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Takt Management

**Mapping and analyzing the supply chain from a takt
implementation perspective at Tetra Pak**

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Preface

Tetra Pak have during some years been and still are in a major change to a new production system. The change has not been as smooth as desired and because of that this project was initiated to give a view of the current state and progress in the change. The project is the final part and master thesis of our Master of Science in Industrial Engineering and management. It has been performed during the autumn 2010 in collaboration with the Institute of Technology in Lund.

We wish to thank our supervisors at Tetra Pak Johan Häggström and Lars Olof Månsson for the support during the project. We also wish to thank Bertil I Nilsson, our supervisor at the department of production management for feedback, comments and guidance in the project. In addition we want to thank all individuals who have been involved and given us some of their time and through that made the project possible. At last we wish to give some special thanks to Hans Söberg who showed great involvement in the project and was a big help in getting started. A special thanks also goes to Carlo Simonini for a warm welcome and rewarding visit in Modena.

Thank You!

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Abstract

Title: Takt management, mapping and analyzing the supply chain from a takt implementation perspective.

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Research question: Investigate the maturity of takt implementation in the organization and suggest areas for further improvements to maximize the outcome of the change effort.

Deliverables: The project has focused on creating a comprehensive view of the maturity in the takt implementation and the results are delivered in a written report and an oral presentation both to Tetra Pak and Lund University

Methodology: Qualitative data was gathered from interviews, observations and internal documentations. A literature study directed mostly towards the lean philosophy, change management and process management and orientation was done. From the data gathered together with the theoretic framework important aspects/attributes of a takt implementation was developed and stated. An investigation of the supply chains in focus was done and then the supply chains were matched against the stated attributes to find gaps and areas for improvement. An analysis of each supply chain is given and then an overall analysis is done stating problems common for all supply chains and not solely connected to one flow. Finally recommendations are given on areas where attention should be focused to improve performance and increase the takt maturity.

Delimitations: The project only deals with some of the machines produced by Tetra Pak. The results concerns takt implementation in a relatively low volume and long cycle production and is not necessary only connected to Tetra Pak specific case but should be applicable also for other organizations with similar circumstances.

Conclusions: The takt implementation is a huge change and there are still areas and functions not aligned with the new production system. The desired takt system is complex and to fully succeed it is essential that a standard way of takt is introduced and communicated through the supply chain and within Tetra Pak. There is also a need of synchronizing the capacity between suppliers in the supply chain to reach

the desired goals and benefits with takt. It is important that Tetra Pak acts consistently in their relationship with suppliers and fully support the takt principles in all interfaces with their partners. Tetra Pak have been working with the takt concept for years and there exists a lot of experience and skills within the organization, it is important that this knowledge is shared to support and help the development of takt in all supply chains.

Key words: Takt, leveling.

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1 Introduction

This chapter gives a background for the project. It also states the purpose and expected results along with delimitations and terminology used in the report. At last an overview of the report is given.

1.1 Background

Few companies have the benefit of not being effected by the extreme forces of increasing competition that have arisen from globalization. Tetra Pak is not one of them! Globalization has created a world of great possibilities, but also a world where the need of change to survive is immense. Being on top today means less than ever for the state of tomorrow. The key for survival in the future is having an adaptive and flexible corporate culture and living in change will have to be the norm rather than the exception to prosper.

Tetra Pak makes filling machines. The machines are big and have a high degree of technical complexity and every machine is produced and assembled according to a specific customer order. This together with inaccurate forecasts has led to long lead times and a need to improve the order fulfillment process.

Tetra Pak continuously launch activities and projects to rationalize the organization, increase the value for customers and be more effective and efficient. The Implementation of takt, a new way for Tetra Pak to manage the supply chain is a big change and will for sure push people and entire functions away from their comfort zones. But change is the only way to go if you want to be on the winning side, and you better start loving it.

1.2 Tetra Pak Challenge

The implementation of takt-controlled production at Tetra Pak is an ongoing change effort and aims at achieving a more cost efficient and higher quality production benefitting the whole supply chain. To gain highest possible value from the change effort, takt must be established and understood not only inside Tetra Pak but all along the supply chain. Takt and leveling will, if managed right, expose many of the existing hidden problems, which of course is a first step in improving processes. The change is a step towards a more integrated supply chain working together to provide higher value for the final customer. A successful transformation would mean big strategic competitive advantages through being able to deliver a big variety of machines with short lead times and high precision.

In the current state some of the production is managed by takt in different degrees and some production not. Implementing takt is a strategic movement toward customer focus. To make this change successful there are numerous tasks to deal with; a full understanding of the takt principles in the supply chain, cross-functional teamwork, higher control of production and standardization of procedures and processes.

1.3 Purpose and Objectives

The implementation of takt started at different times in different parts of Tetra Pak and new activities and projects are continuously launched to improve the

work. This has led to a lack of an overview of the status in the implementation and thereby the full understanding of how and where to focus future work for maximum improvement is missing. The project should result in deliverables in the form of a report and presentation, both to stakeholders at the university and Tetra Pak. The deliverables should provide a comprehensive view and analysis of the current state in the takt implementation. There should also be recommendation on areas, if any are found, where to focus the implementation and where efforts should be directed both in the short and long term to increase performance.

The purpose of this project is to

1. Investigate and map the current state of the maturity of the takt implementation.
2. Analyze the current state. Pinpoint places to focus attention for improvements to maximize the output of the ongoing change effort.
3. Deliver the results in a written report and an oral presentation.

1.4 Delimitations

The investigation and mapping during the project is focused on seven specific machine types given by Tetra Pak. The focus will primarily be on Tetra Pak and the first tier module suppliers. Though, in some cases the work will reach the second tier suppliers or the market companies that constitutes the interface against final customer. A successful implementation of takt requires broad based action not only from Tetra Pak but also further upstream the supply chain. Therefore it would be conflicting with the goals and fatal for the quality of the project to solely focus on the work inside and between Tetra Pak and module suppliers. Further the project is done with a holistic approach and the desired result should provide a comprehensive view of the state and therefore call offs has had to be made concerning deeper analyses to benefit a good creation of the full picture.

One limitation during the project comes from the number of suppliers and how they are geographically located. The depth of the analysis has been greatly increased in the areas where it was possible to meet other parties in the takt implementation and understand their view. As each machine and supplier is unique every meeting with a new partaker could lead to a deeper, more comprehensive and relevant analysis. The fact that there were no direct contacts with all module suppliers and no contact at all with component suppliers is parameters limiting the project.

Even internally at Tetra Pak, when analyzing some of the supply chains the access to different people important for the project has been very limited and in some cases fully denied. A bigger openness from some parts could to a high degree have enabled a better analysis, both deeper and more comprehensive.

1.5 Terminology

The word takt comes from the German language and means pace or rhythm. A change from takt three to two is a decrease in absolute numbers and in takt TIME but an increase of capacity and also a higher pace. The risk of misunderstandings is big. To avoid confusion it is now stated that, in this project

an increase in takt means a change from lower to higher capacity for example a change from takt three to two meaning that the interval between delivered machines, or the takt TIME, is decreased and there is a higher pace in the supply chain. On the other hand a decrease in takt means for example a change from takt three to four and thus the interval and takt TIME between machines is increased and a lower pace is set.

During the project frequent references are made to Tetra Pak’s different supply chains. These different supply chains refer to the organizations, resources and people working with providing the different machines. This division is done to enable easier referencing and comparisons between the filling machines readiness in takt.

GPA – General Purchasing Agreement

OtD – Order to Dispatch

1.6 Disposition of the Report

The report starts with an introduction where the background, purpose and delimitations of the project are given.

The second part of the report contains the methodology and theoretical framework. The methodology describes the strategy chosen for the project and the work procedure. The theoretical framework gives a foundation on which the analyses can be built.

The third part in the report describes the organization Tetra Pak and the takt and leveling system that is in focus in the project. It also gives an overview of the structure of the supply chain that is necessary for understanding the problems Tetra Pak are dealing with.

Part four consisting of the Attribute chapter describes the important characteristics needed for Tetra Pak to have a good supportive environment for the takt. The needed elements are divided and placed into seven attributes.

The description of the supply chains from a takt perspective in part five describes the supply chains investigated during the project with emphasis on the ingredients important for and affecting the possibilities of takt management.

Part six consist of two chapters, the supply chain analyses and the general analyses. This part constitutes the analyses of both the individual supply chains and the overall system in the organization and how well the takt is supported.

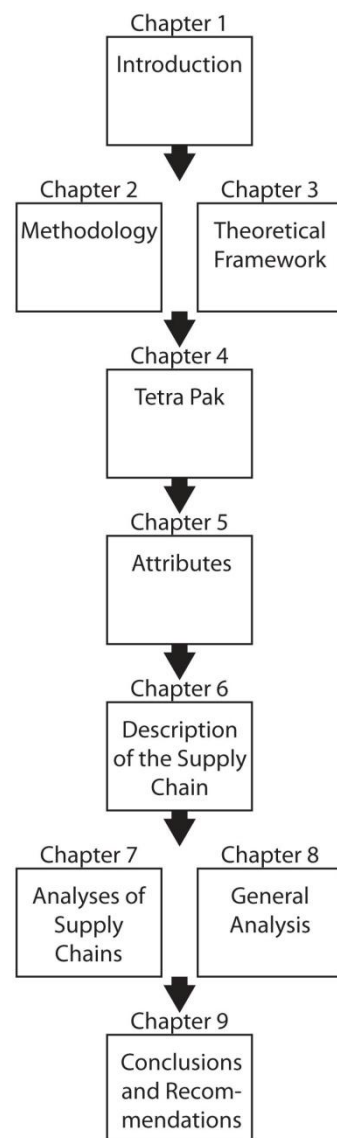


Figure 1 The disposition of the report

At last some recommendations are given concerning where and which efforts could be made to improve performance in takt and speed up the change.

2 Methodology

The following chapter explains the methodology applied in this project. This is to clarify how the empirical data describing the reality was collected and analyzed. At first, the research methods that were chosen in this project are reviewed. This is followed by a description of the work procedure.

2.1 Problem Formulation

The objective was more or less defined from start. But to be able to choose the right approach and appropriate methods for implementing the project it is important to decide what kind of problem you are facing. The problem determines the survey design and the methods that should be used to collect empirical data.

The overall purpose of this report is mainly to describe how something operates and its performance. This kind of research is called a descriptive study. But as in many other cases the descriptive study should lead to identifying problems and therefore a problem solving study is an important part (Höst et al. 2010). When having a descriptive approach to a problem you want to get an overview of a situation at a specific time or how development has been over time. This project is limited in time and should therefore describe the current situation. In cases where the problem is not something you can concretize to any significant degree, you can also talk about an exploratory study. In that kind of research you often should find out what a phenomenon actually consists of. The objective in this project is to some extent exploratory because of the fact that it is not entirely obvious what determines the maturity of the takt implementation. (Jacobsen, 2002)

2.2 Primary Data

Most of the information gathered in this project is primary data. That kind of information is the one you get from the primary information source. In other words, the information you gather directly from someone. This can be done through interviews, observations or questionnaires. (Jacobsen, 2002)

2.2.1 Interviews

There are two extremes when talking about interviews, the unstructured and the structured. Between these there are variations going from that only the topic is decided in advance to questions with fixed response alternatives and fixed order. You can also talk about a half structured interview form where the subjects to be treated is decided in advance and a questionnaire guide is available.

The interview structure that is used in this project can be called an open interview. According to Jacobsen (2002), an open interview is best suited when relatively few units are examined and when interest lies in what certain individuals say and how they interpret and add meaning to a particular phenomenon. He also mentions that a qualitative interview should not be completely open or unstructured. Some form of interview guide should be designed to show which topics will be treated. By working in this way topics are discussed in a sequence that comes naturally to the respondent while you is able to ask follow-up questions to go in depth with some issues.

2.3 Secondary Data

Secondary data is information that has been gathered by someone else. Such information is often collected for other purposes and therefore is it important to treat it with care. (Jacobsen, 2002)

Most of the secondary data that is collected during this project is from books and articles to obtain a theoretical framework. To complement the interviews we have also collected documentations such as PowerPoint presentation and other documents that are found on Tetra Pak's intranet.

2.4 Qualitative or Quantitative

When it comes to gathering information, there are two methodological approaches to apply, the qualitative and the quantitative. The method that is chosen should be selected on the basis of the problem you're working with.

In simplified terms qualitative data collection involves gathering information in the form of words. This allows the respondents to submit their own interpretations of reality and express their individual understanding of a relation. This approach is excellent when you want to elicit details, nuances and the uniqueness of a respondent. A qualitative approach is initially inductive because when using such an approach you should not predetermine or delimit the information that is gathered. (Jacobsen, 2002)

With a quantitative approach data is collected that can be counted or classified. This method can be effective if there are many sources to reach, but relatively few nuances to consider. The precondition is that before starting to gather information you already have to know what information you are looking for. (Höst et al. 2010)

The major difference between the methods is if the collection of information is highly structured from the beginning or more open. This project is based on a deductive approach and therefore is a qualitative approach necessary in order to gather all relevant information. A qualitative approach is appropriate when you do not know much about the topic to be considered and you want to know what lies in a concept or phenomenon. The problem also implies that it is important to find out the stakeholders understanding and attitudes concerning how the takt work should be done. These nuances are difficult to collect using quantitative methods. This work has progressed from a more or less purely qualitative approach to a mixed method with more structured way of gathering information. With the qualitative method one can develop new knowledge and assumptions that leads on to the right questions. In order to compare the level of maturity between different units and how the takt implementation should be, it is necessary to have an incremental increase in the structure of the information gathering. (Jacobsen, 2002)

2.5 Deductive and Inductive

When describing the reality there are two research strategies to apply, the deductive and inductive approach. The deductive approach is based on a work process from theory to empiricism. In other words, starting from the expectations you has of reality you collect data to see if it corresponds to reality.

The expectations we have about reality should with a deductive approach be based on previous findings and theories. But there are some disadvantages of such an approach. It might lead to searching only for the information believed to be relevant and which can provide support for the expectations held from the beginning. Therefore there is a great risk to overlook important information and important aspects of the problem. With an inductive approach the work process is from empiricism to theory. The idea is that you from the beginning, in principle, don't have any expectations. Instead you collect all relevant information that later is processed. In this way you will avoid missing important information that the expectations and preconceptions would result in. There is openness to new information that above all distinguishes the two strategies. But no matter how open-minded you try to be you will always see some things and ignore other. (Jacobsen, 2002)

The problem in this project makes a greater degree of openness important. Some of the attributes to investigate were specified from the beginning, but to understand them and above all avoid missing some important aspects the strategy has tended to be an inductive approach. It is important to obtain own knowledge about the takt implementation before any analysis can be done. Furthermore there are no comprehensive theories about how a takt system should work for a company with Tetra Pak's circumstances and conditions. Investigating the maturity of takt implementation is not only about investigating how far each product flow has reached but also to find out how different people think it should operate at different levels.

A pure inductive method is difficult to obtain when both conscious and unconscious limitations appears when collecting information. The ambition has also been to establish some theory to the project and that leads to a certain degree of deductive approach.

2.6 The Work Procedure

In the first phase of the project it was important to understand the problem faced during this project and decide a strategy to deal with it. It was obvious that a broad approach was needed to understand the takt concept.

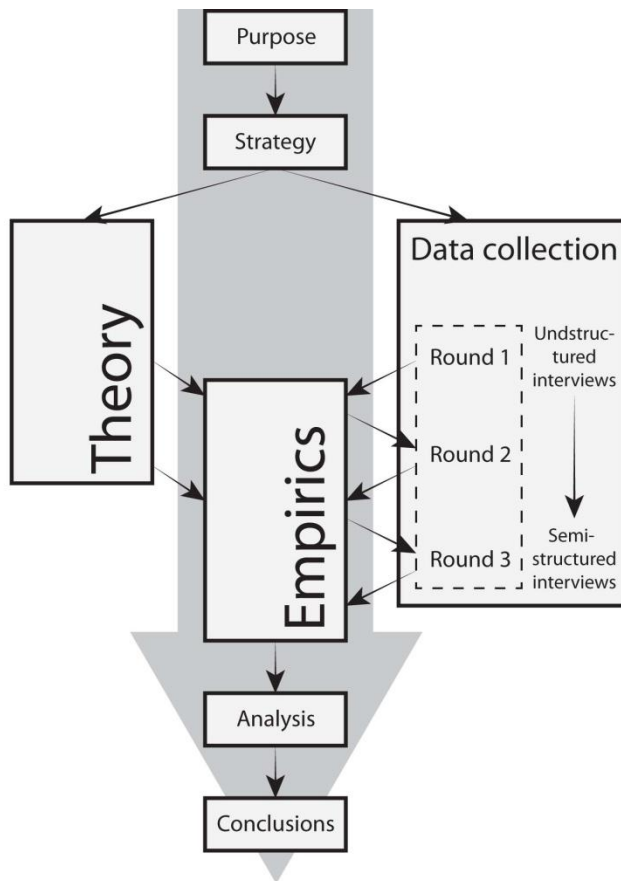


Figure 2 Describing the work procedure during the project

This led to a second phase where several people from different supply chains and functions were contacted and interviewed. In this way we could get an idea of what people think should be in place to be able to work with takt. Before these meetings some questions were prepared but they were primarily used as a support to consider different topics. These interviews together with a visit at a supplier provided a first idea of when a takt implementation could be considered successful.

