

MASTER

A new planning and control concept integrating the internal end-to-end supply chain a case study at Hilti with elaboration on Hilti LEC and Hilti Headquarters

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Eindhoven, January 2014

**A new planning and control concept inte-
grating the internal end-to-end supply chain**
*A case study at Hilti with elaboration on Hilti LEC
and Hilti Headquarters*

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in partial fulfilment of the requirements for the degree of

**Master of Science
in Operations Management and Logistics**

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When eating an elephant take one bite at a time.

Creighton Abrams

Abstract

Supply chain complexity is growing every day as a lot of companies are taking their supply chain under internal control. Collaboration has to be translated into integration and a common interface has to be developed to optimise the value chain over the entire internal supply chain. Until this moment, no attempt has been made in academic literature to integrate the planning and control of an internal supply chain horizontally and vertically at the same time. Developing a hierarchical planning framework helps to visualise the horizontal and vertical decision functions that have to be integrated. Taking this framework, multiple academic approaches such as Sales and Operations Planning and Supply Chain Operation Planning can be combined to come to a complete picture of integrating the entire material flow of a supply chain, in this thesis under internal control. Having a hierarchical planning framework with all these approaches combined, timing, frequency and responsibilities have to be added to this framework in order to be able to talk about an operations planning and control concept - truly integrating the supply chain's planning and control.

Management Summary

This report presents the results of a master's thesis relating to one of the three research projects that all together aim to integrate the planning and control of an internal end-to-end supply chain. The three research projects were initiated by Hilti AG, that as a globally competing company was interested in doing exactly that to their internal end-to-end supply chain. Supply chain integration is concerned with vertical integration across several hierarchical levels, but also horizontal integration crossing several functional stages. This particular research project was carried out at Hilti Germany in Kaufering.

Problem Statement and Case Study

Companies dedicate more and more time to build a more comprehensive view of their own and their supply chain's capabilities. As supply chain complexities increase, the need arises to integrate the supply chain to improve the overall performance. For companies controlling the entire end-to-end supply chain, although its complexity, there lies potential for optimisation of the supply chain with intra-firm integration of planning and control of the company's primary processes. Local optimisation and an overkill of inventory meant to decouple the different echelons of the supply chain should be avoided.

Academic literature is lacking a planning and control framework and/or concept that is focused on internal integration on both axes, horizontally (cross-functional planning) and vertically (hierarchical planning). Furthermore, most literature focuses on only a part of this hierarchy or total functionality of the supply chain and is also mostly focused on inter-company integration and only forms insights in intra-firm integration based on the results. Therefore, there is a need for a planning and control concept that integrates the internal end-to-end supply chain planning horizontally and vertically and the following research aim was defined:

'Development of a new integrated planning and control concept for internal end-to-end supply chains improving the overall supply chain performance'

Hilti, which controls their entire end-to-end supply chain, acknowledged the lack of integrated planning and control and recognised the potential for better supply chain performance. With a reference to their supply chain, a new concept could be developed and the feasibility of implementation could be discussed in the form of a case study. By focussing on two downstream and one upstream part of the supply chain, the full implications for Hilti were covered in the project.

The Design Approach: A New Planning and Control Concept

A bottom-up design approach was used that considers the development of an idealised design, after formulating the problem mess, in order to come to a solution to the problem. This approach is combined with the PCIO paradigm using a given primary process footprint (Hilti) to create the design. For the complete perspective, the procurement, production, distribution and sales stages of the material flow, were considered. On top of this, an abstraction is made to general decision functions that are needed in most industries ensuring generalisability in the academic field of research.

Both a hierarchical planning framework (see Figure 2.8) as well as an extension of the framework including timing, frequency and sequence into an operations planning concept (see Figure 2.9, 2.10, 2.11 and 2.12) are developed based on academic literature. The main concepts used from literature are the Supply Chain based Sales and Operations Planning concept and the Supply Chain Operations Planning concept, integrating the supply chain both vertically and horizontally. Next to this, parameters were set on the strategic and tactical levels providing optimised parameters for the steering of the entire supply chain.

From Theory to Practice: A Case Study at Hilti

Hilti's supply chains showed gaps with the idealised design both in hierarchical planning as well as cross-functional planning. For understanding these gaps from all perspectives, they were identified based on the structure of the planning landscape, decision making, communication and IT-support.

The first main gap was that mid-term decisions, at a tactical level, were missing which is one of the primary prerequisites to an integrated internal supply chain. The second main gap was the lack of cross-functional integration due to silo thinking resulting from the multiple legal entities in Hilti, and the horizontal dispersed supply chain. No processes or clearly defined planning and control concept is in place.

Filling these gaps for Hilti provided a tangible and realistic concept (see Figure 4.1) and the decisions functions were more specified in content using the input of this company. To the sequencing of the planning and control concept there was one deviation where the company decided that tactical distribution planning should already provide input for tactical sales planning, which might lead to missing opportunities by already having to think in a constraint manner at sales planning. A Supply Chain Specialist Team has to be developed taking the responsibility over the procurement, production and distribution stages of the material flow.

A clear design of implementation is provided that considers the environment, such as stakeholders from senior management to operations, driving forces (expected improvement in quality, efficiency, inventory levels, customer satisfaction and commitment) and restraining forces (costs, culture, time and competence), and a consultative type of leadership, the latter being recognised as appropriate for the change leaders/agents. The action plan consists of four phases holding six projects to implement both the Supply Chain Operation Planning and Supply Chain based Sales and Operations Planning concept in an incremental manner.

Hilti Logistics Europe Central and Headquarters

Implications of the adapted and specified concept for Logistics Europe Central, one of the logistics regions, and the headquarters are shown in this thesis. First of all, the logistics region will need trust from the Supply Chain Specialist Team to keep ownership of products in regional distribution centres (due to the current set-up of the organisation) but IT will lose responsibility to this central team.

On one hand, the logistics regions will achieve better reliability of the lead time to the customer as the entire material flow of the supply chain will become transparent and is considered in tactical decisions, on the other hand, they will achieve a centralised and timed release of materials and resources.

Headquarters will lose the unofficial hierarchy they have (being the first distribution echelon control and responsible for corporate planning) in parameter setting which with it will take away the influence they currently have on the region. The region will focus more on market info – forecasting and sales planning - and lose the overkill of replenishment order releases that they are concerned with at the moment.

Conclusions and Recommendations

Hilti was seen as a particularly suited company as it has an internal end-to-end supply chain with a highly complex primary processes structure. Planning and control is locally (or regionally) optimised for the separate echelons in the supply chain and three silos exist within this planning and control: regions, headquarters and plants.

A hierarchical planning framework and an operations planning and control concept is specified that includes and sets the timing, frequency and sequence in the concepts of Supply Chain based Sales and Operations Planning at the tactical level and Supply Chain Operations Planning at the operational level, complementing it with tactical and strategic parameter setting.

Further recommendations for Hilti are:

- Considering the strategic level and transformational units for optimal use of the developed concept;
- Including Warehouse Management and Transportation Management to optimise the concept implementation on the entire logistics range;
- Quantification of results by starting a pilot

Further recommendations for the academic field are:

- Exploring generalisability by multiple case studies in different industries
- Quantification is necessary by filling in content on several case studies in different industries

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This thesis concludes my international graduation project at Hilti, where I was mostly based at Hilti Germany in Kaufering. Not only it is the end of the thesis, but it also means the end of my turbulent student life by completing my master Operations Management and Logistics at the University of Technology Eindhoven, followed with the honours track for design of Logistics Management Systems at the 3TU Stan Ackermans Institute. Although I started with a completely different study in 2005 at this university, in 2007 I made the wise decision to start with my Bachelor Industrial Engineering complemented with a great semester at the MGIMO university in Moscow, Russian Federation, and a minor at Twente University, both concerned with my other passion, international relations. After my Bachelor's degree I started working in Prague, Czech Republic, to top up the international study experience with working experience followed with the decision that not having a Master's degree would just not cut it for me.

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List of Abbreviations

3PL	Third party logistics
ATP	Available-to-promise
BA	Business area
BU	Business unit
BU PM	BU Product Management
CHF	Representing Swiss Francs
CW	Central warehouse
DC	Distribution centre
DM	Demand Management
EDI	Electronic data interchange
EOQ	Economic order quantity
ET&A	Electric Tools and Accessories
eWH	Gebrüder Weiß logistics distribution centre
F&P	Fastening and Protection
FTE	Full-time equivalents
GL	Global Logistics
GL MM	GL Material Management department
GPMS	Global Process Management System
GM	Global Manufacturing
HAG	Hilt AG (representing headquarters)
HAG MM	HAG Material Management department
HC	'Hilti Center'
Hilti IP concept	Hilti integrated planning concept
HIPP	Hilti Integrated Planning Project
HUB PM	Regional Product Management
IT	Information technology
JCL	JCL logistics distribution centre
KPI	Key performance indicators
LCN	'Logistics Center Nendeln'
LEC	Logistics Europe Central
LECM	LEC Material Management department
LECMAM	LEC Article Master team
LECM	LEC Material Management team
LECMSS	LEC Sales Storage team
LRC	Logistics replenishment centres
LW1	Representing Logistics Region North America
MM	Material Management

MO	Market Organisation
MO PM	MO Product Management
MPS	Master production schedule
MRP	Material requirements planning
MTO	Make-to-order
MTS	Make-to-stock
NDC	National distribution centre
OPC	Operations planning and control
PA	Product Availability
PCIO	Process, Control, Information, Organisation
PU	Production Unit
PUC	Production Unit Control
RCCP	Rough cut capacity planning
RDC	Regional distribution centre
RF2	Rolling forecast with a 18-month horizon
ROP	Reorder point
S&OP	Sales and operations planning
SAP	Systems, Applications and Products in Data Processing
SCI	Supply chain integration
SCM	Supply chain management
SCOP	Supply chain operations planning
SCOR	Supply chain operations research
SCP	Supply chain planning
SC-S&OP	Supply chain based sales and operations planning
SCST	Supply Chain Specialists Team
SKU	Stock keeping unit
SS	Safety stock
TM	Transport Management
TrM	Trade Management
TSP	Transhipment point
TU	Transformational Unit
WM	Warehouse Management
WOW	Way of working

Formulating the Mess

1.1 Problem Statement and Context

Having to deal with increasingly competitive and economically unstable markets, companies dedicate more attention to Supply Chain Management (SCM) in order to build a more comprehensive view of their and their own supply chain's capabilities. To be able to deal with the complexity of an internal end-to-end supply chain this comprehensive understanding is of utmost importance. Intra-firm integrations within SCM have proven to enhance company performance and existing literature indicates the importance of Supply Chain Integration (SCI), both vertically and horizontally, where more and more focus is put on Supply Chain Planning (SCP). Up to present time, most literature research on SCP has focused on inter-firm integration and only on one of the axis of integration - in other words dealing with either horizontal integration of SCP at an strategic, tactical or operational level, or with vertical integration between these levels (mostly divided between operations and sales). Very little research described the effects on the other axis while doing so and no research provided an in-depth approach to develop an SCP concept that allowed integration on both axes. The aim of this research is to fill in this gap by presenting a new planning and control concept that represents the fundamentals of supply chain integration on both axes, specifically for a complex internal end-to-end supply chain. The design of this concept is supported by reflecting on a real case study based on Hilti AG. Also the applicability of this concept is presented through this case study and a tangible design of implementation is provided. Eventually the following research aim was defined:

'Development of a new integrated planning and control concept for internal end-to-end supply chains improving overall supply chain performance'

In this report the results of one of the three master's thesis projects related to the Hilti Integrated Planning Project (HIPP) are presented. The HIPP project corresponds to the case study mentioned above and aimed at developing an integrated planning and control concept for the internal end-to-end supply chain of Hilti AG, and was initiated by Global Logistics (GL) – explained in section 1.5. The entire Hilti supply chain is within the scope of the HIPP project to be able to come to a true end-to-end concept. However, to make the planning landscape of Hilti concrete and applicable to the entire supply chain, the research was carried out within two plants, two logistic regions and the headquarters - all specifically chosen - divided among the three projects. This particular research was carried out at Hilti Germany in Kaufering and Hilti AG in Schaan, Liechtenstein, representing a logistic region respectively the Hilti's headquarter and therefore this thesis will elaborate on these locations. For a complete overview of the three projects, this thesis is complemented by the thesis of (Kreuwels, 2014) and the unpublished work of (Mertens, 2014).

In the recent past Hilti AG explored the fitness of the company with the aim to introduce Sales and Operations Planning (S&OP), wanting to integrate the planning decisions made throughout the supply chain. The main conclusion of this exploration was that, according to Hilti, its level of fitness for S&OP is critical. The project was put on hold as an important gap was identified, namely an unclear planning process. Because of the willingness to integrate SCP, the complex internal end-to-end supply chain and the company's need to specify a clear planning landscape, this company serves as a good subject for a business case.

The S&OP project has given some clear indications of where and why Hilti is not fit for S&OP implementation. However, potential gaps might exist that have not yet been indicated. The foremost place of the location of these gaps exists in the planning process, which is said to be insufficiently integrated. The potential of an integrated planning and control concept lies in achieving higher service levels with lower supply chain costs by overcoming the poor cross-functional alignment and optimisation in silos. Hilti's current business structure of is strongly characterised by silo thinking. These silos emerged by the fact that Hilti's supply chain exists of several legal entities, all wanting to perform optimal at their silo. There is a lack of ownership since responsibilities are scattered, eliminating an end-to-end responsibility. This leads to dispersed responsibilities of the Hilti material flow into marketing/sales regions, logistics regions and production facilities. As a result, the current state of the supply chain can roughly be divided in three types of silos: Hilti Headquarters (HAG), Market Organisations (MO)/regions combined with logistic regions, and plants. The existing potential for Hilti can only be realised by recognising the connections and inter-relationships between the dispersed parts of the supply chain and by ensuring a good fit between its design and operations, and the company's competitive strategy Stevens (1989).

The remainder of this chapter is organised as follows: The relevant topics of the three literature reviews performed are presented in section 1.2 to obtain insights into horizontal and vertical integration of the supply chain planning decisions. Based on the problem statement and results of the three literature reviews, the research questions were formulated. Thereafter, the methodology used in this research is discussed in section 1.4. Hilti AG is introduced in section 1.5 to set the stage for the case study and an outline of the remainder of this report finalises this chapter as section 1.6.

1.2 Literature Review

As a preparation for this thesis, relevant academic literature that focussed on different aspects of integrating planning within the supply chain was reviewed. Together they focus on both horizontal and vertical integration which is expected to generate the most possible insight in integrating internal end-to-end supply chains, hence for the HIPP project to succeed. Horizontal integration involves a cross-functional integration between sales and operations on both tactical level (see Broft (2013b)) and operational level (not covered). Vertical integration involves the deployment from a tactical level to an operational level at operations (see Kreuwels (2013)) and at sales/marketing (see Mertens (2013)). Below the most important findings of these reviews are summarised.

1.2.1 Sales and Operations Planning

In the literature review by Broft (2013b), focusing on the research question: *'How does Sales and Operations Planning contribute to the integration of the supply chain?'*, Sales and Operations Planning (S&OP) was defined as:

'A business process that is placed on the tactical level, thus it is placed between and interacts with the strategic and operational levels – it produces plans that balance demand and supply which should be one set of plans settled by several functions and actors.'

Summarising this literature review, an extensive research was performed focusing on the S&OP objectives, parameters, phasing, maturity measurement and assessment. The major findings can be summarised as follows:

- The need for a structured process for the creation of realistic sales and operations plans has been acknowledged by successful companies because it is believed to be necessary in order to compete and respond to the market;
- Supply chain planning is vital for supply chain integration and S&OP integration is fundamental for an integrated supply chain planning;
- As the companies differ in type of their produce, in volume of their production, in size and organisational structure, and geographical location, it is obvious that they also vary in the approaches towards S&OP, or even, in the case of large supply chains, that there may be multiple S&OPs within one chain, acting sometimes independently but preferably in a coordinated, integrated manner;
- S&OP requires a specific company culture, namely managers with an extensive work effort, who are prepared to except process ownership, collaborate within the assigned mandate and focus on a common goal, adjusted incentive schemes and, when the S&OP is properly understood and supported, enabling technology (software);
- It is safe to assume that horizontal integration at the tactical level is mainly about balancing demand and supply planning;
- S&OP needs to be seen from the proper perspective; it cannot replace sound judgment and provide easy answers;
- The effects of S&OP on the firm results are facilitated by mechanisms of planning and control, joint forecasting and planning, information systems between organisational units and horizontal collaboration within the firm.

The above findings show the importance of S&OP for integrated planning and the need for a custom developed concept for integrated planning. S&OP focuses on cross-functional coordination in order to improve the performance of the supply chain. The collaborative planning and relationship quality are the main issues of S&OP – it is claimed to be an effective and inexpensive improvement mechanism. Together with the opportunities showed by the above findings, this leads to the belief that S&OP can contribute to the development of a holistic integrated planning concept.

1.2.2 Hierarchical Planning

Hierarchical planning coordinates the planning modules such that they can interact in an integrated way at the strategic, tactical and operational levels introduced by Anthony (1965). The research field of hierarchical planning agrees on these three levels and all reviewed models and frameworks use them as a cornerstone.

Strategic level - The process of deciding on objectives of the organization, on changes in these objective, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use and disposition of these resources.

Tactical Level - The process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishments of the organization objectives.

Operational level - The process of assuring that specific tasks are carried out effectively and efficiently.

Based on the findings from the literature study a couple of conclusions can be identified that can be linked to the integrated planning research.

Hierarchical Demand Planning

In the literature review of Mertens (2013), the term hierarchical demand planning is defined as: *'the process of providing forecasted demand data on different hierarchical levels.'*

In the hierarchical planning approach, planning processes are conducted on different hierarchical levels of the supply chain. To support planning processes on these different levels, the demand planning process needs to be modelled along the same hierarchical structure. The levels of aggregation and the planning horizon of demand plans differ per level.

The complexity of demand planning increases with a growing number of item/location combinations and number of planning periods. Aggregation in product, time and location can structure the demand planning process that enables forecasts to be accurate and efficient. Besides the item dimension, also the time- and location dimension can be aggregated and disaggregated.

On the mid-term, the main purpose of demand planning is to support tactical decisions on how to utilize production, capacities, inventory and transportation efficiently. On the tactical level it is important to find an aggregation level that limits the amount of demand data, uncertainty of the forecast and complexity of the model. The planning horizons for mid-term demand planning will usually cover at least one seasonal cycle.

On the short-term demand planning provides data for deployment decisions and order acceptance. This planning task is normally carried out daily and needs demand forecasts or known demand orders for one or a few days.

As demand forecasts will change over time, the rolling horizon principle with frozen horizon can limit nervousness in the planning system. The frequency of forecast updating and the length of the frozen horizon need to be chosen such that the right balance between flexibility and stability occurs.

Hierarchical Production Planning

In the performed literature review by Kreuwels (2013) hierarchical alignment of the tactical and operational level in operations environment is analysed. The leading question throughout the review was: *'How does academic literature propose to align the tactical and operational level within a hierarchical production/assembly environment?'*

Architecture - Supply Chain Integration (SCI) methods have been mapped and indicated as possible contributors to alignment between hierarchical levels. The most relevant field for production environment, and therefore the base line of the further review, is integrated logistics. Integrated logistics has a high focus on internal integration and a low focus on external integration making sure the functional boundaries are towards the vertical alignment of production planning.

Hierarchical Planning Frameworks - Hax and Meal (1973) describe a hierarchical planning and scheduling system for a multiple plant, multiple product, seasonal demand situation. In this hierarchical structure, optimal decisions at an aggregate level (planning) provide constraints for the detailed decision making (scheduling). According to Hax and Meal (1973) a model that aims to expedite the overall planning can only be effective if it helps in establishing objectives at the hierarchical levels which are consistent with the management responsibilities at the respective level. Therefore it distinguishes four levels of decision making connecting the strategic to the tactical and operational level and vice versa.

First, using long-term capacity provision and utility decisions products are assigned to manufacturing plants. Second, a seasonal stock accumulation plan is prepared on a tactical level. This plan makes allocations of capacity between product types in each plant. Products that have similar inventory costs define a type. Third, on an operational level, product families are scheduled into detailed plans allocating the capacity among the product families in the type. Fourth, using standard inventory models individual run quantities are calculated for each item in each family.

Schneeweiß (1995) describes the hierarchical structure between tactical and operational levels using a top-level, a base-level and an anticipated base-level. Three key constructs to align these levels are: anticipation, instruction and reaction. *Anticipation* means choosing an anticipated base-level and taking into account its impact on the top-decision. Quite generally an anticipation can be regarded as a bottom-up influence on the base-level on the top level. The information can be seen as a feed forward. *Instruction* is a decision made by the top-level based non the anticipated base-level which influences the actual base-level top down. *Reaction* is a feedback loop from the base-level towards the top level which is triggered as a reaction on the instruction. This can thus be characterized as a feedback loop. In hierarchical planning a reaction is often not possible, but when it is possible it always initiates a communication or negotiation process. Finally the top-level and the base-level reach a final agreement which will be implemented in the operations environment.

Bertrand et al. (1992) describe a hierarchical structure that is directed toward decision functions, which can be allocated to respective organisational positions and responsibility areas. They introduce two key constructs; *goods flow control* and *production units (PU)*. Additionally, the framework incorporates both the detailed item-oriented and the aggregate capacity-oriented aspects of production control in a similar way as Hax and Meal (1973). A PU can be seen as an organised set of resources that, from a production control point of view, should be distinguished. It can be separated because it deals with a certain part or phase of production. In many production situation production units can be distinguished which can operate independently to a certain extent. This independence means that the PU is authorized to use its capacity resources internally as it seems fit but, has a responsibility towards the committed work orders set by the goods flow control. At the level of goods flow control, these work orders are created and released to the PU in a predetermined order. Production control can in this way be decomposed in; production control within a production unit and production control at the goodsflow control level, which refers to the coordination of the PUs and the timing of production and sales.

The actual model uses an aggregated planning level which strongly resembles the production and resource planning as defined in MRP II. However, some clear differences with the MRP II model are elaborated. At the aggregate level (tactical), the availability of the most important capacity resources is established and in relation to these, production volumes, sales volumes, inventory changes and subcontracting budgets are determined. Several interrelated plans are created. Then these aligned plans are used at the detailed supply chain operations planning or SCOP level. Here goods flow control makes a distinction between material coordination, which roughly corresponds with master production scheduling (MPS), and capacity planning. Midway the SCOP level the PU obtains influence in order to align the work orders flowing down into the PU. The work orders then eventually flow to the PU which resembles the operations environment.

1.3 Research Questions

Based on the research aim and the case study (both introduced in section 1.1), and the three literature reviews, the following three research questions were defined:

1. What does the internal end-to-end supply chain of Hilti look like, and how is it currently planned and controlled for?

This research question consists of two sub-questions that build upon each other:

1a. What does the internal end-to-end supply chain of Hilti look like?

Before the planning and control of a complex internal end-to-end supply chain could be diagnosed, it was important to comprehend the full picture of such a supply chain. For this question, the entire internal supply chain of Hilti was considered.

