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Study on Agile Methods in “Unconventional” Organizations

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Abstract

Due to increasing volatility in the business environment, companies are forced to adapt quickly and proactively to new situations. In order to meet these challenges and remain competitive, the production paradigm of agile manufacturing has been developed.

The purpose of this thesis is the finding of new methods and strategies for agile manufacturing.

Therefore, unconventional organizations are investigated on their abilities for dealing with volatility. Unconventional organizations are organizations that have long time experience in dealing with uncertainties and have developed sophisticated methods to succeed in their specific fields of work. The key capabilities of agile manufacturing (speed, flexibility, proactivity, and innovativeness) were defined in order to identify unconventional organizations that meet those requirements. Some examples of organizations that share mutual agile capabilities are the fire brigade, the police, the Red Cross or disaster management.

The methods and strategies were investigated by the means of literature research and expert interviews. As a result, 94 unconventional methods were found, evaluated and ranked according to predefined criteria. By clustering the highest ranked methods, six subject areas could be formulated.

The methods of those subject areas were transformed into a manufacturing environmental context. As a result, six recommendations for an application within the agile manufacturing industry could be provided.

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1 Introduction

The following chapter gives an overview about the topic and content of this thesis. It describes the development of manufacturing and the strategies during the past century which eventually led to agile manufacturing. Furthermore, the purpose of this work is defined and research questions are formulated. To answer these research questions, a study design is introduced and the research methods are briefly described.

1.1 Agility in the manufacturing industry

Over the last century the market has always defined the pressure on manufacturing. In the era after World War II, the market was characterized by a high demand and the incapability to meet the needs of the customer. During this day and age, quality and speed were not the most important features of products. The most important factor was the price of the product. This development led to a massive automation of production systems and to mass production. Due to the high amount of inflexible automation, customization for produced goods and the product range were limited.[1]

The primary objective in the mass production paradigm is the production at low costs. The goal of the production management is the anticipation, reduction and elimination of all sources of change that may lead to additional costs. Attempts to manage the changes are the use of inventory and sophisticated software solutions like material requirement planning (MRP) and manufacturing resources planning (MRP II). The paradigm is characterized by a mechanistic organizational structure, discontinuous technological choice and a financial-based performance measure. The four main characteristics are the following:[2]

1. The reduction of costs by increasing the volume of production (economy of scale). Trade-offs between the cross-functional performance criteria quality, time and cost are necessary and considered.
2. The preferred means to improve the production system is innovation. These innovations are the result of, usually few, large projects which are designed and directed by experts and managers.
3. The workforce is confined to the execution of production tasks under the supervision of managers.

[1] cf. Yusuf et al. (1999) p. 34
[2] cf. Duguay et al. (1997) p. 1184f

4. Suppliers are kept at arm's length and are made to compete against each other. The relationship with suppliers is almost adversarial.

In the late 1960s and during the 1970s, fast and dramatic changes in technology as well as in aspects of scale and scope happened. Topics like market, competition, customer requirements or social factors became the core concerns of companies. The basis of competition, which used to be the product's price, moved to other features like quality, delivery time or customer satisfaction. Mass production systems are limited in their viability to meet the new challenges of constant change.[3]

In the 1980s, the Japanese car manufacturer Toyota developed a new production program called the Toyota Production System (TPS). This production strategy was the focal point of a study that was investigating the practices used by Toyota. These practices and tools became known as lean manufacturing. With methods and tools like Single-Minute Exchange of Die (SMED), Kanban, Heijunka or 5S,[4] the aim of lean manufacturing is the elimination of all forms of waste.[5]

Muda, which is the Japanese word for "waste", describes any human activity that absorbs resources but creates no value: mistakes that need rectification, production of items that no one wants, piling up of inventories, unnecessary production steps, movement of people and transport of goods without any purpose, people waiting in downstream activities because upstream activities do not deliver on time, and goods and services that do not meet the customer's needs.[6]

To counteract the various sources of muda, the paradigm of lean thinking provides five lean principles: value, the value stream, flow, pull, and perfection. These five principles are described in the following way:[7]

1. Value is created by the producer and defined by the ultimate customer.
2. The value stream is a set of all the specific actions to bring a specific product through the three critical management tasks (problem-solving, information management, physical transformation)
3. Flow is about making the remaining, value-creating steps flow.
4. The principle of pull means letting the customer pull the product rather than pushing the product onto the customer
5. Perfection is the continuous process of reducing effort, time, space, costs and mistakes while offering a product that the customer actually wants.

[3] cf. Sharifi and Zhang (1999) p. 7f
[4] cf. Nyhuis et al. (2013) p. 15
[5] cf. Hallgren and Olhager (2009) p. 978
[6] cf. Womack and Jones (2003) p. 15
[7] cf. Womack und Jones (2003) p. 16-26

The consequent elimination of waste within the production system resulted into high efficiency and effectiveness for one operating point. Deviations from this economically optimal operation point due to various forms of volatility affecting a manufacturing system cause problems for lean systems. A fast adaption to changing conditions of larger impact is not always possible. The concept of agile manufacturing enables companies to prepare for changes and uncertainty. Moreover, agility emphasises proactivity to exploit opportunities in times of higher demand and to cut losses during times of lower demand. Fast reactions to volatility are used to further improve the economic situation of a company. The concepts of flexibility and transformability are components of the agile paradigm and by including the potential of the whole supply chain, additional potentials can be exploited.[8]

Companies competing in today's global market have to deal with a heavily dynamic environment as well as economic and social turbulences. The main cause of these volatilities companies have to face nowadays is change. Due to these financial, environmental and social changes, a sound forecast on sales and demand is often not possible. Because of the remaining volatility in the forecasts and unpredictable incidents, companies have to react to all kinds of uncertainties. To stay competitive and gain competitive advantages on volatile markets, today and in the future, a new manufacturing paradigm for the 21st century has been introduced: agile manufacturing.

1.2 Purpose and research questions

The aim of this thesis is the finding of new strategies and methods to support the manufacturing industry in today's volatile business environment by realizing the principles of agile manufacturing. In order to find new strategies and methods, so-called unconventional organizations are investigated. Those organizations do not belong to the manufacturing industry and use agile methods and strategies to meet the challenges of their specific field of work. They operate in a highly dynamically environment and therefor need the ability to react fast and efficiently to changing conditions. Furthermore, unconventional organizations have a long-time experience when it comes to dealing with uncertainty and have developed effective methods and strategies to meet their challenges. Some examples of unconventional organizations are the Fire Brigade, the Police or the Red Cross.

[8] cf. Schurig et al. (2014) p. 957

A literature review on agility in the manufacturing industry and the definition of similar characteristics between the manufacturing industry and unconventional organizations can be seen as the first steps. The investigation process is followed by the selection of unconventional organizations. After the selection of these organizations the appropriate research methods to investigate the agile methods and strategies they use are determined. The identified methods and strategies are evaluated and ranked following certain criteria. The most promising methods are investigated in detail and transformed to be applied in an industrial environment. Five research questions must be answered:

1. What are mutual characteristics of agile manufacturing and unconventional organizations?
2. What are unconventional organizations and how can agile methods and strategies be investigated?
3. How can those unconventional methods and strategies be categorized and evaluated?
4. Is an industrial application of the investigated unconventional methods and strategies viable?
5. How can the unconventional methods and strategies be applied in an industrial environment?

The first research question can be answered by comparing the principles of agile manufacturing and the necessary characteristics for unconventional organizations. Based on the necessary agile attributes unconventional organizations need to possess, the organizations to be investigated can be chosen. The investigation of the methods and strategies is performed by literature review on the chosen organizations as well as expert interviews of selected specialists of those unconventional organizations. To answer the third question, a framework for the evaluation and implementation of the methods is introduced. For the assessment of the evaluated unconventional methods and strategies in an industrial context, a ranking system is applied and the most promising methods are further elaborated. Finally, to answer the last research question, the chosen methods are transformed to be applied in an industrial environment.

1.3 Research methods and study design

The general structure of the study design for this thesis can be seen in figure 1. First, a literature review on agility in manufacturing systems is conducted. The sources for the

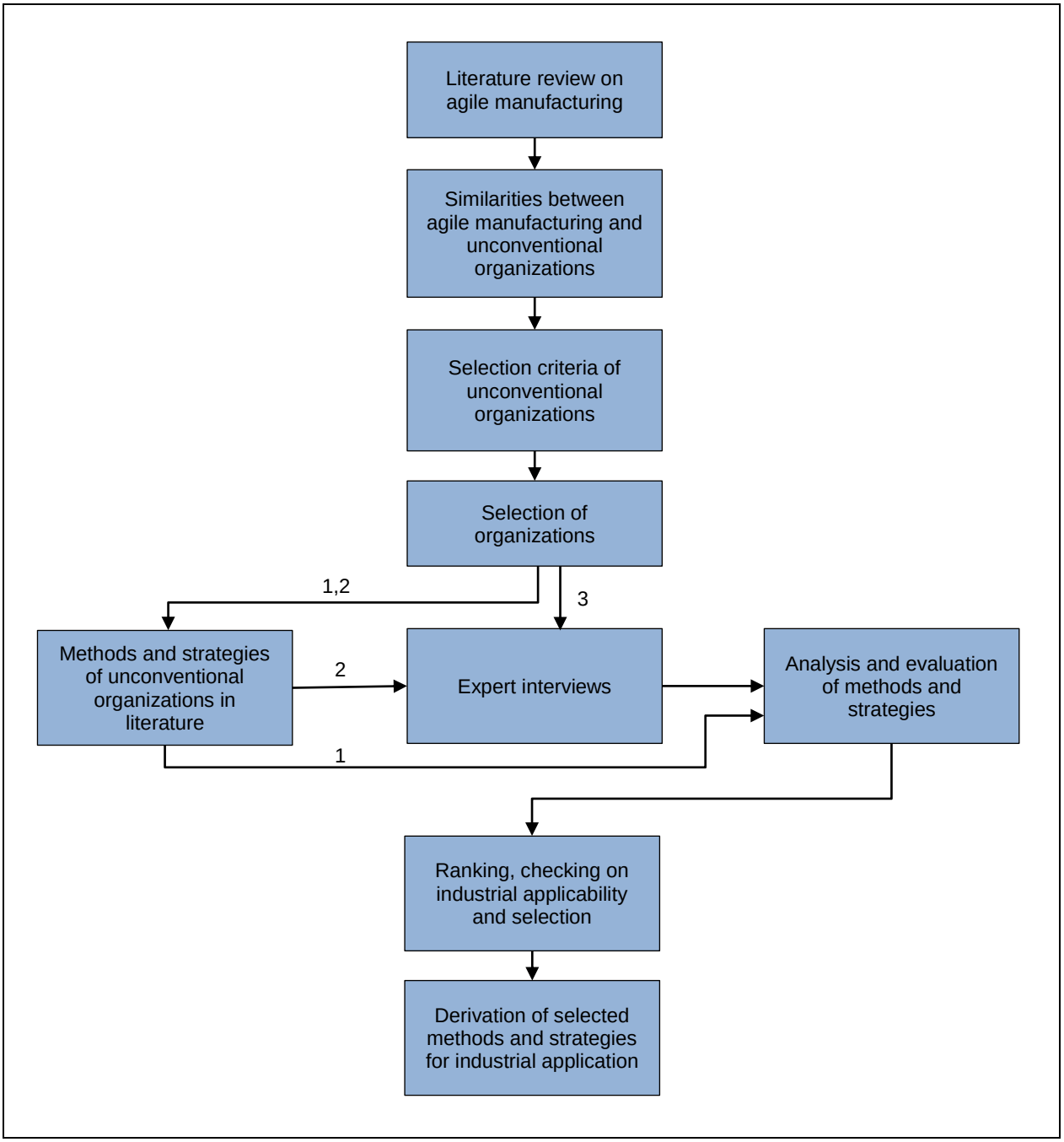


Figure 1: Study design

literature are internet search engines (ScienceDirect, Google Scholar and Scopus[9]) as well as physical libraries (Graz University of Technology and Karl-Franzens University of Graz). The literature research and management as well as citations were conducted under the guidelines of Töpfer.[10]

[9] http://www.sciencedirect.com, http://scholar.google.at, http://www.scopus.com
[10] cf. Töpfer (2012)

The aim of the literature review is the finding of a definition for agility, delimitation to other manufacturing paradigms and key characteristics of the agile manufacturing principle. Based on these characteristics, the similarities between unconventional organizations and agile manufacturing can be pointed out. By formulating the attributes of agile manufacturing in a general context, the necessary criteria for unconventional organizations can be determined. The selection of the organizations that meet the necessary criteria can be seen as the next process step.

After the selection of the organizations, three different approaches for the investigation of the methods and strategies emerge:

1. The methods and strategies described in literature are explained in a detailed way with sufficient information. That enables the direct path to evaluation and analysis.
2. The methods and strategies are only mentioned in the respective literature. Thus, further information on the topics is gathered through interviews with experts of the chosen organizations.
3. The required information cannot be found in literature and is not available in publications due to various reasons like secrecy issues. The information is acquired through expert interviews.

After inquiring the necessary information, the methods and strategies are analysed, evaluated and implemented in an adequate framework. Based on this framework, the findings are ranked in respect to a manufacturing environment. Therefore, a rating system is developed and applied. Thus, the most promising methods for an industrial application can be determined. These highest ranked methods are further investigated and agile measures and strategies for the usage in the manufacturing industry are derived and formulated.

2 Literature review and definitions

In this section, the important terms and notions are defined and a delimitation of the different manufacturing paradigms is provided. First of all, the drivers that force companies to change are described. Afterwards, the different classes of changeability are distinguished and finally, the major changeability classes flexibility, transformability and agility in manufacturing are described.

2.1 Change drivers

Nowadays, companies in the manufacturing industry operate in a turbulent environment. This competitive environment is dominated by technology, internationalization of markets and the constant change of demand and supply. Almost all factors outside of a company are changing dynamically. In addition to the external system, the internal system has to be seen as dynamic too. Changes in the internal organization, the availability of resources and fluctuations in performance act destabilising on the production system.[11]

Figure 2 shows the turbulent influences on a manufacturing system and an allocation into internal and external factors. The external factors are represented by the four major drivers economy and finance, markets, environment as well as social and political factors. These drivers influence the economy of all industrial nations. The internal factors describe the fields in which the dynamic adaption of industrial production has to take place to sustain competitiveness.[12]

Further examples for internal factors are strategic decisions like the development of new markets, the reorganizations of the company due to a new management or the utilization of new technologies. Additional external impulses are the customers' wish for individualized products, new competitors on the market or fluctuations in sales.[13]

All these influences on a production system are termed change drivers. Change drivers affect the production system in the dimensions of change. The dimensions of change are quantity, variants, process quality, costs and time. Due to the constant confrontation with change driver, companies are forced to constantly adapt.[14]

[11] cf. Westkämper and Zahn (2008) p. 9
[12] cf. Wiendahl et al. (2007) p. 783
[13] cf. Wiendahl et al. (2014) p. 16f
[14] cf. Nyhuis et al.(2013) p. 21

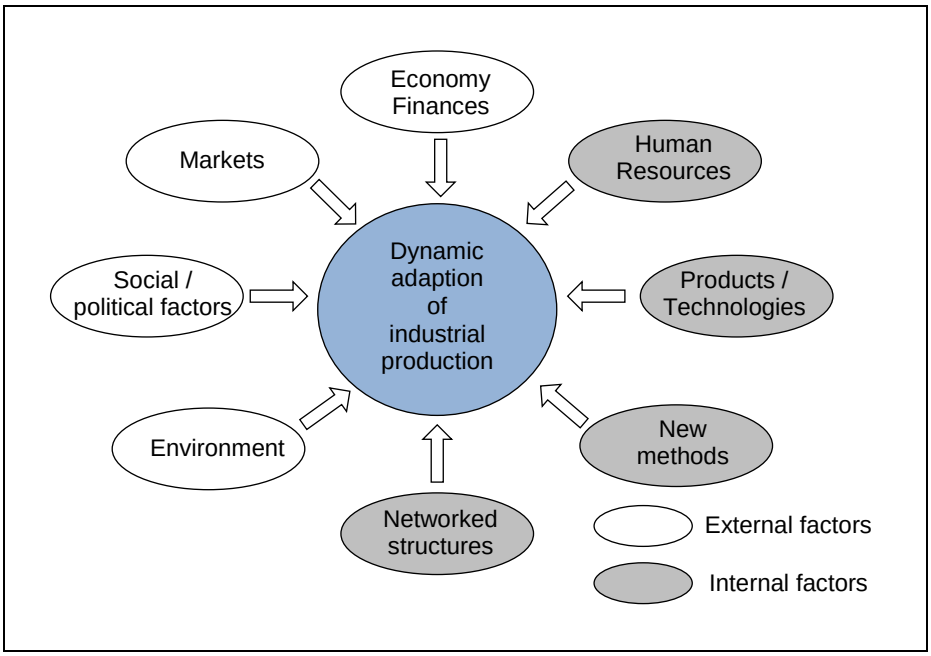


Figure 2: Turbulent influences - Dynamic adaption of industrial production[15]

It has to be pointed out that a classification of change drivers cannot be easily determined. Companies have different characteristics, face different changes in different circumstances that are unique for a certain company. Changes that are harmful for one company might not be harmful for another company or even for the same company in another situation. On the contrary there are common characteristics in change that lead to the same consequence for every company.[16]

To meet today's challenges of constant change due to the various change drivers of the business environment, several manufacturing strategies and principles have evolved over the last decades. The basic model to define the classes of changeability is described in chapter 2.2.