Based on these findings we tried to compile appropriate attributes to investigate further. This led to a new more detailed interview guide that would be needed when mapping and investigating the maturity of takt implementation. The result of these interviews is a description of the current state.

2.7 Validity and Reliability

Regardless if the empirics collected are qualitative or quantitative it should be both valid and reliable. Validity can be divided into two concepts, internal and external validity. External validity will not be treated here but internal validity refers to whether the study examines what it claims to examine. It is about if the description of the phenomenon is correct. This validation can be done by testing against others, by a critical examination of sources and information from sources and by a critical evaluation of the categorization. (Jacobsen, 2002)

A part in the validation is to investigate if the right sources are found. One problem may be that you do not have access to the informants or documents that provide accurate information. But even if you have the right sources it's not certain that they give accurate information. Therefore is it important to evaluate the closeness between the source and the investigated phenomenon. First hand information is preferable. (Jacobsen, 2002)

During the mapping and investigation of the takt implementation several people have been interviewed, some at more than one occasion. All the information has been processed to ensure that an accurate picture is conveyed. There could be uncertainties in some information gathered because respondents lack of comprehensive picture. This may be because some questions are not directly related to the respondent's work task and in these cases the questions instead have been brought up with other directed people. An obvious weakness in this study is that only a few suppliers were visited, which means that employees at Tetra Pak tried to answer questions about how suppliers work. How the information is brought up is also an important to consider. Information that comes spontaneously from the informant is not controlled and ends up closer to the person's actual perception of a phenomenon. During the interviews various topics have been discussed and leading questions was avoided. In this way new thoughts and approaches was brought up.

The collected data must also be reliable. You should consider whether the method used has influenced the results. Both the investigator and context can affect the phenomenon under investigation. Even though accurate information has been provided, errors can occur when notes is taken and during analysis of data. (Jacobsen, 2002)

All information gathered has two readers and interpreters in this project. In this way was it possible to have discussions regarding ambiguities and increase the reliability. If anything seemed unclear follow-ups was done. Own opinions and preconceptions tried to be treated in a way that it should not affect the results.

3 Theoretical Framework

In this chapter the theoretical framework used during the project is presented. It has deliberately been written relatively short as the topics are well known and if a more comprehensive view is wished for, it is also easy found.

The theoretical framework has been directed towards a number of topics chosen because of their importance in the change started at Tetra Pak. First of all the takt concept comes from lean manufacturing why it also is important to have that part present in this chapter. Introducing a new production system is in itself a big task and in an organization the size of Tetra Pak it becomes even more complex. The fact that the change efforts have had various success through the organization and the current problems has led to the need of understanding the needs and possible risks in change management. Further the need of getting all functions working in the same direction, avoiding functional optimization and turf mentality was early discovered why also the direction in the theoretical framework towards process management and orientation was taken. To widen the theoretical foundation on which the analyses and conclusions should be based the theory of constraints and its implications were also chosen as a part of the study.

3.1 Lean

Lean production is not only a multitude of tools to increase efficiency and reduce wastes. Of course, the lean methods do provide a number of tools to improve the performance of both individuals and organizations. Involving engineers, operators, managers etc in continuous problem solving, waste reduction and improvement work. But ultimately lean is about culture. The tools used in lean are of marginal use unless supported by the right culture. A culture of responsibility and pride of the work and always having the customer needs as the number one priority. (Liker, 2009)

One of the main lean principles is the possible benefits of reducing the variations in demand seen by production. Changes in demand can, if managed poor, cause damage to production hence it is a critical task to reduce as much as possible of the variations. Higher possibility to control buffers leading to possible higher throughput and increased quality are examples of benefits from leveled flows. To achieve even flows lean production offers a set of tools like leveling, takt, standardized work, andon, and the heijunka box. (Liker, 2009)

3.1.1 Leveling

Production leveling is one of the lean manufacturing tools and aims at leveling or smoothing the workload to support even and predictable flows. The purpose of leveling is reducing wastes to achieve higher quality and cost reductions. Leveling can typically be visualized with the Heijunka box, an effective aid in production planning. Leveling means that production, instead of following ups and downs in demand, is set to an average volume. This means that demand still can be met but without the fluctuations from demand seen in the manufacturing. (Liker, 2009)

3.1.2 Takt

Another feature in the lean toolbox is takt. The takt is the production rate and defined as available work time divided by demand during the same time. This means that the takt is the time between two finished products. Though the concept is straightforward the implementation of it is not. In a perfect world demand is even and known and the takt is easily calculated in advance with perfect accuracy. But this is seldom the case and a decided takt might be too high leading to overproduction or excess capacity or it might be too low leading to increased lead times or even lost sales, both leading to unnecessary costs and customer requirements not being fulfilled. (Liker, 2009)

Control by takt is one of the tools from lean used to achieve even workflows. By dividing production into different stages or stations and decide at which rate, takt, work should be passed on between workstations, waste in shapes of overburden and unevenness is reduced leading to higher quality and lower cost. (Liker, 2009)

3.1.3 Standardized Work

Another important part of lean production is standardization. Whatever task performed, both on the floor level or in the office, there are benefits to gain by introducing some level of standardized and thoroughly documented work. The standardization should follow best practice. Standardized work constitutes a base for achieving a robust and successful takt guided production. Without standardization the time elapsed in different production steps will vary to a higher degree compared to when using standardized work. This means that the risk of disrupting the takt, creating unevenness, waste or even a total stop in the production line is higher without the standardization. Using standards is also a way to get innovations, big or small, from all levels to be spread and used. (Liker, 2009)

3.2 Change Management

The amount of significant change in organizations has grown immense over the past two decades and the forces driving change may grow even stronger. But change is not easy. Even when the need to change is obvious and visible the change can stagnate because of culture, bureaucracy, poor teamwork, arrogance, lack of leadership and/or a lot of other reasons. All successful change efforts must manage these issues. John P. Kotter Identified eight mistakes often done by organizations in change projects and then developed an eight-stage change framework to manage change. (Kotter, 1996)

1. Establishing a sense of urgency

With complacency high, transformation efforts will not succeed and few people will increase their normal workload and contribute to the change. Sources of complacency can be:

- The absence of a major and visible crisis
- Too many visible resources
- Low overall performance standards

- Organizational structures that focus employees on narrow functional goals
- Internal measurements that focus on the wrong performance indexes
- A lack of sufficient performance feedback from external resources
- A kill-the-messenger-of-bad-news, low-candor, low-confrontation culture
- Human nature, with its capacity for denial, especially if people are already busy or stressed
- Too much happy talk from senior management

2. Creating the guiding coalition

Putting together a group with enough power to drive change and then getting the group to work together as a team.

3. Developing a vision and strategy

It is important to have a clear vision that can guide and direct in the change effort and a strategy that is aligned with and supports the vision.

4. Communicating the change vision.

The vision has to be spread through the organization and should be communicated as often as possible. Not only through seminars and internal educations but also in the daily work. It is of great importance that the guiding coalition acts according to the vision in all decisions as expected by employees.

5. Empowering broad based action.

As many people as possible should participate in the change effort and take action by removing barriers to the implementation of the change vision. Some of the biggest barriers can be, formal structures undermining the vision, lack of skills, information systems not aligned to the vision and supervisors not believing in the vision or unable to adapt to it.

6. Generating short term wins.

Even though a change effort should have a long-term perspective it will not be accepted to ignore the short-term goals. There is a need to plan for short-term improvements in performance and then create and show these improvements and then visibly recognize and reward the people who made the wins possible.

7. Consolidating gains and producing more change.

When come this far a certain respect and belief in the vision and change effort has emerged, use the increased credibility to change the systems, structures and policies that don't fit the transformation vision. Hire, develop and promote people who can work with the change

implementation. Give new life to the change vision by introducing new projects, themes and change agents.

8. Anchoring new approaches in the culture.

Be sure to stress the connection between the good results and change. Focus on more leadership to make sure that the change achieved is there to stay. Develop systems to ensure leadership development and succession.

(Kotter, 1996)

It is essential to be comfortable in change to succeed in the twenty first century. Often a major issue for not accepting change is fear, there has been prior success and it is hard to see what the future consists of, so why change? Instead of seeing opportunities in the new environment and think about growth, personal renewal and developing leadership people desperately cling to the current state and defensively try to hold on to old times. Staying in the past will probably be the failing strategy and the needed changes and development should rather be done sooner than later to be competitive in the future. (Kotter, 1996)

3.3 Theory of Constraints

According to the theory of constraints an organization can be managed by three main measures; throughput, inventory and operating costs. The throughput is the money generated through sold produced units, the inventory is all investments that is needed to enable throughput and operational expenses are the money spent to create output from inventory. The theory assumes that all organizations have a bottleneck or constraint limiting the throughput. The constraint must be found and everything should be done to maximize its efficiency and effectiveness. Batch sizes should be reduced to minimize the time parts spend waiting in production and make it possible to feed the bottleneck with parts actually demanded. Production to stock should be avoided since it does not increase the throughput but instead adds to the inventory. (Goldratt, 1993)

3.4 Process Orientation

Traditionally organizations are managed with a strong hierarchy. Decisions are made at a senior level and communicated downwards the company through a vertical view where cross functional issues seldom are addressed, leading to a high risk of functional optimization where functions have a too small understanding of how their work effects the performance of other functions as well as the whole organization. Business process management provides a horizontal view of the organization, which also is more correct description of how work actually is done. Focus on business processes requires a new way of thinking, from a top-down structure to a flatter and more team-oriented approach. In opposite to the traditional organization where managers are thinkers and employees further down in the hierarchy are doers, business process management demands that each individual is involved in his work and acts both as thinker and doer since he or she not only CAN effect the design and structure of her work but SHOULD do it. Many of the historical problems depending on the vertical organization view are solved through the process

approach. Functional optimization as well as turf mentality is reduced since cross-functional teams are working together towards a common goal. But also the potential problems arising from work between functions are minimized due to the process orientation. (DeToro, McCabe, 1997)

If we had to select one action that makes the greatest contribution to lasting process management, it would be the appointment of an owner for each key process.

Rummler, Geary A, Brache, Alan P, 1991, Managing the White Space.

The process owner is a person responsible for the performance and development of the process. She ensures continuous improvements of the process and acts as a manager of the interfaces between units contributing to the process. (Rummler, Geary, Brache, 1991)

Introducing a horizontal view doesn't mean that the vertical reporting relationships fully disappears. Line managers are still responsible for achieving results and allocating resources. So how can the horizontal process view be combined with the vertical relations without creating rivalry between the process owner and the functional line manager? The solution is establishing customer-focused, process driven performance indicators. Functions should be measured according to their contribution to one or more processes in terms of impact on the process driven performance indicators. The process owner's task is not only to managing the interfaces between departments but also ensuring that the process view is kept and through that prevent a relapse to a functional perspective. By realigning functional goals according to rational processes an environment is created where line managers and process owners have their own distinct responsibilities but common goals. (Rummler, Geary, Brache, 1991)

3.5 Process and Enterprise Maturity

Few executives question the idea that redesigning business processes—work that runs from end to end across an enterprise—can lead to dramatic enhancements in performance, enabling organizations to deliver greater value to customers in ways that also generate higher profits for shareholders.

(Hammer, 2007)

Michael hammer developed the PEMM "Process and enterprise maturity Model". He defines two sets of characteristics that are necessary for a company to have processes delivering high performance over time, the process enablers and the enterprise capabilities. The process enablers relate to the individual processes and the enterprise capabilities to the entire organizations, that is the environment in which the processes should perform. (Hammer, 2007)

The PEMM provides a framework where the maturity of both enablers and capabilities can be evaluated. When the model is used to assess the current maturity it also visualizes the gaps and shortcomings between the current and ideal state. Consequently the framework indicates where improvements should be done to reach a higher maturity level. (Hammer, 2007)

The five process enablers are

- Design: The comprehensiveness of the specification of how the process is to be executed.
- Performers: The people who execute the process, particularly in terms of their skills and knowledge.
- Owner: A senior executive who has responsibility for the process and its results.
- Infrastructure: Information and management systems that support the process.
- Metrics: The measures the company uses to track the process's performance.

(Hammer, 2007)

And the four enterprise capabilities are

- Leadership: Senior executives who support the creation of processes.
- Culture: The values of customer focus, teamwork, personal accountability, and a willingness to change.
- Expertise: Skills in, and methodology for, process redesign.
- Governance: Mechanisms for managing complex projects and change initiatives.

(Hammer, 2007)

Hammer as well as other in the business process area stresses the importance of extending processes over the organizational boundaries and integrating customers and suppliers. The extension of processes will prevent the risk of functional or organizational optimization and support the mindset where not just the corporations but whole supply chain compete together with a common goal. (Hammer, 2007)

4 Tetra Pak

In this chapter essentials for understanding the purpose of the project are given. It describes the structure of Tetra Pak and the supply network Tetra Pak is acting in and how the takt and leveling are adjusted to fit their needs and environment.

Information and data in this chapter comes from the interviews and internal documentation. It is a deliberate choice not to match data and information to specific individuals as that were the premises when doing the interviews.

4.1 Why Takt?

Historically Tetra Pak had problems with keeping their lead times short and stable. In 2004 the takt implementation was started as a reaction to the previous failures and planned remedy for the existing problems.

Tetra Pak provided forecasts with poor precision to the module suppliers. This led to speculations from the suppliers and there was a bullwhip effect seen in the supply chain. Tetra Pak placed orders to module suppliers in batches and that behavior was transmitted to the relationship between module and component supplier where batch sizes in cases could cover quarterly demand. The situation with batch ordering in contrast to real demand that mostly came in single orders and had high volatility became unsustainable. It created high value uncontrolled buffers at all tiers and severely damaged the flexibility in the supply chain. The fact that each machine can be ordered in several different customizations combined with the low volumes led to the conclusion that the batch mindset didn't provide the agile and flexible supply chain needed.

Another problem was the lack of understanding in the sales function concerning their possibility and responsibility to contribute to the core process and facilitate the production planning. They have a responsibility to level and even the flow of incoming orders as much as possible in their contact with customers and not only focus on selling. A high understanding of the production process is necessary to be able to deal with customer requirements and give the customer realistic expectations on lead times. The fact that Tetra Pak already had a hard time keeping their lead times gave the implication for customers to place orders with higher volumes than really demanded. They might place an order of five machines just to be sure to get two of them and then when the two really needed were delivered the rest of the order was canceled. So, the poor performance from Tetra Pak made customers place "fake" orders to be guaranteed some machines and that in turn made it even harder for Tetra Pak to plan production and reach good performance and the trust for Tetra Pak was incrementally decreased. It was a devastating cycle that had to be broken.

The problems of late deliveries could to a high extent be derived from the heavy lack of production control. There was no standard work used and documentation of processes and procedures was missing. Not only did this effect the lead times but also created unevenness in the utilization of resources that inflicted quality and added costs.

Even if unintentionally, the state before takt was a system where functions and companies aimed at maximizing its own profit and the process point of view was undeveloped leading to an unsynchronized supply chain. The more severe consequences of this were long lead times, uncontrolled buffers and poor quality. Once the situation was visualized it was obvious that something had to be done and based on this situation the change to manage production with takt was started.

4.2 Supply Structure

To give some understanding concerning the structure of the Tetra Pak internal organization the picture below, figure 3, is included. It also gives an overview of where in the organization this project has been performed.

