

## MASTER

### A new planning and control concept integrating an internal supply chain a case study at Hilti elaborated on global manufacturing

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A New Planning and Control Concept  
Integrating an Internal Supply Chain:  
*a case study at Hilti elaborated on Global Manufacturing*

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*Master Thesis Project - Public Version*  
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*Education is the most powerful weapon which you can use to change the world.*

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Nelson Rolihlahla Mandela

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# Abstract

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In this research, conducted at Hilti AG, we investigate how a complex internal end-to-end supply chain can benefit from vertical and horizontal integration. Several authors (e.g. Feng et al. (2008), De Kok and Fransoo (2003) and Fleischmann and Meyr (2003)) have investigated different stages of the supply chain. However, most of the research that is conducted till present day is aimed at either horizontal or vertical integrating between production planning and scheduling or respectively sales and operations. In this research we attempt to develop a hierarchical framework that takes all four stages of the workflow; procurement, production, distribution and sales, in consideration and simultaneously focus on alignment of both axis of supply chain integration. This framework has as well been transferred into an operations planning and control (OPC) concept in order to make it more tangible for implementation.

As proof of generalizability and applicability the OPC concept has been adapted, using field data, to fit the Hilti AG supply chain. This adapted model, the Hilti IP concept, serves as a case study eventually exposing critical actions and steps needed to implement the developed framework.

It can be concluded that the developed framework and OPC concept is broadly applicable but that further research is needed in order to quantitatively proof is superiority over existing frameworks. Additionally we can conclude that the case study company, Hilti AG, is still far away from an integrated planning and control system. The developed conceptual model together with the adapted Hilti concept and action plan can help the company to reach a more integrated stage in the upcoming years.

**Keywords:** Supply Chain Management, Supply Chain Planning, Supply Chain Integration, Horizontal Collaboration, Vertical Collaboration, Sales and Operations Planning, Logistics, Hierarchical Planning, Production Planning and Scheduling, Change Management

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# Preface

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This report is the result of a graduation project that has been conducted at Hilti Plant 4 in Thüringen (Austria) and Plant 6D in Kaufering (Germany) in completion of the Master Operations Management & Logistics (OML) at Eindhoven University of Technology. I'm thankful that I had the possibility to graduate within Hilti and I would like to thank all the people that made this project possible.

Some people however, deserve to be mentioned. At first Ton de Kok, who has been my supervisor at university. It was you who made it possible for me to do my graduation project abroad, which was a big desire of me. I want to thank you for this and the many discussions we had when I was in the Netherlands. You have given me plenty to think about on the plane back to Austria.

During the project I spent most of my time in Plant 4 and for that first I'd like to thank the people at Plant 4, especially Peter Spalt, but also Markus Frieser and Karlheinz Niederlander, for their great support. You made my life easier when I made yours worse. Still you kept offering your time and support. Next I would like to thank Thomas Oertel, my official supervisor at Hilti. Although the project was not only focused on your department and drifted further and further away from Plant 4 you kept trying to be of assistance. Also your practical insights and commitment towards me have been greatly appreciated.

I'd also like to thank Plant 6D for their understanding and high standards. You are an example for the other Hilti plants from an operations planning point of view. Special thanks goes to Michaela Geiger, although you were not working for P6 Logistics anymore, you still made time to explain the planning processes at P6D, in quite some detail. And to Tobias Wille, Michaela's successor, for your level of detail, perseverance and precision has thought me a lot.

Last but not least I would like to thank all the people I worked with at Global Logistics. Special recognition goes to; Alessandro Sasso, for your guidance in the global aspects of the HIPPP project, your extensive elaborations and your positive energy. Also to Rüdiger Kübler and Roeland Baaijens, for your confidence and support at the beginning, during and at the end of the project. It was your passion and enthusiasm for Hilti that made me want to succeed even more.

But eventually, what does a graduation project and university degree mean without the support of your loved ones? I want to thank my family for their curiosity and support in the project and for the great week in Austria. I particularly want to mention my parents who have seen me more via FaceTime than in real life in the last years. Still you supported me every step of the way, and not only during graduation but since the very first day. I am grateful to have you.

*Jorik Krewels*

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# Management Summary

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In this report we present the results of a master thesis relating to Supply Chain Integration (SCI) on both the horizontal as vertical axis in a complex internal end-to-end supply chain. This report is one of the three HIPP research projects aimed at developing a new planning and control concept for the Hilti AG supply chain. The project has been initiated by the department of Global Logistics of Hilti AG and carried out under the supervision of the University of Technology Eindhoven (TU/e).

This particular research project was carried out at Hilti Plant 4 in Thüringen (Austria) and Plant 6D in Kaufering (Germany). Therefore, this report has a strong focus on the upstream environment of the Hilti supply chain being the complete set of manufacturing sites combined under the Global Manufacturing umbrella.

## Problem Description

Having to deal with increasingly competitive, economically unstable markets, companies dedicate more attention to Supply Chain Management (SCM) in order to build a more comprehensive view of their 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. However, academic literature is lacking a planning and control concept that is focused on internal integration on both the horizontal and vertical axes together. Hence, there exist a clear need for the development of such a planning and control framework and the following problem statement was defined:

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

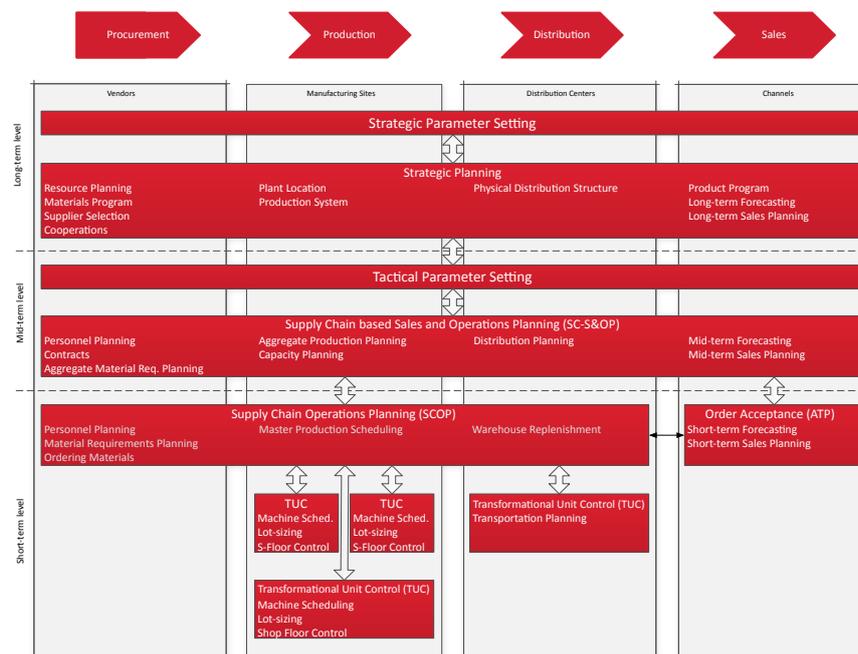
Hilti, controlling an internal end-to-end supply chain, acknowledges that their current planning and control system is not fit for further integration and is in fact fairly segmented. Therefore, the new framework has been developed with the supply chain of Hilti as a reference. As a proof of concept the framework is also fitted to the Hilti supply chain discovering implications and possible effects for the company. To truly come from theory to practice a further action and implementation plan is given.

## New Hierarchical Framework

Using a design approach we developed a new idealized hierarchical framework. This approach is combined with a bottom up principle meaning first the specific features and characteristics of the system processes were mapped and from these a suitable control function could be developed. One of the main characteristics that has been discovered is

the complexity of the supply chain. This complexity is fed by the procurement, production, distribution and sales stages of the workflow that are all internally controlled.

As foundation for the new framework we used the Supply Chain Planning (SCP) Matrix of Fleischmann et al. (2002). Strengths of this matrix, like the hierarchical levels and the four stages with planning modules have been incorporated in the final design but limitations of this model, like a lacking time aspect and integration were replaced using academical literature. The most prominent additions are the Supply Chain based Sales & Operations Planning (SC-S&OP) by Feng et al. (2008) on the tactical level and the Supply Chain Operations Planning (SCOP) concept by De Kok and Fransoo (2003) on the operational level. Additionally, we also introduce parameter setting as a controlling function on both the strategic as the tactical level.



**Figure 1** – Final Ideal Design of Hierarchical Planning Framework

The developed framework, Figure 2.8, is translated to a more usable Operations Planning Control (OPC) concept by showing hierarchy, time and dependencies. Figure 2.9 shows this OPC concept. This way of representations allowed us to perform a case study of the hierarchical framework.

## From Theory to Practice: A Case Study

The case study has been performed at Hilti AG who controls all four stages of the workflow internally and currently has problems integrating decision functions. The company was therefore a good subject to test the applicability and of the developed idealized framework and learn from complications or necessary adaptations.

First, gaps were identified between the idealized design and the current planning and control system in place. The most prominent gap was related to the lack of a tactical level. Due to this gap a lot of necessary decisions are made locally, mostly on an operational level, or even not done at all. In any case, the level of alignment is minimal since the material managers work on local spread sheets that are unavailable for their colleagues in other sites. Next to this major vertical gap several horizontal gaps were identified. A

strong focus on Key Performance Indicators (KPIs) drive sites in different stages of the workflow into separate silos and integration is brought to a minimum level. In comparison with the ideal design there exists a big gap between the SC-S&OP structure and the current silo structure. Concerning IT support we concluded that SAP APO and R/3 systems are well integrated in every stage of the supply chain but poorly designed from a collaborative and/or integration perspective. Since the system is so broadly implemented it should however, be able to support filling the identified gaps.

From the gaps several effects were subtracted. Three main effects, high demand volatility, high inventories and poor reliability to the customer could all in some extent be directed to the identified gaps.

By filling the identified gaps a new Hilti Integrated Planning concept was developed, Figure 4.1. The small adaptations gave more insight in four '*fields of interest*' that need further elaboration and investigation; frequency, aggregation, targets and engagement rules. The OPC concept leaves these fields open so a company can fill in its specific content. This is done explicitly since the fields are highly depended of factors like industry and operating market.

The practical field information of Hilti also gave us the possibility to develop an OPC concept adding roles and responsibilities and thus more detail to the picture. In Figure 4.3 these roles and responsibilities the Hilti IP concept, immediately gets even more meaning for practical implementation. The most noticeable role is the Supply Chain Specialist Team (SCST) that will fulfill a central role in the SCOP function.

From the gaps several expected effects could be drawn reflecting an improvement of the current performance. By building the SC-S&OP and SCOP functions the company is expected to eliminate the main causes on both the horizontal as the vertical axes. For Global Manufacturing this implies reducing or eliminating the bullwhip and volatility. The implementation will also lead to more accurate forecasting and stable demand due to the tactical levels involvement in balancing the needs from the market organisations and production constraints.

## Conclusions & Recommendations

The research and case study have made a first conceptual step towards a feasible integrated planning and control system at Hilti. However, the project's scope was limited and the results are highly conceptual. Therefore several recommendations could be made to Hilti:

- Quantify the IP concept using one or several pilots
- Extend the IP concept by aligning the strategic level and the transformational units with the developed concept
- Optimize the organizational excellence by including Transportation (TM) and Warehouse Management (WM) at Hilti

Next to general recommendations for the case study company further research is recommended on:

- The generalizability of the hierarchical framework for an academic perspective
- The mathematical implications of the theoretical framework

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## List of Abbreviations

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<b>APO</b>	Advanced Planning and Optimizer
<b>BU</b>	Business Unit
<b>CW</b>	Central Warehouse
<b>DC</b>	Distribution Center
<b>DM</b>	Demand Management
<b>EOQ</b>	Economic Order Quantity
<b>ERP</b>	Enterprise Resource Planning
<b>ET&amp;A</b>	Electric Tools and Accessoires (Business area)
<b>EWM</b>	Electronic Warehouse Management
<b>F&amp;P</b>	Fastening and Protection (Business area)
<b>GEO</b>	Global Excellence Award
<b>GL</b>	Global Logistics
<b>GM</b>	Global Manufacturing
<b>GPMS</b>	Global Process Management System
<b>HAG</b>	Hilti AG (headquarters)
<b>HC</b>	Hilti Center
<b>HIPP</b>	Hilit Integrated Planning Project
<b>HNA</b>	Hilti North America
<b>INP</b>	Introduction New Product
<b>JIT</b>	Just It Time
<b>KPI</b>	Key Performance Indicator
<b>LEC</b>	Logistic Europe Central (logistic region)
<b>LRC</b>	Logistics Replenishment Center
<b>LT</b>	Lead-time
<b>LW1</b>	Logistic region Hilti North America
<b>MM</b>	Material Management
<b>MO</b>	Market Organisation
<b>MRP</b>	Material Requeirements Planning
<b>MRP II</b>	Material Resource Planning
<b>MTO</b>	Make to Order
<b>MTS</b>	Make to Stock
<b>NDC</b>	Net Demand Calculation
<b>OML</b>	Operations Management & Logistics
<b>OPC</b>	Operations Planning Concept
<b>P4</b>	Plant 4
<b>P6D</b>	Plant 6D
<b>PU</b>	Production Unit
<b>PUC</b>	Production Unit Control

<b>RDC</b>	Regional Distribution Center
<b>ROP</b>	Reorder Point
<b>S&amp;OP</b>	Sales and Operations Planning
<b>SAP</b>	System, Applications and Products for data processing
<b>SC-S&amp;OP</b>	Supply Chain based Sales and Operations Planning
<b>SCI</b>	Supply Chain Integration
<b>SCM</b>	Supply Chain Management
<b>SCOP</b>	Supply Chain Operations Planning
<b>SCOR</b>	Supply Chain Operations Research
<b>SCP</b>	Supply Chain Planning
<b>SCST</b>	Supply Chain Specialist Team
<b>SS</b>	Safety Stock
<b>TM</b>	Transport Management
<b>TSP</b>	Transshipment Point
<b>TU</b>	Transformational Unit
<b>TU/e</b>	University of Technology Eindhoven
<b>WM</b>	Warehouse Management
<b>WOW</b>	Way Of Working

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# One

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## Formulating the Mess

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### 1.1 Problem Statement and Context

Having to deal with increasingly competitive, economically unstable markets, companies dedicate more attention to Supply Chain Management (SCM) in order to build a more comprehensive view of their and their 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 the company performance and existing literature indicates the importance of Supply Chain Integration (SCI), both vertically as horizontally, where ever more focus is put on Supply Chain Planning (SCP). Until now, most 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 the strategic, tactical or operational level, or 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 has provided an in-depth approach to develop a SCP concept integrating on both axes. The aim of this research is to fill 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. By reflecting the concept on a real case study based on Hilti AG we attempt to support the design of this concept. 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 has been defined:

*'Development of a new integrated planning and control concept for internal end-to-end supply chains improving the 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 to develop an integrated planning and control concept for the internal end-to-end supply chain of Hilti AG, and was initiated by Global Logistics (GL). The entire Hilti supply chain is within the scope of the HIPP project 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 has been carried out within (specifically chosen) plants, logistic regions and the headquarters divided between the three projects. This particular research was carried out at Plant 4 in Thüringen, Austria, and Plant 6D in Kaufering, Germany, representing a production site for tools respectively consumables. Hence this thesis will elaborate on these locations. For the full detailed description of the three projects, this thesis is complemented by the thesis of Broft (2014) and the unpublished work of Mertens (2014).

In the recent past Hilti AG has 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, their 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 to perform a business case on.

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 been indicated yet. The foremost place of the location of these gaps is in the planning process, which is expected 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 optimization in silos. The current business structure of within Hilti is strongly characterized by silo thinking. These silos emerged by the fact that the supply chain of Hilti exists out of several stages of the supply chain with their own legal entity, all wanting to perform optimal within their boundaries, hence the silos. 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 Headquarter (HAG), Market Organizations (MO)/regions combined with logistic regions, and plants, under the Global Manufacturing (GM) umbrella. The existing potential for Hilti can only be realized by recognizing 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 rest of this chapter is organized as follows: First we present the relevant topics of the three literature reviews performed in section 1.2 to obtain insights into horizontal and vertical integration of the SCP decisions. Based on the problem statement and results of the three literature reviews, we formulated the research questions, presented in section 1.3. Thereafter, we discuss the methodology used in this research in section 1.4. Last we introduce Hilti AG in section 1.5 as an introduction to the case study and an outline of the remainder of this thesis, section 1.6.

## 1.2 Literature Review

In preparation for this thesis, relevant academic literature was reviewed that focussed on different aspects of integrating planning. Together they focus on both horizontal and vertical integration which was expected to generate the most insight for the HIPP project to succeed. Horizontal integration involves a cross-functional integration between sales and operations on the tactical level, Broft (2013), and on operational level (not covered). The vertical integration involves the deployment from a tactical level to an operational level at operations, Kreuwels (2013a) and at sales, Mertens (2013). Below the most important findings of these reviews are summarized.

### 1.2.1 Sales & Operations Planning

In the performed literature review by Broft (2013) that focused on the research question: *"How does Sales and Operations Planning contribute to the integration of the supply chain?"*. Sales and Operations Planning (S&OP) has been 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"*.

Summarizing this literature review, there has been an extensive research focusing on the S& OP objectives, parameters, phasing, maturity measurement and assessment. The major findings can be summarized 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 organizational structure, and geographical location it is obvious that they also vary in the approaches towards S&OP, or even, in 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 organizational 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 and 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 in the supply chain. To support planning processes on these different levels, the demand planning process needs to be modeled in the same hierarchical structure. The levels of aggregation and the planning horizon of demand plans are different 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 (2013a) hierarchical alignment of the tactical and operational level in operations environment is analyzed. 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

The research field of hierarchical planning is relatively unanimous in using the three hierarchical levels of Anthony (1965). When it comes to integration of these levels the research field is highly scattered. Supply Chain Integration (SCI) techniques could contribute to the alignment between hierarchical levels. The most relevant 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.

