours becomes clear, the efficiency on specific departments can be determined, which can be learned from for the hour calculation of new projects (iterative process).

Monitoring and control

Monitoring, Insights in the progression of a project must be visible for the stakeholders to keep an eye whether the progression can be kept within the predefined margins. Due to the new tactical structure, the POs can be attached to one of the four main components to monitor the progress of those components for progress determination. It is a good start for increasing the **monitoring** and **control** phase**,** which are important supplements for the control plan and so does the new format cover the condition of ‘progress determination’ as described in Table 1.

It is further investigated how we could create more accuracy in the **monitoring** phase on operational level. Examined is if a PO when it is extracted from BaaN, could be attached to the modules within the project to create narrower overview in the completion process of specific modules. This connection is complex because each project contains different modules and different POs due to customer specific options, therefore a standard link between the POs and the modules cannot be made and therefore, it is hard to monitor the progress of the modules on operational scale. Multiple options have been considered like the use of the BOM structure such that modules within a project should match the BOM structure. This is tested during this research, but this option requires a lot of preparatory work because of the great variation between projects, a standard format cannot be used. Manual implementation needs to be done to create links in the planning, which is not easy to implement, a preview has been made by the planner (Weegen, 2021), but due to the large variability between projects the organization does not saw this as an option, it was very time consuming.

4.3 Improvement of data quality

To validate the solution design to improve the data flow between the systems a trade-off analysis has been made between MS Project and MS Excel. We did deeper research to the functionalities of MS project and MS Excel to determine how the tactical and operational planning can complement and reinforce each other the best and how the conditions described in Table 1, can be covered.

One of the functionalities of MS project is the critical path and the duration that is calculated over the scheduled lead time. For example, there is a project of 1000 hours which is plotted in MS Project, a module that is attached to it has a duration of 150 hours and a lead time of three weeks. MS Project will calculate the working days over which the hours must be distributed. If this is three weeks in advance, MS Project will count 15 working days for that module. This calculation of the duration over the working days can also be generated in MS excel with formula I:
=NETWERKDAGEN.INTL(begindatum; einddatum; [weekend]; [vakantiedagen] &""& "dagen" .

110344 Klockner ECO 1504	Duration	Startdate	Enddate
Onderbouw	40 dagen	10 januari 2022	4 maart 2022

Figure 22, Lead time calculated by formula I in MS Excel.

The 'net' duration of the working days can in this way also be calculated in MS Excel (Figure 22). Furthermore, we have transferred the WBS that is set-up in MS Project for the projects to MS Excel (Figure 15). The projects can be set-out in the same way by highlighting the modules and displaying the departments below the same image returns in a well-structured format with the same functionalities incorporated.

4.3.1 Gantt-chart

A rough but simple way for graphical support of dependencies is the Gantt chart with all on-going projects included in MS Project. A Gantt-chart displays the time on a bar or channel on a chart. The start- and end time of projects can be indicated on the map and thereby the duration over time of a project is visual. It provides a visualization of which projects are running in parallel. Gantt-charts are not an optimization tool: They only facilitate the development of alternative planning by an effective visualization. In a Gantt-chart it is possible to visualize the dependency and variance of the projects. To replace this function of MS Project we created a Gantt-chart format in MS Excel to monitor HH in the realigned method. The Gannt-chart of the active and ongoing projects within Gietart is provided in Figure 23.

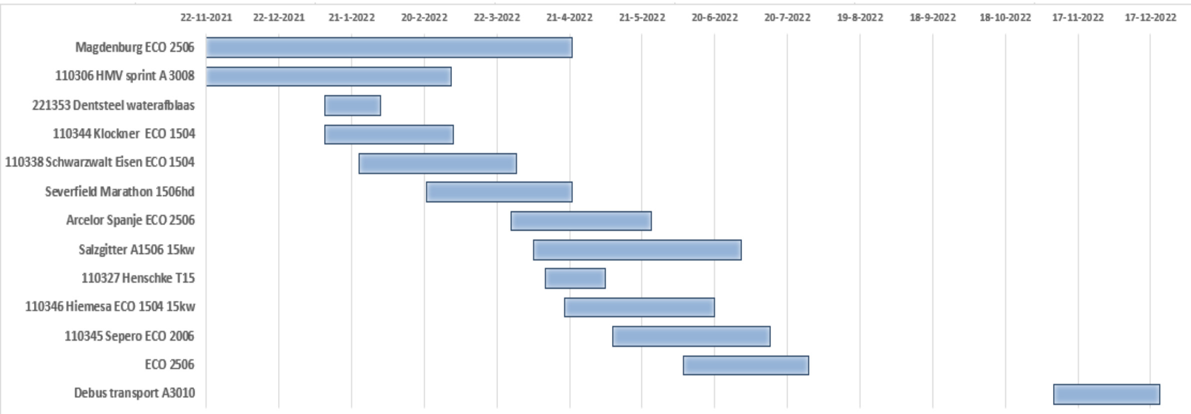

Figure 23, Multi-project view

4.3.2 PERT

The Program Evaluation and Review Technique (PERT) can be used to analyse the time required for a task in a project. It is a tool in MS Excel to analyse the time required for each task when completing a project and to identify the minimum time required to complete the overall project (Heizer et al., 2016). It includes the ability to plan a project without knowing exactly the details and duration of all the activities. PERT provides the possibilities to identify the critical path and is able to replace the critical path function in MS Project that is used by Gietart.

4.3.3 Functionalities MS Project vs MS Excel

Functionalities	**MS Project**	**MS Excel**
Updates or revisions of the project should be easy to implement.	-	+
Provide (visual) insights in progression of projects toward the lead time	+/-	+
Lead time calculation	+	+/-
Inclusion project status	+/-	+
Susceptibility to errors of program	+	+/-
Shift workload (Effects of adjustments)	-	+
Iterative process	-	+
Incorporate different precedence relations (dependencies)	+	+/-
Integration with ERP system BaaN	-	+/-
Graphical support workload	+/-	+
Maintenance approach	+	-
Costs (time)	-	+
Sub calculations projects	+/-	+

Table 11, Functionalities MS Project VS MS Excel

+ = application is suitable for realizing the functionalities.
+/- = application can realize boundary condition with extra effort or editing.
- = application does not support condition.

4.4 SMART analysis.

Several considerations play a role in this selection process between the used information systems and to realize the objectives of both planning levels, which is why this is a multi-criteria decision analysis (MCDA). SMART is often used in these cases, because of the simplicity and transparency it offers in the decision-making process, so that stakeholders from various backgrounds can derive and understand the outcomes.

The SMART analysis consists of 8 steps (Goodwin & Wright, 2012), which are also followed in this study. The same attributes with the same weighting are used for the evaluation of both applications. This was chosen because every precondition was equally important to realize and because the decision maker (described in **step 1**) saw no reason to deviate from this for a system alignment.

Step	Action
1	Identifying decision maker(s)
2	Identifying alternatives (in this study alternatives of MS Excel compared to MS Project)
3	Identifying attributes
4	Scoring alternatives on directly rated attributes
5	Determining attribute weights with **swing weights**
6	Determining the final score by aggregating scores with the additive model (multiplying scores with weights and composing all this)
7	Making a preliminary decision
8	Perform sensitivity analysis

Table 12, Step-by-step approach SMART analysis

Step 1 of the SMART analysis is *to identify decision maker(s).* The input for this SMART analysis is provided by the operations- and production manager. The decision-making power of the operations manager in combination with the background knowledge of the production manager makes them suitable to complete the SMART. They determined the weighting of the attributes as well as the scores of the adjustments.

Step 2 *Alternatives are benchmarked in the Strength, Weakness, Opportunity and Threat (SWOT) analysis.*
A trade-off of the perspectives of MS project and MS Excel is examined. The opportunities and threats of both applications are plotted against each other to generate a picture of the alternatives of the applications in comparison to each other. MS Project carries a lot of threats and weaknesses in comparing with MS Excel as visible in Figure 24 and Figure 25. In Figure 25 is visible that the opportunities of MS Excel overrule those of MS Project. By analyzing the strengths, weaknesses, opportunities and threats of the used information systems we started to explore options the exert the weaknesses and explore new opportunities with awareness of the strengths and weaknesses of both applications.