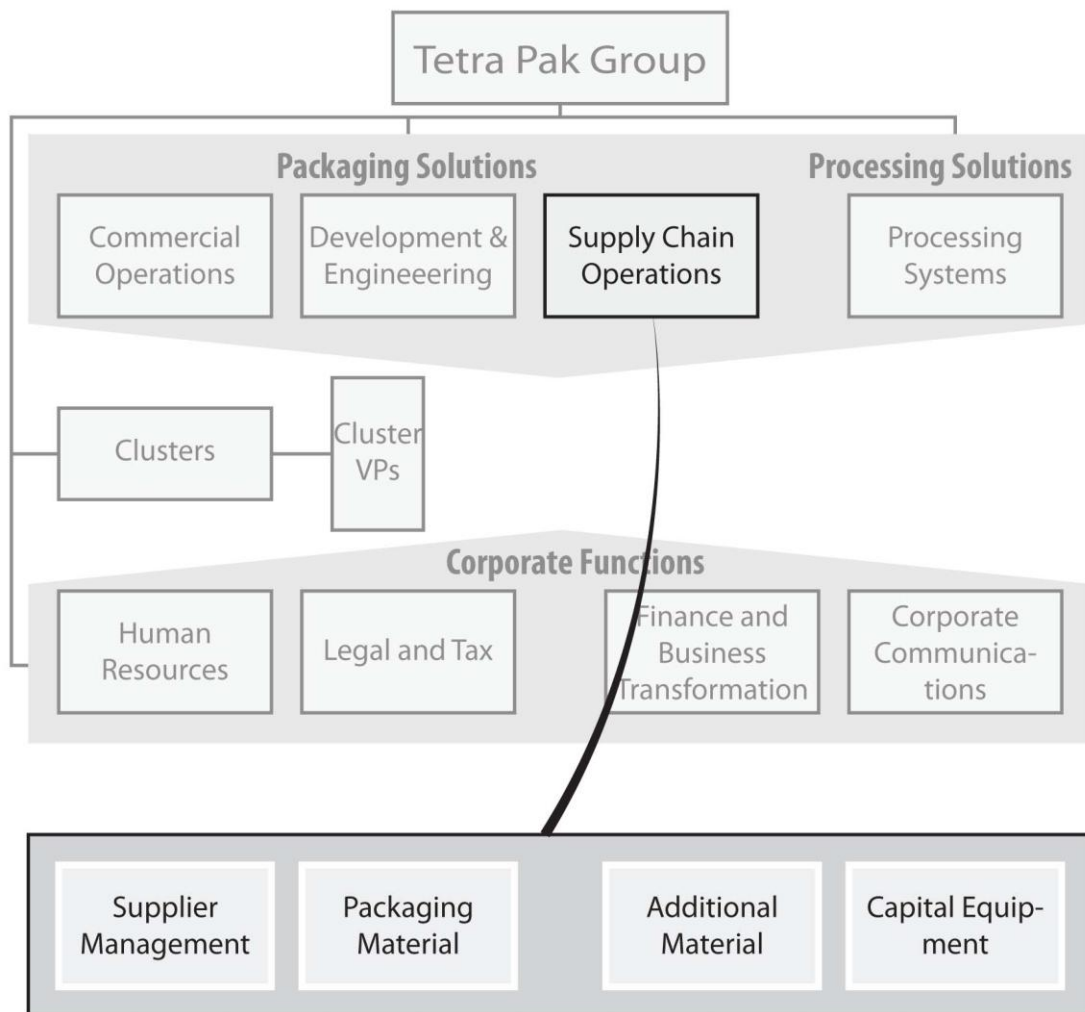


Figure 3 Structure of the Tetra Pak organization

The global process model in figure 4 shows the functions involved in the core processes that need to contribute to and be a part of the takt implementation to make it successful.

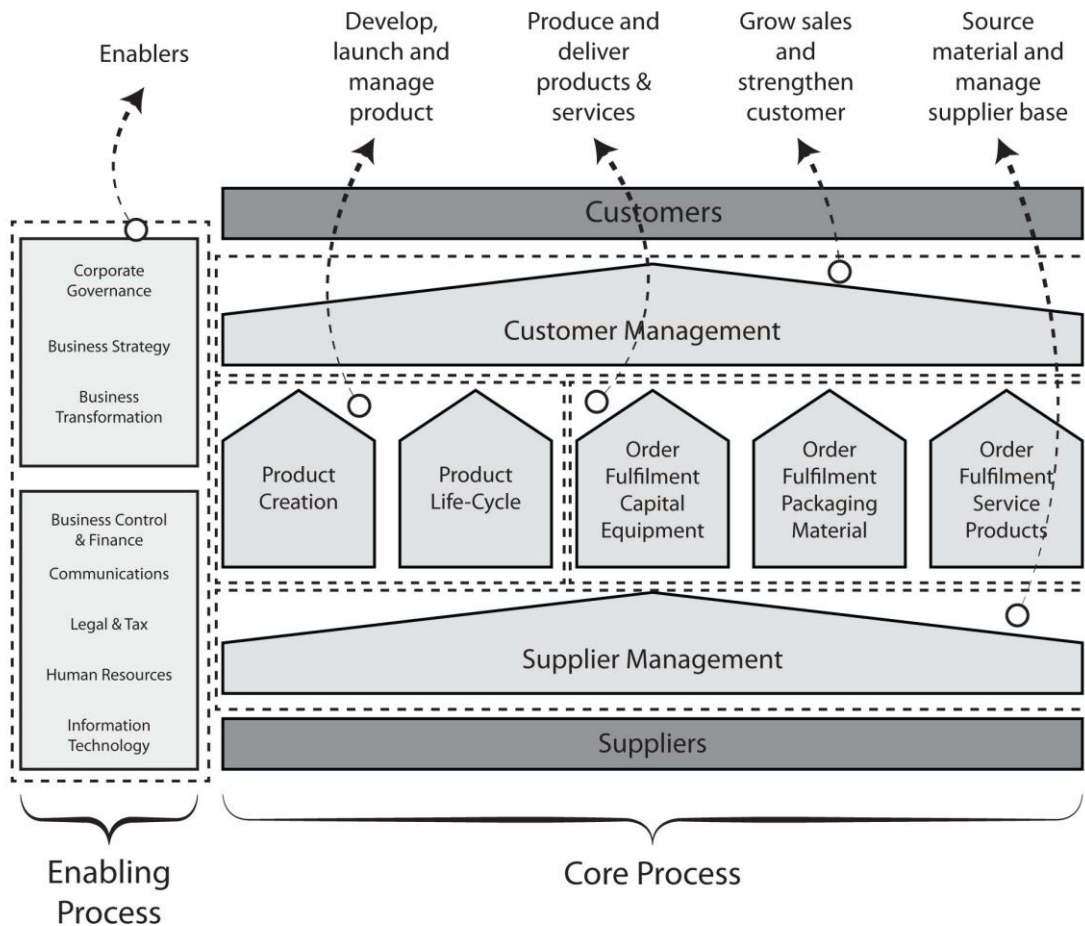


Figure 4 The Tetra Pak global process model

Tetra Pak is providing filling machines with relatively low annual demand. Even though there is a big diversity of volume between the machines even the high volume products for Tetra Pak only reach yearly demand of 150 - 200. The supply chains for the different machines have a similar structure. Market companies receive orders from customer, production at component supplier and module supplier is done and then assembly and testing at Tetra Pak before delivering the machine. For some of the machines the assembly and testing is outsourced and done by a module supplier and Tetra Pak are not physically involved in the production of these machines.

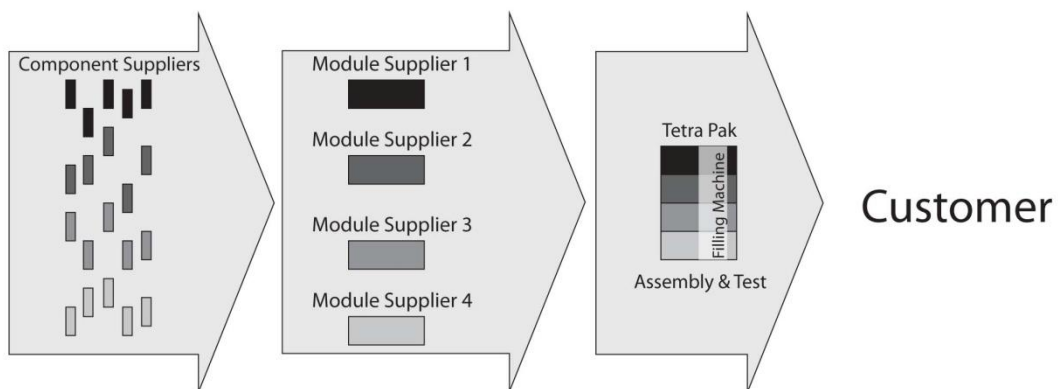


Figure 5 Tetra Pak supply network

The lead time for a filling machine can generally be divided into three different phases, time-for-leveling, internal lead time and external lead time. These three parts constitutes the Order-to-Dispatch (OtD), which is a commonly used measure in Tetra Pak. The time-for-leveling consists of both the period in which the order is waiting before start of production and the time a finished machine is kept in stock. Some of the machines have a fully outsourced production and therefore it sounds wrong to talk about an internal lead-time, but the only difference is really where the assembly and testing is done. The OtD is defined as the time between the complete order is received and requested delivery date with the time of advanced placement deducted. The Advanced placement is the time between first available slot and actual used slot.

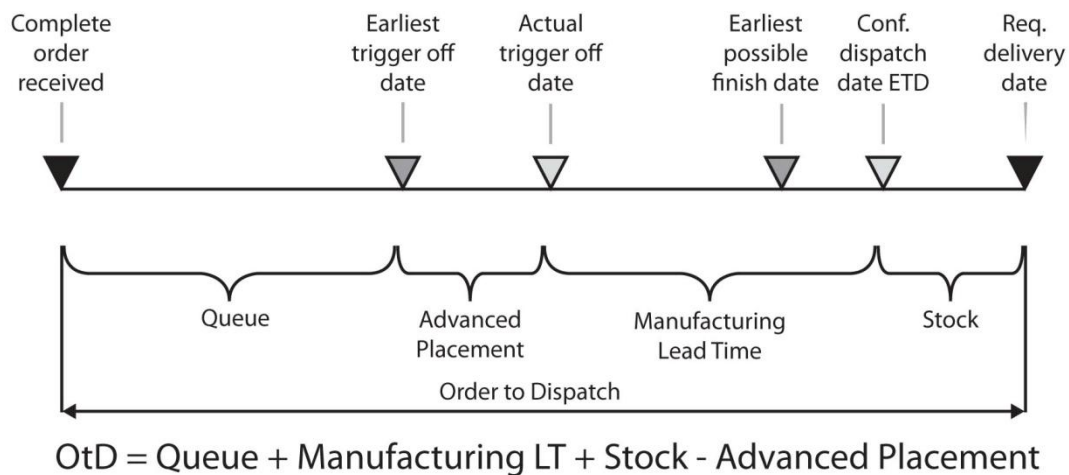


Figure 6 The Order-to-Dispatch calculation for an order

Tetra Pak manufactures and develops filling machines and distribution equipment that is connected to the filling machine to handle the flow of packages. The complete range of distribution equipment includes conveyors, accumulators, cardboard packers, crates, roll containers, film wrappers, straw applicator, cap applicators and line controller to synchronize the filling machine with the downstream equipment. They are specially developed for Tetra Pak's packaging lines and packages. The filling machines provide a cost efficient alternative for packaging food and beverages in an environment friendly way.

During the product life cycle of a filling machine there are frequent design changes. Not only in the beginning but also years after the product is launched. The changes made can be of different importance. Some can be smaller changes to facilitate the production and assembly in a poka yoke manner or just facilitating the production in some other way or changes increasing the robustness and performance of the machine. These changes, for sure are important, but can wait to be introduced until the current buffers with parts produced according to previous blueprints are used. That is, there is no need of scrapping parts because of the design change. On the other hand there might be design changes greatly affecting the robustness or performance of the machine or changes related to safety that cannot wait until the parts in buffers are used.

This situation can lead to high scrapping cost and a lot of wastes in the supply chain and the parts in buffers must be immediately substituted.

In addition to the modules, suppliers also provide kits of spare parts. Today it is only the modules to the Filling machines that are managed with takt leading to that the buffers in the takt-agreements only cover the need of parts for machines. The parts in the spare-kits are the exact same parts as those put directly in the filling machines with the only difference that they are just spare parts.

4.3 Takt & Leveling

The possible benefits and reasons of introducing the takt concept are many. It eases production planning and provides a base for standardization in all tasks and procedures. Sourcing of material is facilitated since speculations depending on insecure demand are decreased and thus leading to performance to a lower cost.

Takt sets the pace of production and provides predictability in the flows. It should support a pull system where each machine produced is a reaction on a pulse from a customer. The takt should be calculated and set to align the output of machines to demand.

$$\text{Takt} = \frac{\text{Available working time}}{\text{Demand}}$$

Equation 1 Takt time

But most of all takt is a way to visualize and force problems in the system to the surface. In a system where buffers are minimized and set just to manage the current takt, a deviation, late delivery or other issue will immediately be noticed since the flow will be interrupted. Because of this, takt is a powerful tool for finding the problems and a first step to improve processes and standards. Thanks to the predictability and even flows the procurement of materials is facilitated through the supply chain and reasons for forecasting and speculating could be drastically decreased. When working with takt management and problems occur it is fairly easy to locate the bottleneck in the supply chain. Since the flow of material is decided by the takt it will be relatively simple to see where the pace wasn't fast enough. This visibility is extremely valuable in the work of continuous improvements and eases the work of finding the failing source.

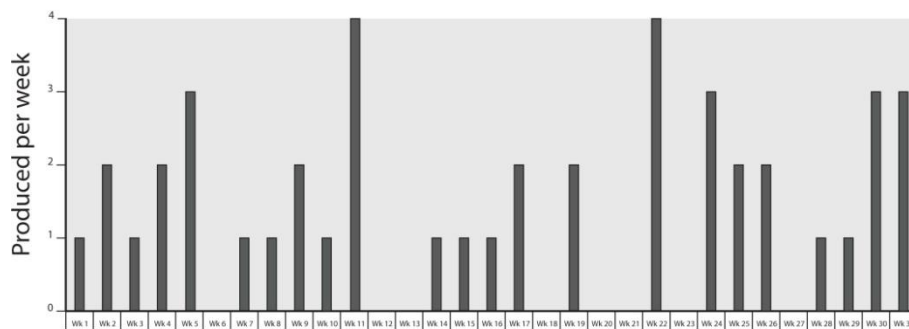


Figure 7 Filling machines completed per week before takt was introduced

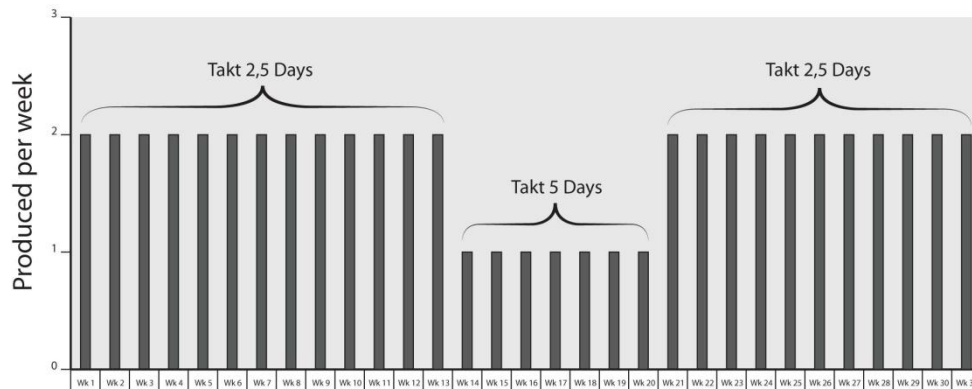


Figure 8 Filling machines completed per week with takt

The benefits of takt for Tetra Pak are indisputable, whenever the question is raised whether it is the right path to go there is a solid support for the transformation, especially from the people who have been involved in the work earlier. The question is how to best adapt the takt implementation to fit Tetra Pak. Just keeping a stable takt where all times, quality standards and deliveries are met is a huge task. But what really limits and puts the supply chain on the edge is the ability to handle changes in demand and takt. A change in takt means that the pace is changed and the established even flow is interrupted. The time it takes to increase the flow and reach the same quality standards with the new takt is really the flexibility and a crucial part in the change to takt management.

The takt provides a plan of how many machines should be produced and in what pace. Consider a takt of five days, meaning that every fifth day there is a machine planned to enter production. However, it is only a plan. The takt of five really means that there is a slot, or resources, available for production but not necessarily utilized every fifth day. If there are no orders to be produced according to the takt the available slot is left empty since there is no possibility to produce pre order. An empty slot inflicts great costs on the supply chain because of the unused resources and it is an indication of a too high takt. The situation of leaving empty slots should be avoided not only by a smart and proactive takt management but also by a support from the other organizational functions working with the supply chain such as sales support, market companies and supplier management. The expected contributions and responsibilities are discussed in chapter 5.

The machines produced by Tetra Pak are provided in a number of variants and this further stress the need of flexibility in production. The problem incurred from the variants is not only the increased difficulty of forecasting or the increased number of different articles in stock. The customization point of the machine is very early in the production and this makes it impossible to start production of any machine before a complete order is confirmed and the design is frozen. Consequently the production is a make-to-order process, and this complicates things when trying to achieve an even flow and keeping lead times short. In many other cases, for other companies, it is either possible to keep a steady pace in production by having a temporary production-to-stock, or start a standardized production and add customization late in the production line. Both these alternatives provides a possibility for keeping lead times short and still

give the customer the opportunity to choose but none of them are suitable for Tetra Pak.

To manage the problem Tetra Pak has introduced a system for leveling orders and through that trying to achieve even flows all over the supply chain despite of the volatile demand. Leveling is done by changing the sequence in which the orders go into production.

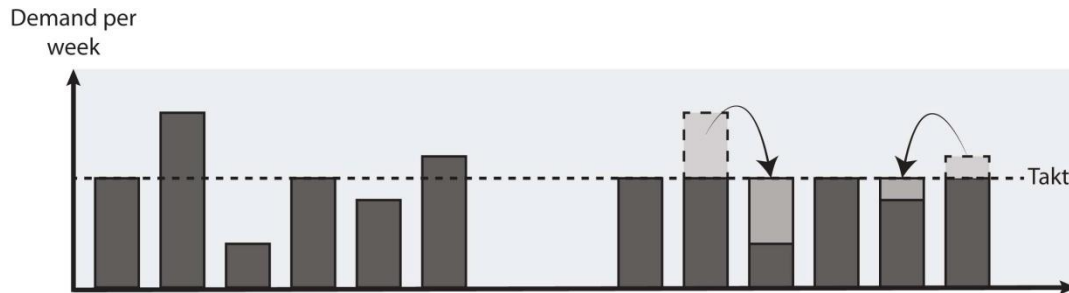


Figure 9 The leveling concept for Tetra Pak.