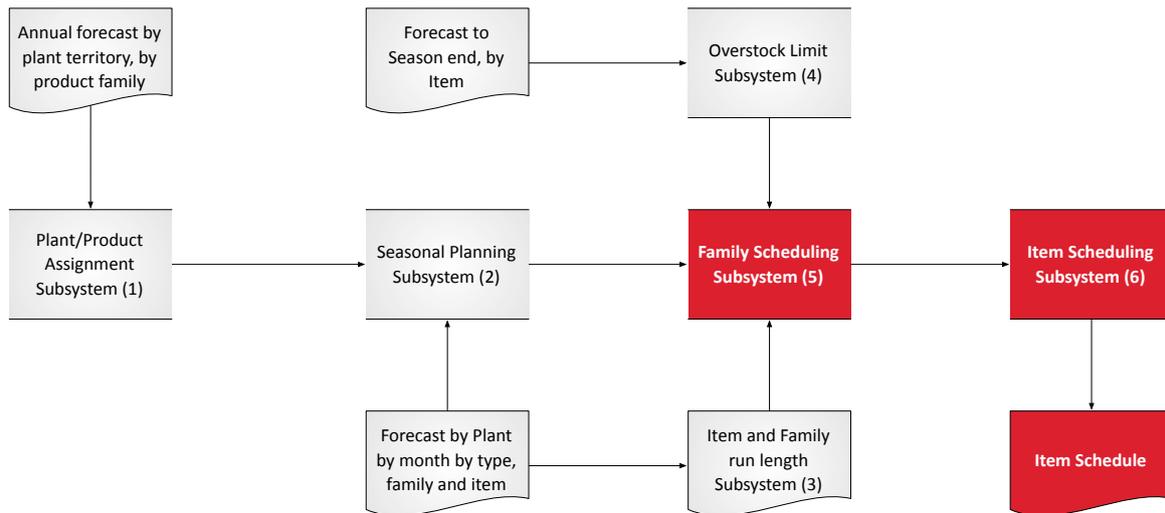
As in most fields of operations management research, communication and information technologies are of increasing importance. Developments of ERP software have driven firms into production planning structures that do not always fit the organizational structure and often have a long commitment due to the software licenses or costs related to change.

## Hierarchical Planning Frameworks

### *Hax and Meal*

The model of Hax and Meal (1973) describes 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



**Figure 1.1** – Model of Hax and Meal (1973)

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.

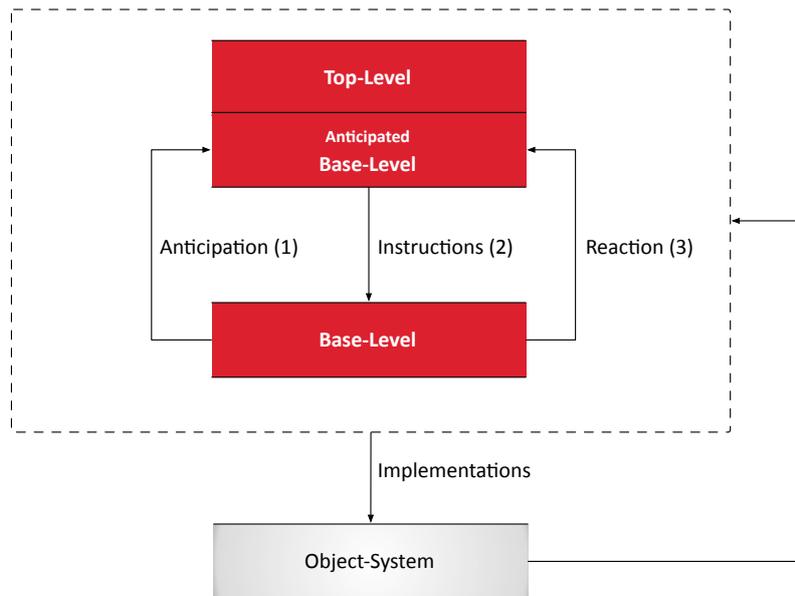
First, using long-term capacity provision and utility decisions products are assigned to manufacturing plants. Second, a seasonal stock accumulation plan is prepared on a tactical level. This plan makes allocations of capacity in each plant among product types. Products that have similar inventory costs define a type. Third, on a 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*

The model of 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 are: anticipation, instruction and reaction.

*Anticipation* means choosing an anticipated base-level and taking into account its impact on the top-decision. Quite generally a 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 often a reaction is not possible, but when it is possible it always triggers 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.



**Figure 1.2** – Model of Schneeweiß (1995)

*Bertrand, Wortmann and Wijngaard*

The model of Bertrand et al. (1992) describes a hierarchical structure that is directed toward decision functions which can be allocated to organizational positions and responsibility areas. They introduce two key constructs; goods flow control and production units. Additionally, the framework incorporates both the detailed item-oriented and aggregate capacity-oriented aspects of production control in a similar way as Meal (1984).

First production units (PU) are explained since they hold a special meaning. A production unit can be seen as an organized set of resources that, from a production control point of view, should be distinguished. It can be logically separated because it takes care of a certain part or phase of production. A production unit is responsible for the production of a specified set of PU end-items which thus do not necessarily need to be finished goods. In many production situation production units can be distinguished which can operate independently to a certain extend. This independence means 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;
- production control at the goodsflow control level, which refers to the coordination of the PUs and the timing of production and sales.

The model uses an aggregated planning level which strongly resembles the production and resource planning as defined in MRP-II. At the aggregate level (tactical), the availability of the most important capacity resources is established and in relation to this production volumes, sales volumes, inventory changes and subcontracting budgets are determined. Several interrelated plans are thus created. Then these aligned plans are used on the detailed supply chain operations planning or SCOP level. Here goods flow control makes a distinction between material coordination, which roughly corresponds to master production scheduling (MPS), and capacity planning. Midway the SCOP level the PU gets an influence in order to align the work

orders flowing down into the PU. Eventually the work orders flow to the PU which resembles the operations environment.

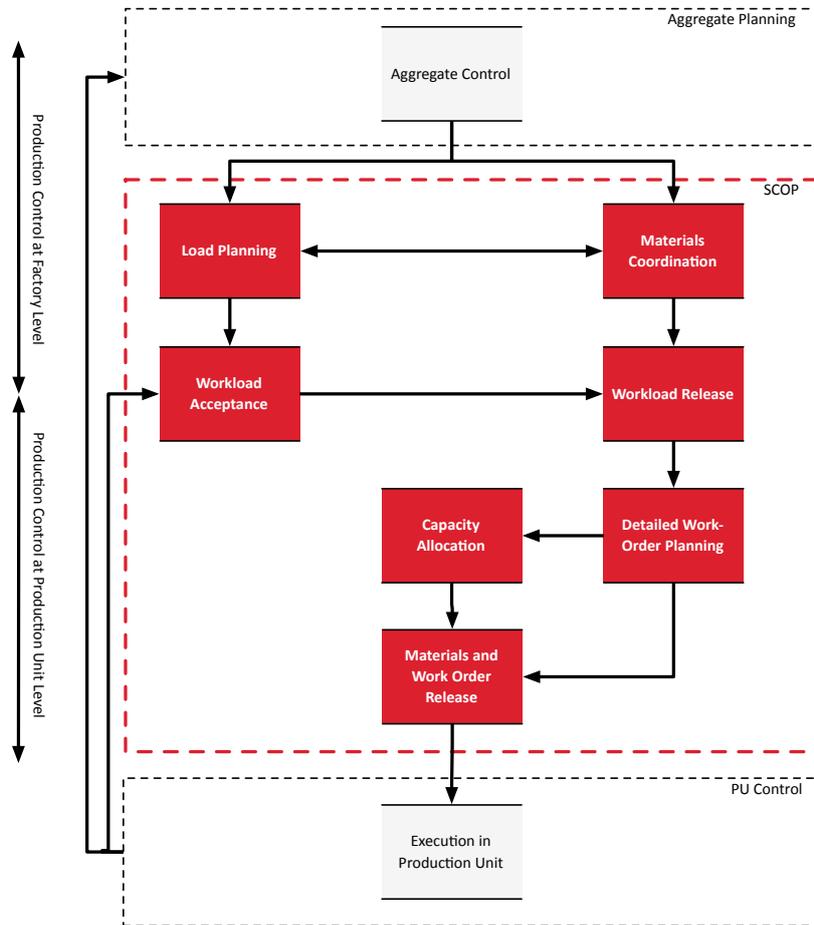


Figure 1.3 – Model of Bertrand et al. (1992)

### 1.3 Research Questions

Based on the research aim, the case study company Hilti and the three literature reviews, the following three research questions were defined:

**1. How 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, we considered the whole internal supply chain of Hilti.

For the remainder of the research questions, the supply chain of Hilti that was defined as within the scope of this thesis is considered. 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, as representation of GM. This scope was believed to make the thesis results applicable to the entire supply chain as mentioned in Section 1.1. As mentioned, this thesis is the result of the project considering Plant 4 and Plant 6D representing upstream stages up the Hilti supply chain. Therefore emphasis and further elaboration is put on these parts of the supply chain during this thesis. The logistic regions LEC and LW1, representing distribution with short respectively long lead times, are further elaborated in the master's thesis of Broft (2014) and the unpublished work of Mertens (2014).

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

In order to comprehend the planning landscape of the internal supply chain of Hilti that represents the complex environment the new planning and control concept has to be build upon, the supply chain within scope was divided through the three projects as mentioned above. First this sub-question was answered separately in these projects. Later we combined them in order to come to the complete planning landscape.

The current planning landscape was defined by analyzing the planning decisions. Also the relationships of the planning decisions and their cross-functional character were analyzed 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, reflecting on the Hilti supply chain?**

As the initial research aim was to development a new integrated planning and control concept and improving the overall supply chain performance, answering this research question considers the development of such a concept. As this research was concerning an internal end-to-end supply chain, the input from question 1a is used to reflect on 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 developed integrated planning concept?*

In order to comprehend gaps between the current planning and control landscape of the internal supply chain of Hilti and the developed concept of question 2, the supply chain within scope was divided through the three projects as mentioned above. First this sub-question was again answered separately in these projects. Later we combined them in order to come to the identified integrated planning gaps for Hilti as a whole. The effects of these gaps have been considered in answering this sub-question.

*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 were considered. As deviation of the ideal implies worse performance whenever these alteration were necessary, the effect is discussed. Next to alterations, the planning and control concept it specified in more extent considering the case study company.

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

A suggested high level action plan with recommended deliverables was specified in order to help show how Hilti could transfer the concept to real life making it more tangible and useful.

## 1.4 Methodology

After we defined the research questions above, we present the methodology regulating this thesis. Simon (1969) argues that the involvement of a structured organizational 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 to come to a solution for the research aim by taking intermediate steps. It starts with formulating a mess which is considered in this chapter and includes the answer of the first research question. The next step is ends planning, which we discuss in chapter 2 and chapter 3. Ends planning entails the development of an idealized 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 idealized design, hence answering research question 2 in chapter 2 and sub-question 3b in chapter 3. Means planning is the next step of this methodology and selects ways of filling the gaps. Resource planning at its turn, being the next step, considers the responsible roles for the means selected. These two steps are both considered 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 feasibility of implementation, considered in chapter 5. Figure 1.4 shows how the design approach of Ackoff (1981) is taken throughout the whole setup of this thesis.



**Figure 1.4** – Design Approach according to Ackoff (1981) reflected on the Thesis Structure

It has to be noted that, since this is an academic research, the design and generalizability of the design is mainly pursued. During the rest of the thesis we attempt to provide a proof of applicability using the Hilti case study.

## 1.5 Hilti AG

The remainder of this chapter, we provide an introduction of Hilti AG. First we discuss the company background is where after the internal Hilti supply chain and its current planning and control are presented. We then elaborate further on both plants, Plant 4 and Plant 6D.

### 1.5.1 Company Background

Hilti AG, hereafter called Hilti, was founded in 1941 by Martin Hilti and is still a family owned company. It is operating in more than 120 countries and has approximately 20,000 employees. Its direct sales model characterizes the organization with annual sales around 4 billion CHF. Hilti produces different products for the construction industry, ranging from specialized tools to perishable chemicals to commodity consumables, in total around 63,000 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 fight the effects of a recent financial crisis the company implemented a number of cost savings operations. However, despite of the company’s recent growth and introduction of the lean management into the production processes the profit remains unsatisfactory.

The products range from specialized tools to commodity consumables and perishable chemicals, indicating a large product portfolio, and are made in their own manufacturing sites. In total, Hilti owns five plants for consumables and three plants for power tools as can be seen in Figure 1.5.



Figure 1.5 – Hilti’s Plant and Allied Suppliers

As a global competitor, its turnover is still largely represented in European sales. As 55 percent of the revenue is from Western Europe, 21 percent from America, 12 percent from Asia and again 12 percent from Eastern Europe and the Middle East as can be seen in Figure 1.6.

### 1.5.2 Hilti’s Internal Supply Chain

A broad overview of the supply chain of Hilti is given in Figure 1.7. The large majority of the value chain is under corporate control, meaning from manufacturing sites till sales channels Hilti controls their product flow, indicating the internal supply chain. Hilti competes globally and has suppliers, plants, Central Warehouses (CW), Distribution Centers (DC) and Hilti Centres (HC) located all over the world. However, as mentioned before, there exists a strong European footprint accounting for more than 50% of Hilti’s total turnover and the majority of manufacturing plants. From the plants and allied suppliers the finished goods are delivered to National (NDC), Regional (RDC) or normal distribution centers (DC). Replenishment can either be done via CWs 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 consolidated in the CWs or a Transshipment Point (TSP) before they are send.

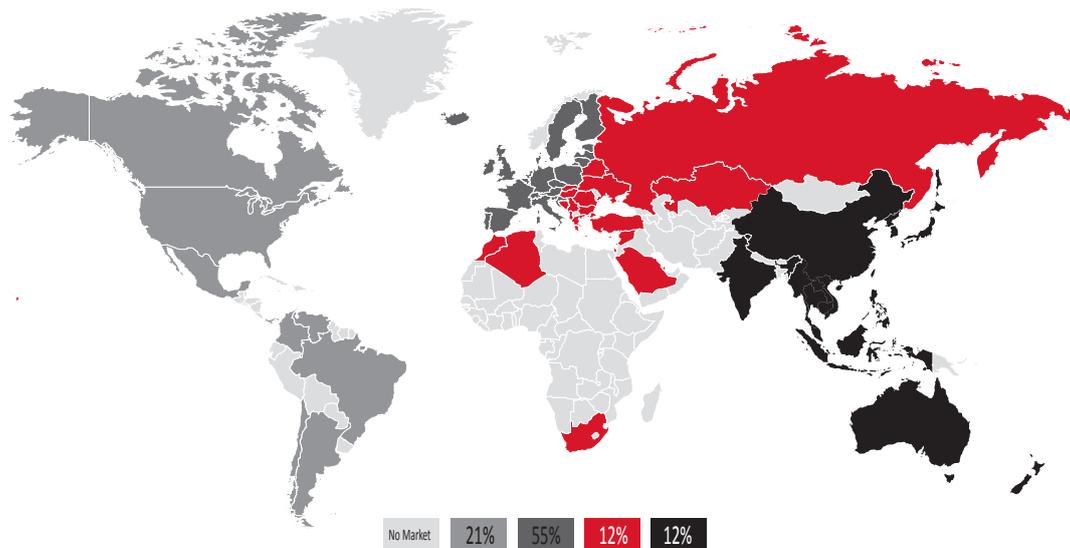


Figure 1.6 – Hilti’s Operating Market

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.

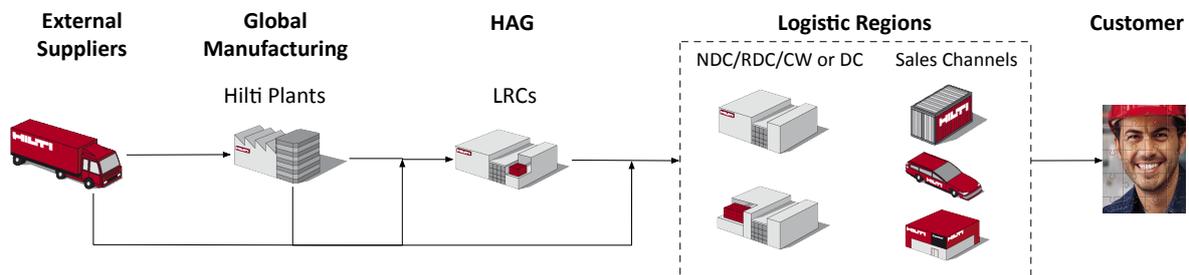


Figure 1.7 – Hilti’s Supply Chain

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 variation of item characteristics in terms of: value to weight ratio (value-density), lead times, sales volumes, storage, handling, transportation and requirements (i.e. hazardous goods). Many items in Hilti’s supply chain can also be characterized by a great seasonality in their demand. This seasonality is strongly driven by the European market, due to its large share in total global demand. In total Hilti produces around 31.000 unique global end-products, of which roughly 7 percent generates 80 percent of the turnover. Since spare-parts are out of scope of this project they are not counted in this number.

### 1.5.3 Planning and Control

As a global competitor Hilti needs to be close to its markets. Hence, the logistic regions are scattered over the world and closely planning and controlling these locations becomes very important. Every logistic region reports back to the head of Global Logistics (GL) who is part of the executive management team. GL at Hilti is split in three main areas: Warehouse

Management (WM), Transport Management (TM) and Material Management (MM) as shown in Figure 1.8. WM, TM and MM are done on GL level but also on regional level. Generally speaking, GL is concerned with the planning and control support of the entire supply chain. The GL department centralizes global processes 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 1.8 report directly to the Head of GL and the three on the left to a member of the executive board.