2.2 Classes of changeability

Due to the effect of various change drivers on a production system, today's companies have to develop certain prerequisites for the successful participation in the dynamic and global production network. The production processes, resources, plant structures, manufacturing systems layouts and the logistical and organizational concepts need to be adaptable. This adaptation has to be accomplished quickly and with low effort. This

[15] Wiendahl et al. (2007) p. 783
[16] cf. Sharifi and Zhang (1999) p. 15

is necessary for production companies to withstand the continuous changes and the turbulent manufacturing environment. This ability can be describes as changeability.[17]

To distinguish between different classes of changeability, Wiendahl et al. introduced a model consisting of two dimensions and five structuring levels (figure 3). The first dimension is the hierarchy of product levels, starting with the product portfolio a company offers on the market. The product portfolio consists of individual products which are usually built up by assembly groups or sub products. The sub products consist of work pieces which are then again subdivided into the smallest structuring level, features.[18]

The second dimension describes the five structuring levels when it comes to classify a factory in a resource–based view like technical and human resources:[19]

- The smallest level in this model is a single workstation that consists of processes. Workstations perform value adding operations like work piece or tool handling.
- The workstations are usually arranged into cells. Here, all the necessary operations to finish a work piece or assembly are performed. Some of these operations are conducted by workers and some are accomplished by machines. The term system is used to refer to manufacturing systems and assembly systems if the processes are automatically interlinked on a high degree.
- The third level is segments where the entire product is manufactured to be ready to ship. A common structure of the segments is manufacturing, assembly, buffers, quality management devices etc.
- The next structuring level is a site. In a site several segments are pooled. It is a production unit that servers as a node to connect a production network or a supply chain.
- The highest level of this dimension is the network. It consists of multiple production units that are linked by the supply chain. In the network, material and information flows along the supply chain.

Furthermore the different responses to variations in demand or changes of variants can be allocated to the changeability classes. Through this allocation, the organizational level on which the responses are taking place can be distinguished. Here, the classes

[17] cf. ElMaraghy (2009) p. 6
[18] cf. Wiendahl et al. (2007) p. 785
[19] cf. ElMaraghy (2009) p. 12

of changeability refer to the systems and products of a company on the level of a general structure.[20]

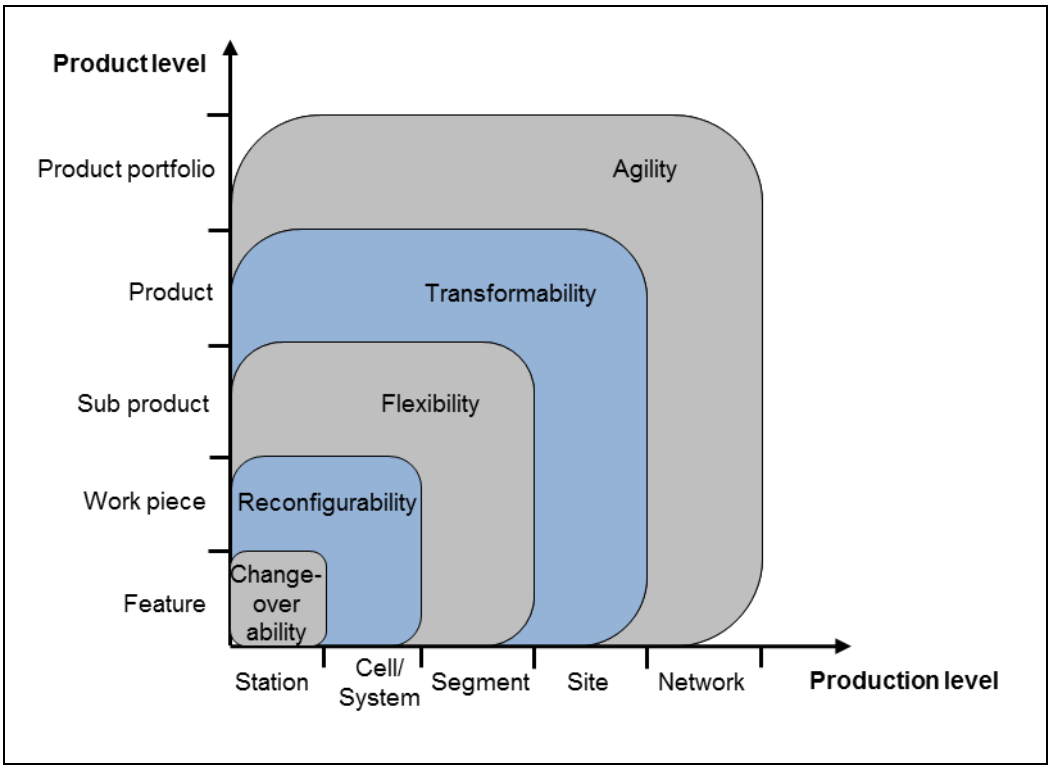


Figure 3: Classes of changeability[21]

Using these definitions, five classes of changeability can be distinguished and illustrated. Changeover ability is the first class of changeability. It describes an operative ability of a single machine or workstation to perform operations on a work piece at any moment and with minimal effort and delay. The second operative ability in the matrix is reconfigurability. It describes the ability of a manufacturing or assembly system to switch between particular families of work pieces or subassemblies with minimal effort and delay. This becomes possible due to the addition and removal of functional elements.[22]

Since the definition of the different changeability classes flexibility, transformability and agility in manufacturing vary from author to author and even between languages, the next chapters are used to give an insight in some of the most influential approaches.

[20] cf. Spath (2008) p. 12
[21] Wiendahl et al. (2007) p. 786
[22] cf. Wiendahl et al. (2007) p. 786

2.3 Flexibility in manufacturing

Flexibility in manufacturing can be seen as the ability of a system to move quickly from one state to another. It can change and assume different positions in response to changing conditions. The reactions and changes can be performed with little penalty regarding time, effort, cost, or performance.[23]

There are various definitions and classification of flexibility in the manufacturing industry throughout the literature. One of the most consistent classifications of manufacturing flexibility is the classification of Slack. This classification proposes four types of flexibility:[24]

- Product flexibility: the ability to develop or modify products
- Mix flexibility: the ability to produce a mix or change the mix of products
- Volume flexibility: the ability to change the level of output
- Delivery flexibility: the ability to change delivery dates

Furthermore, every type of flexibility can be divided into two dimensions, range flexibility and response flexibility. Range flexibility is defined as the ability of a system to change from one state to another. A system is considered to be more flexible than another if it is able to produce wider ranges of products or produce different levels of output. The second dimension, response flexibility, is defined as the ability of a system to move from one state to another. A system that is able to move to other states with minimum effort in time and costs is considered to be more flexible than a system which is able to do the same but with a considerably higher effort.[25]

Additionally to the four types of flexibility already mentioned, Gunasekaran suggest a complementary fifth type of flexibility: “system robustness” flexibility. This type defines the ability of a system to overcome unplanned changes. These changes can be changes in the process like machine breakdown or changes affecting the input side like faulty deliveries.[26]

To clarify the conditions under which a manufacturing system can be described as flexible, Browne et al. defined and described eight types of flexibility as to be seen in table 1. He states that flexibility and automation are the key requirements of flexible

[23] cf. Toni and Tonchia (1998) p. 1591
[24] cf. Slack (1989) p. 35-45
[25] cf. Slack (1989) p. 35-45
[26] cf. Gunasekaran (2001) p.16

manufacturing systems, but the important characterises are the extent of the automation of the system as well as the diversity of parts this system can produce.[27]

Flexibility type	Definition
Machine	the ease of making the changes required to produce a given set of parts
Process	the ability to produce a given set of part types, each possibly using different materials, in several ways
Product	the ability to changeover to produce a new (set of) product(s) very economically and quickly
Routing	the ability to handle breakdowns and to continue producing the given set of parts
Volume	the ability to operate an FMS profitable at different production volumes
Expansion	the capability of building a system and expand it as needed, easily and modularly
Operation	the ability to interchange the ordering of several operations for each part type
Production	the universe of part types that the FMS can produce

Table 1: Taxonomy of flexibility types[28]

A comprehensive analysis of the literature was conducted by Sethi and Sethi in 1990 to clarify the term manufacturing flexibility. For this purpose the authors reviewed the discrete parts of manufacturing like job shops, assembly lines, flexible transfer lines, flexible manufacturing systems (FMS) and flexible assembly lines. Eleven types of flexibility are proposed in this study, consisting of three new types in addition to the eight classes of Brown's original taxonomy (table 2).

Flexibility type	Definition
Material	flexibility of a material handling system is the ability to move different part types efficiently for proper positioning through the manufacturing facility it serves
Program	the ability of the system to run virtually unattended for a long period
Market	the ease with which the manufacturing system can adapt to a changing market environment

Table 2: Additional flexibility types in addition to Brown's taxonomy[29]

Furthermore, Sethi and Sethi provide a distinction of these flexibilities into basic flexibilities, system flexibilities and the aggregated flexibilities. The linkage of the different flexibility types can be seen in figure 4. The figure shows that the basic or component flexibilities contribute to the different flexibilities of the system. These in turn

[27] cf. Browne et al. (1984) p. 114
[28] cf. Browne et al. (1984) p. 114f
[29] cf. Sethi and Sethi (1990) p. 300-313

influence the aggregate flexibilities in a certain way. Seen from another perspective, the flexibility a firm wants to accomplish in its manufacturing strategy dedicates the system flexibilities and, in turn, the component flexibilities that have to be available. The figure also shows that the organizational structure and the microprocessor technology are subject to all of the flexibilities.[30]

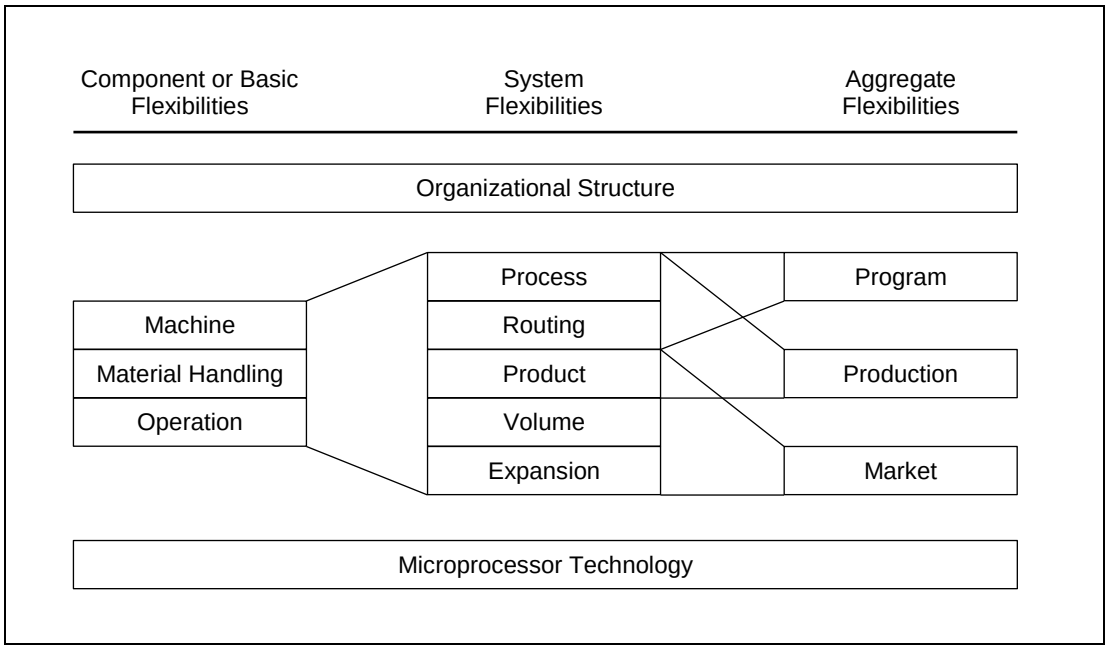


Figure 4: Linkages between various flexibilities[31]

In general, the research on manufacturing flexibility can be broken down to choices (techniques, methods, and criteria) that companies take to obtain flexibility. Although there are many articles concerning this subject, most of articles agree on dividing the choices into:

- design choices, which are technological, plant, or hardware choices;
- organizational-managerial choices, known as software choices.

The majority of articles on flexible manufacturing systems deals with technological choices. In this view, a FMS is composed of technological means to obtain a flexible manufacturing strategy. On the other hand, organizational-managerial choices describe the most suitable organizational solutions and management practices to gain flexibility.[32]

[30] cf. Sethi and Sethi (1990) p. 313
[31] Sethi and Sethi (1990) p. 297
[32] cf. Toni and Tonchia (1998) p. 1608

Most manufacturing industries use a combination of dedicated and flexible manufacturing systems to produce their products. Dedicated manufacturing lines (DML) are based on inexpensive fixed automation and are typically designed to produce a single part at a high production rate. These manufacturing systems are cost efficient as long as they can operate at full capacity. “Flexibility” for DML is mainly the preparation of additional, unused production capacities.[33] On the other hand, Flexible manufacturing systems consist of expensive, general-purpose computer numerically controlled (CNC) machines and programmable automation. However, due to the single-tool operation of CNC machines, the throughput is lower. In combination with the high equipment costs the costs per part are relatively high. Furthermore, the production capacity of FMS is usually lower than that of dedicated lines.[34]

Flexible manufacturing systems were developed as a response to the needs of mass customization with a higher ability to adapt to changes in product, production technology and markets. Flexible manufacturing systems deal with those changes by the anticipation of several variations and with in-advance built-in flexibility. The aim is to produce several types of parts with minimum changeover costs. The parts are pooled into pre-defined part families that can change over time. Furthermore, the parts are manufactured on the same system in the required volume and quality.[35]

Zhang investigates the relationship between different flexibility manufacturing competences and customer satisfaction (figure 6). Machine flexibility is the ability of equipment to perform different operations in a very effective way. Labour flexibility describes the ability of the workforce to perform multiple tasks efficiently. Material handling flexibility is the ability to move different work pieces using various paths between processing centres and routing flexibility which is the ability to effectively use multiple routes to process a predefined set of parts. These are internal competences that could be influenced by the company and have a positive impact on volume flexibility and mix flexibility. These two capabilities can be seen by the customer and are therefore considered to be external elements. Volume flexibility is the ability of a company to produce various patch sizes and master different output levels in an effective and efficient way. Mix flexibility is the ability of producing different products. Both of these capabilities should increase customer satisfaction.[36]

[33] cf. Abele et al. (2006) p. 435
[34] cf. Koren et al. (1999) p. 527f
[35] cf. ElMaraghy (2005) p. 262
[36] cf. Zhang (2003) p. 177ff

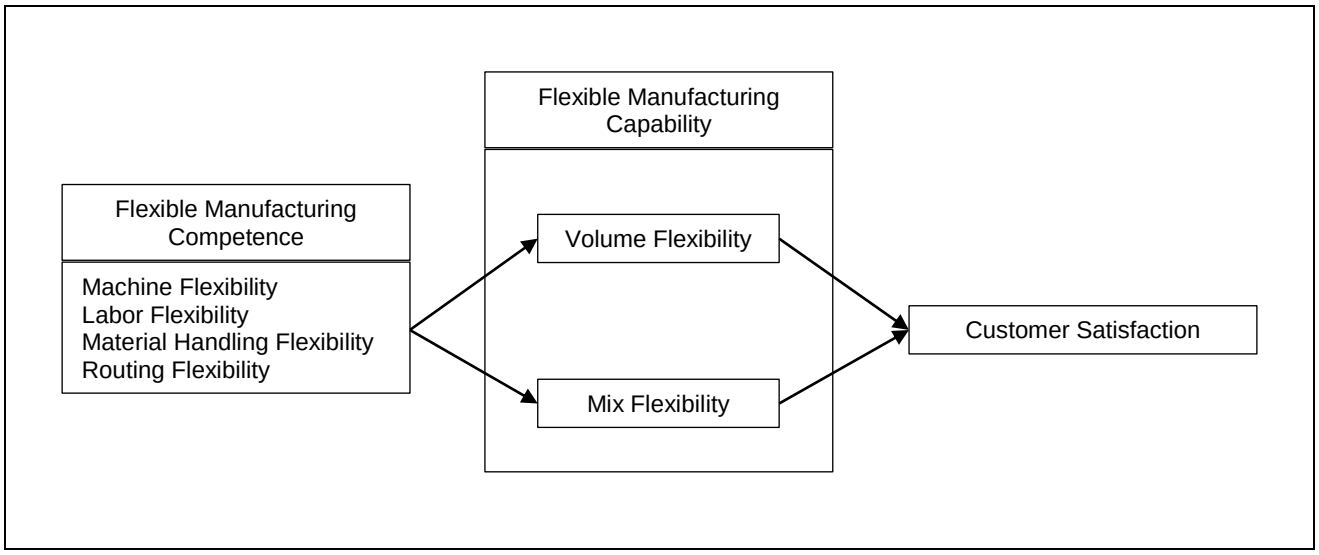


Figure 5: Impact of flexible manufacturing competence on capability and customer satisfaction[37]

On today's fast changing environment, manufacturing companies need to consider their reactivity and flexibility in investment decisions. These decisions become even more difficult when investing into flexible manufacturing systems due to the manifold possibilities of adaptions for the systems. Because of the difficulty to measure the potentials of flexible systems, dynamically cost efficient investment solutions are still rare in practice.[38]

Furthermore, Beach et al. state that manufacturing flexibility is more than an independent variable that could be defined and measure on its own. It is a multidimensional concept that is composed of various enablers like corporate culture, management structure, process technology, facility layout and information systems. Manufacturing flexibility has a strategic and an operational dimension.[39]

To sum it up, flexibility is the potential of a production system to quickly react to change drivers in a cost-efficient way. The production system can be adjusted in various dimensions of change like quantity, variants, costs, time and process quality. However, the scale of which a production system is able to be adjusted is limited by a pre-defined flexibility corridor.[40]

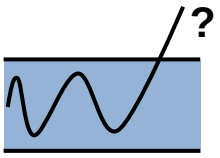
The concept of pre-defined corridors is shown in figure 6 and will be further described in chapter 2.4 since it serves as a linkage between the changeability classes of flexibility and transformability in manufacturing.