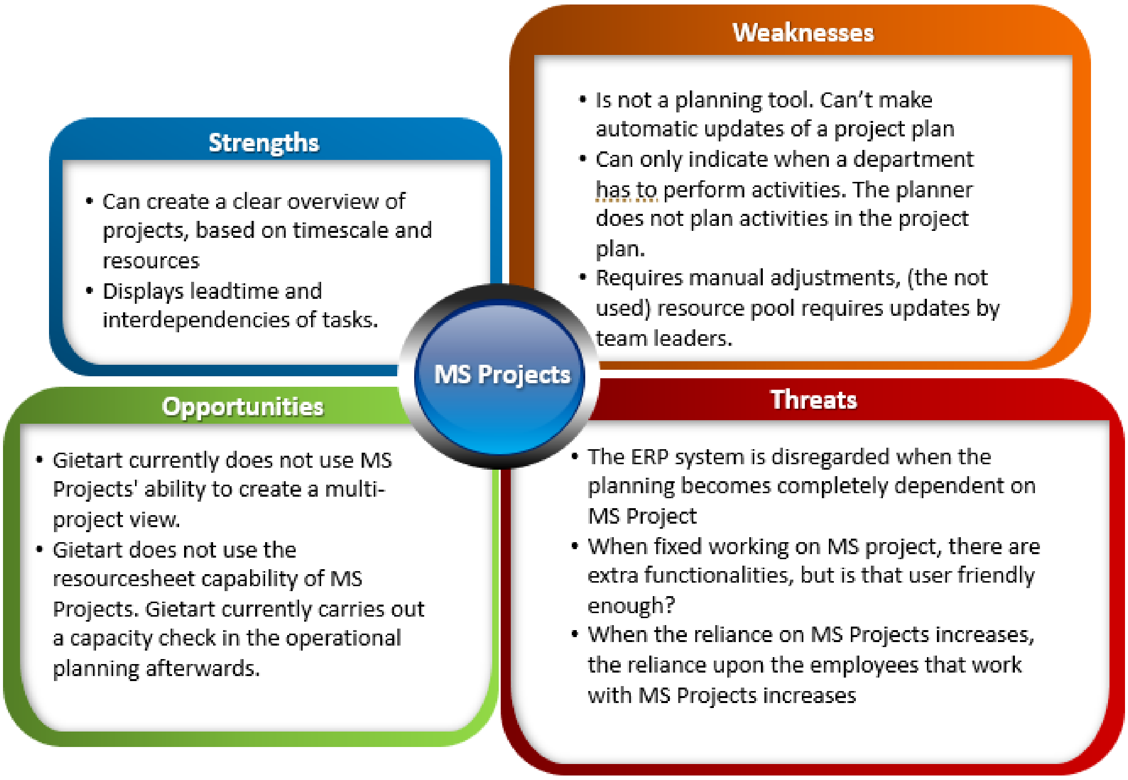

Figure 24, SWOT analyse MS Project

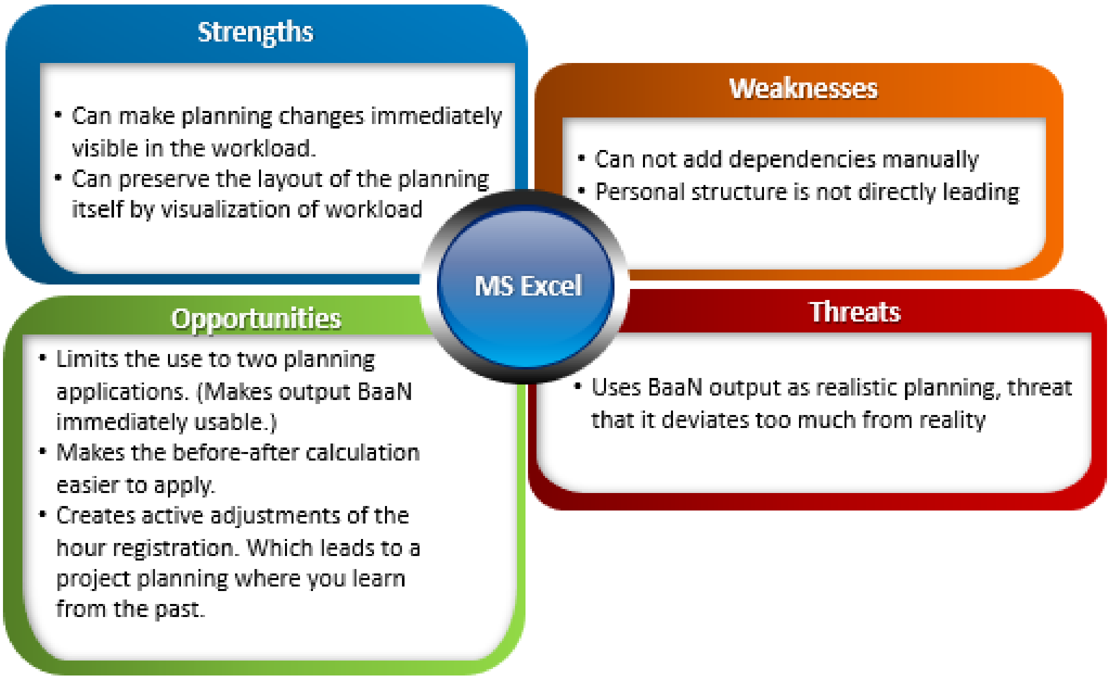

Figure 25, SWOT analyse MS Excel

Step 3 *identifying attributes*
In step 3, the attributes were drawn up together with the decision makers. The decision makers want to weigh-up costs and benefits of both applications, see Figure 26. The costs are taken here as 'effort on the technical side' and 'effort on the user side' those attributes cover the conditions set in table 1 which causes a decrease in costs. This research focusses on an improvement of organizational performance by realizing alignment within the planning hierarchy and thus between the used systems in the organization. A list of essential functionalities which the system should offer is described in Section 4.4.3 those should be accomplished for successful use on long term. In addition, 'complexity reduction' has been added as an attribute under benefits because this pursues the goal: The alignment between the two planning levels should make the information transfer along the applications less complex on the user- and technical side.

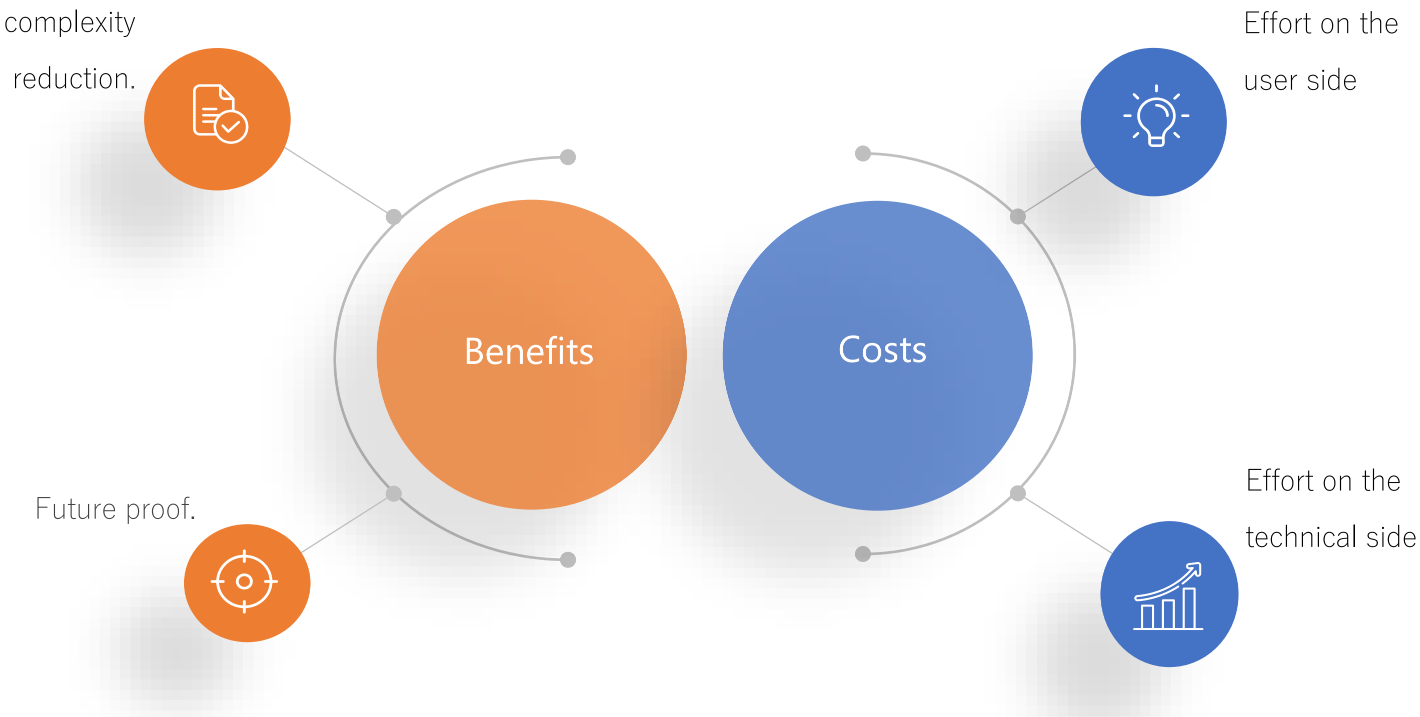

Figure 26, Costs and benefits with attributes

Conditions

All functionalities described in Table 11 are connected to the main conditions set by planning management in Table 1 to weigh them against the attributes to create an adequate decision.

- Transparency: Visibility of the impact of revisions/delays, provide (visual) insights in progression of projects, lead time calculation should be transparent and the derivation of the project status should be transparent for stakeholders.
- Progress determination: Provide insights in progression of projects toward the lead time, effects of project up-dates towards lead time.
- Structure: Susceptibility to errors of the information system, incorporation of different precedence relations (dependencies) within structure, repeatedly use of the structure.
- Cost control: Improvements along reporting stage, costs of maintenance information system, time-consuming approach of information system, analysing the actual costs.

Step 4 *Scoring alternatives on directly rated attributes*
The scores are determined by the direct rating (Goodwin & Wright, 2012). The best scoring adjustment on the attribute gets 100 points, the worst 0, and the rest is scaled in between to make a clear distinction. Table 12 shows the meaning of the scores related to the different attributes defined in step 3.

Step 5 *Determining attribute weights with **swing weights***
The weighing of the attributes is determined by the decision maker with swing weights (Goodwin & Wright, 2012). These attributes are normalized relative to each other so that the total comes to 100 points, as shown in Figure 27.