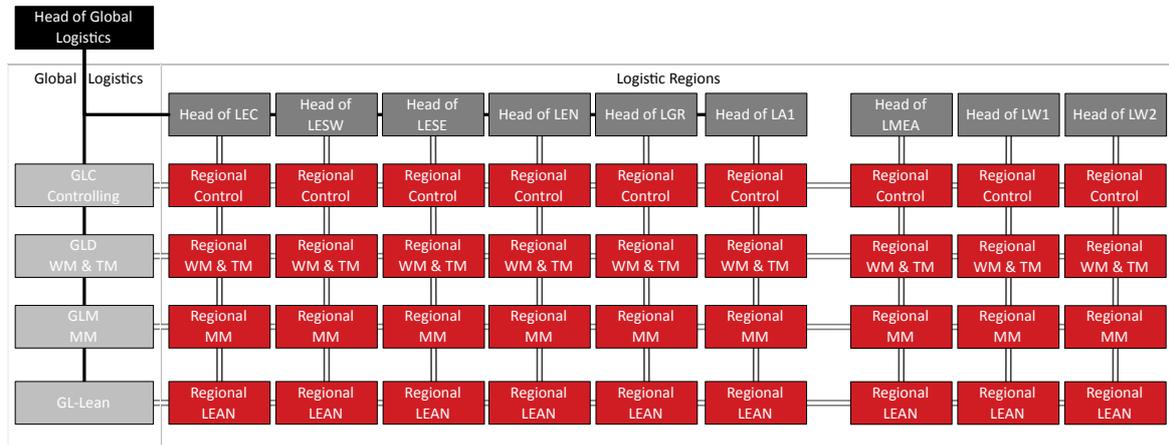


Figure 1.8 – Control Structure of Global Logistics on Logistic Regions

Furthermore, GL supports on issues, exceptions and concept developments in order to establish a continuous improvement cycle together with MM in market/region logistics. GL can therefore best be seen as a business partner instead of a pure service provider. This creates an independent logistic organization integrated with the markets/regions. In this sense independent factors are: distribution network, decision of in/outsourcing, selection of 3PL and people management. And integrated parts consist among other of: customer orientation, level of service, business communication, sales forecast integration meetings, obsolescence, product basket and shared “pain and gain”.

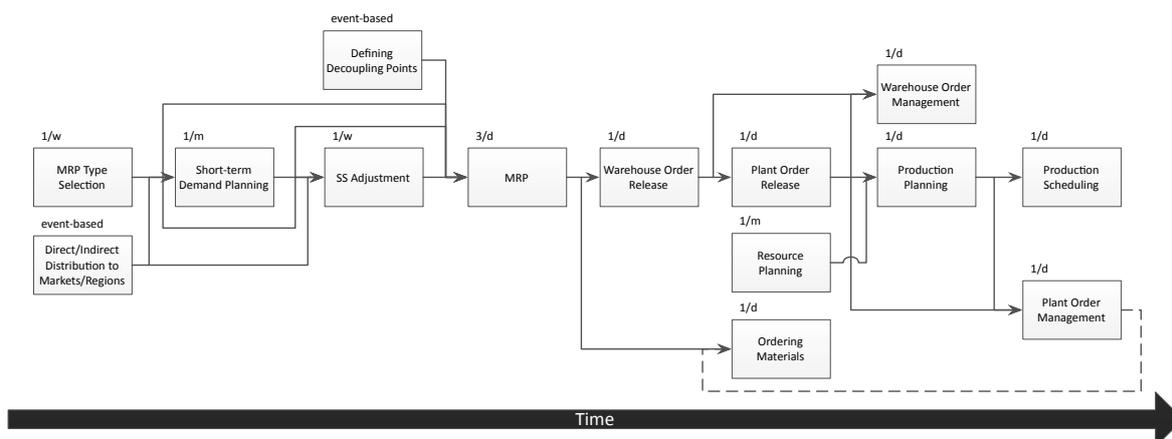


Figure 1.9 – Current Planning and Control System Hilti

Since most of the planning activities takes place under the umbrella of MM we will now elaborate on this subdivision. The planning activities can be seen in Figure 1.9 and roughly take place in three separate silos as mentioned before.

Firstly, HAG MM is divided with responsibilities under three board members of “Emerging and Energy & Industry”, Fastening & Protection and Electric Tools & Accessories. HAG MM is divided in business units (BU) and is planning for both the integrated and non-integrated markets, which don’t have their own MM. Integrated markets forecast and plan at a market/region MM and non-integrated markets are planned and forecasted at headquarters by HAG MM. HAG focus can thus be characterized as global demand. These operations are all on operational level. MRP type selection, direct/indirect distribution, demand planning, defining decoupling points, safety stock (SS) adjustments, MRP (system), warehouse order release, warehouse order management are tasks that are performed on a daily or event based interval.

Secondly, market/region MM has a focus 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 Material Management of its region, which in his place reports to the head of the logistics region as seen before in Figure 5. 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 together by 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. MRP type selection, direct/indirect distribution, demand planning, defining decoupling points, SS adjustments, MRP (system), warehouse order release, warehouse order management are tasks that are performed on a daily or event based interval.

Thirdly, plant MM is focusing on producing products based on global demand, making a distinction between make to stock (MTS) and make to order (MTO) production. Plant MM is operating under two business areas (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 as 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 done in close collaboration with the BUs at HAG. MRP type selection, SS adjustments, production planning, production scheduling, ordering materials, plant order release, plant order management, resource planning, MRP (system) are tasks that are performed on a daily or event based interval.

#### 1.5.4 Global Manufacturing

As mentioned before, for several reasons the supply chain of Hilti has been split in an upstream and a downstream segment. The upstream segment covers the entire GM division of Hilti and we will now elaborate about the two plants that were in scope of this research.

The large product portfolio makes the production plants highly distinctive. In order to create a complete synopsis of GM a plant dedicated towards the production of powertools and a plant dedicated towards production of consumables has been analyzed.

Procurement, planning and scheduling are assigned roles and responsibilities in all plants. They are supported by BU MM and GL MM. Moreover, the plant MM also takes up specific roles and responsibilities that are not always identical to those that have been assigned. For an extensive description and study of the organizational side of planning and scheduling and to understand the role that planners and schedulers actually play in influencing the overall performance, we direct you to the As-Is analysis in Kreuwels (2013b).

All Hilti plants use the same information system that exist of the fully integrated SAP APO and ERP system and an additional EWM system for the warehouse management.

**Problem Statement Global Manufacturing** - We have indicated the concern of Hilti GL that the current planning and control systems' fitness for S&OP is critical. The effects of the current planning and control system are momentarily particularly being felt by the manufacturing sites. As mostly in supply chain management it is the most upstream location that gets the biggest hits. For Hilti plants this is just the same. Plants like Plant 4 see extreme demand volatility that can differentiate up to 500% on a fast running product. They are continuously adapting to a daily changing environment and do not get any commitment from the market organizations concerning forecast or demand figures. Even though they are dealing with 14 week lead-times, promotions are communication in a 1-2 week time span and the information that is available is often hard to translate since all markets talk in different numbers (e.g. sales volume, weight, added value, kWh). Additionally the procurement of raw materials is only the responsibility of the plants but they do not have the ownership over the contracts and choice of suppliers which drives the delivery accuracy down and stock levels up.

**Plant 4 - Setup** - Located in Thüringen, Plant 4 has been founded in 1970 and since then the plant has been expended several times. The latest extension goes back to 2010 increasing the total surface to 41.850 m<sup>2</sup>. The plant operates with about 450 employees and acts as a vocational training company since 1995 educating a constant amount of  $\pm 80$  apprentices. The plant is placed under the Corporate Business Area ET&A and produces electric tools for the Business Units Powertools & Accessories, Diamond and Direct Fastening.

Plant 4 can roughly be split in two pieces, a machining area and an assembly area, as can be seen in Figure 1.10. The machining area produces components from raw materials that come from external suppliers. The assembly area assembles pre-assemblies, called building groups, and complete tools with components from the machining area, external suppliers and other Hilti plants like Plant 9. The power tools are only made on 'customer' order, where the customer is a Hilti MO.

**Table 1.1** – Key Planning Figures Plant 4

	<b>Machining area</b>	<b>Assembly area</b>
Setup	Segmented clusters	Tool related one flow assembly lines
Planning	Based on Corporate Forecast	Based on actual MO demand
Throughput time	<b>Confidential</b>	<b>Confidential</b>
Workforce	<b>Confidential</b>	<b>Confidential</b>
Throughput	<b>Confidential</b>	<b>Confidential</b>

Shipment from Plant 4 can roughly be done in three different ways, tools can either go directly to the central warehouse and regional distribution centers of the market organizations, to one of the warehouses or LRCs, or are shipped via a transshipment point where they are consolidated with other products before they are shipped to the MO.

In comparison to entire GM the plant has high competence in both the planning department as on the production floor. The latter is due to the internal training and continuous improvements.

An internal warehouse decouples the two areas of the plant. Both raw materials and components are stored in this internal warehouse. The warehouse consists of several areas: the pick and pack area, the bin store with a capacity of 35.000 small bins and the high rack store with a capacity of 6.000 Euro pallets.

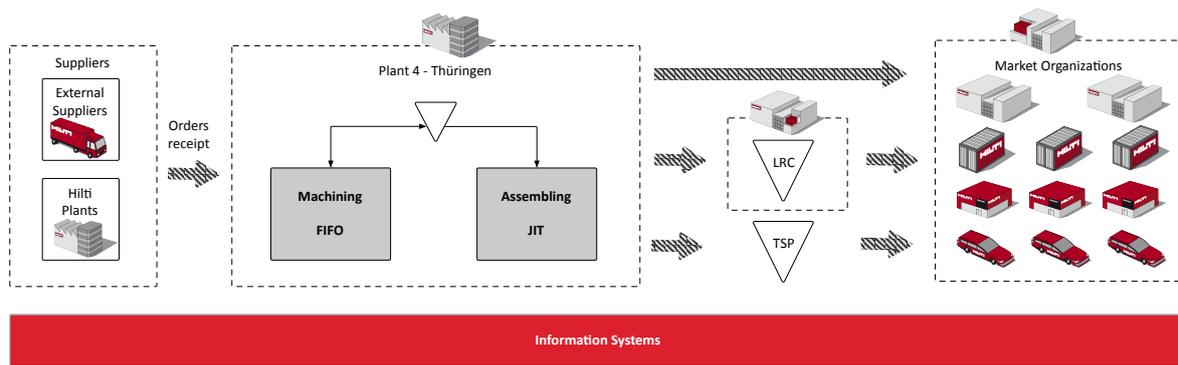


Figure 1.10 – Supply Chain Plant 4

**Plant 4 - Planning** - The logistic department of P4 consists of two main planning departments namely, procurement and materials management. The procurement departments’ main tasks are the procurement of raw materials and external components and the availability of these components for the assembly department. The material managers are mainly responsible for the production planning and scheduling on a daily recurring cycle for the machining and assembly area and ordering of raw materials for the machining area.

**Plant 6D - Setup** - Located in Kaufering the plant was founded in 1971. Today it manufactures drives, premium drill-bits, cast-in channels, chemical anchors, mining and firestop products. In 2003 the plant was decorated with the Germany-wide competition ‘factory of the year’ in the category GEO-Award (GEO = Global Excellence in Operations). The location has been extended by additional production capacities over the years. The extension of the chemical anchor and firestop production as well as the new apprenticeship centre has been completed in 2010. Plant 6 has approximately 200 employees and 90 apprentices and holds a surface of 27.000m<sup>2</sup> of production floor. The entire plant consists of Plant 6B and Plant 6D which both have their own portfolio of consumables. Therefore the focus has been laid on one of the two being P6D, which produces chemical anchors and firestop products for the Business Area Fastening & Protection.

The portfolio of P6D is driving its setup, Figure 1.11. The production process can roughly be split in two segments; a weighting & mixing area and a filling & packaging area. The weighting and mixing area makes several A- and B-mortars from raw materials, which are mostly chemicals. These mortars are used in the filling and packaging area.

Table 1.2 – Key Planning Figures Plant 6D

	Weighting & Mixing area	Filling & Packaging area
Setup	Dedicated dissolvers per mortar	Mass flow filling and packing lines
Planning	Based on aggregated demand filling lines	Based on actual MO demand (EU) and Steering (overseas)
Throughput time	Maximum 3 days (actual mixing less then 1 hour)	3 days for European Markets 12 days for overseas markets
Workforce	<b>Confidential</b>	<b>Confidential</b>
Throughput	<b>Confidential</b>	<b>Confidential</b>

The supply chain is comparable with Plant 4 as we have seen in Figure 1.5. The plant is

also replenished from both external suppliers and other Hilti plants. Shipment from Plant 6 is done using the same three options as described before. The biggest difference is that due to the chemical composition of the products overseas markets are always replenished via reefer containers whereas European markets are replenished by normal containers.

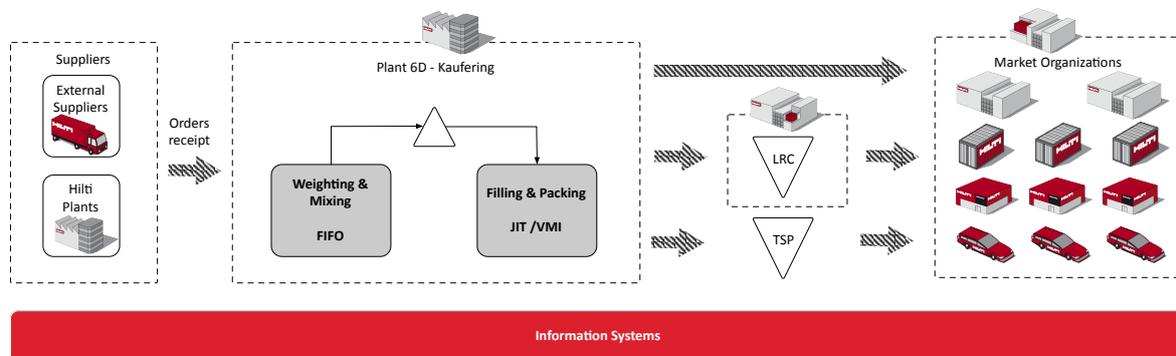


Figure 1.11 – Supply Chain Plant 6D

In comparison to entire GM the plant has high competence in both the planning department as on the production floor. The latter is due to the internal training and continuous improvements. Also the plant ran a pilot for an end-to-end project several years ago, which had great local improvements as a result.

Decoupling of the two production steps is done via a buffer, the so-called vessel station. There are around 10 vessels in the buffer at all times, with different mortars. From the buffer they are used at the filling lines where individual tubes are filled with the mortars and packed. Depending the kind of order and customer finished goods are consolidated in the warehouse and await shipment. The warehouse has around 1600 pallet places for storage of raw materials, semi-finished and finished goods.

**Plant 6D - Planning** - In contradiction to what we have seen at P4 the logistic team of P6D is not split up in sub departments. Instead materials managers deal with procurement and planning of the entire plant. However, the decoupling of the two areas does shift responsibilities of the material managers in a similar way as we have already seen in P4. In the end the material managers are also doing a lot of tasks in Excel spread sheets decoupled from the system.

## 1.6 Thesis Outline

Following this chapter, the idealized design will be presented first in chapter 2. Based on the idealized 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 finalizes this thesis by presenting conclusions, recommendations for Hilti as well as recommendations for the academic field of this research.

# Two

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## End Planning - Idealized Design

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After describing and analyzing the problem definition, or formulating the mess according to Ackoff (1981), the next step in the design phase is the end planning. As mentioned in the methodology, the design approach of Ackoff (1981) is followed during this phase in order to come to a new design for planning and control in an integrated end-to-end supply chain as described at Hilti. The second step of the design approach of Ackoff (1981), ends planning, aims at defining an ideal design first that would represent the future state if the management could design the process all over without restrictions.

In this chapter, we introduce a new theoretical framework for integrated planning that focuses on the needs of a complex, internal, end-to-end supply chain in the context of SCM. This framework has been developed by aligning multiple academic frameworks and continuously reflects towards the Hilti supply chain. In section 2.1, the design approach is elaborated. The complexity of the supply chain is introduced and necessities in development of a new framework are emphasized. Then, in section 2.2, different academic frameworks are compared to align multiple methods of integrated planning based on the hierarchical planning approach. We discuss why several frameworks are needed and what their added value is for the new framework. Eventually, we provide the hierarchical framework in section 2.3 supplemented with a walkthrough based on a decision function diagram. Finally, the generalizability of the model is presented in section 2.4.

### 2.1 The Design Approach

As there is no “standard” framework available in literature that integrates the complete supply chain a design approach is taken to develop a new one. According to Ackoff (1981) Ends planning is defined as: “selecting the ideals, objectives and goals to be pursued by preparing an idealized design”. The design approach thus aims to develop an ideal model. This ideal design can be used if no constraints would be present for the stakeholders and encompasses in this chapter the design of a complete integrated supply chain.

According to Bemelmans (1992) what a designer develops is depending on the target he wants to reach. This target will define the system boundaries in order to show what will be analyzed 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. Hence, in general it is better to develop a partial solution than a total solution that is unusable. Following this reasoning the system boundaries of the newly to be developed framework have further been adapted to the Hilti supply chain. Moreover, the PCIO model of Bemelmans (1990) explains that for every design the first step is to look at the features and characteristics of the system processes (P) and from these the most suitable control (C) can be deducted. This eventually defines the requirements for the information systems (I) and organization (O). Goor et al. (1996) translate this paradigm, originally designed for information systems, to the logistics field of research. Figure 2.1 shows this model of Goor et al. (1996). In

this model the PCIO paradigm is inputted by the company strategy and operational objectives while performance measures can be regarded as the completion of the integrated concept.