[37] Zhang (2003) p. 176
[38] cf. Abele et al. (2006) p. 436
[39] cf. Beach et al. (2000) p. 47
[40] cf. Nyhuis 2008) p. 14

2.4 Transformability in manufacturing

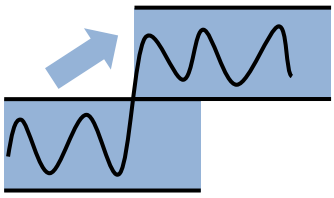
The changeability class on the next higher level is transformability in manufacturing. Especially German researchers focus on this type of changeability. The German translation of the term transformability is “Wandlungsfähigkeit”.

Transformability is manufacturing concept that goes beyond flexibility. As described in the previous chapter, flexibility considers changes like quantity or product variants during the planning phase. These variations can be managed, but the extension of the possible adaptation is restricted to pre-defined flexibility corridors. Manufacturing transformability exceeds flexibility as it enables the reaction to changes which cannot be forecasted during the planning phase. Transformability is given if even severe fluctuations in demand cannot only be treated within a defined quantity corridor, but instead these corridors can be flexible adjusted to a certain demand. Transformable manufacturing systems are conceived in a way that they are open to future developments and have enough space rather than integrating predicted functions and capabilities in an existing system.[41] A comparison of some of the most important differences between these two changeability classes can be seen in figure 6.



Flexibility

- change in a given corridor
- has to be installed preemptively, pre-defined resources



Transformability

- process from the need for change to implemented, functioning measures
- sustainable modification
- structural adjustments within the company
- potential for efficient assignment of resources (funds, technology, material, energy, personnel)

Figure 6: Comparison of flexibility and transformability[42]

[41] cf. Nyhuis (2008) p. 14
[42] Spath (2008) p. 12

Furthermore, transformable manufacturing systems need the ability to be adjustable to the various dimensions of change. These adjustments need to go beyond the pre-defined flexibility corridors. Additionally the changes have to be reactively and proactively possible. Another important characteristic is the acceptable effort which has to be expended to active transformability. Only if the predefined transformability in the manufacturing system can be activated with low effort in time and costs, transformability is able to increase the competitiveness of a company.[43]

In general, companies are considered to be transformable if the structure of the organization and resources can permanently be adjusted according to changing order situations and requirements. The time horizon of these adjustments can be short-term, mid-term or long-term. Essential for the consideration are the structures from resources of single processes, workstations, facilities up to the structures of sites and networks. Short-term measures are changes in of processes, machines, systems or factory layouts while long-term measures deal with network design of factories.[44]

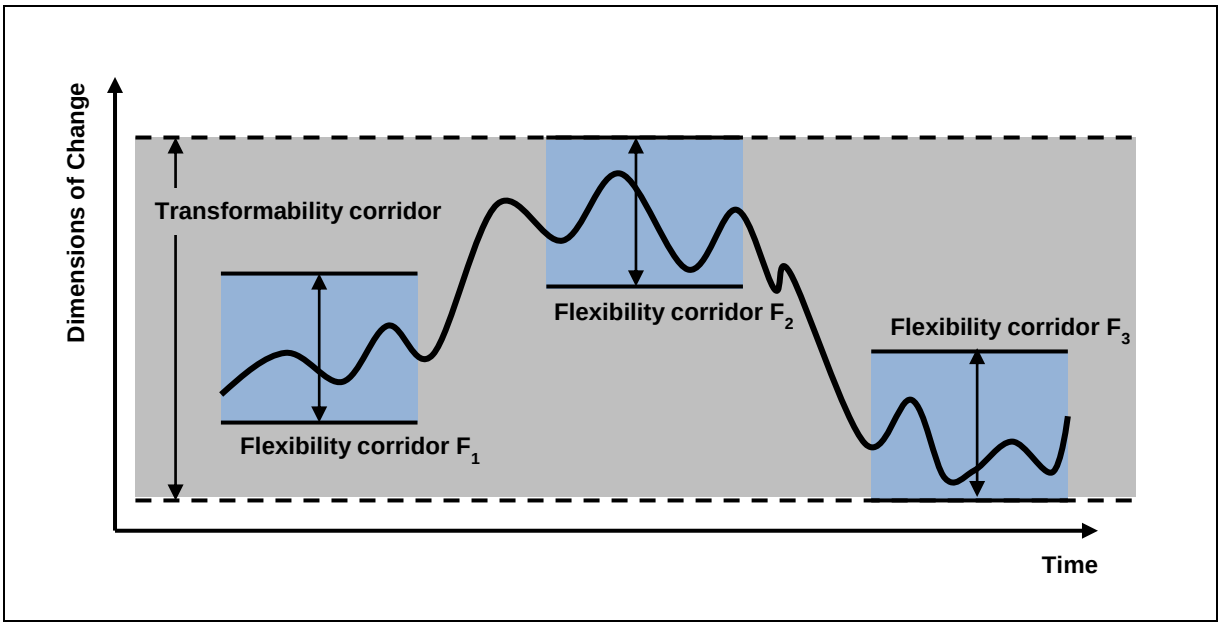


Figure 7: Illustration of the transformability concept[45]

A model in which transformability is described and the changeability classes transformability and flexibility are linked is shown in figure 7. On the vertical axis the dimension of change like quantity, variants, costs, time and process quality as well of

[43] cf. Nyhuis et al. (2010) p. 8
[44] cf. Westkämper and Zahn (2008) p. 11
[45] cf. Wiendahl et al. (2014) p. 129

combinations of those are illustrated. On the horizontal axis the time is displayed. If a manufacturing system is affected by dimensions of change that are limited within a certain scale, the system can adjust to the changes by using the built-in flexibility.

This limited amount of change is described by the flexibility corridors. The necessary changes are undertaken within these corridors. Therefor technical or structural adjustments of the system are not necessary. If the dimensions of change exceed the pre-thought flexibility corridors, the system has to convert. This pre-defined space is a corridor in which the system is able to transform. An adaption outside of the predefined flexibility corridors in the pre-defined space is called transformability. This corridor is called transformability corridor. If the dimensions of change make a transformation necessary, the system is able to adapt to the changes by a structural rearrangement, whether it is by adding (flexibility corridor F_1 to F_2) or removal (F_2 to F_3) of equipment.[46]

On the factory level the change of objects is made possible by five transformation enablers. These enablers characterize the ability of a factory to transform and become only active when change is needed. The five enablers that help making the transformation process possible are universality, scalability, modularity, mobility and compatibility:[47]

- Universality is the characteristic of factory objects to be able to fulfil a range of tasks, demands, purposes and functions rather than one. The objects are designed and dimensioned overdesigned to ensure variety in functions and usage.
- Scalability is the technical, spatial and personnel adaptability. This enabler provides a factory layout with the ability to expand, growth or shrink.
- Modularity is the idea of standardized units and elements with standardized interfaces. Affected are both the technical facilities of a factory like buildings, production facilities or information systems as well as organizational structures like segments or functional units. The modules are working autonomously and can be interchanged and in a fast and cost-efficient way.
- Mobility is the ability to replace objects of a factory with little effort. The objects to be replaced can be production and auxiliary facilities, building elements as well as buildings.
- Compatibility allows interactions of all kinds of supply systems for production facilities, materials and media. This can be within or outside the factory. Furthermore compatibility makes the incorporation or disconnection of

[46] cf. Wiendahl et al. (2014) p. 128f
[47] cf. ElMaraghy (2009) p. 17f

products, product groups, components and production facilities in the existing production structures and processes possible. This can be feasible and effective by using uniform interfaces.

Although some authors claim that transformability goes beyond the factory level and includes the network[48], most of the scientific papers see transformability on the factory level and do not consider the value chain.[49]

To sum it up, transformability is a class of changeability that goes beyond flexibility. It allows a manufacturing system to move over pre-defined flexibility corridors. Transformability has the potential to apply changes in technological, logistical, organizational and personnel ways that go beyond the pre-defined flexibility. These changes are associated with an interaction of system elements, little investments costs and can be performed in a short period of time.[50]

As the system boundary of transformability is the factory level, elements that are above these boundaries are not considered like the supply chain, the production network as well as external partners. A class of changeability that takes those aspects into consideration is agile manufacturing.

2.5 Agility in manufacturing

Since the first introduction of agile manufacturing in 1991, the term has undergone many definitions. Since there is not one coherent definition to this day, some of the most cited and therefor probably most influential literature is reviewed. The following chapter gives an overview about the various definitions, models, core concepts, frameworks and characteristics of agile manufacturing.

The first publication mentioning the term agile manufacturing is found in the 1991 report "21st Century Manufacturing Enterprise Strategy" by the Iaccoca Institute. The report was conducted to help the U.S. industry to become world-class manufacturer in the 21st century. Agile manufacturing is defined as "a manufacturing system with extraordinary capability to meet the rapidly changing needs of the marketplace, a system that can shift quickly among product models or between product lines, ideally in real time to customer demand".[51]

[48] cf. Westkämper and Zahn (2008) p. 11
[49] cf. Nyhuis (2008) p. 99
[50] cf. Nyhuis et al. (2010) p. 10
[51] cf. Nagel and Dove (1991)

The vision of the agile manufacturing enterprise is based on three pillars: innovative management structures, flexible technology and the skill base of knowledgeable workers. The managerial structure of an agile company is highly flexible, intended to have a diffused authority and a loose chain of command to support the needs of cross-functional teams. Furthermore, the formation of virtual companies or the close cooperation of suppliers, producers and customers within networks is emphasised. Flexible technology describes a production system that is reconfigurable, continuously changeable, consists of machine tools that are modular and is information intensive. This manufacturing system is able to achieve the same production costs, independent of variant or quantity. A knowledgeable workforce is considered to be the greatest asset of an agile manufacturing company, for the capabilities of a production system is not the equipment but the abilities of the work force.[52]

Another important contribution to the development of agile manufacturing is given by Kidd. His work, which is based on the publication "21st Century Manufacturing Enterprise Strategy" of the Iaccoca institutes, describes agile manufacturing as "the integration of organization, highly skilled and knowledgeable people, and advanced technologies, to achieve cooperation and innovation in response to the need to supply our customers with high quality customized products".[53]

According to Kidd, key words and phrases that can be associated with the agile paradigm are "fast, adaptable, robust, virtual corporations, reconfiguration, dynamic teaming and transformation of knowledge." An agile company needs to have a high speed of response to exploit new market opportunities and is adaptable to enter completely new market areas. It is robust in terms of withstanding variations and reconfigurable to quickly change corporate structures, facilities, people, organization and technology to meet unexpected market opportunities. Furthermore, the combination of talents through virtual corporations and dynamic teaming to utilize creative and innovative talents of cross-functional team members is mentioned. Moreover, Kidd refers to the importance of transforming knowledge from raw ideas to product and service capabilities.[54]

Another highly influential researcher in the field of agile manufacturing is Gunasekaran. In his 1998 work "Agile manufacturing: Enablers and an implementation framework", he defines agile manufacturing as "the capability to survive and prosper in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services". To

[52] cf. Nagel and Dove (1991) p. 7-10
[53] cf. Kidd (1994) p. 10
[54] cf. Kidd (1995) p. 3f

effectively operate in the competitive environment, Gunasekaran defines key enablers to achieve agility in manufacturing. These key enablers are virtual enterprise, physically distributed manufacturing architecture and teams, rapid partnership formation, concurrent engineering, integrated business/product/production information systems, rapid prototyping tools and electronic commerce.[55]

Additionally to these key enablers, four dimensions that define the agile manufacturing enterprise are defined. The four dimensions value-based pricing strategies, cooperation that enhances competitiveness, organizational mastery of change and uncertainty and investments to increase the impact of people and information are defined in the model. These four dimensions are the cornerstones in his agile manufacturing framework.[56]

Those four dimensions for agility declared by Gunasekaran show some commonalities to the strategic dimensions proposed by Goldman et al. in 1995. The strategic dimensions can be used to describe an agility program for any company and are: enrichment of the customer by selling solutions, instead of only selling goods; teamwork in cross-functional teams and cooperation in virtual organizations to enhance competitiveness; enhance the impact of people and information for they are the major differences for companies in an agile environment; and mastering change end uncertainty by being flexible and reconfigurable.[57]

In a more recent publication Gunasekaran redefined these four dimensions for agility. He generalized the model and defined the cornerstones to be strategies, technology, people and system. This new framework for the design of an agile manufacturing system is shown in figure 8.

Strategies are options that agile manufacturers can utilize for making various resources available. Some examples are partnership formation, virtual enterprise, physically distributed manufacturing systems or rapid production development. Those principles are considered to be key strategies in agile manufacturing. The technology to enable agile manufacturing systems is based on, among other things, modularity for assembly hardware, flexible manufacturing cells, Electronic Commerce or computer-aided design/ computer-aided manufacturing (CAD/CAM). These technologies have to be incorporated under the scope of virtual enterprises to ensure compatibility. Computer-aided manufacturing and information systems such as MRP, enterprise resource planning (ERP) or CAD/CAM are needed to utilize for the principles of virtual enterprises, rapid prototyping and physically distributed manufacturing systems. A

[55] cf. Gunasekaran (1998) p. 1223
[56] cf. Gunasekaran (1998) p. 1233
[57] cf. Goldman et al. (1995) p. 73-75

motivated and properly managed workforce is considered to be the most crucial problem in an agile environment. For when the flow in information is interrupted, agility is lost. To overcome this obstacle, various techniques to enhance information and communication of an agile workforce can be applied.[58]

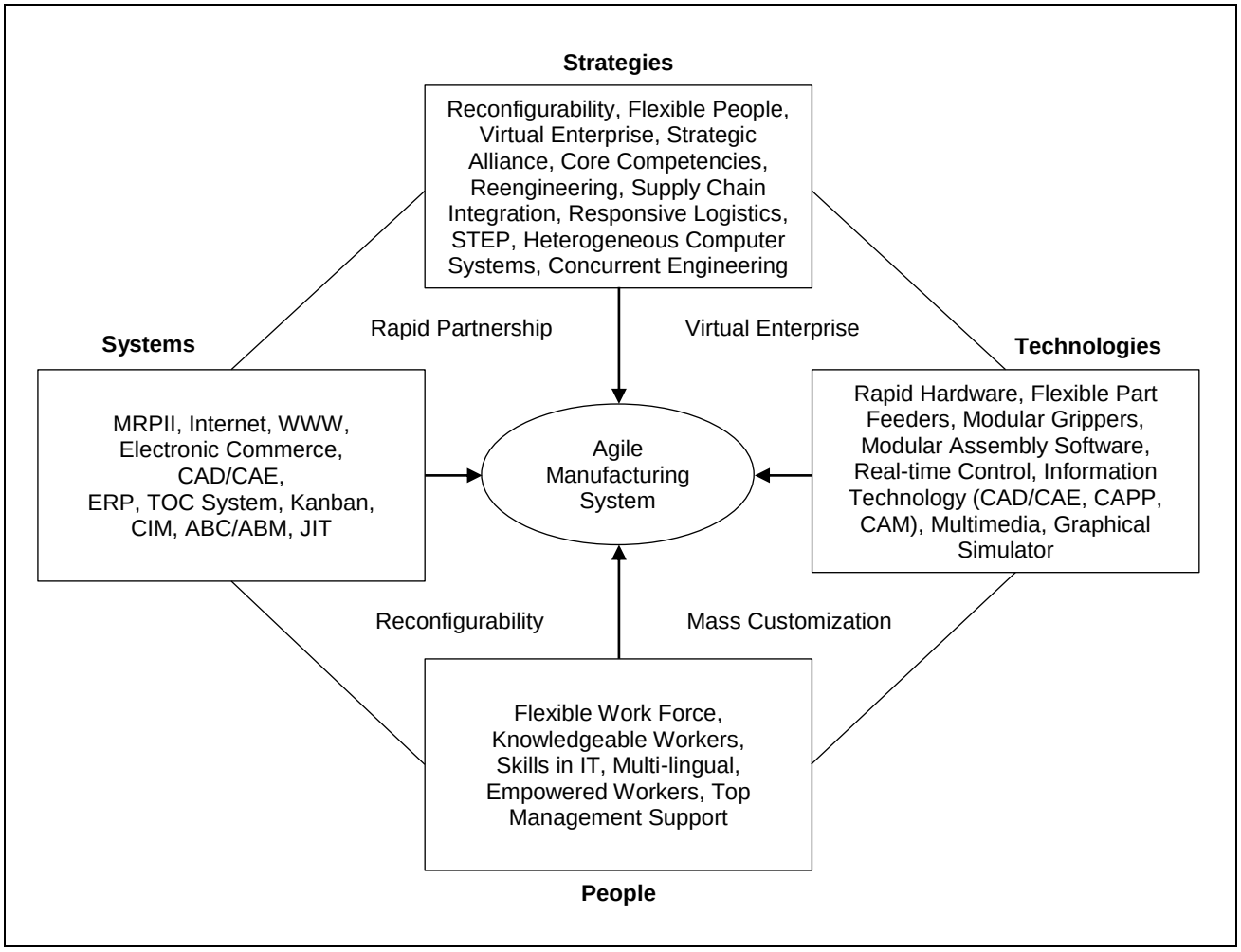


Figure 8: Development of an agile manufacturing system[59]