Attribute	Weight	Score 0	Score 100
Complexity reduction	**10**	Information systems is easy not easy to use within new methodology	Information system is easy to use
Effort on the user side	**30**	Additional training required/not user-friendly	Employees are not disturbed by executing their duties/user-friendly
Effort on the technical side	**20**	Many adjustments to Process flow after implementation	Few adjustments to process flow after implementation
Future proof	**40**	Short-term options	Long-term solution

Table 13, Attributes and weights

Input for the attributes and their weighting is given by the indicated decision makers. The four attributes are weighted using swing weights (Goodwin & Wright, 2012). The decision makers assign the highest value to 'future proof' because this attribute represents the output of the alignment the most.

'Effort on the user side' is scored higher than 'effort on the technical side'. The goal requires a change of approach. This must be executable with the current employees who carry those duties. The decision maker wants to count these costs more heavily than effort on the technical side. If the new methodology can be implemented and used with the qualifications of the current employees, these improvements outweigh the efforts on the technical side because more 'improvements' on the technical side could make the new approach less 'user-friendly' and more 'complex'. Complexity reduction is counted as the least important: 75% less important than future proof because when the other attributes can be accomplished a feasible improvement is achieved and the employees does not have to understand the technology behind the implementation process, only the changes in their working approach. The ability to work with it and understanding the benefits of the alignment for their contribution are more important. These scores are normalized so that the total of weights comes to 100 points

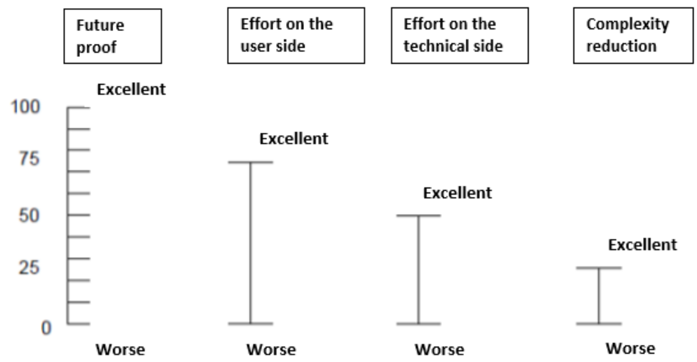

Figure 28, Attributes scaled

Attribute	Score	Normalized
Future proof	100	40
Effort on the user side	75	30
Effort on the technical side	50	20
Complexity reduction	25	10
Total	250	100

÷ 2,5

Figure 27, Attributes normalized

Step 6 *Determining the final score by aggregating scores with the additive model (multiplying scores with weights and composing all this)*

The scores in Table 14 and Table 15 to assess the abilities of MS Excel and MS Project are assigned together with the decision makers.

MS Excel	Weight	Visual managment	Cost control	Progress determination	Structure
Complexity (reduction)	**10**	50	100	50	50
Effort on the user side	**30**	50	100	100	50
Effort on the technical side	**20**	100	50	50	50
Future proof	**40**	100	100	100	100
Total	**100**	8000	7100	8500	7000

Table 14, Final scores MS Excel

MS project	Weight	Visual management	Cost control	Progress determination	Structure
Complexity (reduction)	**10**	0	0	50	0
Effort on the user side	**30**	100	0	100	100
Effort on the technical side	**20**	100	0	0	100
Future proof	**40**	50	0	100	100
Total	**100**	7000	0	7500	9000

Table 15, Final scores MS Project

Step 7 *Making a preliminary decision*
Based on the results of the SMART analysis in combination with the information gained during this research we recommend that planning on tactical- and operational level planning should be assigned to MS Excel and that MS Project should be excluded from the planning process for an improved alignment between the information systems.

For the comprehensive view: At tactical level, scheduling is based on the lead time of the main components (processing time + waiting time) because the components also occupy a production space during the waiting time. This schedule can be developed in MS Excel where adjustments can be made manually, even on specific components by inserting a delay function which was not possible in MS Project. (In MS Project small adjustments shift the overall planning of all projects automatically due to the critical path function which is entangled in the project path. This makes MS Excel much more flexible as well.) The operational planning in MS Excel is still dependent on the ERP system because the start dates of the modules and the routing of the POs together with the database of articles is provided by the ERP system. Therefore, the ERP system offers necessary support for operational planning.

Step 8 *Perform sensitivity analysis*
We presented the results from the SMART analysis regarding the opportunities of the two information systems in Figure 29. These were close to each other, MS Excel scores better in all areas except for structure. This is due to the interdependencies that are automatically indicated in MS Project, which automatically provides relationships between tasks within the WBS. We have investigated options for this in MS Excel and this is replaceable with the PERT technique as described in section 4.4.2, so it is not a valid argument to exclude planning in MS Excel.

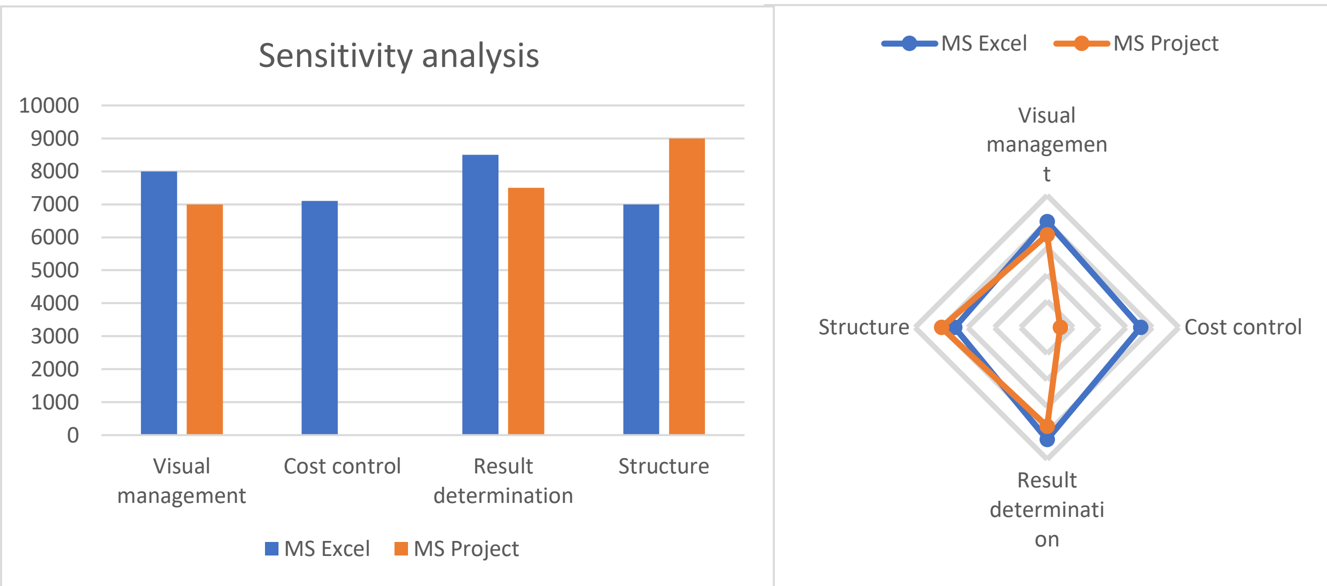

Figure 29, Sensitivity analyses MS Excel VS MS Projects

4.5 Conclusion chapter 4

This chapter provides an answer to the research question*: How to create a structure between the information systems that is repeatedly possible?*

To make a proper assessment, the functionalities of the information systems MS Project and MS Excel have been evaluated by the MCDA approach. It became clear that the added value that MS Project has to offer compared to MS Excel is not being used within this organization. Only a few functions within MS Project are used which currently offer added value, but these can also be formatted in MS Excel. The 'extra' functions of MS Project are therefore replaceable. MS Excel provides everything necessary for the planning process within this organization and can replace all functionalities of MS Project:

- The WBS structure together with the Critical Path Method (CPM) method can also be performed in MS Excel, where changes in the workload can be visualized immediately, so that the capacity can be stabilized with fewer actions compared to MS Project.
- A format in which the activities, minimum duration (days), release date (days), due date (days) and the workload can be displayed based on the main components in combination with the WBS can also be generated in MS Excel
- The planning of main components in MS Excel provides clear guidelines for tactical objectives, customer-specific project hours can be attached by the support of an option list with determined hours to generate a lead time for the customer. (The structure of each project is the same based on those main components, but the attached hours are different through the customer specific options.) Furthermore, other stakeholders need to be included in the tactical planning process for more adequate decision making.
- For visual management, the throughput time of the projects can be displayed on a tactical scale in a Gantt chart in MS Excel for a good view on multi-project management.

Therefore, the conclusion tends to exclude MS Project in the planning process and to limit the planning process to two applications for a better alignment between the information systems and therefore, the planning levels. Thereby, the structure is repeatedly usable in the new format due to the clear expectations that are set in Section 4.1. The applied structure in MS Excel provides a format that can be reused for all projects because every project contains the (main) assembly components. Only the hour calculation must be redefined based on the project options for the lead time calculation. This is an improvement compared to the structure in MS Project where all modules within a project were defined, which more presented an operational point of view than a tactical view. Due to the customer specific options and the difference between projects, the old tactical structure in MS Project could never be reused through the total set-out of all modules. Next to this, the four main components provide clear indicators to monitor the progress of the components and thereby to control the process.

Chapter 5: Improvement proposals for planning management.

