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INBOUND SUPPLY CHAIN STRATEGY DEVELOPMENT FOR A HEAVY MACHINERY MANUFACTURER

Examiner: Associate professor Petri Niemi

ABSTRACT

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The aim of this Thesis was to find a solution for re-organizing the supply chain network of a heavy machinery manufacturer inside Finnish borders. There were two main drivers for the change. Firstly, the capacity had been identified to be insufficient for the future due to a more complex product portfolio and the amount of material numbers. Secondly, the network of external warehouses was scattered, and an opportunity was seen for increased process efficiency and cost control.

The Thesis compared different supply chain strategies based on detailed process score analysis and qualitative weighted benefit analysis. In addition, the impact of possible warehouse location choices was studied. A summary of the analyses was provided to illustrate the differences between alternative strategies.

As a result, the best solution for the supply chain strategy re-organizing was found. The benefits were calculated from process efficiency and cost control perspectives. The relative efficiency can be increased in five primary processes with significant financial benefit. The solution also considers future requirements of the supply chain network.

TIIVISTELMÄ

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Työn tavoitteena oli löytää ratkaisu toimitusketjuverkoston uudelleenorganisoimiseksi kotimaassa. Työn lähtökohtina olivat kaksi tunnistettua pääongelmaa: 1) tulevaisuudessa entistä monimutkaisempi tuoteportfolio ja sen myötä nimikemäärän voimakas kasvu aiheuttavat kapasiteettipulan nykyiselle toimitusketjumallille, sekä 2) ulkoisten varastojen sijoittelussa ja niiden prosessitehokkuudessa nähtiin mahdollisuus kokonaistehokkuuden sekä kustannushallinnan parantamiseen.

Työssä vertailtiin erilaisia toimitusketjuratkaisuja perustuen yksityiskohtaiseen prosessikustannusanalyysiin ja kvalitatiiviseen painotettuun hyötyanalyysiin. Lisäksi tutkittiin varaston sijainnin merkitystä toimitusketjun rakenteeseen. Analyyseistä koostettiin yhteenveto, josta kävivät ilmi vaihtoehtojen eroavaisuudet.

Työn tuloksena löydettiin paras vaihtoehto toimitusketjun uudelleenorganisoimiseksi ja sen tuomat hyödyt laskettiin prosessi- ja kustannustehokkuuden näkökulmista. Suhteellista tehokkuutta voidaan kasvattaa viidessä eri toimitusketjun pääprosessissa, joka tuo huomattavaa rahallista säästöä yritykselle. Tulevaisuuden vaatimukset toimitusketjuun on huomioitu ratkaisuehdotuksessa.

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It has been a busy time fitting work, studies and family together for the past couple of years. Now, when I am close to finishing my studies I feel that I have gained a lot of experience and updated views to further develop my professional skills. I have also noticed that planning, hard work and belief in the future success is the key to get things like this done.

Thank you for the support and trust for colleagues and managers in the company I work for giving me this opportunity. Also, thank you Associate Professor Petri Niemi for good guidance during my studies. Lastly, the most important thanks go to my loving wife, family and friends for all the support!

Yours sincerely,

Panu Tourunen

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ABBREVIATIONS

R&D	Research and Development
EME-area	Europe & Middle-East
LSP	Logistics service provider
3PL	Third-Party Logistics service provider
MSK, GIMA, BHM	Internal names for different suppliers
ERP	Enterprise Resource Planning (system)
SCM	Supply Chain Management
POD	Port of Destination
LTL	Less than truckload
FTL	Full truckload

1 INTRODUCTION

1.1 Background

Continuously evolving manufacturing business is a competitive environment where only adaptable and agile companies will grow and survive. To adapt, management must make strategic changes. When executing a global change in strategy there will always rise questions about the most efficient way to perform the changes. At the point of strategic change no one knows the answers for the questions – but as time passes, lessons will be learned: improvements are done in every function and utilization of continuous improvement will lead to success. This thesis is made in collaboration with high tech machinery manufacturer (later "company") which has lately gone through a strategic change which has caused fluctuation in the existing supply chain and now there is a need to adapt and re-organize.

The primary target in the strategic change was to increase the global co-operation of the factories around the world and implement a common platform thinking, which is familiar from automotive industry, also to the machinery manufacturing. The effects of the strategy change overall were big: new processes and systems around the world had to be implemented with new colleagues. The effect to the supply chain were new supply routes from Asia to Europe, significant increase in container shipments and demand for buffer inventories. All the changes lead to sudden need of more floor space in warehouses and a great fluctuation in demand- and supply chain.

The supply chain is the backbone of company production operations. The production itself is a close collaboration of very sensitive set of functions which all require seamless ability to operate. The supply chain provides the base for production by supplying the materials just in time for the assembly line. Assembly line is developed to produce complex products with thousands of different variation possibilities. For supply chain management, it gives an ultimate challenge to establish enough effective processes to keep up in the pace of assembly line.

The strategy change caused the company to take quick actions to adapt and drive the supply chain into the new circumstances. Now, as the situation has stabilized, it is time to start optimizing the existing processes with an outlook to the future supply chain requirements.

The objective of the project was to recommend a new solution for the future inbound supply chain network, which would both fulfill the strategic demand from the increasing volume and operational complexity, and gain process- and cost efficiency. The nature of the research was multi-dimensional and therefore multiple pieces of the puzzle had to be aligned, e.g. the evolving demand for warehousing, multiple locations and different types of material flows. Thus, it was necessary to approach the objective with the following two research questions:

1. *What will be the difference in network requirements caused by increasing volume and complexity?*
2. *By using the requirements found by the project, how must the supply chain network be re-organized and what are the arguments for doing so?*

1.2 Methods and thesis boundaries

This thesis was done in close cooperation with supply chain management team and many other functions inside the company such as R&D, warehouse planning and manufacturing engineering. Logistics service providers were also involved in data gathering and analysis. By interviewing, asking questions and putting the gathered information together, the project started to take shape.

In the beginning it was important to gather process data, future estimations and build a mock-up of the supply chain. Second, with the data available, the next natural step was to put together the current state analysis and put together the available data of future estimations to get clear overview of the requirements for the supply chain in following years.

Third, the local supply chain experts together with the supply chain management of EME-area were closely involved in developing the frameworks for the supply chain scenarios. The primary method for finding the alternatives was brainstorming and picking the most reasonable alternatives for further investigation.

Fourth, the scenarios were quantitatively evaluated by generating a Relative Process Score Analysis model. The model compared all the major processes in the supply chain in different alternatives. In addition, a qualitative analysis and scoring was done. By combining the quantitative analysis and qualitative analysis into a benefit analysis, the best solution was found. Additionally, a center of gravity analysis was also done to find an optimal location for possible hub implementation.

Fifth, the chosen supply chain scenario was analyzed from financial perspective with an accurate cost-data provided by warehouse operators accounting.

The boundaries for the thesis were agreed in the beginning. The Thesis should not investigate material flows inside the facilities. Since the supply chain is global and every inbound shipment ends to factory in Central Finland, the location analysis was limited inside Finnish borders.

The outbound supply chain is not studied in the Thesis, because the outbound process of finished goods is operated by different organization and it is considered as straightforward and already optimized process with less complexity and process steps. Warehouses and processes included in this Thesis are not related at all with the outbound process.

1.3 Data collection

To make the current state analysis reliable, it was important to take time to collect raw information as much as possible. Therefore, it was natural to start the project with data collection phase with different stakeholders in the supply chain. I had the right contacts to our logistics and financial departments and therefore it was straightforward, but not an easy task to extract the data needed for the project. The transportation partners were very committed to give all the transportation data for project usage.

Warehousing data contain information about the current warehousing area (m^2) and storage bins inside factory site and in external warehouses. Information about goods movements, transfer orders, stock transfers, and labor costs were collected to create the overall picture how much material handling is required in every location. To understand warehousing space allocation, the supervisors of goods receiving, picking and repacking were consulted. Since different material types require different warehousing strategies, it was important to pay attention to all active warehouse types – outside and inside, heated area and cold area, spaces for sequenced and stored materials.

To collect transportation data in a structured manner it was decided to divide also the overall material flow into several different material types, for example, tires and transmissions. In the later phase of project, it was useful to have the variety of the materials aggregated in their own commonalities. The transport planning partner was very helpful in data gathering process and thanks to the used transportation management system we had a huge amount of data available. Transportation data collection focused in volumes (m^3), weights (kg). To visualize the inbound transportation flows inside Finnish borders, a material flow analysis of inland transportation was executed together with 4th party transportation service provider. From this analysis it was visually easy to find the center of gravity as a starting point for developing the new warehousing scenarios.

Logistics is nowadays more and more dependent on information flow and process reliability. It is important to have the systems aspect also in this project to see the cost of systems upkeep, workload and the amount of invisible information flow. It was interesting to find out the share of human interfaces in the total material- and information flow. In addition to the warehousing and transportation analyses, also Relative Process Score Analysis was made. The process analysis studied the deep level of each critical supply chain process from the inbound supply perspective. The process analysis reviewed the active interface (own employee labor, external employee labor and electronic process) and the frequency of process steps (monthly, weekly, daily, multiple times per day). The result gives a good outlook for further process optimization and automatizing.

An important aspect in the project was to have a clear look to future to see how the factory operations will develop. Many stakeholders, experts from their own areas such as warehouse planning and R&D management were interviewed to have complete outlook for future demands for the supply chain. The available timeline for prospecting the future demand was to 2022. By evaluating the ongoing and upcoming new product introductions it was possible to estimate the growth of part numbers and space requirements.

2 BASIS FOR THE PROJECT

2.1 Supply chain network design

The network design is a complex task which must be sliced to smaller pieces in order to find the correct problems and solutions. Frazelle (2002) suggests a program for the optimal result for supply chain network optimization. It is a step by step plan which starts from evaluating the current network. Next step is to design and breakdown the network data, requirements, constraints and flow routes. In this project these phases are included in the current state analysis.