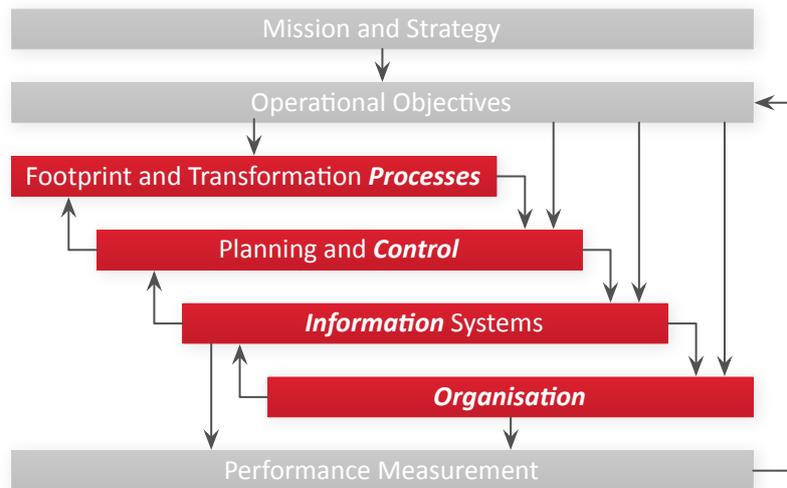


Figure 2.1 – PCIO Model in Logistics according to Goor et al. (1996)

In order to prepare the ideal design we followed the bottom up approach of the PCIO model of Goor et al. (1996) starting with the processes.

### 2.1.1 Fitting Hilti's Supply Chain

We thus set the system boundaries in developing the new framework from a the Hilti reference. Following the PCIO model of Goor et al. (1996) we start by 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 is also mentioned by Wang et al. (2012). Wang et al. (2012) indicates how traditional sales and operations planning (SOP) focus on balancing company supply and demand, and are utilized 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 we use the mindset of Wang et al. (2012) and represent the supply chain of Hilti under the four supply chain stages indicated in the article. This representation was later used as a starting point for our new framework. The result of this representation can be seen in Figure 2.2.

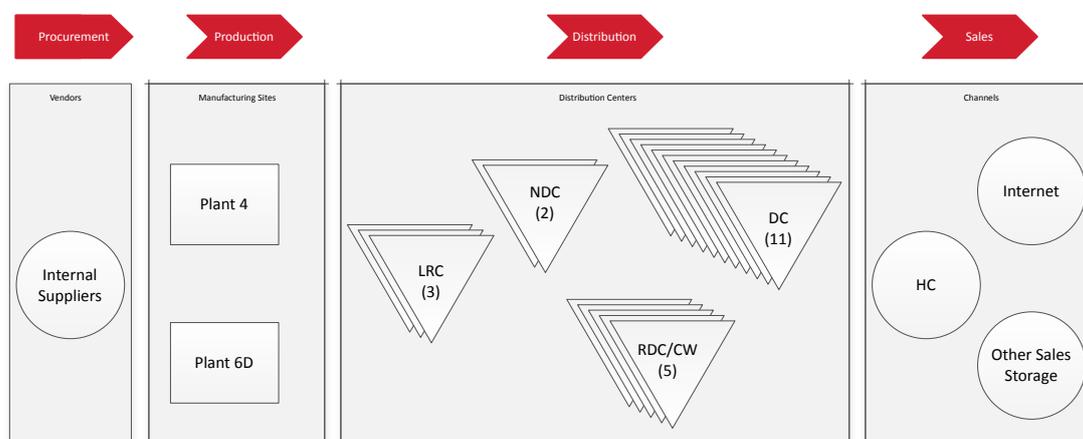


Figure 2.2 – Wang et al. (2010) applied to Hilti's Supply Chain

Next, the complexity is also increasing by the large number of decision that are made in the supply chain network. In order to grasp what important decisions have to be made in the supply chain network the Supply Chain Operations Research (SCOR) method, Figure 2.3, has been used. The SCOR method is a particularly useful tool for analyzing supply chains and revealing redundancies and 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 which have to be planned. Having all four stage 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.

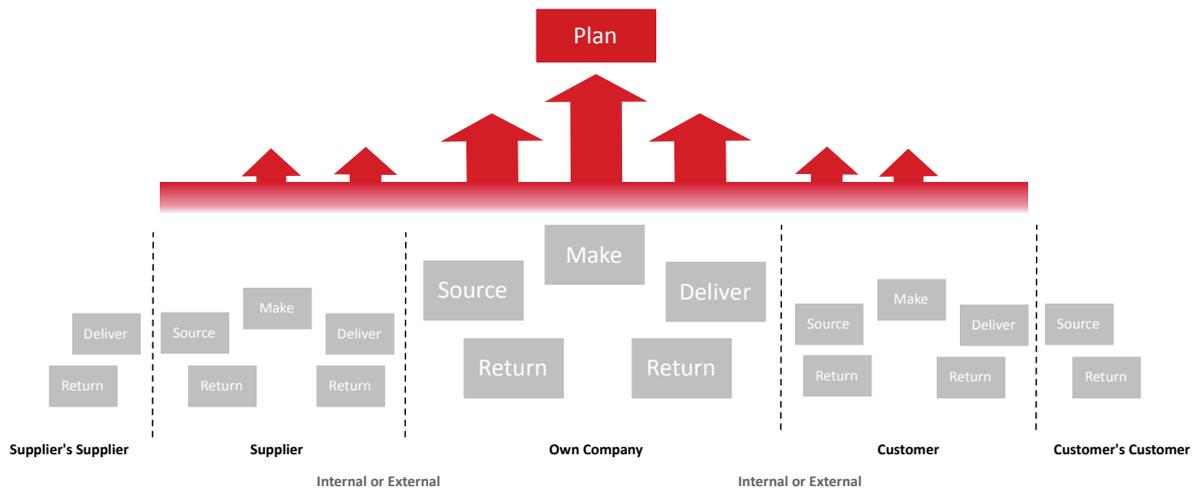


Figure 2.3 – Management Processes of the SCOR Model according to Stephens (2001)

## 2.2 Alignment of Academical Hierarchical Planning Framework

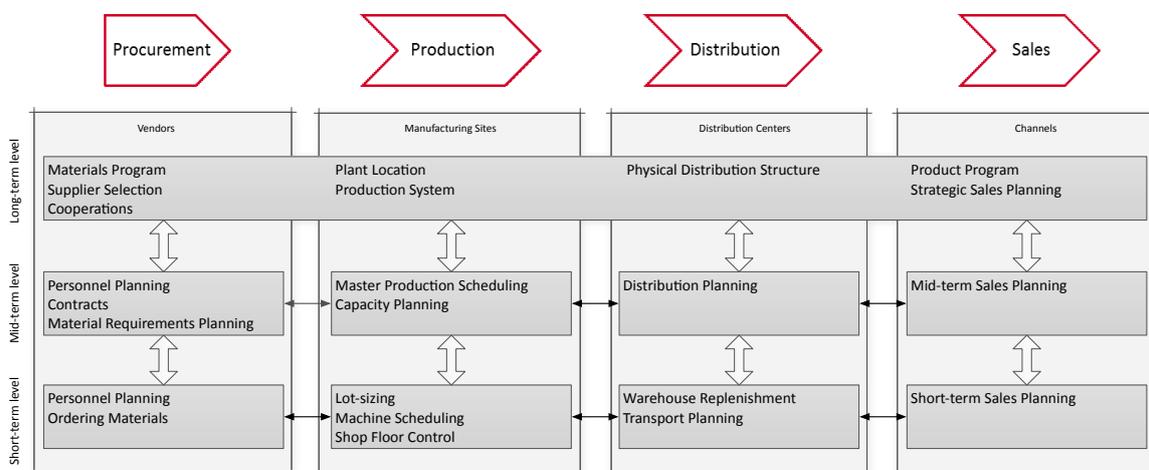
Once the main characteristics and boundaries of the supply chain were clear, we started building the new framework based on existing paradigms in academic literature on hierarchical planning. The choice for hierarchical planning frameworks has been deduced from the literature reviews as a hierarchical framework promises the most success in a complex supply chain.

As mentioned in Kreuwels (2013a), Anthony (1965) formally introduced hierarchical control at three levels (Strategic Planning, Management Control and Operational control) and has become a foundation for academic research on 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 corresponding to the strategic, tactical and operational level. Additionally, De Kok and Fransoo (2003) state that hierarchical planning frameworks enable accurate modeling of consecutive planning and scheduling decisions made in manufacturing organizations. According to Fleischmann and Meyr (2003): *“Hierarchical planning seeks to coordinate planning modules such that the right degree of integration can be achieved“*. Planning modules are derived from a company’s tasks and they pool all decisions within the responsibility of the same planning unit. The planning horizon of planning modules is shared and their timing should be simultaneous (Fleischmann and Meyr, 2003). Planning modules also interact and exchange information and constraints in all directions.

Based on these statements we started our framework with the three hierarchical levels and the 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. Another argument, which seems not to be as academically correct 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. In this aspect, the SCP matrix can be seen as a paradigm in the SCM research area.

Finally, the fitting of Hilti's supply chain under procurement, production, distribution and sales and the SCOR model show the wide variety of decision function 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.



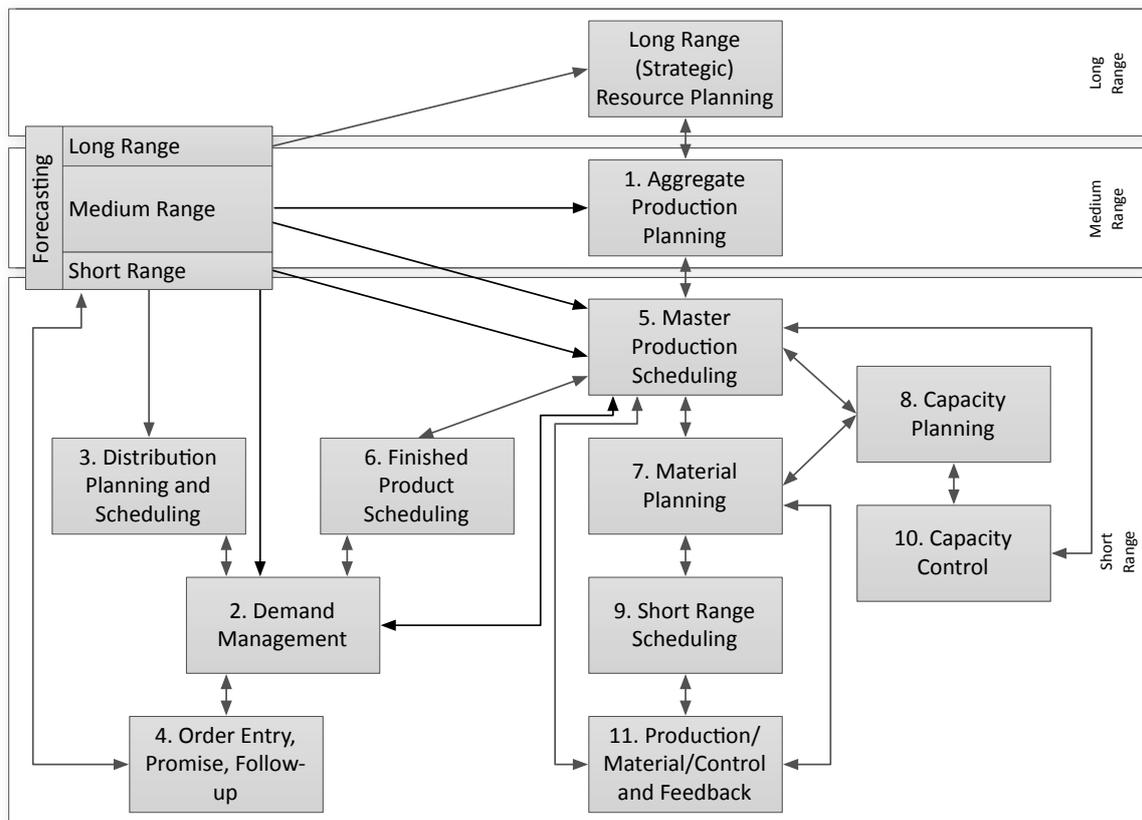
**Figure 2.4** – SCP-Matrix according to Fleischmann et al. (2002)

Figure 2.4 shows the planning modules of the SCP matrix. It is important to note that the same four stages of material flow are used as have already been indicated in previous sections. This makes the fit for the Hilti supply chain more corresponded and allows us to further build the new framework. With the SCP matrix as a base the next step in the development of the new framework is to analyze the level of integration between the planning modules and to improve this integration where possible. Fleischmann and Meyr (2003) state that planning tasks on different planning levels need a different degree of aggregation (frequency, time bucket, product, resources, etcetera). Therefore, in order to analyze the integration we first looked at horizontal integration on the three separate levels. Fleischmann and Meyr (2003) further state the upper planning level coordinates lower planning level and that feedback from lower planning level should give instruction to the upper level. Therefore within every horizontal level we discuss the level of vertical integration. Using a bottom up design we start by adapting the operational 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 requirement (Drexl 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 these processes desire (Silver et al., 1998).

The development of the operational level considered decisions that iterate weekly or even daily and are concerned with 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 we had to fit a production planning concept to the base of the hierarchical framework. As a first step we looked at the MRP-II framework 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).

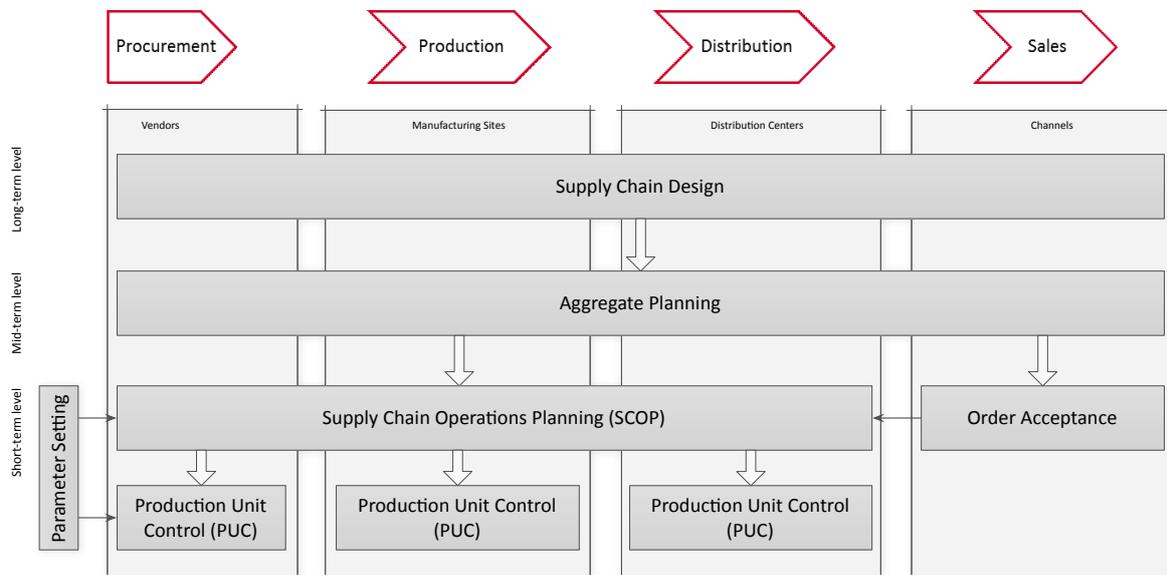


**Figure 2.5 – MRP II Production Decision Framework**

The material requirement planning (MRP) II framework, Figure 2.5, was used first since 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 our purpose the MRP-II framework could thus provide a complete overview for the operational and tactical level on especially the production and procurement stages. Using the input of the MRP-II framework decision functions were adapted on the operational level. Firstly, MRP is placed on the operational level as this considers the stock keeping units (SKU) level. Secondly, the MRP-II framework places master production scheduling the short-term level while it considers the SKU level.

However, the MRP-II framework has several flaws in our opinion. First, the framework makes no distinction between a decision functions which can be assigned to a person of an organization 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 organization. Therefore we fitted the Supply Chain Operations Planning (SCOP) model of De Kok and Fransoo (2003) to the hierarchical framework to come to a redesign of the operational level. Since the SCOP model is already positioned on the operational level by De Kok and Fransoo (2003), with a link to the tactical and strategic levels, it is 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 tactical as well as operational planning by translating aggregated planning decisions into operational execution decisions. This ensures better vertical as well as the horizontal integration of the hierarchical framework and is therefore seen as another argument to fit this model first. When composing a decision problem and constructing 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 centralized 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 such a fixed time bucket eliminates this weakness in the SCP matrix improving our framework.



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

Production unit control (PUC) implies that operational decisions are taken locally (regionally) in order to optimize 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 production units because of the decoupling that takes place with a controlled stocking point. Due to the fact that the PUs will be present in several stages they are renamed 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 supply chain network under consideration where production lead times of 12-14 weeks exist. 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 safety stock, 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 on the tactical level. Parameter setting on operational level would contain too much noise and parameters used in this level should be set already in the higher levels, including a feedback loop from the operational level.

### 2.2.2 Tactical Level

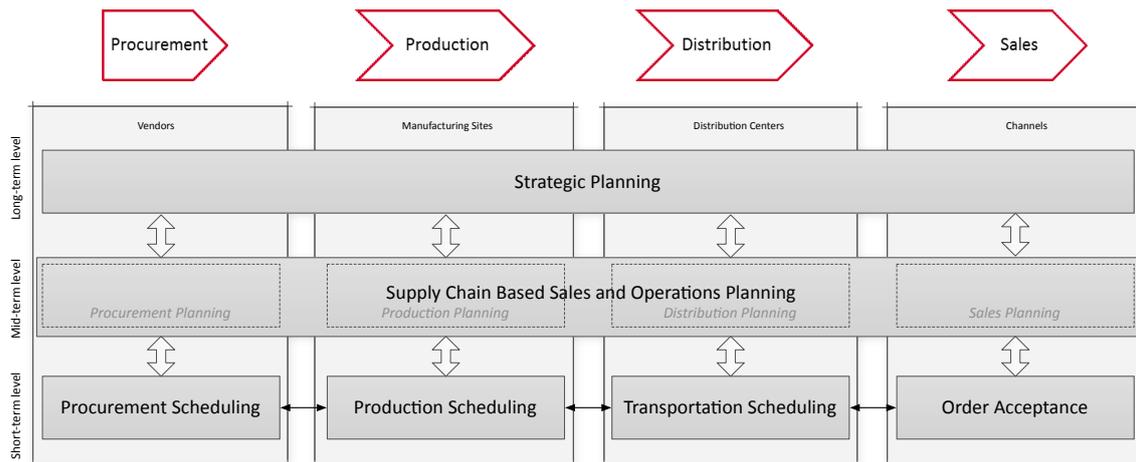
As mentioned before, De Kok and Fransoo (2003) relate to the decision functions considering the planning of operations in the SCP matrix of Fleischmann and Meyr (2003), however, they abstain from other functions like supply chain design and transportation planning. We therefore had to replace the tactical level of the hierarchical framework but keep the link from the aggregated planning to the SCOP decision function.