A theoretical model that combines the different ideas, frameworks and models of the previously mentioned authors (Kidd, Dove, Goldman et al. and Gunasekaran) is provided by Sharp et al. The base of the model consists of world class and lean manufacturing. Supported by this base the ten key enablers or pillars of agile manufacturing are defined. These pillars are: focus on core competences; virtual enterprise; rapid prototyping; concurrent engineering; multi-skilled and flexible people;

[58] cf. Gunasekaran (1999) p. 89-79
[59] Gunasekaran (1999) p. 100

continuous improvement; team work; change and risk management; information technology; and empowering. The top of the pyramid is expressed by the achieved agile manufacturing (figure 9). The model is used as a basis for measuring agility among 110 leading UK manufacturing companies. The findings of the research underline the already mentioned importance of an empowered, multi-skilled and flexible workforce embedded in a dynamic organizational structure.[60]

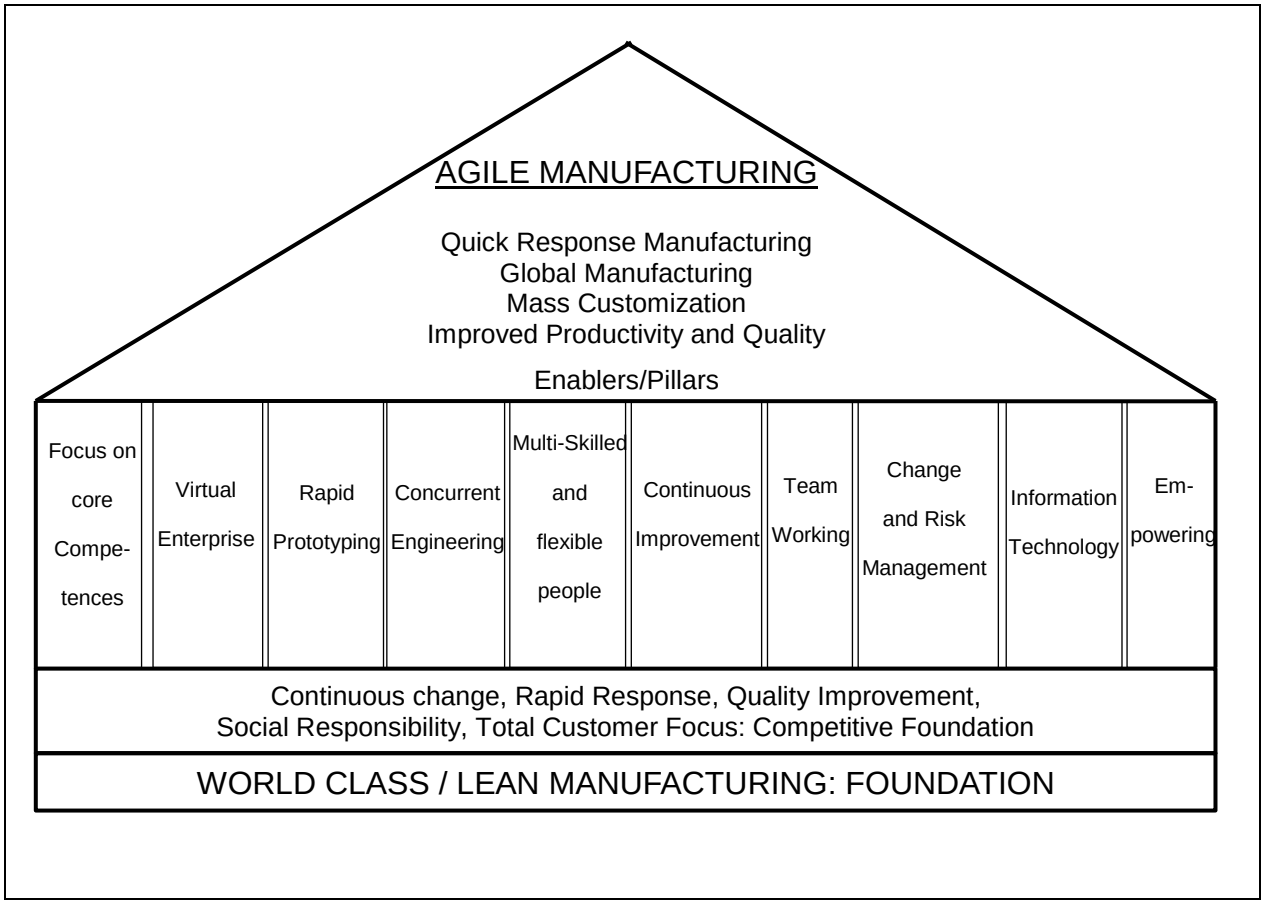


Figure 9: Theoretical model for agile manufacturing[61]

Work force management practices that are found to have a positive impact in times when flexibility is emphasised, are relationship-oriented practices, participative leadership and delegation. Relationship-oriented practices such as networking, team building, recognizing, supporting, mentoring, inspiring and rewarding play an important role during times of uncertainty. Furthermore, variability and uncertainty can be better handled with employees who are encouraged to suggest improvements, generate ideas

[60] cf. Sharp et al. (1999) p. 160-163
[61] Sharp et al. (1999) p. 161

and express concerns and doubts through empowerment. Otherwise do work-oriented practices like problem solving, clarifying, monitoring, informing, and planning not have any influence on managerial performance when flexibility is high.[62]

The core concepts of Yusuf et al (figure 10) also support the importance of the workforce. Core competences can be related to a company's workforce and product on two different levels, the individual and the company. Through investment and training the core competences of individual like skills and knowledge can be upgraded. The likewise use of core competences of partners and competitors in an interactive network ensures the rapid response to changing levels of demand. The cooperation of agile companies in virtual enterprises in the highest stages is characterized by the mutual work on a corporate and operational level. Agile teams work across company borders, knowledge, skills and resources are spread to quickly response to customer specifications. The capability of reconfiguration allows an agile company to shift the focus to other business areas, shift or change the product to realize opportunities on the market ahead of the competition. As knowledge and information become the key factors for successful businesses, a knowledge-driven enterprise uses the skills, knowledge and expertise of its highly skilled workforce to succeed.[63]

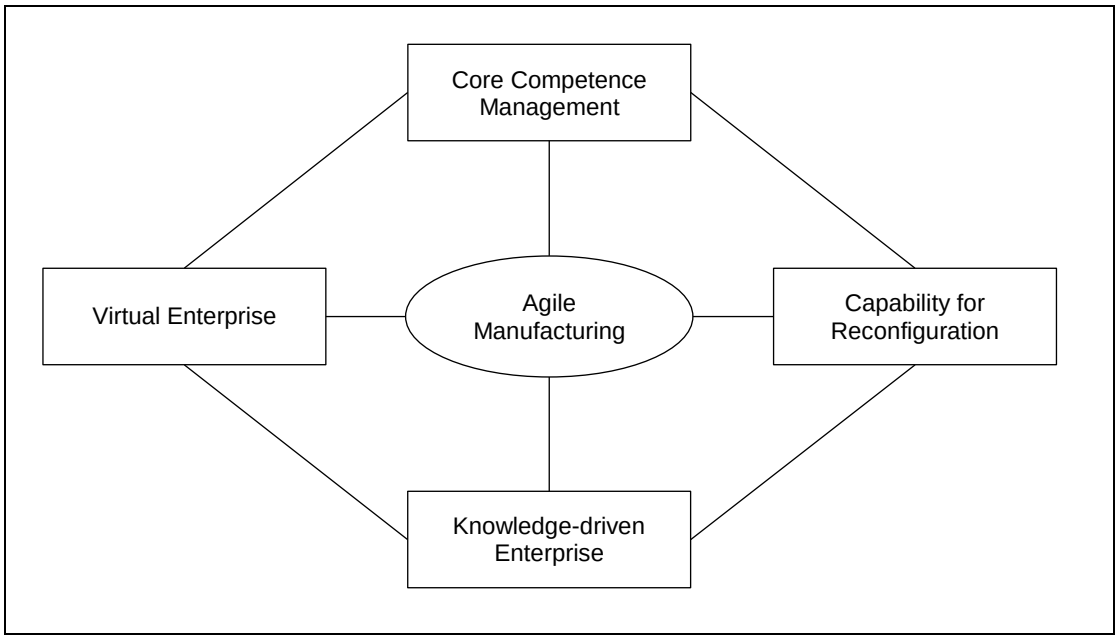


Figure 10: The core concepts of agility[64]

[62] cf. Ravi and Partovi (1999) p. 33f
[63] cf. Yusuf et al. (1999) p. 37-41
[64] Yusuf et al. (1999) p. 38

Another broadly recognized work on the development of agile manufacturing is the methodology of Sharifi and Zhang. The conceptual model consists of three main parts as shown on top of the model (figure 11). Agility drivers are the changes in business environment and force companies to apply new strategies while trying to gain competitive advantages. Based on various change drivers, agility capabilities that allow an agile organization to response properly to the changes are derived. These capabilities form the centre of the model and are responsiveness, competency, flexibility and speed. Responsiveness describes the ability to identify changes and response to them in a timely manner, either reactively or proactively.

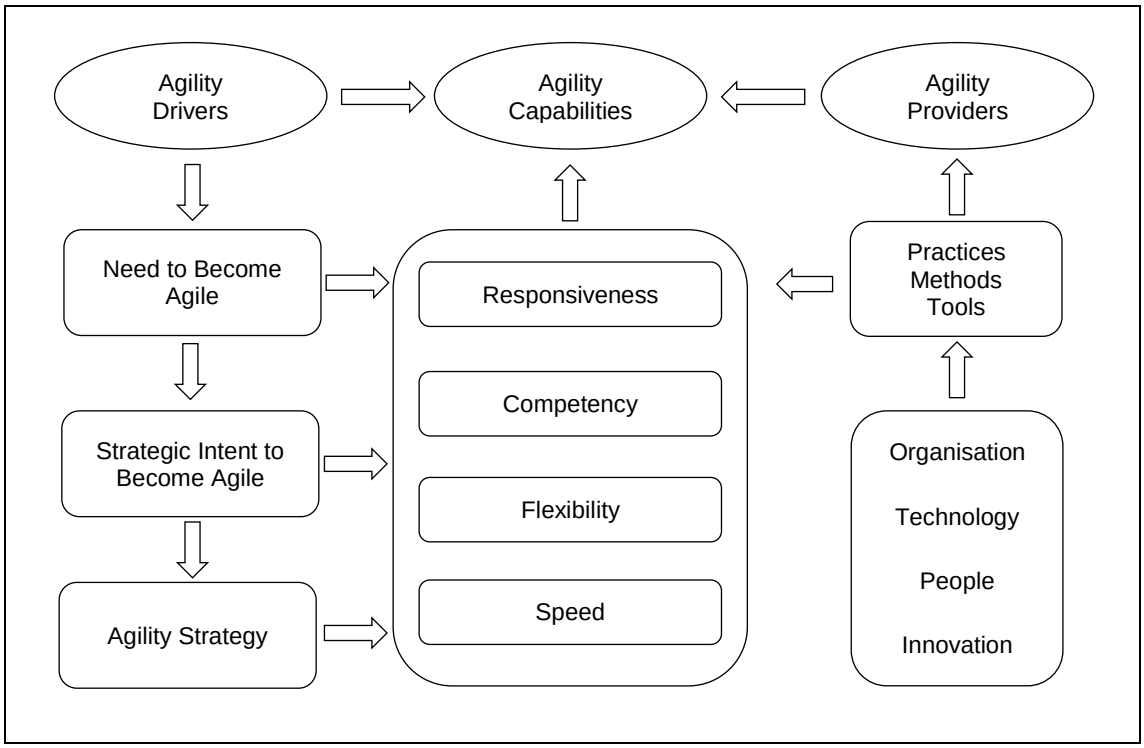


Figure 11: A conceptual model of agility[65]

Competency defines the capability of a company to provide productivity, efficiency and effectiveness for the activities to achieve the goals. Flexibility is the ability of a production system to process a different range of products in terms of volume or configuration, organizational flexibility as well as people flexibility. Speed or quickness allows an agile company to accomplish tasks and operations in the fastest possible way. Finally, agility providers are the required practices, tools, models and methods that are applied to all levels of the organization, from top management to shop floor level, to

[65] Sharifi und Zhang (1999) p. 11

gain the required capabilities. The providers can be classified due to the four major areas of manufacturing: organization, technology, people and innovation.[66]

One contribution that focuses on the profitability aspect of agility is the work of Schurig et al. According to their definition, agility is “a concept to actively prepare for uncertainty to gain the ability to react to changes in the shortest possible time. The goal is the continuous optimization of one company’s financial situation.” The positive effect of agile production, in comparison to flexible production, on the improvement of earnings before interest and taxes (EBIT), return on investment, cash flow or market share during changes to higher demand is illustrated in figure 12. Furthermore, a negative financial impact in times of negative demand fluctuations can be prevented.[67]

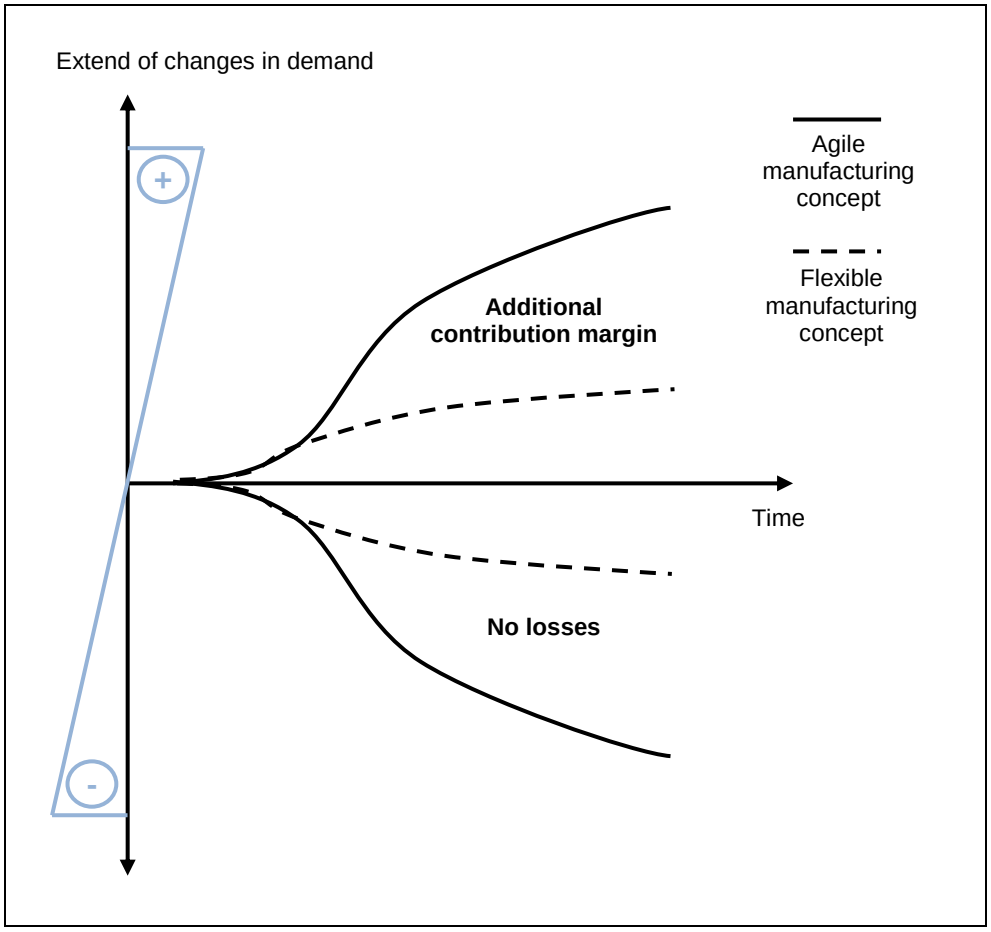


Figure 12: Concept for agile production[68]

[66] cf. Sharifi und Zhang (1999) p. 15-18
[67] cf. Schurig et al. (2014) p. 957
[68] Schurig et al. (2014) p. 957

To sum it up, agile manufacturing is a concept that allows companies competing in today's volatile business environment to react fast and efficiently to changes and uncertainty. To meet these challenges, an agile company prepares proactively for possible changes to gain competitive advantages. Agility allows a company to realise opportunities in case of rising demand and to minimize losses during times of decreasing demand. Flexibility and transformability are components of agility, but agility moreover uses agile capabilities along the whole value chain.