After defining the current state, Frazelle (2002) suggests designing alternatives for the supply chain network. It is underlined, that this phase requires experience and creativity, where brainstorming is the best practice to generate these alternatives. To compare alternatives, it is necessary to implement, or as in this project, to generate a mathematical model and optimization tool to find the most promising scenario.

Lastly, a critical evaluation and “practicalizing” the chosen scenario is to be done to find the real potential of the solution. After that, cost-benefit and financial analysis are required to create a business case which can be presented for the executives.

Frazelle (2002) raises an important issue in the last chapter of the program: even if the analysis is sensible and the savings well prepared, the decisions are still made from experience, feeling and the gut. In an ever-changing environment it is important to have the flexibility when the time is right for decision. In these cases, the winner is usually the company which has signed their logistics agreements with one-year contracts.

2.2 Logistics service providers

There are various reasons why logistics service providers (LSP) are nowadays commonly used in all types of businesses where goods are traded back and forth between the stakeholders. Overall, the requirements are mostly driven by three points: globalization, technological advantages and increasing demand for just-in-time deliveries. This applies in manufacturing industry as well as, for example, in retail market. In the best situation, the given output of logistics service provider is value creation for customer in addition to normal operational process. This can be achieved by in-depth collaboration in customers' supply chain operations and benchmarking the customer processes to other customers. (Razzaque et al. 1998).

There are five requirements for supply chain efficiency: quality, speed, reliability, flexibility and cost-efficiency. Customer is expecting the logistics service provider to operate in level high enough to meet these requirements (Slack et al. 2010). To achieve this level, the cooperation between all supply chain components from shipping party to end customer must be well-aligned and managed. By having a well-integrated supply chain, this is possible.

2.3 Supply chain integration from 1PL to 4PL

The term supply chain integration (SCI) is a rather new in logistics context. It is an advanced arrangement of supply chain stakeholders. Flynn et al. (2010) describes the term by setting up a strategic partnership between customer and the logistics partners and continuously managing the operational processes over the company- and organizational boundaries. The result will lead to benefits in material and information flows and greater value with smaller costs. (Flynn et al. 2010)

The importance of supply chain integration is also proved in terms of operational and business performance. There are two dimensions in supply chain integration. This study is focused on internal integration instead of external integration, which includes suppliers and customers. Internal integration is the key for efficient supply chain because it develops the base for integrating the customer and the supplier.

With strong internal supply chain integration, it is possible to increase the overall performance of strategic and operational operations. (Flynn et al. 2010)

The PL pyramid is an understandable method to describe the relations of different logistics functions. The term PL is originated from Third Party Logistics (3PL) and later extended to more logistics functions. When looking into the level of internal supply chain integration currently ongoing with the company, it is already visible for eye that the integration and collaboration with 3PL and 4PL is continuously evolving and increasing the benefits. (Figure 1.)

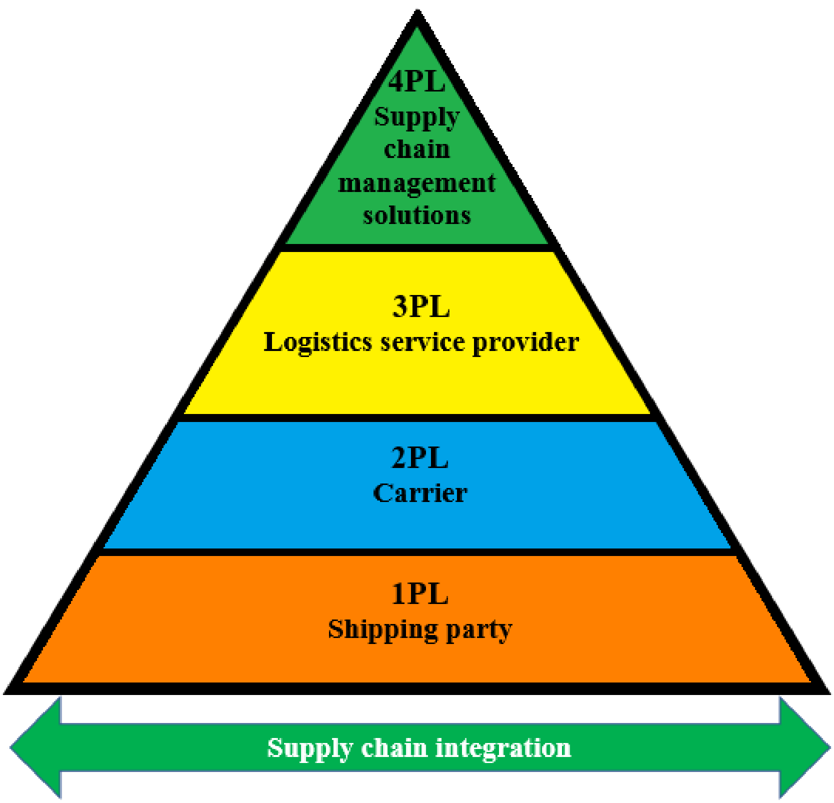


Figure 1. PL pyramid

3PL is an extension for business' supply chain operations in addition for transport and warehousing. It is the long-term partner with a great involvement in the network operations. 3PL operators commonly have multiple clients so the logistics performance is based on their expertise and volume consolidation and the economies of scale. Therefore, it is 3PL providers' interest to present the expertise for customer also in financial and operational metrics. (Vasiliauskas et al. 2007)

4PL is the unit which has the task to integrate the overall supply chain network with carriers and LSP's by using their strong analytical and IT expertise. By optimizing and tendering the network stakeholders, 4PL is in important role to manage the supply chain in the most efficient way for the customer. (Vasiliauskas et al. 2007)

In Europe 4PL is described often as management of various logistics service providers, and most commonly as the transportation management services. European cross-border transportation generates a good environment for transportation management services since it is complex and common supply chain environment in B2B logistics. (Saglietto, 2013)

2.4 Evaluating multiple attributes

The evolution of the thesis research process formed to be a multiple attribute problem. When looking the problem from different aspects, there were always multiple factors which were affecting to the problem, some of them more and some of them less. For example, from supply chain development perspective, warehouse replenishment reliability is more important matter in operative supply chain than possible risk in long-term contract. Both should still be included in evaluation. Amid et al. (2011, pp. 144) studied the supplier selection process in supply chain and came to the conclusion that it is *"a multiple criteria decision making problem that includes both qualitative and quantitative criteria"*. The same conclusion can also be used when researching the new solution for supply chain network in this thesis. Not every factor is equal in terms of importance, cost and frequency. Therefore, weighting was used to simulate the reality in the research. (Amid et al. 2011)

The project uses relative process scoring as a method for comparison. Wu et al. (2006) studied risks of inbound supply. The study used three key factors for calculating the risk: first by determining the relative weights and second, probabilities of occurrence to have realistic outcome from multiple attributes. Third, total risk was then calculated by multiplying weight and probability. There is a major resemblance with the risk study approach and the process analysis of this project. It is explained in later chapters of the thesis, that “interface cost” of process analysis represents the weighting and “frequency“ represents the occurrence and probability. Total score then is calculated exactly in a similar way as in Wu’s risk analysis by multiplying these two factors. (Wu et al. 2006)

Another similarity can be found from impact-probability matrix, which is used commonly in risk evaluation. Impact-probability matrix contain two components: likelihood and severity. In this project, a modified version of the matrix is used as the components are changed to frequency and process cost. Therefore, it could be called process cost matrix where the result is not risk level, but level of process heaviness to support decision making. The bigger the score, the worse the result. (Dumbravă et al. 2013)

2.5 Optimal location

The central warehouse or logistics center location is a long-term strategic decision and needs to be evaluated carefully. Studies has shown that there is not always enough effort put into qualitative and quantitative analysis of the logistic network service level elements. Costs have been and will be the major factor but there is more in location optimization (Korpela et al. 1999).

The traditional approach for finding the optimal location is taking the basic logistics attributes into account, for example, replenishment time, safety stock and replenishment frequency. These values are often used as quantitative restrictions for the model design without understanding their qualitative nature in the operational model. Thus, the designed models have not been able to represent the reality. Therefore, there must be enough experience and knowledge in both perspectives when determining the network model and choosing the optimal location (Korpela et al. 1999).

To underline the previous paragraph even more, the final decision of location must be done primarily based on experience and deeper understanding of nature of the business and area development. The decision will be supported by analysis.

3 THE CURRENT STATE OF THE SUPPLY CHAIN

The objective of the project is to find the best solution for the supply chain set up for factory future requirements. To find the solution it is first crucial to define the current state in a very thorough way. In the following chapters the inbound supply chain will be described in warehousing, transporting and process point of views inside Finland.

The background for current supply chain leads to year 1969 when the company decided to establish a factory in Suolahti, Central Finland. Since then products and Suolahti operations has been changed a lot. Back in 20th century the supply chain was mostly based on Finnish local sub suppliers instead of global supply chain infrastructure with the strong support of stock exchange listed corporation. Nowadays Suolahti is maintaining the state-of-art factory status by having modern and lean production and supply chain solutions. (Company web page 2018)

3.1 Locations and material flow

One of the major drivers for this initiative was the complexity and cost of current inbound supply chain. The current network set up has been developed part after part in a very short notice inside challenging and variable circumstances. Rapid changes have been done due to sudden need of more capacity in warehousing- and operationswise. The company has implemented a new strategic approach which has been globally a major change for the intra-company supply chain. A very large portion of all factory materials are now being delivered in sea containers and there has been a strong learning curve during the last two years developing and optimizing the related processes.

Now, when the situation has stabilized and the challenges have moved from firefighting to normal daily operative work, it is time to have a closer look of the supply chain status quo and analyze the cost breakdown and the pain points and bottlenecks (Figure 2.).