The remainder of the research questions involves the supply chain of Hilti as defined as the scope of this thesis. This scope entails echelons under control of two logistic regions, Logistics Europe Central (LEC) and Logistics North America (LW1), HAG and two production plants, Plant 4 and Plant 6D, representing Global Manufacturing (GM). Furthermore, the scope was believed to make the thesis results applicable to the entire supply chain as mentioned in section 1.1. This thesis is the result of the project involving LEC and HAG - the logistics region with short lead times, respectively the first distribution echelon for all indirect deliveries throughout the Hilti supply chain. Therefore, in this thesis, emphasis is put on further elaboration on these components of the supply chain. GM and LW1 (representing distribution with long lead times) are further elaborated in the master's thesis of (Kreuwels, 2014), respectively the unpublished work of (Mertens, 2014).

1b. What is Hilti's current planning and control landscape?

The supply chain within scope was divided through the three projects as mentioned above, in order to comprehend the planning landscape of the internal supply chain that represents the complex environment upon which the new planning and control concept has to be built. First, this sub-question was answered separately in each of these projects. Later these answers are combined in order to reach the complete planning landscape.

The current planning landscape is defined by analysing the current planning decisions. Also the relationships of the planning decisions and their cross-functional character are analysed on whether they impacts the planning in the supply chain.

2. What integrated planning and control concept can be designed based on a critical evaluation of academic planning reference models and frameworks reflected on the Hilti supply chain?

As the research aim is considered with the development of a new integrated planning and control concept that would improve the overall supply chain performance, answering this research question implicates the development of such a concept. As this research concerns an internal end-to-end supply chain, the input from question 1a is used and reflected upon during this development.

3. What is the applicability of the new integrated planning and control concept?

This research question consists of three sub-questions that build upon each other:

3a. What are the gaps in the current planning landscape at Hilti in relation to the extracted integrated planning concept?

In order to comprehend gaps between the current planning and control landscape of the internal supply chain of Hilti (question 1b) and developed concept of question 2, the supply chain within scope was divided over the three projects as mentioned above. Again, this sub-question was first answered separately in each of these projects and then combined in order to come to an overall overview of Hilti's integrated planning gaps. The effects of these gaps were considered in the answer.

3b. How could the integrated planning and control concept be adopted by Hilti?

For this sub-question the context, current state and constraints of Hilti are considered. If any alterations to the idealised design were necessary, their effect is discussed. Next to alterations, the planning and control concept is specified to a higher extent by considering the case study company.

3c. What way can this concept be implemented at Hilti?

A suggested high level action plan with recommended deliverables is specified.

1.4 Methodology

After defining the research questions above, the methodology regulating this thesis is presented. Simon (1969) argues that the involvement of a structured organisational problem solving process guided by grounded design rules is preferable. This thesis is structured according to the design approach described by Ackoff (1981). Ackoff (1981) proposes a structured methodology leading to a solution for the research aim by taking intermediate steps. It starts with *formulating the mess* which is considered in this chapter and includes the answer of the first research question, followed by *ends planning* in chapter 2 and 3. *Ends planning* entails the development of an idealised design (not having any constraints of the case study company's constraints, context and current state) and identification of the gaps between the current planning and control concept and the idealised design, respectively answering research question 2 in chapter 2 and sub-question 3a in chapter 3. *Means planning* is the next step of this methodology and selects ways of filling the gaps. *Resource planning* in turn, being the next step, considers the responsible roles for the selected means. These two steps are both dealt with in chapter 4. The final step in the methodology of Ackoff (1981) is *design of implementation* which provides the frame to present the proof of the implementation's feasibility, dealt with in chapter 5. Figure 1.1 shows how the design approach of Ackoff (1981) is communicated throughout the whole setup of this thesis.

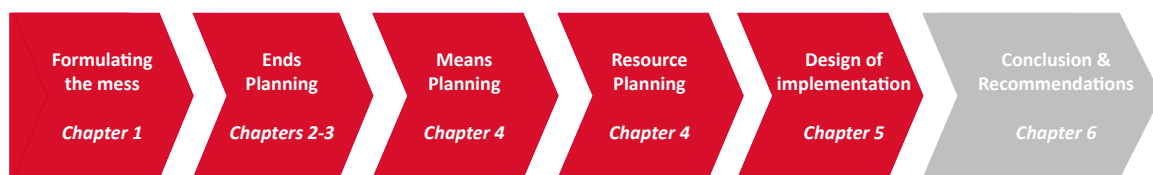


Figure 1.1 – Methodology of Ackoff (1981) reflected on the master's thesis structure

It should be noted that, despite a reflection upon Hilti's supply chain, the generalisability of the developed design is pursued because of the requirements of an academic research. The remainder of this thesis is elaborated using Hilti as a case study to provide a proof of applicability (section 1.1).

1.5 Hilti AG

As a final part of this chapter, the stage for the company used as a case study, Hilti AG, will be set. First the company background is discussed where after the internal Hilti supply chain and its current planning and control are presented. This thesis will elaborate this final part for LEC and HAG (as a planning and control entity) as described in subsection 1.5.4.

1.5.1 Company Background

Hilti AG, hereafter called Hilti, was founded as a family company (and still is) by Martin Hilti in 1941. Still being a family company, it grew significantly and expanded its operations into more than 120 countries, with about 20 thousand employees and an organisation format of almost complete supply chains including production, distribution and sales of more than 60 thousand finished products yearly, mainly for the construction industry. Its direct sales model depicts the organisation with annual sales around 4 billion CHF. Hilti produces various products for the construction industry, ranging from specialised tools to perishable chemicals to commodity consumables, in total around 63 thousand finished products are sold yearly worldwide. The corporate goal of Hilti is to *'passionately create enthusiastic customers and build a better future'*, whereby the strategy up to 2015 focuses on growth, differentiation, productivity and people. In order to combat the effects of a recent financial crisis the company implemented a number of cost saving operations. However, despite of the company's recent growth and introduction of the lean management into the production processes the profit remains unsatisfactory.

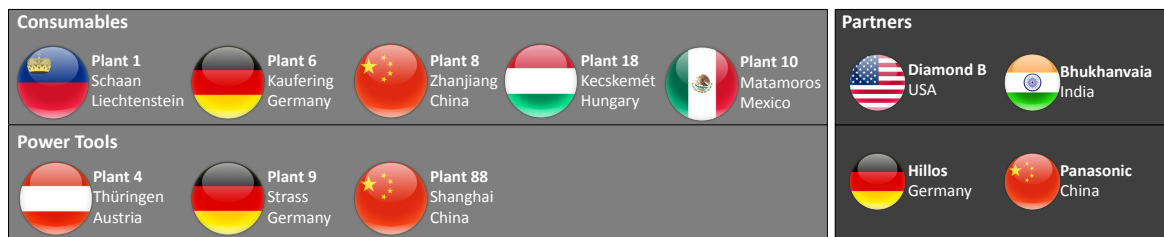


Figure 1.2 – Hilti's plants and allied suppliers

The products range from specialised tools or commodity consumables to perishable chemicals. This contributes to a wide variation in terms of value-density, lead times, sales volumes, and storage, handling and transportation requirements. In total, Hilti owns five plants for consumables and three plants for power tools as can be seen in Figure 1.2. These plants are under corporate responsibility of two so-called business areas (BA): *'Electric Tools and Accessories'* (ET&A), and *'Fastening and Protection'* (F&P).

The figure also shows Hilti's allied suppliers represented as partners. As a global competitor, its turnover is still largely represented in European sales. 55 percent of the revenue comes from Western Europe, 21 percent from America, 12 percent from Asia and another 12 percent from Eastern Europe and the Middle East (Figure 1.3).

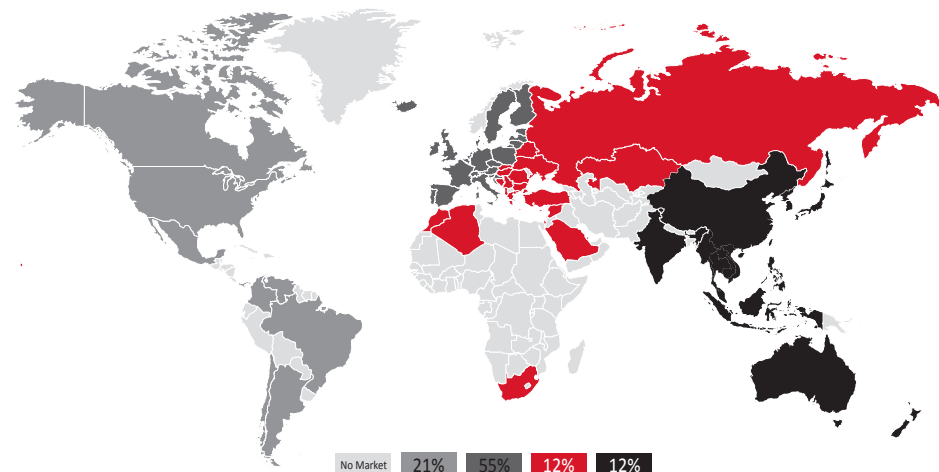


Figure 1.3 – Hilti's operating markets

1.5.2 Hilti's Internal Supply Chain

A broad overview of the supply chain of Hilti is given in Figure 4. The large majority of the value chain, from production up to sales, is under corporate control. This means that Hilti controls its product from manufacturing sites all the way to sales channels – indicating the internal supply chain. Hilti competes globally and has suppliers, plants, central warehouses (CW), distribution centres (DC) and 'Hilti Centers' (HC) located all over the world. There is, however, a strong European footprint accounting for more than 50 percent of Hilti's total turnover and the majority of plants and CWs. From the plants and allied suppliers the materials flow to CWs from where national distribution centres (NDC)/regional distribution centres (RDC)/DCs are replenished, or directly to NDCs/RDCs/DCs. The routing of the material flow mainly depends on the size of the material flow and the lead times. Small material flows or material flows that need to be shipped to locations with a long lead time are firstly consolidated in the CWs or the Transshipment Point (TSP). Customer orders enter the supply chain at HCs and other sales channels, which are directly or indirectly replenished by NDCs/RDCs/DCs – this depends on the distribution design in the region.

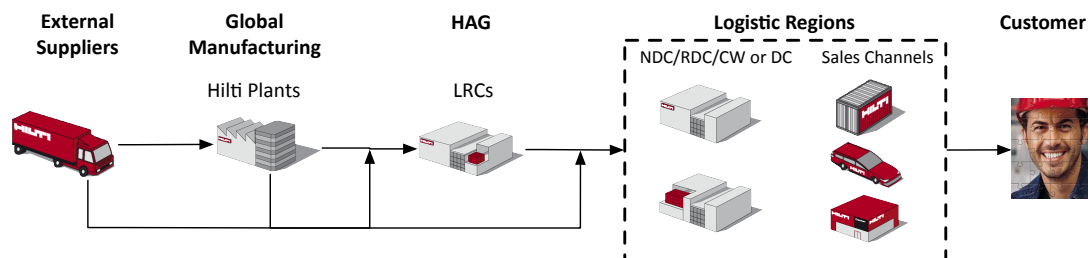


Figure 1.4 – Hilti's supply chain

Hilti's supply chain covers the material flow of a large number of items for the construction industry with great differences in turnover controllability and demand. This leads to a wide range of item characteristics in terms of: value to weight ratio (value-density), lead times, sales volumes, and storage, handling, transportation and requirements (i.e. hazardous goods). Many items in Hilti's supply chain can also be characterised with a great seasonality in demand. This seasonality is strongly driven by the European market, due to its large share in total global demand. In total, Hilti produces around 31 thousand unique global end-products, of which roughly 7 percent generates 80 percent of the turnover. Since spare-parts are out of the scope of this project, these are not included in this number.

1.5.3 Planning and Control

Since the logistic regions are scattered over the world, planning and control of these locations is very important. Every logistic region reports back to the head of GL, who is responsible for all logistic regions and is member of the Executive Management Team. GL at Hilti covers three main areas: Warehouse Management (WM), Transport Management (TM) and Material Management (MM). WM, TM and MM are done at both GL level and regional level. The overview of the global logistics structure is represented in Figure 1.5. Generally speaking, GL is concerned with the planning and control support of the entire supply chain. The GL department centralises the global processes design with involvement of MM in HAG, markets/regions and plants. However, the complexity in control is increased since the logistic regions report back to different parts of the executive team. The six logistics regions on the left of Figure 1.5 report directly to the head of GL and the three on the left to a member of the executive board.

Furthermore, GL supports on issues, exceptions and concept developments in order to establish a continuous improvement cycle in corporation with MM in market/region logistics. GL can

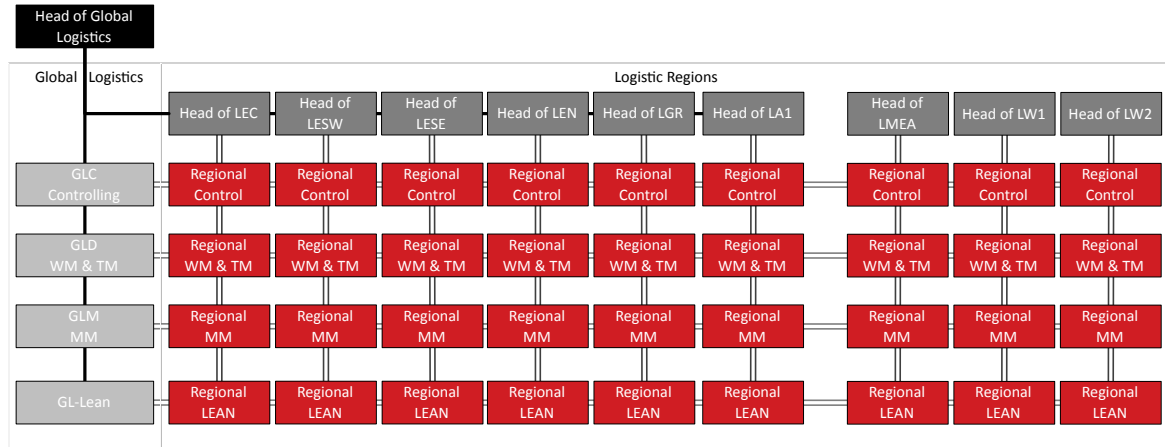


Figure 1.5 – Hilti’s Global Logistics structure

therefore be seen best as a business partner instead of a pure service provider. This creates an independent logistics organisation that is integrated with markets/regions. As an independent body it engages with topics such as distribution network, decision of in/outsourcing, selection of third party logistics (3PL) and people management. The more integrated character involves topics such as customer orientation, level of service, business communication, sales forecast integration meetings, obsolescence, product basket and shared *'pain and gain'*.

Since most of the activities of planning take place under the umbrella of MM, this subdivision is elaborated next. Figure 1.6 shows an overview of the planning decisions, which roughly take place in the three silo-ed MMs. Firstly, HAG MM is divided in responsibilities set out under three board members (of *'Emerging and Energy & Industry'*, F&P and ET&A). HAG MM is divided in business units (BU) and plans for both the integrated and non-integrated markets (markets not having their own MM). Integrated markets are forecasted and planned at a MO/region MM and non-integrated markets are planned and forecasted at headquarters (HAG) MM. HAG focus can thus be characterised as global demand. These operations all take place at an operational level. Planning and control decisions taken at HAG MM entail MRP type selection, direct or indirect distribution to regions/markets, demand planning, defining decoupling points (where to stock?), safety stock (SS) adjustment, MRP (performed locally by the system), warehouse order release and warehouse order management.

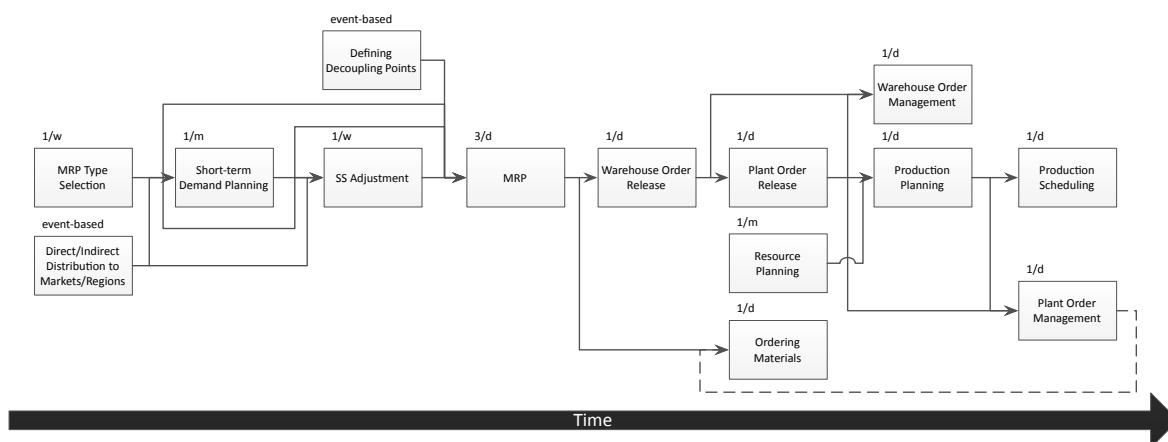


Figure 1.6 – Hilti’s current planning and control

Secondly, market/region MM focuses on local sales trends. It manages local forecasts and relays information on extra demand (i.e. promotions). It also has responsibility over the SS levels

of local warehouses and the coordination of local phase-in and phase-out. Market/region MM reports to the Head of MM of its region, who in his place reports to the Head of Region Logistics. The regions are the responsibility of the head of Global Logistics who is part of the Executive Management Team. As the MM of the integrated markets is divided in regions (e.g. Central Europe, North Europe and Asia Pacific), a couple of countries are planned for together at one of the market/region MMs. On the other hand, the products with a replenishment based on a Reorder Point (ROP) policy are additionally forecasted by HAG MM. Planning and control decisions taken at market/region MM entail MRP type selection, demand planning, defining decoupling points, SS adjustment, MRP (performed locally by the system), warehouse order release and warehouse order management.

Thirdly, plant MM focuses on producing products based on global demand, making a distinction between make-to-stock (MTS) and make-to-order (MTO) production. Plant MM operates under two BAs (F&P and ET&A). The forecast/plan of the integrated markets and non-integrated markets is consolidated by HAG MM and the plant MM eventually sends production orders to the shop floor and manages the orders coming from both HAG MM and market/region MM. Since plant MM is responsible for its own SS levels for raw materials, components, semi-finished and finished goods, it also executes the purchase for components and raw materials. However, a lot of these tasks are performed in close collaboration with the BU under the different BAs at HAG. Planning and control decisions taken at plant MM entail MRP type selection, direct or indirect distribution to the markets/regions, SS adjustment, production planning, production scheduling, ordering materials, plant order release, plant order management, resource planning and MRP (performed locally by the system).

1.5.4 Hilti Logistics Europe Central and Hilti Headquarters

Planning activities in LEC are concerned with the control and replenishment of four RDCs and one CW, and the delivery to the customer through several sales channels. As not all of these logistic activities are in scope of MM, the decision functions of WM and TM will not be taken into account. For LEC, LECM is the regional MM department. LECM was defined within scope of elaboration for this thesis together with the MM of HAG, explained later in this section. The complete description of the planning and control at LEC can be found in Broft (2013a).

LECM is divided in MM RDC, Sales Storage and Article Master (respectively: LECMM, LECMSS and LECMAM). LECMAM maintains the master data in the system and is not considered during the research. LECMM is responsible for the replenishment of the RDC and is divided in two teams: BA ET&A, and BA F&P. Further division is made upon product types and geographical location. LECMSS manages the inventories at the sales storages (containers, HCs, consignment stock and sales vans).

Currently, LECMM is responsible for replenishing the warehouses described above. Also, they are a link to the markets by close communication with marketing and in certain extent with sales. LECMM has communication lines and dependencies with sales (divided in MOs), marketing (divided in product managers of MOs (MO PM), product managers of the E3 sales region (HUB PM), trade managers (TrM)) and MM at HAG. The decisions taken by LECMM involve forecasting (on a short-term horizon), replenishment order release, SS adjustments for the RDCs/CW and order management concerning backorders and adjustment of orders. An available-to-promise (ATP) check in the market region (E3) exists for the stocks in the RDCs/CW and the replenishment of the upstream stocking point (either plant or Logistics Replenishment Centres (LRC)). The identified decision functions for LECMM during the analysis of the current situation of Broft (2013a) are represented in Table 1.1.

Table 1.1 – Planning and control decision functions at LECMM and HAG MM

Identified Decision Functions	LECMM	HAG MM
MRP Type Selection	Selecting the type of order policy for the replenishment of the RDCs/CW	Selecting the type of order policy for the replenishment of the LRCs
Demand Planning	Short-term forecasting for markets in LEC and adjustment of forecasts to market intelligence and data from sales and marketing	Aggregating forecasts for all markets, short-term forecasting for non-integrated markets and forecasting items on the reorder point policy
Defining Decoupling Point	Event-based review of the stocking locations on item level	Event-based review of the stocking locations on item level
Inventory Management	Monthly adjustment of SS levels, releasing replenishment orders daily and daily order management	Monthly adjustment of SS levels, releasing replenishment orders daily and daily order management
Distribution Planning	Item exchange between RDCs/CW for more reliability to customer	Considering if distribution to market/region warehouses goes direct from plants or indirect via LRCs

Planning activities at headquarters, or HAG, are concerned with the control and replenishment of three LRCs, and the communication with the markets and plants. The LRCs under responsibility of HAG MM are Nendeln (LCN), Wolfurt (JCL) and Lauterach (eWH). This section elaborates on HAG MM in short. The complete description of the planning and control at HAG MM can be found in Broft (2013a). HAG MM is divided by the two BAs mentioned above and further divided by BUs. Every BU has its own ability to design the team structure for the MM team. Therefore, at the moment, some BUs have the MMs divided by regions of the world, while others have the MMs divided by product groups (leading to multiple contact points for every region of the world). HAG MM has communication lines and dependencies with marketing (BU PM), plants and suppliers, the export department (part of GL), warehouses and MOs/regions/other customers.

Currently, the main responsibility of HAG MM is the replenishment of the LRCs described above. Also, the communications with the markets/regions and plants is currently regarded as daily business to provide planning decisions as smooth as possible. HAG MM converts the separate forecasts into aggregated forecast and has the responsibility to forecast for the non-integrated markets (markets without an MO or integrated SAP system). These forecasts are complemented with the produced forecasts for ROP items (forecasted by HAG). HAG MM also has a separate order release with economic order quantities different to the markets/regions use for the replenishment of their warehouses. Providing a preview of future demand for external suppliers is a monthly task they perform. These decisions at HAG MM are complemented with order management and SS adjustments. The identified decision functions for HAG MM during the analysis of the current situation of Broft (2013a) are represented in Table 1.1.