Tactical decisions have to be made monthly, consider the start-up and continuance of the goods flow on mid-term (months), and are made separate from the strategic level, by middle management (Fleischmann and Meyr, 2003). Tactical plans encompass a horizon ranging from half a year to two years (Silver et al., 1998). Tactical decision functions consider a planning horizon that consists 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 (2013) on Sales and Operations has been used. When analyzing the tactical level several weaknesses could be discovered which were related to the comprehensive but non-integrated planning modules between 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 of 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 global profitability. In order to overcome these weaknesses, the SOP literature review is used to integrate this level in a cross-functional manner. SOP 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) introduces a Supply Chain based Sales and Operations plan (SC-SOP) integrating all the planning modules in the different stages on the tactical level. The results of Feng et al. (2008) indicate that this SC-SOP 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-SOP and its superior performance led to the adaptation of our hierarchical framework according to the example of Feng et al. (2008).

Feng et al. (2008) already uses the SCP matrix and decision functions of Fleischmann et al. (2002) and defines SOP 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 to be preparations leading to the eventual decision (SC-SOP).

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 in the operational level, this parameter setting has to be introduced to the tactical level. Tactical parameters are ground rules for the decision functions on the tactical level and include self-imposed boundaries coming from physical constraints like capacities or lot sizes. They are controlling the tactical level. Bearing in mind the complexity of the supply chain network under consideration, the entire chain should be taken into account in order to define cost optimal parameters.



**Figure 2.7** – SC-S&OP fitted to SCP-Matrix according to Feng et al. (2008)

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/mid-term level. Firstly, MRP is placed on the operational level as this considers the stock keeping units (SKU) level. Because of this, aggregated MRP is developed to make decisions in volumes and money on 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 on the tactical level.

### 2.2.3 Strategic Level

Following the bottom up approach we conclude the hierarchical framework by adapting the strategic level. The strategic level gives input for the already developed tactical and operational levels. As mentioned in the tactical level, Feng et al. (2008) uses the SCP matrix and defines 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 have to be made only once or have to be thought over very seldom, and consider the structure of the goods flow Fleischmann and Meyr (2003). The strategic/long-term level is defining the strategy and the design of the supply chain and the decision functions in this level have a large impact on the long-term performance of an organization (Goetschalcks and Fleischmann, 2008). The horizon of the decisions is for 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 whole supply chain. Since we strive for more integration this will remain an integrated decision function in our ideal design. Eventually all decision made in all four stages of the material flow are summarized in the strategic plan.

During the development of the operational and tactical level, the MRP-II framework has been used, as has been emphasized before. By using the input of the MRP-II framework several missing links were also indicated on 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 on the strategic level as this is necessary to steer the resource

planning decisions on the lower levels. Using the bottom up adding this decision functions was consistent with further alignment of the strategic and tactical levels has been assured.

Additionally, we made adaptations based on our own judgment. First, on all levels sales planning as mentioned by the SCP matrix is split up in forecasting and sales planning. This has been done to make a clear distinction between only 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 parameter 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 on all three levels a new hierarchical planning framework as shown below has been designed. The framework shows the final decision functions on 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.

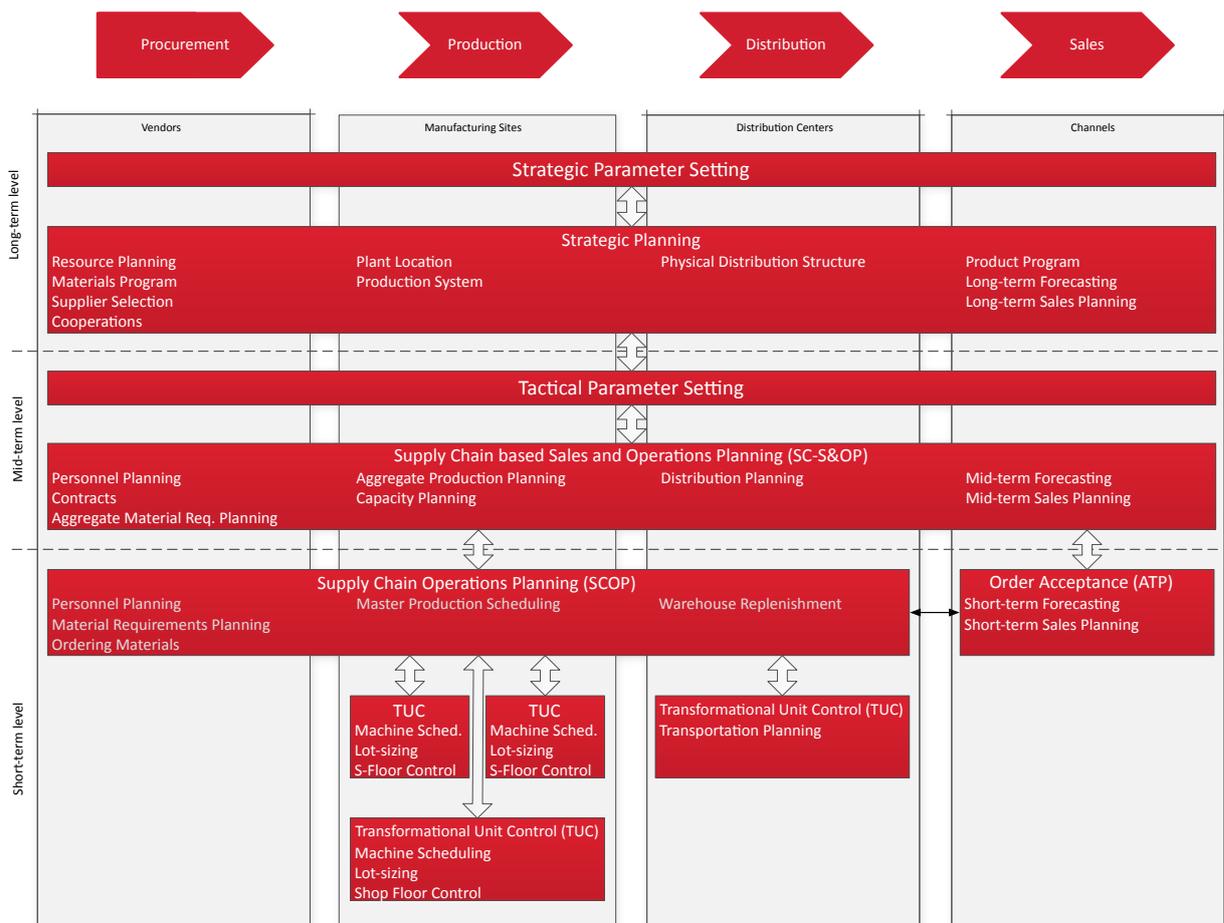


Figure 2.8 – Final Ideal Design of Hierarchical Planning Framework

On 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* is considering 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 organizing single production plants in terms of layout design and the resulting material flows between the machines (Fleischmann and Meyr, 2003). The distribution stage is considering 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 what 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.

On the tactical level, first *tactical parameters* are set for the entire supply chain. To be able to integrate planning processes on the tactical level with SC-S&OP, a number of planning parameters for the process have to be established. Decisions on the tactical level can adapt logistical control parameters like ordering method, order frequency and safety stock (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). *Aggregated material requirements planning* entails the planning of parts of subassemblies on an aggregated level for the mid-term. For the production stage, aggregated production planning and capacity planning are the established decisions. *Aggregate production planning* is part of the process to develop the tactical plan supporting the organization's business plan (APICS Dictionary, 2013b) and defines the production volumes for the next planning horizon. *Capacity planning* entails the amount of capacity needed on aggregate 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 is considering 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 on 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*" (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.

On the operational level, for the procurement, production and distribution stages there is one higher level *SCOP decision* on the operational level that releases materials and resources to be executed by the transformational units (TU). 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 are present to 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 fulfillment of customer orders on this horizon. *Order acceptance* controls the total amount of work accepted by the supply chain, and externalizes the portion of the customer-perceived lead time that is due to varying demand that cannot be processed within the fixed and controlled lead time (De Kok and Fransoo, 2003).

### 2.3.1 Decision Function Diagram

The hierarchical framework only shows the decision functions in their respective hierarchical level and stage but lacks in time aspects. An Operations Planning and Control (OPC) concept can be used to represent these time aspects and consists of a set of hierarchically ordered decision functions that eventually lead to 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 consisting of 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 needed since a decision function in a higher level can control a decision function on a lower level and decision functions on the same level can be input of for each other. To show this reliance a natural time hierarchy has been developed with a certain level of aggregation in order to clearly represent all aspects of the OPC concept. Frequency has been added to indicate the cycle time of a decision function and the amount of repetitions in a certain time period.

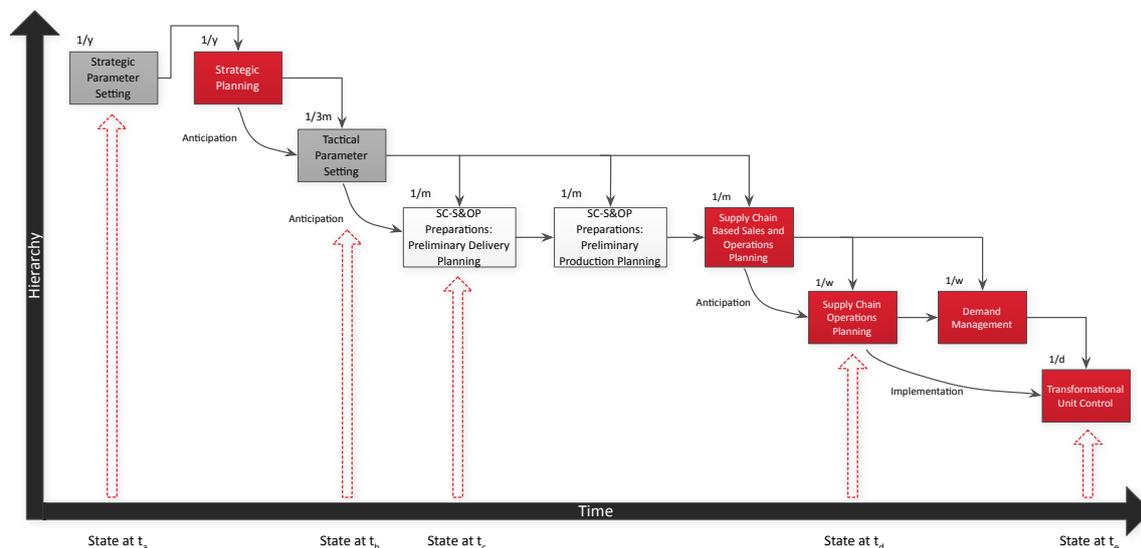


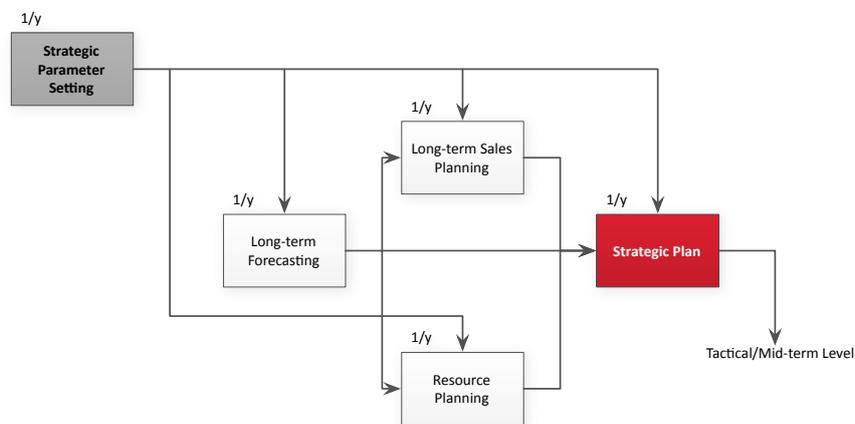
Figure 2.9 – Aggregated OPC concept

The dependencies can be expressed in four ways, anticipation, reaction, instruction and implementation and are deduced from the literature review of Kreuwels (2013a). *Anticipation* is performed by a top-level towards a lower-level. It can be explained as choosing an anticipated lower-level and taking into account its impact on the top-decision. Quite 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 of the top-level on the base-level is called an *instruction* and a feedback loop from the base-level towards the top level, which is triggered as a response on the instruction, is called a *reaction*. Finally, all levels agree on a decision which results in an implementation influencing the object system, this object system can give a formal feedback on the *implementation*.

Once we have indicated the hierarchy we can disaggregate to a lower level to elaborate on the full OPC concept. All three levels of the hierarchical level are disaggregated and elaborated in sequence. It has to be noted that only the planning decisions have been represented in this diagram and that no form of hierarchy is present anymore in Figure 2.10, 2.11 and 2.12 .

**Strategic level** - Strategic parameters are set maximally once a year and control the decision function on the strategic level. It shows that decisions are made in order to come to a strategic plan once a year in a certain sequence. Forecasting provides input for both sales planning and resource planning which in their turn are input for the development of the strategic plan. Eventually, the strategic plan controls the tactical/mid-term level.



**Figure 2.10** – OPC concept of Strategic Level

**Tactical level** - The tactical level has been integrated in the multi site-SC-S&OP approach according to Feng et al. (2008) which leads to an SC-S&OP plan. We deviate from Feng et al. (2008) in the way we come to this final plan. Where Feng et al. (2008) uses an algorithm to come to the final the SC-S&OP plan is our OPC model is based on two preparation plans. This adaption was made since the data collection for the algorithm is recognized to be very challenging, according to Feng et al. (2008) since data is often inconsistent, not standardized or even not available at all. By replacing the total algorithm with preparation plans we overcome this data problem and make the OCP concept feasible for implementation.

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. Second, the production plan uses the input of the delivery to perform an aggregate MRP. This MRP serves as an input for personnel planning, capacity planning and aggregate production planning. Both capacity planning and personnel planning are performed before the aggregate production plan is made. 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 that is made in order to make the master production schedule more feasible. Since in our model the MPS is part of SCOP function we had to incorporate the RCCP in 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 (2013). The SC-S&OP plan controls the demand fulfillment on the sales stage and the weekly SCOP decision on the operational level.

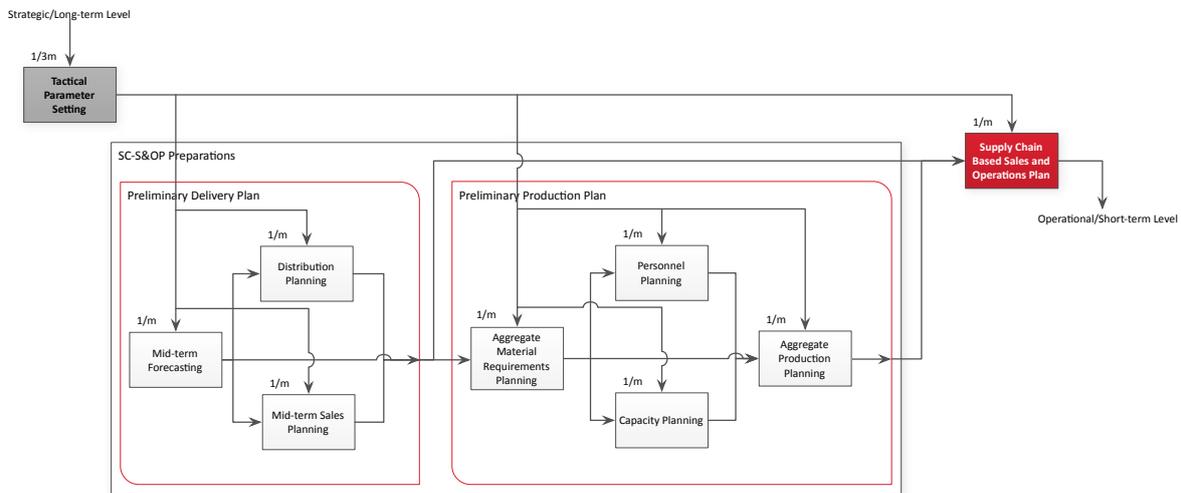


Figure 2.11 – OPC concept of Tactical Level

**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 instead of separately. The SCOP decision eventually sends and 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 optimize 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 and the TUC decisions are performed daily. The 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.