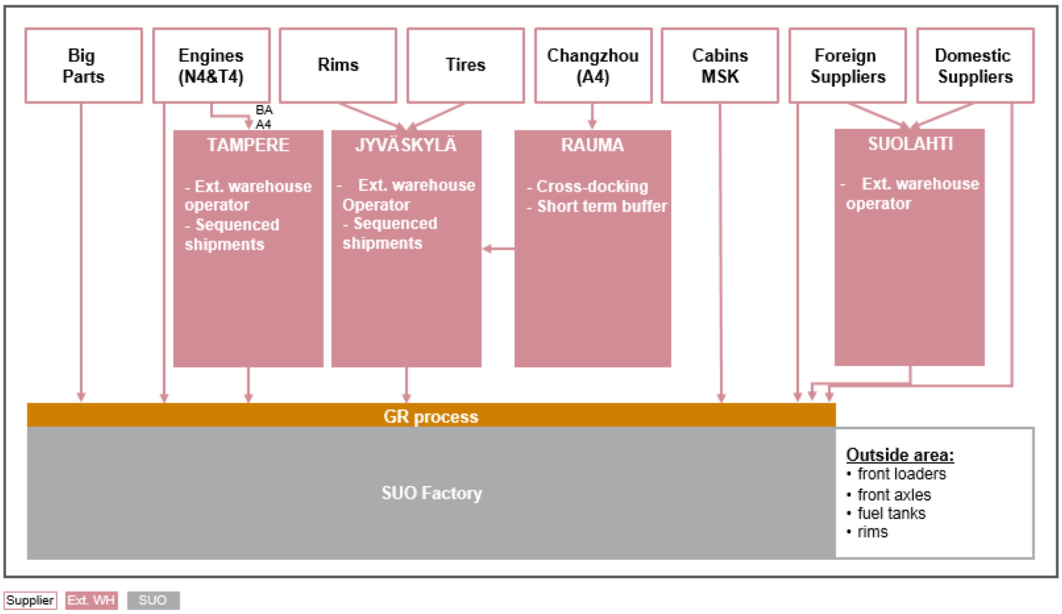


Figure 2. Inbound supply chain explained

Second and even more important reason to find new solution for supply chain is the outlook of the future production scenarios. In next 3 – 4 years the amount of simultaneously produced final products is going to increase dramatically. This leads to fact that the amount of different raw materials and sub-assemblies will also increase. Production facilities are required to spread the activity to larger area inside the factory walls. To understand what this means in terms of warehousing space, the operational warehousing figures are in important role. The current warehousing figures are explained in the next chapter. Future warehousing requirements are then presented in later in chapter 4.1 Future requirements.

3.2 Warehousing figures

The never-ending need for more space is a usual phenomenon when talking about warehousing space in old facility buildings in rapidly evolving business. For example, in past years the product option offering for customers has been dramatically increasing and simultaneously material and production requirements have become more complex. When adding the continuously increasing variety of product mix to this combination, the lack of space realizes, which is the current state (Table 1.).

Table 1. Current warehousing figures

Current warehousing figures

	Cold m²	Warm m²	Total m² used	Transfer orders / month
Factory warehouses	3670	8380	12050	
Suolahti ext. warehouse		4250	4250	1240
Säynätsalo ext. warehouse	2000	1200	3200	540
Rauma ext. warehouse		700	700	
Engine ext. warehouse		700	700	200
TOTAL	**5670**	**15230**	**20900**	**1980**

4 FUTURE SUPPLY CHAIN ALTERNATIVES

The research process contains four main parts. Defining the current state, forecasting the future requirements, brainstorming the possible changes for the supply chain layout and picking the most reasonable alternative for further evaluation. Because I as an author have been working closely around the supply chain for years, it was a straightforward task to draw the model of current supply chain. Now when the task was to redesign the existing model, there had to be new ways to rethink the system from different perspectives. Questions were risen: Is it mandatory to invest in new facilities? Should we reconsider and rearrange the setup in current facilities? What are the supply chain capacity requirements for the future?

The preliminary research of part number and floor space evolution for following years stated clearly that the current capacity will not be enough, and new floor space will be required to continue high performance logistics execution to support production. Therefore, it was commonly agreed with the management to include an option of new facility in the evaluation of models. All alternatives include two similarities: tire and wheel supply from current location will remain as it is and expansion of cold warehousing space is required in factory area.

4.1 Future requirements

To have an outlook to the future, the stored part number scenarios had to be estimated. According to the plans provided by R&D, the future complexity in product ranges will cause increment in part numbers by 74 % in following three years towards 2021 (Table 2.). This leads to situation where the internal logistics operations are requiring 88 % increase in floor space (Table 3.).

Table 2. Outlook to future part number quantity

Year	2018	2019	2020	2021
Total part numbers	7224	7888	9570	12571
Part number increase (%)	100 %	109 %	132 %	174 %

Table 3. Outlook to future floor space requirements inside factory premises

Year	2018	2019	2020	2021
TOTAL, bins	3243	3665	4519	6085
TOTAL, m2	5312	6002	7401	9966
Kitting requirements increase (%)	100 %	113 %	139 %	188 %

In addition to internal operations, also product complexity and the supply chains for space-consuming materials, such as transmissions and cabins, will be rearranged in following years. This will cause more demand for buffer and floor space which will affect the external warehousing operations. The change will increase the demand for floor space and operations by 40 % (Table 4.).

Table 4. Future requirements in warehousing perspective

Requirements based on 2021 volume for external warehouse operations:

	Annual vol. (pcs)	Daily vol. (pcs)	Required buffer (days)	Required buffer (pcs)	Floor space required (m²/pc)	Add. space req. (m²/pc)	Total m² required
Transmissions S1	1200	6	4	24	4	8,5	300
Transmissions S2	2200	11	4	44	4	8,5	550
Transmissions M2	1800	9	4	36	7	8,5	558
Transmissions A4	3070	15	15	230	3,2	6,12	2146
Engines (CH)	3070	15	15	230	1,2	3,4	1059
Cabins	3070	15	4	61	7	10,2	1056
A4 rims & parts buffer	29 % volume increase predicted for current model series						782
A4 repacking	29 % volume increase predicted for current model series						452
General (Alkula)	29 % volume increase predicted for current model series						5483
Total space requirements for external warehouse / cross-docking operations 2021							**12385**
Current space utilization in external warehouse operations							**8850**
Increase (%)							**40 %**

4.2 Alternative 1: Straighten the existing supply chain

The first alternative is a model which is looking quite similar with the current model. This model has no changes in the Suolahti warehouse and the supply from domestic and foreign suppliers. The idea here is to straighten the supply chain of Chinese-supplied materials and big parts by removing one place of handling from the chain. Currently the same parts are handled, stored and shipped from both Rauma and Säynätsalo warehouses to factory. The basic idea is to eliminate double handling in these two locations.

To make this possible, the hub would act as a warehouse and sequencing facility for the big part deliveries, such as transmissions, cabins, space-consuming materials. The hub would also be a centralized re-packing location.

Pros for this model are that the physical change is small and the need for investment would not be big. In this alternative the existing facilities in Rauma or Säynätsalo and Suolahti could be used. Thus, the supply reliability would be improved due to reduced complexity, but the capacity and flexibility constraints would remain. The capacity is still limited in Suolahti warehouse and in addition to that, warehousing-, transport-, and stock balancing systems must be maintained still in multiple locations. (Figure 3.)

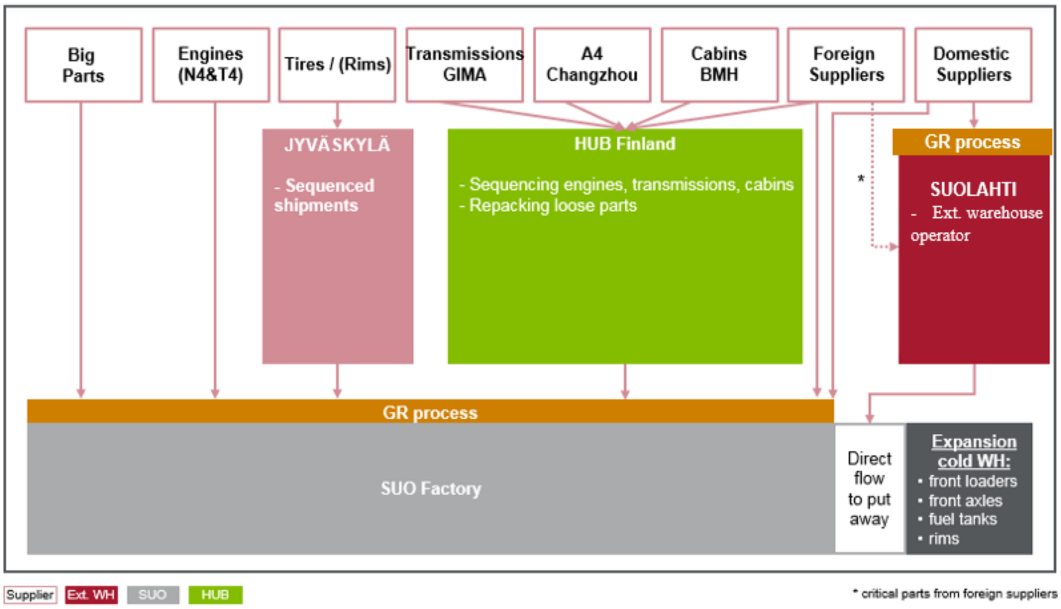


Figure 3. Alternative 1: Straightened supply chain.

4.3 Alternative 2: Shared hub, no direct deliveries

The guiding idea in alternative two is to find out how a single hub for two intra-company factories would fit into the supply chain from the perspective of Suolahti factory operations. Geographically it is obvious that the best location for the hub would then be in Tampere area. The strategic target in this alternative is to minimize the goods receiving activities in Suolahti factory and maximize the direct flow to put away for assembly line. (Figure 4.)