Leveling is made possible thanks to a buffer time, or time for leveling, included in the OtD target. The actual time a machine is in production typically only constitutes 70% of the OtD and hence 30% of the planned OtD is deliberately chosen as non value adding to enable leveling. This system might prolong the lead-time for a specific order but provides a possibility for more stable and overall shorter lead times. Figure 11 shows how the value adding time can be moved inside the time span of the OtD to make leveling possible. As long as the machine is completed in time it doesn't matter, from customer perspective, whether the order waits in a queue pre manufacturing or are placed in a stock of finished machines if manufactured earlier than needed to meet requested dispatch date.

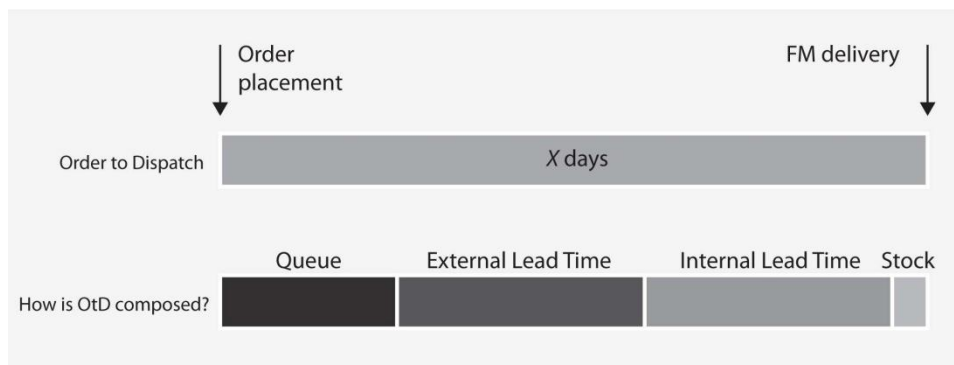


Figure 10 The order-to-Dispatch components

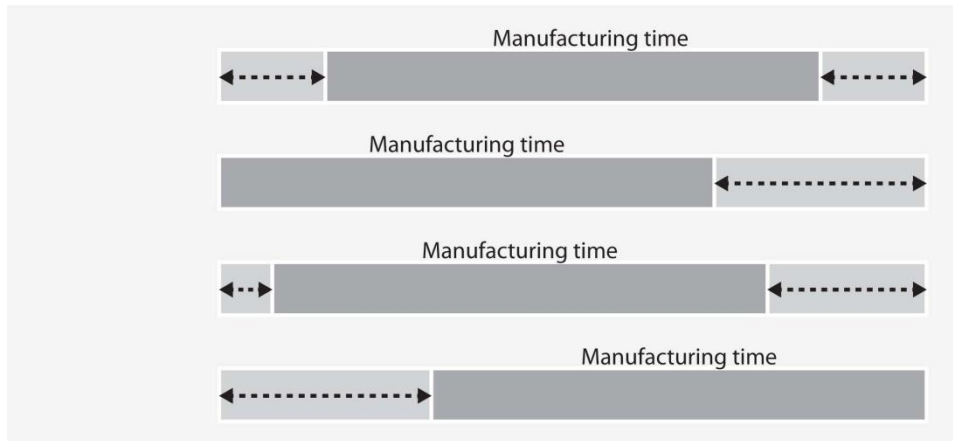


Figure 11 Leveling an order within the Order-to Dispatch

Incoming orders are put in an order stock and each order has an assigned delivery date. Leveling makes it possible to keep the lead times stable even in shorter periods of peaks or dips in demand. Thanks to the buffer time included in the OtD and by rearranging the order stock the lead-time can be kept within target and variations in production is minimized. Leveling is a way to handle temporary changes and fluctuations in demand but when there is a long-term increase or decrease of demand, a change of takt will be necessary and the leveling tool will enable a smoother transition to the new takt and keep OtD stable.

Leveling also offers a way to manage rush orders. Since the order in the order stock can be rearranged there is possibility to leave slots open for possible coming rush orders. In the case where a slot has been left empty and no hurrying order is received, another order in the backlog can be moved to fill that slot. It is important that the takt is revised frequently and that changes in takt have a short reaction time to align the takt with real demand. A too long reaction time will lead to either empty slots or delivery times above target.

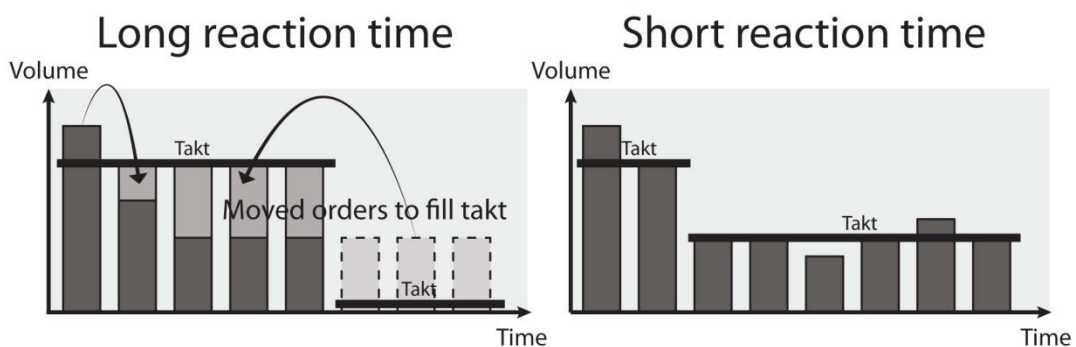


Figure 12 Effects of too long reaction time with leveling

5 Attributes

In this chapter the attributes chosen to evaluate the supply chains from during the project are described along with desired characteristics to support the production system.

The mapping of the supply chains are done mainly by interviews, a small part is done by searching on Tetra Pak's intranet. To get a complete picture of the current situation in the supply chains, questions during interviews are focused on a number of topics. Before starting the interviews the topics chosen were evaluated and divided into sub parts carefully chosen to enable a deeper analysis. Some attributes were chosen early in the project and have with time been changed and modified as the understanding of what implications and requirements a takt system has on the supply chain were increased.

In the beginning of the project a list of areas that Tetra Pak considered important for the takt implementation was available. Some of the areas were very straightforward and easy to grasp, other more abstract and needed to be investigated and more thoroughly expressed. This first list from Tetra Pak constitutes the foundation for the direction of the work in the project and as the areas of interest became clearer and more distinct along the progress of the project they were changed and finally boiled down to the seven clasping attributes in figure 13.

The changes of the attributes were made to better fit with the purpose of the project. They are not meant to simply be listed for each supply chain but should rather work as a way of providing different angles from which the supply chains should be approached and investigated to ease the mapping and find the possible existing problems.

Attributes	
Takt agreements	<i>The contents of the agreement. As well as if agreements are signed with all module suppliers.</i>
Production documentation & Daily Control	<i>How control is maintained in the daily work and how prepared the supply chain are for handling changes.</i>
Roles and Responsibilities	<i>Different functions and organizations must know their role and expected contribution to the takt implementation</i>
Managing the takt	<i>How the takt is managed and controlled and communicated in the supply chain.</i>
Key Performance Indicators	<i>The KPIs of all functions and the performance of the supply chain must be aligned with and support the takt implementation.</i>
Component suppliers	<i>How the component supplier are connected to and involved in the takt managed supply chain.</i>
Management and Support	<i>How the change to takt is managed and what support and help the people working with the change are receiving.</i>

Figure 13 Short explanation of the attributes

5.1 Attribute 1: Takt Agreements

The frames and forms of the work in the supply chain is limited and decided by the takt-agreements. Agreements are necessary but not sufficient in succeeding with the takt implementation. Even though agreements are signed a deeper understanding can be missing.

Changing the management style of production is of course a big challenge and before that is done, carefully written agreements should be signed defining the responsibilities of both Tetra Pak and the Supplier. In this part it is investigated if agreements are signed and then the content in the agreements are revised.

The agreements should cover a wide range of questions concerning the managing of takt. For example, responsibilities should be defined, expectations on both parties stated and the process of pruning components should be agreed. During the projects first phase of interviews and literature study some specific parts of the agreements where chosen to be investigated more thoroughly since they where regarded as particularly interesting and important in the takt implementation.

5.1.1 Flexibility Matrix

One way of defining the different possible takts and takt changes in the supply chain is to use a flexibility matrix in which all possible scenarios are stated. The purpose is to determine and document the capacity that might be required by the actors in the supply chain and through that enable preventive problem solving. Every partner in the supply chain has to look into the different possible scenarios stated in the flexibility matrix and then revise their capacity and find where additional resources will be required.

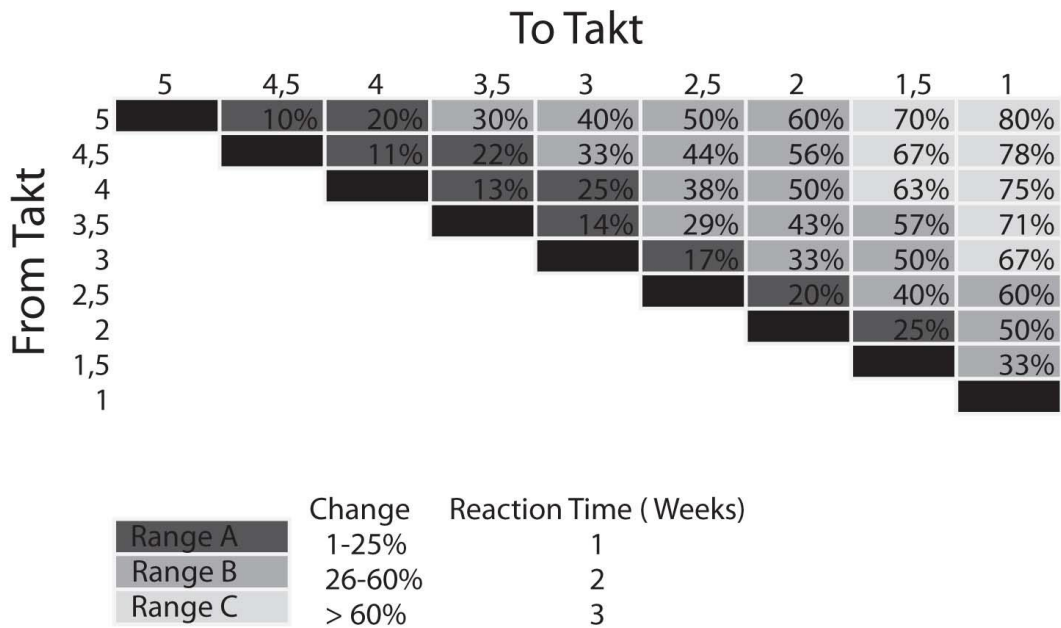


Figure 14 Flexibility Matrix

5.1.2 Buffer Stock Management

Given a certain takt a minimum level of inventory of all parts will be required to prevent shortage. The required buffer level will depend on a number of factors such as the current takt, the replenishment lead time, the ordering policy, how variants are managed and the flexibility agreed concerning takt changes.

The buffer that Tetra Pak takes responsibility for is calculated as the replenishment lead-time divided by the current takt. This is based on batch sizes of one unit and total quality and delivery reliability.

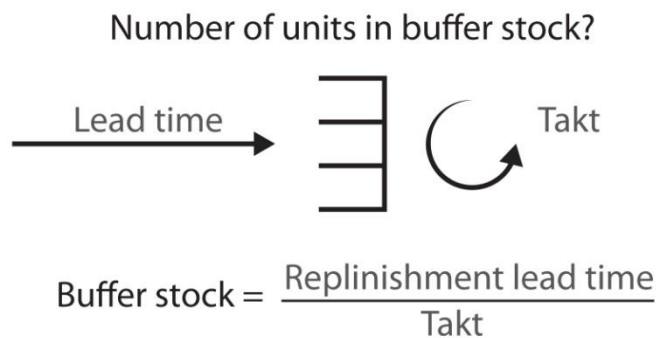


Figure 15 Calculation of buffer levels

The stock at supplier site will be equal or possibly more than the buffer that Tetra Pak takes responsibility for. The size of the supplier stock depends on their planning system, when an order is triggered and the safety stock that is needed to cover variation in quality and delivery accuracy. But the stock will also depend on the batch sizes and frequency of delivery. A one-piece flow is wanted but not always realistic. Therefore an ABC categorization is suitable to have different policies for different parts. In many cases some few parts constitutes most of the value in the stock, according to the classic 80/20 rule or law of the vital few. These parts will have the categorization A and the buffer size should be small and ordered according to takt. Depending on how long and how certain the lead-time is a safety stock have to be considered. Smaller parts with less value such as nuts and bolts falls under category C and can be ordered in larger batches. Because of the varying demand over the variants the buffer levels are also depending on the decided readiness for each variant. Since the takt not is set per variant but per Filling machine the buffer is split between the variant depending parts which will give different actual takts for parts to different variants.

To avoid large values in buffer stock a long-term focus on reduction of replenishment lead-time is needed and the focus should mainly be on A-category parts with long lead-time.

5.1.3 Variant Management

Tetra Pak provides a wide range of variants and the agreements must deal with the problems concerning how to manage the different variants. Keeping buffers for full variant flexibility will be too costly and rules considering appropriate buffer levels to meet actual demand should be agreed. A synchronization of the supply chain is needed where all actors have an equal capacity over the variants. Which means that the suppliers capacity is fitted to the same forecast and the readiness for each variant is the same for all suppliers. Tetra Pak should communicate deterministic capacity requirements to the suppliers and not a forecast with different probabilities for different orders where the suppliers must add their own interpretations. If not agreeing with all suppliers how to manage the low volume products there are incentives for speculation. The speculations will then lead to different forecasts from the suppliers leading to an unequal capacity of the variants driving costs.

5.2 Attribute 2: Production Documentation & Daily Control - Internal & External

There are some tasks required both by Tetra Pak and the Module suppliers to ensure control of production. Ways of working that will minimize the costs of poor quality, long lead times and variation in the production processes. The takt management puts high demands on the control of the supply chain and each disturbance must be dealt with quickly to avoid stopping the flow. Each disruption of the flow might lead to unused resources and late deliveries. There needs to be adequate and thorough documentation of all processes and procedures and in which pace they should proceed to keep the takt.

Having an updated and accurate status of the machines in production at any given time is crucial. Sequencing of the work can be a powerful tool and provide the possibility to easily see when work is behind schedule and additional resources are needed. Standardized, documented work, broken down into smaller tasks is a way to increase quality and secure high performance. It can also increase the possibility of moving staff between areas in production and increase flexibility in production.

The use of Standard operating procedures, sequencing of production or equivalent tools will be necessary in achieving a healthy and reliable supply chain. A standardized documentation of production will also be required to increase quality as well as flexibility.

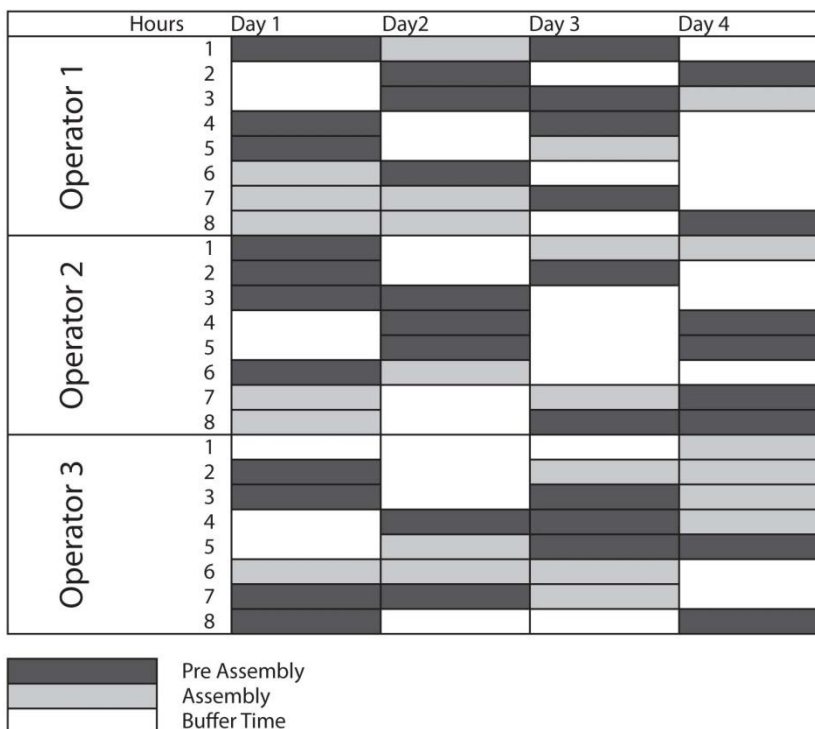


Figure 16 Sequence schedule of production

Having the production documented is not enough. To have control and increase the possibility of finding problems as early as possible there is a need for daily follow-ups where the documentation is used to verify the current status.

It is important that each supplier has a clear picture concerning the requirements concerning resources for each takt. There should be proactive work to prevent disturbances when changing to a higher takt and bottleneck analyses must be made to plan for needed resources if demand and takt is increasing.