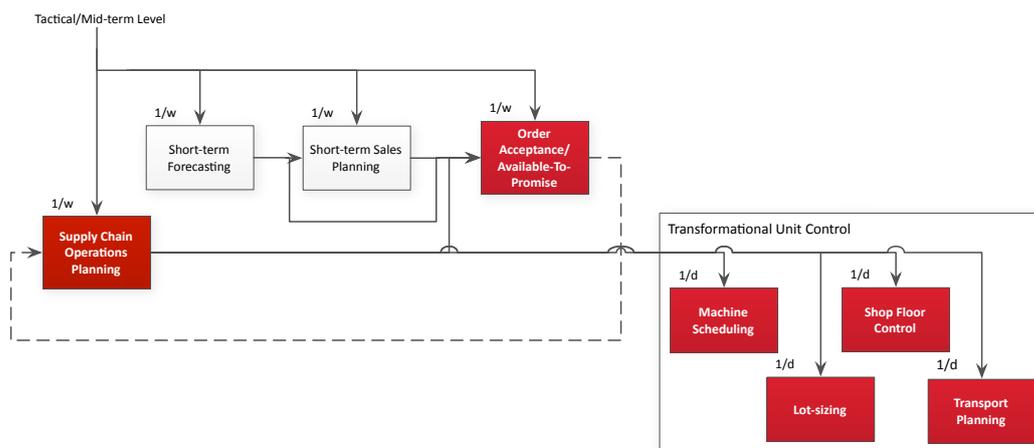


Figure 2.12 – OPC concept of Operational Level

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 OPC concept depicted above refrained itself from the use of swimming lanes as it requires decisions on organizational

structures, which are part of the next step of the PCIO method. Though, as a proof of implementation the swimming lane method is used later to formally document the new planning concept of the Hilti supply chain in chapter 4.

## 2.4 Generalizability

According to the PCIO model presented in section 2.1 the design of planning and control comes after designing the primary processes in a design approach. 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 generalizability can be achieved. In this section an attempt to proof the generalizability is made.

The developed hierarchical framework is a modification of general planning and control frameworks which by itself suggest the generalizability of this framework. Strategic and tactical parameters have to be set for every supply chain and strategic or tactical decisions will be made based on these parameters. Although the strategic and tactical parameters are specific for every company, the way of controlling and planning for them and the hierarchical positioning of the decision functions can be seen as a general model developed from combining multiple academic frameworks developed over time. The specifics of the supply chain coincide with the idea of the transformational units being black boxes with characteristics that have to be controlled. The decision functions represented in our design occur in most supply chain types, but with various contents in the particular businesses. Using a bottom up approach any business should be able to fill in the contents.

As was described in the literature review of Broft (2013), 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/mid-term decisions and their integration possible for all sorts of supply chain complexities. The literature review also described the need of designing the process of S&OP specifically for every company, as also is true for the other processes leading to decisions in the hierarchical model. This leads to our design proving to be general in planning and control for an integrated supply chain in at least some extend.

Referring to Feng et al. (2008) and their multi-site SC-S&OP model, it can be seen that the operational level could be divided between different locations of the procurement, production, distribution and sales stages. It can be concluded that the operational level does not have to be integrated on all sites of the company if the (transformation) processes are unrelated or even in different parts of the global market. If this is combined with the believe of SCOP and its relation with black boxes being the transformational units (already controlled locally), it can lead to multiple operational SCOP decisions and provide generalizability 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 generalizable for all situations as long as the lead times, and input/outputs to the transformational units are known.

We recognize that the developed ideal model will not fit every supply chain. However, the model includes all four stages of the workflow and defines the hierarchical levels with its roles and responsibilities. In doing this it leaves sufficient space for specific company content. Hereby we expect it to be broadly generalizable and applicable to the majority of supply chains.

# Three

## Ends Planning - Gap Identification

As a part of the ends planning, started in the previous chapter with developing an idealized design, in this chapter we attempt to identify the gaps between the idealized design and the planning landscape at Hilti. As mentioned before, in general it is better to develop a partial solution than a total solution that is unusable (Bemelmans, 1992). Therefore, the scope is narrowed further by treating the TUs as black boxes corresponding with the theory of De Kok and Fransoo (2003). In correspondence with the bottom up approach the highest level of the hierarchy, the strategic level, is also left out of scope. This decision was made considering time and resources for the research. In this chapter we first discuss the integrated planning gaps over the entire supply chain in section 3.1. Hereafter, in section 3.2, we further elaborate on the gaps that were identified within GM.

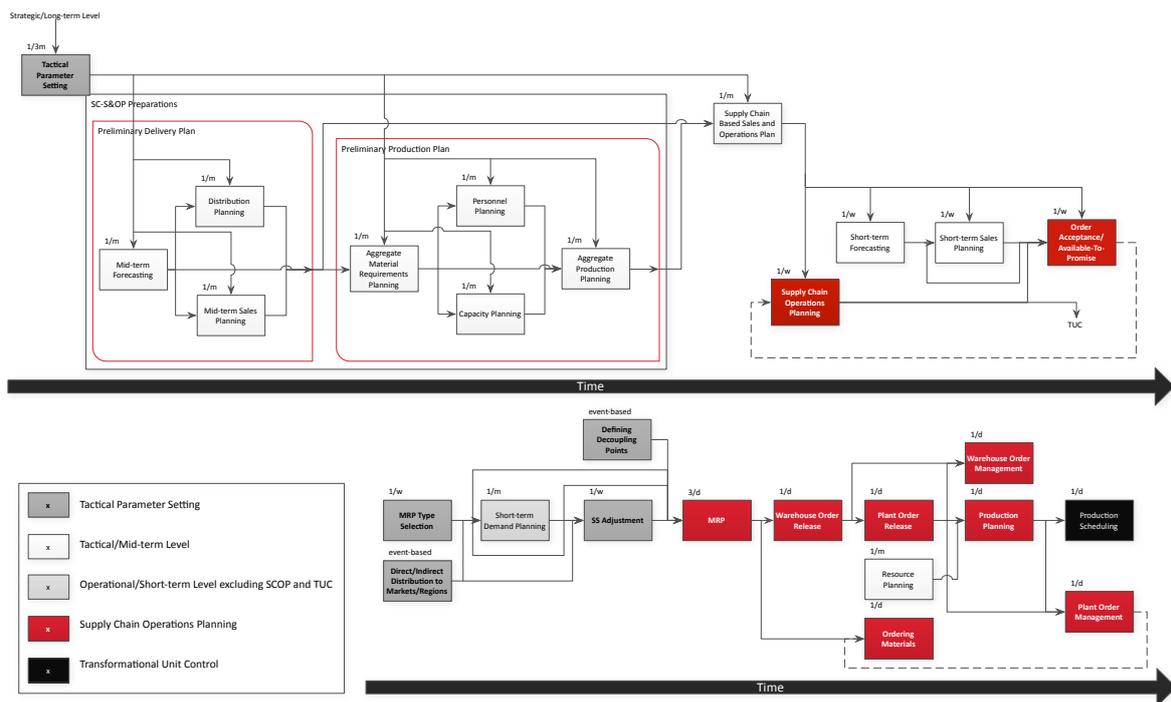


Figure 3.1 – Gap Identification

### 3.1 Identified Integrated Planning Gaps

The identified integrated planning gaps were categorized according to the two axis of SCI. Firstly, the vertical, hierarchical character of the theoretical framework is missing in the current situation, resulting in inappropriate integration between decisions that should be taken on different levels. Secondly, a consistent, horizontal, cross-functional integration is clearly missing, resulting in the identified 'silo' thinking.

### 3.1.1 Hierarchical Planning

**Structure** - Comparing the hierarchical levels of the ideal design with the levels within the Hilti supply chain we find several gaps. Although strategic decisions and strategic plans seem to be present, there is no clear division of the tactical and operational level. For example, distribution planning as depicted in Figure 3.1 on the tactical level 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 tactical level that controls the operational level the decisions made on the operational level only optimize the represented location instead of the entire supply chain.

Not clearly following from the hierarchical planning structure as presented, but noticeable in the hierarchy on 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 fulfillment of internal orders and eventually lower reliability of lead-time to the customer.

**Decision Making** - Tactical decisions are only sometimes 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, also no tactical parameters are set in the current situation to make mid-term decisions. The current parameter setting is divided in multiple decision functions that are controlled independently of decisions of other functions in the supply chain and changed whenever necessary. This means there is no quarterly parameter setting considering the whole supply chain as presented in the idealized design. Due to this missing tactical control, decision making is focusing more on whether what is decided is decided well, 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 ideal design suggests, aggregation is needed in an appropriate level in order to function on both hierarchical levels. Interaction between the hierarchical levels is needed since 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 ideal design the system has to be able to support decisions on different hierarchical levels which is not present now due to the lacking tactical level. The SAP system that is now in place, 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 system wise.

### 3.1.2 Cross-Functional Planning

**Structure** - Comparing the current situation with the ideal design there is 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 division based on the four stages of the material flow.

Additionally, on the operational level the SCOP level is the cross-functional integration of procurement, production and distribution which is not present currently. In stead the tasks are performed strictly within every stage and with limited other communication then the systems proposals.

**Decision Making** - Currently decisions made in the procurement, production, distribution and sales stage are not integrating the complete supply chain, making the supply chain horizontally dispersed. On 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, recognized as a gap before, the decision making between the four stages can be integrated using an S&OP technique. The ideal design uses a SC-S&OP decision that exists of two preliminary plans. These plans give the opportunity to transfer several already existing (tactical) decision functions from the operational to the tactical level and assure supply chain wide development of missing decision functions closing the gap of the horizontal dispersed character.

The SCOP decision in 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 decentralized and is not integrated. This leads for example to nervousness in the system due to lack in transparency and can be seen in the volatility of the demand in the production plants.

**Communication** - The way tactical parameters are currently set is ad hoc and also independently of other functions in the supply chain. As mentioned before, therefore the parameters are not cost optimal. The ad hoc parameter setting leads to the gap that the cross-functional communication of these changes in tactical parameters is not present. The effect of changing a tactical parameter in 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, the four stages are communicating in different numbers making communication harder. The ideal design uses the SC-S&OP plan to balance the sales, capacity, items, volume and monetary values into a 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 is controlling 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 of 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 is considering 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.

## 3.2 Global Manufacturing

The results of the integrated planning gaps that we identified in the previous paragraph can be observed in the plants. For practically none of the integrated planning gaps there exists any kind of GM broad guideline. This does not mean the decision functions are totally lacking. As mentioned before both analyzed plants have a highly competent workforce meaning planners and material managers developed their own Excel spread sheets to cover with missing information or tools. However, due to the missing tactical level, tactical decisions are often made on the operational level. Especially in GM this can be well observed as the following examples will indicate.

For a complete overview of the identified gaps and more field study information we kindly refer to Kreuwels (2013c).

### 3.2.1 Tactical Level

**Personnel Planning** - Personnel planning on a mid-term range is done by the BUs for all plants. So this decision function actually exists. However, the missing tactical level and especially the silos make it so that Plant 4 is not using the calculations at all. While, in Plant 6D planners do use the predictions, but only as one out of three inputs, which gives them a weighted average. Plant 6D needs to do this since German law is strict on people management. However, shift planning as done in P6D should, according to ideal design, be done on the tactical level.

**Capacity Planning** - One of the biggest if not the biggest gap in GM is related to resources. Capacity/resource planning is not at all in place. Plant 4 and several other plants argue that the flexibility of the assembly/production lines is large enough to not have to deal with capacity constraints and thus preparations. As we have already seen in the integrated gaps order release is done unconstrained leading to volatile demand and often a suboptimal mix. Eventually this leads to plants having to postpone or even deny production orders due to capacity restrictions. Also the bad communication during INP and promotions leads to capacity issues.

**Contracts** - This is one of the mentioned inconsistency gaps. For example, Plant 4 has a procurement department and still material managers are ordering raw materials for the machining area. Additionally, the procurement department does not contract the supplier directly but this is done by strategic sourcers at HAG. Since the two procurement divisions have different performance indicators (costs versus availability) the supplier delivery accuracy in Plant 4 is around 60 percent. Also, the procurement department is ordering material for other Hilti plants and transshipping it to these plants when they need it. Plant 4 however, is making the stock costs for these items. In Plant 6D they have far less external suppliers making this a lesser problem, also they do not order for other Hilti plants. The cross-functional silo gap however, is also present in P6D.

**Aggregated Materials Resource Planning** - MRP is fully run by the SAP system but aggregated values are not used by Plant 4 since the JIT orders are leading for the production in any case. Due to this setup the plant can't even pre-produce if it wanted to. Plant 6D does use a form of aggregation but only for the mortar vessels. Since aggregating demand for vessels is a necessity this is done in local Excel spread sheets and is not available to anyone outside P6D. Next to this communication gap, a system gap arises since secondary demand is consumption orientated in stead of demand orientated leading to out of sync orders in the mixing area.

**Aggregated Production Planning** - Aggregation is very hard for P4 since families are defined on assembly line which does not correspond with the BU families who makes the corporate (aggregated) forecast. For 6D production is planned in a different time bucket but resembles the OCP concept. Production is aggregated by the, operational, plant MM in weekly buckets in stead of monthly on a tactical level with a longer horizon.

### 3.2.2 Operational Level

**Master Production Schedule** - In the entire GM division there is no plant who works with a MPS. This is due to various reasons of which flexibility and JIT production are the most common. The 3 to 5 day JIT lead-time and the high volatility of demand related to this short lead time forces Plant 4 to schedule their production in a flexible way. By the use of a montage-plan material managers together with line coaches make a day to day planning at the beginning of each day. In the OCP concept this schedule would be made a week in advance and preferably by a central team with a supply chain vision. This does not only give the plant great smoothing capabilities but it also serves the availability towards the MOs.

**Personnel Planning** - On a short term the scheduling of personnel is done depended of the location. In Plant 4 the amount of people can change from one day to another making scheduling

easy on this time line. However, availability and bad communication from the markets leads to under capacitated assembly lines. In P6D the personnel is scheduled for a two-day time line but is fixed for the entire week according the shift planning.

**Order Release and Net Demand Calculation** - Order release is done in several stages of the Hilti supply chain, again coming from the integrated silo gap. After a MO has released a replenishment order this is, mostly, automatically turned into a production order at one of the plants. This happens unconstrained and without a capacity check leading to volatile demand at the plants. Also the NDC The mentioned algorithm gap can thus be perceived in these decision functions.

### 3.3 General Consequences of 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 we determine the possible effects of filling the gaps according to the ideal design. The actual way of how to fill the gaps is, according to the design approach of Ackoff (1981) subject of means and resource planning which is done in chapter 4. To elaborate on the gaps and their effects we use a cause and effect diagram, Figure 3.2.

#### 3.3.1 Cause & Effect

In the context of SCM where more companies focus on integrating the supply chain, SCP is becoming equally more important. Especially integrated planning is important 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 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.

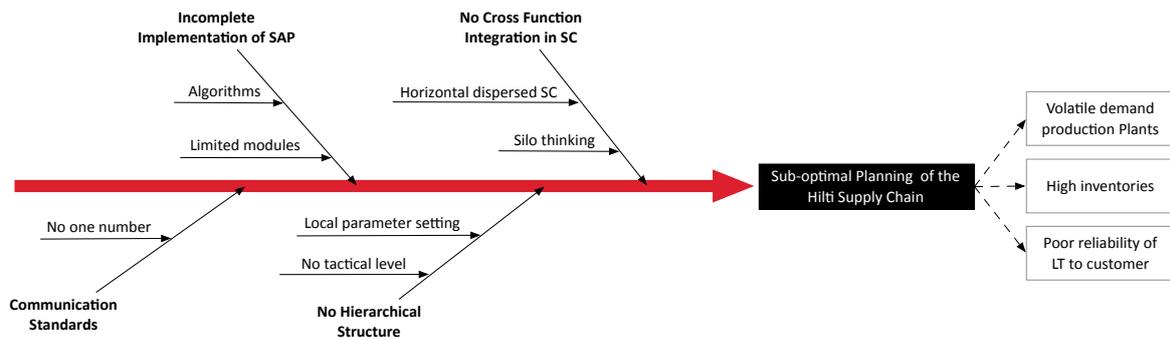


Figure 3.2 – Cause Effect Diagram for Planning at Hilti

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 ideal 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 section above helps to align the necessary data needed in the support.

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 are topics that caused planning to be partitioned. Eventually, silo thinking grew in the organization and is now 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 identified to causing planning problems as the size and reach of the company is too extensive to plan only on 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 of utmost importance in planning. Quality of relationships and communication lines will improve as soon as clear hierarchy, timing and dependencies are defined as in the ideal design.

# Four

## Means & Resource Planning: Filling the gaps

In the previous chapter we closed the ends planning, by identifying the gaps present at Hilti compared to the idealized design. We also linked the gaps to the consequences of the suboptimal performance observed at Hilti. As the idealized design is believed to mitigate or eliminate these causes, the next step of the design approach of Ackoff (1981) is defining the way the identified gaps are filled (means planning). Ackoff (1981) also uses resource planning to determine the required resources for these means. By fitting the ideal model to the Hilti supply chain, we resume the business case proving the applicability of the design. In this chapter first we perform means planning by considering the context, constraints and the current state of Hilti's supply chain. We show in section 4.1, what specifications to the decision functions have been added and what alterations to the idealized design have been made to fill the gaps. section 4.2 shows the implications for both plants. Secondly, in section 4.3, we perform a part of the resource planning by defining responsibilities and roles related to the decision functions.

### 4.1 Adapting and Filling the Idealized Design

Figure 4.1 represents the adapted idealized design for overcoming the gaps at Hilti, hereafter called the Hilti IP concept. Several adaptations have been made to the ideal design based on field data. This data was collected through extensive workshop rounds with important stakeholders of the planning processes at Hilti.