Dependency of LEC from Headquarters, Plant 4 and Plant 6

In order to mark the importance of GM and HAG for fulfilling the demand for LEC, the number of items (products) that flow directly from the plants and external suppliers, and the number of items that flow through LRCs are analysed and depicted below. For the project team of HIPPP, this means transparency in the linkages and dependencies between Plant 4, Plant 6D and HAG, the latter being responsible for the LRCs. For clarity, the inventory points under the responsibility of LECMM encompass the RDCs in Oberhausen, Nürnberg, Wrocław and Vienna plus the CW in Adliswil and the LRCs under the responsibility of HAG MM are LCN,

JCL and eWH. As can be seen in Table 1.2 below, representing the number of items incoming to the RDCs of LEC, most of the items (76 percent) are replenished through the LRCs, and the other items (26 percent) are replenished directly from the plants or external suppliers. This is represented in more detail in Figure 1.7.

Table 1.2 – Number of incoming items from source

RDC/ MO CW	LCN	JCL	eWH	External Suppli- ers	P6	P18	P1	P4	P9	<i>Indirect</i>	<i>Direct</i>	Total
Oberhausen	4954	1643	529	2657	48	150	40	86	122	<i>7126</i>	<i>3103</i>	10229
Nürnberg	2576	1229	270	2337	90	43	20	55	110	<i>4075</i>	<i>2655</i>	6730
Wroclaw	4041	1670	392	543	12	48	29	52	1	<i>6103</i>	<i>685</i>	6788
Vienna	5611	2019	608	2049	34	157	45	93	128	<i>8238</i>	<i>2506</i>	10744
Total	17182	6561	1799	7586	184	398	134	286	361	<i>25542</i>	<i>8949</i>	34491

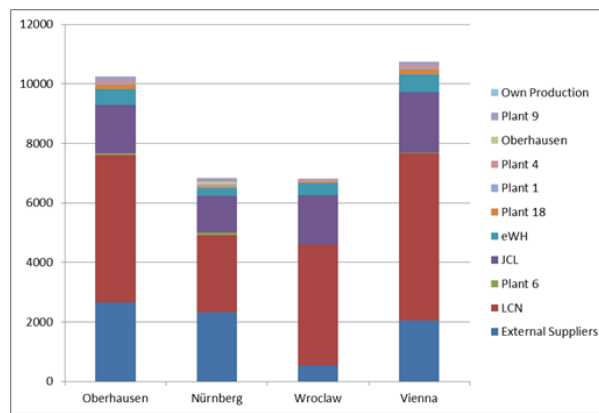


Figure 1.7 – Dependency from LEC of HAG and GM

To put the above mentioned in sound perspective, the information flow is also assessed. Every time an order is reserved by the source it reveals the responsible initiator for this reservation. In the table below this information flow is clearly given. Most (66 percent) of the reservation lines are the responsibility of the HAG MM and the rest (34 percent) is ordered directly at the plants or external suppliers.

Table 1.3 – Number of reservation lines to source

RDC/ MO CW	LCN	JCL	eWH	P6	P4	<i>Indirect</i>	<i>Direct (incl. external sup- pliers)</i>	Total
Oberhausen	30507	10906	5521	1734	2323	<i>46934</i>	<i>29598</i>	76532
Nürnberg	16909	6393	2737	881	1140	<i>26039</i>	<i>20125</i>	46164
Wroclaw	12912	4936	19403	152	515	<i>19403</i>	<i>3965</i>	23368
Vienna	30735	9098	3786	809	1299	<i>43619</i>	<i>15233</i>	58852
Total	91063	31333	31447	3576	5277	<i>135995</i>	<i>68921</i>	204916

In this table, the share of reservation lines for the direct delivery is significantly bigger (34 percent of the total compared to 26 percent at number of items), compared to the number of items, than it was for the number of items delivered directly. This clearly shows the importance of the direct linkage between the plants and LEC. It should also be noted that the number of reservation lines to direct is smaller than to indirect while direct deliveries are ordered in truck loads etc. This supplements to the importance of the linkage between the plants and LEC as the figure of quantities delivered will be a lot larger than suggested by the number of items and number of reservation lines.

1.6 Thesis Outline

Following this chapter, the idealised design will be presented first in chapter 2. Based on the idealised design and the current planning and control at Hilti gaps are identified for integrated planning in chapter 3. Considering the context, constraint and current state of Hilti, chapter 4 discusses the *means planning* and *resource planning* steps for the case study at Hilti. chapter 5 provides a feasible implementation plan and chapter 6 finalises this thesis by presenting conclusions, recommendations for Hilti as well as recommendations for the academic field of this research.

Ends Planning: Idealised Design

As Ackoff (1981) describes in his description of the design approach, a problem mess should be defined as the first phase (see chapter 1) after which the *ends planning* is initiated that starts with the aim to define an idealised design. This chapter defines this idealised design for integrated planning and control in an internal end-to-end supply chain within the context of SCM. The design was developed by aligning multiple academic frameworks while continuously reflecting towards the supply chain of Hilti. This idealised design will then be used (chapter 3) to define the gaps to be filled by Hilti and therefore, complete the *ends planning* step. In section 2.1, the design approach is outlined where after the complexity of the supply chain is introduced and necessities in the development of the design are emphasised. Different academic frameworks are compared to align multiple methods of integrated planning based on the hierarchical planning approach in section 2.2. As several framework are needed for the development of the idealised design, the need and added value are also discussed. A discussion of the final hierarchical model is provided in section 2.3 supplemented with a walk-through based on an operations planning and control (OPC) concept. Finally, the generalisability of the model is presented in section 2.4.

2.1 The Design Approach

As literature does not know any '*standard*' framework that integrates the complete supply chain, the design approach aims at developing one. Ackoff (1981) defines ends planning as: '*selecting the ideals, objectives and goals to be pursued by preparing an idealized design*'. This design would be used if no constraints for the stakeholders would be present. This chapter encompasses the design of a planning and control landscape for the entire internal supply chain.

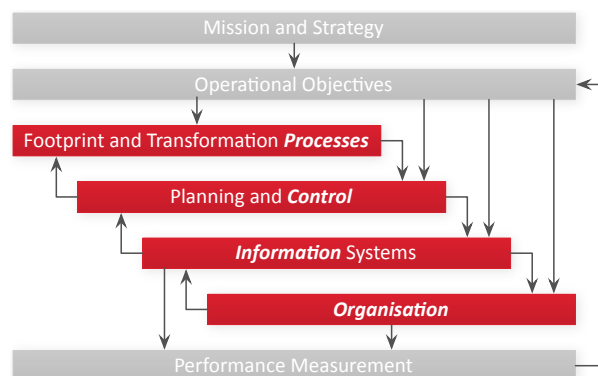


Figure 2.1 – PCIO model in operations model according to Goor et al. (1996)

According to Bemelmans (1992), what a designer develops depends on the target he wants to achieve. This target will define the system boundaries in order to show what will be analysed and what not. In almost every situation *'everything is related to everything'*, nevertheless it is unwise to choose too large of a scope since complexity will make analysis and eventually development (and improvement) impossible. Therefore, it is generally better to develop a partial solution rather than a total solution that is unusable. Following this reasoning the system boundaries of the newly developed framework were adapted to the Hilti supply chain. Furthermore, the PCIO model of Bemelmans (1992) explains that for every design the first step is to look at the features and characteristics of the system processes (P) and to deduct from these the most suitable control (C). This defines the requirements for the information systems (I) and for the organisation (O). Goor et al. (1996) translate this paradigm, originally designed for information systems, to the logistics field of research (Figure 2.1). The company strategy and operational objectives form input for the PCIO paradigm while performance measures can be regarded as the completion of the integrated concept. In order to prepare the idealised design the bottom up approach of the PCIO model in logistics of Goor et al. (1996) is considered (Figure 2.1).

2.1.1 Fitting Hilti's Supply Chain

The system boundaries for the development of the new framework are set by the Hilti supply chain. Following the PCIO paradigm of Bemelmans (1992), the first step is to with showing important characteristics of primary processes of this specific supply chain. First, the internal material flow of the supply chain considers four stages: procurement, production, distribution and sales. This increases the supply chain network complexity as also mentioned by Wang et al. (2012). Wang et al. (2012) indicate how traditional S&OP focuses on balancing company supply and demand, and is utilised to align plans that support a business-strategic goal. An obvious drawback of these decision models is their lack in considering the entire supply chain network. To overcome this drawback the mind set of Wang et al. (2012) is used and the supply chain of Hilti is represented under the four supply chain stages indicated in the article. This representation was later used as a starting point for the new framework. The result of this representation can be seen in Figure 2.2.

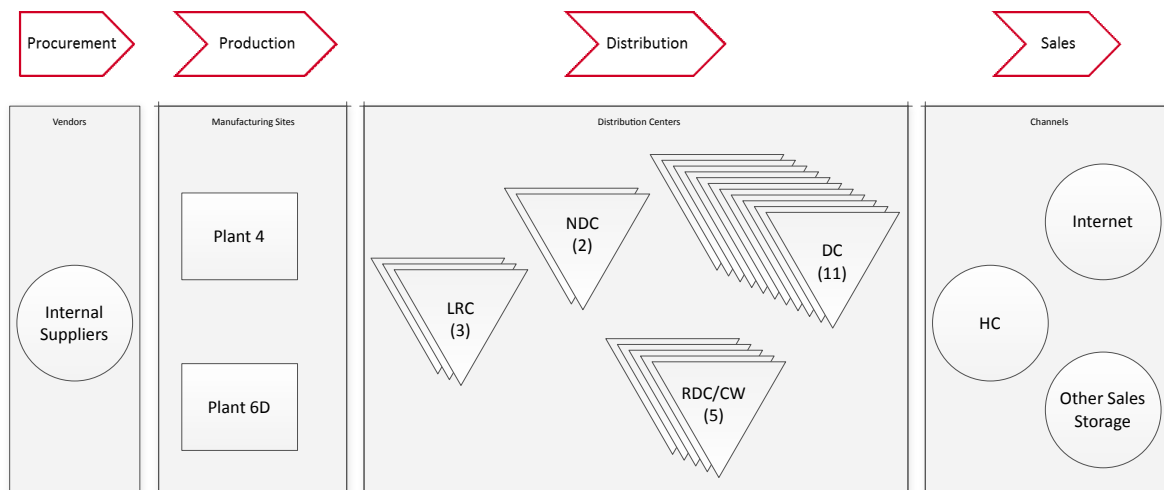


Figure 2.2 – Wang et al. (2012)'s representation applied to Hilti's supply chain

Next, the complexity also increases by the large number of decision that are made in the supply chain network. In order to grasp the important decisions to be made in the supply chain network the Supply Chain Operations Research (SCOR) method, Figure 2.3, was used. The SCOR method is a particularly useful tool for analysing supply chains and revealing redundancies and

2.2. ALIGNMENT OF ACADEMIC HIERARCHICAL PLANNING FRAMEWORKS

weaknesses (Fleischmann and Meyr, 2003). Figure 2.3 gives a proper overview of decisions across a supply chain network. Every stage in the supply chain, either internal or external, has five major management processes that should be planned. Having all four stages incorporated in the same company as seen in Figure 2.3 an increase of complexity is inevitable without proper integration. Therefore, in developing a new framework this need for integration is highly necessary in order to improve current planning methods.

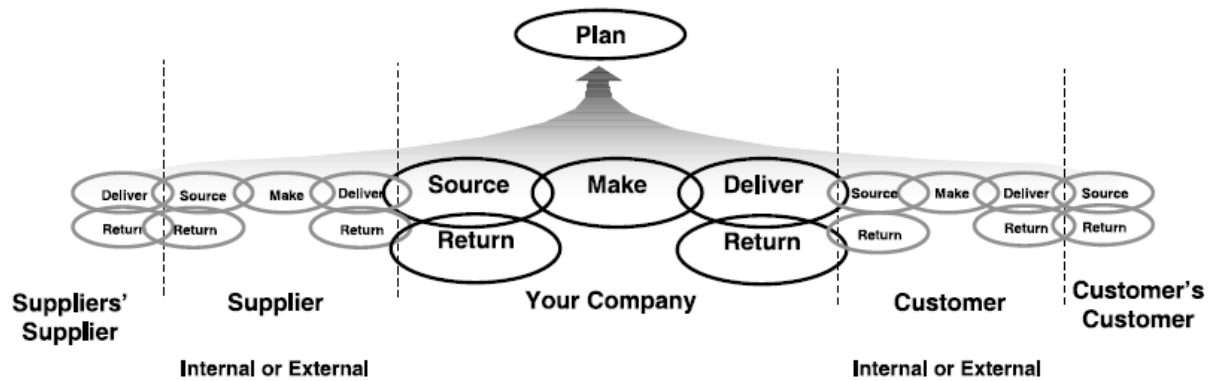


Figure 2.3 – Management processes of the SCOR model, version 5.0a according to Stephens (2001)

2.2 Alignment of Academic Hierarchical Planning Frameworks

Once the main characteristics and boundaries of the supply chain were clear, the development of the idealised design was initiated based on existing paradigms in academic literature on hierarchical planning. As described in Kreuwels (2013), Anthony (1965) formally introduced hierarchical control at three levels (Strategic Planning, Management Control and Operational control) and has become a foundation for academic research at different levels of planning and control. In order to integrate a supply chain Stevens (1989) argues that the management of material flow has to be viewed from three perspectives that correspond with a strategic, tactical and operational level. Additionally, De Kok and Fransoo (2003) state that hierarchical planning frameworks enable accurate modelling of consecutive planning and scheduling decisions made in manufacturing organisations. According to Fleischmann and Meyr (2003): '*Hierarchical planning seeks to coordinate planning modules such that the right degree of integration can be achieved*'. These planning modules are derived from the company's tasks and they pool all decisions within the responsibility of the same planning unit. The planning horizon is shared and the timing should be simultaneous in these modules Fleischmann and Meyr (2003). These planning modules interact and exchange information and constraints in all directions.

Based on these statements the first step in developing the design was the use of the three hierarchical levels and their corresponding decision functions of the SCP matrix as introduced by Fleischmann et al. (2002). Since one of the characteristics of the system is the complexity of the supply chain an abstracted framework is needed (that does not deal with every detail) for designing the planning and control. Fleischmann et al. (2005) argues that the framework shows decision functions which occur in most supply chain types, but with various forms of the actual decision. This form of the actual decision is discussed further in the *design of implementation* in chapter 5. A second argument for starting with this SCP matrix, which seems not to be as academically correct because of the simple reasoning but suits our purpose of developing a new framework extremely well, is that a great deal of existing frameworks on SCI are based on the SCP matrix. Therefore, the SCP matrix could be seen as a paradigm in the SCM research area. Finally, the fitting of Hilti's supply chain under the procurement, production, distribution and sales stages and the SCOR model show the wide variety of decision functions in the supply chain

network. The SCP matrix offers an equally large variety of decision functions making sure the base of the new framework is covering the entire scope. However, as can be seen in Figure 2.4, planning and control decisions are made in different stages of the supply chain and besides the strategic planning concerned with the business plan that is comprehensive, the mid-term and short-term decisions are not integrated.

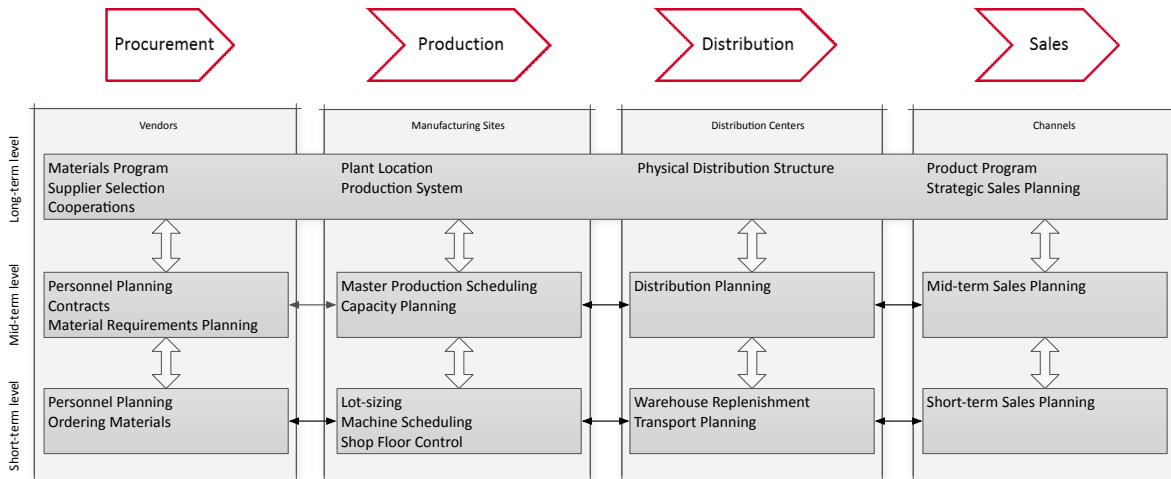


Figure 2.4 – SCP matrix from Fleischmann et al. (2002)

Figure 2.4 shows the planning modules of the SCP matrix. It is important to note that the same four stages of the material flow are used as already indicated in previous sections. This makes the fit for the Hilti supply chain more corresponding and allows for further development of the idealised design. With the SCP matrix as a basis the next step in the development of the new framework is to analyse the level of integration between the planning modules and to improve this integration where possible. Fleischmann and Meyr (2003) state that planning tasks at different planning levels need a different degree of aggregation (frequency, time bucket, product, resources, etcetera). Therefore, in order to analyse the integration, first the integration at the three levels was considered separately. Fleischmann and Meyr (2003) further state that the upper planning level coordinates the lower planning level and that feedback from lower planning level should give instruction to the upper level. Therefore, within every horizontal level the level of vertical integration is discussed. As the design is developed with a bottom-up approach, the operational level is considered and adapted first, followed by the tactical and strategic level.

2.2.1 Operational Level

A single production planning concept, like MRP II or the SCP matrix, cannot cover the large variety of planning problems that arise in practice for different production layouts and market requirements (Drexel et al., 1994). Different types of production processes like job shop, batch flow, assembly or continuous processes imply particular requirements for planning. Therefore, planning concepts will have to be tailored to the special requirements that these processes desire (Silver et al., 1998).

The development of the operational level considered decisions that iterate weekly or even daily and are related to the start-up and continuance of the goods flow on short-term (weeks, days and hours) basis (Fleischmann and Meyr, 2003). Therefore, as a first step a production planning concept had to be fitted to the base of the hierarchical framework. Hence, the MRP II framework has been used since the MRP II framework is particularly suited as an overview of the various types of decision support procedures and models (Bertrand et al., 1992).

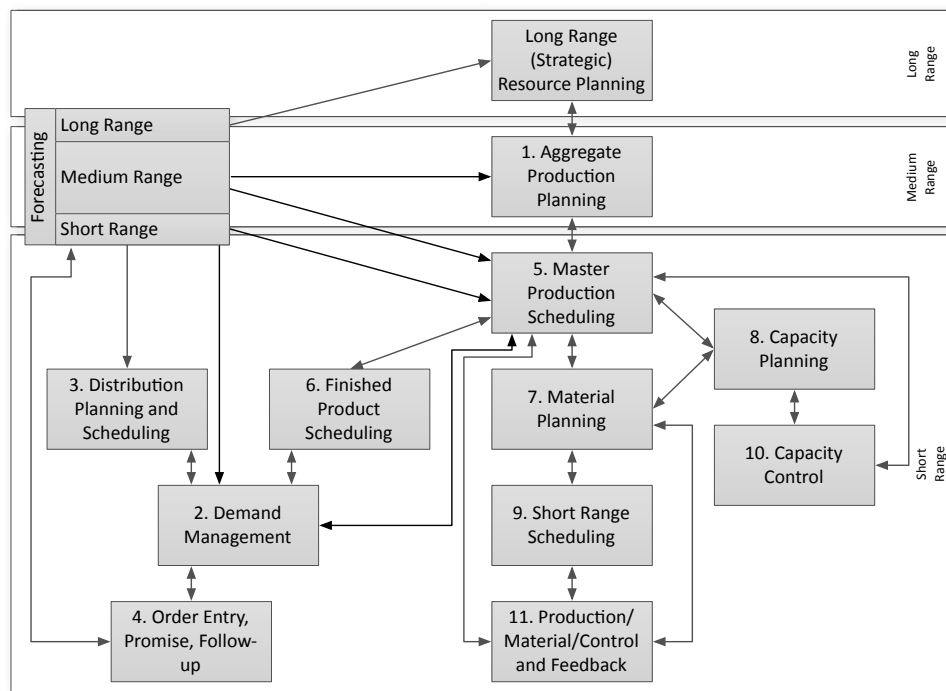


Figure 2.5 – MRP II production decision making framework

The MRP II framework, Figure 2.5, was used first as it is more a framework of different software modules in an MRP-system, than a framework for the design of production control systems (Bertrand et al., 1992). For the purpose of creating a new planning and control concept the MRP II framework could thus provide a complete overview for the operational and tactical level at primarily the production and procurement stages. Using the input of the MRP II framework, decision functions were adapted at the operational level. Firstly, MRP was placed at the operational level as this concerns the stock keeping units (SKU) level. Secondly, the MRP II framework places master production scheduling at the short-term level while it considers the SKU level.

However, the MRP II framework seems to have several flaws. First, the framework makes no distinction between a decision function which can be assigned to a person of an organisation unit and decision support function and models. Second, the framework is hard to use for performance evaluation and third, it is impossible to define an interrelated set of operational, implementable and accountable decision functions which can be assigned to persons of units in an organisation. Therefore the SCOP model of De Kok and Fransoo (2003) is fitted to the hierarchical framework to come to a redesign of the operational level. Since the SCOP model is already positioned at the operational level by De Kok and Fransoo (2003), with a link to the tactical and strategic levels, it was clear how to implement it in the hierarchical framework.

The SCOP method by De Kok and Fransoo (2003), Figure 2.6, contains decisions of both releasing materials and resources coordinated of all release decisions in the supply chain and uses the outcomes of earlier planning decisions. As mentioned before, SCOP overlaps mid-term as well as short-term planning by translating aggregated mid-term planning decisions into short-term execution decisions. This ensures better vertical as well as horizontal integration of the hierarchical framework and is therefore seen as another argument for fitting this model first.

When composing a decision problem and creating a hierarchy, the higher levels of the hierarchy need to aggregate the lower level models in the more or less independent units along the supply chain (De Kok and Fransoo, 2003). De Kok and Fransoo (2003) define the SCOP function

as a centralised control being responsible for the coordination of activities along the supply chain, by making decisions on the quantities and timing of material and resource releases. The introduction of a fixed time bucket eliminates this weakness in the SCP matrix.