3 Mutual agile capabilities and interconnection

In this section, an interconnection between agility in the manufacturing industry and unconventional organizations is provided. First, some of the most important characteristic and essential capabilities for agile manufacturing, as mentioned in the literature, are described. Based on these properties, the necessary capabilities that unconventional organizations need to provide in order to be investigated, are described. Finally, a definition for the term “unconventional organizations” is given and the chosen organizations are named as well as introduced.

3.1 Key attributes and capabilities in agile manufacturing

When it comes to agile manufacturing, a great number of capabilities and characteristics have emerged in the literature. By conducting a literature review on some of the most influential articles and papers on the topic of agile manufacturing, the key capabilities for agile manufacturing can be determined. It has to be mentioned that there are numerous other key capabilities for agile manufacturing like profitability, but for the scope of this work, the most adequate capabilities are speed, flexibility, proactivity and innovativeness.

Table 3 provides an overview of the literature that was reviewed to determine the key capabilities. An “X” indicates that the agile capability is considered to be very important and is included in their definition for agility. A “0” indicates that the capability is not considered as important and is not included in the definition.

Author(s)	Speed	Flexibility	Proactivity	Innovativeness
Nagel and Dove (1991)	X	X	X	0
Kidd (1994)	X	0	X	0
Goldman et al (1995)	0	0	X	0
Gunasekaran (1998)	X	X	0	0
Yusuf et al (1999)	X	X	X	X
Sharp et al. (1999)	X	X	0	0
Sharifi and Zhang (1999)	X	0	X	X
Dove (2001)	0	X	0	X
Brown and Bessant (2003)	X	X	X	0
Jin-Hai et al. (2003)	X	X	X	0
Sherehiy et al (2007)	0	0	X	X

Table 3: Agility capabilities in literature

Speed

Speed, or quickness, is one of the most important qualities of agile companies to survive or gain a competitive advantage in today's fast changing business environment. Speed has to be achieved in all levels of the organization, from production and organization to employees.

On the organizational level, the formation of partnerships, temporary alliances and virtual enterprise allows a quick response to the market which might not be possible for single enterprises.[69]

Bringing new products to the market and deliver services or products in the fastest possible way is a crucial capability when competing against rivals. Speed, or quickness, is the ability to perform tasks and operations as quickly as possible.[70]

An agile enterprise can take advantage of speed by entering markets before competitors do. Through shifting their focus, diversify and re-align the scope of their business, new products can proactively be introduced to the market in order to quickly gain opportunities.[71]

Electronic commerce shortens the time to respond to customer needs while shorter product development cycles can be accomplished through concurrent engineering. Moreover, the importance of rapid prototyping to further shorten product development cycles must not be neglected.[72]

When it comes to personnel, employee empowerment is a concept to enable employees to take decisions and quickly respond to various situations which can highly improve the rate of order fulfilment.[73]

The speedy development of new skills and the quick acquisition of skills needed for changes in business process are considered two of the most important factors for workforce agility.[74]

Flexibility

Flexibility is the ability to process different products and achieve different objectives by using the same facilities. From a technological perspective, flexibility is the ability to

[69] cf. Gunasekaran (1998) p. 1233
[70] cf. Sharifi und Zhang (1999) p. 18
[71] cf. Yusuf et al. (1999) p. 39
[72] cf. Gunasekaran (1998) p. 1232
[73] cf. Yusuf et al. (1999) p. 40
[74] cf. Sherehiy et al. (2007) p. 453

produce different production volumes, product models or configurations. Additionally, organizational and organization issues flexibility as well as people flexibility can be distinguished.[75]

Furthermore, for the utilization of operational flexibility in manufacturing systems, the role of a knowledgeable workforce cannot be overstated as the employees are the most flexible components of the system. Flexibility within organizational structures of a company like flat hierarchies, matrix organization, cross-functional teams and loose boundaries between different functions and units improve the responsiveness to internal and external changes.[76]

Flexibility in product volume and product models can be accomplished by flexible or reconfigurable manufacturing systems. Reconfigurable manufacturing systems use easily upgradeable systems for new technologies and new functions whereas flexible manufacturing systems use built in generalized flexibility.[77]

Proactivity

In a highly competitive and volatile environment companies have to sense and anticipate changes and must react proactively. A proactive strategy offers an advantage when competing in turbulent global markets. In order to be able to achieve advantages trough anticipation, a successful company integrates the knowledge into technical and social capabilities. Those capabilities are based on technology, machinery, functions, strategies, people and management.[78]

A knowledgeable and empowered workforce is often mentioned as the most important asset of an agile company. Through the proactive anticipation and solution of change-related problems, employees enable agility on all levels of a company. A positive attitude to changes and new ideas helps implementing new technologies and processes during uncertain situations.[79]

Innovativeness

For agile companies, innovation is an indicator for good scope of change. Innovations that go to market create positive effects for the company by providing a meaningful and

[75] cf. Sharifi and Zhang (1999) p. 18
[76] cf. Sherehiy et al. (2007) p. 458
[77] cf. ElMaraghy (2005) p. 261
[78] cf. Yusuf et al. (1999) p. 35
[79] cf. Sherehiy et al. (2007) p. 457

positive value for the customer. Furthermore, innovations are self-initiated changes on the part of a producer.[80]

A high degree of innovativeness allows a company to react to changes in the competition criteria by increasing the rate of innovations.[81] These customer-driven innovations are a response to changing market requirements to increase customer satisfaction with new product introductions.[82] An environment of "culture of change" is supportive to innovativeness through a positive and fearless attitude to changes, different opinions, new ideas, and technologies.[83]

3.2 Agile attributes of unconventional organizations and definition

The contents of this section are the similarities between agile manufacturing and non-manufacturing organizations and industries and their mutual characteristics. Therefore, the major capabilities of agile manufacturing described in chapter 3.1 will be transformed in a non-manufacturing scope. By describing these general attributes and capabilities, the selection criteria for unconventional organizations can be determined. Furthermore, the definition for unconventional organizations is derived. With the selection criteria and the definition for unconventional organizations, the appropriate organizations to be investigated are chosen and explained in chapter 3.3.

Speed

As for the manufacturing industry, speed is one of the most important factors. A quick and proper response to certain events is a core competence of unconventional organizations. Actions to handle various events can be planned, but some level of uncertainty still remains and cannot be excluded. Hence the organizations have to adapt and react in the fastest way possible.

One aspect of the need for speed comes from the mission of certain organizations to prevent danger to life and limp or to protect and to help. Another aspect is the need for quick help during disasters and catastrophes. This can be on a national or international level. Furthermore, speed is one of the key factors when helping people in times of need and to save lives.

[80] cf. Dove (2001) p. 84
[81] cf. Sharifi and Zhang (1999) p. 16
[82] cf. Yusuf et al. (1999) p. 41
[83] cf. Sherehiy et al. (2007) p. 457

There are highly diversified forms of quickness and speed:

- Quickness in form of immediate response to emergencies and arrival at an incident scene[84]
- Fast reaction to disasters and catastrophes[85]
- Fast acquisition of required resources or personnel[86]
- Fast communication[87]
- Fast provision and processing of information[88]

Flexibility

Flexibility at all levels of unconventional organizations is an important requirement. It enables a proper response to changing parameters during or in advance of operations.

On a technical level the appropriate hardware has to be provided in the right amount and at the right time. Although technical equipment can be planned for a variety of operational scenarios, due to uncertainty during operations it needs to be flexible to handle multiple operations. Furthermore, additional or special equipment can be provided for large-scale operations or unusual situations in a short period of time through flexible supply channels or cooperation with partners.[89]

Flexibility in their organizational structure is another important prerequisite of unconventional organizations. The configuration of an organizational structure according to the scale of operations, the flexible formation of teams for operations and a flexible structure that allows the integration and collaboration of partners for specific operations is necessary.[90]

Flexible deployment of personnel is another important aspect in the characteristics of unconventional industries. This is demonstrated by the interchangeability of employees between different units and teams. To react to escalations of situations when more personnel than expected is needed, the fast acquisition and integration of additional personnel is required.[91]

[84] cf. Redaktion der Fachzeitschrift BRANDSchutz/Deutsche Feuerwehr-Zeitung (2013) p. 191ff
[85] cf. Steininger et al. 2005 p. 137f
[86] cf. Donner and Adler (2013) p. 549
[87] cf. http://www.katastrophenschutz.steiermark.at [26.01.2015]
[88] cf. Scholz et al. 2008) p. 428-486
[89] cf. Petter (2014) p. 14
[90] cf. Starke (2010) p. 48f
[91] cf. Bundesministerium für Landesverteidigung und Sport (2003) p. 3

Proactivity

The effective and efficient management of highly volatile situations must be proactively prepared and trained. This is especially necessary for situations where there is only a limited amount of equipment, material, goods or personnel available. The need of extensive preparation becomes distinct when considering the definition and characteristics of a catastrophe. According to the National Crisis and Disaster Protection Management, a catastrophe is:[92]

- an unpredictable event, imminent or already happened
- a specific hazard for people, animals, environment, cultural assets, material assets and vital infrastructure
- an event of extraordinary severity
- an event with the need of coordinated governmental guidance
- accompanied by chaotic circumstances
- accompanied with the overextension of the locally available forces and resources.

The preparation of cooperation, both on an internal level like departments and external level like the cooperation with partners and other emergency organizations, is an important part when dealing with uncertain events of large scales, catastrophes or natural disasters.[93]

Unconventional organizations need to proactively prepare for operations and events since the success of the organizations is highly important. The importance of preparation and planning is not limited to financial success. Even more important are the wellbeing of people and the importance of crucial infrastructure for the society. Therefor possible changes and uncertainties during an event have to be anticipated. One efficient way to train for future events is the conduction of simulations. Learning from simulations allows an active preparing for future operations and is important for the further development of an organization.[94]

Innovativeness

Unconventional organizations are innovative to improve the mastering of uncertain situations. Those innovations can concern technological issues; the way information and communication are handled; the application of processes or any other field of work.

[92] cf. Bundesministerium für Inneres, Abteilung II/4 (2007)
[93] cf. Ebner (2014) p. 5f
[94] cf. Scholz et al. 2008) p. 617

Innovation in the technological field is needed because of the necessity of equipment that can be deployed very fast and is provided with a high degree of flexibility. Only then an effective handling of the unpredictability in crisis situations can be guaranteed.[95]

Innovation in the domains of information, communication and coordination enhance the ability of organizations to gather and process relevant information, distribute the information fast and effectively and coordinate appropriate actions.[96]

Furthermore, innovations in the operation of processes are developed for the counteraction of uncertainty. Through new and effective methods the variability in the processes can be improved.[97]

Definition of unconventional organizations

There are non-manufacturing organizations which share certain agile capabilities with agile organizations in the manufacturing industry. These organizations can be called unconventional organizations. By using the generally formulated agile attributes, the definition for unconventional organizations can be derived.

An unconventional organization is an organization that

- reacts fast and effectively to volatility and change;
- is highly flexible and is experienced in dealing with uncertainty and change;
- is proactively preparing for uncertainty;
- uses sophisticated methods and strategies to overcome the obstacles that come with volatility; and
- does not belong to the manufacturing industry.

3.3 Selection of unconventional organizations

Using the attributes, characteristics and the definition of unconventional organizations provided in chapter 3.2, a selection of organizations can be made. An unconventional organization needs to have at least three agile attributes to be considered in the further investigation process.

The selected organizations and departments to be investigated are listed in table 4. Furthermore, the agile capabilities in association with the respective organizations are

[95] cf. Austrian Power Grid AG (2013) p. 18
[96] cf. Bundesministerium für Inneres (2007) p. 33-36
[97] cf. Mützel (2013) p. 10

shown. In the table an “X” indicates that the organization does possess the agile capability. On the other hand a “0” means that this agile capability cannot be identified as distinct as the other ones during the investigation process. It certainly does not mean the organization does not have the ability.

Moreover, the chosen organizations are introduced and their field of work is described. Additionally, the reasons why these organizations need to make use of agile methods are explained.

Organizations and departments	Speed	Flexibility	Proactivity	Innovativeness
Austrian Airlines	X	X	X	0
Austrian Armed Forces ▪ Military Command Styria ▪ Military Command Lower Austria	X	X	X	0
Austrian Power Grid	X	X	X	X
Austrian Red Cross ▪ Red Cross Styria ▪ Red Cross Logistics	X	X	X	0
Emergency and Disaster Medicine Styria	X	X	X	0
Lufthansa Technik	X	X	X	X
National Warning Centre Styria	X	X	X	X
Professional Fire Brigade Graz ▪ Fire Brigade ▪ Civil Protection	X	X	X	0
State Police Headquarter Styria	X	X	X	0

Table 4: Agile capabilities of selected organizations and departments

Austrian Airlines

Austrian Airlines is Austria’s largest aircraft carrier serving about 130 destinations worldwide. The company emphasises strongly on the route network in Central and Eastern Europa. Due to the geographical location of the Vienna International Airport,

the company's hub is a gateway between east and west. Austrian Airlines is part of the Lufthansa Group and a member of Star Alliance.[98]

Aircraft carriers must deal with several factors of uncertainty and change in the aviation business. The flexible rescheduling of cancelled or delayed flights due to weather conditions in a short period of time has to be anticipated. Unexpected high amounts of passengers, for example due to strikes, have to be dealt with fast and efficiently. The provisioning of spare parts in case of malfunction and the overhaul process of a complex machine like an aircraft adds another level of volatility that Austrian Airlines has to be prepared for.

Agile capabilities: speed, flexibility, proactivity

Austrian Armed Forces

The primary task of the Austrian Armed Forces is the military defence of Austria. Additional objectives are the protection of the constitutional institutions, maintaining of order and security within the country and the assistance and humanitarian aid in case of natural catastrophes and disasters of exceptional magnitudes.[99]

For the scope of this work, especially the competencies in dealing with natural catastrophes and disasters of exceptional magnitudes are of interest. Since the magnitude of catastrophes is uncertain, the preparation and actions of the Armed Forces for assistance operations with the required equipment, sufficient manpower and specialists has to undergo in-depth planning and preparation. During operations, a fast and flexible disposition of resources, personnel and equipment is necessary.

Agile capabilities: speed, flexibility, proactivity

Austrian Power Grid

Austrian Power Grid (APG) is Austria's extra-high voltage grid operator that ensures the nation's electricity supply. Operation, maintenance and extension of the APG transmission system is part of APG's mission. A power grid system needs to be a safe and efficient. This has to be ensured by APG.[100]

Electricity and the voltage grid are very important for modern society and blackouts are severe disaster scenarios. To deal with minor and large-scale electricity failures caused

[98] cf. http://www.austrianairlines.ag [26.01.2015]
[99] cf. http://www.bundesheer.at [26.01.2015]
[100] cf. http://www.apg.at [26.01.2015]

by all kind of unpredictable issues like avalanches, mudslides, ice, failures etc. APG needs to proactively prepare and react fast and flexible to minimize the time to restore the power grid. Furthermore, new technologies are acquired to assist during maintenance operations.