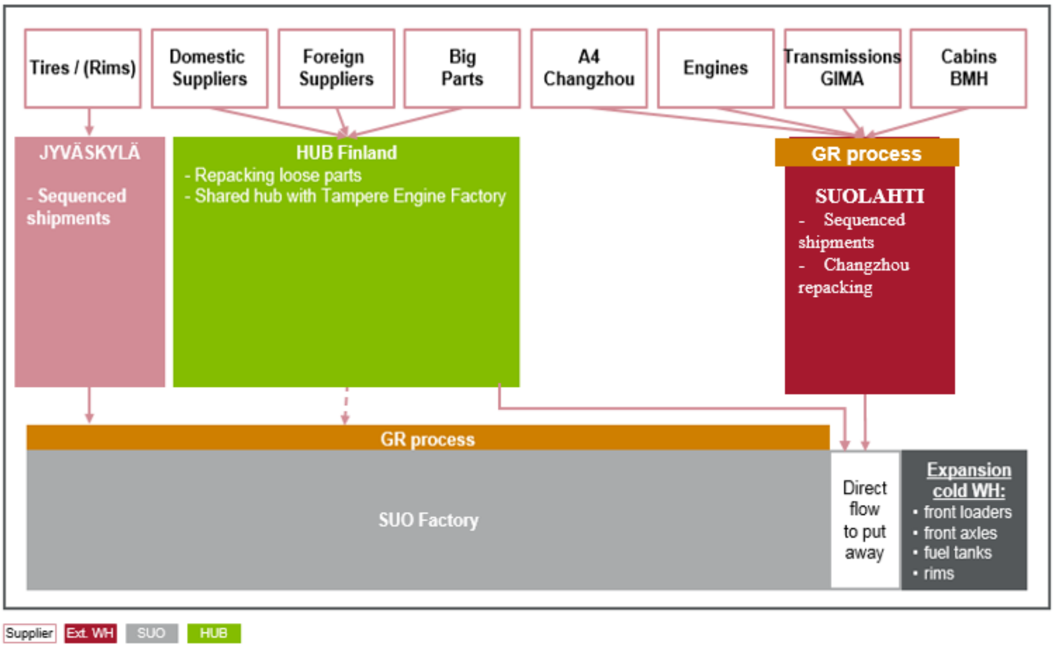


Figure 4. Alternative 2: Shared hub, no direct deliveries.

Shared labor and equipment would bring benefits, but from supply chain efficiency perspective this has challenge in supply reliability. In this alternative the risk for material shortage is increased. The stock levels in factory warehouse are forced to be low due to space constraints and there are continuously time-critical shuttle shipments in transit. Considering Finnish weather conditions and roads with high traffic, it is certain that there will be delays. Also, it is natural that the longer the distance, the worse the visibility is. Visiting, leading and controlling a hub further away is more difficult than a hub in immediate proximity. Another challenge is the infrastructure flexibility: when sharing a hub with another growing and evolving stakeholder, there is a risk for arrangements which are not favorable. On the other hand, cooperation with an engine factory would increase the opportunity to find potential in value added activities.

4.4 Alternative 3: Mixed model with hub in factory proximity

The third alternative is a complete re-organization of the network. In this alternative, the main strategic direction is to secure supply reliability by having hub nearby factory with short distance shuttle. All currently used warehouses will be transformed to one single hub which can support the factory for all its needs. The leading idea is that all big part shipments, from domestic and foreign suppliers, will be delivered to hub and small part shipments with shorter inventory turnover will be delivered directly to factory. Containers shipped by overseas suppliers would be unloaded in deconsolidation hub by an operator in container port and then delivered to repacking operations in the hub.

While writing this Thesis, there is no such facility available. Execution of this alternative requires a major investment. Building a fully customized hub includes the opportunity to develop a lot of value adding activity inside hub, for example: picking, kitting and pre-assembly stations. Also, the handling effort can be optimized when the container handling and repacking operations are concentrated, and slow and fast movers are analyzed and stored separately. (Figure 5.)

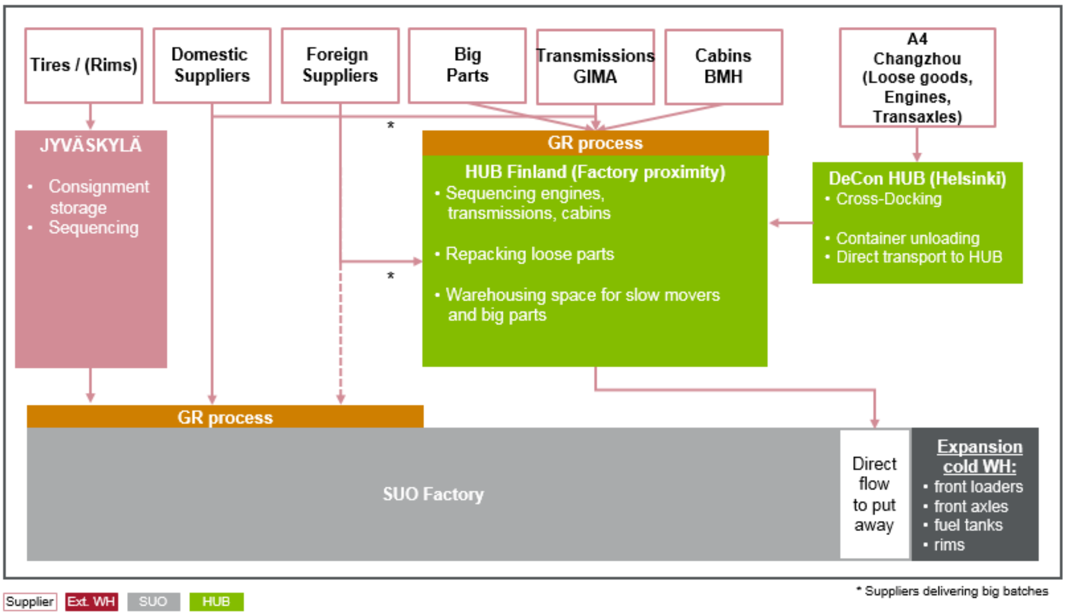


Figure 5. Alternative 3: Mixed model with hub in factory proximity.

This type of investment would be done in collaboration with a 3PL logistics service provider with a long-term contract. The contract length is the risk here due to fact that Suolahti factory is a part of global company infrastructure and the visibility over 5 - 10 years period is not clear, even though no risks are known now. Therefore, to minimize the risks caused by long-term contract, the built hub must fill the requirements to be modular and customizable.

5 EVALUATION OF THE ALTERNATIVES

5.1 Relative Process Score Analysis

The main goal of the process study was to compare primary material flow processes in every alternative. In search of different analysis methods I was unable to find an existing method, which would have taken all the needed attributes into account. To have a reliable comparison of the scenarios presented in the earlier chapter, I developed a new analysis, which I call Relative Process Score Analysis. This approach is based on similar methods as in risk analyses, in which different risks are scored based on their severity and likelihood by multiplying the values given. The Relative Process Score Analysis has a modified approach: the severity is described as a cost per one transaction. This is called interface-cost (I-Cost) in the analysis. Another factor is the likelihood for the transaction to occur. In this analysis it is called frequency-cost (F-Cost).

The interfaces and frequencies are carefully generated to meet the real process definitions. Following interfaces were defined to have different process step costs (I-Cost) for different interfaces.

- Electronic (automatic process handled by ERP)
    - Process cost 0 €
- Warehousing / Transport (a static value for every event when warehousing or transport service is required inside the network)
    - Process cost 2,17 €, based on average of pallet storage cost per week and average warehouse shuttle transport cost per pallet
- Human (human work required to handle one shipment)
    - Process cost was determined by calculating real material handling cost. The cost was calculated from 6 months data of over 31000 received shipments and over 116000 handled units. The calculation showed that average receiving of one complete shipment takes 14,3 minutes and average handling time for one unit is 3,8 minutes. These

values were used together with salary costs to calculate the process cost when human is involved.
    - Average cost for handling one material unit (pallet) is 1,40 € in the factory.
- HumanExt (human work required to handle one shipment in external warehouse operator)
    - External warehouse operators are making profit of their business so similar calculation as above was done to make a difference between human activity in lean, optimized factory environment and in not-so-lean external operator environment plus profit.
    - External warehouse operator is using transaction-based fees. Cost for handling one pallet in external warehouse is 2,50 €. Handling contains Unloading the truck with forklift, visual checking, shelving the pallets and updating the stock bookkeeping, so this is comparable cost with the factory cost.

Frequency determines how often the process step occur and therefore acts as a multiplier for the process interface cost. There are four values for frequencies: monthly, weekly, daily and multiple times per day. Total process step score is calculated by multiplying interface with frequency. For example, a process for normal direct material shipments is very straightforward and the process score is low, which is the target (Table 5.).

Table 5. Example of normal materials process description.

Normal materials (Dom. & Foreign)				**As Is**		
Process step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total score**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				1,4	3	**1,4**

Another good example is a heavy process where complete transmissions are shipped in sea containers from China (Table 6.)

