TOWARDS RADICAL IMPROVEMENT IN PRODUCTION SYSTEMS

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Abstract

As the speed of change is increasing, it’s of great importance that manufacturing companies strive to achieve not only incremental improvements, but also radical improvements within their production systems. Thus, more research has to be focused on how to realize radical improvement. In accordance, the objective of the licentiate thesis is to, through theoretical and empirical work, increase the understanding about radical improvement in production and identify what elements need to be considered when designing support on how to implement radical improvement in industrial production. Throughout the research process these issues has been addressed through theoretical and empirical studies. Three studies have been conducted in total, of which two are mainly of theoretical character and one of empirical character. Besides, a state-of-the-art theoretical review has been carried out as well, further framing the findings.

The research results imply that radical improvement in production is a teamwork process that embraces the facilitation of creativity and innovation. The research further implies that there are a number of issues to consider when creating industry-applicable support on how to realize radical improvement in industrial production. For instance, what level of innovation is striven for must be decided, creativity must be facilitated throughout, the opposing cultures of incremental and radical innovation must be managed, and there is a need to apply a holistic perspective, thus embracing not only productivity results but organizational learning as well.

As further work, creating industry-applicable support on how to realize radical improvement in industrial production is advocated, focusing not only on meeting the issues addressed above, but also how to make the support industry-applicable.
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Publications

Appended papers


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1. Introduction

The introduction gives a brief background of challenges in modern manufacturing industry. After the background has been presented, the research motivation and objective, the research questions, and the delimitation are outlined in order to clarify the scope of the licentiate thesis. Finally, the chapter concludes with a presentation of the thesis outline.

1.1 Background

The competitive climate in which Swedish manufacturing companies find themselves today bears the stamp of a constantly increasing demand on production capability. The changes within as well as outside the machinery of production become more complex and dynamic, which in turn also changes the conditions for competition. The manufacturing industry does not only need to manage larger fluctuations in demand today, but also shorter product life cycles, faster product realization, more rapid development of technology, integration of value chains, advanced automation strategies, new service concepts as well as changes of laws and regulations. Besides, every product needs to be delivered at the right time, at the right place, at the right price, and in the right quality. Also, China and India are increasing their consumption, and in parallel there are hundreds of millions of people on their way into the European Union, further emphasizing the increasingly competitive environment constantly putting pressure on manufacturing competitiveness. As a consequence, the competition in Europe is increasing at twice the pace as in the rest of the world (IVA, 2005).

Given today’s competitive situation, maintaining the status quo is not sufficient in order to stay competitive; there must be a continuing effort in improvement to even maintain the status quo. Thus, in order to achieve and maintain competitive world-class production, the severe challenge requires manufacturing companies in Sweden to continuously develop their production systems for greater efficiency and speed (Teknikföretagen, 2011). The production system can be described as a transformation system, “transforming input to desired output” (Bellgran and Säfsten, 2010), but also as “23 factors in four groups constituting the organizational work setting: organizing arrangement, social factors, physical factors and technology” (Porras and Robertson, 1992). The improvements can be made in any element of the system such as organizational culture, production processes, information processes, materials, equipment, etc. As regards improving the production system, Yamamoto (2010) states that it is widely recognized that there are two approaches today: incremental continuous improvements and infrequent but radical improvements. The basic characteristics of incremental improvement imply small-step improvements that are process- and people-oriented as well as continuous. Radical improvement at the other hand is characterized by episodic occurrence, bringing about fundamental change, and intending dramatic results. (Yamamoto, 2010)
Since the speed of change is increasing, it is of great importance that manufacturing companies strive to achieve not only incremental improvements, but also radical improvements in their production systems, resulting in the competitive edge required. This is emphasized by Mr. Watanabe, former CEO at Toyota Motor Company, stating that they, in today’s reality, have no other choice but to carry through radical changes when the speed of change is too slow (Stewart and Raman, 2007). Hence, in a business environment characterized by a fast pace of change, it is hard to sustain manufacturing competitiveness as long as the speed of improvements is moderate. Thus, a company’s ability to compete on today’s global market depends on its capability to combine (1) continuous improvements, characterized by incrementally improving existing products and production processes, with (2) radical improvement, characterized by development of new innovations and making use of new opportunities (Yamamoto, 2010). Therefore, radical and innovative change in the production system is not only a possibility but a requirement when maintaining competitiveness in Swedish production (Yamamoto, 2010).

1.2 Research motivation and objective

The VINNOVA-granted research project Kaikaku- radical and innovative production development has emphasized the need to increase the understanding about how to realize radical improvement in production as a means to increase competitiveness in Swedish manufacturing (VINNOVA project with ref. no. 2009-03978). Thus, more research on how to develop structure, processes, and support on how to realize Kaikaku in production is needed. This is further emphasized by Yamamoto (2010, p.68), stating that “future research should be more focused on how to realize Kaikaku”.

However, consulting the literature, radical improvement in production has been discussed during the last two decades using various approaches such as Kaikaku (Yamamoto, 2010), business process reengineering (Hammer and Champy, 1993), process innovation (Davenport, 1993), and Kaizen Event/Blitz (Van Aken et al., 2010, Laraia et al., 1999), all different yet similar in meaning. However, similarity aside, the definitions found in literature are still somewhat confusing as to what exactly constitutes radical improvement in production (O'Neill and Sohal, 1999, Childe et al., 1994). Consequently, as the understanding of the concept of radical improvement in production is somewhat confusing, how to develop proper realization support is confusing and unclear as well. This situation provides an impetus to research the radical production improvement process as a means to realize competitive production systems. Thus, the long-term research objective is to increase the understanding and knowledge about radical improvement in order to develop industry-applicable support for implementing radical improvement in industrial production.

The objective of this licentiate thesis is, through theoretical and empirical work, to increase the understanding about radical improvement in production and identify what elements need to be considered when designing support on how to implement radical improvement in industrial production.
1.3 Research questions
The following two research questions have been formulated with the background, the research motivation, and the outlined objective in mind:

RQ 1: What constitutes radical improvement in production?

The first question aims at creating a broad understanding about the concept of radical improvement in production. As mentioned, there are several similar approaches to radical improvement. Thus, similar concepts within the category of radical improvement/change will be identified and analysed.

RQ2: What fundamental issues need to be considered when developing industry-applicable support?

The purpose of the second research question is to shed light on the main issues that need to be taken into consideration when creating support on how to realize radical improvement in industrial production.

1.4 Delimitations and focus areas
The research presented in this thesis covers the area of production development. The term production development refers to the improvement of existing production systems in operation, “brownfield development”, as well as to the development of totally new production systems, “greenfield development” (Bellgran and Säfsten, 2010). The research presented is limited to the development of production systems in operation, which is what the term “production development” will refer to in the thesis. Further, the term “Kaikaku” is widely applied in the thesis since it is the name of the research project in which the research has been undertaken (see Section 3.2.1 for further information). However, the term Kaikaku is regarded as part of the concept of “radical improvement in production” in the thesis.

The theories applied in the thesis are mainly derived from the area of operations management, yet including some change theory and innovation theory as well. Operations management in particular, and to some extent change theory, constitute the academic background of the author. Thus, the area of innovation theory has been consistently regarded with humility throughout the thesis.

When it comes to the research process, mainly one large empirical study has been undertaken. Also, this study has been carried out at one case company. Consequently, the research results are to some extent influenced by the specific characteristics and conditions at that specific company at that specific time (further described in Paper 3). The research has also been undertaken in the context of a large research project, influencing the direction and scope of the research. The context is further described in Section 3.2.
1.5 Outline of the thesis

Chapter 1 introduces the research by presenting the background, the research motivation, the research objective as well as the guiding questions. Chapter 2 presents the theoretical framework applied in the thesis, followed by the applied research design in Chapter 3. Chapter 4 presents the research results and an analysis, followed by the conclusions, a discussion, and suggestions for further work in Chapter 5.
2. Frame of Reference

The frame of reference embraces theory on production system development in general, and about radical improvement in particular, and thus, constitutes the knowledge base of the research. Improvement maturity as an organizational evolution is covered, as well as the concept of radical improvement and its alleged success factors.

2.1 Production system development

The main focus of the production system is to create value from raw material and components into goods and services that a customer is willing to pay for, and thus, in a wider perspective, the production system embraces the whole supply chain from natural resources to the end customer (Jackson et al., 2008). Generally, production is viewed as a very complex activity involving several elements such as materials, machines, humans, and information. Consequently, the need of a holistic view on production is generally accepted, and thus, the production system tends to be described from a system perspective (Bellgran and Säfsten, 2010). A system has been defined as “a collection of different components, such as for example people and machines, which are interrelated in an organized way and work together towards a purposeful goal” (Bellgran and Säfsten, 2010, p.38). Consequently, having a system perspective implies taking the relations and interplay between different components in a system into consideration (Bellgran and Säfsten, 2010).

There are many ways to describe a production system. For instance, Porras and Robertson (1992) describe it as 23 factors in four groups which constitute the organizational work setting: organizing arrangement, social factors, physical factors, and technology, thus taking an organizational perspective on production system. Groover (2007) describes the production system as the people, equipment and procedures, organized for the combination of materials and processes that constitutes the manufacturing operations. According to Bellgran and Säfsten (2010), the production system can be described as a transformation system, transforming input to desired output. Further, Hubka and Eder (1984) characterize the production system as a transformation system with the core elements of a process, an operand and operators. Depending on the perspective of the observer, a production system can be described in different ways. For instance, if an observer is interested in analysing the transformation process, a flow chart or a value stream map might be used. If taking an organizational perspective instead, other criteria might be more important than the actual transformation. When improving production systems, changes can be made in any element of the production system such as organizational culture, production processes, information processes, materials, equipment, etc. (Bellgran and Säfsten, 2010). Thus, the description by Hubka and Eder (1984), taking a holistic perspective on the production system describing it as a transformation system, is suitable in this
thesis. The objective of the transformation system is to add value of an operand from its initial state to the desired state by the support of the subsystems, the human system, the technical system, the information system, and the management and goal system (Hubka and Eder, 1984).

![Figure 2:1: A simplified model of the transformation system (Hubka and Eder, 1984)](image)

There are many reasons to change a production system, such as new market requirements, new legislation, technology development, or the introduction of new products or product families (Bellgran and Säfsten, 2010). The changes might be initiated either internally or externally, depending on the origin of the reason why the production system needs to be changed (Bellgran and Säfsten, 2010). Yamamoto (2010) further states that it is widely recognized that there are two approaches to production system improvement today: incremental continuous improvement and infrequent but radical improvement (in Japanese Kaizen and Kaikaku, respectively). The basic characteristics of incremental improvement imply small-step improvements and are process- and people-oriented as well as continuous. Radical improvement at the other hand is characterized by episodic occurrence, bringing about fundamental change, intending dramatic results and being driven by top-down initiatives. (Yamamoto, 2010)

### 2.2 Radical improvement in production

Radical improvement in production has been discussed during the last two decades using different approaches such as business process reengineering (Hammer and Champy, 1993), process innovation (Davenport, 1993), Kaizen Event/Blitz (Van Aken et al., 2010, Laraia et al., 1999), and Kaikaku (Yamamoto, 2010), all different yet similar in meaning. Similarity aside, the definitions found in literature are still somewhat confusing as to what exactly constitutes radical improvement in production (O'Neill and Sohal, 1999, Childe et al., 1994). The field of research has been in focus since the late 1980s and early 1990s, and considerable theoretical and empirical work has been undertaken since (McAdam, 2002). For instance, researchers have been discussing the definition and content of radical improvement in production (O'Neill and Sohal, 1999, Yamamoto, 2010, Hammer and Champy, 1993), the related result and impact (Guimaraes and Bond, 1996, Ozcelik, 2010), the factors critical to success (Abdolvand et al., 2008, Paper and Chang, 2005, Jarrar and Aspinwall, 1999), different methods, tools, and techniques applied (O'Neill and Sohal, 1999), the implementation process (Davenport, 1993), as well as different types of implications and challenges (Marin-Garcia et al., 2009). However, based on research presented by
several authors in the last two decades, a consolidated understanding implies that radical improvement in production is characterized by dramatic change through radical redesign of business processes (O'Neill and Sohal, 1999). The design may be radical, but the implementation tends to be stepwise (Stoddard and Jarvenpaa, 1995). Radical improvement is generally initiated top-down, but concurrently requires bottom-up acceptance in the organization (Stoddard et al., 1996). Radical improvement is also about innovation (Jarrar and Aspinwall, 1999, McAdam, 2003), where the core elements are organizational learning and company-wide commitment (Smeds and Boer, 2004, Boer and Gertsen, 2003). Also, radical improvement in production is cross-functional and business-process-focused, and it covers organizational design, IT, and culture (Stoddard et al., 1996).

Radical improvement in production generally offers great benefit if applied correctly, even though it might differ considerably between companies (Guimaraes and Bond, 1996). Since there is no secret recipe exactly on how to conduct radical improvement in production successfully apart from a number of fundamental principles and guidelines, companies tend to tackle the issue in different ways. Researchers claim that 50 to 70 per cent of all reengineering efforts fail to deliver the results intended (Hammer and Champy, 1993). Since radical improvement projects are often directed and boosted by very challenging set targets on performance increase, it might be considered a failure to only reach halfway. However, even without reaching the stretched targets, the production performance increase might still be radical and considered a very successful improvement. Thus, radical improvement in production seems to be considered worthwhile by the majority of the researchers (Jarrar and Aspinwall, 1999, Muthu et al., 1999). Another aspect of performance increase is the fact that it tends to be unaffected during the implementation stage, yet considerably increased afterwards (Ozcelik, 2010). Consequently, management of expectations is very important when realizing radical improvements in production (Stoddard and Jarvenpaa, 1995).