Agile capabilities: speed, flexibility, proactivity, innovativeness

Austrian Red Cross

The Austrian Red Cross Society is part of the 188 Red Cross and Red Crescent societies around the world with mission "to improve the lives of vulnerable people by mobilizing the power of humanity" and works according to the seven Red Cross principles humanity, impartiality, neutrality, independence, volunteerism, unity and universality. The Austrian Red Cross National Society acts nationally as well as internationally and coordinates and operates all relevant activities on these levels. The Austrian Society is subdivided into nine regional branches with operational independence and regional subsidiaries that implement activities.[101]

The Austrian Red Cross takes the responsibility to help people with aim-oriented use of resources within their professional competence in complex disasters and catastrophe scenarios. The assistance requires internal cooperation as well as long term external cooperation with partners to achieve the overall goal.[102]

Agile capabilities: speed, flexibility, proactivity

Emergency and Disaster Medicine Styria

The Emergency and Disaster Medicine Styria is part of the department of disaster prevention and national defence of Styria. Selected activities are the development of concepts to shorten rescue times, consulting of other catastrophe-dealing organizations, collaborating in exercises and simulations and contribute in the adaptation of disaster protection plans for hospitals.[103]

Agile capabilities: speed, flexibility, proactivity

[101] cf. http://www.roteskreuz.at [26.01.2015]
[102] cf. Landesrettungskommando (2007) p. 3
[103] cf. http://www.katastrophenschutz.steiermark.at [26.01.2015]

Lufthansa Technik

Lufthansa Technik is the leading provider of maintenance, repair, overhaul and modification services for civil aircraft with maintenance stations at over 60 airports around the globe and serving about 750 customers worldwide. The company is subdivided into six business areas Maintenance, Overhaul, Component Services, Engine Services, VIP (Very Important Person) Services and Landing Gear Services.[104]

Since punctuality and safety are the most important features of airlines, Lufthansa Technik needs to provide inventive, fast and efficient maintenance and overhaul solutions for the highly complex system aircraft. Speed, efficiency, flexibility or the need to proactively prepare for unscheduled situations, if it is maintenance, longer overhaul or very short term Aircraft on Ground situations, are key properties to succeed in the aircraft maintenance business.

Agile capabilities: speed, flexibility, proactivity, innovativeness

National Warning Centre Styria

The National Warning Centre is part of the department of disaster prevention and national defence of Styria. It helps the citizens in emergencies by providing service and information. Furthermore, it supports the relief forces as a nationwide coordination and control room. During catastrophes, natural disasters and any kind of large-scale disaster in which the parameters are not entirely predictable and the available resources have to be deployed fast and efficiently, the National Warning Centre is a permanent coordination office. During these situations, it serves as the operational command and coordinates the cooperation of multiple emergency response organizations.[105]

Agile capabilities: speed, flexibility, proactivity, innovativeness

Professional Fire Brigade Graz

The Professional fire Bridge Graz performs over 6000 operations a year covering a great variety of different operational scenarios. It is distributed into three fire stations that are spread across the city region of Graz. The range of operational scenarios covers rescue missions, conflagration and natural disasters as well as catastrophes. As the impact of these scenarios is subject to countless parameters and sometimes even

[104] cf. http://www.lufthansa-technik.com [26.01.2015]
[105] cf. http://www.katastrophenschutz.steiermark.at [26.01.2015]

multiple simultaneous operations have to be conducted, the Professional Fire Brigade needs to react fast, flexible and has to be prepared. Very good education and training as well as sophisticated equipment and machines ensure the proper response and assistance in case of emergency.[106]

Agile capabilities: speed, flexibility, proactivity

State Police Headquarter Graz

Competency and flexibility of the Austrian executive authority is important for its daily business, but a major challenge are large-scale operations with a high degree of complexity. Flexible information preparation and communication channels, a flexible organizational structure and the cooperation and coordination between the Police, other emergency organizations and the Armed Forces are some of the keys issues when preparing and dealing with large-scale scenarios.[107]

Agile capabilities: speed, flexibility, proactivity

[106] cf. http://www.katastrophenschutz.graz.at [26.01.2015]
[107] cf. Dudek (2008) p. 67f

4 Study on unconventional methods

The contents of this chapter are the fundamentals of the investigation process. The core topics of the investigation and basics for conducting interviews with experts are named. Finally, the evaluation and selection process of the unconventional methods to be transformed are described.

4.1 Core topics

The focus on the study of unconventional organizations can be classified into six core topics. They are technology, logistics, organization, personnel, communication and information (figure 13).

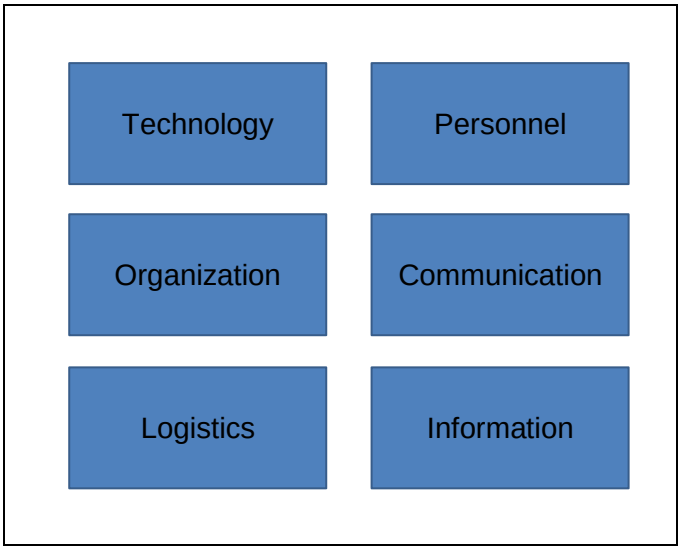


Figure 13: Core topics of the study

Four of the core topics are, in accordance to the classification of a manufacturing system, technology, logistics, organization and personnel.[108]

- The field of technology describes all the physical components of a manufacturing system except personnel. Examples are manufacturing equipment, means of transportation or buildings.

[108] cf. Nyhuis et al. (2013) p. 20

- Logistics includes elements of the non-physical internal logistic as well as interfaces to customers and suppliers. The model of distribution, procurement or the principles of assembly are some of the elements.
- The field of organization describes the design of personnel elements concerning the non-physical environment of a factory. Elements are the organizational structure, information or communicational structures.
- The elements of personnel are the employees of a company.[109]

Although the topics of communication and information are elements within the field of organization in the former classification, they are treated separately in this investigation. The reason behind this is that some of the organizations to be investigated are very skilled in these fields. The provisioning, processing and distribution of information and sophisticated communication are even key competences for some organizations.[110]

Moreover, adequate information systems and fast communication are often mentioned as important attributes for agile manufacturing. Due to the increasing importance of information technologies, companies need to use new and efficient information and communication systems. For the transformability of a company, the availability of technologies for a timely deployment and processing of relevant information are a prerequisite to support productivity and efficiency.[111] Moreover, information and communication technologies and systems are crucial integrating operations within the whole value chain.[112] Communication concepts for agility need to ensure that the employees of an organization are interconnected and are able to correspond directly and fast. Furthermore, these concepts have to go beyond obstructive hierarchical communication structures.[113]

In the context for the investigation of unconventional organizations, the six core topics are described as follows:

- Technology describes all physical assets of an unconventional organization that are used during operations. These can be emergency equipment or other technological means that allow a fast and efficient deal with volatility.
- Organization describes the organizational structure and cooperation, internal as well as external. On an internal level, the change of the organizational structure or the formation of teams in special situations is investigated. On the external

[109] cf. Klemke (2014) p. 49ff
[110] cf. http://www.katastrophenschutz.steiermark.at [26.01.2015]
[111] cf. Westkämper and Zahn (2008) p. 160
[112] cf. Vázquez-Bustelo and Avella (2006) p. 1160
[113] cf. Buchholz and Knorre (2012) p. 19

level, the formation of partnerships and the cooperation of organizations during operations are understood.

- The processes for the acquisition and distribution of supplies, goods or equipment are combined under the topic of logistics. Especially the logistical processes in times of very limited resources and the flexible distribution are of interest during the investigation.
- The topic of personnel deals with all the competences that employees contribute to enable the successful execution of tasks and operations such as education, special knowledge or training.
- The issue on information deals with the allocation of important data by digital or analogue means.
- And finally, there are means of communication in order to effectively communicate between departments, groups of people within one organization or the communication between multiple partners on an inter-organizational level during unusual situations.

4.2 Expert interview

A way for the exploration of contents for a research project is interviews. Expert interviews are a special kind of oral interviews. In this case the experiences and interpretations of the interviewee regarding the interesting research content are in the focus of the inquiry.[114] During the interviews semi-standardized questionnaires or interview guides are used to ensure that the core topics are addressed but enough freedom for individual statements is available.[115]

Verbal data in the qualitative research is collected by narrations or guided interviews. Are specific statements to a topic the scope of an investigation, guided interviews are the more economical way.[116]

Representative for a guided interview is the open formulation of questions. The interviewee can freely answer to the questions and the acquired data gets a structure. The guideline acts as an orientation and ensures that important aspects of the research questions are not overlooked. The interview however does not have to strictly follow the guideline. It is within the judgement of the interviewer to ask for further details, allow the interviewee further remarks or when to return to the guideline. As the guided interview

[114] cf. Töpfer (2012) p. 244, respectively Borchardt und Göthlich (2009) p. 34ff
[115] cf. Töpfer (2012) p. 245
[116] cf. Mayer (2008) p. 37, respectively Flick (1999) p.114

follows the demand of qualitative research for openness, the interviewer should not try to stay close to the guideline under any circumstances and interrupt statements, but statements far off topic should be prevented as otherwise the interview time becomes too long and the amount of data becomes overlarge.[117]

In advance to the selection of experts from unconventional organizations, the term expert has to be defined. An expert is a person with profound and available knowledge on a confined topic area. The opinions are substantiating assertions and not tentative assumptions or guessing. The classification of experts is furthermore dependent on the respective research topics.[118] However there are some general criteria to people that can be addressed as experts. People can be described as experts

- if they are responsible in some kind of way for the plan, the implementation or the control of a problem solution and
- if they have a privileged access to information on groups of people or decision processes.[119]

Often the experts for a specific topic are not on the highest level of the hierarchy of an organisation but on the second or third level. On those levels the decision are often prepared.[120] To make a profound decision on the experts to be interviewed, an analysis of the organizations is inevitable. Based on the organizational structure, the allocation of competences or the development processes of the different fields of actions this decision can be made. Although the state of knowledge grows during the research process, the theoretical considerations on the organizations in advance are necessary to support the decision process.[121]

After the selection of unconventional organizations and the analysis of the organizations considering the mentioned characteristics and attributes of experts, the experts to be interviewed are chosen (table 5).

Based on theoretical preliminary considerations and other investigations a concept used as the basis of the guideline can be made. The most important aspects of the investigation are comprehensively considered in respect to the statement of the problem.[122] The guideline has to be individually formulated due to the different fields of actions of the interrogated organizations. The guideline is developed in regard to the six core topics of technology, organization, logistics, personnel, communication and

[117] cf. Mayer (2008) p. 37f, respectively Flick (1999) p. 112ff, Friebertshäuser (1997) p. 376f
[118] cf. Meuser und Nagel (1997) p. 484
[119] cf. Meuser und Nagel (1997) p. 443
[120] cf. Meuser und Nagel (1997) p. 443
[121] cf. Meuser und Nagel (1997) p. 486
[122] cf. Mayer (2008) p. 43

information. Furthermore, different worst-case scenarios for the organizations are thought out to investigate the response and actions during unusual situations and events.

Organizations and departments	Experts
Austrian Airlines	DI Dr. Peter Woditschka Head of Department, Airlines Operation Controlling
Austrian Armed Forces ▪ Military Command Styria ▪ Military Command Lower Austria	 Rudolf Wabnegg Colonel, Operational Command and Planning Werner Suez Lieutenant-Colonel, MilGeo
Austrian Power Grid	Ing. Wolfgang Prießnitz Crisis Manager
Austrian Red Cross	Jürgen Kunert Head of Purchase and Logistics
Emergency and Disaster Medicine Styria	Prim. Dr. Klaus Pessenbacher Medical Director
Lufthansa Technik	Dr. Tobias Brendel Head of Lean Management
National Warning Centre Styria	Günter Hohenberger Head of National Warning Centre Styria
Professional Fire Brigade Graz	Johann Kirnich Fire Director Ing. Heimo Krajnz Acting Fire Director
State Police Headquarter Styria	Gottfried Röxeis Chief Inspector, Special Operations

Table 5: Selected experts and organizations

The evaluation of quantitative data is conducted through interpretative procedures. Basis for the interpretation are the transcriptions of tape records. One central aspect of the interpretation is not only the evaluation of the statements of the interviewee but the interpretation of the statements. It has to be taken into account that there is not one clear interpretation but a variety of interpretations. Beside the precise record of the

spoken content, the holistic interpretation of all expressions, the general context and the consideration of theories has to be taken into account for the entirety.[123]

As expert interviews deal with common shared knowledge, elaborate notation systems that are inevitable for other forms of interviews, are redundant.[124] It is not necessary to repeat every interview as exactly and extensively as possible. Instead the important problem areas are identified and assigned to the respective topics of the guideline. Not every sentence has to be taken into account for the evaluation.[125]

4.3 Analysis and framework

By using the means of literature research and expert interviews, the required data can be acquired. The information represents strategies, methods and the means and processes that allow unconventional organizations the fast, flexible, efficient and effective response to changes and uncertainty in their respective field of action. For a further process, these strategies and methods are evaluated and classified using several criteria. These criteria are summarized in a framework in which the methods are implemented. As not all criteria of a method can be described in literature and be explained during interviews, the completion of the framework is within the responsibility and the interpretation of the author. Table 6 shows the framework for the implementation and the particular segments are described in the following.

Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Effect on Organization	Level in Organization	Internal/External

Table 6: Analysis criteria for the framework

[123] cf. Mayer (2008) p. 25, respectively Spöhring (1995) p. 158ff
[124] cf. Meuser and Nagel (1991) p. 445
[125] cf. Mayer (2008), respectively Lamnek (1995) p. 206

Organization

The column organization describes the organizations and departments from which the method is acquired.

Strategy/Method

This column gives a name for the different methods and strategies.

Description

Description offers a brief but telling explanation of the method.

Preparation Time

Preparation time describes the required time for an organization to implement the actions and processes that are prerequisites for the usage of the method or strategy. This time is divided into three levels:

- Short-term: hours to a week
- Mid-term: a week to several month
- Long-term: several month to several years

Preparation

Preparation describes the necessary measures, actions and processes that are required to prepare a method and set it to action.

Time of Activation

Time of activation describes the required time to activate the method, from the detection of the need for the method to the actual activation. Time of activation is divided into two levels:

- Short-term: less than an hour to several days
- Mid-term: several days to a week

Affected Area

Affected area describes the area of an unconventional organization that is affected by the method. This classification is performed in accordance to the core topics technology, organization, logistics, personnel, communication and information.

Positive Effect on Organization

This column describes why the organization uses a certain methods by highlighting the positive effect of the method on the organization.

Level in Organization

This column describes the level or the department in the organization on which the methods is used respectively the level or department that is effected by the method.

Internal/External

This criterion classifies the method on an organizational level by the range of the method. Internal means the application of the method within an organization whereas external the involvement of partners and cooperation with other organization describes.

4.4 Evaluation of methods

The framework with its implemented methods and strategies as described in chapter 4.3 is the basis for the evaluation and ranking of the methods concerning an industrial application. For this purpose the framework has been assessed by six researchers currently working on the topic of agile manufacturing.

For the assessment, the methods of unconventional organizations are imagined for the application in a manufacturing context. The assessment of the methods underlies three different criteria. The three criteria, as shown in table 7, are innovation, impact and feasibility.

Innovation is the creation of a new process resulting from a study and the act of introducing something new. The meaning of impact is having an effect on something. And finally, feasibility is defined as the quality of being doable.[126]

The assessment range for the three criteria goes from one to five in integers with one being the worst rating and five being the best rating. The figures in the columns for innovation, impact and feasibility represent the average grading of all six evaluators. Furthermore, the criteria are weighted due to the scope of the research. The column of sum represents the sum of the weighted ratings of the three criteria.

Assessment Criteria	Innovation	Impact	Feasibility
Weighting	50%	30%	20%

Table 7: Assessment criteria

[126] cf. http://dict.tu-chemnitz.de [20.5.2015]

Innovation

Innovation describes the new character of a method for the manufacturing industry. The range for the assessment goes from “1 = the method is a common known standard in the industry” to “5 = the methods is not known in an industrial context and is a new approach”.

Impact

Impact describes the positive effect the method would achieve for a manufacturing company if implemented. The range goes from “1 = the method would have a minor positive impact” to “5 = the method would have a major positive impact on the agility of a manufacturing system”.

Feasibility

Feasibility describes the ability of the method to be applied in a manufacturing environment. The range goes from “1 = an application is not possible” to “5 = a suitable application for the manufacturing industry is possible”.

Since the aim of this evaluation is the finding of new methods for agile manufacturing, the criterion of innovation is being considered the most important one. Therefore, innovation is weighted 50% of the sum. The criterion of impact is weighted 30%, since the aggregated methods have to affect a manufacturing system in a considerably positive way. To emphasise the visionary character of this thesis, the criterion of feasibility is 20% of the sum.

4.5 Selection process of unconventional methods

The result of the analysis and the following evaluation are 94 methods and strategies of unconventional organizations, weighted due to their innovativeness, impact and feasibility for the application in the manufacturing industry. The 11 highest ranked methods and strategies, according to the sum, are taken into consideration for the further process. The whole ranked framework with all methods and strategies can be seen in appendix A.

When taking a closer look at the complete framework, it can be seen that some of methods have a correlation to each other. Certain methods are used by more than one unconventional organization, in the same way or with slight differences.