Table 6. Example of Chinese transaxle shipment process description

Chinese transaxles				As Is		
Process step	**Process description**	**Interface**	**Frequency**	**I-score**	**F-score**	**Total score**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Port to Rauma warehouse	WHTransport	Weekly	2,17	1	2,17
5	Container unloading	HumanExt	Weekly	2,5	1	2,5
6	Warehousing	WHTransport	Weekly	2,17	1	2,17
7	Picking and loading in Rauma wh	HumanExt	Weekly	2,5	1	2,5
8	Transport to Jyväskylä warehouse	WHTransport	Daily	2,17	5	10,85
9	Goods receiving in Jyväskylä	HumanExt	Daily	2,5	5	12,5
10	Warehousing	WHTransport	Daily	2,17	5	10,85
11	Transaxle picking in prod. sequence	HumanExt	Daily	2,5	5	12,5
12	Transaxle repacking & loading	HumanExt	Daily	2,5	5	12,5
13	Transport Jyväskylä to Factory	WHTransport	Daily	2,17	5	10,85
14	Unloading & Goods receiving	Human	Daily	1,4	5	7
				26,15	42	**87,79**

By evaluating all the primary supply processes separately in alternative supply chain scenarios, a conclusion was done (Table 7.). The current supply chain setup has the process score of 512,66 points. This is the base level (100 %) for the relative comparison. Alternative 3 has the lowest score compared to current supply chain (416,55 / 81,3 %), mostly due to reduced external warehouses and the most straightforward process with Chinese container deliveries. Alternative 1 is the second-best solution (419,85 / 81,9 %), which is a good result when taking the minimal investment requirements into account. Alternative 2 proved to be worst option with minimal process saving potential to the current supply chain (495,64 / 96,7 %). For the whole analysis, see appendix 1.

Table 7. Relative Process Score Analysis summary

Summary	As Is	Alt. 1	Alt. 2	Alt. 3
Normal materials (Dom. & Foreign)	1,4	1,4	28,42	1,4
Tyres	99,45	99,45	99,45	99,45
Chinese loose goods	33,54	22,38	28,98	21,28
Normal materials (Ext. Warehouse)	10,74	10,74	0	8,54
Chinese Engines	38,59	31,99	38,59	31,99
Engines	7	7	7	7
GIMA transaxles	66,2	49,7	66,2	49,7
Chinese transaxles	87,79	51,24	59,05	51,24
Cabins (as is)	53,55	53,55	53,55	53,55
Cabins (future)	114,4	92,4	114,4	92,4
TOTAL Process score	**512,66**	**419,85**	**495,64**	**416,55**
TOTAL Process score (%)	**100 %**	**81,9 %**	**96,7 %**	**81,3 %**
Difference (%)		**18,1 %**	**3,3 %**	**18,7 %**

5.2 Qualitative analysis

In addition to the quantitative (Relative Process Score) evaluation there must be the consideration of qualitative aspects for each alternative to select the best possible supply chain strategy. The criteria were carefully defined for the qualitative analysis to support the strategy approach in the best way from very detailed factory operations perspective. It took several brainstorming sessions together with supply chain experts and colleagues to define the final criteria used for qualitative analysis. The weighted criteria for the analysis are defined so that it

- cannot be measured with numbers (e.g. transport costs)
- don’t correlate with each other
- make differences clear between solutions

The first and the most important criterion with weight of 30 % is “**Supply reliability, lead time, replenishment speed**”. This criterion scores the reliability for safe supply of parts into the factory – the closer the proximity to the factory and the clearer the material flow structure, the higher the expected reliability. The replenishment speed describes the time required to supply material through the network – the more direct the flows, the less handling steps, the shorter the overall lead time.

The next criterion is “**Infrastructure capacity flexibility**”, weight 20 %: Possibilities to adjust the network structures and hubs according to future capacity and throughput requirements. Additionally, potential to free up surfaces within factory premises.

Third criterion is “**Supply chain transparency & visibility, complexity**”, weight 15 %: Transparency over inventory levels, transports and hub deployments – ideally, provided by adequate SCM IT tools. The lower the network complexity, the easier it will be to receive online data from the supply chain.

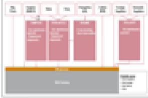
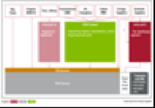
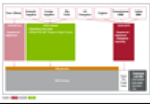
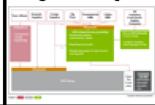
Fourth criterion is “**Handling effort**”, weight 15 %: which describes the reduction of human interactions to decrease possible quality issues for parts and processes. The reduction in handling effort will also decrease the amount of different human errors.

Fifth criterion is defined to “**Value added activities potential**”, weight 20 %: Since the hub processes and equipment are optimized for factory requirements, it has potential to include also value adding activities, for example repacking or pre-assembly activities to act as a supporting facility. Most external warehouses are offering only storage related services so therefore hub can be more beneficial from this perspective.

The last criterion is “**Long-term contract risk**”, weight 10 %: The contract risk describes the potential investment / contract commitment the company would face when implementing the supply network alternative. Also, the quantity of active contracts and the risks included must be considered.

The scoring was done by giving a score from 1 to 5 for every criterion per alternative and multiplying them with weight percentages. (Table 8.)

Table 8. Qualitative analysis results

Criteria / Alternatives		As Is Multiple locations 		Alt 1. Straightened supply chain 		Alt 2. No direct deliveries 		Alt 3. New big hub in factory proximity 	
	Weight	Value	**Score**	Value	**Score**	Value	**Score**	Value	**Score**
Supply reliability, Lead time, Replenishment speed	30 %	3	**0,9**	4	**1,2**	2	**0,6**	5	**1,5**
Infrastructure capacity flexibility	20 %	2	**0,4**	2	**0,4**	2	**0,4**	4	**0,8**
Supply chain transparency & visibility, complexity	15 %	2	**0,3**	2	**0,3**	1	**0,15**	4	**0,6**
Handling effort	15 %	1	**0,15**	3	**0,45**	3	**0,45**	4	**0,6**
Value added activities potential	10 %	3	**0,3**	3	**0,3**	4	**0,4**	5	**0,5**
Long-term contract risk	10 %	5	**0,5**	3	**0,3**	3	**0,3**	1	**0,1**
Total	**100 %**		**2,55**		**2,95**		**2,3**		**4,1**

5.3 Integration of Relative Process Score- and qualitative analysis

The method finding the best solution for the future supply chain strategy was to evaluate the alternatives from the two different perspectives presented in earlier chapters. To get a visual answer for the question of the best solution, a benefit analysis was done in a scatter plot form to combine these two results. The analysis combines the both scores, total process score and the qualitative score into one two-dimensional chart where the lowest right corner represents be the best-found solution. (Figure 6.)

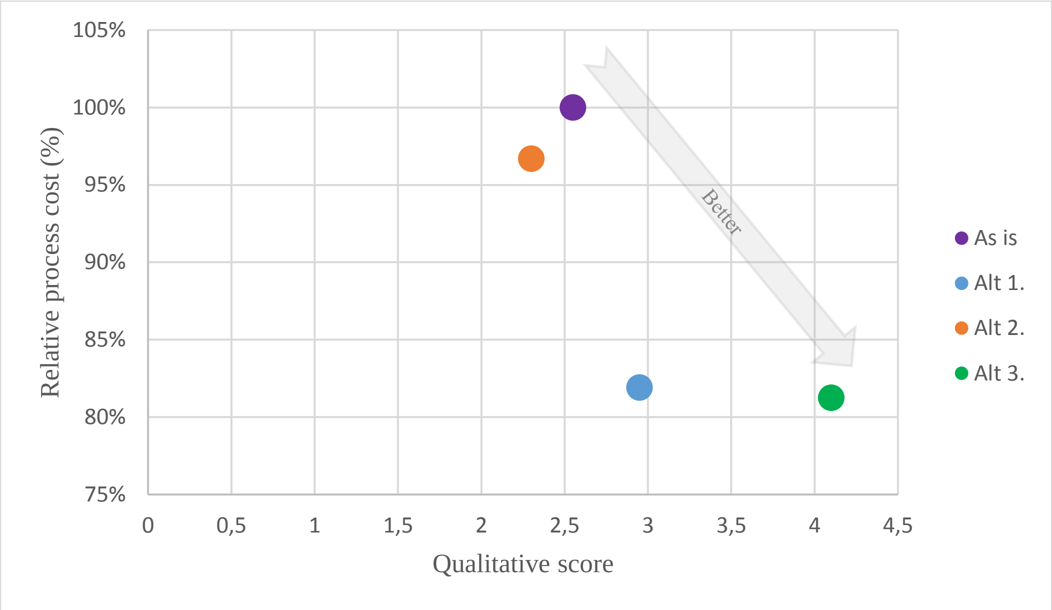


Figure 6. Score vs. benefit analysis

5.4 Location analysis

There is a huge amount of transportation data available thanks to the intelligent transportation management system used by all company factories in Europe. The target for using the system is to optimize and consolidate shipments and provide data for further network development. It is operated by 4th party logistics service provider. Transportation data was gathered to find out the theoretical location of "center of gravity" in Finland. The purpose of the location analysis was to find out if there were heavy material flows from different ports (Rauma, Pori, Helsinki) which are affecting to the center of gravity. Also, the analysis was used to simulate what the flows would look like if, for example, the Chinese container shipment port of destinations (POD) were changed from Rauma to Helsinki.

The analysis had an analytical approach for determining the inland material flow. This has never done before, but the overall estimations and the results were aligned with the expectations. The analysis also considered another factory in Finland located in Tampere area. First, only the domestic network was analyzed. The result was not unexpected, and it seems very balanced. (Figure 7.)

Figure 7. Domestic inbound network

Next, the volumes from international shipments were added to the analysis, and the overall share of domestic deliveries decreased significantly. At this point, it seemed reasonable that the optimal location would be Tampere area (1), second best Helsinki area (2), and last the Jyväskylä area (3). Helsinki area overrides Jyväskylä area because the level of consolidation and quantity of full truck shipments would be higher. (Figure 8.)

Figure 8. Complete current inbound network including international deliveries

Next task was to figure out, how the new and proposed supply chain solution would act in these supply lanes. The analysis led to two important findings. First, the most significant effect would be to change port of destination for Chinese suppliers' container shipments. It would move the center of gravity towards east. Now, port of destination Rauma is forced to be used because there is a hub located in Rauma and it is causing dispersion in domestic traffic. Re-organizing the Chinese shipment port of destination to Helsinki would lead to conclusion that the center of gravity is somewhere between Helsinki and Suolahti – by the E75 highway. With current port setup the center of gravity is in Tampere area because of the heavy volume from Rauma. When looking towards 3 - 5 years to future, the outlook is that the global inbound volumes will significantly increase. This leads to the fact, that Finnish domestic volumes are marginal and they can be excluded from the gravity analysis. Domestic supply lanes can be integrated into hub case by case.