		Takt									
		10	9	8	7	6	5	4	3	2	1
Resources	Testrigger	1	1	1	1	2	2	2	3	3	4
	Assembly bays	1	1	2	2	2	3	3	4	6	8
	Preassembly bays	1	1	1	1	1	1	2	2	4	6
	Material handlers	1	1	1	1	2	2	3	4	6	8
	Assemblers	10	10	10	12	12	18	20	25	30	40
	Final testers	2	2	2	2	3	3	3	3	4	6

Figure 17 Table of needed resources given certain takt.

Having immediate visualization of problems in production is crucial to enable quick responses and solutions in order to prevent disturbances from propagating through the supply chain. The visualization can be some form of andon-system. The andon-system is not required to be in the shape of electronic devices or even connected to a computer. Considering the takt times are fairly long it will be possible to reach success with a much simpler andon-system. When having a well documented production and standard operating procedures are introduced, keeping control of production and planning will be a much simpler tasks. It will make an even allocation of resources possible and prevent the need of fire fighting and rushing with orders to manage the delivery times promised. It will be easier to have a balanced workload during the lead time which also contributes to a higher quality.

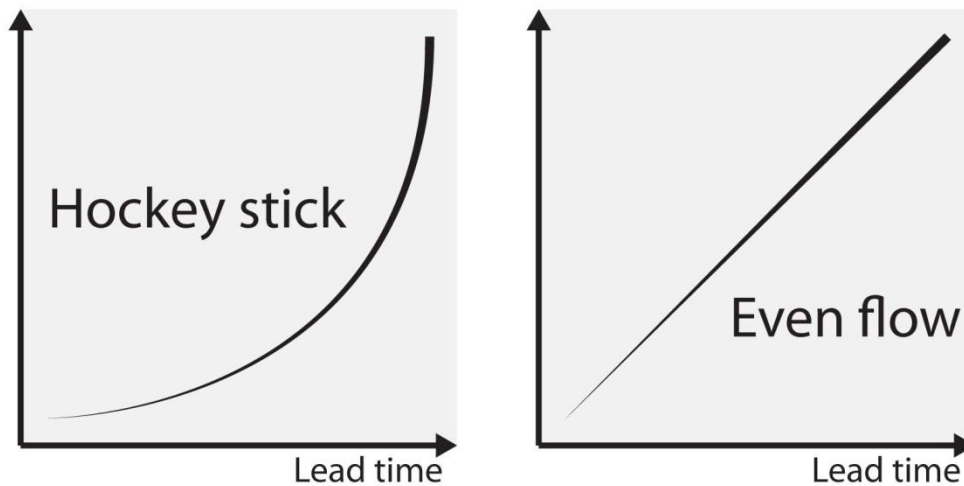


Figure 18 Uneven vs. Even use of resources over time

5.3 Attribute 3: Roles and Responsibilities

To ease the implementation and management of the supply chain it is crucial with well-defined roles and responsibilities. Even if a responsibility is delegated there might exist a gap between the communicated and perceived role that can create misunderstandings or worse, an open conflict if someone feels their territory is threatened. Having clear responsibilities is also a way to secure quality in the processes. The responsibilities of the different functions of the organization must be clearly stated and the different parts of the organization must understand how their work can contribute to and ease the takt management.

During the project it was found that Tetra Pak already have a thorough definition and distribution of the roles and responsibilities required to enable great performance. The challenge left after defining the functions role mainly consists of establishing cross-functional teamwork and decision-making processes where all functions have a full understanding of their role and can contribute to a well-managed supply chain. The expected responsibilities from different functions are listed below.

- Sales & planning
 - Keeping control of the order stock, enquiries and forecast
 - Leveling (place orders according to takt)
- Production
 - Planning for scenarios for different levels of takt
 - Shortening replenishment lead-time of material and internal
- Supplier Management
 - Setting agreements with suppliers supporting the takt management
 - Handling variants, synchronizing the supply chain
- Suppliers

- Planning/Preparing for scenarios for different levels of takt
- Shortening replenishment lead-time of material and internal
- All
 - Setting takt regular
 - Visual follow up
 - Discipline in attending meetings
 - Setting parameters for when to change takt
 - Follow up and improving the process

To have a clear communication of roles in the takt system it is important that the roles and responsibilities are further divided into smaller parts and more directly connected each individuals work and clearly expresses how processes should be changed to support the new system and what task should be introduced or quitted.

5.4 Attribute 4: Managing the Takt

When a takt management system is used it is important to keep the takt aligned with demand as it changes. In order to do that there needs to be tools supporting the managers and providing some data and information to base decisions on. Tools that provide a consolidated picture of all inputs and can be used as guidance. It is also important to have a mindset of customer focus and supporting stable delivery times.

5.4.1 Control Limits for Takt

Setting takt and deciding when it is time to change takt is a complex task. This means that every bit of help available while doing the analysis of the current state is needed and there should be control limits and tools developed to support decisions of changed or maintained takt. Inputs like forecasts, current backlog and other more or less unsecure data are needed and taken into consideration. What is important is that focus always is on keeping the customers satisfied. An active control and frequent revision of the takt is necessary. The purpose of controlling and changing the takt is to keep lead times to customers short and stable and while doing this still minimize the number of slots left empty.

A way of setting control limits for takt management is using the estimated time to delivery as an upper limit. When the estimated time to delivery exceeds the target level it is time to increase the takt and capacity to keep the delivery times within target. The estimated lead time however doesn't fit equally well when it comes to setting a limit in the other direction, that is when it's time to decrease the takt. Instead it is complemented with a measure of the current backlog in time. When the backlog gets shorter the possibility of leveling decreases and when the backlog falls below a certain limit the takt should be decreased to prevent leaving empty slots thus having a too high level of resources available. Neither the upper nor lower limit can be deterministic since other inputs than represented in the model effects the future requirements on the takt. But it provides an easy way of visualizing and grasping the current state trends in demand.

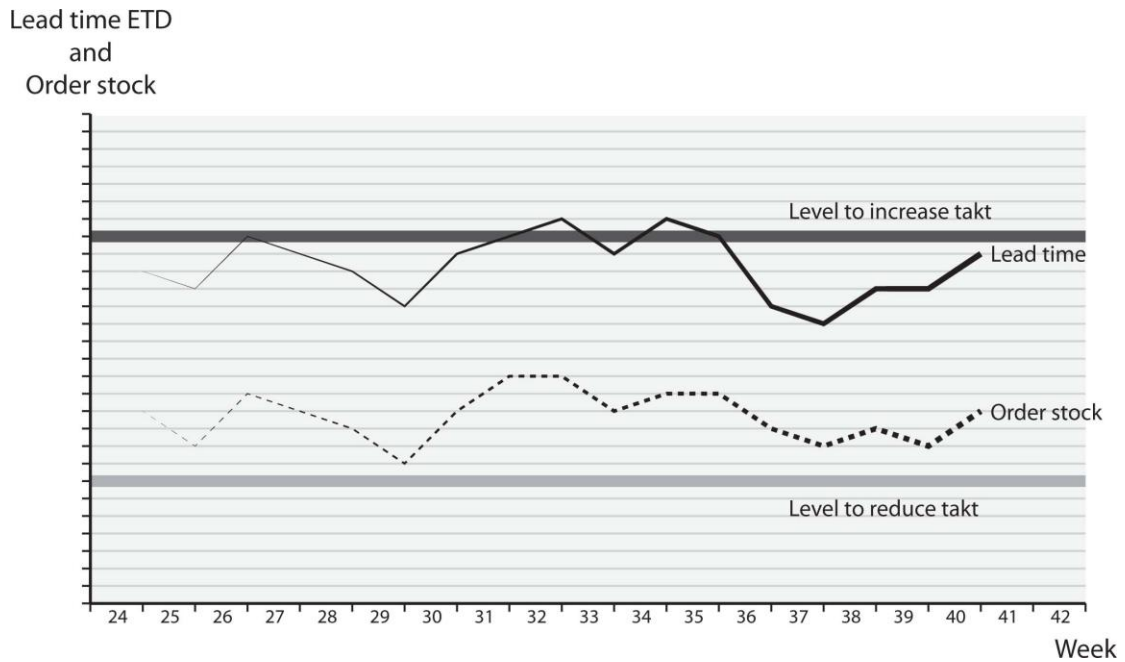


Figure 19 Control diagram for takt management

The estimated lead time of a new order can be calculated by placing the order last in the order stock. This is done under the assumption of a first-come-first-served policy, which means that during the calculations, no leveling is allowed. Calculating the estimated lead time is just a matter of evaluating the current takt in comparison to the current order stock. Given the number of orders in the order stock and the current takt it is possible to calculate when the order first can be triggered and put into production. Then the fixed internal and external lead times are added to the time waiting in the order stock to get the estimated delivery time.

$$\text{Estimated Time to Dispatch} = \frac{\text{Order stock}}{\text{Takt}} + \text{External lead time} + \text{Internal lead time}$$

Equation 2 EtD

If the estimated delivery time is below the target, there is still capacity to handle additional orders and the takt could be maintained. However in the case where the estimated lead time exceeds the target an assessment of the current state must be performed with more inputs to enable a decision whether the takt should be changed. The control limit on the other end should be alerting when the takt is too high and there is a risk of leaving slots empty. The order stock is simply calculated as the time it takes for all orders in the backlog to enter production.

5.4.2 Supplier Communication

What information do the suppliers want to get from Tetra Pak? Or even more important, what information do the suppliers need to be able to handle the commitment they have against Tetra Pak. Much of the theory within supply chain management campaigns for more visibility. But, when the forecasts not are even close to exact, and Tetra Pak can't change takt more often than decided in the agreements, isn't it enough with knowing the takt?

Working with takt gives knowledge of the exact need of resources in the close future. If the suppliers are convinced that they can handle the possible takt changes documented in the takt agreement, then there is an even longer horizon in which they can be sure to deliver a high quality service. This will reduce both the possible benefits and the losses of speculation, minimize the bullwhip effect and give smaller buffers leading to higher cost efficiency.

Considering the range of variants provided it is necessary for Tetra Pak to synchronize the capacity in the supply chain. This has to be done by evaluating the forecasts and through that decide a common service level that should be kept for each of the different variants. For some variants it might be appropriate to have a full readiness, whilst other variants have a lower expected demand leading to the decision of having a lower degree of readiness which might lead to longer delivery times if demand goes above the forecasts. The important thing is that the capacity is synchronized in the supply chain to minimize the costs and wastes.

5.4.3 In and Out of Takt

In some cases when demand is low it might be more effective to leave the takt arrangement and instead let production handle and be prepared for random incoming orders. For example if the demand is low enough to set a takt time that is longer than the replenishment lead time it might be better to “go out of takt”. Though, it is not obvious when this decision should be made. There are still advantages in keeping the takt agreement since it eases production planning and resource allocation both for suppliers and Tetra Pak. Just like many other decision situations in takt management, leaving takt is based on a comprehensive multi variable analysis, each case will be unique and should be handled that way. One parameter setting the lower limit on the takt is when the takt is so low that delivery times to customers becomes unreasonably long not because of the actual internal or external lead times but because of the slots placed according to takt. Assume a takt of six months. It would mean that two machines are produced annually and with six months between each planned slot. But even if there just are two orders coming in that year, and they are received approximately at the same time, the delivery times might be six months for the first customer and a whole year for the second. The takt is set to manage the yearly demand but takes no consideration of the requested delivery times for the customers. So the takt should not only be fitted according to yearly demand but also keep the delivery times within reasonable limits. When the takt time is longer than the requested and targeted delivery time it might be time to leave the takt system.

The risk and possible cost of having to scrap materials in buffers are not realized until an immediately needed design change is done or demand decreases very quickly and doesn't recover and the buffers are left unused. Given a certain takt a buffer level is kept not only to manage the current takt but also to handle possible increases in takt. For parts with replenishment lead time exceeding the takt changeover time larger buffers must be kept and the risk of decreasing demand is bigger because of the safety buffers. This situation further point at the need of keeping lead times short to minimize the need of buffers.

5.5 Attribute 5: Key Performance Indicators

Choosing KPIs is a very important part of the implementation. KPIs should be aligned with strategy to assess whether the takt management really provides the expected advantages. All functions with responsibility to contribute to the takt system should be measured and have some KPIs related to the takt. This is necessary and will work both as a signal of the importance with takt but also a way to give directions concerning how Tetra Pak should support the takt. There should also be KPIs indicating a poorly managed takt and by that highlight possible changes needed in the management or daily work.

KPIs should be standardized through the organization. A supply chain with “weaker” KPIs should be able to benchmark the internal best practice and move away from poor performance. KPIs should also be a way of showing people involved in the takt management what is important for a successful managed takt, the direction in which Tetra Pak is heading and what is expected from the employees.

One of the more important measures on internal assembly is the number of nonconformities discovered. A higher number should give a better measure. This might sound wrong but the purpose is to reduce the amount quality defects and customer claims when the machine is delivered and therefore it is better to find the nonconformities internally. At the same time the supplier of each module should also be measured on the amount of nonconformities found, but of course in this case a lower number of nonconformities would give a better measure. This forces also the supplier to find, report and solve as many nonconformities as possible and by doing this the number of claims from final customers should be reduced and a higher quality perceived. Naturally the chain doesn't end at the module supplier, the same incentives should be passed on to the component supplier and the earlier a nonconformity is found the easier the work of finding and correcting the root cause will be.

When it comes to managing the takt it must be clearly understood that each change of takt should be done with the purpose of aligning the supply chain closer to real demand and keep delivery times stable and within the target. Poor management of takt can be visible in two ways, empty slots and delivery times above target. The management should be measured on to which extent these extremes are avoided, or to which degree the takt is aligned with demand. The measure should consist of two parts, first the delivery precision and secondly the number of empty slots which should be as few as possible. The dimension of delivery precision is of course important to make sure that customers get their machine in time but in addition, a machine finished before requested date is undesired because of the employed capital and interest cost. This makes the delivery precision to a two dimensional measure and it is important to clearly prioritize the delivery time in front of the cost of keeping finished machines in stock.

Since the delivery time to customers is a measure of such great importance there should also be measures of the module suppliers concerning their ability to have short and deterministic lead times. This also concerns the component suppliers who not only should provide high quality but also have an important task in

keeping their lead times. Firstly it is important that the promised lead times are kept and no late deliveries occur since buffers are dimensioned depending on the lead times and late deliveries can stop the flow in the entire supply. Secondly the lead times should be shortened to enable smaller buffer and a more flexible supply chain.

The change management also consists of aligning all functions in the organization to the takt production system. The takt management will put new needs and requirements on all functions and this must be made visible through implementing new measures and KPIs where consideration to these new requirements are taken. Unless this is done the change can be prevented by the old principles. Changing measurements will also be a good way to involve people and create a bigger understanding for the takt principles.

5.6 Attribute 6: Component Suppliers

The focus of the project was from the beginning said to be mainly on the module suppliers, Tetra Pak and the relation between them and it was seen as a too big task of involving the component suppliers. However, soon it was realized that it would be a too big limitation of the quality in the project to leave the component suppliers outside the scope. The possibility to succeed with the takt implementation is directly connected to the component supplier performance and how they are treated and involved in the supply chain.

Tetra Pak have general purchasing agreements (GPA) signed with the component suppliers where the terms of the cooperation is decided, prices, annual volumes and lead times. When the component supplier is involved in a takt supply chain new agreements are developed and signed in addition to the GPA.

In the work of implementing takt one big part is to make sure the sub suppliers have capacity to deliver according to the current takt and can handle the changes in takt that is set by Tetra Pak. It's not obvious how to handle this problem. Ideally, every tier from raw material supplier to final customer is a part of takt management, all working with the same pulse and the common goal of increasing the total value for final customer. Of course this is utopian thinking and if even possible, lies far into the future. But even just including all of the component suppliers in the takt project is a big task.

Tetra Pak or the module suppliers have to make sure that a certain level of capacity in takt and takt-changes is reached by all component suppliers. This should be done by agreeing maximum lead times for every supplier, defining the critical articles with longest lead time and start the work of shortening these lead times and strive toward a 100% delivery accuracy and quality.

Assume an increase of takt. That means a higher frequency of upcoming slots and delivered machines. This will directly lead to a faster reduction in buffers at every tier. Since the buffers should have been adjusted to manage the previous lower takt, a new higher buffer level should now be set. One of the parameters limiting the change over time to a new higher takt is the replenishment lead time and particularly the long lead time items. The new takt will lead to a faster reduction of buffers and higher quantities or more frequent incoming deliveries

are needed. Until these new quantities are delivered the security buffers are decreasing and there is a risk for shortage.

Building larger buffers that cover the need also with the new higher takt can solve the problem. The question then is, which takt changes should be possible to manage with the buffers? Building buffers of course is a huge cost driver and if possible should be avoided. The other way to go is working with cutting the replenishment lead time in order to shorten the change over time to new takt. The suppliers need to have full control of which their long lead time items are and continuously work with their suppliers to increase flexibility through cutting lead times to decrease the value needed in buffers to support the takt.