In this chapter we are substantiating the proposed solutions. To start in Section 5.1, we will elaborate on how the new tactical format combined with new instructions for tactical planning will result in more proactive decision making. In Section 5.2 we will present a redesigned planning framework for Gietart, which is composed based on our findings and scientific literature for clear expectations. We will continue with new predictions which has been developed by our results in Section 5.3. Thereafter, we lined out the advantages and disadvantages for commitment of the stakeholders in Section 5.4 and in Section 5.5 we proposed the estimated impact on the performance of the different indicators which are related to this research. Finally, we discuss the success factors for a clear perspective of the alignment and end this chapter with a short summary of the findings in Section 5.6

In the original methodology the tactical, which was indirectly the operational planning, was constructed in isolation. To improve the quality, at least a tactical and an operational planner must be integrated in the planning process for constructing the planning, because due to the operational experience of the planner in this case, operational consequences are incorporated in the tactical planning, which is reflected in the utilization of the capacity. As stated earlier there is a capacity of 420 hours per week and only 350 hours is utilized (Kok, 2021). By assigning a tactical planner and an operational planner a more objective representation of the planning can be generated. *Therefore, Adjustments and insertions have to be made to the current planning methodology.*

5.1 Proactive decision making

By spreading the responsibilities of tactical and operational planning, the communication structure among stakeholder will change. To give an idea, a diagram has been drawn up in Appendix F where all stakeholders are described and what input they should provide and thereby the expected output to create a tactical planning in which the needs of a tactical planning are reflected. Next to this, a tactical planning meeting to discuss the progress and control of the planning should result in more proactive decision making. The process-flow of this meeting is sketched in Figure 30.

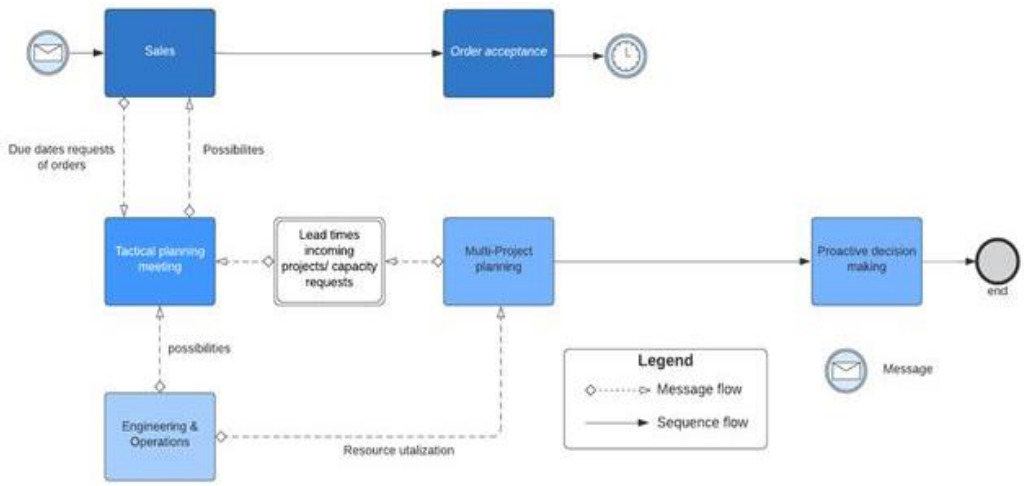

Figure 30, Process model stakeholders regarding tactical meeting

5.2 Redesigned planning framework Gietart

During the research we conducted a new lay-out for the organization on tactical and operational level according to the hierarchical planning framework for project-driven organizations by (De Boer, 1998) as mentioned in Section 3.2 in combination with the expertise of the operations manager (Kok, 2021). In Figure 31, we presented the lay-out of the recommended hierarchical framework for clear expectations of the output from the tactical- and operational levels within Gietart.

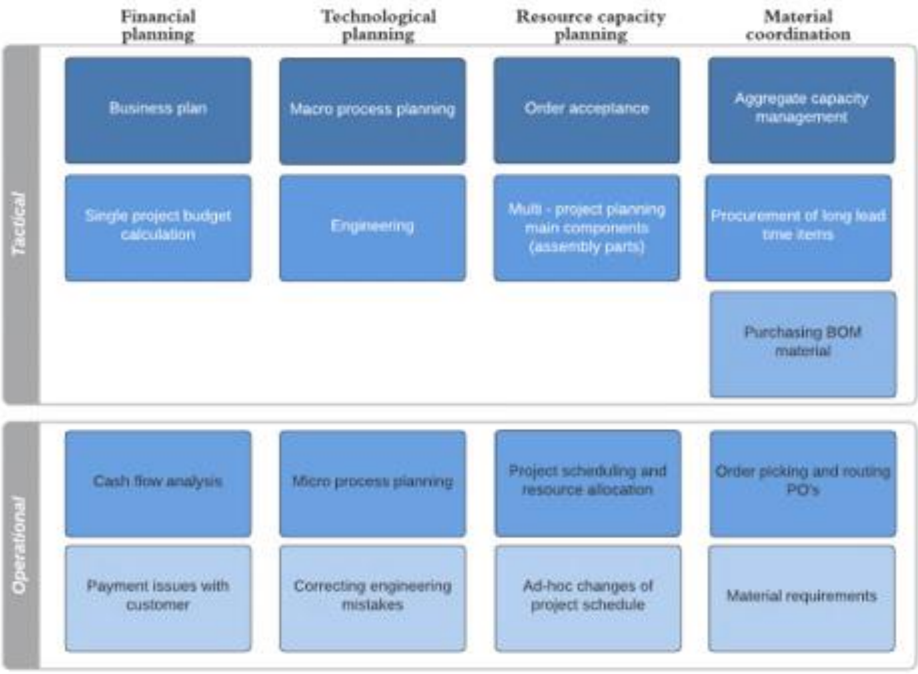

Figure 31, Hierarchical planning framework Gietart Kaltenbach

Furthermore, as we stated in section 4.2 it has been decided to plan the main (assembly) components at tactical level, which are: The substructure, superstructure, additional parts and transport of a machine. This results in a '4-level structure' in the methodology (Figure 27), instead of the original three- level structure which was used by the organization. On tactical time interval there were no clear indicators in the original methodology of Gietart. All projects were expanded with all modules below and a total lead time was estimated based on the modules which were on the critical path. It has been decided to apply this extra layer for unambiguous indicators for stakeholders. This differentiation is repeatedly usable because those assembly components are included in all projects, only the attached hours underneath are different through the customer specific options. In Appendix D the assembly layer in the production scheme is displayed. The assembly layer is indicated by a gauge and furthermore all (possible) modules of a machine are visible in that production scheme.

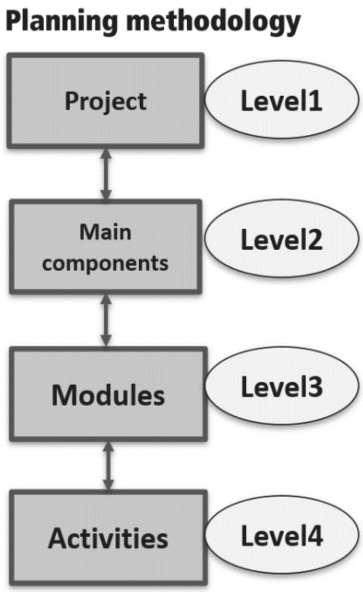

Figure 32, Planning methodology: 4-layer structure

5.3 Visualization occupation departments

As result of the new tactical format we designed, new valuable insights can be visualized. Through the inserted structure, it is possible to visualize the scheduled occupation of the departments. We created a pivot of the department occupation (Figure 34) which can be deduced through the applied WBS in the new structure of the format.

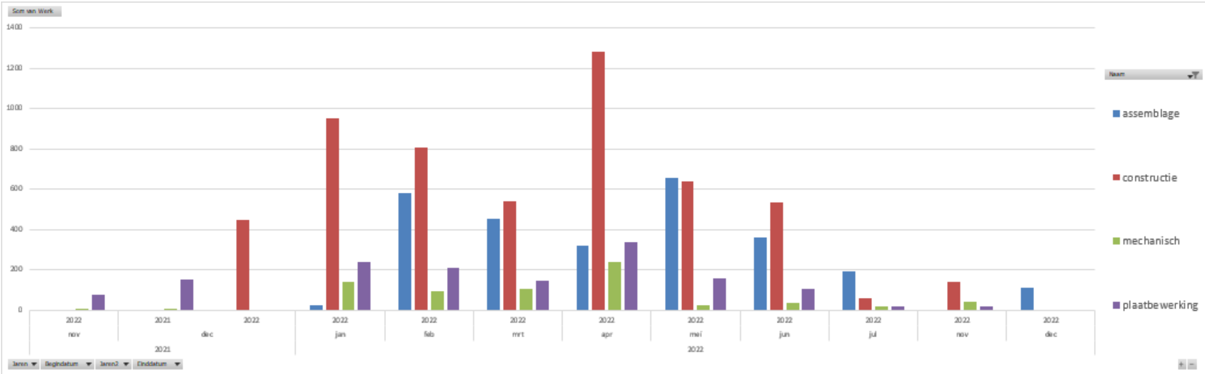

Figure 33, Visualization department occupation deduced from 'new' tactical format