The second result is a trade-off between material replenishment speed and consolidation of shuttle shipments between the hub and factory. If the hub location would be in the southern part of Finland, the advantage of consolidated, full truck load shipments would be better. Usually the most expensive trip for European LTL (Less-than-TruckLoad) shipments is the “last mile” from Finnish port to Suolahti. Consolidating the LTL shipments to FTL (Full TruckLoad) in the southern Finland would lead to transportation cost savings. This was investigated: a last-mile cost analysis was done, and the financial impact is minor wherever the consolidation happens: in Helsinki area or in Central Finland area. The other side of choosing the location is the replenishment speed. Factory has daily situations where an express delivery is required from an external warehouse. Currently, the production is used to receive express shipment in 1-2 hours from ordering from the external warehouse. Hub location in south would increase the time so the urgent replenishment would almost always be on the next morning.

The conclusion of the center of gravity analysis is that the most reasonable location for hub or warehouse facility is nearby plant operations by the highway E75. Due to importance of material replenishment speed and heavy truck flow via E75 the recommendation is well justified.

6 RESULTS

6.1 The suggestion for new supply chain network

The new supply chain network suggestion is determined as a combined result by the before mentioned analyses. The Relative Process Score Analysis and qualitative benefit analysis stated that the best solution for network layout is the alternative number three. Therefore, it suggests establishing completely new hub where most of the costly processes would be handled. The center of gravity -analysis suggests the location for the hub in proximity of the factory by the E75 highway. With this solution, three external warehouses would be transformed into one single hub and the relative process efficiency would gain a significant boost with major improvements in process efficiency in many primary processes (Table 9.).

Alternative 1 can be described as an improvement compared to current supply chain, but it still has the complexity and flexibility constraints. It is basically an easy and quickly applicable fix for the most critical problems in current model from process perspective. The problem is that the straightened version of current model would not be able to fill the upcoming capacity requirements without investing to more space. Therefore Alternative 1 cannot be considered as long-term solution.

Table 9. Potential for process efficiency

Process / relative score	As is	Alt. 3.	Potential for process efficiency
Chinese loose goods	33,54	21,28	36,6 %
Normal materials via external warehouse	10,74	8,54	20,5 %
GIMA Transmission process via external warehouse	66,2	49,7	24,9 %
Chinese Transaxles process	87,79	51,24	41,6 %
Cabin process in future	114,4	92,4	19,2 %

To convert the estimated saving potential to actual business case, a financial analysis based on this information is done in the next chapter.

There is one main element of risk in the chosen alternative. It requires an investment and probably long-term contract with the owner of the property. To minimize the risk, the hub must be flexible for example by using modular building architecture and having other companies partnering in the property. Flexibility will support the floor space demand variation in the future. To underline the challenge with demand fluctuation can be described in the table in chapter 4 by using the floor space demand prospect to year 2021. (Table 4.)

6.2 Financial analysis of the suggested alternative

The chapter has confidential corporate information, which is why the real values of costs are not published.

The base demand for initiating this project had two perspectives: one was to find out how the company can succeed in the complex, changing future supply chain environment. The other perspective was to find the saving potential in supply chain process. The current supply chain has been slowly drifting to its current state – piece by piece – and there was an assumption and feeling that it is not the most cost wise process. External operations cost structure is described in the below table (Table 10.).

Transport costs will be cropped out from the analysis, because in the future scenario goods must still be transported and the saving potential calculation is not applicable for transport. In 2018, the annual sum for external handling, warehousing and other (packaging material etc.) costs is *X* €.

Table 10. Annual costs for external operations (2018) ***(Not published in this version)***

Potential saving analysis was done by gathering the complete cost breakdown from the logistics service providers' monthly invoicing since 2017. Operations have changed a lot during past years, so 2017 was decided to be used as a reference for 2018 and the saving potential will be calculated from 2018 figures. To simulate the following years' changes, previously calculated 40% increase in part numbers, space, - and handling requirements are also included as a future saving potential.

Invoicing data was analyzed and divided to the five processes, which were in earlier chapter discovered to have a potential for savings. Three of these five processes were well-documented, and the data was available. Two processes are currently still ramping up and there is no cost-data available, so an estimation was calculated based on known future volumes. These two processes are minor compared to the three existing: Chinese supplies and normal material supply via external warehouse. (Table 11.)

Table 11. Annual saving potential ***(Sums not published in this version)***

Processes where saving potential is found	**2017 spend (€/a)**	**2018 spend forecasted (€/a)**	**Future spend: space & handling requirement (€/a)**	**Process saving pot. (%)**	**Saving pot. to 2018 (€/a)**	**Saving potential in future (€/a)**
Chinese loose goods	x €	x €	x €	36,6 %	x €	x €
Chinese transaxles process	x €	x €	x €	41,6 %	x €	x €
Normal materials via external warehouse	x €	x €	x €	20,5 %	x €	x €
Gima transmission process	x €	x €	x €	24,9 %	x €	x €
Cabin process in future	x €	x €	x €	19,2 %	x €	x €
Administrative costs	x €	x €	x €	66,6 %	x €	x €
TOTAL	**x €**	**x €**	**x €**		**x €**	**x €**

The calculated saving potential shown in Table 11. is 40 % of current (2018) spend in logistics service provider services in the evaluated processes. The following list explains, where the saving is coming from in every process:

- Chinese loose goods will be unloaded in cross-docking deconsolidation hub, where warehousing activities, such as put-away and picking are not needed as in Rauma currently. The goods will be directly transported to the hub, where repacking work is centralized, and process-efficiency optimized. The hub work is cheaper with no profit margin requirements.

- Chinese transaxles will follow the same procedure as loose goods and the handling will be focused in the hub with cheaper hourly rate and transaction rate.
- Normal materials process via external warehouse will remain same as it is now, but the hub work will be optimized and without profit margin.
- The new processes, such as Gima transaxles and future cabin process will be also facing a saving potential because the handling work will be without profit margin and the process optimization is done by company for itself.
- Administrative cost saving is coming from consolidation advantages: reducing the number of facilities requires less supervisors, equipment, and systems which will indirectly reflect in costs.

To reach all these savings, a principled change must be done to invest in material handling headcount for cheaper labor cost and process optimization. The hub implementation requires also an investment to a facility which supports the planned activities.

7 DISCUSSION

The project started with data collection and current state analysis. It was an eye-opening observation of complexity, costs and lost efficiency when everything was put on paper. In the past, no analysis of current supply chain had been done in this level of detail. It can be stated, that the project managed to fulfill the objective:

- *The objective of the project was to recommend a new solution for the future inbound supply chain network, which would both fulfill the strategic demand from the increasing volume and operational complexity, and gain process- and cost efficiency.*

Requirements for the future network were found in terms of warehousing space, complexity and six important qualitative criteria. By using these requirements as a basis for re-organizing the supply chain, three different alternatives were compared against the current supply chain setup and the best solution was found. Additionally, a potential financial saving was calculated based on efficiency increase in chosen supply chain processes. In the end, financials are the most crucial finding when calculating the potential investment options. It can be concluded that the thesis succeeded in answering the following research questions:

1. *What will the difference be in network requirements caused by increasing volume and complexity?*
2. *By using the requirements found by the project, how must the supply chain network be re-organized and what are the arguments doing so?*

It was decided that three of the most promising alternatives would be evaluated in this project. Because of the limited number of alternatives, it cannot be guaranteed that the current finding is absolutely the best solution available. However, if another promising alternative is later discovered, it can easily be added in this evaluation scheme to find out its potential.

Implementing the chosen alternative requires a major investment and change in the way the company operates its logistic functions. The calculated cost savings give the investment planning a good starting point since the value of the saving potential is high. Because inbound logistics is not value-adding work for the final product, it is important to take action wherever the saving potential is available without compromising the quality. It is better for the company to take the ownership of most of the supply chain processes to be more controlled and efficient. As a result, the number of employees in supply chain operations would increase. It is necessary to remember that low headcount in local logistics processes is not the optimal performance indicator if the costs are distributed somewhere else in the chain.

The investment will give the supply chain obligatory conditions to efficiently support the growth of the company. The results allow the calculation of payback time for the investment, which can be seen as the cost for enabling company growth. Lastly, I want to highlight the fact that the current company strategy direction is leading to increasingly globalized supply chain with bigger loads, batches and logistical requirements. Therefore, the supply chain must be evolved to meet the requirements for the continuously changing environment.