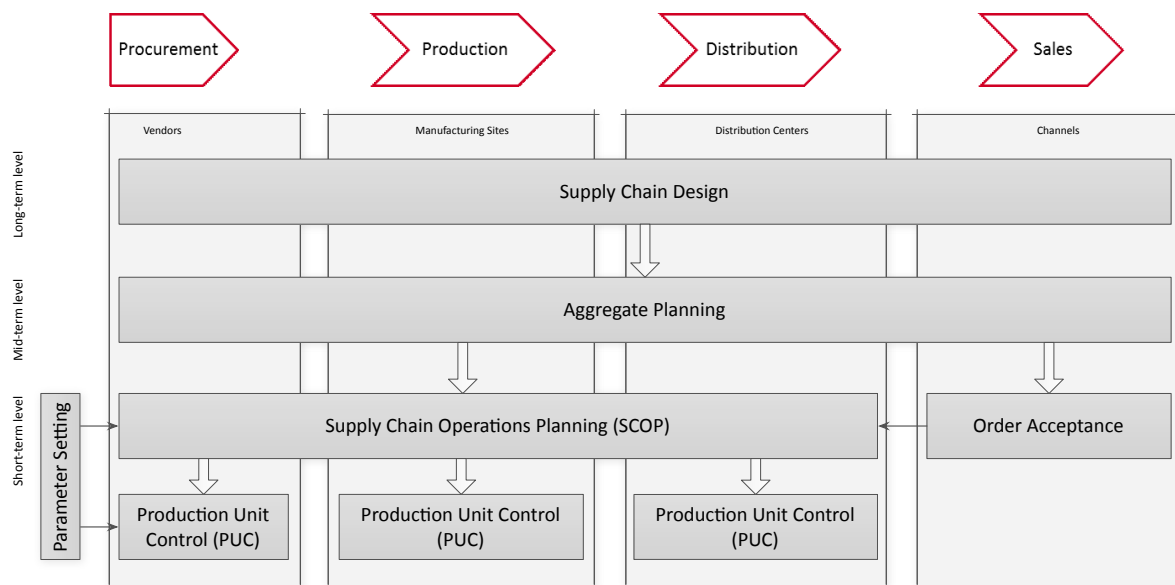


Figure 2.6 – SCOP method according to De Kok and Fransoo (2003)

PU control (PUC) introduced by the SCOP method implies that operational decisions are taken locally (regionally) in order to optimise the process that considers the steering from SCOP in terms of requested input and output and complies with the tactical parameters. They are responsible for controlling lead time in a particular unit of the supply chain Bertrand et al. (1990). To SCOP the PUs are black boxes with certain planned lead times. The machining and assembly units of Plant 4 could therefore be divided in two PUs as they are decoupled by a controlled stocking point. Due to the fact that the PUs will be present in several stages they are renamed as transformational units (TU) in the hierarchical framework.

Additionally, Fleischmann and Meyr (2003) argue that the planning horizon of short-term planning is restricted to a few weeks while De Kok and Fransoo (2003) argue that in most industries SCOP deals with a horizon up to several months with weekly time buckets. This again is seen as an improvement when looking at the considered supply chain network where production lead times of 12-14 weeks arise. Next to the SCOP decision and PUC decisions, short-term forecasting, sales planning and order acceptance are defined. These decisions are in line with both the SCP matrix as well as the SCOP method and are therefore kept in the hierarchical framework.

Finally, according to De Kok and Fransoo (2003) a parameter setting function needs to coordinate the SS, lead-time and work load of the supply chain. Since these parameters should not be set in the same time bucket as the operational SCOP decision they were placed at the tactical level. Parameter setting on operational level would contain too much noise and parameters used in this level should already be set at the higher levels, including a feedback loop from the operational level.

2.2.2 Tactical Level

As mentioned before, De Kok and Fransoo (2003) relate to the decision functions considering the planning of operations in the SCP matrix of Fleischmann and Meyr (2003), however, they abstain from other functions like supply chain design and transportation planning. Hence,

the tactical level of the hierarchical framework had to be replaced whereas the link from the aggregated planning to the SCOP decision function had to be preserved.

Tactical decisions have to be made monthly, have to consider the start-up and continuance of the goods flow on mid-term (months), and are made, unlike at the strategic level, by middle management (Fleischmann and Meyr, 2003). The mid-term plans encompass a horizon ranging from half a year to two years (Silver et al., 1998). Tactical decision functions consider a planning horizon composed of weekly or monthly buckets which leads to the use of aggregated capacities (Fleischmann et al., 2005).

For the horizontal integration, the literature review of Broft (2013b) on S&OP was used. When analysing the tactical level, several weaknesses were discovered which were related to the comprehensive but non-integrated planning modules of the traditional four stages in the SCP matrix. Due to the decoupled character of this matrix, decisions are made within each of the functional departments, independently from each other. Although this approach reduces the complexity of the decision process, it ignores the interactions of the different stages and limits the potentials of further cost reduction and/or increase of global profitability. In order to overcome these weaknesses, the S&OP literature review is used to integrate this level in a cross-functional manner. S&OP can be seen as a periodically occurring planning process, providing links along both axes, linking the long-term strategic and business plans with the short-term operational plans vertically and the demand with supply capabilities horizontally (Ling and Goddard, 1988; Wallace, 2004). Feng et al. (2008) introduce a Supply Chain based Sales and Operations Plan (SC-S&OP) integrating all the planning modules in the different stages at the tactical level. The results of Feng et al. (2008) indicate that this SC-S&OP model show superior performance in shipping, purchase, production and raw material inventory cost, particularly in a varying demand and/or market price environment. The high level of horizontal integration of SC-S&OP and its superior performance led to the adaptation of the hierarchical framework according to the example of Feng et al. (2008).

Feng et al. (2008) already use the SCP matrix and decision functions of Fleischmann et al. (2002) and define S&OP as a monthly tactical planning process formed by breaking down the strategic long-term plans with input from various functional areas bridging the strategic plans to operations. Eventually, the decision functions used in the SCP matrix are defined as preparations leading to the final decision (SC-S&OP).

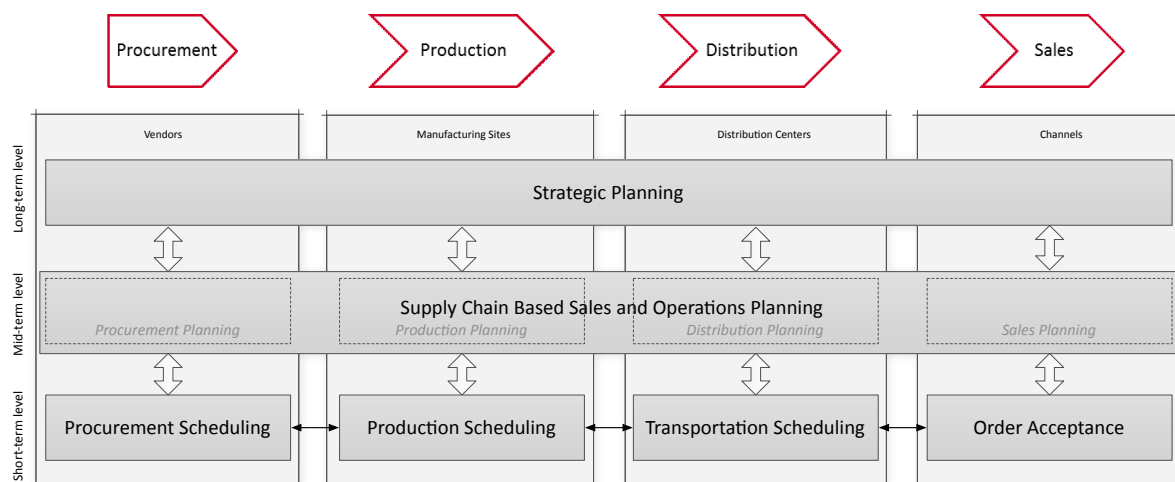


Figure 2.7 – SCP matrix adapted according to Feng et al. (2008)

In the hierarchical framework parameter setting is retrieved from the decision function parameter setting by De Kok and Fransoo (2003) which refer to this need for this decision function

as: *'... a parameter setting function needs to coordinate the safety stock, leadtime, and workload parameters of the Supply Chain.'* As mentioned at the operational level, this parameter setting has to be introduced to the tactical level. Tactical parameters are ground rules for the decision functions at the tactical level and include self-imposed boundaries caused by physical constraints like capacities or lot sizes. They are controlling the tactical level. Bearing the complexity of the considered supply chain network in mind, the entire chain should be taken into account in order to define cost optimal parameters.

Using the input of the MRP II framework, as seen before in Figure 2.5, the SCP matrix decision functions are also adapted for the tactical level. Firstly, MRP is placed at the operational level as this considers the SKU level. Because of this, aggregated MRP is developed to make decisions regarding volumes and money at the tactical level. According to the MRP II framework, master production scheduling is done on the short-term and considers the SKU level. Therefore, it is moved to the operational level and aggregated production planning as described in the MRP II framework is added to the tactical level.

2.2.3 Strategic Level

Following the bottom up approach, the hierarchical framework is concluded by adapting the strategic level. The strategic level provides input for the already developed tactical and operational levels. As mentioned in subsection 2.2.2, Feng et al. (2008) use the SCP matrix and define S&OP as a monthly tactical planning process performed by breaking down the strategic long-term plans with input from various functional areas hereby bridging the strategic plans to operations.

Strategic or (relatively) long-term decisions that have to be taken only once or thought over very seldom consider the structure of the goods flow (Fleischmann and Meyr, 2003). The strategic level defines the strategy and the design of the supply chain and the decision functions at this level have a large impact on the long-term performance of an organisation (Goetschalcks and Fleischmann, 2008). The horizon of the decisions covers several years and the decisions are made by top management (Fleischmann and Meyr, 2003). Identifying the key products, markets, primary manufacturing processes and suppliers is the essence of strategic planning. Multiple decisions have to be taken which at the end form the strategic plan.

In the SCP matrix of Fleischmann et al. (2002) this strategic plan is represented as an integrated decision over the entire supply chain. As the development of the idealised design strives for more integration this will remain an integrated decision function in this ideal design. Eventually, all decisions made at all four stages of the material flow are summarised in the strategic plan.

During the development of the tactical level, the MRP II framework was used, as emphasised before. By using the input of the MRP II framework several missing links were also indicated at the strategic level. This has led to adaptation of several SCP matrix decision functions and the addition of a new decision function, resource planning. Resource planning was added at the strategic level as this is necessary to steer resource planning decisions at the lower levels. By using the bottom-up approach further alignment of the strategic and tactical levels was assured.

Additionally, adaptations were made based on personal judgement. First, at all levels sales planning is split up in forecasting and sales planning. This was done to make a clear distinction between just using statistical forecasting methods and market intelligence in forecasting, and also considering the delivery possibilities in sales planning. Second, in order to guide the strategic decision making, strategic parameters are needed. Strategic parameters are ground rules to accomplish the mission of the company and additionally include self-imposed boundaries that sharpen and clarify the focus of the company's mission. They are controlling the strategic level.

2.3 New Hierarchical Planning Framework

After adapting the hierarchical framework at all three levels a new hierarchical planning framework, Figure 2.8, was designed. The framework shows the final decision functions at every hierarchical level including the strategic and tactical parameter setting. It considers and integrates all four stages making it applicable to the complex internal end-to-end supply chain of Hilti.

At the strategic level, first strategic parameters have to be set for the entire supply chain. For the procurement stage, *resource planning*, *materials program*, *supplier selection* and *cooperations* are decisions that are included. *Resource planning* entails the process of establishing, measuring, and adjusting limits or levels of long-range capacity at business plan level (APICS Dictionary, 2013c). The *materials program* decision considers materials needed to buy from suppliers. *Supplier selection* is a comprehensive approach for locating and sourcing key material suppliers (APICS Dictionary, 2013a). *Cooperations* considers what type of strategic cooperation might be useful (Fleischmann and Meyr, 2003). For the production stage, *plant location* and *production system* are the established decisions. *Plant location* considers where to locate the plants and is usually taken together with the decision of the *physical distribution structure* (Fleischmann et al., 2005). The *production system* decision considers the organisation of single production plants in terms of layout design and the resulting material flows between the machines (Fleischmann and Meyr, 2003). The distribution stage considers the *physical distribution structure* usually in cooperation with *plant locations* as mentioned above. The physical structure for distribution is decided. Finally, the sales stage considers the *product program*, *long-term forecasting* and *long-term sales planning*. The *product program* together with *long-term forecasting* and *sales planning* consider which products to place on which markets (Fleischmann and Meyr, 2003). Together, all the decisions of the supply chain come to the final decision that is called *strategic planning*. *Strategic planning* outputs a strategic plan that steers all the levels below.

At the tactical level, tactical parameters are set for the entire supply chain first. To be able to integrate planning processes at the tactical level with *SC-S&OP*, a number of planning parameters for the process have to be established. Decisions at the tactical level can adapt logistical control parameters like the ordering method, order frequency and SS (Fleischmann and Meyr, 2003). For the procurement stage, *personnel planning*, *contracts* and *aggregate material requirements planning* are decisions that are included. *Personnel planning* considers specific personnel groups and their availability according to labour contracts (Fleischmann et al., 2005) and shows the necessary amount of needed employees on a mid-term. *Contracts* considers the price, the total amount, and other conditions for the materials to be delivered during the next planning horizon for suppliers (Fleischmann et al., 2005). *Aggregate material requirements planning* entails the planning of parts of sub-assemblies at an aggregated level for the mid-term. For the production stage, *aggregate production planning* and *capacity planning* are the established decisions. *Aggregate production planning* is part of the process to develop the tactical plan supporting the organisation's business plan (APICS Dictionary, 2013b) and defines the production volumes for the next planning horizon. *Capacity planning* entails the amount of capacity needed at aggregated level. Together, the procurement and production decisions merge their preparations to come to a preliminary production plan that will be used for the *SC-S&OP* decision. The distribution stage considers the *distribution planning* that decides on the planning of transports between the warehouses and determination of the necessary stock levels. Finally, the sales stage considers *mid-term forecasting* and *sales planning* at aggregated level. *Forecasting* considers the potential sales for product groups in specific regions where the products are grouped according to their production characteristics (Fleischmann et al., 2005). *Sales planning* gives a: 'time-phased statement of expected customer orders anticipated to be received (incoming sales, not outgoing shipments) for each major product family or item'

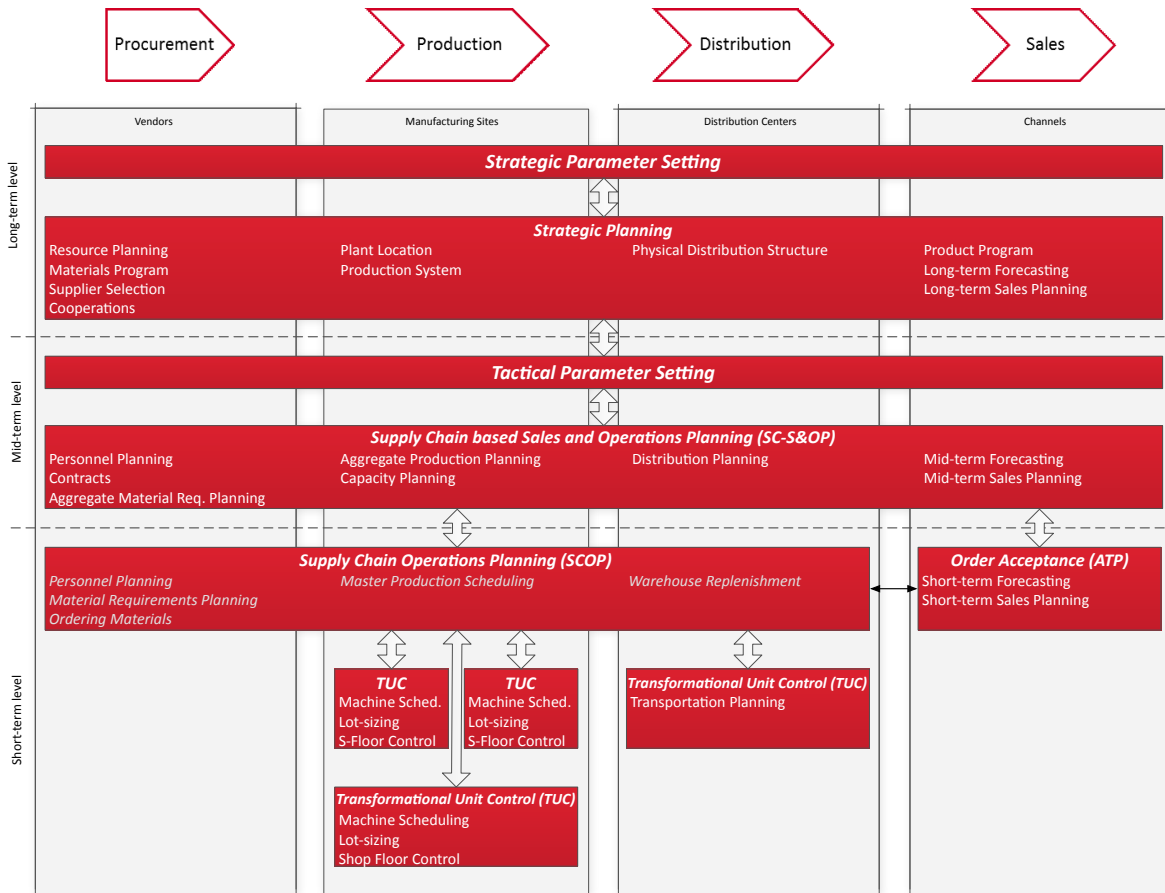


Figure 2.8 – New hierarchical planning and control framework

(APICS Dictionary, 2013d). The distribution and sales decisions merge into a preliminary delivery plan used for the preliminary production plan and for the final *SC-S&OP* decision. The *SC-S&OP* decision aligns the two plans and agrees to a final number for all parts of the supply chain on a mid-term horizon.

At the operational level, for the procurement, production and distribution stages there is one higher level *SCOP* decision that releases materials and resources to be deployed by the TUs. This basically integrates the following decisions shown in the framework of Fleischmann et al. (2002): *personnel planning*, *material requirements planning*, *ordering materials*, *master production scheduling* and *warehouse replenishment*. Next to the *SCOP* decision, the TUC considers local decisions about *machine scheduling*, last minute *lot-size* adaptations and *shop floor control* for production and specific *transportation planning* for distribution. For sales, *short-term forecasting* and *sales planning* give feedback to *SCOP* and *order acceptance*. *Short-term forecasting* predicts future demand with statistical models and supplements this with market intelligence from marketing and sales on the short-term horizon and *sales planning* considers the fulfilment of customer orders on this horizon. *Order acceptance* controls the total volume of work accepted by the supply chain, and externalises the portion of the customer-perceived lead time resulting from a varying demand that cannot be processed within the fixed and controlled lead time (De Kok and Fransoo, 2003).

2.3.1 Operations Planning and Control Concept

The hierarchical framework solely shows the decision functions at their respective hierarchical level and stage but lacks the time aspects. An OPC concept can be used to represent these

time aspects and consists of a set of hierarchically ordered decision functions that lead to the timing and quantity of the release of material and resources related to work orders for items, as well as the timing of the transformation processes which convert the material for these work orders in the associated items (De Kok, 2013).

Figure 2.9 shows the aggregated decision functions of the hierarchical framework as an OPC concept. It shows three main aspects, hierarchy, time and dependencies. The hierarchy consists of three hierarchical levels and an executive object system containing the TUs. The time aspects that are considered in the OPC concept can be split in two main facets, sequence and frequency. A sequence is essential since a decision function at a higher level can control a decision function at a lower level and decision functions at the same level can be input for each other. To demonstrate this reliance a natural time hierarchy was developed with a certain level of aggregation in order to clearly represent all aspects of the OPC concept. Frequency was added to indicate the cycle time of a decision function and the amount of repetitions in a certain time period.

The dependencies can be expressed in four ways - *anticipation*, *reaction*, *instruction* and *implementation* - and are deduced from the literature review of Kreuwels (2013). *Anticipation* is performed by a top level towards a lower level. It can be explained as choosing an anticipated lower-level while taking into account its impact on the top-decision. Generally an anticipation can be regarded as a bottom-up influence of the lower-level on the top level. The information can thus be seen as a feed forward. In the same line of reasoning, which comes from (Schneeweiß, 1995), the control executed by the top-level on the base-level is called an *instruction*. A feedback loop from the base-level towards the top level, which is triggered as a response to the instruction, is called a *reaction*. Finally, all levels agree on a decision which results in an *implementation* influencing the object system, whereby this object system can provide a formal feedback on the implementation.

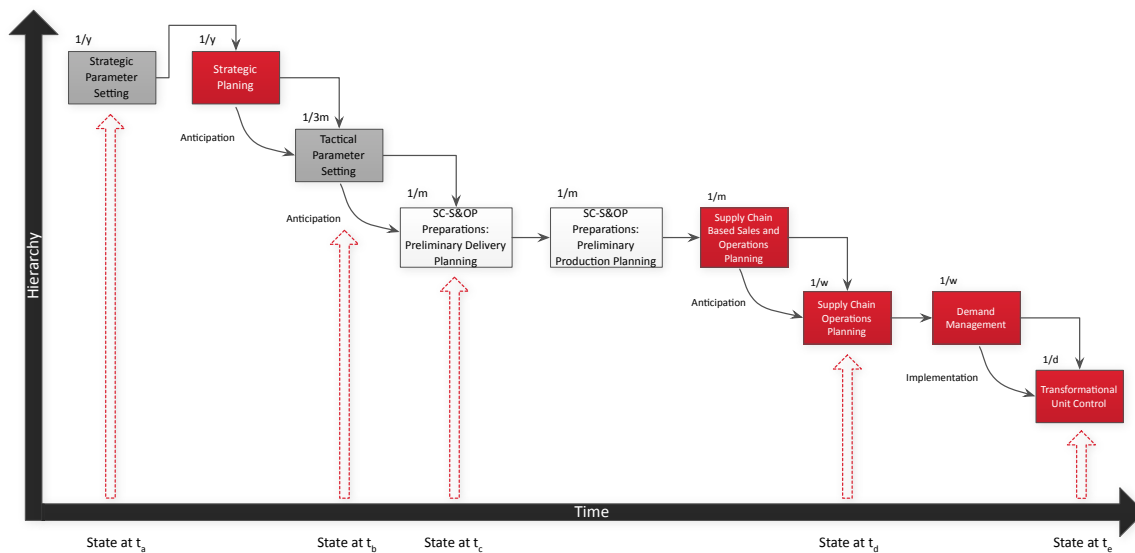


Figure 2.9 – Natural time hierarchy of the OPC concept

Once the hierarchy is indicated, disaggregation to a lower level is possible for the elaboration of the full OPC concept. All three levels of the hierarchical level are disaggregated and elaborated in order. It has to be noted that only the planning decisions are represented in this diagram and that no more form of hierarchy is represented in Figure 2.10, 2.11 and 2.12.

Strategic Level – Strategic parameters are set maximally once a year and control the decision function at the strategic level. It shows that decisions are taken in order to come to a strategic

plan, once a year and in a certain sequence. Forecasting provides input for both *sales planning* and *resource planning* which in their turn serve as an input for the development of the strategic plan. Eventually, the strategic plan controls the tactical level.