Som van Werk Rijlabels	Kolomlabels assemblage	constructie	mechanisch	plaatbewerking	Eindtotaal
2021		**449**	**14**	**229**	**692**
nov			**10**	**76**	**86**
2022			10	76	86
dec		**449**	**4**	**153**	**606**
2021			4	153	157
2022		449			449
2022	**2708**	**4957**	**714**	**1246**	**9625**
jan	**28**	**953**	**142**	**241**	**1364**
2022	28	953	142	241	1364
feb	**580**	**808**	**95**	**213**	**1696**
2022	580	808	95	213	1696
mrt	**456**	**542**	**108**	**145**	**1251**
2022	456	542	108	145	1251
apr	**320**	**1279**	**242**	**338**	**2179**
2022	320	1279	242	338	2179
mei	**656**	**637**	**23**	**158**	**1474**
2022	656	637	23	158	1474
jun	**360**	**536**	**40**	**109**	**1045**
2022	360	536	40	109	1045
jul	**196**	**58**	**20**	**22**	**296**
2022	196	58	20	22	296
nov		**144**	**44**	**20**	**208**
2022		144	44	20	208
dec	**112**				**112**
2022	112				112
Eindtotaal	**2708**	**5406**	**728**	**1475**	**10317**

Figure 34, Department occupation over time in numbers

This is valuable information for planning management because for example, in Figure 33, it is visible that in April there is a high outlier by the construction department. Through this visualization, measures can be taken in time to stabilize the workload of the specific department. With the old format in MS Project, it was not possible to deduce this view. The tactical planning was only visible in MS Project, therefore an export to MS Excel had to be made for visualization. This export did not generate a consistent structure as displayed in Appendix E and structuring it was very time consuming. Due to the new Format in MS Excel with the consistent 4-layer structure as described in Section 5.2 this visible prediction can be made.

5.4 Advantages and disadvantages stakeholders

For commitment from the stakeholders, we introduced Table 16, where we provide a view on the advantages and disadvantages to empathize their personal interests.

stakeholder	Advantages	Disadvantages
Management team	• Employee satisfaction due to better organisation of duties • Cost decrease (time and application costs.) • New valuable predictions	• Monitoring impact new approach.
Manager operations	• Possibility to increase the utilization of the already existing resources. • Better indicators set for planning management. • Workload is more stable due to flexibility and insights; this results in more control of the process. • Possible lead time reduction due to iterative process and reduction of waste within the process. • Less dependency on human intuition.	• Investment (time) in training to get employees familiar with new approach. • Get along with the progress of the planning approach and the impact of the organizational change.
Sales department	• Improved decision-making regarding rush orders. • Better arguments for order acceptance. • More reliable due-date quotation for customer.	• No disadvantage for sales department
Tactical planner	• Focus on tactical area -> adequate decision making • Multi-project view of main components	• New function, new responsibilities • Less experienced than old planner
Operational planner (production manager)	• Focus on operational area • Limited to two applications • Visualization available	• Responsibilities changes • Get used to change
(Others involved by project coordination)	• Increased coordination planning • Should translate in less ad-hoc changements • progress can be better monitored and controlled due to improved alignment.	• Input of project plan might change
Engineers	Better forecast workload	

Table 16, Advantages and disadvantages stakeholder

5.5 Key Performance Indicators

The alignment along with distributed responsibility in the planning hierarchy can make significant difference within the organization at multiple levels involving multiple stakeholders.Table 17 provides an overview of the measurable performance and the stakeholders involved per indicator against the magnitude of the impact. At this point it is still difficult to quantify the impact because the concept must be executed and monitored over a longer time interval to collect the necessary data such that the measurements can be performed. In Appendix G, are the formulas displayed to measure the impact in numbers.

KPI	Stakeholders	Performance	Impact
Customer satisfaction	Management team	*Increases because:* 1. More transparency in the due dates can be generated. 2. Transparency often results in an increase in reliability of lead times this will result in improved delivery performance.	*Little because:* 1. Agreed lead time can be binding for customer order fulfillment 2. However, customer satisfaction depends upon other aspects (service, quality of the machine etc.)
Deviation on scheduled lead time	Management team Operational manager Production manager Sales team	*Decreases because* 1. Increase in utilization of capacity due to adequate decision making by segregation of duties 2. As a result the deviation should decrease through more accurate data	*Significant because* 1. Operational manager can focus more on operational management due to the segregation of duties there will be more focus on the production process.
Percentage of deviation between scheduled and reported	Management team Operational manager Production manager	*Decreases because* 1. Alignment between the systems delivers more accurate data input for the planning system. 3. Idea is to learn from discrepancies in the past by reporting start- and enddate in ERP system, such that the deviations will decrease.	*Moderate* 1. Takes a lot of time till the data is updated in the ERP system and ready is for use.

Percentage of modules completed on time	Production manager Manager operations	*Increases because* 1. POs can be attached to main components. This makes it easier to track the progress.	*Moderate because* 1. Interdependencies between activities within modules can still disturb the process of total completion. 2. Only the progress of the main components can be traced significantly.
Number of revisions in the tactical planning	Operational manager Planners	*Decreases because:* 1. System alignment provides a better visual interpretation of the workload distribution 2. Planning is no longer made in isolation and more fact based.	*Significant because* 1. Gaps in production over tactical term can be aligned through visual insights of actions in the workload distribution 2. More adequate decision making through distributed responsibility 3. The goals of the tactical planning are better defined.
Number of revisions in the operational planning	Operational manager Planners	*Decreases because:* 1. More attention for the reporting stage in ERP and thereby the information provision on projects. 2. Operational planner focusses only on active projects (operational view), therefor we expect a better controlled/monitored operational process.	*Moderate because* 1. Tactical planning provides input for operational planning. When the performance of the tactical planning increases should it also effects operational level.

Table 17, Key Performance Indicators planning performance

5.6 Success factors

We have selected six success factors to clarify and evaluate how the proposed alignment can be implemented in this section.

Success factor 1: Clear formulation of tactical and operational objectives
Formulating a clear vision, objectives and expectations of the 'improved' alignment contributes to a successful implementation (Umble & Haft, 2003).
Therefore, the vision, objectives and expectations of the alignment are extensively described in a report and in several minutes taken during meetings. These have been communicated with the involved stakeholders to give them an interpretation of the organization specific tactical- and operational objectives to develop their performance and to insert a clear vision about the benefits of the alignment.

Success factor 2: Commitment of the management team
Successful implementation requires leadership, commitment, and participation from management (Umble & Haft, 2003). This provides certainty in allocating money and resources. In addition, this behaviour can stimulate other employees, so that they can follow this example (Lauden & Lauden, 2012). This is done by setting up a meeting with the operations manager, who is authorized to direct the decisions. These interests have been communicated to those involved to planning management. Repeatedly on a weekly basis to keep the subject up-to-date and to discuss questions and problems about the developments with each other.

Success factor 3: Excellent project management
Excellent project management consists of clear objectives together with a feasible but progressive project plan that is monitored (Umble & Haft, 2003). Project management for information systems must take into account the five variables: Scope, time, cost, quality and risk (Lauden & Lauden, 2012). This is done:

- Progressive, the project plan has been drawn-up with clear achievements (quality, conditions) and possible risks that are incorporated.
- Progress of the alignment has been assessed during interactive presentations and meetings during this research with stakeholders.
- Afterwards, the implementation of the plan is evaluated and weaknesses are noted.

Success factor 4: Change management
Implementation of a new method can lead to a drastic redesign of business processes, sometimes even resulting in changes in corporate culture and structure. Implementation is therefore more than a technological challenge, chaos or resistance can arise among employees (Umble & Haft, 2003). Research into project implementations shows that the most common reason for implementation project failures is not technology, but organizational resistance to change. Involving employees during the changement contributes to positive cooperation (Laudon & Laudon, 2012).

- Through all interviews and organized meetings, the employees are involved step-by-step in the change process. Their requirements are incorporated in the alignment.
- Questions, experiences, and complaints in the process are discussed weekly during meetings to reassure employees and keep them involved in the possibilities of the changes and the operations manager has been assigned as contact point for questions.

Success factor 5: Data accuracy

Data accuracy is important, so a full transition is initiated for a successful implementation, thus MS Project will have to be eliminated immediately then to prevent employees from continuing to use the old system as well as MS Excel. When two parallel systems continue to run, employees will possibly continue to use the old system, which can lead to inaccuracy and confusing.

- Therefore, should be communicated that the old system will disappear and give people time to make the files suitable for the new system and indicate that they can ask for help with this.
- Afterward should be evaluated with the employees whether the system is working as expected.

Success factor 6: Education and training

If employees do not understand the goal of transition well, there is a chance that they will develop their own processes and use the system incorrectly.

- The benefit of the alignment is clarified from an employee perspective.
- The time to go through steps in the in step-by-step with the employees needs to be taken so that they can get familiar with the new method.

5.7 Conclusion Chapter five

To answer the research question: *How is the quality of the planning management improved using the recommended realigned planning method?*

Based on scientific literature and practical findings we conclude that the designed structure and alignment between the planning levels contributes to a better controlled planning management:

- It introduces visual insights and proactive steering measuring due to the increased data of decision making and involvement of multiple actors in the process.
- Due to the new planning framework unambiguousness objectives and expectations are attached on the different planning levels to formulate clear visions for all employees.
- Workload and occupation of departments can be visualized which contributes to flexibility in the decision-making process. Adjustments are visible immediately which prevents the process from unnecessary failure due to wrong estimation based on intuition.
- Success factors are used to evaluate the expectations and the realization of the goal of the alignment. Following the steps will aid the step-by-step introduction of the alignment and makes the improvements of the quality of planning management clear for the involved actors.