For years, researchers have created and presented several methods on how to realize radical improvement in production. The methods are most often positivistic, plan-driven, and based on step-wise processes in which the key ingredients are planning, mapping, and analysing the current state, creating a future state, implementing, evaluating, and beginning an effort of continuous improvements in the area concerned (Davenport, 1993, Povey, 1998, Muthu et al., 1999, Vakola and Rezgui, 2000, McNichols et al., 1999). The planning phase usually implies preparing for radical improvement by, for instance, creating a team and developing the strategic objectives. The mapping of the current state is conducted in order to get an understanding of “as is” regarding how the production processes are currently run. The third step is all about being creative and benchmarking world-class alternatives in order to come up with a future state to aim for. Subsequently, the new ideas and designs on how to reach the desired future state need to be implemented. Finally, a number of methods address the need to initiate a subsequent continuous improvement effort. One of the identified distinctions between the methods found in modern literature is that some emphasize the importance of an ongoing improvement effort initiated after the implementation
stage (Vakola and Rezgui, 2000). Methodologies more focused on the innovation aspect of radical improvement put more focus on elements necessary for innovation, taking the human aspect, knowledge creation, and organizational learning more into consideration, rather than advocating a stepwise process for reengineering (Smeds and Boer, 2004, Boer and Gertsen, 2003). The need to create a culture of innovation in the organization is therefore addressed, implying that the organization needs to constantly encourage creativity and exploration, promote and tolerate diversity, take risks, and pay more attention to the values and feelings that grow from the organization’s philosophy (Markic, 2006, O'Reilly and Tushman, 2004, McLaughlin et al., 2008). Accordingly, there is a vast range of methods and guiding principles on radical improvement available today, as well as a large number of tools and techniques to be used. There is no given suggestion for exactly what support to use, or when to use it. Instead, it depends on the purpose and objective of the improvement since one of the most important aspects is that radical improvement is seen as a strategic activity. Thus, to benefit the organization, it needs to be integrated with other aspects of management as well (O'Neill and Sohal, 1999).

2.3 Improvement maturity – an organizational evolution
Continuous improvement (CI) is widely recognized as the organizational concept of Kaizen, a Japanese management idea of lean production focusing on sustained incremental innovation (Imai, 1986). Continuous improvement has also been explained as “an evolutionary learning process associated with acquiring key behavioural patterns, putting these patterns into practice so that they then become routines and diffusing them across the whole organization” (Bessant and Caffyn, 1997, p.26) and as “an organizational concept which aims to improve firm-specific organizational routines which represent key resources of firms” (Kirner et al., 2011, p.216).

Boer and Gertsen (2003) argue that the continuous improvement research scene has changed dramatically, focusing on shop-floor level CI a few years ago, now focusing on continuous innovation constituting continuous improvement, learning, and innovation. Continuous improvement in this particular case does not only constitute incremental improvement but also radical and innovative improvement (Bessant et al., 2001). Thus, continuous improvement (CI) should be viewed as “the evolution and aggregation of a set of key behavioural routines within the firm”, and not as a short-term activity only (Bessant et al., 2001, p.75). Accordingly, Bessant et al. (2001) present a maturity model for the evolution of continuous improvement capability, shown in Table 2:1 below.
Continuous improvement (CI) is widely recognized as the organizational concept of incremental innovation (Imai, 1986). Continuous improvement has also been explained as “an evolutionary learning process associated with acquiring key organizational routines which represent key resources of firms” (Kirner et al., 2011, p.26) and as “an organizational concept which aims to improve firm-specific innovation. Continuous improvement in this particular case does not only constitute incremental improvement but also radical and innovative improvement (Bessant et al., 2001). Thus, continuous improvement (CI) should be viewed as “the evolution and innovation. The need to create a culture of innovation in the organization is therefore addressed, implying that the organization needs to constantly pay more attention to the values and feelings that grow from the organization’s work but on an ad-hoc basis. Caucasian, etc.

### Table 2.1: Different levels of maturity for improvement (Bessant et al., 2001)

<table>
<thead>
<tr>
<th>Level</th>
<th>Performance</th>
<th>Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0: No CI activity</strong></td>
<td>No impact from CI</td>
<td>Dominant mode of problem solving is by specialists.</td>
</tr>
<tr>
<td><strong>1: Trying out new ideas</strong></td>
<td>Minimal and local effect only. Some improvements in morale and motivation.</td>
<td>CI happens as a result of learning-curve effects associated with a particular process – and then fades out again. Or it results from a short-term input – a training intervention, for example, and leads to small impact around those immediately concerned with it. These effects are often short-lived and very localized. Problem solving random. No formal efforts or structure. Occasional bursts punctuated by inactivity and non-participation.</td>
</tr>
<tr>
<td><strong>2: Structured and systematic</strong></td>
<td>Local-level effects. Measurable CI activity – e.g. number of participants, ideas produced, etc. Measurable performance effects confined to projects. Little or no bottom-line impact.</td>
<td>Formal attempts to create and sustain CI. Use of a formal problem-solving process. Use of participation. Training in basic CI tools. Structured idea-management system. Recognition system. Often parallel system to operations. Can extend to cross-functional work.</td>
</tr>
<tr>
<td><strong>3: Strategic</strong></td>
<td>Policy deployment links local- and project-level activity to broader strategic goals. Monitoring and measurement drive improvement on these issues, which can be measured in terms of impact on bottom line – i.e. cost reductions, quality improvements, time savings, etc.</td>
<td>All the above, plus formal deployment of CI against these goals. In-line system.</td>
</tr>
<tr>
<td><strong>4: Autonomous innovation</strong></td>
<td>Strategic benefits, including those from discontinuous, major innovations as well as incremental problem solving.</td>
<td>All the above, plus responsibility for mechanisms, timing, etc. devolved to problem-solving unit. High levels of experimentation.</td>
</tr>
<tr>
<td><strong>5: The learning organization</strong></td>
<td>Strategic innovation. Ability to deploy competence base to competitive advantage.</td>
<td>CI is the dominant way of life. Automatic capture and sharing of learning. Everyone actively involved in innovation process. Incremental and radical innovation.</td>
</tr>
</tbody>
</table>

The first step in the maturity model is no CI activity, which corresponds to random problem solving, most often carried out by specialists. In this stage, there is no impact on performance since there is no CI activity carried out. In the next level, CI level 1, the organization is trying out new ideas, leading to some minimal and local effects on performance. Bessant (2001) argues that this often tends to be a one-shot thing as a result of an event or as a learning-curve effect associated with a new product/process,
which then tends to fade out again. Further up the maturity model, CI level 2, the organization has achieved a more structured and systematic approach to CI with local effects on performance as well as with measurable CI activity (e.g. number of ideas produced, performance effects, etc.). In this stage of maturity, formal attempts at problem solving, structured idea management system, and use of participation imply a more formal attempt to create and sustain CI activity in the organization. Strategic CI constitutes the next stage in the maturity evolution advocating deployment of strategic goals as well as monitoring key performance indicators against these goals. Strategic CI implies measuring and monitoring improvements, which in turn will drive the improvements towards, for example, cost reductions, thus having impact on the bottom line. Further on, the organization will reach CI level 4, or autonomous innovation. This particular stage contains, among other components, a problem-solving unit as well as a widespread high level of experimentation. As to performance, discontinuous, major innovations as well as incremental problem solving imply strategic benefit. The last stage of the maturity model, CI level 5, involves the learning organization. This stage signifies that CI is the dominant way of life, the organization is focusing on both incremental and radical innovation, and every employee is actively involved in the improvement activities. Also, performance will be affected by strategic innovation as well as by the acquired competence to deploy strategic initiatives for competitive advantage (Bessant and Francis, 1999, Bessant et al., 2001).

Further, Bessant (2001) addresses the fact that the improvement maturity evolution is a lengthy learning process, embracing culture change – a change of organizational routines and behaviours. “The way we do things around here” becomes explicit in symbols, structures, and procedures that will reinforce behavioural norms in the organization. Thus, in order to manage cultural change, new behaviours and routines need to be reinforced in the organization during a long period of time for the new pattern to root.

In line with Bessant and Francis (1999), and Bessant et al. (2001), taking an evolution perspective on improvement maturity, Bellgran and Säfsten (2010) discuss the production system development process. They argue that, given the awareness of the value of continuously improving the development process, the process will evolve over time. As shown in Figure 2:2, the development process starts at a low level of maturity characterized by fire fighting, immediate problem solving and an unstable development process. Further on, evolving over time, the development process will first become “under control”, and at the next step, also include improvement considerations. In the last stage of the “maturity to change evolution”, the development process might reach a sense of maturity and thus also undergo large innovations towards radically changed development procedures (Bellgran and Säfsten, 2010).
There are different stages in the maturity to change, all described in different ways (Bellgran, 1998, Bessant et al., 2001). At the beginning it is all about fire fighting and a striving towards stable and predictable production, characterized by behaviour patterns of unawareness, a lack of routines for improvement activities as well as being reactive. The development of the company’s maturity to change then evolves from fire fighting through local improvements towards cross-organizational improvements strongly connected to strategy, being proactive and increasing the innovation capability. Thus, the improvement maturity evolution contains the capability of both incremental innovation and radical innovation (Bessant et al., 2001, Bessant et al., 2005, Bellgran and Säfsten, 2010).

2.4 Critical success and failure factors in radical improvement

There are several success factors related to radical improvement in production that have been identified and discussed by a number of researchers (Crowe et al., 2002, Abdolvand et al., 2008, Paper and Chang, 2005, Jarrar and Aspinwall, 1999). For instance, Abdolvand et al. (2008) have presented a hierarchy of success factors based on earlier work by, among others, Crowe et al. (2002). This hierarchy covers five main categories of success factors: egalitarian leadership, collaborative working environment, top management commitment, change in management systems, and the use of information technology. Likewise, Paper and Chang (2005) have discussed success factors related to radical improvement by exploring organizational change dynamics through five theoretical lenses: environment, people, methodology, IT perspective, and transformation (vision). In addition, Jarrar and Aspinwall (1999) have listed a number of success factors in the categories of culture, structure, process, and IT.
Consequently, most of the success factors (as well as failure factors) found in literature could be linked to a few main categories. Figure 2:3 presents a chart by Abdolvand et al. (2008) providing an overview of success factors and failure factors related to radical improvement in production and covering the majority of such factors identified in literature.

**Figure 2:3: Success and failure factors for radical improvement in production.**
*Adapted from Abdolvand et al. (2008).*

**Egalitarian leadership**
Egalitarian leadership implies that top management creates a culture characterized by inter- and intra-organizational confidence and trust (Abdolvand et al., 2008) where the positive changes can take place with little resistance (Crowe et al., 2002). Egalitarian leadership also requires top management to drive change together with the staff, where employees are involved in the change, understand it, and are responsive throughout it.
Abdolvand et al. (2008) also advocate the importance of top management driving change by providing a vision, a shared vision. The vision offers a blueprint for the change and it is essential for driving radical improvement in production (McAdam, 2003). This is further emphasized by Paper and Chang (2005) stating that the change vision is the glue that ties the other components together into a cohesive whole. Further, they agree that top management is responsible for directing, monitoring, and controlling the activities related to the change since they set the cultural and political tone of the organization; “They are the only ones who can resolve real conflicts between managers” (Paper and Chang, 2005, p.130).

Another important aspect of egalitarian leadership and, consequently, also a critical success factor for radical improvement in production is communication (Abdolvand et al., 2008, Jarrar and Aspinwall, 1999, Paper and Chang, 2005, Farris et al., 2008, Guimaraes and Bond, 1996). The importance of open communication is explicitly emphasized by Farris et al. (2008) arguing that the employees affected need to understand and be part of the objectives set of the radical improvement initiative. Also, open communication might help managers to be better informed about potential problems but also make it easier for employees to participate in the change (Paper and Chang, 2005). Hence it is crucial that top management creates and provides communication channels so that the employees more easily can understand each other (Abdolvand et al., 2008). If there is no widespread understanding, there is a risk that the implementation might fail to meet expectations even though the result objective, such as performance increase, might be achieved. Consequently, for top management to make this happen, they need to provide an environment or culture where people are keen to share information willingly (Guimaraes and Bond, 1996). Besides, the better informed people are about their business, the better they will feel about what they do in the organization (Abdolvand et al., 2008).

**Working environment**

Providing a collaborative working environment is closely related to the culture of egalitarian leadership, where the employees should work and interact in a friendly way characterized by trust in each other, while their work is also being recognized by the top management (Crowe et al., 2002). For a successful realization of radical improvement in production, teamwork is therefore very important (Herzog et al., 2007, Abdolvand et al., 2008). Not only is working in teams important, but it is also crucial that the team represents all departments/functions involved (Farris et al., 2008) and that the team/group of individuals working with radical improvement is cross-functional (Jarrar and Aspinwall, 1999) and multi-disciplinary (Vakola and Rezgui, 2000) and encompasses a diversity of human resources (Raymond et al., 1998).

People are naturally discouraged to take risks in a command and control management, which is why top management must cultivate an environment conducive to taking risks and being creative. Thus, top management must ensure an environment that is supportive of change (Paper and Chang, 2005). Besides, since people are the key to change given that they conduct the actual work involved, the environment must be
conducive to the change in the perception of the people that are to enact the change (Paper and Chang, 2005).

**Top management commitment**

Researchers imply that radical improvement in production is initiated and led top-down, even though it concurrently requires bottom-up acceptance (Stoddard et al., 1996, Yamamoto, 2010). Further, Herzog et al. (2007) argue that there is a current consensus on a strong belief in the correlation between proactive leadership and organizational success. Hence, top management commitment is a basic requirement for any radical improvement in production to be successful (Tikkanen and Pölänen, 1996, Jarrar and Aspinwall, 1999, Abdolvand et al., 2008, Paper and Chang, 2005, Guimaraes and Bond, 1996).

Since top management are the only people in the organization in a position of being able to influence the environment and staff (Paper and Chang, 2005), there are many requirements associated with the role:

- They must have an understanding about radical improvement in order to manage realistic expectations (Abdolvand et al., 2008).
- They need to have a clear knowledge about the current situation in the organization (Abdolvand et al., 2008).
- They need to define the strategic mission and identify themselves with the goals set (Herzog et al., 2007).
- They must foster commitment among the employees as well as be aware and sensitive about their own role in the change, implying that they need to create a sense of freedom allowing people to act on their ideas in the workplace, yet have some semblance of control (Paper and Chang, 2005, Winklhofer, 2002).

Thus, top management need to be involved actively in both planning and execution of the change initiative, including an adequate budget for training and education, technology, and compensation for innovative thinking (Paper and Chang, 2005). The authors imply that top management need not only to understand and drive the radical improvement but also plan for organizational learning throughout it.