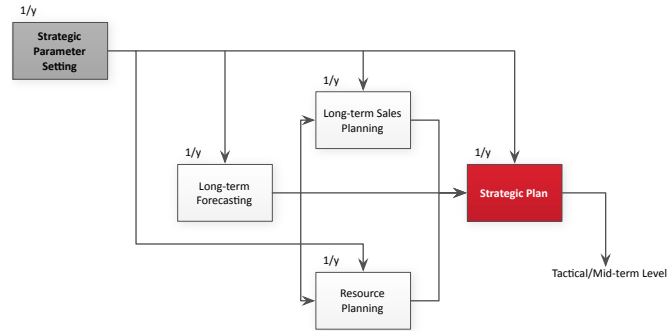


Figure 2.10 – Strategic level of the OPC concept

Tactical Level – The tactical-term level was integrated in the multi-site SC-S&OP approach according to Feng et al. (2008) which leads to an SC-S&OP plan deduced from the literature review of Broft (2013b). A deviation from Feng et al. (2008) is chosen as the method for reaching the final plan. Where Feng et al. (2008) use an algorithm to reach the final SC-S&OP plan, the developed OPC concept is based on two preparation plans. This adaptation was made since Feng et al. (2008) recognised that the data collection for the algorithm used is very challenging, since data is often inconsistent, not standardised or even not available at all. By replacing the total algorithm with preparation plans this data problem can be overcome and the OPC concept can be made feasible for implementation.

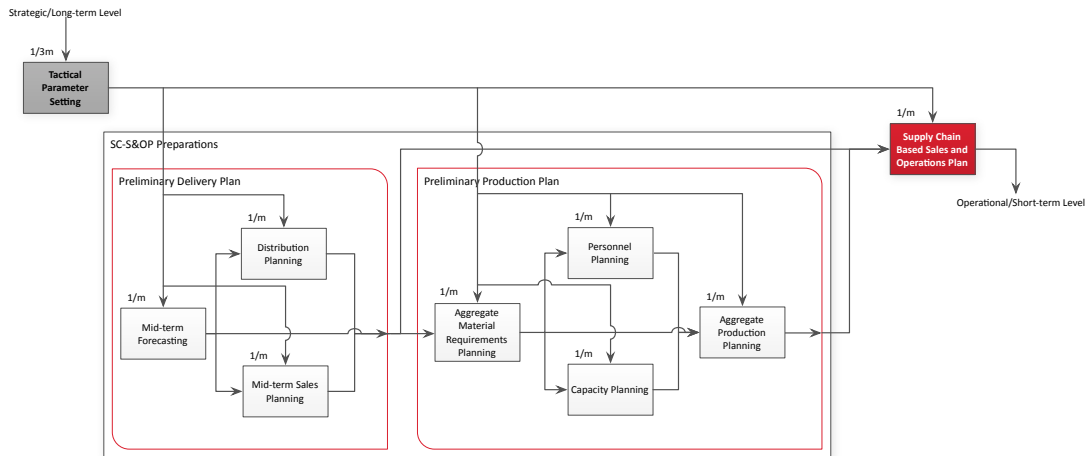


Figure 2.11 – Tactical level of the OPC concept

The first preparation plan is the delivery plan. Here *forecasting* is used to define *distribution planning* and *sales planning*. Eventually the distribution plan and sales plan are balanced into the delivery plan. Subsequently, the production plan uses the input of the delivery to perform an aggregate MRP. This MRP serves further as an input for *personnel planning*, *capacity planning* and *aggregate production planning*. Both *capacity planning* and *personnel planning* are performed prior to making the aggregate production plan. This way the production plan is based on the available resources and has more value to the operational level below. In a way, it can be compared to the rough cut capacity planning (RCCP) that is made in order to ensure the feasibility of the master production schedule. Because the MPS was part of the SCOP function in the developed model, the RCCP had to be incorporated at the tactical level to maintain the capacity constrictions.

Both preliminary plans as well the SC-S&OP plan are controlled by tactical parameters. These parameters are revised once every three months to keep them accurate. They receive a reaction, through the tactical preparation decision functions, from the operational level. The preparations and setting of this SC-S&OP plan is a monthly recurring process as advised by the literature review of Broft (2013b). The SC-S&OP plan controls the demand fulfilment on the sales stage and the weekly SCOP decision at the operational level.

Operational Level - The *SCOP* decision releases both materials and resources coordinating all release decisions in the supply chain and consists of traditional decisions like *personnel planning*, *MRP* and *MPS*. The difference with *SCOP* is that these decisions are made jointly and balanced rather than separately. The *SCOP* decision eventually sends an implementation to the object system. Additionally, the *SCOP* decision can receive a reaction from the *order acceptance* decision function. When a reaction occurs, *order acceptance* can trigger to adapt the *SCOP* decision and eventually the implementation. The TUs have their own level of control and can optimise their processes as long as they comply with the implementation given by the *SCOP* decision. The *SCOP* decision, *short-term forecasting* and *sales planning* are performed once a week while TUC decisions are performed daily. *Sales planning* acts as an exception mechanism together with the *order acceptance* decision function to provide flexibility in case of excessive demand on a short term.

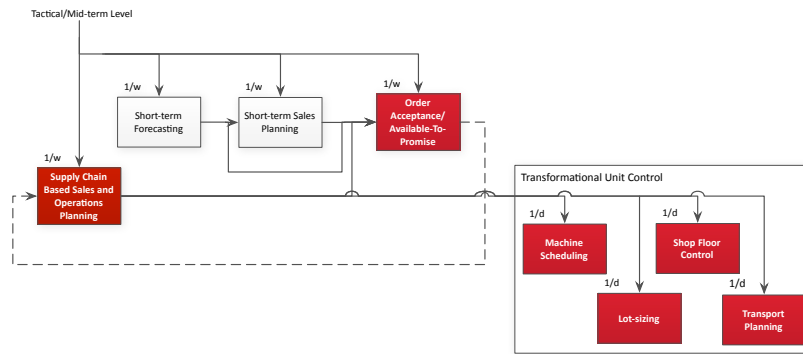


Figure 2.12 – Operational level of the OPC concept

Another way of documenting the OPC concept is to use swimming lanes. These show, next to the timing of decision, also the responsible role for the decision. The design depicted above refrained itself from the use of swimming lanes as it requires decisions on organisational structures, which are part of the next step of the PCIO method. As a proof of concept this method is used in a later stage to formally document the new planning concept of the Hilti supply chain in chapter 4.

2.4 Generalisability of the Model

According to the PCIO model presented in section 2.1 the design of planning and control in a design approach, comes after designing the primary processes. However, as this design approach started with a given set of transformation processes and combined academic frameworks to come to the planning and control design, it can be argued that some level of generalisability can be achieved. In this section an attempt to proof the generalisability is made.

The developed hierarchical framework is a modification of general planning and control frameworks which by itself suggest the generalisability of this framework. Strategic and tactical parameters have to be set for every supply chain and strategic or tactical decisions will be taken based on these parameters. Although the strategic and tactical parameters are specific

for every company, the way of controlling and planning and the hierarchical positioning of the decision functions can be seen as a general model that is created by combining multiple academic frameworks developed over time. The specifics of the supply chain coincide with the idea of the TUs being black boxes with characteristics that have to be controlled. The decision functions represented in our design occur in most supply chain types, however, with various contents in the particular businesses. Using a bottom-up approach, any business should be able to fill in the contents.

As described in the literature review of Broft (2013b), the tactical level decisions containing S&OP might be divided in multiple local S&OP processes and a Global S&OP for alignment of the local S&OP numbers. Basu (2007) refers to global S&OP as an extended local S&OP for global multinational enterprises. This positioning of the S&OP process throughout different locations makes the tactical decisions and their integration possible for all sorts of supply chain complexities. The literature review also described the need for a process of S&OP that is specifically designed for every company, which is also true for the other processes leading to decisions in the hierarchical model. This leads to a design proving to be general in planning and control for an integrated supply chain in at least some extent.

Referring to Feng et al. (2008) and their multi-site SC-S&OP model, it is evident that the operational level could be divided over different locations of the procurement, production, distribution and sales stages. It can be concluded that the operational level does not have to be integrated at all sites of the company if the (transformation) processes are unrelated or if it concerns different parts of the global market. If this is combined with the believe in SCOP and its relation with black boxes being the transformational units (already controlled locally), it can lead to multiple operational *SCOP* decisions and provide generalisability for a multi-site environment. Thus, next to the described TUs of Plant 4 and Plant 6D this model can also be applied to the other plants in GM as well as in other multi-site companies in different industries. As De Kok and Fransoo (2003) mention, SCOP needs to be positioned hierarchically above the unit control functions. SCOP however, does not influence the way the lead time is controlled in the transformational units, leaving the operational level generalisable for all situations as long as the lead times, and input/outputs to the transformational units are known.

It is recognised that the developed idealised model will not fit every supply chain. However, the model includes all four stages of the work flow and defines the hierarchical levels with its roles and responsibilities. In doing this, it leaves sufficient space for specific company content. Hereby it is expected to be broadly generalisable and applicable to the majority of supply chains.

Ends Planning: Gap Identification at Hilti

As a part of the *ends planning*, where the previous chapter started with developing an idealised design, this chapter identifies the gaps between the idealised design and the planning landscape at Hilti. As mentioned before, it is generally better to develop a good partial solution than a total solution that is unusable (Bemelmans, 1992). Therefore, the scope is narrowed by treating the TUs as black boxes corresponding with the theory of De Kok and Fransoo (2003). Since a bottom-up approach is used, the highest level of the hierarchy, the strategic level, is also out of scope. This decision was made considering the available time and resources for the research. In this chapter the integrated planning gaps within the entire supply chain are discussed first in section 3.1. Hereafter, in the same section, the gaps are further elaborated on the researched locations, in this thesis, with an emphasis on LEC and HAG. Finally, in section 3.2 the consequences of these gaps are depicted.

3.1 Identified Integrated Planning Gaps

Two main integrated planning gaps were identified. Firstly, the hierarchical character of the idealised design is missing in the current situation, resulting in an inappropriate integration between decisions that should be taken at different levels. Secondly, a consistent cross-functional integration between decisions of the theoretical framework is clearly missing, resulting in the identified silo-thinking (section 1.1). Both types of identified gaps are represented in Figure 3.1 and elaborated in the following subsections. For understanding these gaps from all perspectives, they were identified based on the structure of the planning landscape, decision making, communication and IT-support.

3.1.1 Hierarchical Planning

Structure – While comparing the hierarchical levels of the idealised design with the levels within the Hilti supply chain, several gaps are found. Although strategic decisions and strategic plans seem to be present, no clear division between the tactical and operational levels exists. For example, *distribution planning* at the tactical level, as depicted in Figure 3.1, is currently divided in several operational decision functions. Since the tactical level for this function is not present, Hilti is unable to deal with uncertainties by aggregating demands for the entire supply chain. Without a tactical level that controls the operational level the decisions made at the operational level only optimise the represented location instead of the entire supply chain.

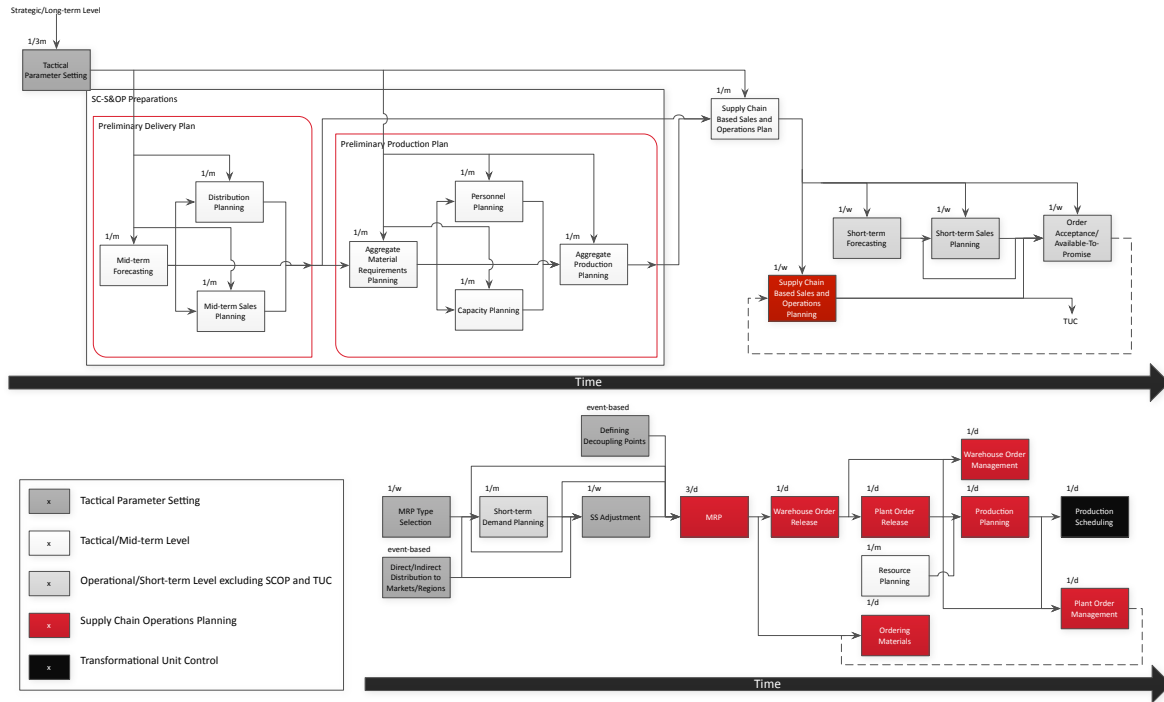


Figure 3.1 – Identified gaps at Hilti

Not clearly following from the presented hierarchical planning structure, but noticeable in the hierarchy at the operational level itself, *SCOP* and *TUC* are not divided in the current situation. At Hilti there is no *SCOP* controlling the different TUs but uncapacitated release of orders by the system between all parts of the supply chain. This leads to lower timely execution of internal orders and eventually lower reliability of lead time to the customer.

Decision Making – Tactical decisions are occasionally present, not present or substituted by operational decisions with a short-term horizon. This leads to inconsistency in the current implementation of tactical decision making. Next to this incompleteness of tactical and operational decisions, no tactical parameters are set in the current situation for making mid-term decisions. The current *parameter setting* is divided in multiple decision functions that are controlled independently from decisions of other functions in the supply chain and changed whenever necessary. This means there is no quarterly *parameter setting* considering the entire supply chain as presented in the idealised design. Due to this missing tactical control, decision making focuses more on deciding well on what is decided, instead of making the right decision.

Communication – Due to the structural gaps mentioned before there is no need to aggregate or disaggregate material requirements or other information between hierarchical levels in the current planning landscape. However, as the idealised design suggests, an appropriate level of aggregation is needed in order to function at both hierarchical levels. Interaction between the hierarchical levels is needed as it makes it possible to share information between the levels. For example, reaction/feedback is an important communication technique. If this communication does not take place, proper planning of a lower level on a higher level is not possible since relevant data might be missing.

IT Support – For optimal use of the idealised design the system has to be able to support decisions at different hierarchical levels which is currently not present due to the lacking tactical level. The SAP system that is in place at the moment should be able to close the gap that arises when a tactical level is introduced. For example, aggregation and disaggregation modules are necessary to align the tactical and operational levels within the system.

3.1.2 Cross-functional Planning

Structure – Comparing the current situation with the idealised design shows a clear inequality in the horizontal planning structure. The current landscape is horizontally dispersed based on the different legal entities belonging to Hilti instead of divided based on the four stages of the material flow.

Additionally, at the operational level, the SCOP level is the cross-functional integration of procurement, production and distribution, currently not present.

Decision Making – Decisions made in the procurement, production, distribution and sales stage are currently not integrating the complete supply chain, making the supply chain horizontally dispersed. At a tactical level, S&OP can be considered a significant mediator for the improvement of operational performance in the environment of market uncertainty. By introducing the missing tactical level, recognised as a gap before, the decision making between the four stages can be integrated using a S&OP technique. The idealised design uses a *SC-SCOP* decision that involves two preliminary plans. These plans ensure the transfer of several already existing (tactical) decision functions from the operational to the tactical level and, at the same time, the development of missing decision functions, covering the entire supply chain, in order to close the gap of the horizontal dispersed character.

The *SCOP* decision at the operational level is meant to integrate the decisions made about procurement, production and distribution and therefore, suggests the cooperation between these functions. In the current situation the release of resources and materials is done in a decentralised manner and is not integrated. This, for example, leads to nervousness in the system due to lack of transparency and can be seen in the volatility of the demand in the production plants.

Communication – Tactical parameters are currently set ad hoc and also independently from other functions in the supply chain, which leads to them not being cost optimal. The ad hoc *parameter setting* leads to the gap that the cross-functional communication of these changes in tactical parameters is lacking. The effect of changing a tactical parameter at a location can have consequences for the entire supply chain. To mitigate these consequences the supply chain needs to be informed. In the current landscape this is not always done, indicating a communication gap. Additionally, functions in the four stages communicate in different numbers making communication more difficult. The idealised design uses the SC-S&OP plan to balance and express the sales, capacity, items, volume and monetary values in '*one number*' that can be translated to the number needed for every of the four stages.

IT Support – In the current planning landscape the SAP system controls all echelons in the Hilti supply chain and is even connected to several external suppliers via electronic data interchange (EDI). The system in the current situation supports decision making based on the integration of the complete supply chain, but is currently not used correctly because of silo thinking and a lack of a calendar for changing data or giving input. As an effect the market adjusts orders last minute to assure flexibility to the customer but also keep stock levels as low as possible. This creates demand volatility in the plants. Also, certain cross-functional support is not present at the moment. For example, an ATP check that considers the complete supply chain from suppliers to sales channels is not supported. The current local ATP checks are unconstrained by the more upstream system status and promise unreliable lead times to customers.

3.1.3 Gaps in Hilti Logistics Europe Central region and Hilti Headquarters

After identifying the integrated planning gaps, further elaboration on the gaps present at LEC and HAG are presented in this section. Referring to subsection 1.5.3 on the planning and control

of Hilti LEC and HAG, and considering the material flow structure for Hilti's perspective as seen in Figure 2.2, decision functions concerning the distribution and sales stages will be further discussed. For more information, the documentation of all the planning and control gaps identified at LEC and HAG can be found in the deliverable presented in Broft (2013c).

Hierarchical Planning

Structure – As mentioned above, the hierarchical levels seem incorrectly placed. Although strategic decision making is present at Hilti, these are out of scope and not discussed. The division between tactical and operational levels at LEC and HAG are unclear and ill-defined. HAG takes some decisions informally that would normally be identified as higher in the hierarchy affecting LEC (e.g. decision on direct or indirect delivery). The gap, which is further elaborated in the decision making below, indicates that both departments, in operations, take some of the tactical decisions when needed.

Also, decisions in LEC concerning distribution are not divided into tactical and operational decisions with different horizons and aggregation levels. This is further discussed below.

Decision Making – The strategic plans that currently exist per BU management team are not used for deriving tactical parameters for the complete functions of the supply chain from it. Therefore, there are no decisions that control decision making in LEC and HAG (leaving out process improvement decisions coming from GL MM). Also, there is no other central process that quarterly sets tactical parameters for the supply chain.

No mid-term decisions for sales and for distribution are taken at this point. Tactical matters as *distribution planning* are dealt with de-centrally with a short-term horizon and on an item-level. Defining decoupling points is currently not a decision made on a regular basis and therefore not related and corresponding to the *forecasting* and *sales planning* frequency of one month in the idealised design.

Also forecasting is only carried out with a short-term horizon and on an item-level. *Short-term forecasting* is currently done once a month, as defined in the idealised design. It is adjusted in case of an event which does not seem to be a gap. *Short-term sales planning* based on the short-term forecasts is not present. Events are planned in order to increase sales and communicated to MM directly to adapt the forecast.

In general, *forecasting* at mid-term level is absent where some kind of *sales planning* at this level exists. Trimester plans are available in the best case scenarios to adapt the mid-term forecasts. Currently the frequency of such kind of forecasts does not correspond with the idealised design as this forecast does not exist. The current *sales planning* at mid-term level uses the history of product groups but does not cooperate with an aggregated mid-term forecast as this is not available. There is a tool that aggregates the forecasts that are currently in the system which is used in aligning marketing and MM in LEC, but the forecasts in the system are produced with an operational horizon and at an item-level as stated before.

The current *sales planning* takes place on a yearly basis and therefore does not correspond with the monthly frequency of the reference model. HAG aggregates for all markets when it converts the separate forecasts for the replenishment of the LRCs, which despite a form of aggregation, still takes place at an operational basis or at least working with operational forecasts. The items on the reorder point ordering method are therefore added on an aggregated basis as well. This aggregation is not defined for disaggregation to the decentralised distribution functions and therefore indicates a gap in hierarchical planning (it indicates some informal hierarchical structure of HAG for decision functions which is not defined).

Communication – The first gap identified for the LEC department indicates no specified control from a tactical level as the related decisions are not clearly defined. As mentioned above,

HAG seems to have a higher informal hierarchy when it comes to *forecasting* and distribution, but there are no clear communication lines and decisions taken for LEC that would possibly be identified as more operational. Also, certain tactical parameters (which imply a higher level hierarchy) are taken at HAG and not communicated to LEC, causing problems with planning at that operational level.

IT Support – In the hierarchical planning perspective, the identified gap of the SAP system can be experienced as a lacking support for decisions at separate levels as discussed in the section on the identified gaps over the entire supply chain. For LEC and HAG the identified gap is that important influencing decisions filled into the system (although currently seen as operational only) do not cause an alert about this change for the lower level decisions at LEC and HAG.

Cross-functional Planning

Structure – Distribution is dispersed over several locations, which includes regions, separate markets and HAG, based on the warehouses within their control. Stocking points, as well as TUs in the supply chain, are controlled locally (or regionally). LEC controls for their RDCs/MO CW and HAG controls the LRCs.

A part of distribution is integrated locally (regionally) with sales in the current planning landscape of LEC. This implies that distribution is divided between HAG MM and LECMM which indicates a gap at the operational level (as there is no defined tactical level). Meetings between MM and the marketing department result in decentralised plans for alignment of distribution and marketing in that region/market (in this case LECMM and marketing). HAG MM has to deal with this decentralisation as they control the upstream distribution.

Decision Making – *Forecasting* is currently done locally (regionally) for specific markets and is also a shared responsibility with HAG. Items on the reorder point ordering method are forecasted in HAG at an aggregated level. This clearly indicates a gap with the *forecasting* done close to the sales channels. *Forecasting* at MM replaces the sales planning function close to the sales channels and therefore, this also indicates a gap in comparison with the idealised design. Sales and marketing decisions at the operational level are decentralised to be close to the market and do not indicate a gap. The BU marketing is separated from the marketing in LEC and might indicate a gap at higher levels in the hierarchy. This is not examined in detail because of the focus on MM of this thesis.

Tactical parameters, such as SS levels and defined decoupling points, are decided upon locally (regionally) or at HAG MM without taking the complete supply chain into account. Also, the preliminary delivery plan is not present at this point. There is no monthly process that relates to the mid-term forecast, *sales planning* and *distribution planning* at aggregated level to come to a preliminary delivery plan that can be used for input to the preliminary production plan and the SC-S&OP plan. HUB SFI meetings align MM and marketing and are therefore a correct step towards the preliminary delivery plan. The output of these meetings however, is not binding and is used to communicate to HAG MM. Therefore, every market currently has its own '*plan*'. This should ideally be used centrally in order to come to an SC-S&OP plan with the mid-term preliminary production plan taken into account.