Chapter 6: Conclusion, evaluation, recommendations and discussion

By analysing the possibilities, added-value and impact of alignment between the information systems within the planning environment of a project-oriented organization, we were able to answer our research question in Section 6.1: "*How can tactical and operational information systems be better aligned within Gietart Kaltenbach to generate accurate output that can be monitored and controlled for improved production performance?*" Thereafter, we drawn-up some recommendations based on finding of this research in combination with other improvement proposals for further research in Section 6.2. Furthermore, we will describe how this research contributes to theory in Section 6.3 and some limitations of this research are discussed in Section 6.4.

6.1 Conclusion

The main flaws of the original planning environment within this organization entail that:

- Three information systems are running in parallel as support for the planning, where parallel entails that these systems are not aligned with each other. Changes in information have to be made manually in all systems to reinforce quality provided by the planning levels. Due to the lack of alignment, the information transfer along the systems is disrupted and not consistent.
- There are no clear indicators on tactical- and operational level, which makes it hard to monitor and control of projects.
- The input of planning (duration times of activities) is not unambiguously determined on accurate data, this reduces the quality and reliability of the planning.
- Decisions about order intake are mainly made on good faith there is lack of valid foundation.

We started our investigation by examining the added-value of monitoring and controlling project phases within project-oriented organizations. Therefore, in the theoretical research we investigated which qualifications are essential in a planning environment for project-oriented organizations such as Gietart and how certain parameters reflect on the organizational performance.

The original planning environment was complicating the information transfer between the tactical- and operational level due to use of multiple information systems. Based on a trade-off between the information systems used for planning management: BaaN, MS Project and MS Excel, a combination of MS Excel and BaaN has been accomplished for use in the redesigned methodology because an increasement in flexibility could be quantified directly, as adjustments in the planning could immediately be visualized in MS Excel and BaaN was indispensable for routing and material planning in the process, those applications 'fed' each other. The 'additional support' of MS Project within the original planning methodology can be replaced by functionalities of MS Excel, which limits the information transfer to two systems.

By switching to MS Excel and BaaN as the leading information systems, the planning process can be carried out in a similar way with some extras. To validate these findings, we designed a new tactical structure in MS Excel. This redesigned tactical planning in MS Excel offers support to determine the throughput time of a project and provides thereby an identification of the lead time of the main components, which we have added as indicators to monitor and control the project on tactical scale.

The main components are added as a fourth layer (project, *main components*, modules and activities) in comparison to the original methodology, which consisted of a 3-layer structure (Project, module and activities). This 4-layer structure is applicable to every project because all projects consist of those components. The completion of the main components provides transparency in the progress to stakeholders and customers. Next to this, for awareness of the parallel execution of projects and thereby interdependencies, all projects are visualized in a Gantt-chart model in MS Excel for a multi-project view. The effects of shifts can immediately be visualized in the Gantt-chart. For instance, when a project is delayed for two months it can immediately be adjusted in the Gantt-chart. There will be visible which other projects have to be produced in parallel when delaying the project for two months, what the effects are on the production planning.

Thereby the tactical and operational systems are better aligned due to information transfer is limited to two applications and provides extra support by means of visualizations, which can be provided by the redesigned format in MS Excel. Hereby, extra information to support the decision process is available to reduce motions and highlight defects in the planning process. Next to this, an extra indicator is incorporated in the new design to increase the monitor and control phase of the project on tactical scale to provide more transparency. Those four main components are the core for a structure which is repeatedly usable and offer an improvement in cost calculation of the projects, because the whole project no longer has to be enfolded in MS Project to determine the costs and throughput time, but options can just be attached to the main components in MS Excel by the support of an option list with the related prices and project hours such that the project costs and time can be pre-determined for a global idea for the customer and stakeholders. Also, this indicator offers opportunities to quantify the (increase) in performance with the illustrated formulas to improve the control plan because it provides clear points within the project.

6.2 Recommendations

We recommend excluding MS Project from the planning process, which can immediately be done because we converted the old structure of the already scheduled projects in MS Project to the new structure in MS Excel. Thereafter we have been investigating possibilities for further alignment between the systems BaaN and MS Excel, but due to the short time span of this research, the complexity and lack of data at this point, we recommended to investigate these opportunities in further research. Therefore, for now we recommend keeping controlling the day-to-day planning manually with the familiar block schedule in MS Excel and involving more stakeholders by constructing the tactical planning for increased decisiveness on tactical scope. To introduce system support within the planning process in the future, we recommend improving the monitoring and reporting phase on operational level to improve the quality of the data(base) in the ERP system such that a correct hour estimation can be done by the ERP system in the future and the planning no longer fully dependent is on human intuition as it is now.

For improved execution of the planning other improvement proposals are:

- To better monitor the progress of POs during the execution of a project. This can be done by weekly exports from BaaN to MS Excel with a control function for filtering ‘completed’, ‘on going’ and overdue orders. By keeping track of the progress of the POs, waste can be eliminated from the system weekly (incorrect information) or preventive measures can be inserted in an earlier stage when the process is stucking somewhere, to improve the smooth flow of the sub-process and thereby the control plan.

- To provide an operational overview in the available FTEs, department-specific i.e. a forecast of one or two weeks of the available man power filtered by department. For instance, the available hours attached to: The construction-, assembly department etc, against the expected need. Currently, rough estimations are made in the operational schedule based on estimated available FTEs. Data based decision making would create overview in what is scheduled and what is actual possible with the available FTEs. This will create more proactive steering instead of reactive due to failure of estimations.
- An improved data storage. By keep correcting the input and coordination between the operational- and tactical planning, both schedules are continue tested for improved data quality on long-term. By afterwards reporting the data from MS Excel in the ERP system a calculation can eventually come from the ERP system such that the hours can be benchmarked (the acting step) and the database will become increasingly representative.

6.3 Theoretical contribution

Literature studies are applied within in an organization to validate the investigated theory and to enhance the impact of good monitoring and controlling the tactical- and operational planning within project-oriented organizations. Thereby we wanted to provide a vision on the added value of visualizations in the decision-making process and the illustrate the effect based on some common performance indicators which are recognizable for multiple organizations. Therefore, the contribution of this thesis can be seen as a constructed case study with the illustrated impact on the performance.

6.4 Discussion

In this research, conclusions were drawn based on scientific literature, interviews with Gietart employees, internal documentation and knowledge gained during the bachelor phase of the Industrial Engineering and Management study. Although confirmation and validation has been made to ensure the reliability of the conclusions in the best possible way, there is still room for discussion.

Interviews were chosen as important source of information because this research is company specific, and it is important to hear the experience of all employees who work with the information systems daily. The interviews mainly provide qualitative information. To ensure that biases were distinguished from truth information was, if possible, verified with literature studies and qualitative analyses were performed for confirmation.

Last, as indicated, it was decided not to quantify the current complexity of the alignment we encountered. Given the limited time, it was decided to pay more attention to the adjustments to reduce complexity and to describe the complexity with illustrations.

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Appendices

Appendix A – Old structure MS Project

A project is substantiated in three levels within MS project. The highest level consist of the overall project, for example an Eco 1504. Below that, the modules are substantiated to the options and the underlying activities. The activities have always the same order from engineering to assembly. Currently, the three level structure is not applied everywhere, there is a lack of a consistent structure. For each part, the duration of the task or activity is indicated and a lead time is attached to this.

nr	Taaknaam	Duration	Start	Finish	exp
ECO...	ECO Westeria 1504	233 days?	Mon 11/23/20	Tue 10/19/21	38
ECO...	Westeria st.kon.Machinehuis	99.88 days?	Mon 11/23/20	Tue 4/20/21	
ECO...	Westeria st.kon.buitenkast hc	116.13 days?	Mon 11/23/20	Mon 5/17/21	
ECO...	Westeria st.kon binnenframe	114.31 days?	Mon 11/23/20	Tue 5/11/21	
ECO...	sam.onderbouw	43.06 days?	Mon 5/3/21	Thu 7/1/21	
ECO...	Westeria bovenbouw	36.69 days	Mon 5/10/21	Wed 6/30/21	
ECO...	Westeria aanvullende delen	38.19 days	Mon 5/10/21	Thu 7/1/21	
110336	opties	36.44 days	Wed 9/1/21	Tue 10/19/21	38
110336	rolbokken	36.44 days	Wed 9/1/21	Tue 10/19/21	
110336	engineering	3 days	Wed 9/1/21	Fri 9/3/21	
110336	wvb	2 days	Tue 9/14/21	Wed 9/15/21	
110336	plaatbewerking	3 days	Tue 9/28/21	Thu 9/30/21	
110336	mechanisch	3 days	Mon 9/27/21	Wed 9/29/21	
110336	constructie	7 days	Mon 10/4/21	Tue 10/12/21	
110336	spuiten	2 days	Tue 10/12/21	Thu 10/14/21	
110336	assemblage	3 days	Thu 10/14/21	Tue 10/19/21	
110336	trechter	35.81 days	Wed 9/1/21	Mon 10/18/21	
110336	engineering	1 day	Wed 9/1/21	Wed 9/1/21	
110336	wvb	1 day	Wed 9/15/21	Wed 9/15/21	
110336	plaatbewerking	6.38 days	Mon 10/4/21	Mon 10/11/21	
110336	mechanisch	1 day	Tue 9/28/21	Tue 9/28/21	
110336	constructie	3 days	Tue 10/12/21	Thu 10/14/21	
110336	spuiten	1 day	Thu 10/14/21	Fri 10/15/21	
110336	assemblage	1 day	Fri 10/15/21	Mon 10/18/21	

Figure 35, Current tactical planning MS project

Appendix B - Operational schedule MS Excel

A visualisation of the current operational planning. This is a visual block schedule created manually. It is created without the support of any scheduling tool, based on intuition the schedule is classified.