**Change in management systems**

Change in management systems, or supportive management, implies the changes in the human resource infrastructure necessary to support better information sharing and decision making (Vakola and Rezgui, 2000). This is crucial since humans play a decisive role in change (Abdolvand et al., 2008), being the primary decision makers (Grant, 2002). Farris et al. (2008) further emphasize the role of the staff by stating that they as well need some decision making authority, and that top management should not ultimately invalidate people’s ideas and accomplishments without consideration.

In the hierarchy of success factors related to radical improvement in production, Abdolvand et al. (2008) advocate reward system, performance measurement, employee empowerment, and timely training and education as important aspects of
supportive management. Performance measurement and review are important since measuring and conducting audits encourages a positive attitude towards radical improvement (Glover et al., 2011). The importance of a new recognition/reward and compensation system is supported by Jarrar and Aspinwall (1999), as well as by Paper and Chang (2005), who further advocate that compensation and recognition must be recast into teamwork, information sharing, and innovation incentives to promote radical improvement. Besides, to foster radical improvement in production, people need to be empowered to enact change (Paper and Chang, 2005) and perceive ownership of the change process (Davenport and Stoddard, 1994). Thus, education and training are crucial elements when it comes to making people thrive in a dynamic and ever-changing environment, implying that management must create and implement plans that link proper education and training to what people actually must do to enact change (Paper and Chang, 2005). This is further emphasized by Wong (1998) stating that training and education is the single most important factor when it comes to cultural change.

**Use of information technology**

The importance of IT support in radical improvement is emphasized by several authors (Paper and Chang, 2005, Abdolvand et al., 2008, McAdam, 2003, Herzog et al., 2007, Jarrar and Aspinwall, 1999). For instance, Abdolvand et al. (2008) argue that IT plays a critical role in radical improvement and that overlooking it could result in failure. Likewise, McAdam (2003) states that IT is an enabling part of radical change.

IT covers hardware, information systems, and communication technology, and it pulls humans, organizations, and businesses together (Abdolvand et al., 2008, Grant, 2002). Paper and Chang (2005) advocate that IT architecture needs to be built around adaptive learning, where IT can facilitate a proper flow of knowledge capture and sharing while people learn and adapt as the change unfolds. However, in order to succeed with valuable changes in IT infrastructure during radical improvement (radical change), creativity must be encouraged and be part of the top management’s change plan (Paper and Chang, 2005).

**Realization methodology**

In addition to the success factors presented in the hierarchy in Figure 2:3, a number of authors also emphasize the importance of the realization methodology (Paper and Chang, 2005, Jarrar and Aspinwall, 1999, O’Neill and Sohal, 1999).

Paper and Chang (2005) argue that, even though a map/method is just a blueprint and that it is up to top management to lead the change, it is still important to have a proper map/method to act as a rallying point during the change. However, the methodology must be customized to fit the specific needs, environment, and culture of the organization, and so there is no general method at hand (Paper and Chang, 2005, Vakola and Rezgui, 2000). Thus, top management must create and adapt a detailed methodology on how to address the change prior to the undergoing change. Based on literature, these methods tend to be positivistic and stepwise (McAdam, 2002). Taking a more innovation-centred perspective on radical improvement, concordant with
innovation management aspects, calls for a more evolving process characterized by contingency and learning (McLaughlin et al., 2008). Such a process is further characterized by exploration, being flexible and adaptive, taking risks, and experimenting (O'Reilly and Tushman, 2004).

**Resistance to change**

In contrast to the success factors described, resistance to change is described as equally important to consider, however as a failure factor. Guimaraes (1999) states that resistance is the most common barrier to radical improvement, and thus change navigation is crucial (Tikkanen and Pölönen, 1996). In general people fear and resist change (Paper and Chang, 2005, Abdolvand et al., 2008), mainly since they feel uncertain about their job positions and job authority (Crowe et al., 2002). Glover et al. (2011) state that companies with a more flexible production characterized by frequent and rapid changes in their product mix tend to create a culture more likely to accept changes. Since accepting changes is vital to radical improvement success, a continuous improvement awareness thus needs to be created and reinforced in the organization in order to achieve a sustainability of change (Glover et al., 2011). Abdolvand et al. (2008), discussing success and failure factors with a readiness perspective on radical improvement, consequently see resistance to change as an indicator of not being ready.
3. Research Methodology

This chapter outlines the design of the research, starting with a description of the scientific outlook, followed by a description of the context in which the research has been undertaken. Further the research process is described including the methodological approach applied, as well as the studies that have been conducted. The chapter concludes with a discussion about the quality of the research.

3.1 Scientific outlook

There are different epistemological views and traditions that form a researcher’s fundamental perception of the world. Thus, for the research to be valid to the academic community, the researcher’s approach, reflecting the perception of the world as well as his or her view of science, has to be described.

Concepts or thought patterns applied to approach the world in terms of research is often referred to as paradigms, commonly acknowledged as positivistic and hermeneutic. The positivistic paradigm implies validated, systematic experience in contrast to speculation (Johansson, 2011) and can therefore be referred to as “explanatory knowledge” (Arbnor and Bjerke, 1997). The hermeneutic paradigm implies the understanding of meaning (Johansson, 2011) and can therefore be referred to as “understanding knowledge” (Arbnor and Bjerke, 1994). Thus the positivistic researcher looks for presupposed causal laws explaining empirical events, while the hermeneutic researcher interprets why and how people act in a certain way in a specific situation in order to understand it. Both these paradigms can be related to methodological approaches called analytic, systems, and actors approach, respectively, visualized in Figure 3:1 below (Arbnor and Bjerke, 1997). The analytical approach, which is positivistic, strives to explain reality as objectively as possible. The systems approach also considers reality to be objective yet constructed in a sense where the whole deviates from the sum of the parts, and thus the components are mutually dependent. The actors approach however, being hermeneutic, sees reality as a social construct, suggesting that it is difficult not to influence the phenomena under study.

![Figure 3:1: Scientific positioning, adapted from Arbnor and Bjerke (1994).](image-url)
The objective of this licentiate thesis is, through theoretical and empirical work, to increase the understanding about radical improvement in production and identify what elements need to be considered when designing support on how to implement radical improvement in industrial production. When conducting research on production systems the areas of consideration are somewhat diversified. For instance, the production system could be studied using an analytical approach considering, for example, manufacturing performance measures. However, the production system has been defined as “the people, equipment and procedures that are organized for the combination of materials and processes that comprise a company’s manufacturing operations” (Groover, 2007), implying that it is affected by non-analytical factors such as social and cultural contexts as well, which is not considered in the positivistic-based analytical approach. Thus, neither an analytical nor an actors’ approach could be exclusively applied in this research. As production is viewed as a very complex activity involving several elements, the production system tends to be described from a systems perspective. Consequently, in accordance with Bellgran and Säfsten (2010) arguing that it is almost necessary to have a systems approach when studying production systems, the systems approach has been applied throughout the research. Applying a systems approach implies in this case that the researcher takes a holistic perspective of the production system (the system under study) and recognizes that it includes several subsystems and components.

3.2 Research context

The research presented in this thesis has been strongly influenced by the context in which it has been undertaken. Mainly, this environment can be characterized by two contextual influences: 1) The Kaikaku project, which is the research project in which the thesis has been conducted, and 2) Innovation & Design, which is the research area of the department.

3.2.1 The Kaikaku project

In late 2009 the three-year-long research project “Kaikaku – radical and innovative production development” was initiated with a grant from the Swedish innovation agency VINNOVA (VINNOVA registration number 2009-03978). The research project is multidisciplinary, implying that the research comprises several areas, which in this case are production development, innovation management, and spatial design, all focused on radical and innovative production development in agreement with the purpose of the project. The project is structured in five different work packages, each covered by a PhD student addressing the area of radical and innovative production development yet applying a different perspective since the students come from different academic backgrounds. The expected results, somewhat simplified, are to identify why and when a Kaikaku is needed as well as how to support the realization of Kaikaku in production in various ways.

Throughout the entire research process, dialogue seminars have been arranged, in which a topic related to radical and innovative production development has been discussed by the entire project team, including not only the PhD students, but also a number of professors and senior researchers. In addition to the dialogue seminars,
several studies have to some degree been planned, conducted, and published jointly. Thus the results presented in the thesis are strongly influenced by an evolving understanding of the topic, derived by the multidisciplinary Kaikaku project context.

3.2.2 Innovation and design
The research presented in the thesis has been conducted in the context of innovation and design, which is the research area of examination in the department. The long-term overall objective of the research is to develop industry-applicable support on how to realize radical improvement in industrial production. Within the concept of radical improvement, a central aspect is that of innovation. Thus, in a sense, the research objective is to design support on how to apply creativity and innovative thinking in a way that innovative improvements are achieved in the production system. Consequently, the research conducted in the licentiate thesis, being the foundation for further research, strongly corresponds to the academic focus of the department.

3.3 Research design
The research design includes the specific design according to which the research in the licentiate thesis has been undertaken throughout. More specifically, it comprises the research methodology applied, the research process, and a description of the studies included.

3.3.1 Research methodology
The research process was inspired by the Design Research Methodology framework (DRM), presented and advocated by Blessing and Chakrabarti (2009) as a research framework on how to create knowledge, depicted in Figure 3:2. The DRM framework consists of four main stages: (1) Research clarification, (2) Descriptive study 1, (3) Prescriptive study, and (4) Descriptive study 2. Research clarification aims at finding a clear motivation and objective of the research. The researchers do so by trying to find some evidence or indications that support their assumptions in order to formulate a realistic research objective. The purpose of the descriptive study is to gain a vast understanding about the phenomena under study by applying both theoretical and empirical research. The deliverables are assumptions, experience, or synthesis that describes the current situation. In the prescriptive study the researcher then proposes how to improve the current situation. The research presented in this thesis corresponds to the first two stages in the DRM framework, embracing a research clarification and a descriptive study. The outcome of the research clarification is the research objective: “through theoretical and empirical work, to increase the understanding about radical improvement in production and identify what elements need to be considered when designing support on how to implement radical improvement in industrial production”. The outcome of the descriptive study is a broad understanding about the phenomena under study, that is, radical improvement in production.
3.3.2 The research process

The research conducted through the methodological framework is founded in three studies, two of which are mainly based on theoretical reviews (Study A and B) and one on a major empirical case study conducted during one year (Study C). The studies each correspond to a certain stage in the DRM framework, they all make some contribution to the research questions (In Table 3:1, x implies contribution, X implies strong contribution), and they have all been presented as academic papers.

The nature of study A and B is mainly theoretical, with the objective of gaining knowledge about important concepts by scrutinizing relevant literature. Thus they are both part of the research clarification stage (RC), aiming at formulating a realistic research objective and more precise research questions. In contrast, Study C is of a more empirical nature, yet including a literature study as well. Thus it corresponds to the descriptive study (DS1), striving for further knowledge and a broad understanding about radical improvement in production. As pointed out by Blessing and Chakrabarti (2009), in reality there are many iterations and parallel executions between the stages throughout the research process, and thus the research process is not as linear as it might appear in theory, and this may be true also for this thesis. When it comes to contribution, Study A strongly contributes to research question 1 (RQ 1), “What constitutes radical improvement in production?”. In addition, it also contributes to RQ 2, “What fundamental issues need to be considered when developing industry-applicable support?”, yet not as strongly as to RQ 1. Study B, as well as Study C, contributes to both research questions. However, in this case, both studies contribute most to the second research question. In addition, all three studies have been presented as separate academic papers. The connections between studies, DRM phases, research questions (RQ), and papers are outlined in Table 3:1 below.
Table 3:1: The relationship between research questions, phases, studies, and papers

<table>
<thead>
<tr>
<th>DRM phase</th>
<th>Research question</th>
<th>Presented in paper:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RQ 1</td>
<td>RQ 2</td>
</tr>
<tr>
<td>Study A</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Study B</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Study C</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

In order to further clarify the overall research process, the main activities conducted throughout have been visualized in chronological order in Figure 3:3 below. First, an initial literature study was conducted in order to delineate the research and to gain further knowledge about the area to be researched. Then Study A was conducted, mainly based on the initial literature review, but also covering some additional literature. Based on Study A, Study C was planned and executed during a period of over one year. The study was mainly of an empirical character, but a theoretical review was conducted consistently throughout the study. During Study C, Study B was also initiated, executed, and finished. In Study B, the concept modelling conducted was coupling both theory and practice. Based on the studies conducted, a state-of-the-art literature review (SOTA) was carried out in the later stage of the research process. The purpose was to find literature embracing the overall findings of the research. Thus, the state-of-the-art literature review partly constitutes the theoretical foundation applied in the frame of reference chapter in the licentiate thesis.

Figure 3:3: Visualization of the research process.

3.3.2.1 Literature studies

In addition to the separate literature reviews conducted in each study/paper, two literature studies were carried out throughout the research process. The thesis, being of descriptive nature, heavily rests on the theory applied. Thus, as emphasized by Karlsson (2009), the literature reviews help establish the authority and legitimacy of the research conducted.

The purpose of the first literature study was to increase the understanding about the research topic, and, as argued by Yin (1994), develop sharper research questions. The literature study was initiated by searching the Discovery database, which covers over 20 databases such as Emerald, ScienceDirect, and Web of Science. In addition, Scopus and to some extent Google Scholar were searched as well. Throughout the literature
search, the following set of keywords were used: Kaikaku, radical improvement, speed of improvement, breakthrough improvement, production system development, production development, evolution, revolution, transformation, Kaizen, Kaizen Blitz, Kaizen Event, business process reengineering, process innovation, continuous innovation, continuous improvement, lean enterprise, lean production, and performance increase. In addition to the search, a number of articles and books related to the research area were provided by colleagues and supervisors.

The second literature study, being a state-of-the-art literature review, was conducted in a more systematic and structured way. Before initiating the literature review, a number of articles were already known from the studies conducted, as well as from the dialogue seminars attended. Based on those articles, as well as the overall research findings, the following process was adhered to, resulting in an overview of the state-of-the-art literature on radical improvement in production.

1. A number of articles were already known from the papers/seminars, from which keywords and areas were derived.

2. A number of detailed searches were made according to the keywords using the Discovery database, Scopus, and Google Scholar, until approximately 150 articles had been found.