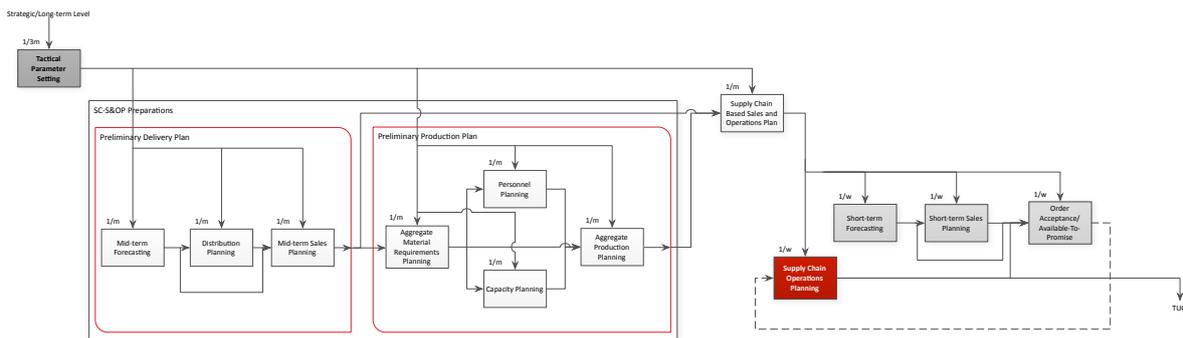


Figure 4.1 – Hilti Integrated Planning Concept

#### 4.1.1 Tactical Level

As mentioned, fitting the OPC concept to the Hilti supply chain forced several adaptations. Table 4.1 shows how the Hilti framework is related towards the OPC concept. The changes on the tactical level will be described and supplemented with the recognized necessary inputs and outputs, considering the context, constraints and current state of Hilti.

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

<i>Idealized Design</i>	<i>Hilti IP</i>	<i>Concept</i>
<b>Decision Function</b>	<b>Change</b>	<b>Nature of Change</b>
Tactical Parameter Setting	No	-
Preliminary Delivery Plan	No	-
- Mid-term Forecasting	No	-
- Distribution Planning	Yes	Now providing input for sales planning
- Mid-term Sales Planning	Yes	Now considering distribution planning
Preliminary Production Plan	No	-
- Aggregate MRP	No	-
- Capacity Planning	No	-
- Personnel Planning	No	-
Aggregate Production Plan	No	-
SC S&OP	Yes	Different input

Tactical parameter setting will remain part of the Hilti IP concept as it was presented in the idealized design. They 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.

The idealized 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 into account distribution planning instead of a separate sales planning based only on the forecast, this extra step was removed in the Hilti IP design. The reasoning for this alteration was 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 of distribution planning that can be used while coming to the sales plan. Implicitly adaptations to the ideal design make the Hilti IP concept weaker than the original ideal design. This adaptation from the idealized design, leads to sales planning being constraint by the distribution plan while in the ideal design the sales plan is only controlled by tactical parameters. The ideal design deals with balancing the distribution plan and sales plan to come to the preliminary delivery plan. Still, the distribution planning preparations can be overruled later. However, the adaptation to make the distribution an input to the sales plan probably will 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 recognized 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 supply chain based sales and operations plan. Next to the advised parameters determined by the ideal design such as: safety stock levels, lead times and lot-sizes Hilti also mentioned maximum utilization of the warehouses, priority rules, profit contribution and service level agreements as possible parameters. These values will be set by integrally considering all relevant supply chain information. Hilti recognized 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 organizations timing of mid-term distribution and sales planning to limit unnecessary re-planning. The mid-term forecast 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 like 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 at the distribution and sales stages, a preliminary delivery plan will be established weighting 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 also available raw materials and components are 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 requirement. 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 aggregated 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 aggregated material requirements planning function.

Based on the preparations at the procurement and production stages, a preliminary production plan will be established weighting 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 organized quarterly with the purpose to come to a ‘one number’, representing the latest estimate on the tactical level. As the preliminary production plan is 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 type in order to be able to make sensible decisions.

### 4.1.2 Operational Level

Fitting the idealized design to the current, context and constraints of the Hilti supply chain resulted in the identical use of the idealized design on operational level. Table 4.2 shows how the Hilti IP concept is related towards the OPC concept. Here it can clearly be seen that there are no adaptations 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 with the field data of Hilti.

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

<i>Idealized Design</i>	<i>Hilti IP</i>	<i>Concept</i>
<b>Decision Function</b>	<b>Change</b>	<b>Nature of Change</b>
Supply Chain Operations Planning	No	-
Short-term Forecasting	No	-
Short-term Sales Planning	No	-
Order Acceptance	No	-

As the SCOP decision is not present at Hilti at the moment, 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. As output, there will be a weekly plan for procurement, production and distribution where the TUs are free to optimize within the boundaries of the set lead times. This 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 to the longest critical lead time within a business unit. This way, for example, chemical anchors 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 business units. However, this only works without complications as long as there are no commonalities between the business units. Therefore, when two or more business units share a raw material the longest critical lead time of all the business units will become leading.

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 theoretical framework 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 functions and responsibilities clear the actual alignment can be discussed. Several fields of interest have been identified that need attention when aligning the two levels. These are the alignment through different frequencies, aggregation levels and targets. The ideal design leaves these fields open so they can be fitted to the content of the company. Using field data we attempt to give further meaning to these field for the Hilti IP concept.

**Frequency** - Both levels have a different frequency; monthly for the tactical level and weekly for 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 way of working (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. As mentioned during the development of the ideal design timing is important.

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 and some can be in parallel.

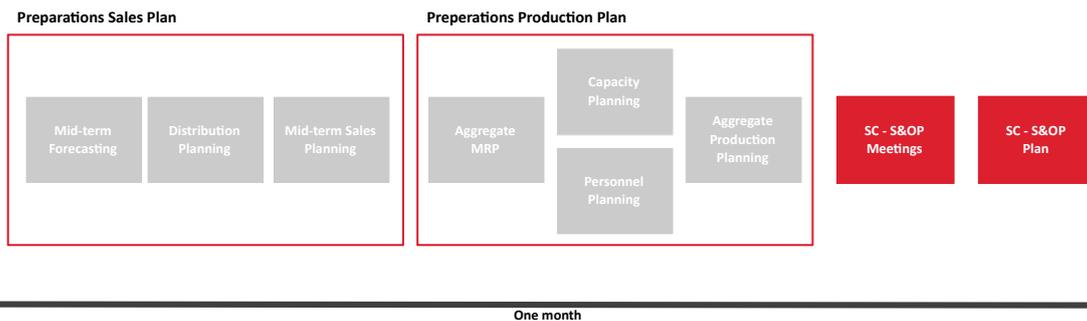


Figure 4.2 – Calendar Sequencing Example

**Aggregation Level** - An important aspect of planning on the different levels is the level of aggregation. On the tactical level the aggregation level is a lot higher than on the operational level. This is because the calculations and decisions on the tactical level are more rough-cut and high levels of detail would unnecessarily add to the complexity of these calculations. On 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 it will be needed/preferred to talk in monetary values on the tactical level where on the operational level always item or item-location numbers are required. Therefore, to be able to align the levels first the correct levels of aggregation have to be decided

for the different constructs (e.g. demand forecasting unit, stock keeping unit, family types and resources).

The formulation of families and their aggregation levels will need special attention since the existing product groups are handled differently in the MO/region, HAG (BU) and Plants. In order to be able to aggregate families, clear decisions have to be taken to what a products form a family so that disaggregation makes sense for the production locations.

The development of aggregation/disaggregation logic in form of algorithms is also of 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 realized by recognizing 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. We have described the design and operation but 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 as they are at the moment strongly focusing on local improvement.

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, suggested before.

**Engagement Rules** - Next to 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
- Prioritization (e.g. priorities based on profitability)
- Exception management
- Stock Positioning

## 4.2 Responsibilities

The ideal design has been depicted in an OPC concept indicating hierarchy, time and dependencies. When fitting this OPC concept to the Hilti supply chain, developing the Hilti IP concept real field data became available. This field data gives us 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 and dependency characteristics of the OPC concept. Furthermore, responsibilities have a high significance to be able to implement the concept in real life.

In order to come to the roles that are responsible for the decision functions, input from Hilti was gathered based on the RAPID (Recommend-Agree-Perform-Input-Decide) method, developed by Bain Analysis (2011), which is 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. Combining the field data with the RAPID model the following roles and responsibilities were determined:

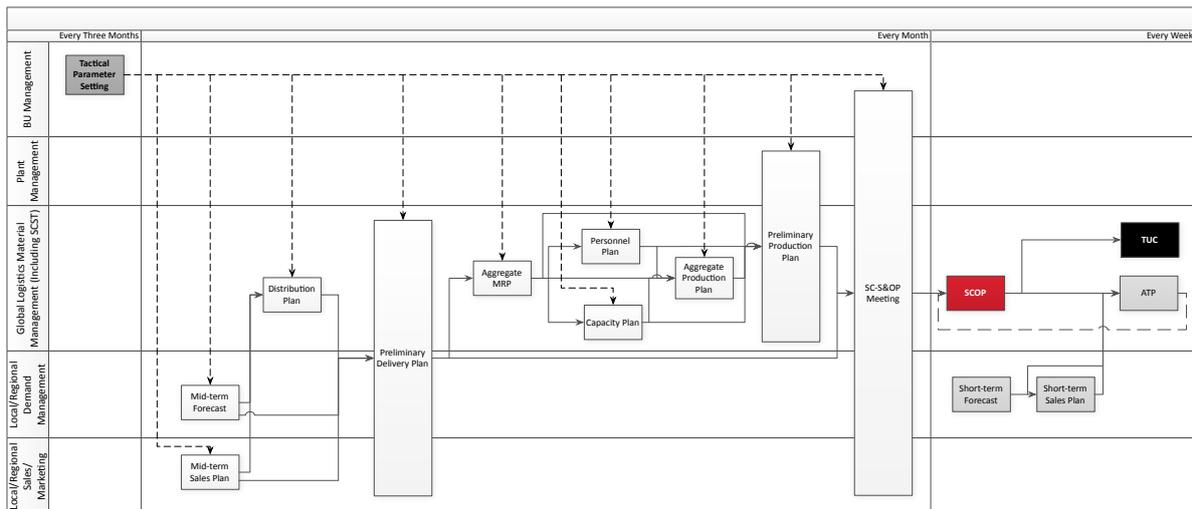


Figure 4.3 – OPC Concept Adapted by the use of Swimming Lanes

**Market/Region Sales and Marketing** - These are the current sales and marketing departments in Hilti which are decentralized to the markets in MOs or regions. They will be responsible for sales planning on the tactical, as well as on 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 if the process is well developed with clear responsibilities.

**Market/Region Demand Management** - The current MM in the markets/regions is combining 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 except the sales functions on tactical level (distribution planning, aggregate material requirements planning, capacity planning, personnel planning and aggregate production planning) and operational level (SCOP and order acceptance) will be formed. Instead of the dispersed decision functions belonging to distribution as-is now, the central team will be responsible for the complete distribution network. 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 supply specialist team will be the main contact point for the plants as well as for the markets/regions in case of exception management.

**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 for the whole 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 have responsibility for the TUC decision functions. As they are represented by the BU Management in the SC-S&OP meetings, they will not have responsibility for this. The biggest challenge will be to transfer their local knowledge to the responsible levels.

Concluding, as has been indicated before, the biggest change in the IP concept is that a lot of responsibilities in decision making are shifting from the silos to a supply chain based team. This team of supply chain specialists is currently not in place but will get a lot of the responsibilities that are aimed at balancing the supply chains needs and capabilities.

### 4.3 Implications for Global Manufacturing

In section 1.5 we have mentioned the effects of the current planning and control system in place at Hilti. The implementation of the Hilti IP concept is expected to have positive effects on the overall performance. However, since the upstream location are hurting the most, the biggest implications and potential to improve also lies in these locations. Table 4.3 shows some of the implications for Global Manufacturing.

**Table 4.3** – Implications for Daily Business in Global Manufacturing

<b>Decision Function</b>	<b>Consequences and/or Implications</b>
Tactical Parameter Setting	Tactical parameter setting will result in more ability to give constraints towards the downstream parts of the supply chain. Lot sizes, EOQ and distribution is out of the hands of the plants planners at the moment. They will get more influence on the tactical level through the parameter setting.
Preliminary Delivery Plan	The delivery plan will be an synchronized figure for all markets worldwide. The latest estimate of this plan will give a far more reliable expected marketing figure then the plants have available in present day.
-Mid-term Forecasting	A prerequisite of the model is better forecast accuracy which will directly benefit the plants since the long lead time raw materials can be planned more accurate implicating lower uncertainty and lower stock levels.
-Distribution Planning	Is now done with fixed lead-times and sometimes leads to excessive pallets of finished goods in the warehouse. This will not happen anymore since distribution can be synced with production.
-Mid-term Sales Planning	Provides a committed number. Can be used in negotiations on S&OP plan but are not important until they are transferred to production volumes.
Preliminary Production Plan	The production plan will be a synchronized net calculated production figure of what will be expected from the plants. It will be on an aggregated level so the plants will get rough cut information about capacity and personnel. This information is expected to be for more reliable then the current forecast information in the SAP APO system. Material reservations for long lead-time materials can be done in a timely manner with higher accuracy then before. The plants will not have to perform a lot of extra actions to get far more reliable information.
SC S&OP	The SC-S&OP plan will provide every plant with a one number that can be translated to own production volumes bringing more transparency.
SCOP	The introduction of the SCOP decision function will be the biggest but possible also most beneficial change. The plant planners will lose a lot of freedom in production planning but by giving away this freedom the quality of the production plan can perfectly smooth production in weekly time buckets. The main task will shift to scheduling and exception management on the shopfloor.
Order Acceptance	The Plant will no longer get excessive demands from last minute promotions. Only undedicated stock is available on the short-term and the ATP check will not accept higher demand without consultation with the SCST. This way the KPIs of the plants should be positively influenced.

# Five

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## Design of Implementation

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The last phase of the design approach of Ackoff (1981) concerns the design of implementation. It is concerned with the questions of who is to do what, where and 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 can be executed in real life. Hence, it can be seen as a final step coming from the high conceptual ideal design to a concrete set of actions to be performed in order to reach the ideal situation in real life.

As indicated in Kreuwels (2013a) in order to succeed ‘softcore’ or human aspects are 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 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. They are caused by factors or are influencers that are often hard to control. By identifying them in a force field analysis, Figure 5.1, especially the restraining forces can be handled before they can influence the project in to large of a scale.

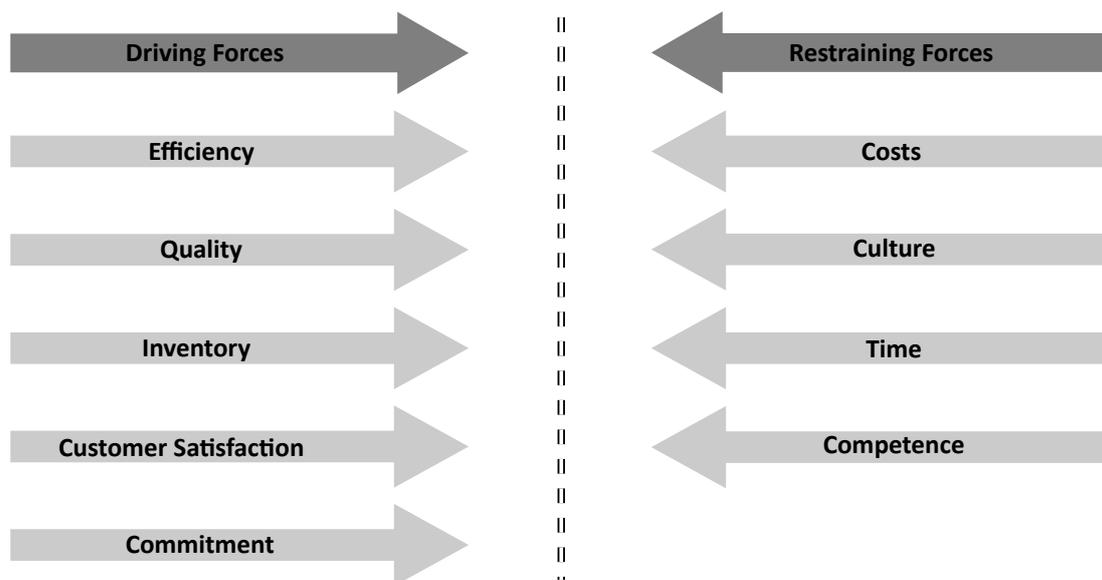


Figure 5.1 – Driving and Restraining Forces for Implementation Hilti IP Concept

**Driving Forces** - Efficiency is the first driving force. By implementing the IP concept and following the design the efficiency of especially material managers can improve a lot. If the workforce and management recognize this potential efficiency can be a great driver as Hilti has a strong lean culture that constantly searches for better improvements. Closely related to efficiency is quality. It refers to the quality of the information, which will improve in accuracy, transparency and comprehensibility, but also to performance indicators such as product availability (PA). As both information and availability are often frustrating the KPIs this can be a big driver as well. Inventory levels are expected to decline since the integrated planning concepts ensure less nervousness and higher accuracy in the entire supply chain. This eventually will lead to higher customer satisfaction. And since the company vision is aimed towards the customer this force can influence the workforce in all layers of the organization. It also has the potential to win 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 Global Logistics and Global Manufacturing and the support of the IT department can be seen as a great driving force for the future implementation plan.

**Restraining Forces** - Costs are almost always a restraining force in change management. Although the project has high commitment there are many initiatives at Hilti that require funding and financial gain is often an important decision tool. For the IP concept it is hard to give an accurate number of financial gain since the implementation plan will indirectly influence a lot of factors. If the financial gain cannot be made clear the costs of the project might be a serious threat. Also the company culture can be a restraining force since the project does not fit the lean management way of thinking. 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. But real results will be hard to show in the first years since the SCST team has to be built up gradually. This brings us to the last restraining force, competence. Momentarily Hilti does not have the right competence in-house to form the SCST team without risking to lose vital knowledge in other areas. Therefore new and highly ambitious employees have to be hired which can be difficult in the current market. Highly educated supply chain specialists are scarce and it might be hard to find a team of these people in a short amount of time.

### 5.1.2 Stakeholder Analysis

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

The formal decision maker that can authorize the change is the Head of GL (here, GL senior management). 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 be the responsibility of middle management, affecting in Hilti also the responsibilities of senior management as they have a multi-entity structure in their organization.