Employees are assigned to a specific module of a machine on daily basis as visible in Figure 36.

Week 47	Monday	Tuesday	Wednesday	Thursday	Friday
Samuel Meyer	St.kon.Machinehuis - 110343 ECO 2506	St.kon.Machinehuis - 110343 ECO 2506	St.kon.Machinehuis - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506
Dawn Brown	St.kon.Machinehuis - 110343 ECO 2506	St.kon.Machinehuis - 110343 ECO 2506	St.kon.Machinehuis - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506
Stewart Foster	St.kon.Machinehuis - 110343 ECO 2506	St.kon.Machinehuis - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506	St.kon.buitenkast afbl. - 110343 ECO 2506
Larry Woolery	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon
Justin Holden	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon	Uitvoerkast 3 - 110341 Standish Metaltreatment Triathlon

Figure 36, Operational schedule MS Excel (van Diermen, 2022)

Appendix C - Format structure tactical level with consistent layering (WBS)

To determine the workload a consistent structure was necessary. So the WBS structure is applied, where the module got an extra indicator by means of a dot and a number, so the first module of a product equals .1 and the fourth module .4 and all activities have been given a letter.
So .4.C refers to sheet metal working within the fourth module. The same structure is applied to all modules and activities within a project. Therefore, the notation .E will always refer to construction. This way there can also be filtered on activities or modules or a combination within the planning (what is very close to operational planning). In addition, the status is also added as indicator for the projects, possibilities are: Active, planned and on hold for the workload. On hold is not included in the workload.

Projectstructure	Name	Startdate	Enddate	Project status	Work	Complete	Remaining	Workload		
110304	110340 Librado sprint 1504	26 juli 2021 07:00	17 december 2021 15:29	Actief	1221	1217,84	3,16	1221		
110304.1	invoerkast 4	26 juli 2021 07:00	17 november 2021 13:00		401	401	0	401		
110304.1.A	engineering	28 juli 2021 07:00	3 augustus 2021 13:00		4	4	0	0		
110304.1.B	wvb	9 augustus 2021 10:00	20 oktober 2021 15:30		325	325	0	0		
110304.1.C	plaatbewerking	25 augustus 2021 07:00	31 augustus 2021 13:00		13	13	0	13		
110304.1.D	mechanisch	23 augustus 2021 07:00	23 augustus 2021 15:00		1	1	0	1		
110304.1.E	constructie	31 augustus 2021 13:00	11 november 2021 08:30		48	48	0	48		
110304.1.F	spuiten	11 november 2021 07:00	12 november 2021 14:30		4	4	0	0		
110304.1.G	assemblage	12 november 2021 14:30	17 november 2021 13:00		6	6	0	6		
110304.2	machinehuis 3	27 juli 2021 07:00	23 november 2021 12:00		112	112	0	112		
110304.2.A	engineering	27 juli 2021 07:00	2 augustus 2021 13:00		4	4	0	0		
110304.2.B	wvb	5 augustus 2021 11:00	30 augustus 2021 10:00		4	4	0	0		
110304.2.C	plaatbewerking	30 augustus 2021 07:00	3 september 2021 13:00		14	14	0	14		
110304.2.D	mechanisch	27 augustus 2021 07:00	27 augustus 2021 15:00		0	0	0	0		
110304.2.E	constructie	3 september 2021 13:00	12 oktober 2021 09:00		80	80	0	80		
110304.2.F	spuiten	9 november 2021 07:00	10 november 2021 14:30		4	4	0	0		
110304.2.G	assemblage	15 november 2021 07:00	23 november 2021 12:00		6	6	0	6		
110304.3	afblaas 1	26 juli 2021 07:00	22 november 2021 11:30		165	165	0	165		
110304.3.A	engineering	26 juli 2021 07:00	30 juli 2021 13:00		6	6	0	0		
110304.3.B	wvb	30 juli 2021 13:00	15 oktober 2021 15:30		6	6	0	0		
110304.3.C	plaatbewerking	23 augustus 2021 07:00	27 augustus 2021 13:00		19	19	0	19		
110304.3.D	mechanisch	5 september 2021 07:00	8 september 2021 14:00		2	2	0	2		
110304.3.E	constructie	15 september 2021 07:00	2 november 2021 10:30		72	72	0	72		
110304.3.F	spuiten	2 november 2021 10:30	4 november 2021 09:30		12	12	0	0		
110304.3.G	assemblage	11 november 2021 07:00	22 november 2021 11:30		48	48	0	48		
110304.4	bovenbouw 2	4 oktober 2021 07:00	6 december 2021 13:30		203	203	0	203		
110304.4.A	engineering	4 oktober 2021 07:00	8 oktober 2021 13:00		6	6	0	0		
110304.4.B	wvb	14 oktober 2021 07:00	15 oktober 2021 14:30		6	6	0	0		
110304.4.C	plaatbewerking	15 oktober 2021 14:30	22 oktober 2021 12:00		24	24	0	24		
110304.4.D	mechanisch	18 oktober 2021 07:00	20 oktober 2021 14:00		1	1	0	1		
110304.4.E	constructie	9 november 2021 07:00	22 november 2021 10:30		70	70	0	70		
110304.4.F	spuiten	22 november 2021 10:30	25 november 2021 09:00		16	16	0	0		
110304.4.G	assemblage	25 november 2021 09:00	6 december 2021 13:30		80	80	0	80		
110304.5	restdelen 5	4 oktober 2021 07:00	24 november 2021 09:30		65	65	0	65		
110304.5.A	engineering	4 oktober 2021 07:00	8 oktober 2021 13:00		4	4	0	0		
110304.5.B	wvb	19 oktober 2021 07:00	20 oktober 2021 14:30		4	4	0	0		
110304.5.C	plaatbewerking	20 oktober 2021 14:30	27 oktober 2021 12:00		10	10	0	10		
110304.5.D	mechanisch	21 oktober 2021 07:00	21 oktober 2021 15:00		1	1	0	1		
110304.5.E	constructie	9 november 2021 07:00	17 november 2021 12:00		28	28	0	28		
110304.5.F	spuiten	17 november 2021 12:00	19 november 2021 11:00		8	8	0	0		
110304.5.G	assemblage	19 november 2021 11:00	24 november 2021 09:30		10	10	0	10		
110304.6	transport 16mtr.inv+10mtr uitv rolb.	4 oktober 2021 07:00	14 december 2021 10:30		138	138	0	138		
110304.6.A	engineering	4 oktober 2021 07:00	8 oktober 2021 13:00		8	8	0	0		
110304.6.B	wvb	13 oktober 2021 07:00	15 oktober 2021 14:00		8	8	0	0		
110304.6.C	plaatbewerking	15 oktober 2021 14:00	22 oktober 2021 11:30		10	10	0	10		
110304.6.D	mechanisch	18 oktober 2021 07:00	22 oktober 2021 13:00		24	24	0	24		
110304.6.E	constructie	15 november 2021 07:00	26 november 2021 10:30		32	32	0	32		
110304.6.F	spuiten	26 november 2021 10:30	2 december 2021 08:30		16	16	0	0		
110304.6.G	assemblage	2 december 2021 08:30	14 december 2021 10:30		40	40	0	40		
110304.7	dwarstransport inf.5x6mtr-outf.5x6mtr	4 oktober 2021 07:00	17 december 2021 15:29		137	133,84	3,16	137		
110304.7.A	engineering	4 oktober 2021 07:00	8 oktober 2021 13:00		8	8	0	0		
110304.7.B	wvb	11 oktober 2021 07:00	13 oktober 2021 14:00		8	8	0	0		
110304.7.C	plaatbewerking	13 oktober 2021 14:00	20 oktober 2021 11:30		13	13	0	13		
110304.7.D	mechanisch	18 oktober 2021 07:00	20 oktober 2021 14:00		4	4	0	4		
110304.7.E	constructie	1 november 2021 07:00	9 november 2021 12:00		40	40	0	40		
110304.7.F	spuiten	15 november 2021 07:00	24 november 2021 11:30		24	24	0	0		
110304.7.G	assemblage	25 november 2021 07:00	17 december 2021 15:29		40	36,84	3,16	40	Project hours	Som hours tasks
									1221	1221