3. The articles were first read in their abstracts and then sorted out as relevant or not, depending on their relation to radical improvement in production. About 75 articles were identified as relevant at least to some extent.

4. The results and conclusion chapters of the articles were then read in order to further sort and categorize the literature. Finally, 56 articles were identified as highly relevant and then further categorized by their relation to radical improvement in production. Based on the content of the articles, the following categories were identified: result and impact; success factors; creativity; approaches, methods, tools, and techniques; definition, nature, content, and principles; future research challenges; holistic perspective; implementation; SME perspective; evolution and maturity level; implications; strategy and objectives; assessment; and organizational learning.

5. The 56 articles categorized by their relation to radical improvement in production were then further scrutinized, thus constituting the theoretical foundation in the licentiate thesis.

3.3.2.2 Study A: Literature review and concept modelling of Kaikaku
Study A was intended to result in a conceptual Kaikaku realization methodology that in turn could be tested and thus provide further insight into the challenges and implications of Kaikaku realization. The development method that was chosen is the DFMTsme model (Design For Method Transfer to SMEs). The DFMTsme model consists of six development steps that are repeated in multiple phases. The six development steps are: (1) requirement analysis, (2) process modelling, (3) selecting
performance measures, (4) compiling manual, (5) compiling workbook, and (6) verification (von Axelson, 2007). This study includes the first phase of development, resulting in a requirements description/analysis.

Thus in order to reach the objective of the study, concept modelling was used to first provide a definition of the phenomenon of Kaikaku, from which a requirements specification on the Kaikaku realization methodology could be derived. The concept modelling method applied consists of a work process and a notation standard. Concept modelling is here used to clarify terms (approx. ‘words’) and concepts (approx. ‘meanings’) relationship to each other in order to define the specific terms. Fundamental steps in the work process are (Astrakan, 2003, SIS, 2008):

1) Project definition
2) Term inventory and prioritizing
3) Modelling and definition of selected terms
4) Decision and use

After defining the project, the study was initiated through an overall literature review in order to investigate the phenomenon of Kaikaku. According to the Astrakan concept modelling method (Astrakan, 2003), the second step after defining the project is to make a term inventory and prioritisation. This step was carried out in a series of workshops based on the literature review, attended by three researchers. The terms were found mainly in literature and prioritised through brainstorming and discussion. The gross list of terms included activity, breakthrough improvement, continuous innovation, evolution, extreme production makeover, fundamental, infrequent step, innovation, Japanese Sea, Kaizen, Kaizen Blitz, Kaizen Event, lean enterprise, lean production, learning, magnitude, maturity, new knowledge, new technology, performance increase, phenomena, production development, production system development, radical improvement, ratio of improvement, reengineering, revolution, scale of globalism, scale of rethink, speed of improvement, and transformation.

In the third step the term Kaikaku and the closest terms were selected by the team in consensus based on the current understanding of Kaikaku in the specific project context. A graph and a definition were derived.

3.3.2.3 Study B: Literature review and concept modelling of a holistic improvement system

The aim of Study B was to gain an increased understanding about the different components in a business concerning improvement work and in particular their interaction. Thus, the second study was of conceptual nature, aiming at visualizing the context of production system improvement, taking a holistic perspective.

In order to reach the objective of the study, concept modelling was applied as in Study A, yet in this case based on both literature reviews and empirical data collection interactively. The concept modelling in Study B was inspired by an interactive research model, in which the modelling is based on interactive work coupling both theory and practice as shown in Figure 3:4.
Study B was initiated through an overall literature review in order to investigate the term holistic improvement work in order to underpin the theoretical background and problem description, thus also defining the purpose of the study. Subsequently, improvement work was further investigated through a review of relevant literature. Further, a gross list of terms connected to holistic/integrated improvement work was assembled based on the literature review. In the next step the group, regularly comprising three individuals, identified a number of headings under which the addressed terms could be placed based on discussion and prioritisation. Afterwards, a first version of the map (concept model) was derived.

As emphasized in the interactive research model (Ellström et al., 1999), the graph was then revised according to comments from industry representatives in interviews and discussions. Throughout the interactive process, the initial graph was revised several times based on both theoretical and empirical comments and remarks.

3.3.2.4 Study C: Realizing Kaikaku in production

The objective of Study C was to realize a Kaikaku in production based on the specific Kaikaku realization methodology created in Study A. The purpose of the study was to gain an increased understanding about (1) how to realize Kaikaku in production, and (2) what major contextual implications need to be considered with regard to Kaikaku realization. In order to analyse Kaikaku realization in production, as well as its contextual implications, a single-case study was conducted using five data collection components. The study object was an SME sheet metal manufacturer in Sweden. Given the objective, a case study approach employing several data collection methods was a logic and reasonable research approach (Yin, 1994). The main reason to apply a case study was the possibility of an in-depth (Bell, 2000) as well as holistic (Arbnor and Bjerke, 1994) study of the phenomenon researched. The research project was also dependent on access to proper industrial settings to collect necessary qualitative data in order to conduct a qualitative data analysis. This type of research is commonly referred to as qualitative research (Yin, 2010). Further, the case study conducted was of exploratory nature, indicating that it was primarily a pilot study of Kaikaku realization that can be used as a basis to formulate more precise research questions later (Yin, 2010).
Case study design

Before initiating the described Kaikaku realization project, a robot welding cell was chosen as the focus area in consensus with company management for mainly two reasons: (1) proper delimitations had to be made considering the time and resources available, and (2) a screening of the entire production was made, indicating that this particular area was especially important for the company. The Kaikaku realization project was thoroughly planned from the beginning regarding the main phases as well as the roles of the company and the researchers. Even though there was one party responsible in each phase, there was still a collaborative approach requiring both parties to be consistently active. The Kaikaku realization approach primarily consists of three main activities: (1) to identify and present the current state of the production system, (2) to come up with a future state that is in line with the production strategy, directed by a challenging target, and (3) to create an action plan to carry out. Throughout the list of activities, there is also some guidance on how to achieve the desired output of every activity, for example by setting a very challenging target and by encouraging the participants to be innovative. The main plan of the case study including responsibilities and the main phases is presented below.

Table 3:2: Case study process

<table>
<thead>
<tr>
<th>Project phases</th>
<th>Responsible</th>
<th>Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping the current production status</td>
<td>Research team</td>
<td>Company</td>
</tr>
<tr>
<td>Creative workshop/idea generation</td>
<td>Research team</td>
<td>Company</td>
</tr>
<tr>
<td>Creating action plan</td>
<td>Company</td>
<td>Research team</td>
</tr>
<tr>
<td>Realizing action plan</td>
<td>Company</td>
<td>Research team</td>
</tr>
<tr>
<td>Follow up &amp; evaluation</td>
<td>Research team</td>
<td>Company</td>
</tr>
</tbody>
</table>

The first phase, mapping the current state of production, was mainly carried out by the researchers in order to achieve an impartial understanding. The phase contained mapping of the robot welding cell with regard to four areas: (1) work process, (2) internal logistics, (3) productivity, and (4) changeover routines. The second phase, facilitating idea generation through a workshop, was planned and carried out by the researchers. There was one workshop facilitated during one day with the primary purpose and agenda to:

- obtain a common understanding of the current state of production regarding the robot welding cell
- come up with and agree on a challenging target for the Kaikaku realization
- generate ideas for implementation
- strengthen the Kaikaku project team

The event was attended by 16 individuals including one workshop leader, three observers taking notes, six internal staff from the shop floor as well as senior management, and six external researchers and consultants. The action plan was then created by the case company with support and guidance from the research team. All decisions were made by the company management team, yet based on discussions with
the research team experts. The action plan was then carried out during several months by the company staff. These activities were coordinated by the company project leader and consistently supported and/or discussed by the research team. One year after initiating the project, a follow-up and evaluation phase was conducted.

Data collection and analysis
During the single-case study, the following data collection methods were applied:

- direct observations
- document reviews
- archival data usage
- participation
- telephone reflections

Direct observations were applied consistently during the case study in meetings and factory tours. Documents concerning, for example, planning, strategy, and manufacture were also reviewed consistently. Archival data, including the financial database, information system, and operation/process system, were also used throughout the entire project. During a few specific project phases, such as the creative workshop and idea generation, participation was applied. Also, telephone reflections were used before the creative workshop, in which four key employees reflected on the current state of production and came up with ideas for the future, based on guiding questions formulated in a reflection guideline.

Collecting and analysing data is a simultaneous process in qualitative research (Merriam, 2009, Miles and Huberman, 1994), where data analysis is the process of making sense of data, to create meaning (Merriam, 2009). Throughout the project, data were consistently analysed when collected. Reflections, hunches, ideas, and things to pursue were constantly written down in a field-journal type of memos as proposed for qualitative research (Merriam, 2009). There are also a number of helpful means on how to analyse data as they are being collected (Bogdan and Biklen, 2007), of which a few were applied in the study:

- writing many observers’ comments
- writing memos/field notes as you learn
- beginning to explore the literature while still being in the field

The data analysis in this study was conducted interactively based on three steps of qualitative analysis advocated by Miles and Huberman (1994): (1) data reduction, (2) data display, and (3) conclusion drawing and verification. Data reduction refers to selecting, simplifying, and transforming the data; this was done frequently in response to collected data, both at a detailed level in the different project phases and at an overall project level. The data display, which is an organized assembly of information that permits conclusion drawing and action (Miles and Huberman, 1994), was done multiple times by structuring, visualizing, and organizing thoughts and findings. The
conclusions emerged in the interactive model based on data collection, data reduction, and data display visualized in Figure 3:5.

![Figure 3:5: Components of data analysis: interactive model (Miles and Huberman, 1994).]

### 3.4 Quality of research

Judging the quality of data is difficult, yet very important, especially when working with qualitative data. The most common way to assure the quality of the research conducted is validity and reliability.

#### 3.4.1 Validity

Validity has been described as the extent to which researchers are able to use their method to study what they had sought to study rather than (often without being aware of it) studying something else (Gummesson, 2000). Qualitative research, which has been applied in the licentiate thesis, always faces a threat to validity. A threat in this case (validity threat) is simply a way in which you might be wrong. Thus, as a component of the research design, validity consists of the strategies used to identify and try to rule out the threats (Maxwell, 2005). Consequently, a strategy for avoiding these threats should be systematically applied throughout the entire research process.

**Internal validity**

Validity can be divided into two subgroups, internal and external validity. According to Merriam (1998), internal validity signifies the degree to which the research results describe reality. Further, Merriam (1998) has proposed six basic strategies on how to ensure internal validity:

- **Triangulation** pertains to the goal of seeking at least three ways of verifying a particular event (Yin, 2010).
- **Member checking** – the participants of the studies, that is those who have provided the information, are given the opportunity to assess the plausibility of the researcher’s interpretations and findings (Merriam, 1994).
• **Long-term observation** – the researcher observes the environment/phenomenon under study long-term in order to increase the validity of the results (Merriam, 1994).

• **Peer examination** – the researcher asks fellow researchers to comment upon and review his or her results (Merriam, 1994).

• **Participatory research approach** – the researcher involves the participants in all stages of the study (Merriam, 1994).

• **Researcher’s biases** – the researcher clarifies the viewpoints, underlying assumptions, and theoretical orientation (Merriam, 1994).

In order to strengthen the quality of the research, these strategies have been applied in various ways throughout the research process. In Study C in particular, the one-year-long qualitative single-case study, multiple data sources were used, thus enabling triangulation of the results. In Study B as well as in Study C, the participants and/or interviewees were also given the opportunity to assess the plausibility of the findings by reading through key notes provided by the researcher or by attending workshops, seminars, and discussions in which results were presented. Besides, in case Study C, the researcher was continuously engaged long-term with the participating company. Thus, the company participants have been involved to some extent throughout all stages of the study. The theoretical orientation and the underlying assumptions, composing the biases of the author, have to some extent been addressed in the introduction, as well as in the research context description.

Peer examination, or horizontal review and evaluation, was conducted consistently throughout the research process by several means, such as:

• **public seminars**. The research plan, process, and results were presented as a research proposal in an early stage, but also as a licentiate thesis proposal later on, and have thus been thoroughly scrutinized by peers on two separate occasions during a period of 2-3 years.

• **closed seminars**. The results have been discussed continually in the dialogue seminars addressing relevant topics.

• **writing/presenting papers**. The academic papers appended to the thesis have been reviewed, discussed, and revised accordingly.

**External validity**

External validity describes the degree to which the research results can be generalized (Merriam, 1998). A prerequisite to generalizability, however, is that the internal validity is fulfilled. When working with case studies, it is always difficult to facilitate generalizing the results (Gummesson, 2000). The results in this thesis are based on limited empirical studies, thus affecting the possibility to generalize from them. However, generalization is not necessarily a desired outcome when choosing a case methodology.

The objective of this licentiate thesis is to gain a broad understanding about the phenomenon under study. Since the research presented covers a limited amount of
empirical study and, as mentioned in Section 3.3.1, is of a descriptive nature, the results have to some extent been verified through comparison with relevant literature instead. However, in the later stages of the research process, conducting prescriptive studies, the possibility to generalize the results will be aimed at. However, this might still be difficult since realizing radical improvement in production is highly context-dependent, being described as an area where there is no general key solution (Paper and Chang, 2005, Vakola and Rezgui, 2000).

3.4.2 Reliability
Reliability implies that if two or more researchers are studying the same phenomenon with similar purposes, they should reach approximately the same results (Gummesson, 2000). In qualitative research, however, reliability is problematic. Humans and organizations are not static but dynamic and constantly changing. Thus, a problem in qualitative research is that it is impossible to recreate the state of the environment and its actors as they were when being studied the first time (Merriam, 1998). Thus, in order to make the research repeatable, the research methodology applied in the studies has been outlined as transparently as possible.
4. Research results and analysis

This result and analysis chapter summarizes the empirical and theoretical findings of the research conducted. First, a short summary and analysis of the most significant theory is presented. Second, three studies that have been conducted throughout the research process are presented in chronological order with purpose, findings, and conclusions. Then the overall research findings, based on knowledge acquired in the studies and through theory, are presented. Finally, based on the research findings, a synthesis is presented regarding important issues that need to be considered when creating support on how to realize radical improvement in industrial production.