As mentioned in decision making for hierarchical planning, events in LEC are planned in order to increase sales and are communicated to MM directly in order to adapt the forecast. This indicates the integration between the distribution and sales stages at the operational level as discussed above. As *short-term sales planning* for LEC is not present in the current landscape, it does not work with short-term forecasts that define the *order acceptance* decision in according to an *SCOP* decision.

The *SCOP* decision regarding release of materials and resources is not present at the moment. Order release is currently performed in LEC for the replenishment of the warehouses which does not comply with the centralised decision of releasing materials. This decision should take the procurement, production and distribution supply chain stages into account. Next to this, the frequency of *SCOP* of once per week is exceeded by the daily order release currently present in LEC and HAG. Also, the *order acceptance* at LEC and HAG is done separately for only a part of the supply chain, between two stocking points (not taking the complete supply chain into account).

Communication – Tactical parameters that are defined in LECMM or HAG MM are not communicated properly throughout the supply chain which creates difficulties in planning upon changes that take place. Communication lines between marketing and MM in LEC are well integrated with regular meetings for alignment. The division of distribution decisions between LEC and HAG causes problems for Hilti, as there are no clear communication lines for decisions established. Communication takes place at own initiative and the regular meetings between marketing and MM in LEC are an effort to align the message communicated to HAG, thus trying to create integration on the horizontal axis. As mentioned before, these decisions in the meetings are not binding and concrete enough to make this communication flawless.

IT Support – The order acceptance in the system for LEC and HAG is calculated between two stocking points and should provide the possibility to entail the entire supply chain within the boundaries of the *SCOP* decision. Also, changes between LEC and HAG should be made visible by i.e. the use of alerts, as the distribution decisions are dispersed. Separate input for forecasts and sales plans is not available and thus a gap in order to keep the valued forecasts after changing the sales plan numbers.

3.2 Consequences of the Identified Gaps

The identified gaps imply that current supply chain planning at Hilti is sub-optimal. Filling the gaps will eventually result in eliminating this sub-optimality. In this section the possible effects of this according to the idealised design are determined. The actual way of how to fill the gaps is, according to the design approach of Ackoff (1981), subject of *means* and *resource planning*, done in chapter 4. To elaborate on the gaps and their effects a cause and effect diagram is used which can be seen in Figure 3.2.

In the context of SCM where more companies focus on integrating the supply chain, SCP is becoming equally more important. Integrated planning in particular, is important when bearing in mind the complexity of the supply chain of Hilti - with a large number of suppliers, multiple production plants, multi-echelon distribution network and integrated sales channels. The result of better SCP will be visible in topics that are important for Hilti such as lower inventories, better reliability of the lead time to the customer and less volatility in the production sites. This ultimately will be leading to a better competitive position for Hilti throughout the world.

As represented in Figure 3.2 the incomplete implementation of SAP is one of the causes for the sub-optimal planning of the supply chain. Not all modules of the advanced planning system (APS) are implemented or not implemented the correct way due to the complexity of the fit between the modules and the planning and control landscape. Also, the algorithms in the system are not optimal for well-valued planning decisions for Hilti's supply chain.

The idealised design gives a clear guideline for adapting the IT support in the implementation phase to mitigate this cause. The content of the decision functions discussed in the chapter 4 helps to align the necessary data needed in the support.

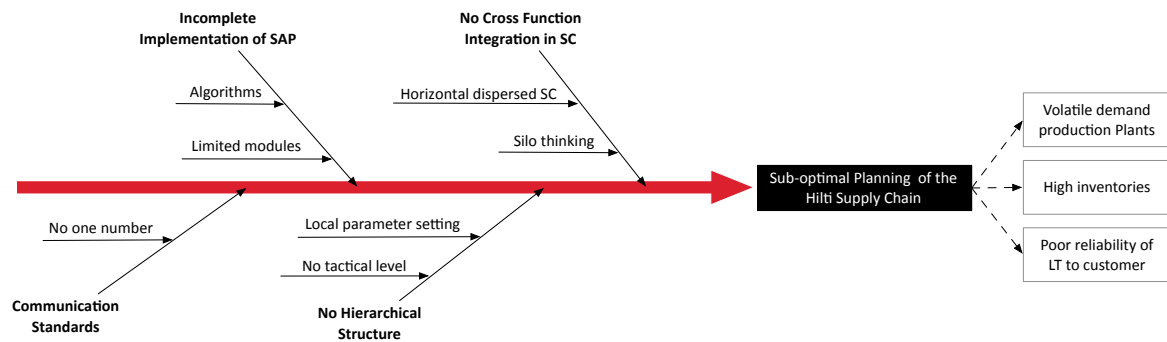


Figure 3.2 – Cause and effect diagram for planning at Hilti

Secondly, the lack of cross-functional integration in the supply chain is causing more complexity for planning at Hilti. The worldwide footprint of Hilti's supply chain network with their different entities caused planning to be partitioned. Eventually, silo thinking grew in the organisation and is now a contribution to the lack of cross-functional alignment. Integrating planning responsibilities into central responsibilities for specific cases, removing the dispersed nature of distribution decision functions and putting all the sales decision functions close to the market will create a clear understanding of responsibilities throughout the supply chain. It will also offer a positive effect on collaborative planning without having to decide on ownership.

The missing hierarchical structure at Hilti is recognised as a possible cause of planning problems as the size and reach of the company are too extensive to plan at only a detailed level. As Stevens (1989) argues, companies that have a well-integrated internal supply chain focus on medium-term planning and on tactical issues, rather than strategic issues. As there is no tactical level in the current situation, Hilti barely aggregates on production volumes, sales volumes, inventory changes and subcontracting budgets. Filling the gap, by introducing the tactical level, means using more aggregated, non-allocated, volumes and is expected to lead to lower inventories and lower costs.

Last but not least, communication standards are highly important in planning. Quality of relationships and communication lines will improve as soon as clear hierarchy, timing and dependencies are defined as in the idealised design.

Means and Resource Planning: Filling the Gaps at Hilti

As the second part of *ends planning*, the previous chapter identified the gaps present at Hilti's planning and control landscape compared to the one defined by the idealised design. It also showed the consequences of these gaps linking them to a cause and effect analysis of the suboptimal supply chain performance observed at Hilti. As the idealised design is believed to mitigate or eliminate these causes, the next step of the design approach of Ackoff (1981) defines the way the identified gaps are filled (*means planning*). Ackoff (1981) also uses *resource planning* to determine the required resources for these means. Fitting the idealised design to the Hilti supply chain is, after identifying the gaps, the second step of the business case, proving the applicability of the design. In this chapter, first means planning is performed considering the context, constraints and the current state of Hilti's supply chain. Hence, specifications to the decision functions were added and even small alterations to the idealised design have been made to specify the best way to fill the gaps for Hilti – discussed in section 4.1. Hereafter *resource planning* is elaborated with defined responsible roles for the means discussed in subsection 4.1.4. Concluding, the implications for LEC and HAG will be explained.

4.1 Adapting and Filling In the Idealised Design

The figure below (Figure 4.1) represents the adapted idealised design for Hilti, hereafter called the Hilti IP concept. First, the Hilti IP concept will be elaborated based on both the tactical and operational levels as well as the cross-level linkage. Several adaptations were made to the idealised design based on field data. This data was collected through extensive workshop rounds with important stakeholders of the planning processes at Hilti.

4.1.1 Tactical Level

Fitting the idealised design to the Hilti supply chain forced several adaptations concerning the tactical level. Table 4.1 shows how the Hilti IP concept is related to the idealised design. The changes will be described and supplemented with the recognised necessary inputs and outputs, considering the context, constraints and current state of Hilti.

Tactical parameter setting will remain part of the Hilti IP concept as it was presented in the idealised design. The parameters will be set centrally and will steer the tactical decisions in Hilti's supply chain. The supply chain based sales and operations plan still consists of two main preparation steps. However, as can be seen in Table 4.1, one adjustment is made to the first preparation phase.

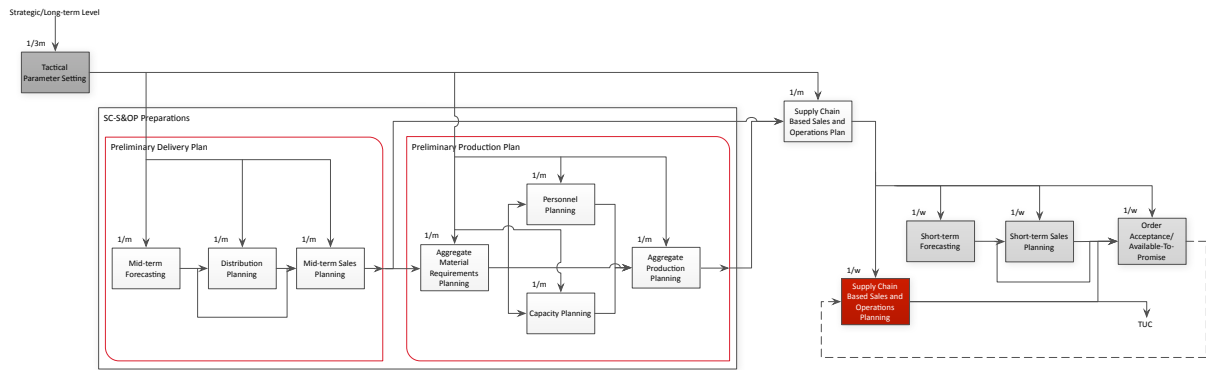


Figure 4.1 – Hilti IP concept

Table 4.1 – Adaptations to the tactical level of the OPC concept

<i>OPC concept</i>	<i>Hilti IP concept</i>	
Decision Function	Change	Nature of change
Tactical parameter setting	No	-
Preliminary Delivery Plan	No	-
- Mid-term Forecasting	No	-
- Distribution Planning	Yes	Now providing input for mid-term sales planning
- Mid-term Sales Planning	Yes	Now considering distribution planning
Preliminary Production Plan	No	-
- Aggregate Material Requirements Planning	No	-
- Personnel Planning	No	-
- Capacity Planning	No	-
- Aggregate Production Planning	No	-
SC-S&OP Plan	Yes	Different inputs

The idealised design suggested completing *mid-term forecasting* and then simultaneously performing both *distribution planning* and *mid-term sales planning*. Together with input from the forecast a decision, the preliminary delivery plan, was made. As Hilti’s input on this was that *sales planning* can already take *distribution planning* into account instead of a separate sales planning based only on the forecast, this extra step was removed from the Hilti IP concept. The reasoning for this alteration involved an easier implementation as sales/marketing is currently feeding their plans directly into the system in cooperation with MM. The integrated SAP system should be able to provide insight in *distribution planning* that can be used while coming to the sales plan. Implicitly adaptations to the idealised design make the Hilti IP concept weaker than the idealised design. These adaptations, lead to sales planning being constraint by the distribution plan while in the idealised design the sales plan is only controlled by tactical parameters. The idealised design deals with balancing the distribution plan and sales plan to come to the preliminary delivery plan. Of course, the *distribution planning* preparations can then be overruled. Therefore, the adaptation to make the distribution an input to the sales plan will probably lead to lesser opportunities for the company concerning the tactical *sales planning* preparations.

Features of Decision Functions – Finally, some insights in the decision functions (e.g. needed inputs and outputs) have been recognised for Hilti. These requirements help to guide the projects that will define the process of making these decisions for the future state. Tactical parameters will use the recommended quarterly frequency. Values of parameters will be set in compliance with the strategic plan and will also be based on continuous reactions from operational decision functions. In its turn the *tactical parameters setting* will influence the

decision functions during the preparations of the SC-S&OP plan. Next to the advised parameters determined by the ideal design - SS levels, lead times and lot-sizes - Hilti also mentioned maximum utilisation of the warehouses, priority rules, profit contribution and service level agreements (SLA) as possible parameters. These values will be set by integrally considering all relevant supply chain information. Hilti recognised as input: product characteristics, demand and supply characteristics, capacities, inventories and costs.

Mid-term forecasting at Hilti will entail statistical forecasting based on historical sales data, including seasonality patterns, and human interaction, incorporating market intelligence. The forecast will be structured according to a pre-defined calendar, which aligns the market organisations timing of mid-term distribution and sales planning to limit unnecessary re-planning. The *mid-term forecasting* is particularly focused on critical items in the supply chain and items that represent a high share of value. The aggregation level is different for tools (region-item) and consumables (region-family). The right level of disaggregation will be location-item specific but stays dependent on the supply chain setup involving MO-plant routing and product characteristics. The recommended horizon for the mid-term forecast is approximately 18 months, which is in coherence with the already existing rolling forecast (RF2) made every June by the financial department.

The mid-term forecast is input for *distribution planning*. This decision function aligns the distribution plan with the forecast and determines the required warehouse and transportation capacities. *Distribution planning* considers the transportation and storage requirements, distribution rules and other distribution related characteristics. The recommended horizon and frequency of this decision function is equal to the *mid-term forecasting* function.

The distribution plan and mid-term forecast are both input for *mid-term sales planning*. In the IP concept for Hilti the *sales planning* creates an aggregated sales plan that is balanced with the mid-term forecast and distribution plan and is expressed in both a monetary value and volume. Both types of quantities are expressed to enable communication between the sales function and the other functions in the supply chain. The aggregation level again is dependent on supply chain characteristics that can be item- and location-specific. The horizon and frequency will be aligned with the previous decision functions.

Based on the preparations performed at the distribution and sales stages, a preliminary delivery plan will be established weighing all the preparations for the optimal combination. This plan is input for *aggregate material requirements planning*. The preliminary delivery plan is transformed into net requirements and purchase volumes together with information about current stock levels, lead times and scheduled receipts. In this decision the timing is considered according to a pre-defined calendar. The aggregation levels need to be chosen in accordance to the product specific supply chain characteristics. A monthly frequency and the same 18-month horizon are determined for the implementation design.

The aggregate net requirements that result from *aggregate materials requirements planning* are subsequently used in the *capacity planning* decision and *personnel planning*. Besides the net requirements, raw materials and components also available serve as input for this decision. The output of the *capacity planning* decision is a set of constraints that have to be respected to come to a feasible production plan. The level of aggregation, frequency and horizon of this decision are equal to the *aggregate material requirements planning* function. In *personnel planning* the aggregate net requirements are input to determine for example, the quantity of full-time equivalents (FTE) and the shift model for the production needed to meet these requirements. It is controlled by the tactical parameters and constrained by regulations and guidelines on the availability of the workforce. Again, the level of aggregation, frequency and horizon of this decision are equal to the *aggregate material requirements planning* function.

The next tactical decision function is *aggregate production planning*. The net requirements,

capacity restrictions and personnel restrictions are input for this decision. Hence, available raw materials and components are considered, together with outputs like the shift model. The output of the *aggregate production planning* consists of the aggregated production quantities. In the Hilti IP concept the product specific supply chain characteristics determine the level of aggregation. Also, for this decision function, the level of aggregation, frequency and horizon is determined to be equal to the *aggregate material requirements planning* function.

Based on the preparations at the procurement and production stages, a preliminary production plan will be established weighing all the preparations for the optimal combination. The preliminary delivery plan and preliminary production plan serve as final advisory plans for *SC-S&OP*. One or more SC-S&OP meetings are organised quarterly with the purpose to come to a '*one number*', representing the latest estimate at the tactical level. As the preliminary production plan receives input from the preliminary delivery plan, the balancing of these plans is guaranteed. The SC-S&OP meetings are determined to be divided in a '*one plant all MO*' groups. This means every plant will have a SC-S&OP meeting where all markets/regions will be aggregated as demand. The aggregation level and type of the *SC-S&OP* decision will be a translation of the preliminary delivery plan, and preliminary production plan levels and types in order to be able to make sensible decisions.

4.1.2 Operational Level

Fitting the idealised design to the current state, context and constraints of the Hilti supply chain resulted in the identical use of the idealised design at operational level. Table 4.2 shows how the Hilti IP concept is related to the idealised design. Here it can clearly be seen that no adaptations have been made. As the scope limits the changes for Hilti to the SCOP level and the operational decision functions under sales, only the content of these decisions will be discussed together with the field data of Hilti.

Table 4.2 – Adaptations to the operational level of the OPC concept

<i>OPC concept</i>	<i>Hilti IP concept</i>	
Decision Function	Change	Nature of change
Supply Chain Operations Planning	No	-
Short-term Forecasting	No	-
Short-term Sales Planning	No	-
Order Acceptance	No	-

Features of Decision Functions – As the *SCOP* decision is currently not present at Hilti, the concept of this decision follows the specification of the theoretical framework. The determined input for the *SCOP* decision is the '*one number*', set by the SC-S&OP meeting described in the previous section at tactical level. As output, there will be a weekly plan for procurement, production and distribution in which the TUs are free to optimise within the boundaries of the set lead times. This output shows the timing and quantities in the form of a plan at item-level for all locations. The horizon of the *SCOP* function will ideally be the longest critical lead time. Since the range of the product portfolio is fairly large, this horizon will be split according to the longest critical lead time within a BU and therefore can differ per BU. This way, chemical anchors for example, do not suffer under the availability of steel, and electric tools have no liability on the availability of chemicals. This implicitly means that the horizon can differ for all BUs. However, as long as no communalities exist between the BUs, from a planning perspective, this will not form any complications. When two or more BUs share a raw material, the longest critical lead time of all the BUs will become leading again.

Short-term forecasts will be adapted following a predefined calendar in order to align all markets in their way of working (WOW). The determined output is a forecast (on item-level) that will benefit the historical data for the future and should therefore not be adapted in the way it is currently done (*sales planning* and *forecasting* combined). *Short-term sales planning* will be concerned with foreseeing important changes (on item-level) as last-minute events or important new market possibilities (e.g. new large clients). *Forecasting* and *sales planning* will provide information to the *order acceptance* decision which will have a feedback loop for exception management to the *SCOP* decision. This order acceptance will remain as defined in the idealised design and will be the only possibility to feedback to *SCOP* for making a trade-off within the possibilities to change the SCOP plan, differing from the original received 'one number'.

4.1.3 Cross-level Alignment

With the decision function and its features being clear, the actual alignment can be discussed. Several fields of interest – frequency, aggregation level and targets – were identified that need attention when aligning the two levels. The idealised design leaves these fields open so they can be fitted to the content of the company. Using field data, an attempt is made to give further meaning to these fields for the Hilti IP concept.

Frequency - Both levels have a different frequency – monthly for the tactical level and weekly for the operational level. In order to cope with this, a calendar has to be developed in such a way alignment becomes a natural flow of actions or WOW. The calendar will take the needs of both levels into account and will give all contributors of the planning process clear guidelines on how to partake in the preparations, meetings and planning decisions.

Figure 4.2 shows an example of how a calendar could look like. It is important to note that several decision functions have to be performed in successive order, whereas others can be in parallel.

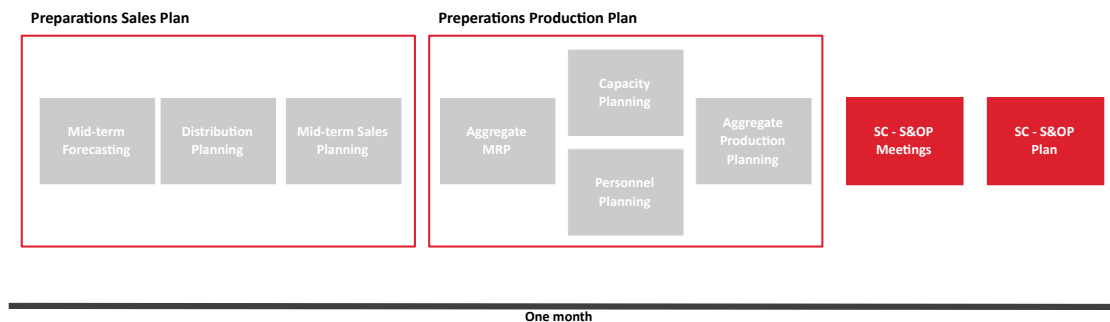


Figure 4.2 – Planning calendar example

Aggregation Level – An important aspect of planning at the different levels is the level of aggregation. At the tactical level the aggregation level is a lot higher than at the operational level. This is because the calculations and decisions at the tactical level are more rough-cut and high levels of detail would unnecessarily add to the complexity of these calculations. At an operational level, the rough-cut figures are no longer useful since detailed (item-level) production plans and schedules are needed in order to plan procurement, production and distribution (item-location). Also, sometimes at the tactical level it will be easier to talk in monetary values, whereas at the operational level always item or item-location numbers are required.

Therefore, to be able to align the levels, the correct levels of aggregation have to be decided first for the different constructs (e.g. demand forecasting unit, SKU, family types and resources).

Formulating families will need special attention since the existing product groups are handled differently in the markets/region, HAG (BU) and Plants. In order to be able to aggregate families, clear decisions have to be taken so that disaggregation makes sense for the production locations.

The development of an aggregation/disaggregation logic in form of algorithms is also a high priority. To be able to translate the different levels of aggregation into the required format, algorithms are key in aligning the tactical and operational decision functions.

Targets – As mentioned before, the potential of integrated planning can only be realised by recognising the connections and inter-relationships between different parts of the supply chain and ensuring a good fit between its design and operations and the company's competitive strategy. The design and operations have already been given attention, however, part of the strategy is also of great importance. Targets, which are translated into key performance indicators (KPI) at Hilti, are key examples of the company's internal strategy. The current KPIs will have to be reassessed in order to make alignment possible between the two levels – at the moment they are strongly focusing on local improvement only.

Also important to note, is that since the responsibilities of the supply chain team will lie in procurement, production and distribution, their KPIs will have to be equally diverse insuring a full supply chain focus. Moreover, these (new) KPIs will have to be shared with other departments, which often will be local departments, such as plants or MO/regions, in order to make connections and inter-relationships between different parts of the supply chain possible. Therefore, they can be a driving force in the reassessment of the local KPIs as suggested before.

Engagement Rules – On top of these three fields of interest, engagement rules have to be developed to guide all the new processes. Engagement rules are general rules of the game. These rules have to be developed and have to guide at least the following topics:

- Service level requirement and agreement;
- Prioritisation (e.g. priorities based on profitability);
- Exception management;
- Stock positioning.

4.1.4 Responsibilities

The idealised design was depicted in an OPC concept indicating hierarchy, time and dependencies. When fitting this OPC concept to the Hilti supply chain, in other words, when developing the Hilti IP concept, real field data became available. This field data presented the opportunity to translate the Hilti IP concept in an absolute manner by adding swimming lanes. Using swimming lanes the responsible departments and accountabilities for the decision functions can be made clear without losing the sequence, frequency and dependency characteristics of the OPC concept. Furthermore, responsibilities have a high significance for the implementation of the concept in real life. Figure 4.3 represents the alternative way of documenting an OPC concept, adding these swimming lanes to the Hilti IP concept.