Figure 37, new structure to make to workload visible at a specific time interval

Appendix D – Layers production scheme

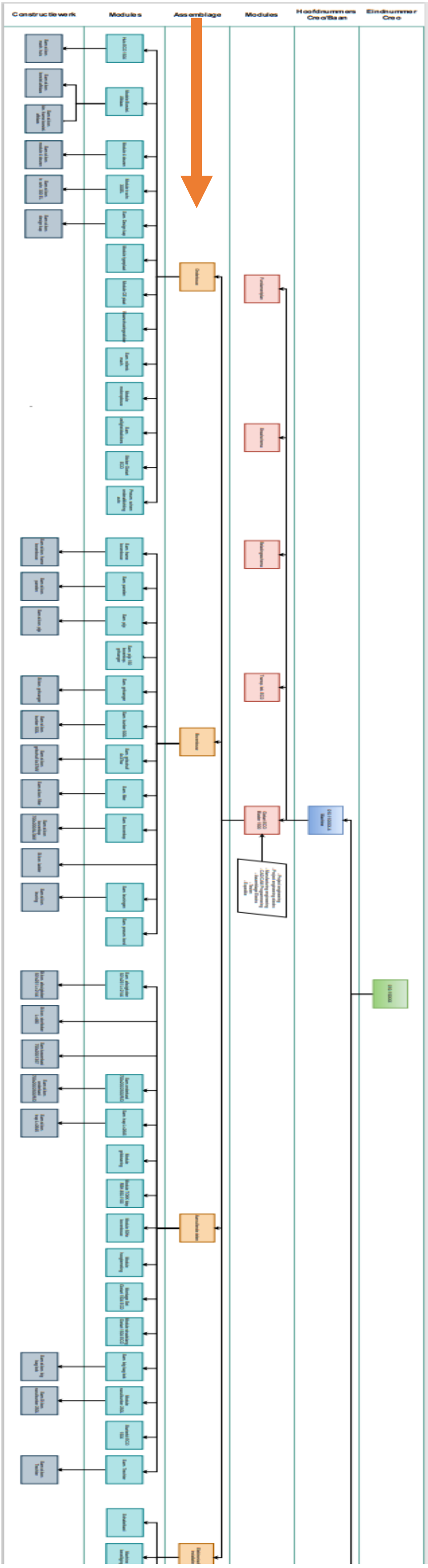

Figure 38, The work breakdown structure for the production orders

The orange arrow indicates the assembly branch which has been used as the extra 'level' to plan on for the multi-project view on tactical level. Thereby the expression of the tactical planning is defined for every project.

Appendix E - View export data MS Project to MS Excel

Projectstr	Naam	Duur	Begindatu	Einddatun	Project_St	Werk	Werkelijk	Resterenc	Procent_voltooid
									1.912861841073374E+183
150009	150009 Pa	123,81 dag	27 septem	10 maart 2	Actief	525u	187u	338u	0.48999999999999999
150009.1	Dwarstran	75,44 dage	11 oktobe	17 januari	On hold	67u	59u	8u	0.72999999999999998
150009.1.A	wvb	3 dagen	11 oktobe	13 oktober 2021 14:0		0u	0u	0u	1
150009.1.B	plaatbewe	1 dag	8 novemb	8 november 2021 15:		3u	3u	0u	1
150009.1.C	mechanis	5 dagen	15 novem	19 november 2021 1:		0u	0u	0u	1
150009.1.D	constructi	2 dagen	6 decemb	21 december 2021 1:		16u	16u	0u	1
150009.1.E	spuiten	3 dagen	20 deceml	22 december 2021 14		8u	8u	0u	1
150009.1.F	assembla	10,63 dage	4 januari 2	17 januari 2022 15:30		40u	32u	8u	0.38
150009.2	aanvoerb	59,5 dage	1 novemb	17 januari 2022 15:30		96u	72u	24u	0.56999999999999995
150009.2.A	wvb	5 dagen	1 novemb	5 november 2021 13:		0u	0u	0u	1
150009.2.B	plaatbewe	3 dagen	29 novem	6 december 2021 12:		22u	22u	0u	1
150009.2.C	mechanis	2 dagen	6 decemb	7 december 2021 14:		18u	18u	0u	1
150009.2.D	constructi	2 dagen	13 deceml	14 december 2021 14		16u	16u	0u	1
150009.2.E	spuiten	1 dag	20 deceml	20 december 2021 15		8u	8u	0u	1
150009.2.F	assembla	11,69 dage	3 januari 2	17 januari 2022 15:30		32u	8u	24u	8.9999999999999997E-2
150009.3	boormach	88,69 dage	27 septem	20 januari 2022 11:00		90u	8u	82u	0.42999999999999999
150009.3.A	wvb	10 dagen	27 septem	8 oktober 2021 10:30		0u	0u	0u	1
150009.3.B	plaatbewe	3 dagen	10 januari	12 januari 2022 14:00		16u	8u	8u	0.5
150009.3.C	mechanis	2 dagen	12 januari	14 januari 2022 13:00		10u	0u	10u	0
150009.3.D	constructi	3 dagen	14 januari	19 januari 2022 11:30		16u	0u	16u	0
150009.3.E	spuiten	1 dag	19 januari	20 januari 2022 11:00		8u	0u	8u	0
150009.3.F	assembla	8 dagen	30 novem	9 december 2021 11:		40u	0u	40u	0
150009.4	machinefr	118,5 dage	4 oktober	10 maart 2022 11:30		272u	48u	224u	0.34999999999999998
150009.4.A	wvb	5 dagen	4 oktober	8 oktober 2021 13:00		0u	0u	0u	1
150009.4.B	plaatbewe	5 dagen	15 novem	19 november 2021 1:		16u	16u	0u	1
150009.4.C	mechanis	2 dagen	22 novem	23 november 2021 14		8u	8u	0u	1
150009.4.D	constructi	5 dagen	6 decemb	10 december 2021 1:		32u	24u	8u	0.75
150009.4.E	spuiten	3 dagen	10 januari	12 januari 2022 14:00		16u	0u	16u	0
150009.4.F	assembla	25 dagen	7 februari	10 maart 2022 11:30		200u	0u	200u	0

Figure 39, Unstructured export from MS Project

Appendix F - Segregation of duties

Segregation of duties within planning hierarchy requires a step-by-step plan. Possible to introduce with a 'tactical planner meeting' for a clear information flow. Stakeholders can exchange input to optimize the output and decision making based on tactical planning.
In table 18 is a set-up created with the expectations of different departments inclined.

Stakeholder	Input	Output	Decision	Action after meeting
Manger operations	Budget, order intake	Current order intake and utilization of capacity	Importance of orders	Transfer decisions to management director.
Operational manager	Capacity utilization	Set requirements based on forecast of possible incoming orders Workload distribution	Structural capacity extensions	Update department leaders and operational planner about incoming projects
Tactical planner	Present multi project overview and status: Possible internal and external due dates		Adaptations to plan when necessary	Update the multi project view regarding order intake. Discuss due dates (internal and external) with sales manager.
Sales department	Forecast incoming orders for entire planning horizon Concrete opportunities with project content	Possibilities for rejecting or accepting incoming orders	Order acceptance	Provide information regarding order intake and due dates to customer
Engineering and manufacturing department	Opportunities	Requirements and possibilities based on forecast of possible incoming orders	Temporal capacity extensions	Prepare information for operational planner concerning incoming projects for operational meeting

Table 18, Duties stakeholders tactical planner meeting

Appendix G - KPI formulas

This appendix provides the formulas to illustrate how the KPIs described in Table 17 can be measured. The KPIs explained are:

- Customer satisfaction
- Percentage of deviation between executed and planned hours
- Percentage of modules completed on time
- Number of revisions in the tactical planning
- Number of revisions in the operational planning

Customer satisfaction

The customer satisfaction is difficult to express, because it is depend on multiple aspects and is not objective. An option to obtain a picture regarding the satisfaction is to execute a questionnaire to retrieve information by the customers. We set some aspects for the general satisfaction;

Quality

The quality of the machine depends upon the lifespan of the machine and maintenance after expedition.

On-time delivery

An indicator to measure the ‘on time delivery’ can be tracked by “modules delivered on time. The total number of modules delivered on time also gives an indication of the delivery time. A questionnaire can be used to check whether the delivery date corresponds to what the customer intended.

Budget exceeding per project

The discrepancy between the budgeted price and the actual costs of the delivered machine should be used to indicate the satisfaction. The exceeding budget can be measured by dividing the final costs of the project by the original budget.

$$Customer\ satisfaction = \frac{Final\ costs}{Original\ budget} \leq 1$$

When the indicator is higher than one, unexpected costs have occurred within production, which has led to higher costs and we can assume 'dissatisfaction'.

Percentage of modules completed on time.

This KPI measures the percentage of the modules that are completed on time. An indicator function need to be used to measure the number of modules which are completed on time. In total there are X modules within a project: $m_1,\ldots,m_x$. Every module m has a planned end date e_m and an actual ‘completed’ date c_m. If the actual completed date is before or equal to the planned date of the module, the indicator function is equal to 1 and 0 otherwise.

To calculate the percentage of modules completed on time, the number of modules completed on time is divided by the total number of modules within a project.

$$Modules\ completed\ on\ time = \frac{\sum_{m=1}^{X} IE_m \ \leq C_m}{Total\ number\ of\ modules} * 100\ \%$$

Deviation between scheduled and reported hours per project.

This KPI indicates the planning accuracy in percentage, this can be measured by dividing the scheduled hours by the reported hours and multiply that by 100 to get an percentage of the accuracy.

$$Deviation\ between\ scheduled\ and\ reported\ hours = \frac{Scheduled\ hours\ per\ project}{Reported\ hours\ per\ project} * 100\%$$

Number of revisions on tactical and operational level.

For the number of revisions on tactical and operational level the same formula can be used. This formula indicates the number of milestones that are not finished before the due date. Different actors can require a revision in the project plan as discussed. Due to an integration of the information systems a better estimation should occur. This can be measured by this KPI:

$$Number\ of\ revisions\ on\ tactical\ and\ operational\ level = \sum_{m=1}^{p} E_m \leq C_m$$

Where P is the total number of milestones. A project exists of $m_{1,}$ … m_p milestones. Every milestone has a scheduled end date E_m and an actual ‘completed’ date C_m. If the actual completed date is before or equal to the planned date of the module, the indicator function is equal to 1 and 0 otherwise.