4.1 The research results – an emergent process

Throughout the research process the results have emerged over time. Thus the formulation of the overall research results in the thesis is based on a process where the results have slowly emerged through a process in several steps. Consequently, the understanding and standpoint might change a little throughout the process as well. In the first step, a short analysis of the literature has been made since the frame of reference itself is the result of a state-of-the-art literature study conducted at the end of the research process. In parallel to the analysis of the literature, a paper summary has been made, presenting objective, methodology, and result of the appended papers and studies conducted. Based on the theory analysis combined with the paper summaries, the central and most important research findings have been identified, classified, and presented as the “findings”, later presented as “synthesis”. The model below indicates how the research result has emerged as the different sub-results and activities have been processed.

**Figure 4:1: Result outline.**
4.2 Literature essentials

The theoretical review led to some important conclusions for the research that are presented below. First, a short summary of the core of production system development is presented, followed by a take on the concept of radical improvement as it appears in literature. Second, improvement maturity as a contextual implication as well as other factors critical to radical improvement success is briefly described and analysed.

4.2.1 Production system development

Based on the literature analysed it is evident that a production system is all about creating value from raw materials into a product or service that a customer is willing to pay for (Jackson et al., 2008). Also, the production system is very complex and thus applying a holistic perspective is generally accepted (Bellgran and Säfsten, 2010). When it comes to production system development, it covers both the development of totally new systems and the improvement of existing systems. In this thesis, the improvement of existing production systems (brownfield development) is in focus. The production system is a very complex system consisting of several different elements and subsystems such as technology, information, organization and management, and human/social factors. Improvements of the production system can be made in any element of the production system. It seems to be a general view that improvements of the production system are made by applying either an incremental but continuous approach to production system improvement or a more episodic and radical approach (Yamamoto, 2010).

4.2.2 Radical improvement in production

It has become evident that there is not only one way how to perceive the concept of radical improvement in production. First, radical improvement has been extensively researched from a reengineering perspective of improvement, such as, for example, business process reengineering (Hammer and Champy, 1993) and Kaizen Event/Blitz (Van Aken et al., 2010, Laraia et al., 1999). In the reengineering perspective, radical improvement tends to emphasize stepwise processes, often run as a project in the organization. Second, radical improvement has also been implicitly discussed from an innovation perspective, where comparisons can be made between radical improvement and radical innovation (Smeds and Boer, 2004, Boer and Gertsen, 2003, McLaughlin et al., 2008). The innovation perspective has been discussed in the production context from a continuous improvement aspect (Boer and Gertsen, 2003, Bessant et al., 2001). In this case, radical improvement is seen as a capability that is achieved by organizational learning. This organizational learning is done by continuous improvements, thus referred to as an organizational evolution (Bessant et al., 2001).

The different perspectives on radical improvement discussed above are further emphasized through the difference in characteristics addressed by realization methodologies identified in literature. For instance, reengineering methods are most often positivistic, plan-driven and based on stepwise processes whose key ingredients are planning, mapping and analysing the current state, creating a future state, implementing, evaluating, and starting an effort of continuous improvements in the area concerned (Davenport, 1993, Povey, 1998, Muthu et al., 1999, Vakola and
The theoretical review led to some important conclusions for the research that are presented below. First, a short summary of the core of production system development and improvement tends to emphasize stepwise processes, often run as a project in the organization. This implies creating a vision, a shared vision, and continuous approach to production system improvement or a more episodic and radical approach (Yamamoto, 2010).

4.2.3 Improvement maturity

In the literature on production system improvement the concept of Kaizen, usually referred to as continuous incremental improvement, is normally addressed in some sense. Continuous improvement has been referred to as an evolutionary learning process and should thus not be considered a short-term activity only (Bessant and Francis, 1999, Bessant et al., 2001). Besides, it has been stated that the research scene of continuous improvement has changed from focusing on shop-floor level issues to focusing on continuous improvement, innovation, and learning combined (Boer and Gertsen, 2003). Thus, continuous improvement does not only constitute incremental improvement but radical and innovative improvement as well.

4.2.4 Factors critical to radical improvement success

The research results imply that there are numerous factors critical to radical improvement success. First, top management and leadership are crucial to radical improvement success, involving not only leadership itself, but also work environment and company culture. Further, the realization approach is discussed, followed by the notorious failure factor resistance to change.

Top management and leadership

The role of top management and their leadership is emphasized as a vital aspect of successful change (Tikkanen and Pölönen, 1996, Jarrar and Aspinwall, 1999, Abdolvand et al., 2008, Paper and Chang, 2005, Guimaraes and Bond, 1996). Not only do top management need to understand the concept of radical improvement and the current context in which it is to be realized. They also need to actively be involved throughout the entire improvement initiative, from planning to execution, leading the change together with the staff. This implies creating a vision, a shared vision, and
fostering a sense of inter- and intra-organizational trust and commitment making the employees willing to participate and contribute in the change. Thus, top management must facilitate the necessary support such as proper communication channels, time, and resources. From a long-term perspective, top management also need to plan for organizational learning throughout the radical improvement.

The employees and the environment
Besides the role of top management, the employees as well as the environment play a decisive role in successfully realizing radical improvement in production (Paper and Chang, 2005, Abdolvand et al., 2008, Herzog et al., 2007). For the improvement initiative to succeed, the employees need to be involved and understand the fundamentals of the change. Thus they must be involved in the objectives set and in general have some decision-making authority as well. For this to happen, there must be a collaborative working environment where employees can interact in a friendly manner and in trust and work in multidisciplinary and/or cross-functional teams. Also, from an employee perspective, the environment must be supportive in the way that employees are empowered to act, recognition is recast to, for instance, teamwork and creativity, and the proper education and training facilitated when necessary (Paper and Chang, 2005, Wong, 1998, Vakola and Rezgui, 2000). Further, important performance measures should be followed up in order to achieve a positive attitude throughout the change (Glover et al., 2011). In this way, the environment will be conducive to change in the people to enact the change, the staff.

Resistance to change
Resistance to change has been mentioned as the number one most common barrier to radical improvement, and consequently change navigation is of greatest importance when realizing any radical change (Guimaraes, 1999, Tikkanen and Pölönen, 1996). In general, people fear and resist change since they feel uncertain about their job positions and authority. However, at companies with a more flexible production characterized by, for example, rapid changes in their product mix, people are more likely to accept changes (Glover et al., 2011). Thus, creating a culture of accepting changes is very important, and a culture of continuous improvement should be promoted in the organization. Resistance to change could also be interpreted as an indicator of not being ready for radical improvement (Abdolvand et al., 2008).

The realization approach
Based on the literature review it has become evident that it is important to have a method or similar to function as a rallying point when realizing radical improvement in production (Paper and Chang, 2005, Jarrar and Aspinwall, 1999, O'Neill and Sohal, 1999). However, it is also evident that it is up to management to lead the change, and that the method applied needs to be customized to fit the specific need, culture, and environment of the organization undergoing the change (Paper and Chang, 2005, Vakola and Rezgui, 2000). Consequently, there is no key solution at hand, but top management must create and adapt a detailed methodology on how to address the radical improvement process. However, the specific literature analysed implicitly brings out two different perspectives on radical improvement in production, thus also
differing in realization approach. Based on literature covering the reengineering aspect of radical improvement in production, the methods tend to be positivistic, stepwise, and very systematic (Davenport, 1993, Povey, 1998, Muthu et al., 1999, Vakola and Rezgui, 2000, McNichols et al., 1999). Taking a more innovation-centred perspective on radical improvement instead calls for a more evolving process characterized by exploration, being flexible and adaptive, taking risks, and experimenting (Markic, 2006, O'Reilly and Tushman, 2004, McLaughlin et al., 2008).

4.3 Papers summary

Below is a summary of the appended papers. The purpose is to give a short but comprehensive insight into the main results achieved, including purpose and procedure as well as results and conclusions.

4.3.1 Paper 1: Towards a methodology for Kaikaku realization

The first paper is a conceptual paper on the understanding of Kaikaku realization. Consequently, this paper is of an exploratory nature implying that its object is to result in further research clarification. The understanding of Kaikaku as a phenomenon was derived from concept modelling, which in turn was built on a theoretical review of relevant literature. The objective of the paper was to come up with a first draft on a Kaikaku realization methodology that could be tested later and, consequently, provide more insight into the challenges and implications of Kaikaku realization as a basis for further research. Thus, concept modelling was used to first get a definition of the phenomenon of Kaikaku, from which a requirements specification on the Kaikaku realization methodology was derived.

From the literature study, it became evident that support on how to realize radical and innovative improvement in production, analogue with the case of incremental improvement, is a necessity especially for SMEs to attain the competitive advantage needed. From concept modelling it is concluded that Kaikaku is a process that requires aggressive target setting, leads to radical change, and is facilitated by innovative thinking. Thus, it leads to a number of requirements set on a Kaikaku realization methodology:

- An aggressive target is set
- A production strategy is used
- A radical change in the production system is planned and performed
- The change leads to a performance increase of critical measures
- Innovative thinking is facilitated

However, it is concluded that more research is needed in order to further develop support on how to realize Kaikaku in production. First, the need of further research on how to facilitate radical improvement in production is addressed. Second, more research is advocated in the actual support required for Kaikaku realization, for example how to facilitate being innovative in a production development context.
4.3.2 Paper 2: Towards a holistic perspective on production system improvement

The second paper is a conceptual paper on production system improvement, taking a holistic perspective. The understanding of production system improvement from a holistic perspective was derived from concept modelling, where the modelling was based on a literature review and empirical reviews interactively. The purpose of the study was to gain further insight into the different components of a business and especially their interaction. The objective of the study was to visualize the context of production system improvement.

The findings of the study imply that organizations that are seeking long-term success will need a holistic and balanced approach to production system improvement that, as emphasized by Hoerl and Gardner (2010), includes methods for basic problem solving, approaches to continuous process improvement, and systems to identify opportunities for disruptive innovation. The study further implies that there are several different perspectives of production improvement such as speed, organisational level, scope, level of innovation, approach, and so on. In addition, there are numerous methods, tools, and techniques available today on how to conduct improvements. Consequently, having a holistic perspective on production system improvement implies the capability to address the production system requirements and vision by matching the different perspectives of improvement (speed, scope, etc.) with the improvement approaches available (programs/methods/tools), in order to make the improvements more effective and worthwhile.

4.3.3 Paper 3: Kaikaku – radical improvement in production

This paper is based on a single-case study carried out during one year at an SME case company using a collaborative approach including researchers as well as company representatives. The objective of the study was to realize a Kaikaku in production based on the methodology presented in Paper 1. The purpose was to gain an increased understanding about (1) how to realize Kaikaku in production and (2) what major contextual implications need to be considered with regard to Kaikaku realization.

The Kaikaku realization methodology

The Kaikaku realization methodology can help a company (in this specific context) up the improvement maturity evolution, but, most likely, only in the earlier phases. However, to reach higher levels, including being more innovative, the methodology needs to be revised in order to embrace the main characteristics of both production improvement and innovation management in the context of improving a production system in operation.

Improvement maturity and culture

There is a maturity to change that needs to be considered in this context. First, incremental improvement (incremental innovation) and radical improvement (radical innovation) are said to constitute two different cultures with rather opposing mindsets. Hence, being expert and really understanding the means of incremental improvement is likely to restrain the radical improvement capability, based on the innovation
perspective. However, mastering incremental improvement is also said to be a prerequisite to being able to realize radical improvement. This is emphasized in the study, implying that when working in the context of improving something in operation, it is really important to have the practical means necessary, time and resources. Further, it implies that companies in this context first need to master Kaizen. However, when striving for the highest levels of maturity to change, really challenging the current ways of working, innovation capability needs to be increased.

The results clearly imply that what kind of improvements can be made at a company is to a great extent dependent on the maturity to change, that is, the current improvement capability including different cultures and mindsets. Consequently, the question of how to manage these cultures in coexistence with regard to the later stages of the evolving improvement capability process needs further research.

4.4 Radical improvement in production- concept, context, and success factors

Described below are the concept, context, and critical success factors of radical improvement in production. The objective of the findings chapter is to present knowledge of importance for further research on the development of industry-applicable support on how to realize radical improvement in industrial production. Thus, the research findings below are presented in a descriptive manner, in concordance with the thesis research methodology.

4.4.1 The concept of radical improvement in production

The theoretical and empirical work undertaken implies that there are several similar concepts to be found in literature today such as business process reengineering, Kaizen Event/Kaizen Blitz, process innovation, and Kaikaku, that can all be considered in the category of radical improvement in production. This is further emphasized by Bicheno (2004), stating that Kaikaku, business process reengineering, and Kaizen Blitz belong to the same category of change, classified as an enforced improvement initiative characterized by breakthrough impact.

Looking into the different concepts, Kaizen Blitz/Event is a team-based approach focusing on realizing radical improvement in production during a few days, where the “task forces” often follow a predetermined schedule. Thus, a Kaizen Blitz is “a rapid improvement effort that emphasizes teamwork and innovative thinking” (McNichols et al., 1999, p.1). Another concept, business process reengineering, has been defined as “the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed” (Hammer and Champy, 1993, p.32). Here, dramatic redesign of business processes is key to success. Process innovation is another radical improvement concept, which, according to Davenport (1993), combines a structure for doing work with an orientation to visible and dramatic results. “It involves stepping back from a process to inquire into its overall business objective, and then effecting creative and radical change to realize order-of-magnitude improvements in the way that objective is accomplished” (Davenport, 1993, p.10). Besides the obvious character
of radical change, the essence in process innovation is doing something new, that is, not just doing the same thing but better. Similarly, Kaikaku has been defined as “an infrequent but radical improvement where fundamental changes occur in the production system and a dramatic performance increase is obtained. Initiated by top management, fundamental changes are often made through reformations or replacements of the system by introducing new knowledge, work methods, strategies, production technologies, or equipment and so forth” (Yamamoto, 2010, p.27). Besides, in accordance with the concept model visualized in Figure 4:2, it was concluded in Study A that Kaikaku is a process that requires aggressive target setting, leads to radical change, and is facilitated by innovative thinking.