In order to gain the maximum amount of information about a topic, methods with a strong correlation to the 11 highest ranked methods are taken into consideration too. The methods with a strong correlation are pooled in subject areas. The entire selection process can be seen in figure.

The methods and strategies of the six subject areas are the basis for the derivation for agile manufacturing in chapter 5. The six subject areas are:

- Emergency equipment
- Information and control tool
- Scenario-based planning
- Simulations
- Catastrophe control room
- Crisis management guidelines

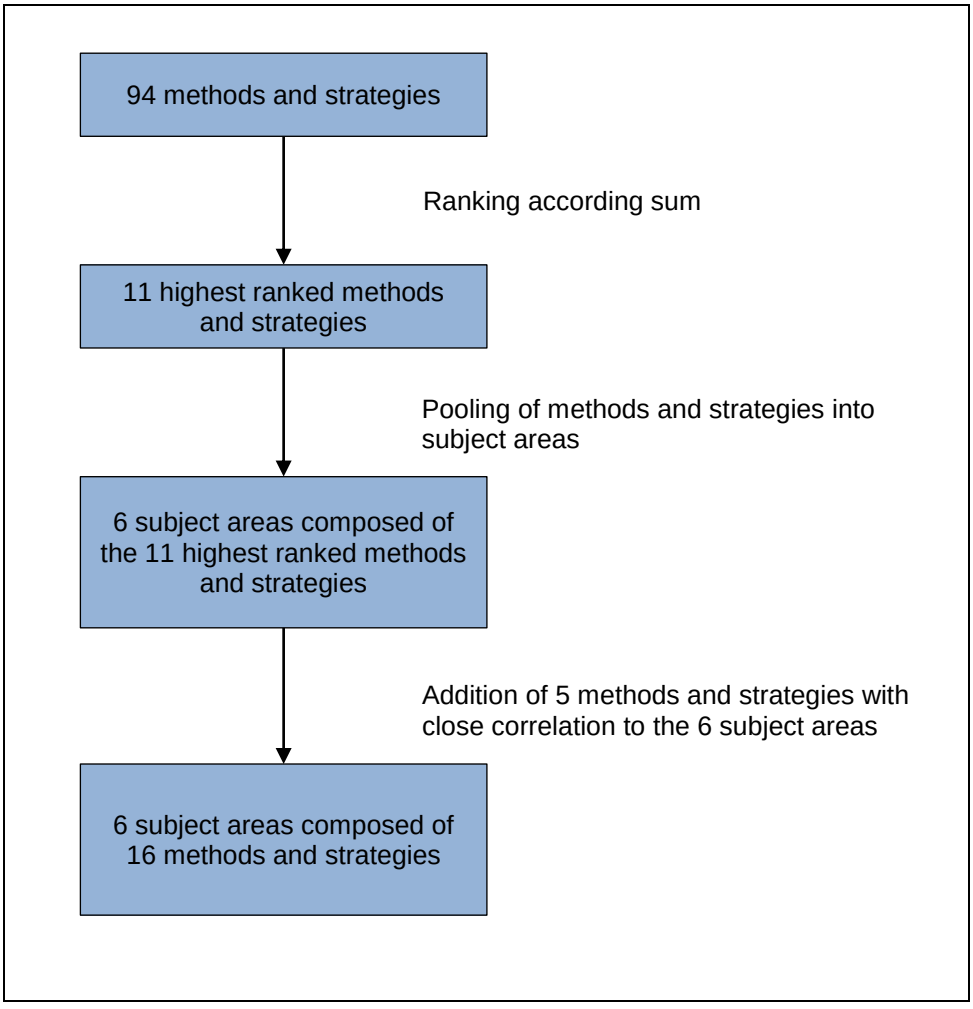


Figure 14: Selection and clustering process

Table 8 shows six subject areas and the additional methods and strategies that are closely correlated to the eleven highest ranked. In further consequence, these 16 methods are described in detail and transformed to be applied in the manufacturing industry.

Organization	Strategy/Method	Impact	Feasibility	Innovation	Sum
Emergency equipment					
Austrian Power Grid	Tower construction kit (APG security package)	3,83	3,33	4,17	3,90
Austrian Red Cross	Emergency Response Units (ERUs)	2,83	4,17	1,83	3,78
Information and control tool					
National Warning Centre Styria	Planning and Response Tools	4,33	3,83	3,67	3,90
Professional Fire Brigade Graz	Disposition of fire engines	2,83	3,83	2,83	3,75
State Police Headquarter Styria	EPSweb	4,00	4,00	2,50	3,73
Scenario-based planning					
Austrian Power Grid	6 main incident scenarios	3,83	3,50	4,00	3,85
National Warning Centre Styria	Operational scenarios	4,00	4,00	3,17	3,58
Professional Fire Brigade Graz	K20 concept	3,83	3,33	3,50	3,57
State Police Headquarter Styria	Statewide planning	3,17	4,50	2,33	3,02
Simulations					
Austrian Power Grid	Training scenarios for crisis management staff	3,83	3,33	4,17	3,87
Austrian Armed Forces - Military Command Styria	Simulations	4,00	3,00	4,00	3,80
Austrian Power Grid	Simulations	4,00	3,67	3,67	3,77
Catastrophe control room					
State Police Headquarter Styria	Control room	3,83	4,17	3,50	3,73
Austrian Power Grid	Crisis room	3,50	4,33	3,17	3,50
Professional Fire Brigade Graz	Catastrophe control room	3,33	4,00	2,83	3,22
Crisis management guidelines					
Professional Fire Brigade Graz	Guideline for leadership in disaster operations	3,50	3,67	3,83	3,70

Table 8: Further processed methods and strategies

5 Derived methods for agile manufacturing

In this chapter, the selected unconventional methods and strategies (table 8) are presented and described in detail. Additional information on those methods can be seen in appendix A. Furthermore, the six subject areas, as described in the previous chapter, are used as a basis for the transformation process of unconventional methods to a manufacturing environment.

5.1 Emergency equipment

Emergency equipment is standardized and transportable stored equipment that is activated in large emergency situations. This mobile equipment is used by the International Federation of Red Cross and Red Crescent Societies (IFRC) and Austrian Power Grid. The Red Cross uses Emergency Response Units (method number 8) in large emergency response situations while Austrian Power Grid uses tower construction kits (method number 74) to repair or substitute broken high-voltage transmission poles in the fastest possible way.

5.1.1 Emergency equipment in unconventional organizations

Austrian Red Cross - Emergency Response Unit (ERU)

The ERUs are property of the national societies and are deployed in large emergency response operations, when global assistance is needed and the Federation's delegation and the affected national society are not able to handle the emergency on their own.

"An Emergency Response Unit (ERU) is a standardised package of trained personnel and modules of equipment, ready to be deployed at short notice. The units are fully self-sufficient for one month and can be deployed for up to four months. They are designed to provide an essential, basic and standardised service platform for use in any part of the world."[127]

If the assistance is needed for a longer period than four month, the service provision and equipment is taken over by the international society's on-going operation, the host national society, the local government or other competent organizations.[128]

[127] cf. http://www.redcross.eu [19.11.2014]
[128] cf. http://www.ifrc.org [19.11.2014]

Types of ERU:[129]

- Basic Health Care
- Referral Hospital
- Water and Sanitation
- IT & Telecommunication
- Logistics
- Relief

Not every National Society is equipped with all types of ERU but focus on core competences. The focus of the Austria Red Cross is on water and sanitation as well as IT & telecommunication, whereby the water and sanitation module is outstanding. The standardized equipment enables the interchangeability of modules and personnel within the International Federation. An example would be the provisioning of water and sanitation equipment by Austria and the operation at the incident scene by a German or Swedish team. The equipment of the Emergency Response Units is designed to be transported by aircraft and has the ability to be put to operation everywhere in the world within 48 hours.[130]

Austrian Power Grid – Tower Construction Kit (APG Security Package)

The Austrian Power Grid Security Package is an essential component of the APG crisis management.

It is a construction kit for high-voltage transmission poles that is used for the tentative bridging of damaged or destroyed power grid sections in case of avalanches, mudslides or other incidents that can lead to breakdown. Another application is the mutual help for other power grid providers during breakdowns or the support during planned reconstructions or new grid constructions.[131]

The construction kit is a modular system to build transmission poles in any shape and form. The equipment is stored in containers and airworthy barred boxes and is strategically positioned across Austria. Supporting units like office containers are also provided. The usage and construction of the Security Package is regularly practised during crisis trainings.[132]

[129] cf. http://www.roteskreuz.at [19.11.2014]
[130] Kunert, Jürgen. Personal interview. 05.08.2014
[131] cf. Austrian Power Grid AG (2012) p. 27
[132] Prießnitz, Wolfgang. Personal interview. 01.10.2014

5.1.2 Transformation for agile manufacturing - temporary equipment

Temporary equipment are standardized and transportable stored production equipment, production cells and assembly or process modules. These mobile modules can be used to temporarily expand or modify a production system in a short period of time. As a result, additional production capacity can be generated or other product configurations can be manufactured. Furthermore, temporary equipment can be used to replace malfunctioning modules for the time of reparation.

Requirements and preparatory measures

Identification of crucial equipment

The production and assembly system has to be investigated to find the limiting factors in volatile situations. This can be accomplished by applying different change scenarios (5.3.2) to the production system and verifying the results by conducting simulation on the given situation (5.4.2). Thus possible bottlenecks in the system can be identified and the necessary process modules can be determined.

The parts that can be manufactured by temporary equipment modules are limited in size and weight for the size of the mobile modules is restricted. This limits the possibilities for substitution or additional modules.

Quality and certification

The quality of products manufactured by mobile modules might be different to the quality of products manufactured during normal operation. This has to be taken into consideration and possibly needs to be checked with the customer.

Every country has specific laws and regulations for the operation of production equipment. Thus, for an international application, temporary equipment might need to be verified according to the standards of the respective countries before operation is permitted.

Plans for daily business

Production or assembly systems that are only activated in times of volatility and change are barren capital and not feasible. Plans for the utilization of temporary equipment modules during the normal business need to be defined. Universal equipment like CNC universal milling machines or universal lathes can easily be integrated into a process.

This integration becomes more complicated the more specialized the production machines are.

Modular layout and space

A modular structure of the manufacturing system is a key prerequisite for its implementation. Only with layout according to the principles of reconfigurable manufacturing systems, a fast and inexpensive exchange can be accomplished. Standardized interfaces between the permanent process modules and the temporary modules are a necessity. Additionally, the required space for these temporary modules has to be considered.

In case the temporary equipment is not integrated into the normal production process, the modules can be arranged outside the factory. In this case, only products that are not directly integrated into the production flow can be manufactured. Furthermore, prearrangements for the required space have to be made. Additional facilities might have to be rented and the material flow and supply of power has to be planned.

Definition of transportation and storage

A central location within a production network which is sharing the mobile equipment is the best place for the storage or operation of the equipment in times when mobility is not needed. In that way, other plants can be reached in a minimum of time. Proximity to various means of transportation is beneficial for a fast transportation.

In case the mobile equipment is not needed for a longer period of time, the storage conditions need to be appropriate to ensure the equipment is ready to use when it is put back to work.

The definition of the means of transport for the temporary equipment highly depends on the size and weight of the process modules. One approach is the integration of process modules like additive manufacturing, CNC-milling, automated assembly and cleaning into a 20’ ISO-container as shown in figure 15.[133]

[133] cf. http://www.cassamobile.eu [19.11.2014]

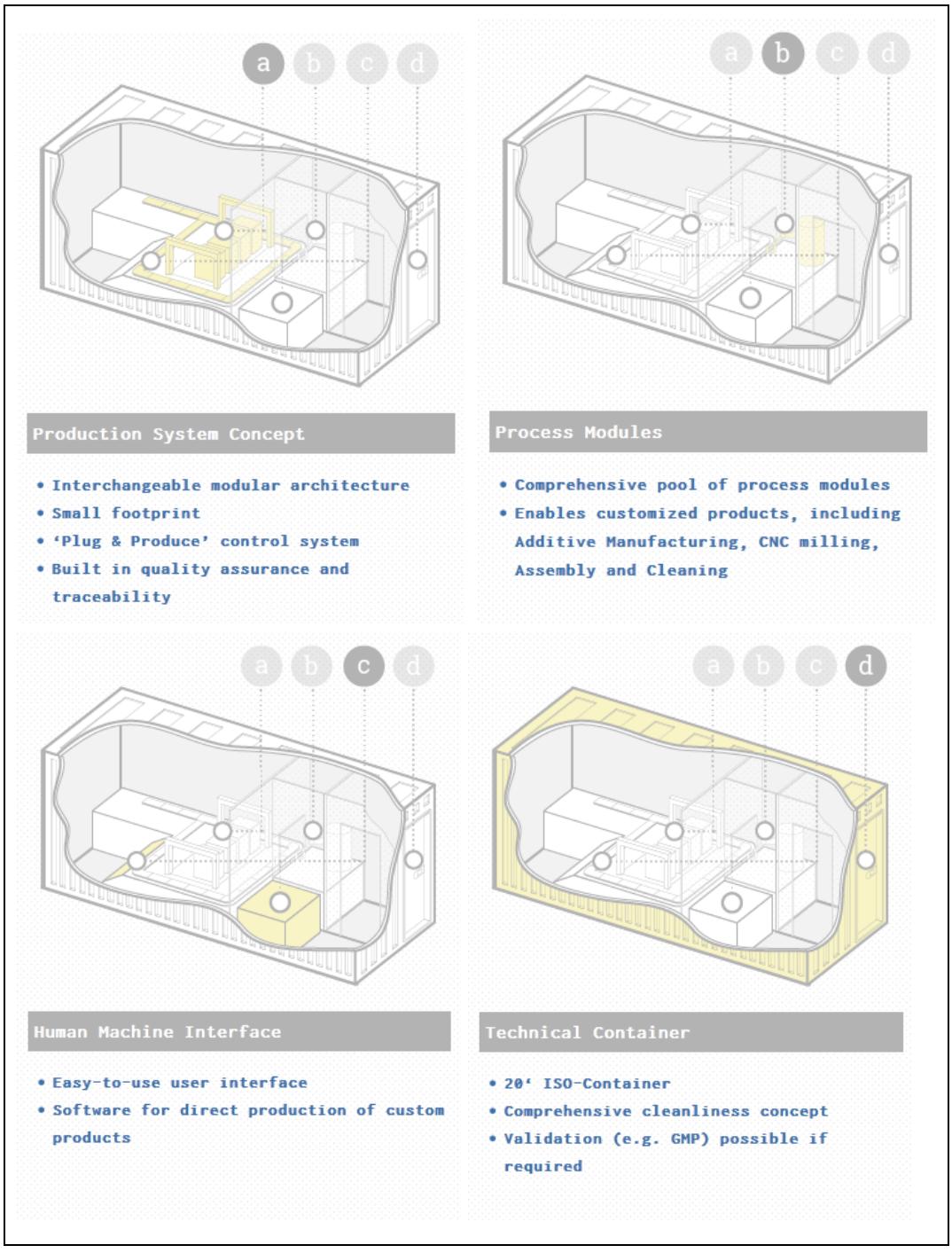


Figure 15: Embedded modules in a 20' ISO-container[134]

Training of personnel

When it comes to the personnel that is operating the mobile equipment, two possibilities emerge. The personnel can be from the local factory or it can move with the equipment from one factory to another. The personal that travels with the equipment knows the

[134] http://www.cassamobile.eu [19.11.2014]

equipment and is trained on the machines. On the other hand, local personnel might operate the manufacturing machines for the first time. Initial training might be needed. This becomes even more important when mobile equipment is used in different countries due to different educational standards of workforces and language barriers.

Additionally, the number of employees needed for a new process configuration has to be determined in advance. The process of integrating additional or modified process modules in an existing production line has to be trained to ensure a fast and effective reconfiguration.

Production planning

Production planning has to prepare for a fundamentally different production scenario. All parameters for the new configuration have to be planned in advance of a modification. These plans can be elaborated using scenario-based planning (5.3.2) and verified by large-scale simulations (5.4.2)

The new production situation also has influence on the product's quality. A mobile machine might not be able to produce as precisely as a standard machine. The new tolerances that might occur have to be checked with quality management and the customers' tolerance expectations.

Improvements after implementation

Flexible production capacity and variety

The variety and quantity of products manufactured in one location can be quickly modified. Through the expansion of the production or assembly system by adding process modules, additional production or assembly capacity can be generated. On the other hand, production capacity can be reduced through the removal of temporary equipment and by going back to the original production process layout with the permanent equipment. Through the very fast transportation and deployment of the mobile equipment, a timely response to changing conditions is possible.

Increase in the product portfolio

Mobile equipment can support a wide range of different production or assembly modules. If the product is modularly constructed, a broad product range can be supported.

The integration of different process modules and module arrangements can lead to a wider product range in case the product is designed according to the principles of agile product development.

Counteraction of bottlenecks

Possible bottlenecks might occur in times of additional production. In order to identify these bottlenecks, simulations and combinations with scenario-based planning can be conducted. So the lead time for transportation and the setup of mobile equipment can be planned accordingly.