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. The senior management of WM, TM and MM is therefore also a stakeholder. Senior management of MM is involved from the

**Table 5.1** – Stakeholder Analysis

Stakeholder Preposition to Change		Commitment	Aware	Interested	Want Change	Desire Action
<b>Senior Management</b>						
GL	Innovator	Committed	x	x	x	x
MM	Innovator	Committed	x	x	x	x
WM	Early Adapter	Supportive	x	x		
TM	Early Adaptor	Supportive	x	x		
GM	Early Adaptor	Committed	x	x	x	x
Sales/ Marketing	Early Majority	Supportive	x	x	x	
<b>Middle Management</b>						
MM	Early Adaptor	Committed/ Supportive	x	x	x	x
WM	Early Adaptor	Supportive	x			
TM	Early Adaptor	Supportive	x			
<b>Operations</b>						
MM	Early Majority	Committed/ Supportive	x	x	x	
WM	Early Majority	Supportive	x			
TM	Early Majority	Supportive	x			
TU	Early Majority	Supportive	x			
<b>Support Departments</b>						
BUs	Late Majority	Suspicious	x	x		
IT	Early Majority	Supportive	x	x		x
HR	Laggards	Neutral				x
3PL	Laggards	Supportive		x		

beginning of the project and have shown great support to the project as well. The driving factor for this 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 the senior management of the logistic regions and HAG (and might in some cases even be one person). As a supplement to this, the senior management of the sales/marketing regions is a stakeholder for implementation of the decision power on the sales plans. These are expected to have a positive attitude towards the project as they will gain decision power on the latest estimate of the sales plan and also will get a (expected) more reliable lead time to the customer. Finally, senior management of GM has to be involved as a lot of responsibilities will be taken away from their department. Their attitude is leaning towards the positive despite the loss of responsibility, because of the gain in more stable production plants. Also, their concerns are mitigated by the stay of the TUC responsibility.

As mentioned, in the new hierarchical structure existing decisions and responsibilities will be shifted towards middle management. These stakeholders have been involved in the HIPP project from the start and all have 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 of 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, 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 created, taking over responsibilities from the local MM teams. The negative attitude towards this change might become visible in these stakeholders, as there is a possibility that a lot of their jobs might become redundant. Especially, as the central team will need employees with high 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 has to 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 a different party, the central team. This is not seen as bringing a negative attitude towards the change but the change has to be communicated in a proper way.

Last there are several support decisions that have to be considered. The BUs as a department are not part of the preparing HIPP project and have to be brought on board later in the project. At this time several big decisions have already been taken. This could lead to a negative influence towards the project. The opposite goes for the IT department that is already brought on board early to support decisions and give input of the possibilities. Human Resources (HR) have to be involved since a lot of material managers are shifting responsibilities around and new SCST team members have to be hired. They are not specialists and do not share the same goals as GL so will be neutral in their commitment. Other departments will have to get equal attention. Last but not least there are the 3PL who will see a lot of information and material flows change. It is not yet clear whether the new way of working will increase or decrease their business with Hilti but less inventory and more FTL would imply a decrease in storage and transshipment. Nevertheless, in principle they will be supportive but mostly interested in the changes.

### 5.1.3 Leadership

Since full implementation of the IP concept can take up to 8-10 years, leadership is going to be very important. Preferably leaders will be part of the change management as long as possible and there will be limited to no changes in high positions, particularly among change leaders a core group of forerunners is preferred.

Especially for these forerunners the leadership style will be important. Using the model of Vroom-Yetton-Jago a style has been determined that fits the action plan best. The underlying assumption of the Vroom-Yetton-Jago decision model is that no single leadership style or decision-making process fits all situations. Analyzing the situation and evaluating the problem based on time, team buy-in, and decision quality can help make a conclusion about which style fits the situation best. The model defines a very logical approach for selecting a leadership style to adopt 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 we are dealing with a complete chain and thus with different structures, visions and cultures, the decisions model is based upon a dynamic environment. The model uses seven structured questions that all direct to a certain leadership style to adapt. The 'team' consists of all Hilti material managers and the 'leader' consists of the Hilti managers present in the steering board. Appendix B shows the clarification of the questions. Figure 5.2 shows the model for the Hilti IP



## 5.2 Action Planning and Implementation

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 to gradually 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 require a more radical approach.

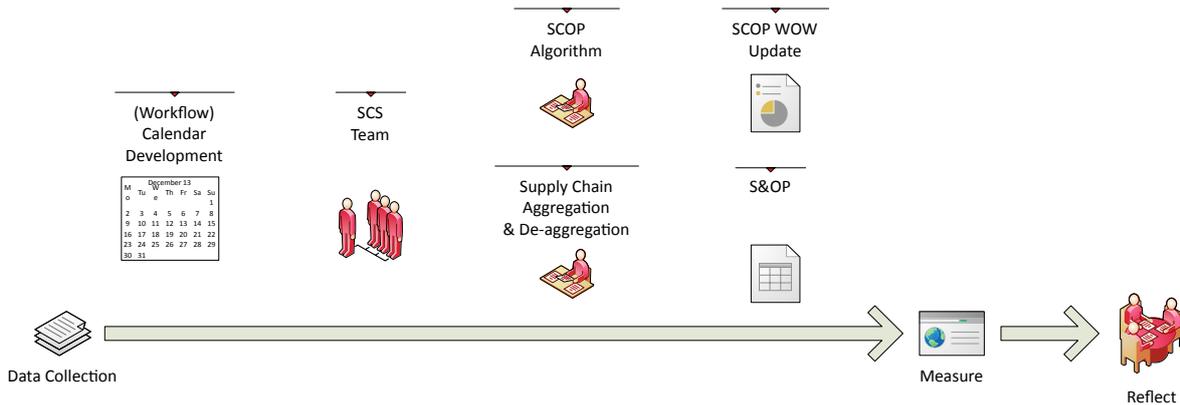


Figure 5.3 – Phased Implementation of Hilti IP Concept

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 Figure 5.4 all of these four phases exist 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.

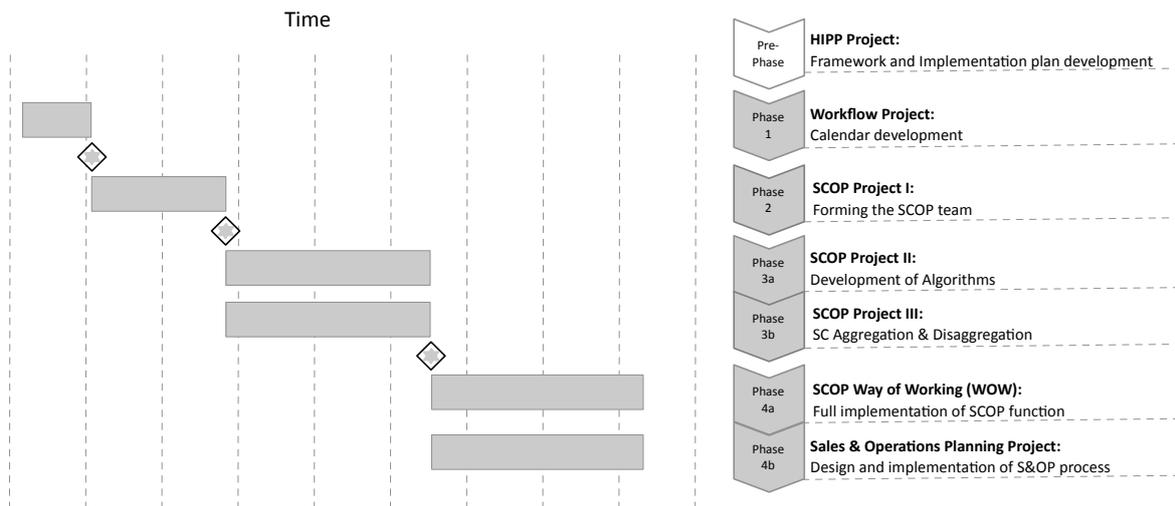


Figure 5.4 – Gantt Chart Phased Implementation of Hilti IP Concept

The phases described in Table 5.2 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 Implementation of the Hilti IP Concept

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

### 5.2.1 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 action plan, if one of the phases fails. The contingency plan is described in Table 5.3.

**Table 5.3** – Contingency Plan

Phase	Prob.	Description/Explanation
1	90%	There is a probability that stakeholders cannot agree on a calendar. The calendar will restrict several material managers in their freedom, which may cause dissatisfaction and/or delays. The communication plan can act as a mitigate to increase the chance of success.
2	80%	As mentioned in the force field it might be hard to find a SCST team that is sufficiently competent. Eventually this should not be a problem but delays are a realistic option since quality of the SCST team should go before quantity. A pilot with a smaller SCST team could mitigate. 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.
3a	70%	Developing the algorithm will be a challenge. Recent safety stock algorithm development has taken several years to complete. The SCOP algorithms should incorporate more aspects and will be far more complex then the safety stock 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. 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.
4b	90%	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.

Eventually the chances of successfully implementing the projects are high as long as the commitment stay equally high and all phases are communicated transparent. The biggest threat is the IT implementation since this might be more complicated than assumed at the moment. Also, some IT changes might cost a lot on development.

### 5.2.2 Responsibility Chart

The action plan requires a clear division of responsibilities, which is shown in Table 8. 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 have an involvement 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 the project this will most likely be a GL employee.

**Table 5.4** – Responsibility Chart

Change Action	Responsibility					
	GL	GM	HAG	Region MM	IT depart.	Senior Mgmt.
Calendar Development	S/I	S	S	S	S/I	A/I
SCST Team Project	S/I	S	S	S	S	A/I
Algorithm Project	S/I	S	S	S	S/I	A/I
- Development	S/I	S	S	S	S/I	A/I
- IT Implementation	A/I	S/I	S/I	S/I	R	A/I
Aggregation project	S/I	S	S	S	S/I	A/I
- Aggregation methods	S/I	S/R	S/R	S/R	S/I	A/I
- IT implementation	A/I	S/I	S/I	S/I	R	A/I
SCOP WOW Project	S/I	S	S	S	S/I	A/I
- IT implementation	A/I	S/I	S/I	S/I	R	A/I
S&OP Project	S/I	S	S	S	S/I	A/I
- Alignment of levels						
- IT implementation	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)

### 5.2.3 Communication Plan

Good communication is key 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. Next to 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 they are part of the change. Table 5.5 shows specific communication recommendations for all phases. The video messages and updates are not places in the table since they should iterate every month and give a relevant update if applicable.

**Table 5.5** – Communication Plan

<b>Phase</b>	<b>Communication</b>	<b>Type</b>	<b>Sender</b>	<b>Receiver</b>
HIPP	Hilti BOD	Document	HIPP team	
	Master Thesis (3x)	Document	HIPP team	
	Communication Pack- age	Document	HIPP team	
Phase 1	Calendar Training	Presentation	Project Team	Logistics
	Cookbook	Handbook	Project Team	GPMS
	Calendar Framework	Milestone	Project Team	Logistics
Phase 2	Introduction	Meeting	SCST Team	Logistics
	Official Start of SCST	News Letter / Re- ception	SCST Team	Logistics
Phase 3a	Algorithm requirements	Documentation	Project Team	IT department
	Documentation	Handbook	Project Team	GPMS
Phase 3b	Requirement GM	Questionnaire	All Plants	Project Team
	Requirements 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 Documentation	Workshop Handbook	GM/Regions Project Team	Project Team GPMS
Phase 4b	S&OP Training	Presentations	Project Team	All users
	S&OP Cookbook	Handbook	Project Team	GPMS

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## Conclusions & Recommendations

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### 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 in order to integrate the SCP for their entire end-to-end supply chain.

In order to be able to comprehend the planning decisions which have to be taken for the functioning of the entire end-to-end supply chain of Hilti, the current situation had to be analyzed in the first phase of the research. This exploratory phase was based on the first research question:

#### **1. How 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 and by scoping the internal supply chain to LEC, HAG, LW1, Plant 4 and Plant 6D the answer to the next sub-questions has been made tangible.

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

Some aspects of the current planning landscape came to light after having read into the three performed literature reviews. Combining this knowledge, it clearly showed that the current planning landscape of Hilti is characterized by strong local/regional optimization and decision making. We found no hierarchical planning structure and no end-to-end responsibility over the entire supply chain. Following from the literature reviews it was clear that the supply chain therefore performs sub-optimal which gave insights for and helped to answer 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, reflecting on the Hilti supply chain?**

This question represents the ends planning step of the design approach of Ackoff (1981) coming to an idealized design. The knowledge of the literature review was used in order to answer this second research question. Some more extensive academic review was performed to answer this sub-question, using a bottom up approach following the PCIO paradigm. Hierarchical planning frameworks have been combined with literature on cross-functional integration to come to an integrated hierarchical planning framework which is elaborated into an OPC concept adding the time-aspect, dependencies 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 whole supply chain under their control (internal supply chain). Furthermore, comprehensive integrated planning and control is necessary for these companies Stevens (1989). This led 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 has been 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 generalized for implementations in other companies ('chains of' supply chains). To find the gaps between the current planning landscape and the idealized 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 a part of ends planning, for the answer of this research question the scope of the idealized design has been limited to the tactical and operational level, excluding the TUC, based on the fact that changing the strategic level and TUC would make the project intangible in its deliverable for the short research period of five months.

First of all, the current planning and control system of Hilti is characterized 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 (silo thinking).

These identified gaps have been 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. Therefore the third research question was answered.

*a. 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** – Adaptations to the idealized design in order to develop the Hilti IP concept the context, constraints and current state of the Hilti supply chain are taken into account. There has been one alternation, distribution planning is the input for sales planning in the Hilti IP concept. This leads to less scenarios being developed in the preparations for the SC-S&OP which might in turn lead to missed business opportunities as they might not have been 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 as main stakeholders, driving and restraining forces have been captured and discussed. Following from this, a leadership style for the needed change leaders has been determined. Finally, action planning was considered with the development of an incremental change process with four project phases, existing out of six projects. A calendar to align the WOW is a prerequisite for all the other projects, afterwards some projects can run simultaneously to first implement the SCOP decision with its WOW and afterwards 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 have been established.

## 6.2 Recommendations

### 6.2.1 Hilti

The HIPP has made great conceptual steps towards a feasible integrated planning at Hilti. However, the project's scope was limited and the results are highly conceptual. Therefore several recommendations can be made 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 is not only considering 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/mid-term level provides feedback for adaptations of strategic/long-term decisions and it is therefore recommended to take this level into account for development taken the final outcomes of the HIPP project;
- *Alignment of the transport management and warehouse management with the developed Hilti IP concept.* All logistic departments at Hilti are divided in MM, TM and WM. The Hilti IP concept however, only looked at MM and improved their tactical and operational decision functions. In order to fully benefit 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 have been 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 for the covering of the complete range of Hilti's functional decisions.* The communication lines and dependencies of MM with sales and marketing have been 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 one or several pilot studies, 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.

### 6.2.2 Research Field

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

- *The generalizability of the theoretical framework and OPC concept.* Although this point has been 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 generalizability of this concept. Complementing this, these case studies could also 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 theoretical framework and OPC concept.* Further research on the contents of the designed OPC concept will provide more insights for the field of research in applicability to supply chains.

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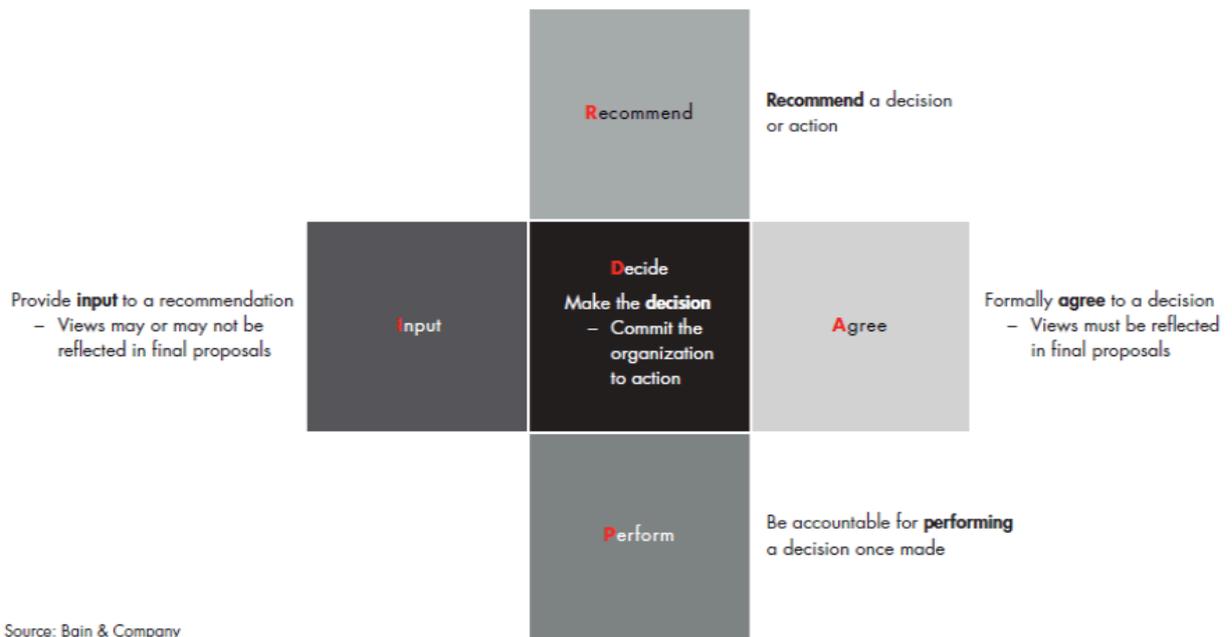
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# A

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## RAPID Model

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**Figure A.1** – RAPID Model by Bain & Company

# *B*

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## Vroom-Yetton-Jago Decision Model

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See next page for Table B.1

**Table B.1** – Leadership Decision Model by Vroom and Jago (1988)

Nr.	Questions	Description/Explanation
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, organized, 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 organizational 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.