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APPENDICES

Appendix 1. Relative Process Score Analysis

APPENDIX 1. Relative process cost analysis

Legend:

Abbreviation	Legend:	Process cost	Details
Electronic	Electronic data transfer	0	
WHTransport	Warehousing / Transport	2,17	Average of daily warehousing 1,33 €/pallet + transport 3,00 €/pallet
Human	Human, internal physical material handling	1,4	1 pallet handling avg. 3,4 min, 25 €/hr = 1,4 €
HumanExt	Human, external operator physical material handling	2,5	1 pallet handling 2,50 €
		Shipment frequency	
Monthly	Monthly	0,25	
Weekly	Weekly	1	Baseline
Daily	Daily	5	
Multi	Multiple times per day	15	

Process as is:

Normal materials (Dom. & Foreign)				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				1,4	3	**1,4**

Tyres				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Tyre supplier weekly confirmations	Human	Weekly	1,4	1	1,4
4	Material planning operations	Human	Daily	1,4	5	7
5	Tyre picking & loading in prod. sequence	HumanExt	Multi	2,5	15	37,5
6	Shipping documents warehouse / supplier	Electronic	Multi	0	15	0
7	Transport Jyväskylä to Factory	WHTransport	Multi	2,17	15	32,55
8	Unloading & Goods receiving	Human	Multi	1,4	15	21
				8,87	72	**99,45**

Chinese loose goods				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Unloading in Rauma Warehouse	HumanExt	Weekly	2,5	1	2,5

APPENDIX 1. Relative process cost analysis

5	Container unloading	HumanExt	Weekly	2,5	1	2,5
6	Warehousing	WHTransport	Weekly	2,17	1	2,17
7	Maintaining stock balance in Jyväskylä	Electronic	Daily	0	5	0
8	Parts repacking	HumanExt	Daily	2,5	5	12,5
9	Parts picking & loading in Rauma	HumanExt	Weekly	2,5	1	2,5
10	Unloading in Jyväskylä	HumanExt	Weekly	2,5	1	2,5
11	WHTransport activities	WHTransport	Weekly	2,17	1	2,17
12	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
13	Parts picking & loading in Jyväskylä	HumanExt	Weekly	2,5	1	2,5
14	Transport Jyväskylä to Factory	Human	Weekly	1,4	1	1,4
15	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				23,54	27	**33,54**

Normal materials (Ext. Warehouse)				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	HumanExt	Weekly	2,5	1	2,5
4	Warehousing	WHTransport	Weekly	2,17	1	2,17
5	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
6	Parts picking & loading in Ext. warehouse	HumanExt	Weekly	2,5	1	2,5
7	Transport Ext. warehouse to Factory	WHTransport	Weekly	2,17	1	2,17
8	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				10,74	12	**10,74**

Chinese Engines				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Harbour to Warehouse	WHTransport	Weekly	2,17	1	2,17
5	Unloading & Goods receiving	HumanExt	Weekly	2,5	1	2,5
6	Warehousing	WHTransport	Weekly	2,17	1	2,17
7	Engine picking & loading in sequence	HumanExt	Daily	2,5	5	12,5
8	Transport Tampere to Factory	WHTransport	Daily	2,17	5	10,85
9	Unloading & Goods receiving	Human	Daily	1,4	5	7
				14,31	21	**38,59**

Engines				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Daily	1,4	5	7
				1,4	7	**7**

GIMA Transaxles				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**

APPENDIX 1. Relative process cost analysis

1	Order processing (EDI)	Electronic	Daily	0	5	0
2	Unloading & Goods receiving	HumanExt	Daily	2,5	5	12,5
3	Warehousing	WHTransport	Daily	2,17	5	10,85
4	Transaxle picking in prod. sequence	HumanExt	Daily	2,5	5	12,5
5	Transaxle repacking & loading	HumanExt	Daily	2,5	5	12,5
6	Transport Jyväskylä to Factory	WHTransport	Daily	2,17	5	10,85
7	Unloading & Goods receiving	Human	Daily	1,4	5	7
				13,24	35	**66,2**

Chinese transaxles				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Port to Rauma warehouse	WHTransport	Weekly	2,17	1	2,17
5	Container unloading	HumanExt	Weekly	2,5	1	2,5
6	Warehousing	WHTransport	Weekly	2,17	1	2,17
7	Picking and loading in Rauma wh	HumanExt	Weekly	2,5	1	2,5
8	Transport to Jyväskylä warehouse	WHTransport	Daily	2,17	5	10,85
9	Goods receiving in Jyväskylä	HumanExt	Daily	2,5	5	12,5
10	Warehousing	WHTransport	Daily	2,17	5	10,85
11	Transaxle picking in prod. sequence	HumanExt	Daily	2,5	5	12,5
12	Transaxle repacking & loading	HumanExt	Daily	2,5	5	12,5
13	Transport Jyväskylä to Factory	WHTransport	Daily	2,17	5	10,85
14	Unloading & Goods receiving	Human	Daily	1,4	5	7
				26,15	42	**87,79**

Cabins (as is)				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Transport	WHTransport	Multi	2,17	15	32,55
4	Unloading	Human	Multi	1,4	15	21
5	Goods receiving	Electronic	Daily	0	5	0
				3,57	41	**53,55**

Cabins (future)				**As Is**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & GR in external warehouse	HumanExt	Daily	2,5	5	12,5
4	Warehousing	WHTransport	Daily	2,17	5	10,85
5	Cabin loading in production sequence	HumanExt	Multi	2,5	15	37,5
6	Transport from Warehouse to Factory	WHTransport	Multi	2,17	15	32,55
7	Unloading	Human	Multi	1,4	15	21
8	Goods receiving	Electronic	Multi	0	15	0
				10,74	76	**114,4**

APPENDIX 1. Relative process cost analysis

Alternative 1:

Normal materials (Dom. & Foreign)				Alt. 1		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
4	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				1,4	3	**1,4**

Tyres				Alt. 1		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Tyre supplier weekly confirmations	Human	Weekly	1,4	1	1,4
4	Material planning operations	Human	Daily	1,4	5	7
5	Tyre picking & loading in prod. sequence	HumanExt	Multi	2,5	15	37,5
6	Shipping documents warehouse / supplier	Electronic	Multi	0	15	0
7	Transport Jyväskylä to Factory	WHTransport	Multi	2,17	15	32,55
8	Unloading & Goods receiving	Human	Multi	1,4	15	21
				8,87	72	**99,45**

Chinese loose goods				Alt. 1		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from harbour to DeCon hub	WHTransport	Weekly	2,17	1	2,17
5	Container unloading in DeCon hub	HumanExt	Weekly	2,5	1	2,5
6	Transport to HUB	WHTransport	Weekly	2,17	1	2,17
7	Repacking loose goods	Human	Daily	1,4	5	7
8	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
9	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
10	Parts picking & loading in HUB	Human	Weekly	1,4	1	1,4
11	Transport HUB to Factory	WHTransport	Weekly	2,17	1	2,17
12	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				16,78	20	**22,38**

Normal materials (Ext. Warehouse)				Alt. 1		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	HumanExt	Weekly	2,5	1	2,5
4	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
5	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
6	Parts picking & loading in Ext. warehouse	HumanExt	Weekly	2,5	1	2,5
7	Transport Ext. warehouse to Factory	WHTransport	Weekly	2,17	1	2,17
8	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4

APPENDIX 1. Relative process cost analysis

10,74	12	**10,74**

Chinese Engines				**Alt. 1**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Harbour to HUB	WHTransport	Weekly	2,17	1	2,17
5	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
6	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
7	Engine picking & loading in sequence	Human	Daily	1,4	5	7
8	Transport HUB to Factory	WHTransport	Daily	2,17	5	10,85
9	Unloading & Goods receiving	Human	Daily	1,4	5	7
				12,11	21	**31,99**

Engines				**Alt. 1**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Daily	1,4	5	7
				1,4	7	**7**

GIMA Transaxles				**Alt. 1**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Daily	0	5	0
2	Unloading & Goods receiving	Human	Daily	1,4	5	7
3	Warehousing activities	WHTransport	Daily	2,17	5	10,85
4	Transaxle picking in prod. sequence	Human	Daily	1,4	5	7
5	Transaxle repacking & loading	Human	Daily	1,4	5	7
6	Transport HUB to Factory	WHTransport	Daily	2,17	5	10,85
7	Unloading & Goods receiving	Human	Daily	1,4	5	7
				9,94	35	**49,7**

Chinese transaxles				**Alt. 1**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from harbour to DeCon hub	WHTransport	Weekly	2,17	1	2,17
5	Container unloading in DeCon hub	Human	Weekly	1,4	1	1,4
6	Direct transport to HUB	WHTransport	Weekly	2,17	1	2,17
7	Goods receiving in HUB	Human	Weekly	1,4	1	1,4
8	Warehousing activities	WHTransport	Daily	2,17	5	10,85
9	Transaxle picking in prod. sequence	Human	Daily	1,4	5	7
10	Transaxle repacking & loading	Human	Daily	1,4	5	7
11	Transport HUB to Factory	WHTransport	Daily	2,17	5	10,85
12	Unloading & Goods receiving	Human	Daily	1,4	5	7
				17,08	32	**51,24**

Cabins (as is)	**Alt. 1**

APPENDIX 1. Relative process cost analysis

Step	Process description	Interface	Frequency	I-Cost	F-cost	Total cost
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Transport	WHTransport	Multi	2,17	15	32,55
4	Unloading	Human	Multi	1,4	15	21
5	Goods receiving	Electronic	Daily	0	5	0
				3,57	41	**53,55**

Cabins (future)				**Alt. 1**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & GR in HUB	Human	Daily	1,4	5	7
4	Warehousing activities	WHTransport	Daily	2,17	5	10,85
5	Cabin loading in production sequence	Human	Multi	1,4	15	21
6	Transport from Warehouse to Factory	WHTransport	Multi	2,17	15	32,55
7	Unloading	Human	Multi	1,4	15	21
8	Goods receiving	Electronic	Multi	0	15	0
				8,54	76	**92,4**

Alternative 2:

Normal materials (Dom. & Foreign)				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
4	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
5	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
6	Parts picking & loading in Ext. warehouse	Human	Daily	1,4	5	7
7	Transport Ext. warehouse to Factory	WHTransport	Daily	2,17	5	10,85
8	Unloading & Goods receiving	Human	Daily	1,4	5	7
				1,4	3	**28,42**

Tyres				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0

3	Tyre supplier weekly confirmations	Human	Weekly	1,4	1	1,4
4	Material planning operations	Human	Daily	1,4	5	7
5	Tyre picking & loading in prod. sequence	HumanExt	Multi	2,5	15	37,5
6	Shipping documents warehouse / supplier	Electronic	Multi	0	15	0
7	Transport Jyväskylä to Factory	WHTransport	Multi	2,17	15	32,55
8	Unloading & Goods receiving	Human	Multi	1,4	15	21
				8,87	72	**99,45**