In general, a spectacular performance increase of critical measures is the outlined objective of radical improvement in production. This is in line with the results of Study A implying that Kaikaku leads to a radical change in the production system, which in turn involves a performance increase of critical measures. Interpreting the literature though, the expected end results have been expressed in terms of 30 to 50% performance increase of critical measures (or more). In addition, as expressed in literature as well as in Study A, radical improvement is about creativity and innovation, which is even more hazily described, if described at all. However, it is implicitly expressed that the new solutions need to involve some level of novelty to it, thus not only lead to “do what has always been done, but better”. What this level of novelty implies is not well described in literature. However, Yamamoto (2010), who has discussed the level of innovativeness with regard to Kaikaku, presents a model of innovativeness in two dimensions, (1) incrementally innovative Kaikaku and (2) radically innovative Kaikaku, also expressed as locally innovative and globally innovative, respectively. This is in line with the explanation by Tidd and Bessant (2011), describing innovativeness in three levels: (1) incremental innovation, (2) new to the enterprise, and (3) radical innovation. Incremental innovation expressed by Tidd and Bessant closely corresponds to the characteristics of Kaizen described by

Figure 4:2: Concept model of Kaikaku derived from Study A.

In general, a spectacular performance increase of critical measures is the outlined objective of radical improvement in production. This is in line with the results of Study A implying that Kaikaku leads to a radical change in the production system, which in turn involves a performance increase of critical measures. Interpreting the literature though, the expected end results have been expressed in terms of 30 to 50% performance increase of critical measures (or more). In addition, as expressed in literature as well as in Study A, radical improvement is about creativity and innovation, which is even more hazily described, if described at all. However, it is implicitly expressed that the new solutions need to involve some level of novelty to it, thus not only lead to “do what has always been done, but better”. What this level of novelty implies is not well described in literature. However, Yamamoto (2010), who has discussed the level of innovativeness with regard to Kaikaku, presents a model of innovativeness in two dimensions, (1) incrementally innovative Kaikaku and (2) radically innovative Kaikaku, also expressed as locally innovative and globally innovative, respectively. This is in line with the explanation by Tidd and Bessant (2011), describing innovativeness in three levels: (1) incremental innovation, (2) new to the enterprise, and (3) radical innovation. Incremental innovation expressed by Tidd and Bessant closely corresponds to the characteristics of Kaizen described by
Yamamoto. Thus, based on the explanation of levels of innovation by Tidd and Bessant (2011) in combination with the level of innovativeness of Kaikaku explained by Yamamoto (2010), the dimensions of innovation related to production system improvement could be expressed in three main levels as in Figure 4:3 below.

*Figure 4:3: Dimensions of innovation related to radical improvement in production.*

These dimensions imply that for radical improvement to contain a higher level of innovativeness than incremental improvement it should correspond to being at least new to the enterprise/locally innovative, otherwise the novelty better corresponds to Kaizen. However, regarding the level of innovation, it is the perceived degree of novelty that really matters since novelty is very much in the eye of the beholder (Tidd and Bessant, 2011), and thus what is new to the enterprise/locally innovative is in this case rather subjective. Besides, when it comes to the improvement of key performance indicators, the improvement advocated, 30 to 50% performance increase of critical measures, or more, is not described in correlation to any specific time frame. Thus, exactly what constitutes radical improvement in production becomes contextual and quite subjective. However, the principal understanding of radical improvement as a result, thus somewhat framing the concept, has been visualized in Figure 4:4 below.

*Figure 4:4: Radical improvement in production.*

Reasonably, as the expected end result is quite diffuse, there are different methodological characteristics advocated when realizing radical improvement in production. Traditionally in operations management, the methodologies tend to
advocate stepwise, plan-driven, and normative methods to realize radical improvement in production (Davenport, 1993, Povey, 1998, Muthu et al., 1999, Vakola and Rezgui, 2000, McNichols et al., 1999). This is also in line with the Kaikaku realization methodology created in Study A, comprising the phases of (1) mapping the current state, (2) analysing the current state and creating a vision for the future, and (3) coming up with alternatives for reaching that vision. However, methodologies that are more focused on the level of innovation with regard to radical improvement in production take the human aspect, knowledge creation, and organizational learning more into consideration, rather than advocating a normative and stepwise process (Smeds and Boer, 2004, Boer and Gertsen, 2003). Thus, as the expected end results are not clear, what is advocated as realization guidelines differs as well.

Yet, based on the results of the empirical studies and the theoretical reviews, a comprehensive understanding of radical improvement in production has emerged along the research process. Thus, the general understanding is described in Table 4:1 as a number of characteristics that have been identified throughout the research process.

Table 4:1: Description of radical improvement in production

| General characteristics | Radical improvement in production is a process that intends dramatic redesign of business processes where the design may be radical, yet the implementation is carried out step-wise. It is top-down-initiated but requires bottom-up acceptance in the organization. Radical improvement is also about creativity and innovation. |
| Expected end results | The end result is an improvement of key performance indicator(s) expressed as a percentage, at least 30-50 % or more. In parallel, the solution requires some level of novelty to it, thus being at least new to the enterprise/locally innovative. |
| Realization methodology: Main characteristics advocated | 1) Positivistic, normative, stepwise, top-down-initiated, plan-driven and structured |
| | The methodology tends to be systematic and is often run as a project comprising the following phases: planning, mapping and analysing the current state, creating a future state, implementing the new ideas, evaluating the new state. |
| | 2) Evolving, emergent, contingent, learning |
| | The methodology takes the human aspect, knowledge creation, and organizational learning into consideration. |

4.4.2 Radical improvement in production put into context

A critical factor to consider when realizing radical improvement in production is that all improvements conducted needs to be considered in a context. Since the whole is greater than the parts, nothing can be entirely understood or managed without considering a context. Thus, as emphasized in Study B, there is a need of a holistic approach to production system improvement covering both incremental and radical improvement.
When addressing the context of production system improvement, the concept of continuous improvement (CI) is most often discussed in some sense. Continuous improvement, also called Kaizen in Japanese, implies continuous improvement of the production system, yet normally conducted in an incremental manner, thus emphasizing “doing what we already do, but better”. However, according to Boer and Gertsen (2003), the research scene has changed from focusing on shop-floor-level CI some years ago, to focusing more on continuous innovation instead, constituting continuous improvement, learning, and innovation, thus taking a wider perspective on the concept of continuous improvement. This is further emphasized by Bessant et al. (2001) arguing that CI constitutes not only incremental improvement but also radical and innovative improvement today. Accordingly, continuous improvement, or continuous innovation, constitutes both incremental and radical improvement, as well as innovation and learning, and could therefore be considered a context of production system improvement.

Bessant et al. (1999, 2001) present a view of continuous improvement as an organizational evolution where companies work their way up, continuously improving their own improvement capability over time. At the lower level in the organizational evolution, companies work in a passive manner where problems tend to be solved by fire fighting. However, by enhancing their improvement capability over time through continuous improvement, organizations will achieve more reactive and strategic improvement capabilities and, eventually, also a stronger innovation capability. Similarly, Tidd and Bessant (2011) discuss an organization’s capability to organize and manage the innovation process by considering (1) how well the firm is aware of the need to change and (2) how far the firm is prepared and able to change in practice. When the values are low, the organizations are “unconsciously ignorant”, indicating that they don’t know that they don’t know (also referred to as the learning paradox). Instead, when the values are high, the organizations tend to be high-performing, creative, and knowledge-based, thus being able to search, select, and implement new knowledge. Likewise, Bellgran and Säfsten (2010) discuss the production system development process taking an evolutionary perspective on the capabilities addressed in it, indicating that, given the awareness of the value of continuously improving the development process, it will evolve over time.

### 4.4.2.1 Improvement capability building – a learning process

Besides the fact that continuous improvement not only constitutes incremental improvement but also radical improvement, innovation, and learning, the main point addressed is that the improvement maturity of a firm could be visualized as an organizational evolution based on learning. Improvement maturity corresponds to the specific improvement capability of an organization, indicating what kind of improvements can be made. Thus, in order to improve the improvement capability, being capable of conducting a wider spectrum of improvements and innovations in the future, the organization must constantly learn from its endeavours. This is further emphasized by Bessant (2001), arguing that the improvement maturity evolution is a long learning process that embraces culture change.
In case study C, realizing radical improvement in production at a Swedish sheet metal manufacturer, the results indicated not only a 67% productivity increase in the focus area addressed, but also a change in behaviours and routines by the company personnel involved. This can be explained in accordance with a model of continuous improvement levels and their corresponding behaviours expressed by Bessant et al. (2001). Before initiating the radical improvement realization project, the behaviour and understanding of the company representatives involved corresponded to the lower level of the improvement maturity evolution (referred to as CI level 1 according to Bessant, 2001); problems were to a high extent solved randomly, there was no formal structure for improvement work in practice, solutions tended to benefit short-term goals, staff were unaware of how to run CI successfully, and so on. However, one year after initiating the realization of the radical improvement, new structures and routines for improvement work were initiated. The new structures and routines regarding how to work with improvements in the area concerned were characterized by, for example, formal and structured processes for problem solving, measurable effect, and staff participation, which corresponds more to CI level 2 according to Bessant (2001). Thus, according to the behavioural characteristics at the case company before and after the radical improvement compared with the behaviour characteristics expressed by Bessant (2001), it is evident that the company staff involved in Study C to some extent increased their improvement capability during the radical improvement project.

Looking at radical improvement from the context of improvement maturity as an organizational evolution, it becomes evident that what is key in successful continuous improvement, regardless of being incremental or radical, is the organizational learning associated with it, that is, to constantly improve the improvement capability, “capability building”. This is further argued by Bessant et al. (2001) stating that continuous improvement should be viewed as an evolution and aggregation of a set of key behavioural routines in order to be run effectively, and not as a short-term activity only. Thus, applying the improvement capability building view on radical improvement in production as a part of the continuous improvement context, the realization methodology as a learning process to facilitate an improved improvement capability seems increasingly important in contrast to the short-term productivity-increase type of results most often striven for.

4.4.2.2 Two improvement cultures
An important contextual implication concerning the realization of radical improvement in production is the different cultures related to the evolving maturity to change. In the organizational evolution, the improvement maturity of the company involves building a capability to achieve both incremental and radical improvement by continuously learning as improvements take place. As described earlier, for radical improvement to differ from incremental improvement, Kaizen, it should not only signify a dramatic performance increase in contemporary measures, but also correspond to being at least locally innovative or new to the enterprise and thus not only incrementally innovative. However, a problem raised in the literature is the cultural differences of incremental and radical innovation, that is, that they are basically two different cultures since their mindsets are so diverse (McLaughlin et al., 2008). While incremental innovation is
characterized by exploitive initiatives focusing on cost reduction and profit increase, having a more formal and systematic structure as well as a culture of efficiency and low risk, radical innovation on the other hand is characterized by exploration, applying a more adaptive structure, and having a culture of risk taking, speed, flexibility, and experimentation (O'Reilly and Tushman, 2004). To be able to conduct radical innovation in organizations, the culture of incremental innovation is said to be a prerequisite. However, what is interesting is the fact that the culture of incremental innovation in parallel with radical innovation is said to hinder the latter since the mindsets are so different (McLaughlin et al., 2008). This is further underpinned in Study C, where the company culture to a great extent corresponds to the characteristics of Kaizen and incremental innovation. Throughout the project as well as in the specific idea-generating workshop, it was difficult to facilitate more radically innovative options and ideas since the company staff tended to apply an incrementally-based thinking pattern in line with “doing what has always been done, but better” when working with improvements.

Another contextual issue of importance when realizing radical improvement in production is the general prerequisites of being “ready” to change. This is in line with the findings in Study C, implying that, when working in the context of improving a production system “in operation”, the practical means necessary, basic skills, time, and resources to conduct incremental improvement most likely need to be in place before being able to conduct radical improvement, regardless of whether being innovative or not. Since there always will be operations run concurrently with the improvement initiative, the ability to manage these activities in parallel needs to be in place. Thus, as advocated, a culture of incremental innovation/Kaizen will most likely be a prerequisite to radical improvement realization in an organization.

The results clearly imply that what kind of improvements can be made at a company is to a great extent dependent on the maturity to change, that is, the current improvement capability including different cultures and mindsets. The organizational evolution signifies improvement capability building over time, indicating that organizations eventually will need to challenge their current ways of working, striving for a higher level of innovation capability. Thus there will eventually be a need of coexisting innovation cultures with the capability of combining both incrementally and radically innovative improvements in the production system. Besides, the organizational evolution will encourage the growth of an ambidextrous organization, which according to McLaughlin et al. (2008) is the ultimate goal of high performers upholding a philosophy of continuous improvement. This insight further implies that a methodology for realizing radical improvement must be customized to the specific context of the organization – environment and culture, and thus that there is no general key solution at hand.
4.4.3 Factors enabling realization of radical improvement in production

There are several important factors enabling successful realization of radical improvement in the industrial production context. For instance, the role of top management is frequently addressed in literature as perhaps the single most important success factor, which is also further emphasized in Study C. Without top management commitment, skill, and dedication, there will most likely not be any success. In addition, the organizational environment as well as its employees is a key to success.

4.4.3.1 The role of top management

The importance of top management and its leadership when realizing radical improvements in production is widely emphasized by several researchers (Abdolvand et al., 2008, Paper and Chang, 2005), as well as by the empirical case study C. It is evident that in almost every case of change, irrespective of what has to be done in the organization, it is up to top management to facilitate the possibility for it to actually be carried through. Thus, top management must drive the improvement and be actively involved in both planning and execution, yet involve all employees and all departments and thus foster a sense of commitment throughout the organization. This involves showing commitment and being reactive throughout the entire change and not only sporadically during certain events. Throughout the radical improvement realization at the case company in Study C, top management showed commitment and involvement, which seemed to correlate with the effort made by the employees in the improvement endeavour. At the beginning of the project, the employees to some extent chose to sit on the fence. However, as top management showed their commitment by being actively involved in the activities carried out at both shop-floor level and management level, the effort made by the employees increased constantly during the project.

In the case study, the radical improvement project team did not cover all departments since the project focus was narrowed down to the manufacturing operation of one specific department and since there was a general resource constraint in the organization. However, top management should also promote teamwork consisting of cross-functional teams characterized by diversity, creativity, and risk taking. Thus, they must reward employees for undertaking initiatives supporting radical improvement. For this to happen, top management need to create a culture of trust among the employees, based on good communication. In order to create a culture of good communication where people are keen to share information willingly, top management must create and provide proper channels for communication in the organization. This was further stressed in case study C where the need of communication was underestimated at the beginning of the project, thus creating some reluctance to change among uninformed employees.