In order to come to the roles that are responsible for the decision functions, input from Hilti was gathered through the RAPID (Recommend-Agree-Perform-Input-Decide) tool (developed by Bain Analysis (2011)) which was used as a Hilti company standard. This tool, represented in Appendix A, helps to develop clear decision making guidelines (Rogers and Blenko, 2006) and shows the complete perspective of accountabilities. This input determines the following final roles for departments responsible for the following decision functions:

Market/region Sales and Marketing – These are the current sales and marketing departments within Hilti which are decentralised to the markets in MOs or regions. They will be

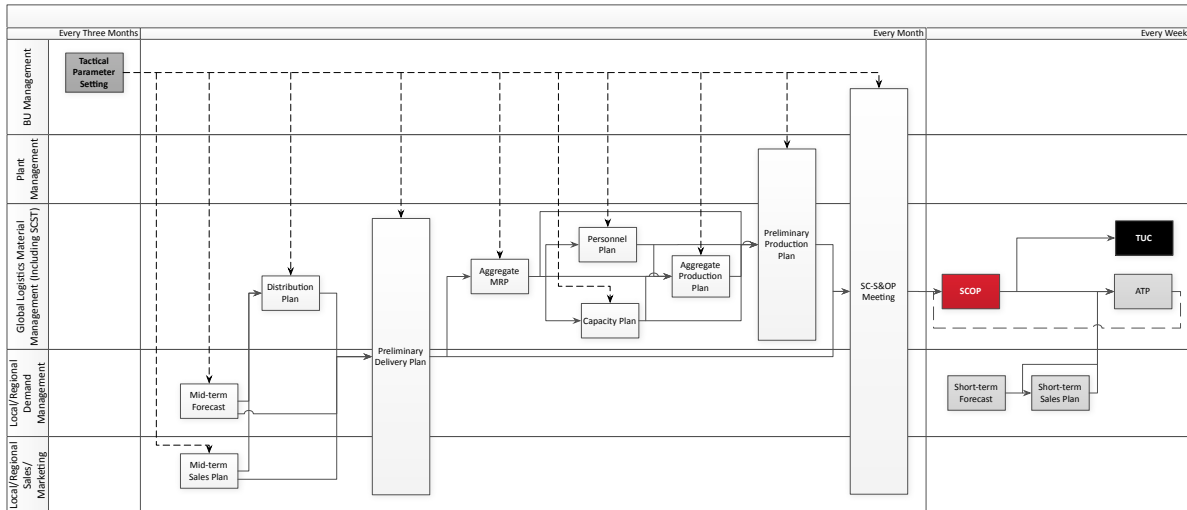


Figure 4.3 – Hilti IP concept in swimming lanes

responsible for *sales planning* at the tactical, as well as at the operational level as described in the previous sections. Close-to-market information is necessary and putting this responsibility at this team will provide better cross-functional integration at Hilti. They will be responsible for the final number in the preparations of distribution and sales for the SC-S&OP meetings in their market/region. As Oliva and Watson (2011) argue, even if goals or incentives are not aligned, better integration takes place when the process is well developed with clear responsibilities.

Market/region Demand Management – The current MM in the markets/regions combines *forecasting* and *sales planning*, as mentioned before. They are also concerned with the *warehouse replenishment* of the warehouses they control. As this *warehouse replenishment* will become a part of the SCOP decision, this will slim down the responsibilities that are done by the teams in the markers/regions. *Forecasting* will be performed close-to-the market and separated from *sales planning*. MM will get the responsibility and transform to a Demand Management (DM) department.

Global Logistics Material Management – Under GL MM, a central team that is responsible for the entire supply chain will be formed - excluding the sales functions at tactical level (*distribution planning*, *aggregate material requirements planning*, *capacity planning*, *personnel planning* and *aggregate production planning*) and operational level (*SCOP* and *order acceptance*). The central team will be responsible for the complete distribution network rather than for the dispersed decision functions belonging to distribution as-is now. This central team will be the **Supply Chain Specialists Team (SCST)** and should be a 10 to 12-person team that is highly competent and educated in supply chain management. It will reconcile market/region needs with production capacities and has an independent role in this balancing. Main tasks of the team within the SCOP function will be:

- Weekly revert market/region needs into a feasible production plan at item-level;
- Manage exceptions from both plant as market/region needs;
- Manage the order release activities.

The SCST will be the main contact point for the plants as well as for the markets/regions.

Business Unit Management – This role currently exists at Hilti and is responsible for GM, which in turn is responsible for the plants, GL, as well as the sales functions. Therefore, it is the team that should be responsible for the *tactical parameter setting* of the entire supply chain

(receiving input from the separate stakeholders) and SC-S&OP (also receiving input from the separate stakeholders).

Plant Management – This role will provide input (e.g. constraints) for the *SC-S&OP*, *tactical parameter setting* and will have responsibility for the TUC decision functions. As they are represented by the BU Management in the SC-S&OP meetings, they will not bear responsibility for this.

Concluding, as has been indicated before, the biggest change in the Hilti IP concept is that a lot of responsibilities in decision making will shift from the silos to a supply chain based team. This team of supply chain specialists is currently not yet in place but once created it will be given a lot of the responsibilities.

4.2 Implications for Hilti Logistics Europe Central region and Hilti Headquarters

After adapting the idealised design to the Hilti IP concept, implications for LEC and HAG are elaborated in this section. In order to provide a clear overview, the decision functions that are believed to influence the responsibilities of LEC and HAG are considered with their implications in Table 4.3. LEC is currently responsible for the distribution and sales function whereas HAG is mainly responsible for distribution functions. The other functions of HAG are more concerned with GM and elaborated in Kreuwels (2014). From the tactical level, *distribution planning*, *mid-term forecasting* and *mid-term sales planning* are recognised as essential, complemented with *tactical parameter setting* and *SC-S&OP*. At the operational level, *SCOP*, *short-term forecasting* and *short-term sales planning* are among these responsibilities. *Order acceptance* is added as it shows some implications as well.

Summarising, tactical parameters will be set with the input from LEC, however, as a responsibility of the BU management team. LEC will lose the responsibility for replenishment of the RDCs/CW and HAG will lose responsibility for the replenishment of the LRCs. Through this, they lose the tactical parameters which each of them currently set at an operational level. It results in a clearly set responsibility of the SCST for tactical decisions except *mid-term forecasting* and *mid-term sales planning* which both will be the responsibility of LEC. The mentioned loss of warehouse replenishment is caused by the *SCOP* decision that will be created for the SCST, meaning that the LEC MM will transform to DM and HAG MM will hand over the remaining responsibilities to the SCST. The BU management team will be responsible for balancing the supply chain needs at tactical level which will influence the decisions that are made at operational level in LEC.

Table 4.3 – Implications of the Hilti IP concept for LEC and HAG

Decision Function	Implication	Nature of implication
Tactical parameter setting	Yes	<ul style="list-style-type: none"> · LEC no longer set local tactical parameters (e.g. SS/inventory positioning) · HAG will no longer set local tactical parameters influencing other parties (e.g. EOQ, inventory positioning)
Mid-term Forecasting	Yes	<ul style="list-style-type: none"> · Will be added in LEC and will follow a calendar developed with a monthly frequency · Shifted responsibility to DM meaning a decrease in responsibilities of MM and being converted into DM for both LEC and HAG
Distribution Planning	Yes	<ul style="list-style-type: none"> · Deletion of operational WM and TM decisions from LEC and distribution decisions from LEC – now made tactically by the SCT · Creation of distribution planning affecting storage requirements of RDCs/CW of LEC and LRCs of HAG · Distribution rules will be set for both parties implicating the change of dependency between LEC and HAG · Will receive the prepared distribution plan from the central SCST according to the calendar
Mid-term Sales Planning	Yes	<ul style="list-style-type: none"> · In LEC, it will be based on the preparations of the mid-term forecast and the distribution plan received from the central team according to the calendar. · Will set the latest estimate for LEC markets combining the distribution plan from the central SCST, the forecast and inputs from sales and marketing.
SC-S&OP Plan	Yes	<ul style="list-style-type: none"> · A latest estimate has been provided from LEC markets which is balanced by BU management monthly · Adaptations in the LEC markets according to this number will have to be made for operational decisions
Supply Chain Operations Planning	Yes	<ul style="list-style-type: none"> · Warehouse replenishment is taken out of the control of MM at LEC and HAG · Short-term forecasting in LEC and short-term sales planning in the markets of LEC can only influence the SCOP decision by providing input to the order acceptance decision
Short-term Forecasting	Yes	<ul style="list-style-type: none"> · LEC will forecast without adapting the forecast based on the current sales plans · The forecast will not be steering the production one-on-one anymore · HAG will not forecast anymore, this will be performed decentralised for all forecasts
Short-term Planning	Sales Yes	<ul style="list-style-type: none"> · Based on the short-term forecast received by DM · Separated from the short-term forecast · Responsibility shifted to sales and marketing of the LEC markets
Order Acceptance	Yes	<ul style="list-style-type: none"> · The decision on order acceptance it moved to the SCST and will take into account the complete supply chain · LEC and its markets can only provide input via short-term forecasting and short-term sales planning

Design of Implementation

The last phase of Ackoff (1981)'s design approach concerns the design of implementation. It is concerned with the questions of *'who is to do what, where, when and how'* in order to make the implementation a success. In light of the business case this design of implementation provides the company with a tangible implementation plan that could be executed for real. Hence, it can be seen as a final step coming from the high conceptual ideal design to a more concrete set of actions to be performed in order to reach the ideal and realistic situation in real life. As indicated in Kreuwels (2013), in order to succeed, *'softcore'* or human aspects are as equally important to align as the *'hardcore'* decision functions and frameworks. Therefore, section 5.1 will first deal with the environment that has to be considered when filling the gaps by means of a force field and stakeholder analysis and by defining the leadership style. In section 5.2 the actual action plan and roadmap are presented.

5.1 Environment

5.1.1 Force Field Analysis

A number of forces will be driving or restraining the projects' development. Whether these are caused by factors or are influencers themselves, in both cases it means that these are often hard to control. By identifying them in a force field analysis the restraining forces in particular, can be handled before they can influence the project on a large scale. The forces are represented in the Figure 5.1 and will be discussed below.

Driving Forces – Efficiency is the first driving force. By implementing the Hilti IP concept and by following the design the efficiency of especially material managers can improve a lot. If the workforce and management recognise this potential efficiency can be a great driver as Hilti knows a strong lean culture that constantly searches for better efficiency. Closely related to efficiency is quality. It refers to the quality of the information, which will become far more accurate, transparent and comprehensible, and also to performance indicators such as product availability (PA). The fact that both information and availability are often frustrating the KPIs, can be a big driver as well. Inventory levels are expected to decline since the integrated planning concept ensures less nervousness and higher accuracy within the entire supply chain. This will eventually lead to higher customer satisfaction. And since the company vision is aimed at the customer, this force can influence the workforce at all layers of the organisation. It also has the potential to reach commitment from the workforce since it makes the goal of the project more tangible for the workforce. Ultimately the already high commitment of the highest management of both GL and GM and the support of the IT department can be seen as a great driving force for the future implementation plan.

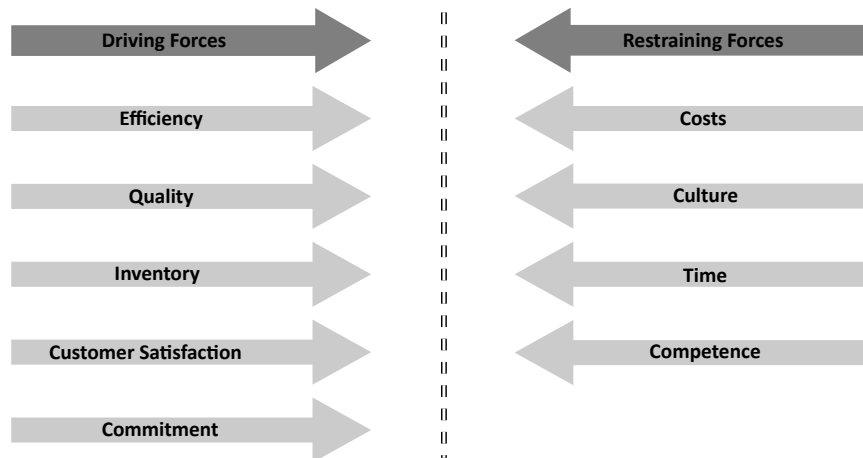


Figure 5.1 – Force field analysis

Restraining Forces – Costs are almost always a restraining force in implementing a change. Although the project knows high commitment there are many initiatives at Hilti that require funding - financial gain is often an important decision tool. For the Hilti IP concept it is hard to determine an accurate number of financial gain since the implementation plan indirectly influences a lot of factors. In case that the financial gain cannot be made clear the costs of the project might become a serious threat. The company culture can be threatening too since the project does not fit the lean management way of thinking very well. Also, the culture exists of a lot of nationalities and local cultures which are not all in line with the headquarters company culture. Furthermore, the long time span of the project can really restrain the workforce from committing to the project. This force is mitigated partly by the sub-projects in the implementation plan. Real results, however, will be hard to show in the first years since the SCST has to be build up gradually. This brings us to the last restraining force, competence. At this moment Hilti does not have the right competence in-house to form the SCST without risking to loose vital knowledge in other areas. Hence, new and highly ambitious employees have to be hired which could be difficult to find in the current market. Highly educated supply chain specialists are scarce and therefore, it might be hard to build a team of such specialists within a short span of time.

5.1.2 Stakeholder Analysis

A stakeholder is a person, group, department or organisation with an interest or concern in an organisation. A stakeholder can affect or can be affected by the organisation's actions, objectives and policies. In order to make a good stakeholder analysis, the main stakeholders of the implementation effort were identified first. Afterwards, other stakeholders are described. An overview of the stakeholders including their expected attitude towards the implementation is shown in Table 5.1.

The Head of GL (here, GL senior management) is the formal decision maker that can authorise the change. This stakeholder is the initiator of the HIPP project and sees a lot of added value for Hilti with the use of SCI by changing the landscape of SCP. This positive attitude is driven by the efficiency increase, transparency and removal of the silos in decision making that are foreseen by the senior management as a result of the project. With the clearly defined tactical level and SC-S&OP, more decisions will become the responsibility of middle management, affecting the responsibilities of senior management as well as Hilti knows multiple entities in their organisation.

Table 5.1 – Stakeholder analysis for the design of implementation

Stakeholder	Predisposition to Change:	Commitment	Aware	Interested	Want change	Desire action
GL senior	Innovator	Committed	X	X	X	X
MM senior	Early adaptor	Committed	X	X	X	X
WM senior	Early adaptor	Supportive	X	X		
TM senior	Early adaptor	Supportive	X	X		
GM senior	Early adaptor	Committed	X	X	X	X
Sales/Marketing senior	Early majority	Supportive	X	X	X	
MM middle	Early adaptor	Committed/ Supportive	X	X	X	X
WM middle	Early adaptor	Supportive	X			
TM middle	Early adaptor	Supportive	X			
MM operations	Early majority	Committed/ Supportive	X	X	X	
WM operations	Early majority	Supportive	X			
TM operations	Early majority	Supportive	X			
TU operations	Early majority	Supportive	X			

Together with the senior management of GL, the divisions WM, TM and MM (under the responsibility of GL) will be influenced to a great extent. Therefore, the senior management of WM, TM and MM is also a stakeholder. Senior management of MM is involved from the beginning of the project and has shown great support to the project as well. Their driving factor was more trust and transparency in the supply chain, leading to a more reliable product flow. Senior management of WM and TM have not been included so far, and might have a slightly resistant attitude towards the change. The combination of these senior managements implies the involvement of both the senior management of the logistic regions and HAG (and might in some cases even involve one person). In addition, senior management of the sales/marketing regions represents a stakeholder regarding implementation of the decision power on the sales plans. These are expected to show a positive attitude towards the project as they will gain decision power on the latest estimate of the sales plan and will also get a (expected) more reliable lead time to the customer. Finally, senior management of GM should be involved as a lot of responsibilities are removed from their department. Their attitude leans towards the positive despite this loss of responsibility, because of a gain in more stable production plants. Also, their concerns are mitigated by the remaining TUC responsibility.

As mentioned before, existing decisions and responsibilities will be shifted towards middle management in the new hierarchical structure. In the HIPP project, these stakeholders have been involved from the start and have all shown a great attitude towards the change as it is believed to set clearer communications lines and responsibilities. For the GM side, more trust is needed in the numbers coming from the markets, whereas for the markets, more reliability throughout the chain for the lead time to the customer is important.

In addition, the operational force of GL MM, the logistic regions MM, HAG MM, plant MM as well as all the WM and TM departments are stakeholders. With the implementation of the SCOP function a central team will be composed, taking over responsibilities from the local MM teams. These stakeholders might develop a negative attitude towards this change, as there is a possibility that a lot of their jobs might get redundant. More so, as the central team will require employees with a possibly higher education and SCP experience. For the employees that will remain, a shift of responsibilities and the formation of tactical decisions might require adaptations to the WOW. This is known to be a human factor that can bring negative attitude as this often gets more attention than potential benefits of the new WOW. For successful

implementation of the developed concept the shift in decision making and responsibilities should be accepted, and full cooperation is required. Finally, the operational force in the warehouses, in transportation and on the plants' shop floors will have to adapt to getting input from another party, the central team. This cannot cause a negative attitude towards the change as long as the change is communicated in a proper way.

5.1.3 Leadership Style and Change Leaders

Since full implementation of the Hilti IP concept can take between eight up to ten years, leadership is going to be of importance. Preferably, leaders will take part in the change management for the longest period possible and limited changes occur at high positions - among change leaders a core group of forerunners is preferred.

For these forerunners in particular, the leadership style will be important. Using the model of Vroom-Yetton-Jago (Vroom and Jago, 1988) a style was determined fitting the implementation plan best. The underlying assumption of the Vroom-Yetton-Jago Decision Models is that no single leadership style or decision-making process fits all situations. Analysing the situation and evaluating the problem based on time, team buy-in, and decision quality, can help to conclude which style fits the situation best. The model defines a logical approach for selecting a preferred leadership style and is useful for managers and leaders who are trying to balance the benefits of participative management with the need to make decisions effectively. Since it is concerning a complete chain and thus different structures, visions and cultures, the decision model is based on a dynamic environment. The model uses seven structured questions (Appendix B) that all direct to a selection of a certain leadership style. The 'team' consists of all Hilti material managers and the 'leader' of the Hilti managers who are present in the steering board. Figure 5.2 shows the model for the design of implementation at Hilti.

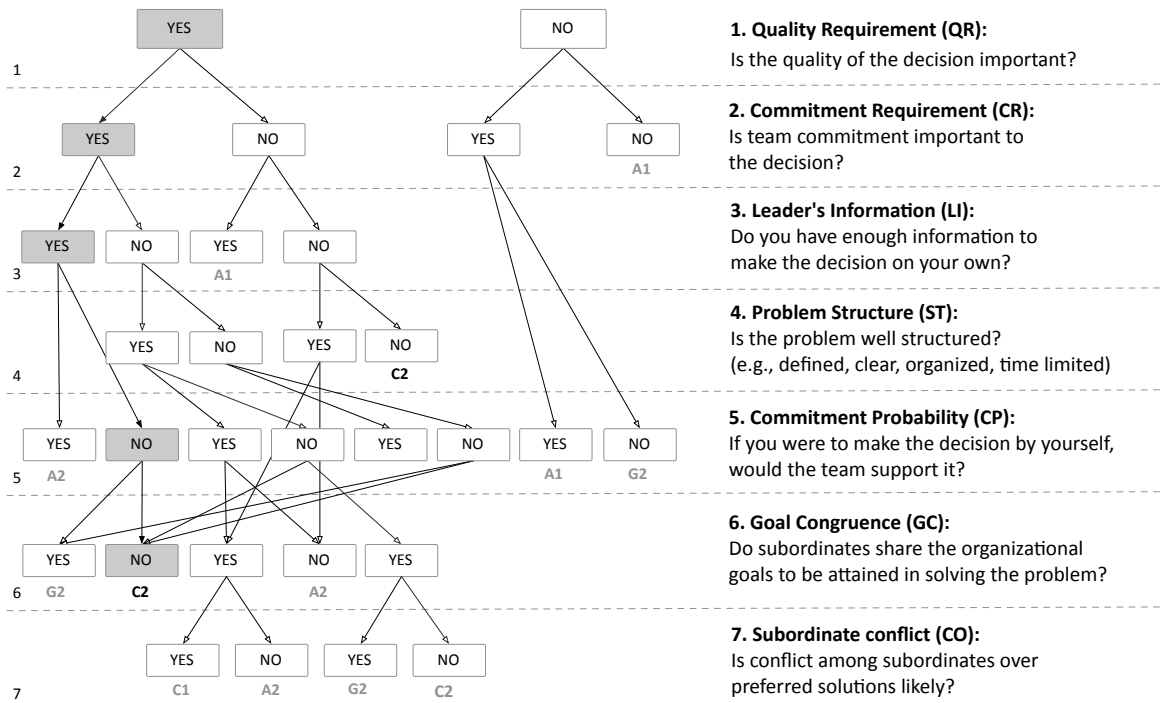


Figure 5.2 – Vroom-Yetton-Jago leadership styles according to Vroom and Jago (1988)

As the model above shows, the consultative type of leadership will fit the change best. According to the model the C2 type of leadership means: 'Leader shares problem to relevant followers as a group and seeks their ideas and suggestions and makes decision alone. Here followers meet

each other, and through discussions they understand other alternatives. But the leader’s decision may or may not reflect his followers’ influence. So, here followers involvement is at the level of helping as a group in decision-making.’ This means decisions are made by the steering board, but not without consulting the affected MM operational levels. Part of this consultation already took place as part of the project described in this thesis (analysis of the current situation) but during the change many more decisions should be taken where the Vroom-Yetton-Jago model advises further consultation.

Change Leaders – Main change leaders or change agents can be subtracted from the stakeholder analysis. As mentioned before, they should remain in their role for as long as possible to ensure continuity and transparency during the implementation plan. They represent the faces of the implementation plan and should be able to anticipate on basically every question involving the project. As internal ambassadors they will ensure the project holds high focus and commitment during the implementation. In the responsibility chart (Table 5.4 the specific tasks of the change agent are elaborated.

5.2 Action Planning

The proposed change style of the implementation is primarily incremental, rather than radical. The changes should not be implemented at once, but as sequential sub-changes leading to a gradual move from the current state to the desired state. This approach will most likely experience the least resistance and has the lowest risk of failure. Most of the changes imply adjustments or repositioning of existing functions and will not require a redesign from scratch. However, the SCOP function can only function if it is implemented as a whole, which makes incremental change difficult and will thus require a more radical approach. Different aspects of action planning will now be considered.