Chinese loose goods				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Harbour to DeCon HUB	WHTransport	Weekly	2,17	1	2,17
5	Container unloading in DeCon hub	HumanExt	Weekly	2,5	1	2,5
6	Transport to Warehouse	WHTransport	Weekly	2,17	1	2,17
7	Repacking loose goods	HumanExt	Daily	2,5	5	12,5
8	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
9	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
10	Parts picking & loading in Warehouse	HumanExt	Weekly	2,5	1	2,5
11	Transport Warehouse to Factory	WHTransport	Weekly	2,17	1	2,17
12	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				18,98	20	**28,98**

Normal materials (Ext. Warehouse) - No more relevant				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
4	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
5	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
6	Parts picking & loading in Ext. warehouse	Human	Daily	1,4	5	7
7	Transport Ext. warehouse to Factory	WHTransport	Daily	2,17	5	10,85
8	Unloading & Goods receiving	Human	Daily	1,4	5	7
				8,54	24	**0**

Chinese Engines	**Alt. 2**

APPENDIX 1. Relative process cost analysis

Step	Process description	Interface	Frequenc y	I-Cost	F-cost	Total cost
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Harbour to Warehouse	WHTransport	Weekly	2,17	1	2,17
5	Unloading & Goods receiving	HumanExt	Weekly	2,5	1	2,5
6	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
7	Engine picking & loading in sequence	HumanExt	Daily	2,5	5	12,5
8	Transport Warehouse to Factory	WHTransport	Daily	2,17	5	10,85
9	Unloading & Goods receiving	Human	Daily	1,4	5	7
				14,31	21	**38,59**

Engines				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Daily	1,4	5	7
				1,4	7	**7**

GIMA Transaxles				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Daily	0	5	0
2	Unloading & Goods receiving	HumanExt	Daily	2,5	5	12,5
3	Warehousing activities	WHTransport	Daily	2,17	5	10,85
4	Transaxle picking in prod. sequence	HumanExt	Daily	2,5	5	12,5
5	Transaxle repacking & loading	HumanExt	Daily	2,5	5	12,5
6	Transport Warehouse to Factory	WHTransport	Daily	2,17	5	10,85
7	Unloading & Goods receiving	Human	Daily	1,4	5	7
				13,24	35	**66,2**

Chinese transaxles				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from harbour to DeCon hub	Human	Weekly	1,4	1	1,4
5	Container unloading in DeCon hub	HumanExt	Weekly	2,5	1	2,5

6	Direct transport to Warehouse	Human	Weekly	1,4	1	1,4
7	Goods receiving in Warehouse	HumanExt	Weekly	2,5	1	2,5
8	Warehousing activities	WHTransport	Daily	2,17	5	10,85
9	Transaxle picking in prod. sequence	HumanExt	Daily	2,5	5	12,5
10	Transaxle repacking & loading	HumanExt	Daily	2,5	5	12,5
11	Transport Warehouse to Factory	Human	Daily	1,4	5	7
12	Unloading & Goods receiving	Human	Daily	1,4	5	7
				19,17	32	**59,05**

Cabins (as is)				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Transport	WHTransport	Multi	2,17	15	32,55
4	Unloading	Human	Multi	1,4	15	21
5	Goods receiving	Electronic	Daily	0	5	0
				3,57	41	**53,55**

Cabins (future)				**Alt. 2**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & GR in Warehouse	HumanExt	Daily	2,5	5	12,5
4	Warehousing activities	WHTransport	Daily	2,17	5	10,85
5	Cabin loading in production sequence	HumanExt	Multi	2,5	15	37,5
6	Transport from Warehouse to Factory	WHTransport	Multi	2,17	15	32,55
7	Unloading	Human	Multi	1,4	15	21
8	Goods receiving	Electronic	Multi	0	15	0
				10,74	76	**114,4**

Alternative 3:

Normal materials (Dom. & Foreign)				**Alt. 3**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0

2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				1,4	3	**1,4**

Tyres				**Alt. 3**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Tyre supplier weekly confirmations	Human	Weekly	1,4	1	1,4
4	Material planning operations	Human	Daily	1,4	5	7
5	Tyre picking & loading in prod. sequence	HumanExt	Multi	2,5	15	37,5
6	Shipping documents warehouse / supplier	Electronic	Multi	0	15	0
7	Transport Jyväskylä to Factory	WHTransport	Multi	2,17	15	32,55
8	Unloading & Goods receiving	Human	Multi	1,4	15	21
				8,87	72	**99,45**

Chinese loose goods				**Alt. 3**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from harbour to DeCon hub	WHTransport	Weekly	2,17	1	2,17
5	Container unloading in DeCon hub	Human	Weekly	1,4	1	1,4
6	Transport to HUB	WHTransport	Weekly	2,17	1	2,17
7	Repacking loose goods	Human	Daily	1,4	5	7
8	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
9	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
10	Parts picking & loading in HUB	Human	Weekly	1,4	1	1,4
11	Transport HUB to Factory	WHTransport	Weekly	2,17	1	2,17
12	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
				15,68	20	**21,28**

Normal materials (Via HUB)				**Alt. 3**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI/SNC)	Electronic	Weekly	0	1	0
2	Shipment documentation	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
4	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
5	Maintaining stock balance in Factory	Electronic	Daily	0	5	0
6	Parts picking & loading in HUB	Human	Weekly	1,4	1	1,4
7	Transport HUB to Factory	WHTransport	Weekly	2,17	1	2,17
8	Unloading	Human	Weekly	1,4	1	1,4
				8,54	12	**8,54**

APPENDIX 1. Relative process cost analysis

Chinese Engines				Alt. 3		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from Harbour to HUB	WHTransport	Weekly	2,17	1	2,17
5	Unloading & Goods receiving	Human	Weekly	1,4	1	1,4
6	Warehousing activities	WHTransport	Weekly	2,17	1	2,17
7	Engine picking & loading in sequence	Human	Daily	1,4	5	7
8	Transport HUB to Factory	WHTransport	Daily	2,17	5	10,85
9	Unloading & Goods receiving	Human	Daily	1,4	5	7
				12,11	21	**31,99**

Engines				Alt. 3		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & Goods receiving	Human	Daily	1,4	5	7
				1,4	7	**7**

GIMA Transaxles				Alt. 3		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Daily	0	5	0
2	Unloading & Goods receiving	Human	Daily	1,4	5	7
3	Warehousing activities	WHTransport	Daily	2,17	5	10,85
4	Transaxle picking in prod. sequence	Human	Daily	1,4	5	7
5	Transaxle repacking & loading	Human	Daily	1,4	5	7
6	Transport HUB to Factory	WHTransport	Daily	2,17	5	10,85
7	Unloading & Goods receiving	Human	Daily	1,4	5	7
				9,94	35	**49,7**

Chinese transaxles				Alt. 3		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Order processing (EDI)	Electronic	Weekly	0	1	0
2	Shipment pre-advice	Electronic	Weekly	0	1	0
3	Handling the pre-advice and destination	Human	Weekly	1,4	1	1,4
4	Transport from harbour to DeCon hub	WHTransport	Weekly	2,17	1	2,17
5	Container unloading in DeCon hub	Human	Weekly	1,4	1	1,4
6	Direct transport to HUB	WHTransport	Weekly	2,17	1	2,17
7	Goods receiving in HUB	Human	Weekly	1,4	1	1,4

8	Warehousing activities	WHTransport	Daily	2,17	5	10,85
9	Transaxle picking in prod. sequence	Human	Daily	1,4	5	7
10	Transaxle repacking & loading	Human	Daily	1,4	5	7
11	Transport HUB to Factory	WHTransport	Daily	2,17	5	10,85
12	Unloading & Goods receiving	Human	Daily	1,4	5	7
				17,08	32	**51,24**

Cabins (as is)				**Alt. 3**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Transport	WHTransport	Multi	2,17	15	32,55
4	Unloading	Human	Multi	1,4	15	21
5	Goods receiving	Electronic	Daily	0	5	0
				3,57	41	**53,55**

Cabins (future)				**Alt. 3**		
Step	**Process description**	**Interface**	**Frequency**	**I-Cost**	**F-cost**	**Total cost**
1	Orders in production sequence	Electronic	Daily	0	5	0
2	Production forecast from Factory demand	Electronic	Weekly	0	1	0
3	Unloading & GR in HUB	Human	Daily	1,4	5	7
4	Warehousing activities	WHTransport	Daily	2,17	5	10,85
5	Cabin loading in production sequence	Human	Multi	1,4	15	21
6	Transport from HUB to Factory	WHTransport	Multi	2,17	15	32,55
7	Unloading	Human	Multi	1,4	15	21
8	Goods receiving	Electronic	Multi	0	15	0
				8,54	76	**92,4**

APPENDIX 1. Relative process cost analysis

Summary

	As Is	Alt. 1	Alt. 2	Alt. 3
Normal materials (Dom. & Foreign)	1,4	1,4	28,42	1,4
Tyres	99,45	99,45	99,45	99,45
Chinese loose goods	33,54	22,38	28,98	21,28
Normal materials (Ext. Warehouse)	10,74	10,74	0	8,54
Chinese Engines	38,59	31,99	38,59	31,99
Engines	7	7	7	7
GIMA Transaxles	66,2	49,7	66,2	49,7
Chinese transaxles	87,79	51,24	59,05	51,24
Cabins (as is)	53,55	53,55	53,55	53,55
Cabins (future)	114,4	92,4	114,4	92,4
TOTAL Process cost	**512,66**	**419,85**	**495,64**	**416,55**
TOTAL Process cost (%)	**100 %**	**81,9 %**	**96,7 %**	**81,3 %**
Difference		**18,1 %**	**3,3 %**	**18,7 %**