The mindset of purchasing components in batches because of lower price per part is not supporting the takt system. The low value standard components included in the C-parts and possibly B-parts could of course be purchased in batches because of the frequent use, it would be very inefficient buying the smallest parts, like nuts and bolts, in an exact need according to the takt. But when procuring the parts with higher value the volumes ordered should be based on the actual demand, a pull flow, and not additional parts because of quantity discounts. This will currently not be possible for all parts, some supplier might have an own calculated “minimum economic order quantity” saying that a one-piece-flow not is accepted.

5.7 Attribute 7: Management and Support

To succeed with the change it is important that the structure of the organization contributes to a smooth change process and not aggravates it. There must be people responsible of driving change from inside the supply chains as well as from top management. The people working closely and hands on with the management and implementation of takt must feel supported from higher level to be motivated and feel pride and meaning with their work. During the implementation of a new machine to takt it is crucial that the experience gained in the earlier projects are communicated and used to avoid the pitfalls and major difficulties in the change. There needs to be an assigned project leader with experience and skills who can control and empower the change and maintain momentum to keep the effort from stagnating.

In a change effort the size of the takt implementation it is essential with a carefully developed vision. There is need for a common view of the purpose and goal among the people working with the change. The vision should be both motivation to keep the pace of change high and guidelines when decisions must be made. It is also important that the momentum is kept high and not lost due to size and long time needed for the change to be effective and show results.

6 Description of the Supply Chains from a Takt Perspective

This chapter describes the different supply chains with a perspective from the attributes stated in chapter five.

Information and data in this chapter comes from the interviews and internal documentation. It is a deliberate choice not to match data and information to specific individuals as that were the premises when doing the interviews.

6.1 Filling Machine: A1

The A1 filling machine consists of four modules delivered by three suppliers. One of the suppliers is responsible for two modules as well as the assembly and final testing of the machine. All modules are manufactured by suppliers located in China. The module suppliers consist of both old and new business partners and the supply chain is in an early phase of its development and still struggles with achieving required quality and building a higher level of trust. The Assembly and testing has recently been outsourced from Tetra Pak. This situation has created a low focus on the takt implementation. Currently the production is managed and planned in batches and this is an attempt to build a robust and reliable production process. The current state would not allow working with the takt principles in the supply chain since there are a too high degree of uncertainty in quality and lead times. The batch management is supposed to be a step against the continuous flow in a takt controlled and customer driven supply chain.

Because of the recent restructuring in the supply chain there are a lot of ongoing activities to facilitate and get the production working smoothly and takt control implemented. Tetra Pak has recently performed a value stream mapping with the module suppliers to facilitate and drive the improvement work in the supply chain. Currently the supply chain is in a phase of implementing solutions to the gaps identified in the value stream mapping. There is a TQM team focused on improving the quality from the component suppliers that has been a major problem and practically all incoming parts are tested. Tetra Pak are continuously training suppliers and strive to create a mindset of customer focus and an understanding of the implications that mindset has on production.

6.1.1 Takt Agreements

Currently there are no takt-agreements signed, the intension is to use the A3 takt agreement as a template. The flexibility matrix is under development as well as a coverage matrix that provides a frame for how to manage the different variants. Currently there are only written lead time agreements with some of the component suppliers. Before the takt agreements are signed with Tetra Pak the module suppliers are responsible for signing lead time agreements with all their component suppliers.

Comparing this supply chain with the others there is a big difference concerning the current level of trust towards the suppliers. In the long run suppliers should be involved in the development of machines and give early feedback on design changes to ease their work and prevent designs hard to realize in production. Not only are there lacks of skills from the suppliers on this point but also currently Tetra Pak has an anxiety concerning sharing blue prints with the

Chinese suppliers and having the same visibility in the production system as is present in the other supply chains.

6.1.2 Production Documentation and Daily Control

Sequencing of production and Standard operating procedures are under development. These areas are some of the important targets of the pending value stream mapping where module suppliers and their biggest suppliers are participating.

6.1.3 Roles and Responsibilities

Because of the current situation where production is not managed by takt the process of deciding and changing takt is not ongoing. But when the production eventually goes into takt there are already people feeling responsible for handling this task.

The suppliers are under close observation and have currently a strong support from Tetra Pak. Their ableness to handle the coming continuous production in takt and its implications and requirements on production and quality when Tetra Pak lower their support is a moment of disturbance. Worries concerning the suppliers' capacity to manage their responsibilities on their own accord are expressed.

6.1.4 Managing the Takt

The supply chain is currently not managed with a takt system.

6.1.5 KPI

To measure the performance of the supply chain two main KPIs are used. The number of nonconformities and the percentage of machines delivered "on-time-in-full", that is complete order fulfilled within the by customer requested lead time.

6.1.6 Component Suppliers

The A1 supply chain has problems both concerning the quality from component suppliers where in some cases a 100% control of parts is needed but also concerning poor delivery precision. The module suppliers are working with signing lead-time agreements with the component supplier to enable an eventually fully working takt implementation.

6.1.7 Management and Support

With current efforts like the value stream mapping together with suppliers and trainings and workshops organized to increase suppliers understanding of the takt system and customer focus Tetra Pak shows the importance and focus of takt. Even if the efforts not are directly said to be a part in the takt implementation but have other primary goals concerning suppliers performance they will be necessary for the takt implementation.

In the A1 takt implementation there is an individual feeling the responsibility for the change and who could be said to have the role of a project leader.

6.2 Filling Machines: A3 speed & A3 Flex

Soon after starting the mapping it was discovered that the A3 Speed and A3 Flex machines have almost all the interesting characteristics from a takt-perspective in common. Therefore, to avoid redundancy, it was decided to combine them in both description of current state and in the analysis part. To clarify, the machines have their own individual set takt and are treated as separate machines in the supply chain.

The A3 machines are the high volume products of Tetra Pak. With takt-times down to 0,8 days over 150-200 machines of the A3 speed and A3 Flex are provided annually reaching far above the internal competition where takt was introduced and annual volumes only were around 50 machines. Considering the higher volume and the fact that some experience had been gained in the previous takt implementation one could expect a smooth and fast change to the new takt system. But still, more than two years after the change was started, the A3 supply chain still has problems with too long delivery times, empty slots and inventory built up.

The A3 machines are provided in many different configurations. Some suppliers provide modules with up to 20 different variants where each consists of 2800 components of which 75% are variant dependent. For suppliers, the complexity in variations combined with a demanded five-day lead time from received order to delivery, requires a high flexibility in production to manage according to the takt-agreement, a flexibility not yet reached. In addition there are lead times from component suppliers of up to 10 weeks or more on some of the variant dependent parts. To handle the requirements from the market the only solution, until a more flexible production is achieved, is keeping buffers. The buffers are set by looking at a consolidated picture of forecasts and historical behavior.

6.2.1 Takt Agreements

Even though the takt system was introduced in the A3 supply chain two years ago takt-agreements are still not signed with all suppliers. This makes the task of managing and collaborating with suppliers immensely more complicated since the foundation for a flexible and aligned supply chain is missing. Generally suppliers understand the potential benefits of the takt implementation of which some already have been realized. So the problem is not a resistance towards the takt system in itself but rather anxiety concerning how the details in the collaboration should be designed.

The suppliers have expressed a need of clarification or limitation concerning the frequency of takt-changes. According to the flexibility matrix a change of takt in the range 50-80% gives the suppliers a buffer or reaction time of 6 weeks before the change is realized whilst a change in the 0-20% range should have an immediate effect. This makes it technically possible for Tetra Pak to do three consecutive changes in the 0-20% range and force the supply chain to a total change lying in the 50-80% range in only three weeks. Even though this is not the intention of Tetra Pak it is still a concern that need to be dealt with before agreements can be signed.

The major issue with the current presented flexibility matrix is the immediate possible change of 0-20%. This implicates that suppliers always should have a readiness of a 20% higher takt than used in the current state. This means that buffers should be adapted to a higher takt and resources available to at any time increase the takt 20%. This readiness creates wastes in the supply chain and is one of the main objections suppliers have against the proposed agreement.

6.2.2 Production Documentation and Daily Control

During the project two of the A3 module suppliers were visited and more closely investigated, the mapping done is from the perspective given from these visits.

The suppliers have to a varying degree created production documentation from which the production can be controlled and monitored. At one supplier the comment was “each worker knows when his work is on time or late” when asked how disturbances in the flow are noticed. This is a system highly dependent on the individual worker and her capacity and provides a low visibility to early detect problems. They had a sequencing done where the progress of work was divided in days and the other supplier showed no sequencing at all in the assembly of the module. Internally Tetra Pak has a visual and clear control of the progress of each machine in the assembly and testing.

Suppliers have adapted their assembly and aligned it successfully with the takt and modules can be seen in different stages in the assembly depending on how close the particular module is to dispatch, all according to the takt. There are however cases where the same alignment not is present and the production stage before assembly is managed and planned in batches. The impression was that batch sizes are calculated according to some economic order quantity, this can lead to unnecessary big batch sizes and prevent a more flexible production.

6.2.3 Roles and Responsibilities

The planned roles and responsibilities in the supply chain have been communicated several times since the start of the takt implementation but still the expected contribution from the different departments are not made. Sales, with the interface against customers still has more responsibility to take concerning the possibility to level incoming orders to ease the production planning. Supplier management has not reached success neither in their task to synchronize the suppliers capacity nor signing the takt-agreements. Also the desired actions from suppliers in creating a proactive approach to prevent problems in the takt work have been omitted. The supply chain has taken the point of view that the supplier should be involved in setting the takt together with the internal stakeholders.

6.2.4 Managing the Takt

Currently a coverage forecast is communicated to suppliers, which is a forecast of the expected distribution of the variants. Not only are the intervals between updates of the forecast varying but the forecasts are poor and create an uncertainty in the supply chain where suppliers add their own expectations to the forecast leading to an uneven capacity between the suppliers. This creates unnecessary costs that could be avoided if a synchronized approach towards the distribution of variants were reached.

In the A3 supply chain there has existed a mindset where orders placed outside the takt is accepted. Instead of leveling or increasing the takt to manage rush orders the extra capacity coming from the poorly designed flexibility matrix have been used to accept additional orders in parallel with the takt. This leads to a situation where suppliers actually are encouraged and rewarded for keeping some additional resources and buffers above the levels needed according to the takt. This additional preparedness is undesired since it neither is synchronized within the supply chain nor against real demand.

Historically there have been tendencies of doing big changes in takt with a low frequency. Instead of fast reactions to changes in demand the takt has been kept stable leading to either empty slots or longer delivery times and when the situation eventually is dealt with a big change in takt is done. This despite of clear internal communication concerning that, big changes in takt should if possible be avoided by using a higher frequency of smaller takt changes to keep the supply chain aligned with demand. Big changes in takt are harder to achieve than small changes and therefore that mindset of working not only leads to poor customer service but also a system with bigger requirements on suppliers than necessary.

6.2.5 KPI

The suppliers are measured on number of nonconformities and deliveries on-time-in-full. The internal assembly and testing is also measured on finding the number of nonconformities found and the performance of the entire supply chain is measured by the Order to Dispatch as well as the delivery precision.

6.2.6 Component Suppliers

Tetra Pak has the GPA signed with the component suppliers but because of the problems in takt agreements with module supplier, the work up-streams with signing takt agreements between module and component supplier has had a low priority during the investigation in the this project.

6.2.7 Management and Support

The A3 takt implementation has been troublesome and delayed and the current state gives evidence concerning that the support and management during the project has been deficient. The Experience and skills existing within Tetra Pak has not been used sufficiently to enable the creation of a healthy and sound takt-managed supply chain. The problems concerning how to deal with the many variants and how they should keep a high customer service without an exploding value in buffers together with a nonfunctional flexibility matrix has led to a high uncertainty in the implementation that could have been avoided with better support.

6.3 Filling Machine: A6

The A6 is a newly developed filling machine that produces packages similar to Tetra Top. The main difference is that it's an aseptic package that ensures a sterile environment for the packaged food. There are six suppliers delivering A6 modules to Tetra Pak in Lund where the assembly and final testing are done. Almost all suppliers have been working with Tetra Pak before and some of them deliver modules for other filling machines.

Because it's a new filling machine, the production is in a phase with intensified work of continuous improvement, the first machine is not yet delivered. In the present stage it's important to get the manufacturing working and assure good quality. It's for example extremely vital that the filling machines deliver packages that really are aseptic. The next step is going from a project way of working to a more stable and standardized manufacturing. To manage this transition without an exploding number of disturbances and nonconformities the project is run with full speed principles. This means that the deployment machines should be produced in the same takt that is expected to be set from the market and by this force the problems to the surface now and prevent coming problems when going to continuous production. It's clear that they early in the process of starting up the supply chain have been working to secure that production planning should work according to takt. Currently the A6 machine is produced according to a takt of 30 days. This is to ensure that every supplier as well as Tetra Pak have time to investigate and fix all nonconformities to have a smooth transition from the project stage to continuous production. A plan to reduce the takt time is already discussed and analysis has been done at every supplier to map the bottlenecks for such a change. In the takt agreements there are an appendix showing the plan for takt time reduction.

It seems as the people involved in the A6 machine has a pretty clear idea of how the takt implementation should be managed, probably because it's the same organization within Tetra Pak that started the implementation of takt and therefore have some years of experience. All but one of the suppliers involved have experience from working with Tetra Pak and takt since earlier. It is a commonly held view that the benefits of working with takt are the control gained in terms of delivery time, quality and cost. A large part is that you remove interference in the flow and thus obtain quality assurance.

6.3.1 Takt Agreements

A takt agreement is signed with all module suppliers and most of them seem to know what's expected from their part. The flexibility matrix is agreed and was developed together with all the suppliers. Some suppliers still have problems with the procurement of materials. Since the machine still is in the development phase and very early in production there has been some measures taken to handle these kind of problems and there where buffer times included in the planned schedule to compensate for late deliveries. Eventually the buffer times will be removed to reach a shorter delivery time and the late deliveries will have fatal consequences, as the whole supply chain will be stopped. During the development phase and manufacturing of the first deployment machines there have been a mindset of looking for as many nonconformities and quality defects as possible to be able to find root causes and solve the problems by finding and correcting its source. The amount of nonconformities discovered has created new bottlenecks in the form of too few people doing root cause analyses' and preventing the problem from repeating. To ensure capacity in the supply chain the module suppliers are signing takt-agreements with their component suppliers. Most of the suppliers have completed this task but there still are some agreements left to sign.

Variant management is not present at the moment because there's only one variant available. But eventually additional variants will be developed and it will be very important to have good management of the system. The suppliers need to know how to deal with the variant mix in the buffer stock.

6.3.2 Production Documentation and Daily Control

Internally Tetra Pak has a good control of the bottlenecks when it comes to takt changes. Mainly the bottlenecks are about staff and floor space. Checklist for takt changes is developed internally but contains only a few parameters. Also some modules suppliers have developed checklists.

To obtain daily control different kinds of meetings is held several times a day, at least at Tetra Pak's site. Sequence diagram is developed down to half hours as well as standard operating procedures. If problems appear they are in this way of working quickly highlighted. When it comes to deal with the upcoming problems there is a clear process to tag them into a system. The sequence diagram and standard operation procedures are documents that are continuously changing especially at this early stage of the manufacturing process. To ensure that the suppliers will deliver in time Tetra Pak has frequent updates of the status. This is done several times a day by phone calls. If late deliveries occur the quality pillar perform a follow up and an analysis.

6.3.3 Roles and Responsibilities

Different roles will be determined in form of functions. When it comes to takt decisions the production manager together with the product management group will have a dialog. The supplier will not be directly involved, only indirect with their capacity constraints. It's also clear how and who will communicate the takt changes. A map showing all the communication channels will be in place eventually. This is needed to have some control over the information communicated to the suppliers. To control and set the takt several parameters are considered. The queue, order stock, current delivery time, current takt and forecasts are consolidated and analyzed to assess the need of takt changes. To keep control of the situation and prevent lacking resources in future takt scenarios there is model providing the user with the need of resources given a certain takt to ease the planning and preparations for takt changes.

6.3.4 Managing the Takt

In addition to takt the planned production with confirmed orders and variant specification is communicated to the module suppliers. Some of the suppliers would like more information and some are satisfied with only the takt. Apparently it is not established from Tetra Pak which information that should be shared. Some think that it is good to provide more than takt and give the suppliers the possibility of having certain preparedness for different scenarios. Others are very clear that only the takt need to be shared and that it should be sufficient to manage and plan production according to a given takt.

The general mindset is that additional orders on top of or outside the takt to manage rush orders is not appropriate since it undermines the takt system by implying that suppliers should have a certain amount of excess resources to

handle variations outside the takt. Cases of rush orders should be handled with leveling and if needed a takt change.

6.3.5 KPI

Direct KPIs concerning the management of takt exists. A plot as showed in chapter 5, figure 19, shows the KPIs used to help managing the takt. Even though the efforts towards takt in the A6 supply chain is big there still is a lack of new takt aligned measurements in other tasks not directly but indirectly affecting the takt.

6.3.6 Component Suppliers

Concerning the component suppliers there are takt-agreements signed dealing with delivery times and prices. At the moment it doesn't seem like there are any directives from Tetra Pak that the module suppliers should work with shortening the delivery time for long lead-time items from component suppliers. Keeping the lead-times short are not crucial for the takt, just for the buffer stock and therefore it's up to the module suppliers to decide how they should manage this.