Ultimately, radical improvement as well as change in general, is a very complex issue. The literature review along with the empirical case study C indicates that in order to become successful in realizing radical improvement in production, top management not only need to be committed to and lead the change, they must also understand the
concept of radical improvement as well as the organizational context in which the radical improvement is to be realized.

### 4.4.3.2 The organizational environment and its employees

Besides top management, who are ultimately responsible for leading and monitoring radical improvement success, there are some requirements on the organizational environment and its employees as well.

At first, it is crucial that the employees understand the change so that they can be responsive throughout it. If not informed and agreeing with the fundamentals of the change, there will likely be some resistance to the change since the employees in general will fear change, feeling uncertain about their jobs. Resistance to change is the most common reason why radical improvements fail (Guimaraes, 1999), and therefore change navigation is imperative to radical improvement success (Tikkanen and Pölönen, 1996). Thus, top management must inform the employees about the change and provide them with some decision-making authority and involvement in the change process. This was shown to be an important success factor in case study C, where the employees, when given some authority and responsibility, began to come up with their own initiatives and became more creative in, for example, problem solving.

To promote radical improvement success in any organization, the environment must be conducive to a change in the perception of the people to enact the change, the employees (Paper and Chang, 2005). Making people thrive in a very dynamic and ever-changing environment is therefore necessary. Thus, timely training and education might be the single most important factor to accomplish this environment (Wong, 1998). Working with continuous improvements, thus creating a culture of awareness and acceptance of change among the employees, is a good way to succeed.

### 4.5 Considerations on how to design realization support

The synthesis of the research findings is presented as a number of issues in need of consideration when creating support on how to realize radical improvement in industrial production. They have emerged from the overall research results and must all be taken into account when designing an industry-applicable support. The issues of concern are somewhat diverse, yet all-important, covering the concept of radical improvement, the role of creativity, the context in which radical improvement will be realized, as well as a number of organizational aspects. Below are the identified issues visualized in a model and briefly described. Further on, these issues are described in more detail, both why they are important and how they affect the design of an industry-applicable support on how to realize radical improvement in industrial production.
4.5.1 Interpretation of radical improvement and its implications for the realization methodology

Depending on how radical improvement is understood the requirements and guiding principles set on the realization approach will most likely differ. Based on the general understanding of the concept of radical improvement, the realization method should be concordant with its characteristics corresponding to, for instance, structure and systematic dramatic redesign, stepwise implementation, and being positivistic/normative, top-down initiated, and plan-driven. However, if emphasizing the innovation aspect part of the concept, trying to promote a higher level of innovativeness to the solutions, and thus a higher level of novelty of the ideas to implement, the requirements on the realization approach will differ, thus promoting knowledge creation, organizational learning, creativity, exploration, risk taking, etc., being concordant with the characteristics of how radical innovation is facilitated instead.

Consequently, the realization methodology will vary depending on how the concept of radical improvement in production is understood. Depending on how to interpret the innovativeness part of radical improvement, the methodology might advocate systematic, plan-driven, and stepwise realization (McAdam, 2002) as it is generally advocated in radical improvement literature, or, if being concordant with radical innovation management aspects, advocate an evolving process characterized by contingency and learning instead (McLaughlin et al., 2008).
Thus, when it comes to realizing radical improvement in production, the realization approach advocated could either be referred to as a systematic approach or, when embracing the radical innovation aspects, as a contingency and learning approach. Applying a systematic approach to radical improvement implies following a well-defined and prescriptive process (Yamamoto, 2010), thus being concordant with what has been described as general characteristics. Initiatives applying a systematic approach can bring about radical improvement in production, but in parallel, there is a risk involved in applying these “solutions”. For instance, organizations may apply them without really understanding the concept behind them, thus hindering organizational learning (Wu, 2001). Also, radical changes, such as, for example, lean transformation, rarely follow a predetermined linear process (Drew et al., 2004). However, Paper and Chang (2005) argue that, even though a method is just a blueprint and that it is up to top management to lead the change, it is still important to have a proper method to act as a rallying point during the change. This is further emphasized in Study C, indicating that the systematic approach applied generated benefits in planning and preparation of the improvement project. In addition, the systematic approach provided valuable insight into and understanding about the improvement initiative, thus making it easier for the company representatives to comprehend and manage the realization process to come. However, Study C also indicated that a considerable implication in the stepwise and systematic approach is to encourage creativity and innovation. This is emphasized by the creative idea-generating workshop in the realization project resulting in quite non-innovative ideas such as “to implement basic structures and routines for improvement work” and “to invest in new technology”. Thus, to better promote creativity and innovation when realizing radical improvement in production, an evolving process characterized by contingency and learning is advocated instead (McLaughlin et al., 2008). The contingency approach considers a change to be very context-dependent and therefore, that there is no “one best way” to organize the change. The learning approach is closely related to organizational learning, or “the learning organization”, which implies an organization that continuously expands its capacity to create its own future (Senge, 1990).

Thus, depending on how to interpret the concept of radical improvement, especially concerning the level of innovativeness required/striven for, there will be different requirements and guiding principles set on a realization methodology. Therefore, an active choice has to be made on how to exactly interpret radical improvement with regard to the results striven for.

4.5.2 The need of creativity in radical improvement

Research has shown that creativity is an essential part of successful radical improvement. Creativity can be described as “the production of novel and useful ideas in any domain” (Amabile, 1996, p.1), while innovation, from an organizational perspective, can be described as “the successful implementation of creative ideas within an organization” (Amabile, 1996, p.1). Thus, an invention or a creative idea does not become an innovation until it is implemented, and consequently a key measure of innovation success or outcome, such as radical improvement, is the
currency of the idea generated (Van de Ven, 1986). In this view, creativity by individuals and teams is the starting point for any innovation (Amabile, 1996, Van de Ven, 1986).

In literature as well as in the empirical case study C, the importance of being creative has been corroborated. The fact that creativity is a key to competitive advantage and thus that radical improvements hinge on it has been stated (Feurer et al., 1996). This is further emphasized by Paper (1997), advocating the value of creativity in radical improvement, by McFadzean (1999), arguing that radical change needs to be built on a creative culture as a key element, and by McAdam (2003), stating that creativity has a strong and important influence on radical change. However, not many methodologies for radical improvement provide support on how to be creative today. This is further emphasized by McAdam (2003) calling attention to the fact that several of the radical improvement approaches and methodologies available today blithely state “create new process” or “create new solution” when encountering the step going from vision to future-state solution. As a consequence, individuals tend to apply incrementally-based thinking as their comfort zone, since creativity has not yet been incorporated into their thinking patterns (McAdam, 2003). This implication is further highlighted by Harrington (1998) stating that one of the reasons why business process reengineering did not make any further ground was that people did not understand the “being creative” part of the methodology.

The view of creativity as an unsolved piece of the radical improvement puzzle, thus also a practical implication, is further accentuated by McFadzean (1999) stating that there is a lack of information on how to develop creativity in the context of large-scale change such as radical improvement in production. Consequently, organizations need help in creating future-state solutions related to radical improvement (Harrington, 1998). Thus, in order to identify how to facilitate creativity in radical improvement and subsequently manage innovative solutions, the area of creativity and innovation relating to radical improvement in production needs to be further understood and then also incorporated into the methodology/support.

4.5.3 Applying a holistic perspective on radical improvement

The research results imply that radical improvement should be regarded from a wider perspective, thus taking a holistic view on production system development. Continuous improvement, a concept embracing both incremental and radical improvement as well as innovation and learning today (Boer and Gertsen, 2003) seems to be a proper context for production system improvement, especially as most manufacturing companies in some sense work with continuous improvements, yet normally focus on incremental improvement. The view on continuous improvement applied in this thesis is that of an organizational evolution where manufacturing companies are improving their own improvement capability over time, thus in a sense climbing “the improvement maturity ladder”.

This insight sets some guiding principles on a supposed radical improvement realization methodology. First, in this view it is evident that the key in successful
continuous improvement, irrespective of whether being incremental or radical, is the organizational learning associated with it. The realization methodology as a learning process to facilitate an improved improvement capability is therefore increasingly important in relation to the short-term productivity-increase type of results most often striven for. Thus, a methodology for realizing radical improvement should not only achieve specific results associated with radical improvement, but also, and most importantly, facilitate organizational learning, in this case synonymous with improvement capability building. This insight also emphasizes the importance of the methodology applied and the actual process of improving in contrast to focusing on the end results.

4.5.4 Different cultures

In the continuous improvement maturity evolution companies will work with incremental as well as radical improvement, and the improvements will be both incrementally and radically innovative. However, a problem raised is that incremental innovation and radical innovation are two different cultures since the mindsets are so opposed (McLaughlin et al., 2008). Thus, even though incremental innovation capability is a prerequisite to radical innovation, it is also an obstacle since the way of thinking and acting is totally different. At the same time, the ultimate goal for companies working with continuous improvement is to become ambidextrous (McLaughlin et al., 2008), that is, to be equally good at both, thus being capable of managing both cultures in co-existence.

Also, in addition to the innovation aspect of radical improvement, there is also a general “being ready” aspect that seems important in the context of improving a production system in operation. As mentioned earlier regarding the innovation aspect, the culture of managing incremental innovation is said to be a prerequisite for managing more radical innovation. In the same sense, empirical case study C as well as literature (Glover et al., 2011) implies that it is more likely to succeed with radical improvement if there is already a continuous improvement effort in place at the company at hand. When improving a production system already in operation, the practical means, time, skills, and resources, have to be in place. Also, since resistance to change is the most common reason why radical improvement fails (Guimaraes, 1999), an existing culture of continuous improvement makes the employees more likely to thrive in a dynamic and changing environment, making the organization further ready to change.

As a consequence, a methodology for supporting the realization of radical improvement in production, taken into the continuous improvement maturity context of a specific organization, must be able to manage these cultural issues irrespective of what the specific objective of the improvement is. However, not stating that a certain level of maturity is required, it is most likely advantageous to be at least somewhat mature/experienced when striving to realize radical improvement in production. Thus, a methodology for realizing radical improvement in production must take the cultural aspects into account, irrespective of what level of maturity a specific company possesses.
4.5.5 Management, staff, and organizational environment

Realizing radical improvement in production is a complex issue, calling for several aspects to be managed properly and in accordance with existing circumstances. As improvement is a learning process, it is important that it is the management and the employees that conduct the change. As mentioned earlier, there are a great number of responsibilities placed on especially top management when realizing radical improvement in production, as with any type of radical change. They are responsible for driving the change (Abdolvand et al., 2008), creating a culture of trust and commitment (Paper and Chang, 2005), creating communication channels (Farris et al., 2008, Abdolvand et al., 2008), rewarding good behaviour and incentives (Paper and Chang, 2005), involving the employees in decisions and activities (Farris et al., 2008), and so forth. The employees have to understand the change and be part of it throughout the entire process. Also, to sum up, the organizational environment must be conducive to the change in the perception of the people to enact the change (Paper and Chang, 2005).

Consequently, there are some requirements set on the realization methodology concerning top management, employees, and the organizational environment. First, since top management are so crucial, it is absolutely necessary that they not only consent to the change, but are also competent and committed to leading the change. Thus, the methodology must ensure that top management fulfil these requirements/guiding principles before initiating any large-scale radical improvement. Second, as the employees are such an important part of executing the actual change, they must be informed as well as involved throughout the entire change. Thus, the methodology must ensure that the employee role is accounted for already in the planning stage of the improvement. Third, since the environment must be supportive of the people that enact the change, this must be constantly managed throughout the entire change process.
5. Conclusion, discussion and further work

This chapter presents and discusses the main conclusions from the research conducted. First, conclusions are drawn from the separate studies carried out as well as the applied theory. The fulfilment of the objective and the answers to the research questions are then presented, as well as the contribution and quality of the research. The results are then discussed, and finally areas of further research are outlined.

5.1 Conclusion

The main objective of the licentiate thesis has been to, through theoretical and empirical work, increase the understanding about radical improvement in production and identify what elements need to be considered when designing support on how to implement radical improvement in industrial production. Three studies as well as a state-of-the-art literature review have been conducted, embracing both empirics and theory, thus resulting in further understanding of the concept of radical improvement in production.

Based on the earlier theoretical reviews, it became evident that radical improvement as a means to increase the overall speed of improvement is an exciting area of research, given the competitive environment of the manufacturing industry today. Thus, different aspects of production system development and in particular radical improvement have been introduced and discussed, implying that radical improvement in production is a rather diffuse and subjective concept. However, applying a systems perspective entails the concept of radical improvement being put in a relevant context. Therefore, continuous improvement, being a proper and interesting context of radical improvement in production, has been applied and described accordingly. Further, the importance of top management and leadership, employee involvement and a supportive environment have been introduced as general success factors crucial for any radical improvement success.

Furthermore, Study A investigated the phenomenon of Kaikaku in order to create a first draft of a Kaikaku realization methodology that could be empirically tested later on and thus provide further knowledge and understanding about radical improvement in production. It was concluded that Kaikaku is a process that in turn requires aggressive target setting, leads to radical change, and is facilitated by innovative thinking. Thus it provided further insight into the concept of radical improvement in production as well as how to realize it in industrial production.

Study C was a single-case study with the object of realizing Kaikaku in production based on the methodology derived from Study A. In addition, the study was designed to gain
further insight into (1) how to realize radical improvement in production as well as (2) what major contextual implications there are to it. First, the study indicated that the methodology applied, being normative and systematic as advocated in operations management literature, can bring a less mature company up the improvement maturity evolution. However, in order to reach higher levels of improvement capability, including being more innovative, the methodology needs to be revised accordingly. Second, the study implies that there is a context to consider when realizing radical improvement in production. When improving a production system in operation there are always operations run in parallel. Thus, Kaizen, or incremental improvement, was found to be a favourable precondition to radical improvement since it to some extent ensures that available resources for improvement are present. Third, the study also shows that incremental innovation and radical innovation imply two different cultures since their mindsets are so opposing by nature. A culture of incremental innovation is a prerequisite, as well as an obstacle, to radical innovation. Thus, as the level of innovation is an important aspect of radical improvement in production, these cultural issues must be managed.