5.2.1 Project Plan Phase Planning

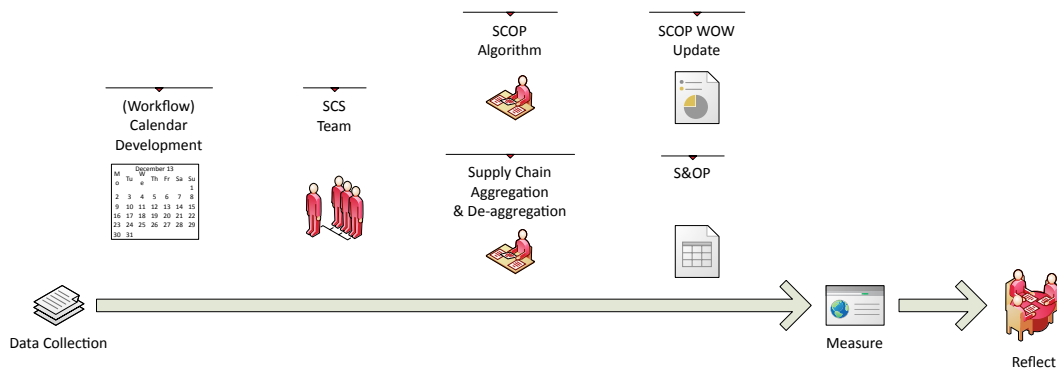


Figure 5.3 – Phased implementation of the Hilti IP concept

In order to develop the project plan, the implementation of the Hilti IP concept is structured into four phases represented in Figure 5.3. As can be seen in Table 5.2 all of these phases consist of separate projects each with a milestone that has to be achieved before the next phase can start. Some phases entail the execution of multiple projects simultaneously, as can be seen in the Gantt chart (Figure 5.4).

The phases described in the table above will all be reflected on before the start of the following project. This will be complemented with the measuring and evaluation of the implementation at the completion of all phases. Based on this a reflection will take place and adaptations or further projects will be created to ensure smooth working with the Hilti IP concept.

Table 5.2 – Phases of the implementation of the Hilti IP concept

Phase	Project	Content of the Project	Milestone
1	(Workflow) Calendar Development	<ul style="list-style-type: none"> · Alignment of workflow timing · Suggestion timing S&OP · Snapshots taken at certain times 	A calendar aligning the WOW throughout the entire Hilti SC for all operational and tactical decisions
2	SCS Team	<ul style="list-style-type: none"> · Defined tasks (releasing material and resources) · Tool kit development · Defining supply chain tasks (procurement /production/ distribution) 	A SCST responsible for all operational decision functions for procurement, production and distribution
3a	SCOP Algorithm	<ul style="list-style-type: none"> · Algorithm development · System update (algorithm) · Cooperate with SC Aggregation & Disaggregation project 	An algorithm taking the SCOP decision with all needed inputs, providing outputs for all controlled functions of the
3b	Supply Chain Aggregation & Disaggregation	<ul style="list-style-type: none"> · Analyse all parts of supply chain for levels of aggregation · Optimal 'one number' design with translations into different parts of supply chain · Cooperate with SCOP Algorithm project 	'One number' with its belonging translation in aggregation/disaggregation
4a	SCOP Update WOW	<ul style="list-style-type: none"> · System update (roles) · SCOP team tasks update · Replace toolkit by system transactions · Cooperate with S&OP project for receiving 'one number' 	WOW workflow with detailed description of processes
4b	S&OP	<ul style="list-style-type: none"> · Design S&OP process · Define roles · Implement S&OP process · Develop toolkit or system support · Cooperate with SCOP WOW Update project 	Workflow based on the calendar; responsibilities for tactical decision functions added to SCST and specified roles for the other stakeholders

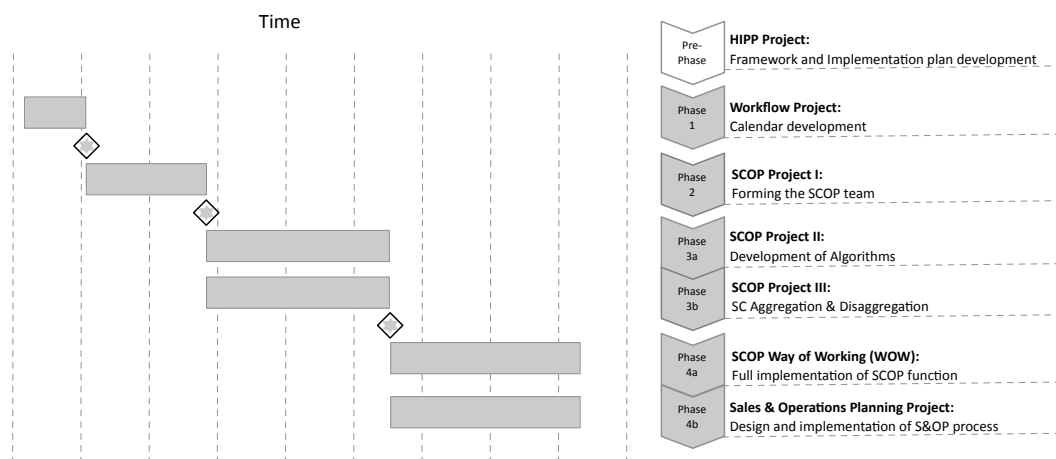


Figure 5.4 – Gantt chart of the phased implementation plan

5.2.2 Contingency Plan

All phases that are part of the action plan can be subject to failure. A contingency plan is developed to avoid total failure of the change implementation, in case one of the phases fails. The contingency plan is described in Table 5.3.

Table 5.3 – Contingency plan

Phase	Probability	Description
1	90%	There is a probability that stakeholders cannot agree on a calendar. The calendar will restrict several MMs in their freedom, which may cause dissatisfaction and/or delays. The communication plan can mitigate this to increase the chance of success.
2	80%	As mentioned in the force field it might be hard to find a SCS team that is sufficiently competent. Eventually this should not be a problem but delays are a realistic option since quality of the SCS team should go before quantity. A pilot with a smaller SCS team could mitigate.
3a	70%	Also the tool kit development might suffer from IT constraints. The IT department is committed but not everything will be possible in the system. Strong relationships en timely communication with the IT department could mitigate. Developing the algorithm will be a challenge. Recent SS algorithm development has taken several years to complete. The SCOP algorithms should incorporate more aspects and will be far more complex than the SS levels. Development together with knowledge institutions like a University of Technology might mitigate.
3b	95%	As pointed out in the previous projects, the IT implementation might frustrate the timing of the project. Again, strong relationships and timely communication could mitigate the possible delay.
4a	95%	Once both projects 3a and 3b are successfully completed the success rate of this project should be fairly high. A highly competent SCS team should be able to further define the WOW as long as the algorithms are working properly.
4b	90%	Since this is the last time frame the implementation plan the commitment and support might have decreased. Also change leader might not be in the same place as in the beginning of the project. It is important to keep commitment and support high even if the previous projects were a great success. Designing the S&OP process can be frustrated by many different opinions. There is a lot of literature about S&OP and it can be developed in numerous ways. Every stakeholder will form a vision towards the S&OP process for several years before the actual project starts. If the process is then different as expected this might frustrate the project. Having alignment sessions in the intermediate time, so during the preceding projects might mitigate.
		Since this is the last time frame the implementation plan the commitment and support might have decreased. Also change leader might not be in the same place as in the beginning of the project. It is important to keep commitment and support high even if the previous projects were a great success.

The chances of successfully implementing the projects are high as long as the commitment remains equally high and all phases are transparently communicated. The biggest threat is the IT implementation since this might be more complicated than currently assumed. Also, some IT changes might cost a lot in development.

5.2.3 Responsibility Chart

The action plan requires a clear division of responsibilities, which is shown in Table 5.4. In each department specific people have to be selected and assigned to the responsibility that is reflected in this chart. Besides these people, the earlier described change leaders will be involved during each step of the action plan. Every project will have a project leader who will have main responsibility for the progress, milestones and deliverables of the sub-project. Depending on the project this will most likely be a GL employee.

Table 5.4 – Responsibility chart

Change action	Responsibilities					
	GL	GM	HAG	Region MM	IT department	Senior management
(Workflow) Calendar Development	S/I	S	S	S	S/I	A/I
SCS Team	S/I	S	S	S	S	A/I
SCOP Algorithm Development	S/I	S	S	S	S/I	A/I
Algorithm - IT implementation	S/I	S	S	S	S/I	A/I
Supply Chain Aggregation & Disaggregation	A/I	S/I	S/I	S/I	R	A/I
SCOP Update	S/I	S	S	S	S/I	A/I
S&OP - IT implementation	S/I	S	S	S	S	A/I
	A/I	S/I	S/I	S/I	R	A/I

Coding:

R = Responsible (not necessary authority)

A = Approval (right to veto)

S = Support (put resources toward)

I = Inform (to be consulted before action)

5.2.4 Communication Plan

Good communication is *conditio sine qua non* to keep commitment and support from the environment. The head of Global Logistics currently gives an update of the latest developments via a video message. Incorporating the latest news regarding the implementation in this video message would be a good way to keep employees involved even if they are not directly influenced.

Besides this video message, a news update via mail or on message boards in the canteen and entrance hall could keep awareness up to a healthy level. It will prevent that actual changes will come as a surprise and gives employees the idea to be part of the change. Table 5.5 shows specific communication recommendations for all phases. The video messages and updates are not included in the table as they should iterate every month and give a relevant update if applicable.

Table 5.5 – Communication plan

Phase	Communication	Type	Sender	Receiver
HIPP	Hilti Business Opportunity Document	Document		
	Master Thesis (3x)	Document	HIPP team	
	HIPP Communication Package (AS-IS, GAP, etc.)	Document	HIPP team	
Phase 1	Calendar training	Presentation/ training	Project team	Logistics
	Documentation	Handbook	Project team	GPMS
	Calendar framework	Milestone	Project team	Logistics
Phase 2	Introduction of team	Meeting / news letter	SCST	Colleagues of SCST
	Official start of team	Reception	SCOP team	Logistics employees
	Way of working	Handbook	Project team	GPMS
Phase 3a	Algorithm requirements	Documentation	Project team	IT department
	Documentation	Handbook	Project team	GPMS
Phase 3b	Requirements GM	Questionnaire	All Plants	Project team
	Requirement Logistic Regions	Questionnaire	All Regions	Project team
	Documentation	Handbook	Project team	
Phase 4a	System training	Training	Project team/IT	All users
	'One number' alignment	Questionnaire	GM/regions	Project team
	'One number' alignment	Workshop	GM/regions	Project team
	Documentations	Handbook	Project team	GPMS
Phase 4b	S&OP training	Presentation/ training	Project team	All users
	Documentation	Handbook	Project team	GPMS

Conclusions and Recommendations

6.1 Answering the Research Questions

In this master thesis, a new planning and control concept for internal end-to-end supply chain was developed. As a case study, Hilti was used for integrating the SCP for their entire end-to-end supply chain.

In order to enhance the comprehension of the planning decisions necessary for effective functioning of the entire end-to-end supply chain of Hilti, the current situation had to be analysed during the first phase of the research. This exploratory phase was based on the first research question:

1. What does the internal end-to-end supply chain of Hilti look like, and how is it currently planned and controlled for?

As mentioned before, this question was answered by answering two sub-questions. These answers are provided below.

1a. What does the internal end-to-end supply chain of Hilti look like?

This sub-question led to the representation of Hilti's internal end-to-end supply chain presented in chapter 1. It showed the complexity, however, by scoping the internal supply chain to LEC, HAG, LW1, Plant 4 and Plant 6D the answer to the next sub-questions was formulated in a tangible manner.

1b. What is the current planning and control landscape of Hilti?

Some aspects of the current planning landscape came to light after having read the three performed literature reviews. Combining this knowledge, it clearly showed that the current planning landscape of Hilti is characterised by strong local/regional optimisation efforts and the style of decision making. A defined hierarchical planning structure and end-to-end responsibility over the entire supply chain are both lacking. Following from the literature reviews it was clear that the supply chain thus performs sub-optimal, subsequently giving insights for the second research question.

2. What integrated planning and control concept can be designed based on a critical evaluation of academic planning reference models and frameworks, reflected on the Hilti supply chain?

This question represents the *ends planning* step of the design approach of Ackoff (1981) coming to an idealised design. The knowledge of the literature review was used in order to answer this second research question. Additional and in-depth academic review was performed to answer

this sub-question, using a bottom up approach following the PCIO paradigm. Hierarchical planning frameworks were combined with references from literature on cross-functional integration to come to an integrated hierarchical planning framework. This framework is elaborated in an OPC concept adding the time-aspect, relations and frequency. The design consists of three hierarchical planning levels (strategic, tactical and operational). Stevens (1989) argues that the use of a tactical level with mid-term decision is a must for companies wanting to integrate the entire supply chain under their control (internal supply chain). Furthermore, comprehensive integrated planning and control is necessary for these companies (Stevens, 1989). This leads to the use of frameworks concerned with S&OP at the tactical level and SCOP at the operational level. The combination of these methods facilitates the well-integrated cross-level integration, so important in hierarchical planning frameworks concerned with vertical integration.

The OPC concept was developed based on leading academic literature from the research field of supply chain management. The framework is suited for the wide reach of the Hilti supply chain and can be generalised to suit implementations in other companies (*'chains of'* supply chains). To find the gaps between the current planning landscape and the idealised design, and the ways to fill these gaps the next research question was defined.

3. What is the applicability of the new integrated planning and control concept?

As mentioned before, this question was answered by answering three sub-questions. These answers are provided below.

3a. What are the gaps in the current planning landscape at Hilti in relation to the extracted integrated planning concept?

Still being a part of *ends planning*, for the answer of this research question the scope of the idealised design was limited to the tactical and operational levels, excluding the TUC, based on the fact that changing the strategic level and TUC would make the project's deliverable intangible for the short research period of five months.

First of all, the planning landscape of Hilti is characterised by the absence of a clearly defined tactical level leading to one of the most important gaps: several decisions are taken with a short-term horizon at the operational level that should be part of *tactical parameter setting* or tactical decisions. Most needed tactical parameters are set locally/regionally and tactical decisions are made without considering the entire supply chain. Next, the proposed *SCOP* decision function is not present and the operational decisions are made without steering from a tactical level (missing cross-level integration) and without considering the rest of the supply chain (hence, silo thinking).

These identified gaps were linked to their effects on the supply chain performance. They ideally have to be filled in order to solve the sub-optimal supply chain performance. Hence, the next sub-question was answered.

3b. How could the integrated planning and control concept be adopted by Hilti?

This sub-question was answered using the *means planning* and *resource planning* steps of the design approach of Ackoff (1981):

Means planning – In this step, for alterations to the idealised design in order to develop the so-called Hilti IP concept, the context, constraints and current state of the Hilti supply chain were taken into account. There has been one alteration, distribution planning was the input for sales planning in the Hilti IP concept. This leads to a decrease of the number of scenarios being developed in the preparations for the SC-S&OP. That, in turn, might lead to missed business opportunities as they might not be discovered. Furthermore, the contents of decision functions specific for Hilti were added in order to provide a better understanding of the decisions.

Resource planning - Responsibilities were added with the use of Hilti's input and engagement rules were described. All of this lead to a better fit of the Hilti IP concept to the current landscape.

Keeping this Hilti IP concept in mind, implementation of the concept was considered by defining the third sub-question for this third research question.

3c. What way can this concept be implemented at Hilti?

This research question was linked to the *design of implementation* step of the design approach of Ackoff (1981). In order to answer this sub-question environmental factors, influencing the implementation of the concept, such as main stakeholders, and driving and restraining forces were captured and discussed. Following from this, a leadership style for the needed change leaders was determined. Finally, action planning was considered with the development of an incremental change process with four project phases, consisting out of six projects. A calendar to align the WOW is a prerequisite for all other projects, whereupon some projects can run simultaneously starting with implementing the SCOP decision with its WOW and followed by adapting this WOW with the among others the establishment of a new algorithm. Finally, S&OP can be set up. For this a contingency plan, responsibility chart and communication plan were established.

6.2 Recommendations for Further Research Directions

The HIPP has made great conceptual steps towards a development of feasible integrated planning at Hilti. However, the project's scope was limited and the results are highly conceptual. Therefore several recommendations can be formulated for further research/analysis:

- *Alignment of the strategic level with the developed Hilti IP concept.* The current concept only takes the tactical and operational levels into consideration. Eventually, as the ideal model states, these levels are also aligned with the strategic level and company vision. The strategic level does only consider logistics, but all other factors of business steering. It sets objectives and goals for the lower hierarchical levels in the supply chain. Next to that, the tactical level provides feedback for adaptations of strategic/long-term decisions and it is therefore recommended to take this level into account for development of further projects;
- *Alignment of TM and WM with the developed Hilti IP concept.* All logistic departments at Hilti are divided in MM, TM and WM. The Hilti IP concept however, looked at MM only and improved their tactical and operational decision functions. In order to benefit fully, the introduced tactical level alignment with the other two logistic departments can be of great value. Especially transport, which is touched by the Hilti IP concept, has great potential since it directly fits in the SCOP solution;
- *Investigate operational excellence of black boxes.* In order to get sufficient understanding of the problem and planning structure the production facilities were analysed on a detailed level. The eventual Hilti IP concept, however, treats them as black boxes or TUs. The logic of the Hilti IP concept should greatly improve the capabilities of the manufacturing sites and once the SCOP team goes live, operational excellence at the manufacturing sites could be interesting field of research for further improvement;
- *Investigate Sales in order to cover the complete range of Hilti's functional decisions.* The communication lines and dependencies of MM with sales and marketing were included in this research. For further research more emphasis should be put on the influence of sales/marketing and their WOW for input of integrated decisions;

- *Quantify the effects of the Hilti IP concept by usage of a pilot.* By using a pilot study, quick and tangible results can be retrieved in the current situation. These can be used to make adaptations when necessary and show the potential of the solution.

Next to the IP concept for Hilti the methodology of this thesis already mentioned possible added value for the research field. The idealised concept that was developed combined leading paradigms in the field of supply chain management and came up with a model that might be applied universal. It might be interesting to further investigate the following:

- *The generalisability of the idealised design.* Although this point was touched in chapter 2, more research could be set up to validate the model at different companies. This would provide more case studies that could prove the generalisability of this concept. Complementing this, these case studies could be set up at other industries or end-to-end supply chains that are not controlled internally. Consider the usability with collaborative planning;
- *The mathematical implications of the idealised design.* Further research on the contents of the designed OPC concept will provide the field of research more insights in its applicability to supply chains.

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RAPID Tool

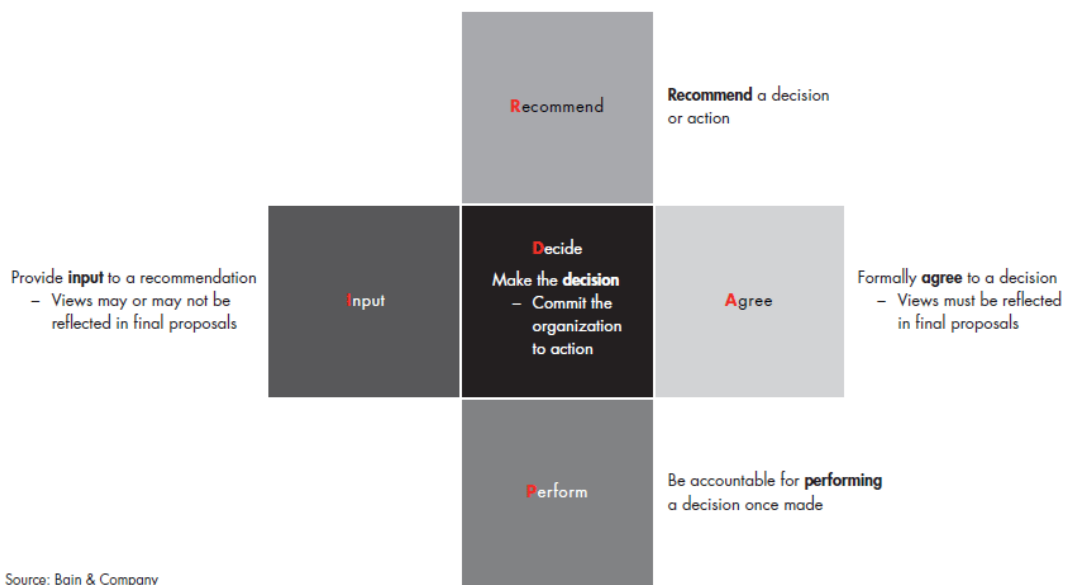


Figure A.1 – RAPID tool of Bain Analysis (2011)

Vroom-Yetton-Jago

The seven questions of Vroom and Jago (1988) are answered on the next page for the case study company Hilti.

Table B.1 – Vroom-Yetton-Jago answered

Question	Answer/Clarification
1 <i>Is the quality of the decision important?</i>	The first question concerns a quality requirement; it asks the leader whether a decision with a low or moderate quality is a complication. Since this is a very important decision which affects both the quality and efficiency of daily operations and with possibly large associated costs, the quality and reasoning behind this decision has to be of high quality. A lot of resources may be involved in making this decision and quality is key in the Hilti culture.
2 <i>Is team commitment important to the decision?</i>	This questions deals with a commitment requirement. In a change project it is important that there is sufficient commitment from the workforce to implement the changes. In our case the steering board team consists of a company-wide delegation. Every single individual in this steering board is touched by the implementation plan and the team consists of their workforce. The commitment of the workforce is of high importance since there will be a lot of operational changes to their daily tasks.
3 <i>Do you have enough info to make the decision on your own?</i>	The third questions answers to leadership information; do the leaders have enough information to change a company-wide platform? The steering board consists of all division of the company that are affected. They have good knowledge about what is happening and the missing (practical) knowledge has been provided by the HIPP project. Decision making can therefore be done by the steering board without further questioning.
4 <i>Is the problem well-structured?</i>	This question deals with the problem structure; is it well defined, clear, organised, time limited and so on. In our case the answer to this question not so important since the model is not guiding us past this question. However, we are dealing with a very clear problem, including a clear and straightforward solution. The Hilti IP concept is a custom made solution for the entire supply chain. Part of the implementation plan is further development of the IP concept but all within a clearly defined structure that can guide the rest of the implementation.
5 <i>If you made the decision yourself, would the team support it?</i>	Here the likelihood of team commitment is discussed; it does not deal with the actual decision but with the probability of support when deciding without consulting the team. Although the steering board has secured commitment from the higher management, team support is vital for the implementation plan. Our team is very broad and can therefore not be underestimate. Hilti's culture of continuous improvement has the downside of high change and sometimes failing projects. In the recent past a similar project has failed which will make the workforce resilient to support it out of the blue. The workforce has to be informed that representatives have input to the decision making. For Global Manufacturing these were the logistic heads of Plant 4 and Plant 6d and the plant managers of plant 1, 4, 9 and 6D.
6 <i>Does the team share organizational goals?</i>	The sixth question concerns the goal congruence of the team, do all members of the team share common values or do they have personal or departmental goals that frustrate organisational goals. Hilti is a highly competitive company, both the vision and company culture are aimed at improving processes, people and therewith ultimately improving customer satisfaction. KPIs are often not aligned and however the company's vision is shared by all, the main drivers for the team are their personal goals which are sometimes frustrating the overall goals.
7 <i>Is conflict amongst the team over the decision likely?</i>	The last question deals with subordinate conflicts; what are the relationships within the management team. All members of the management team have good relationships with the colleagues in their own department. Overall Hilti has a hierarchical culture but through several meetings the higher, intermediate and lower management can communicate reasonably. The setup of the steering board tries to overcome any conflict but going from strong silo thinking to corporate thinking can bring conflict within the management team if they keep "protecting" their own workforce.