6.3.7 Management and Support

The implementation of takt in the A6 supply chain has been strongly supported and a big amount of resources have been allocated to enable a good performance from the start. Employees with experience from takt have been involved and there has been a focus also from higher up in the hierarchy on the implementation. The mindset of implementing takt from the start has made massive resources accessible and the implementation is done jointly on all fronts. The implementation is done by supporting and creating a takt mindset for all employees involved in the A6 project to make sure that the system supports a takt management from the start.

6.4 Distribution equipment: CBP 30 Speed

Until now the distribution equipment organization has not been working according to takt. But thanks to relatively high volumes there are big potential for a smoothly working takt system. The whole manufacturing is outsourced and there are about seventeen suppliers of which some produce more than one type of equipment. The work of implementing takt began early in 2010. With hindsight, a too optimistic view and unreasonable expectations from the start of the change project has led to several delays and postponements of the takt introduction compared to the first targeted dates. The first distribution equipment planned to be managed by takt is the Cardboard Packer 30 Speed (CBP 30 Seed).

CBP 30 speed is a machine packing carton packages into trays and wrap-around units. The annual volume is about 90 machines and the production is completely outsourced. Because of the supplier's previous experience with takt as a module supplier for different filling machines one could say that they are well chosen for the introduction of takt in the distribution equipment organization. Module purchasing together with representatives from the supplier has collaborated to form the takt agreements by tuning the A6-agreement that was used as a

template. Since one supplier is responsible for the entire machine there are only one agreement needed to be signed from Tetra Pak's perspective. The task lies heavier on the supplier's shoulders, needing to secure sourcing of materials from several component suppliers according to the takt agreement. The idea is to get the takt system up and running with CBP 30 speed and later use this as template when implementing takt with the other distribution equipment.

6.4.1 Agreements

The flexibility matrix developed for the CBP 30 Speed is in contrast to the flexibility matrixes used within both the A3 and A6 supply chains fixed in the takt changeover time. It means that the time between a new takt is communicated and the new takt is realized is the same regardless the size of the change.

The CBP 30 speed is the machine chosen for the distribution equipments takt pilot. Although yearly sales volumes indicate that the machine is well suited for takt there are some characteristics complicating the transformation. The machine is provided in 15 different variations with a big difference in demand between variants. Some variants have not been sold for years while others are produced on a weekly basis. The complexity of handling the different variants and determine the buffers have been one of the main issues during the implementation project.

During the negotiations and development of agreements and appendices there has been a big focus on the design of the flexibility matrix and how the limits should be set. The supplier representatives have seen this as somewhat wrongly directed efforts since the supply chain not should be limited by the lines in the flexibility matrix and if the demand goes beyond the takts agreed in the matrix the supply chain must of course follow. The focus should instead be on a correct management of takt. There has been a coverage agreed for all the variants available, the coverage defines the needed buffers of all parts given a certain takt.

6.4.2 Production Documentation and Daily Control

The Module supplier has good knowledge and skills concerning documentation of production. This has been showed not only in the A6 supply chain where the supplier is involved but also in results from recent internal measurements where the performance has improved. The supplier has reached a big preparedness concerning the different possible takts through using checklists showing which resources are needed for different scenarios of takt. The supplier has daily meeting where progress reports are given and possible problems are visualized on a board.

6.4.3 Roles and Responsibilities

The supply chain is still in a very early phase in the takt implementation, which makes it hard if not impossible to evaluate the current state of this attribute. What can be said is that there are already informal discussions going on concerning participants for setting and changing the takt. However, there are many tasks to be performed and roles to fulfill and these problems still lies a bit ahead in the writing moment.

6.4.4 Managing the Takt

Since the supply chain for CBP 30 speed neither are managed by takt now nor have been earlier there is no possibility to evaluate the performance of the takt management.

The module supplier has made it clear that they only want the takt to be communicated throughout the supply chain to avoid speculations. Though there will be a close communication between the parties concerning when and how to change the takt. The supplier has also stated that they think the takt should be changed more frequently in small steps rather than seldom with bigger steps to closer follow the changes in demand. They show a mindset where delivery should be kept short and robust time should not be punished because of the benefits from keeping a stable takt.

6.4.5 KPI

The supplier is measured according to their delivery performance and quality. Having a mindset of finding nonconformities early should be natural for the supplier after the participation in the A6 supply chain.

6.4.6 Component Suppliers

The component suppliers have not been reached with a takt agreement in this supply chain. The GPAs are signed and some component suppliers are not willing to sign additional agreements. One of the big concerns in the supply chain is the risk of delayed deliveries from component supplier stopping the flow.

6.4.7 Management and Support

The change to takt is managed by staff both from Tetra Pak and the module supplier. The supplier's representative has previously been involved in working with takt and has through that contributed with essential knowledge and experience to drive the project. The Tetra Pak employees conducting the transformation have no prior experience of takt and in addition the implementation is done outside their scheduled work. This has led to frequent hesitations of how to continue the work.

6.5 Filling Machine: Tetra Top

Initially the Tetra Top was one of the machines to focus on during the project. The current situation and recent history of low demand has led to a decision to leave takt. This together with the input from early interviews and a discussion with the project coach resulted in a choice to reduce efforts toward the Tetra Top supply chain and there are no analysis directed to the Tetra Top supply chain.

The machine is assembled and tested internally at Tetra Pak before going out to customers. Tetra Top was one of the first machines managed with takt. The takt management was introduced during 2004 and the yearly volume at the time was roughly 40 machines. The last year actual demand has been two machines and therefore the supply chain is currently not managed by takt. Recently there have been tendencies that volumes are increasing and that leads to a situation where the interesting problem concerning when takt should be reentered must be addressed. During the time with takt control there were three variants of Tetra Top available. The variants were handled by limiting the number of consecutive

orders of one variant and by this the buffer levels were decreased comparing with a situation of full flexibility.

6.6 Filling Machine: Tetra Rex

Just like in the case with the Tetra Top machine there are some circumstances around the Tetra Rex machine that has made focus slide away and instead efforts are directed to the, from a takt-perspective, more interesting machines. The production of Tetra Rex including assembly and testing is outsourced. There has recently been a restructuring of the supply chain where production was moved from the US to Sweden and new suppliers introduced. With the new module suppliers primary focus is not on the implementation of takt management but directed towards securing performance. As a consequence of the low demand and restructured supply chain there are no analysis directed to the Tetra Rex machine and overall efforts have been very limited.

6.7 Comments on the description of the Supply Chains

Because of the fact that most of the supply chains are in a very early stage in the takt implementation it has been hard to really get a full and clear picture of the current state of some of the attributes. It is for example hard to evaluate the current ability of managing the takt and how well it is aligned with demand when the supply chain still not has introduced takt. It comes to a situation where it is the readiness for the future that is evaluated, often from some few individuals perception which weakens the following analysis.

Further it should be stated that many of the problems found are common for all the different supply chains and the analysis for these findings are done in chapter 8.

All data and information in the chapter comes from the interviews and internal documentation.

7 Analyses of Supply Chains

This chapter gives analyses for the individual supply chains.

7.1 Filling Machine A1

The A1 supply chain stands before a big challenge in quickly developing the new suppliers and achieving the high quality standards expected by Tetra Pak and the final customers. Before the batch production can be abandoned and the takt system entered the quality and delivery precision from suppliers must be improved.

Currently a takt management would not be possible depending on the many disturbances that would be created by the lack of delivery precision and poor quality. The feeling is that there is a long path ahead before a takt system can be introduced in a successful way. The journey to takt has started and the first step concerns improving the suppliers internal control of production to enhance the performance of delivery accuracy and quality. To reach progress in the work it is essential that all suppliers create systems for having early detection of nonconformities. They should have well documented production, standard operating procedures and use these tools in frequent follow ups to avoid defects and late deliveries. The mindset should encourage finding nonconformities and have thorough investigations to locate and solve the root causes. The mindset of having deliveries and production in batches might obstruct the work of improving quality. The feedback of each nonconformity will be delayed compared to the case with one piece flow or smaller batches and the nonconformities coming from the same source might occur in all machines in a batch and also in machines in the coming batch because of the delayed feedback.

The Batch production creates a state where deliveries can, in most cases, have poor precision without inflicting any damage and thus the poor performance might not be visible enough to drive a change.

For the implementation of takt to be successful the control of production and assuring quality is a major factor. The tools needed to have full control such as sequenced production, standard operating procedures are under development and it is of absolute necessity that these efforts are completed to evade the poor quality and train suppliers into the customer focus Tetra Pak are seeking.

It is essential that the experience from the prior implementations are used and the problems still complicating the state in the A3 supply chain are avoided by adequate training of suppliers in the takt principles. But also the internal training is crucial and to have an understanding concerning how the takt should be managed and how the capacity over variants should be synchronized between the suppliers. The A3 takt-agreement has been used as a template and it is important to change those parts in the agreements that have created the confusion and anxiety because of takt in the A3 supply chain. The communication to supplier should be kept clear and exact requirements on buffers stated. There should be no incentives for suppliers to deviate from the agreed capacity because of orders placed outside the takt or pushing for variants not available in the agreed coverage. It is important that Tetra Pak is consistent

with their behavior and that the actions truly support the principles mediated in trainings.

The supply chain is currently providing machines through batch production and when the takt is entered there is an expected increase of the pace in production. When the pace increases the performance requirements of the supply chain will also increase and when it does new problems will be visible just because of the higher production pace. In the A6 flow the mindset has been to work according to the full speed principles to prevent many of the future problems. To have a somewhat smooth takt introduction the same approach should be used in the A1 flow and the production during the batch stage should be driven in the same speed that the takt will demand.

7.2 Filling Machines: A3 Speed & A3 Flex

One thing mentioned during many of the interviews has been the problem of applying the takt principles on a low volume production and that Tetra Pak doesn't have the same potential with takt as the high volume industry e.g. the car industry. But strangely the takt implementation was not started in the supply chain with the highest volume of machines but in the low volume segment. Still the first efforts reached success and the major problems came during the implementation of the higher volume machines.

An example concerning why the change is hard to implement with the suppliers can be the previously reached high performance from some parts of the supply chain. Some suppliers have a history of close to 100% on time deliveries and feel that they already are a very high performing organization and don't feel that there is a need of change. As mentioned in the theoretical framework, change efforts have a high risk of stagnating if there is a lack of urgency and even if they are in an imagined security this is the exact situation for some suppliers. They don't truly see the need of changing their performance and by that misses the opportunity to move from good to excellent.

The situation of short lead times in production, big possibility of variations in demand and long lead times of components creates a need for keeping a high inventory to be able to deliver all the variants. The situation of keeping parts for full variant flexibility in stock has been unsustainable because of the costs and instead a forecast of the expected distribution over the variants is communicated to suppliers. They should then adjust their buffers according to that forecast. First it can be noted that these forecasts have been inaccurate leading to a misalignment of the supply chain in comparison to real demand. Another problem comes from the bullwhip effect created from the forecast. Each supplier is free to interpret the forecasts according to expectations and prior experience leading to an uneven capacity between the suppliers.

Another problem with the proposed agreements arises from the fact that stock levels are calculated as if all parts are ordered in a one-piece flow. As this is not the case and components are ordered in batches it will be hard or even impossible to keep the buffer levels stated in the takt-agreement. The suppliers want Tetra Pak to either find a new way of calculating buffers where the batch sizes are taken into consideration or simply agree to take responsibility for a

bigger part of the buffers. The best solution would be to have agreements providing an option of quantity to order and through that be adjustable according to the buffer agreements. On the other side of the same coin is the relationship with some component suppliers where Tetra Pak only constitutes a marginal part of their total turnover. This leads to a situation where there's no possibility to apply pressure on the suppliers to shorten lead times or require their involvement in any special efforts to improve service towards Tetra Pak. In some cases it might be possible to coordinate purchasing of parts to one supplier and in that way increase the potential of pushing for higher service levels. This approach will however not be possible in all cases and the remaining option, to provide high flexibility, is keeping buffers.

In the takt agreements Tetra Pak commits responsibility for a certain buffer level of each part. This level is the minimum level to be able to manage according to the current takt and all materials in buffers in excess of that will be a responsibility of the supplier. Tetra Pak should not intervene in the way suppliers plan their buffer levels concerning parts beyond the Tetra Pak's responsibility. It should be up to each supplier to plan buffers and purchasing to be able to provide the service levels committed in the takt agreement. However, in the cases where an agreement between Tetra Pak and component supplier exists from which module supplier purchases parts and the agreement limits the possibility of keeping low buffers, Tetra Pak should look over the possibility to commit responsibility of a higher buffer level than previously to ease the cooperation with suppliers.

It might never be possible to produce and plan all parts in a one-piece flow since set-up times on machines not are zero. But each reduction off batch sizes means a reduction of wastes in terms of less waiting times and production becomes more flexible and able to handle the difficulties with the module variations. A thorough investigation is proposed where first of all the fraction of actual value-added time of the lead-time for produced parts are calculated. Then an effort with focus on minimizing the set-up times for each machine in production is needed. Through doing as much as possible of the set-up online, the downtime between batches can be reduced, less produced parts is put in buffers enabling a higher throughput. The purpose is to produce parts in smaller buffers closer connected to the actual demand and through that enable a higher flexibility and reduction of costs. One big part in this change is to create a new mindset concerning how cost is measured. The cost for produced parts will, with the classical way of calculating costs, be higher with the smaller batch sizes. But as long as demand is fulfilled and no further personnel are needed there are no increased costs, only different distribution of the work.

Concerning the suppliers there have previously been some efforts initialized on analyzing the need of resources for future possible takts. But the efforts failed and there were never any documented results. Comparing with best practice there is a gap concerning the documentation of production. Sequence schedules as well standardized and documented work should be developed. Skills and experiences within this area exist in the Tetra Pak organization and it's a matter of getting each supplier involved and focused in the improvement work as well as sharing the present knowledge. It is also necessary to perform bottleneck

analyses to investigate how much resources are needed for the different takts and create an action plan for how the needed resources should be obtained if not already available. For each possible takt there should also be developed checklists, stating the need of all resources, to ease the transition to a new takt. This proactive work is needed to be prepared for and avoid the coming limitations and problems.

7.3 Filling Machine: A6

Although a new machine, the focus toward creating a flexible and robust supply chain providing high quality has been rewarding. The potential for a well managed supply chain and reaching the benefits made possible by takt management is big. The main obstacle left is the transition to continuous production where the takt will be set by demand and the capacity and flexibility will be truly tested instead of having an internal decided takt. Another challenge not to be underestimated is to accomplish a management of the takt that truly is aligned with demand and can provide customers with desired lead times and avoid leaving slots empty.

During the project different opinions were caught concerning what information should be communicated to suppliers to best support their performance. Some argue for a higher visibility where a forecast should be communicated along with the takt while other argue for a more restrictive information sharing where only the takt and current variant mix should be included. It is important that a common understanding is reached on this point and that all the incentives and risks for suppliers to speculate and build uncontrolled buffers are minimized. Ultimately this is a question of insight concerning how to best support the takt and the fact that there is different opinions in this question signals that there is a diverse level of understanding of the takt principles.

7.4 Distribution Equipment: CBP 30 Speed

Considering the amount of machine types Distribution Equipment has to deal with, some kind of software support will eventually be needed for production planning, both for the ordering and takt management process. Tetra Pak employees have also expressed this as a future rising problem when more machines are introduced in the takt management. To handle the work of leveling and planning slots manually for up to seventeen different machines would be a too complex and time-consuming task.

There has been no expressed project leader involved in the transformation with responsibility to maintain momentum in the change and keep all partakers focused. As a result the project has been delayed several times and the sense of urgency as well as inspiration and interest in the project is steadily decreasing. There has been and still exists a clear need of guidance and support in the project which not have been available. The CBP 30 Speed has big potential to reach benefits with the takt management but it also brings some of the difficulties seen within the A3 supply chain with many variants of the machine. To avoid another elongated takt implementation, years of misaligned supply chain and inadequate performance the urgency level need to be raised and the problems properly dealt with now. Considering that it is the first in a line of several planned takt implementations for distribution equipment a successful

result could be a source of inspiration and increase willingness for other suppliers to partake in a similar change.

The project has been driven by foremost a couple of employees within Tetra Pak and the support from higher-level managers has been poor which also has delayed the project. The lack of involvement from managers combined with the small amount of resources made available to manage the change has led to a sense of unimportance. Managers must be involved in and support the project to keep momentum, when managers signals low interest in the project, it can indisputably be pushed out to the periphery. Even if employees want to drive the change they are prevented from the fact that the project is not a part of their scheduled work and also how their performance is measured. The implementation should be a natural and mandatory part of the involved employees' working day and not something done in the fringes when the other work is completed or on over time. A restructuring of the employees' distribution of work and measurements with higher focus on the takt implementation will also signal the importance of the change.

The situation of not having agreements signed, with component suppliers, that are aligned with the takt system constitutes a big risk and forces the module supplier to arrange security by buffers. It is a gap that must be filled by Tetra Pak and the extra buffers cannot be a long term solution since it doesn't support the flexible and lean supply chain Tetra Pak wishes to be a part of.

8 General Analysis

Each of the supply chains has their own issues and problems to deal with. There are also some common problems that need to be dealt with on a higher level and is treated in this chapter.