Further, Study B, which aimed at visualizing the context of production system improvement, showed that there is a need of a balanced approach to production system improvement. A balanced approach in this case implies the need of combining methods for basic problem solving, approaches to continuous process improvement, and systems to identify opportunities for innovation. Thus it emphasizes the need to apply a holistic approach to production system improvement.

To sum up, radical improvement in production has been understood as a quite subjective concept, due to its vague descriptions. There might be debate regarding what exactly constitutes radical improvement in production and thus also whether an improvement conducted is radical or not. Nonetheless, as its main characteristics and principles have been unfolded throughout the research process, the concept has been framed in the thesis.

In this thesis, radical improvement in production has been viewed from the context of continuous improvement. In the continuous improvement context, the companies’ improvement maturity corresponds to their improvement capability, holistically perceived as an organizational evolution in which companies evolve over time. In this case, improvement capability building can be referred to as organizational learning. Given this view, it becomes evident that what is key in successful continuous improvement, regardless of being incremental or radical, is the organizational learning associated with it. Thus, considering the realization of radical improvement in production as a learning process to facilitate an enhanced improvement capability seems far more important than the short-term productivity increase most often striven for. This insight corroborates the idea of De Geus (1988), arguing that the ability to learn faster than our competitors may be the only sustainable competitive advantage.
5.2 Fulfilment of research objectives

The main objective of the licentiate thesis has been to, through theoretical and empirical work, increase the understanding about radical improvement in production and identify what elements need to be considered when designing support on how to implement radical improvement in industrial production. By answering the two research questions, the research objective can be considered fulfilled.

RQ 1: What constitutes radical improvement in production?

Throughout the research process, what exactly constitutes radical improvement in production has appeared to be somewhat vague. Nonetheless, the concept has been principally framed, thus providing an increased knowledge and understanding about it.

Through the research process in general and Study A in particular, it has become evident that radical improvement in production is a process (further described in Sections 4.3.1 and 4.4.1). Being a process implies that there is an input that through transformation becomes an output. When it comes to radical improvement in production, the input is the initial state of the production system, whereas the output is the future state of the production system. The transformation is the actual process in which the input is transformed into the output through a sequence of procedures adding value. The transformation process might be either problem-oriented or solution-oriented. Being problem-oriented, the process might be triggered by the formulation of a very challenging/aggressive set target for how to realize the production strategy in regard to the current state of the production system. Being solution-oriented instead, generally more unprejudiced and visionary, the process might be triggered by a vision of a future state of the production system, regardless of the current state of the production system.

Based on the results of Study A and Study C, the sequence of procedures addressed to transform the input into a desired output mainly refers to facilitation of creativity and innovation, applied to improvement of the production system, as it has become evident throughout the research process that radical improvement in production is about doing something new and not just doing the same thing but better. Since radical improvement in production embraces radical and fundamental rethinking of the production system and its key business processes, the facilitation of creativity as a means to achieve innovative solutions, specifically applied to the production system, is thus required as a key ingredient in the process of transforming the production system from its initial state into its future desired state. However, even though radical improvement in production provides a radical change of the production system, it is the design or the solution that is radical, yet the implementation tends to be stepwise.

Not only Study C but also the theoretical framework indicates that radical improvement in production constitutes teamwork, being a team-based approach to production system improvement in which it is the employees, together with the management, that have to
realize the change in the production system. Thus, in order to execute the actual change, the employees need to understand, be informed, and involved throughout the entire change. Radical improvement in production could therefore be described as a teamwork process that, based on creativity and innovation, transforms a production system from its initial state into a visionary future state.

**RQ2: What fundamental issues need to be considered when developing industry-applicable support?**

As presented in the thesis, there are several important issues that need consideration when designing support on how to realize radical improvement in production. Described below are a number of important considerations identified throughout the research process.

*What level of innovation is striven for?*

Based on the understanding of the concept of radical improvement in production, it has become evident that the level of innovation associated with it is quite complicated. As described in Section 4.5.1, comparing the methodological characteristics of how to realize radical improvement in production, the ones generally advocated (normative, stepwise, structured, plan-driven) better correspond to how incremental innovation is achieved (McLaughlin et al., 2008). However, looking into how radical innovation is achieved, the methodological characteristics (evolving process, learning, and contingency) differ considerably (McLaughlin et al., 2008). Consequently, depending on how innovative solutions and novel ideas to aim for through the radical improvement realization process, the realization methodology will differ accordingly.

*Facilitation of creativity when realizing radical improvement*

It has been recognized through the empirical Study C in combination with the theoretical review that creativity is a vital part of radical improvement in production, being the starting point of all innovation (further described in Section 4.5.2). However, there is not much support on creativity to be found in available radical improvement methodologies today. Thus, new support/methodology on how to realize radical improvement in industrial production must embrace the facilitation of creativity properly and in accordance with the strategic objective.

*Applying a holistic view of radical improvement – embracing organizational learning*

By applying a systems perspective in the research it has become evident that there is a need to apply a holistic perspective on the production system and thus on radical improvement as well (described in Sections 4.3.2 and 4.5.3). Accordingly, radical improvement has been put in the context of continuous improvement, a concept embracing incremental improvement, radical improvement, innovation, and learning. In this context, continuous improvement is viewed as an organizational evolution during which organizations over time enhance their own improvement capability. So, learning is a central aspect of realizing radical improvement, since the improvement capability
building itself is considered far more important than the actual improvement of certain KPIs. Thus, embracing the learning aspect, in this case synonymous with improvement capability building, is a central aspect of a radical improvement realization methodology.

**Two opposing cultures**
As emphasized in Section 4.5.4, incremental innovation and radical innovation are said to be two different cultures since their ways of thinking and acting are so opposing in nature. That is to say, incremental innovation is both a prerequisite and an obstacle to more radical innovation. Consequently, depending on the improvement capability of the company as well as the existing culture(s) in place, the support needed might differ. Thus, a methodology for realizing radical improvement in production must consider and manage the issue of different cultures.

**Management, staff, and organizational environment**
Since the organizational aspects of management, staff, and environment are crucial to any improvement, they must be considered in a methodology for realizing radical improvement in production as well (further described in Section 4.5.5). Throughout the research, three proposed guidelines have been identified:

- The methodology should ensure that top management are not only competent (know the organizational context as well as the concept of radical improvement), but also committed to leading the change.
- The methodology should ensure that the employees are informed and involved throughout the entire change.
- The methodology should ensure that the environment is supportive to the people that enact the change.

5.3 **Scientific and industrial contribution**
The research conducted in this thesis is of a descriptive nature with the object of gaining further understanding about the phenomenon under study, which in this case is radical improvement in production. Thus, the contribution of this thesis is mainly scientific. However, as explained in the research methodology (Section 3.3.1), the results in this thesis constitute the input to the next step in the research process, designing industry-applicable support on how to realize radical improvement in industrial production.

**Scientific contribution:** The scientific contribution is an increased understanding about what constitutes radical improvement in production as well as what issues need to be considered when creating support on how to realize such improvement. First, the concept of radical improvement has been investigated through structured literature reviews as well as empirical studies. Consequently, an understanding of the concept has been framed in this thesis, embracing not only the main characteristics of the concept itself but also the characteristics of the realization methodologies advocated. Further, several important
issues in need of consideration when creating support on how to realize radical improvement in industrial production, and consequently also being important when realizing radical improvement, have been identified and analysed.

**Industrial contribution:** As a first draft of a radical improvement realization methodology has been designed in Study A, the research provides some practical hands-on contribution, yet most likely more eligible for less mature companies only. However, as the methodology was designed with the purpose of gaining further understanding about how to realize radical improvement in production rather than to actually realize a radical improvement, it should be considered accordingly. Further, the company that is part of the case Study C has not only been provided with the results from the Kaikaku realization project (further described in Paper 3) but has also gained an increased understanding about how to address radical improvement in production.

### 5.4 Quality of the research

The research conducted in this thesis has been of a descriptive nature, implying that it mainly describes and analyses existing theories, thus increasing the knowledge and understanding about radical improvement in production. Besides, since the research conducted has been qualitative in nature, the results are hard to compare with any predetermined goals and assumptions. Thus, the best way to assure the quality of the research is by the methodology applied throughout.

The research has been conducted according to scientific methodological approaches, as described in detail in Section 3.4. However, there are always possible critiques of the research. One concern is the choice of case company. In this case, the company was part of the research project and thus prepared and willing to participate in the study throughout. However, in retrospect, collaborating with a mature company with a more developed improvement organization might have provided additional information as to how radical improvement in production ought to be realized. Besides, as the case company represents a common context for Swedish manufacturing companies (especially SMEs), it most likely constitutes a good foundation of understanding about company contexts to address in a realization support. However, further research should probably focus on more mature organizations in order to broaden the contextual aspect related to realizing radical improvement in industrial production.

Further, it is arguably difficult to state that the research conducted is fully repeatable. The reason is that the empirical studies are conducted in the very dynamic manufacturing industry, characterized by constant change. Thus, duplicating the research might lead to the same results if conducted in the near future. However, as the time span increases, the likelihood of fully repeating the studies and drawing the same conclusions diminishes considerably.
5.5 General discussion

Throughout the research, radical improvement in production has been approached as a concept with the main purpose of simplification, thus enabling a higher level of thinking. In this case, conceptualizing radical improvement in production enabled several similar approaches to radical improvement in production to be scrutinized, thus resulting in a broad understanding. Based on identification of its main characteristics, it has been principally framed in this thesis. Thus, the research conducted describes and analyses existing theories rather than proposing any revolutionary new theories.

The results imply that radical improvement in production is a diffuse and quite subjective concept. However, it has been understood as a process with the expected end result of not only an innovative design leading to a dramatic performance increase, but also of an enhanced improvement capability of the company, facilitated through the organizational learning associated with the process of realization. This insight leads to a number of demands set on a realization methodology; the level of innovation striven for has to be considered, creativity has to be facilitated throughout, a holistic approach should be applied, and the issue of opposing cultures in an organization must be addressed as well as the important soft values of management, employees, and organizational environment.

By applying a holistic approach to radical improvement in production, thus placing it in the context of continuous improvements (embracing incremental improvement, radical improvement, innovation, and learning), it became evident that the organizational learning associated with carrying out improvements is more important than the specific performance increase most often striven for. Thus, an objective generally expressed as “a 30-50% performance increase, or more,” should not be considered as the main objective when realizing radical improvement in production. Besides, whether an objective of a KPI expressed as a certain percentage is achieved or not is very contextual and does not necessarily reflect the value of the improvement made.

Further, based on the holistic perspective, several issues important to radical improvement success became clear, further emphasizing the complexity of radical improvement in production, not only as a concept but as a realization process as well. In the light of the complexity of the concept and also how complex and contextual the realization process of radical improvement is, the principal understanding of the concept presented is appropriate in order to design industry-applicable support on how to realize it in industry. However, as the realization process is so complex and contextual, there are several avenues for further research related to the realization process instead. For instance, the question of how to manage opposing cultures in the organization has to be addressed. How to facilitate organizational learning when realizing radical improvement in production must be clarified. How to best facilitate creativity throughout the process needs to be elucidated. How to ensure the soft parameters required in the methodology regarding management, employees, and environment must be addressed. Also, a decision on what level of innovation to strive for must be taken (I propose radical rather than
incremental), and subsequently, how to best facilitate radical improvement in the production context needs to be clarified accordingly. Consequently, there seems to be no general key solution at hand, but it has to be customized to fit the specific conditions of the organization.

5.6 Further research

Throughout the research process several potential areas of further research have emerged. Below, the areas highest on the priority list are described.

Development of support on how to realize radical improvement in production

Throughout the research, the objective of the long-term research process has been stated as to create industry-applicable support on how to realize radical improvement in industrial production. However, throughout the research process, several issues have emerged, emphasizing the complexity of such a support. For instance, a major issue is the company context and how the realization support should relate to it. Should the support be context-dependent? That is, will the support only be viable for a company of a specific improvement maturity, company culture, etc., or can it be flexible? Besides, there are the questions of how to:

- facilitate learning throughout the realization process
- facilitate creativity throughout
- manage opposing cultures
- make sure that the support is industry-applicable (corresponding to industrial expectations and conditions)
- ensure that top management is committed and skilled
- ensure employee involvement and participation
- make sure that the environment is supportive to the people enacting the change

Consequently, several issues need to be addressed by further research in order for this support to be developed appropriately.

How to become ambidextrous in production system improvement

The organizational evolution, describing the maturity of a company regarding the improvement capability building over time, implies that an organization eventually has to become more innovative in order to enhance its improvement capability. Thus there will eventually be a need for coexisting innovation cultures facilitating both incrementally and radically innovative improvements in the production system. This should also be the ultimate goal for companies embracing a philosophy of continuous improvement (McLaughlin et al., 2008). However, it has been clarified that incremental innovation and radical innovation constitute two different cultures since their mindsets are so diverse. Thus, how to become ambidextrous in the production system development context needs further research.
Thus, how to become ambidextrous in the production system development context needs radical innovation constitute two different cultures since their mindsets are so diverse. (McLaughlin et al., 2008). However, it has been clarified that incremental innovation and ultimate goal for companies embracing a philosophy of continuous improvement radically innovative improvements in the production system. This should also be the eventually be a need for coexisting innovation cultures facilitating both incrementally and become more innovative in order to enhance its improvement capability. Thus there will improvement capability building over time, implies that an organization eventually has to The organizational evolution, describing the maturity of a company regarding the How to become ambidextrous in production system improvement support to be developed appropriately. Consequently, several issues need to be addressed by further research in order for this Development of support on how to realize radical improvement in production. Below, the areas highest on the priority list are described. Throughout the research, the objective of the long-term research process has been stated as to create industry-applicable support on how to realize radical improvement in production context needs to be clarified accordingly. Consequently, there seems to be no incremental), and subsequently, how to best facilitate radical improvement in the company context and how the realization support should relate to it. Should the support emerged, emphasizing the complexity of such a support. For instance, a major issue is the general key solution at hand, but it has to be customized to fit the specific conditions of industrial production. However, throughout the research process, several issues have emerged, highlighting the complexity of such a support. For instance, a major issue is the manage opposing cultures facilitate creativity throughout.

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