8.1 Working in Functional Silos

Takt has unfortunately been positioned as foremost the production's and planning's business and responsibility. Other functions such as supplier management and component management that also have important parts to fill in the takt implementation still lack much of the understanding needed to fulfill their roles. For example, the takt is not mentioned one single time in the KPIs of component purchasing. When the measurements still support some old system and way of working, why should they then change their behavior when the measurements remain the same?

Supplier management has several times during the project and interviews received hard criticism concerning their poor alignment to and understanding of how they should support takt. One explanation is simply that the sufficient understanding of the takt principles doesn't exist and therefore the function becomes isolated from the flow and the performance is evaluated according to the usual goals and targets that are not aligned with takt. There is a level of functional thinking that clearly limits the possibilities of takt. The problem is ultimately to get the support from managers in the functions, when their full attention is received and they believe in the change they can drive the change and align the function independently.

Tetra Pak aims at being a process oriented organization, which also is needed to stay competitive in today's market. However there are still departments with a too low focus on the core processes and prioritizations are mainly on the own functions goals and interests. The market companies are the part of the organization with closest contact to customers and have through that an invaluable possible source of information and data. This information must be used in the daily procedures to support and facilitate the work in other processes. The variation in demand is the source to many of the internal problems at Tetra Pak and should be neutralized as much as possible by the market companies. They must have a clear view and understanding of how the production process works and how their work of smoothing demand can be crucial to enable high performance. An online tool for visualizing the current state in production is now available which makes it possible for employees in the market company to have an updated view of the production. But without the full understanding of the takt system and what implications and needs it puts on the supportive functions and processes the visibility might just as well have a negative effect on performance. The risk is that the visibility tool becomes a way for market companies to do their own planning of production and thus give customer unreasonable expectations. The employees at the market companies do not have the consolidated picture from all the different clusters and thus don't have sufficient information to promise or dedicate a slot to a special customer. But in a scenario where the understanding of the takt system and how to best

support it from the market companies exists, the visibility tool can be very beneficial. It can make it easier to give customers a realistic view of when machines can be delivered and through that smooth the demand when peaks are coming.

Tetra Pak should have an internal synchronization of how and which parts to order. The spare parts should be included in the takt agreement to ease the planning for suppliers. This will mean that the buffer agreements once again have to be revised and fitted to the new situation to avoid keeping excess inventory.

8.2 Management and Support

The takt implementation has started not only on different times in the supply chains but also with a big variation in focus and available resources in terms of experienced and skilled employees in the area. The A6 machine is still in the development stage and the supply chain providing the machine is performing several different efforts and projects in order to improve the performance and reach a fully operating takt management when the Filling machine is released on the market. There is a “project leader” responsible for driving the project, ensuring progress and that a full and sufficient takt-system is developed. It should be said that this is a new machine and a lot of prestige lies in the success of its introduction on the market explaining why the efforts are strong here. However the same effort and focus is not existing in all of the supply chains transformation to takt. The change for distribution equipment was started previously this year and the contrast between efforts in this and the A6 supply chain is big. The distribution equipment has many of the same characteristics as the A3 Speed and Flex supply chain and in spite of the obvious history concerning the difficulties of implementing takt, a rather negligent approach is taken toward the change within distribution equipment. The problem is to get the existing knowledge and skills spread through the organization and beyond to reach the suppliers. History shows that there are huge possible benefits with the takt-system for Tetra Pak and it is not sufficient to let each transformation be managed as if it is the first. The experience exists and must be used. It is important that each transformation is supervised and driven by an experienced individual who can maintain momentum in the change and direct and guide efforts when problems occur.

To reach a complete change to takt with the desired benefits it is important that senior managers are driving the change from a higher level in the hierarchy and also have a deep understanding of how the change should be conducted. Currently there is a lack of drive and support for the takt change from many of these managers leading to a sense of unimportance and despair among the employees doing the change. The feeling is that there is tiredness toward the takt talk, which has made the momentum in change and efforts fall drastically. This is a result both from the somewhat prolonged implementation in the A3 supply chain and maybe a lack of the understanding needed to fully believe, support and even drive the change.

8.3 Involving Component Suppliers in Takt

Tetra Pak are signing General Purchasing Agreements (GPA) with all component suppliers containing the general terms and conditions for the cooperation including price and lead times for all components. The module suppliers are then buying components from these agreements. From a takt implementation perspective, one important aspect is having guaranteed fixed delivery times when sourcing material. To compensate for the uncertainty in deliveries and long replenishment lead times the component suppliers have to use buffers. In addition to the GPA, when implementing takt, some new terms and condition are added in the partnership between the component supplier and module supplier in the takt-agreement. For every machine implemented to takt, agreements must be signed between Tetra Pak and module supplier and between module and component supplier. This means that Tetra Pak are directly involved in signing about 5-10 agreements but the module supplier are responsible for signing closer to 50 takt agreements. This should be done by each module supplier meaning that there are hundreds of takt agreements needed to be signed in each supply chain moving to takt. In some cases module suppliers are delivering modules to more than one filling machine to Tetra Pak and are sourcing components for more than one module from one component supplier. This situation will require more than one takt-agreement between the module and component supplier, one for each module since the takt are set per machine.

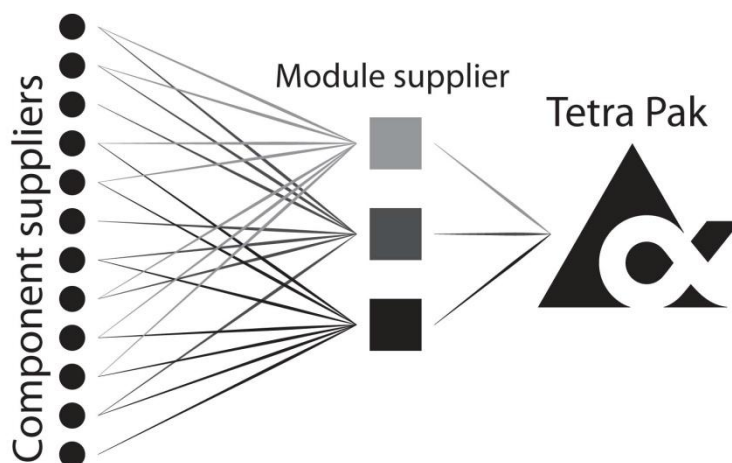


Figure 20 Takt-agreements needed in the supply chain

The GPAs are not including any information concerning the takt production system and that is a big misalignment. Instead an additional takt agreement are signed with each component supplier and that work is mainly the module suppliers task. This sends double signals to the supply chain and Tetra Pak comes in a position where they are partially thinking takt and partially just looking for quality and price benefits rather supporting a batch production system.

8.4 What is the Order Stock?

A problem for all the machine types comes from setting a limit on when an order is frozen and should be included in the order stock. The result is a limited possibility of leveling and managing the takt as long as an order can be changed

or modified. Each filling machine has a targeted delivery date. During the time, counting backwards from the by customer requested dispatch date to the date when complete order should be received to meet OtD target, the order should be considered fix and frozen. That would mean a definite point when orders are included in the order stock and through that also provide a more stable foundation for managing the takt and having a successful leveling.

8.5 The Queue Measure

In a system with leveling and takt such as Tetra Pak's there are no obvious way to define the queue or order stock. Yet it is currently used as one of the main parameters in the work of managing takt. The queue is defined as the time between a complete order is received and the earliest possible trigger off in production. Since this queue time is measured and a shorter time is desired the strange situation occurs where an order placed with better planning, that is a longer time before requested delivery, is punished with a longer queue time compared to a rush order with where the requested delivery date is very close.

An example is given in the picture below. There are two scenarios illustrated, the customer can place the order early as in scenario one or late as in scenario two. The assumption in the example is that the first available trigger-off in scenario one still is available in scenario two.

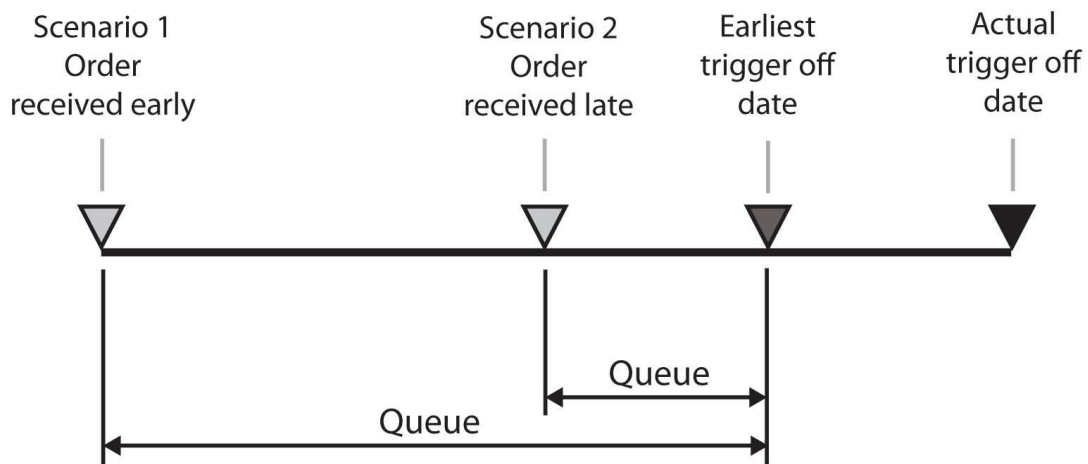


Figure 21 Describing problem with current queue definition

The problem is that the queue-measure is punished when customers have a good planning of their orders and give Tetra Pak a long horizon and possibility to plan production, which on the contrary is the desired situation. The purpose of the queue-measure is to alert when the waiting times are too long and the takt needs to be revised. However, the current queue-measure only provides a view concerning how long the machines are waiting in the order stock before being triggered into production, which is useless since the customer doesn't care how long the machines are in the order stock. The faulty assumption in this is that customers always want the filling machine as soon as possible. The measure doesn't provide any information concerning how long the customer is waiting for the order compared to what is requested and this is the problem. The Queue

measure is not connected to customer requirements and should therefore not be used as a measure when managing the takt.

9 Conclusions and Recommendations

This chapter gives the results and implications from the analyses and a short discussion concerning our expectations from the beginning of the project as well as areas for further investigation for Tetra Pak.

First it should be said that although the change efforts have come to a halt and currently the problems are big the feeling is that the knowledge concerning takt exists within Tetra Pak and there is a well developed plan concerning how the system should work and how it should be supported. The problem is that the deeper understanding and involvement isn't spread through the Tetra Pak organization explaining why the change efforts are fading.

Based on our analyses, our recommendations are:

- Synchronize capacity between suppliers
- Communicate best practices through all supply chains
- Develop standards for production control
- Include takt principles in the General purchasing agreements with component suppliers
- Align all functions with takt. Measurements, KPI, processes
- Assign project leader in all implementations
- Build a Tetra Pak Way for takt

One of the major issues in the A3 supply chain is the poor synchronization of capacity in the supply chain. So it is proposed that Tetra Pak instead of communicating forecasts to be interpreted by each supplier, shares a file with the exact requirements of capacity concerning the variants. It means that all the forecasting is done by Tetra Pak, which also is the actor closest to the customer leading to a better synchronization of capacity between the suppliers and the incentives for speculations will be gone. A mindset of not pushing for more of a variant than forecasted is necessary to keep down speculations from suppliers. It is also important that the takt agreements finally are signed and to make this happen it is important that flexibility matrix is redesigned and the 20% extra buffers added in the flexibility matrix are removed.

It is important that suppliers at all times are treated with respect. To make the supplier start improvement projects in their internal work despite a history of, from their point of view, close to perfect performance can be tough and hard to accomplish whilst the incentives for change are low in their opinion. It is important to show the possibilities of further improving performance if more efforts are made and by that avoiding the situation of being satisfied with the current state.

There exists much knowledge within Tetra Pak's supply chain concerning how to control production and work toward higher quality. Although some suppliers have currently good performance it can be better by sharing a best practice within the supply chain. It is a matter of not just being satisfied with being sufficiently good but driving for a higher service and higher profit. So Tetra Pak

should develop standards for production control and quality assurances and spread those standards to all suppliers. In the cases where there already exist equally good systems there might just be small or no changes made whilst in other cases there are big changes needed.

It is obvious that there is unnecessary work done when two agreements, both the GPA and takt-agreement, are negotiated and signed with each component supplier. Instead the GPA should include the takt-principles, since this is where Tetra Pak has its future production system and it should be a natural part in the collaboration with all suppliers. Then in a later stage the parts for which the agreement should be applied could be specified in some smaller appendix in each interface between module and component supplier. This would give a much lighter task for each implementation and an obvious closer alignment with the production system. Instead of giving a major part of the responsibility of negotiating and signing takt-agreements with the component supplier to the module supplier, Tetra Pak should be more involved and ease the implementation of takt in all supply chains by having the takt paragraphs included in the GPA. This also communicates and shows that takt is the new way for Tetra Pak and makes the relationship to supplier more consistent.

One thing discussed in the general analysis above concerns the understanding and support from different functions in the organization. The view acquired during the project is that, generally, in the current state the understanding of takt is not as widely spread as needed for functions to know their expected contribution. One risk when training employees is that the message is focused too much on the principles of takt but misses the direct implications that takt has on the different functions, their work and how they best can and should support the new production system. It is important that more direct requirements are communicated to the functions and more exactly how they should change their daily work. Not only the general principles of takt and leveling.

Another part preventing full success in the takt implementation is the poorly adjusted measurements in some functions in the organization. It is recommended that the KPIs are revised and corrected to support the takt. This will not only give guidance concerning what is expected and needed from each function to support takt but also be another way to communicate the importance of change and a new mindset.

During a takt implementation in a supply chain there needs to be a project leader with responsibility to make the change happen. The project leader should have experience and skills from prior changes to takt and the project should be the project leaders primary task and not just something done in parallel with normal business. The importance of the project should be visual in the resources allocated to it. Also in a supply chain where the change has stopped half way through, like the A3, there needs to be a project leader assigned who can get the change going again and to straighten up the prior mistakes.

The change efforts are in a too high degree made separated from each other and much of the experience and knowledge available is lost and there are too many different interpretations concerning how the takt system should be supported and implemented. Tetra Pak should create a standard design, or blueprint, of

their desired “best practice” takt system. It should show the desired takt system both on a high and low level. Each supply chain can then contribute to or learn from the standard as it is a living documentation and should be updated when improvements in the system are made. In the current state there is a well developed takt-system available and some people know very well what the system should look like and how it should function. But this knowledge is not sufficiently spread in the organization. It is important to create a comprehensible visualization of the desired future system which can facilitate the spreading of the takt system should be designed, how it should function through this visualization increase the overall understanding which is crucial for succeeding.

9.1 Discussion

Tetra Pak are purchasing parts to directly go into production of filling machines, but the exact same parts are also purchased as spare parts. These two different flows are managed separately and the suggestion is to investigate a future synchronization of parts to ease the planning for suppliers and for Tetra Pak to be more consistent in the relation with their partners. The spare parts are currently ordered outside the takt.

While visiting suppliers the feeling was that the batch sizes in the production stage before assembly was managed in an old fashioned and stiff way. No deeper analysis was done at the time since this not was the current object for investigation. But when asking questions about the control of production and how batch sizes are decided (the buffers in front of machines looked very big) some comment about “economic order quantity” was received and then the topic was dropped. It could be interesting to look into the possibilities of increase the flexibility in production by reducing batch sizes.

Another topic for investigation is to look over the possibilities of standardizing more parts between different filling machines but also between the different variants for each machine type. This could drastically ease the management of buffers and also lead to a reduction of capital employed.

For the future it could also be investigated how to enable more parallel working when building the filling machines. The design of the machines not only could, but should allow a greater possibility to divide the filling machines into even smaller modules during production to make more parallel working possible and in that way help reducing the lead times.

Our first intention was to deliver some kind of table showing the maturity of the takt implementation from different aspects for every machine type. In that way one could get a simple overview of the situation in every supply chain. But this was found to be hard because of the big differences in the supply chains and our focus was not equally spread. This led to descriptions of every machine type where only the characteristics and relevant aspects were described. The analyses were then done on every machine type. But because of many common problems among the supply chains it seemed natural to also do a general analysis. Besides the lack of an easy visual description of the current state the purpose of the project have been fulfilled. Concerning expectations on the result there were not many present from the start more than the ones stated in the

introduction of the report. The topic was new and the knowledge had to be built during the project why expectations of any specific results also were missing.

9.2 New from this project

Generally there is very much literature to read when takt and leveling are the topics. The theory found often refers to the car industry with Toyota in the front. Literature with frameworks or theory concerning takt and leveling, with lower volume production, longer takt times, products with a high degree of customization and a very small or no possibility of making-to-stock is much more rare. It is in this field that this project can have something new to offer, it gives some important aspects of how to manage takt and leveling and what difficulties one can run into in a change to takt managed production.

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10.3 Electronic Resources

Tetra Pak intranet

10.4 Interviews

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Supply Chain Engineer Quality (2010-09-10)

External Supply Manager (1) (2010-09-14)

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- Supply Manager

- Supplier representative

- Supply Chain Operations, Project Manager

- Manager Distribution Equipment (2)

- Supply Chain Planner

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