If a bottleneck in the production system occurs due to malfunction of a machine, the lead time is very short. In this case, the type of machine that malfunctions plays an important role. A very specialized machine might not be available or repaired in due time. The relocation of specialized machines realized as mobile equipment can be a possible answer to these kinds of problems.

Mutual help within production networks

Sharing of temporary equipment within a production network can be beneficial to all members. By providing help in form of additional equipment for network partners, the volatility of supplies for companies further down the supply chain can be reduced. Furthermore, investment cost for the temporary equipment can be distributed between several members of the production network and therefore be reduced.

5.2 Information and control tool

Programs and software tools for situation reports, operation command or information processing are used by various emergency organizations. The focus lies on the information and control tools used by the State Police Headquarter Styria (method number 17), National Warning Centre Styria (method number 50) and the Professional Fire Brigade Graz (method number 87).

5.2.1 Information and control tools in unconventional organizations

State Police Headquarter Styria – EPSweb

The operation control system EPSweb (webbasiertes Einsatz-Protokoll-System) is the nationally implemented system of the Austrian Police. All the information regarding an operation is available in real time for all police forces involved on this mutual platform.

Operational sections and organizational structures for special occasions can be added or adapted if required.[135]

The core functions[136] of EPSweb are

- distribution of information between all involved authorities, organizations and departments during an operation;
- distribution of messages, requirements or orders within an operational management; and
- documentation of operations.

Advantages[137] of this system are

- a web browser based application;
- the inclusion of additional organizations during an on-going operation and therefore fast information exchange;
- the low training effort because of the easy usability; as well as
- the incorporation of mobile devices by using web browsers.

National Warning Centre Styria – Planning and response tools

Planning and response tools are used by the National Warning Centre Styria for situation reports and tactical situation control. With these tools the place of action can be illustrated in advance of an operation. Moreover, different operational scenarios can be planned and simulated. During an operation, changes in the own situation as well as general situation can be displayed. Through the interconnection of all units involved in an operation, these changes and situations are made available for all emergency forces, which allows an improved collaboration.[138]

One of the core functions of this tool is the strategic positioning of action forces (units of Red Cross, Fire Brigade,…) during the planning phase according to certain criteria like critical places or the stream of visitors. Furthermore, the incident commander has the current position of units displayed and can move the units through repositioning the icons on the situational map. The basis of the situational map is a geographical map of the incident scene (figure 16).[139]

[135] Röxeis, Gottfried. Personal interview. 12.09.2014
[136] cf. Sachgebiet ID4 (2008) p.3
[137] cf. Sachgebiet ID4 (2008) p. 3
[138] Hohenberger, Günter. Personal interview. 25.07.2014
[139] Hohenberger, Günter. Personal interview. 25.07.2014

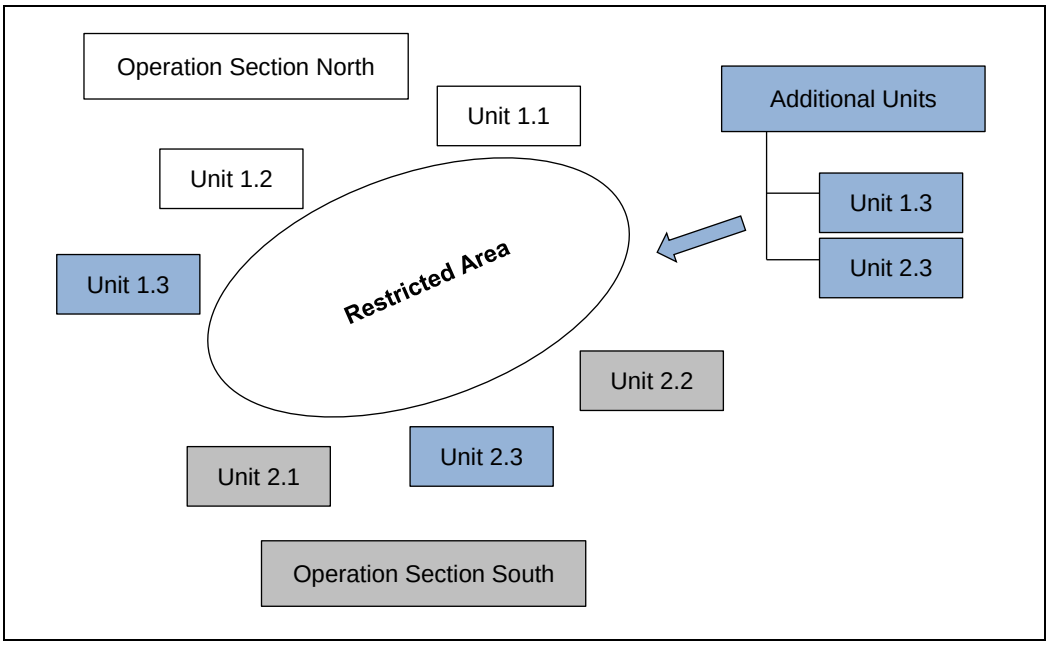


Figure 16: Display of a situational map[140]

In case the situation during an operation requires additional forces and means (unit 1.3 and unit 2.3), the incident commander can add these to the situational map (figure 16) by a drag and drop menu. The organizational structure for the current mission is automatically updated and extended (figure 17).[141]

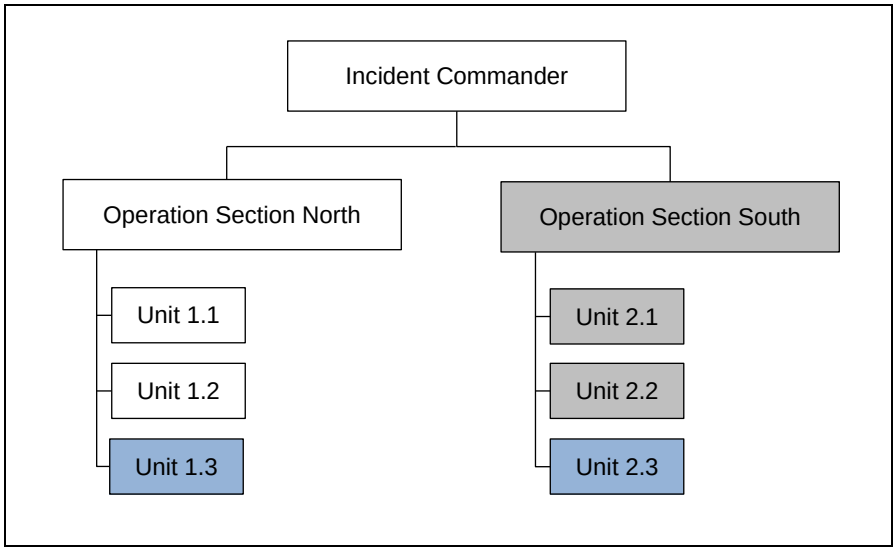


Figure 17: Extension of organisational structure[142]

[140] Own representation, based on Hohenberger, Günter. Personal interview. 25.07.2014
[141] Hohenberger, Günter. Personal interview. 25.07.2014
[142] Own representation, based on Hohenberger, Günter. Personal interview. 25.07.2014

Furthermore, the tool provides additional information about the action forces and units currently in action. This additional information can be the time in action, special training of people or special units. Orders by the commander can be implemented directly into the system and a time frame for the fulfilment of the orders can be given.[143]

Professional Fire Brigade Graz – Mission control system

The mission control system of the Professional Fire Brigade Graz enables the operator to have a fast and clear overview over the status and the availability of the various units and action forces. Additionally to the units and forces available in the main fire station, the status of Graz's other two fire stations and their units can be displayed. Therefore, the operator can request additional units from other fire stations. Every unit is displayed as a colour-coded entity and illustrated in respect to the current position and status. Additionally, the different unit's functions are shown. In case of deviation in the alarm and march out order, these changes can be displayed as well (figure 18).[144]

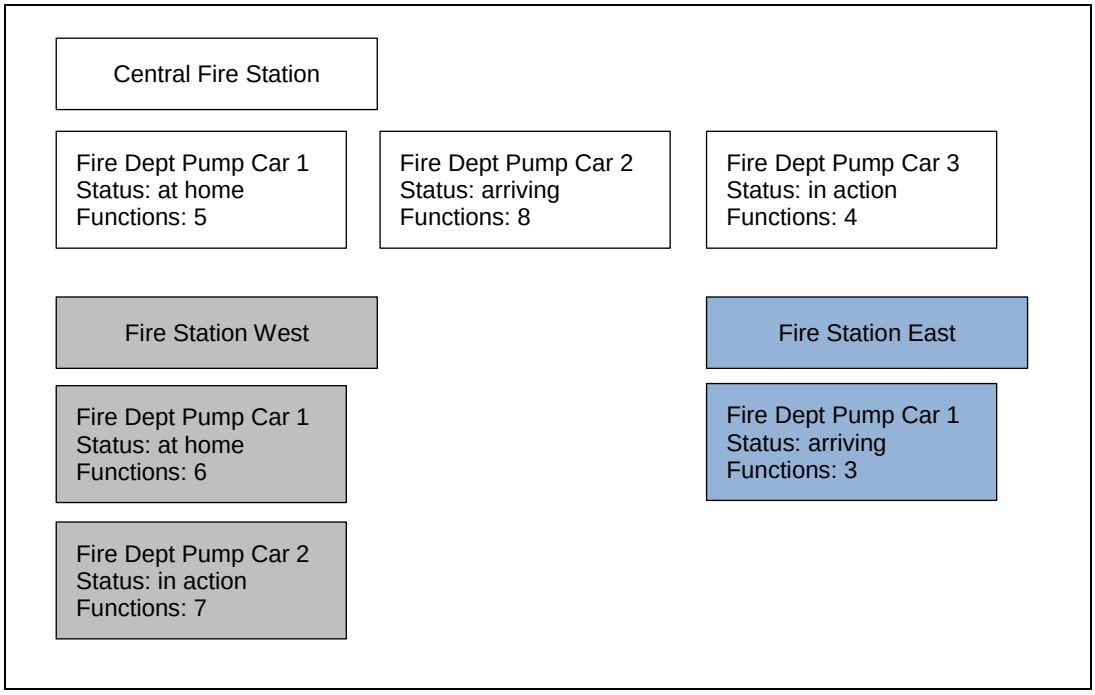


Figure 18: Interface of mission control system[145]

[143] Hohenberger, Günter. Personal interview. 25.07.2014
[144] Krajnz, Heimo. Personal interview. 18.09.2014
[145] Own representation, based on Krajnz, Heimo. Personal interview. 18.09.2014

5.2.2 Transformation for agile manufacturing - real-time information and control tool

Information and control tools are software solutions for the real time depiction of an entire company. Through enhanced information distribution and a common communication platform, the management of technological, organizational and personnel changes can be improved.

Requirements and preparatory measures

Reconfigurable manufacturing system

To utilize all of the tool's features, a manufacturing system according to the principles of configurability is beneficial. This principle enables a manufacturing system to adjust to different levels of capacity and different functions. Therefore, the machine components, manufacturing machines, cells, modules or material handling units can be added, removed or modified.[146]

Virtual factory

The implementation of intelligent systems according to principles of virtual factories is a prerequisite for the real time monitoring of a manufacturing system. By determining the configuration of the production system in terms of machines and equipment, decisions regarding production process, schedule and plans can be made. The virtual factory paradigm assists by implementing simulations, production control, manufacturing system design and visualization.[147]

Predefined factory layout

The factory's layout of has to be determined for changing conditions and therefore different production strategies. The planning of multiple production configurations by anticipating possible scenarios (5.3.2) is necessary to guarantee an effective and fast physical reconfiguration of the production system. Furthermore, employees have to be trained for different configurations of the manufacturing system as well as for the physical restructuring process of the system.

[146] cf. Wiendahl et al. (2007) p. 789
[147] cf. Tolio et al. (2013) p. 26ff

Improvements after implementation

Planning of multiple manufacturing configurations

Multiple manufacturing configurations can be planned in advance of a disturbing scenario that can force an adaption of the manufacturing system. The adding of additional process, manufacturing or assembly modules in case of higher demand, the removal of modules or a general reconfiguration of the system can be planned for the physical manufacturing assets (figure 19).

Through the pre-configured layout during the planning phase, the actual reconfiguration of the manufacturing system can be performed fast and efficiently. Real time monitoring enables fast response to various situations and possible bottlenecks can be prevented through rearrangements of the system.

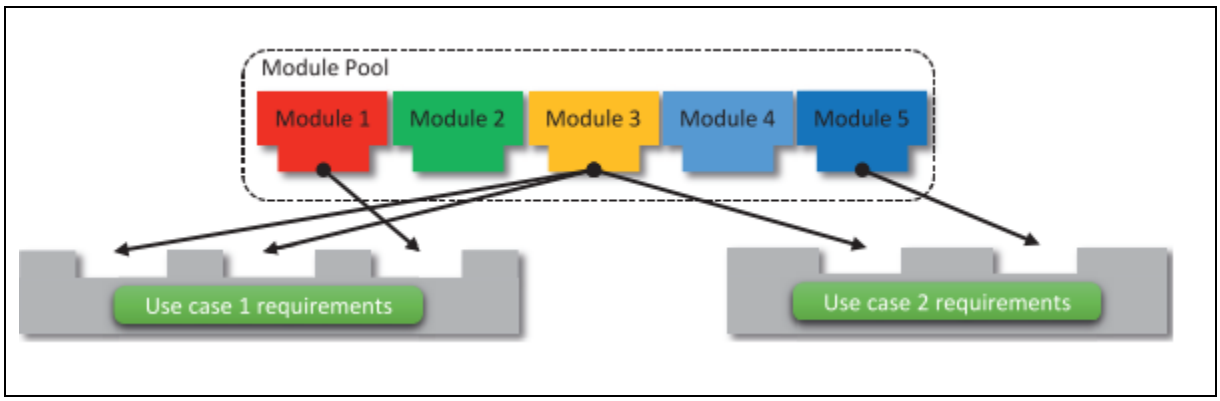


Figure 19: Concept of the modular production system[148]

Changes of the organizational structure

The changes of an organizational structure in dependence to different manufacturing configurations and due to anticipated situations can be managed and displayed. The assignment of employees to changing manufacturing modules and equipment can be scheduled proactively. Furthermore, employees can be specifically assigned to modules or module configurations on the basis of their training or education.

Mutual information platform

The tool can serve as a mutual information platform for project organizations like a team responsible for the reconfiguration process of a manufacturing line. The project leader

[148] cf. Scheifele et al. (2014) p. 400

is able to give assignments to project members by implementing them into the information tool. Moreover, the tasks can be linked to a timeframe in which the tasks need to be accomplished. The current status of the project is available to all members involved. The organizational structure of the project team can be extended or reduced and displayed for everyone.

5.3 Scenario–based planning

Scenario-based planning is conducted by various unconventional organizations to proactively prepare for future operations. The focus lies on the methods used by Austrian Power Grid (method number 72), National Warning Centre Styria (method number 48), Professional Fire Brigade Graz (method number 77) and State Police Headquarter Styria (method number 13).

5.3.1 Scenario-based planning in unconventional organizations

Austrian Power Grid – 6 main incident scenarios

Austrian Power Grid conducts in-depth planning for 6 main incident scenarios that pose the biggest risks. Some examples for those are control system failure, transformer fire or accidents involving people. The topic of those crisis plans are pre-defined actions and processes for dealing with the scenario as well as the composition of crisis management staff. Additionally, the representatives of departments which have to be present during a certain incident are defined. In case additional equipment is needed for dealing with the incident, partner companies are used to provide it.[149]

State Police Headquarter Styria – State-wide planning

Large scale operations like high-risk football games are planned on a state-wide level. After the evaluation of the scenario on the basis of further standards, the requirements for an operation, like units or force level, are decided. This planning is conducted by specialists at the State Police Headquarter. Moreover, the experience of these specialists plays an important role during the planning process. This central planning

[149] Prießnitz, Wolfgang. Personal interview. 01.10.2014

ensures that the most experienced specialists are in charge of planning and all the important information is provided.[150]

National Warning Centre Styria – Emergency scenarios

The National Warning Centre develops plans for approximately 100 emergency scenarios on state-wide level. These scenarios include floods, large scale road accidents, chemical hazards or mud slides. These emergency scenarios are, in fact, an alerting of organizations and people about an incident. After the alarming through the National Warning Centre, the informed organizations and people already know how to respond. Every organization makes internal emergency plans for possible incidents in advance of an operation. If the internal plans are changed, every other organization involved in the emergency plan has to be informed.[151]

Figure 20 describes the structure of an alarm- and emergency plan for a tunnel with two possibilities and the coordination of multiple emergency organizations. The first part of the alarm plan is the general plan of actions and a short description of the involved action forces tasks. The uncertainty is covered by the provisioning of two possibilities: emergency with fire and without fire. All the relevant information is adjusted and provided to fit both cases. The next sections provide an overview about the communication and information structure and the detailed alarm and emergency plans for the action forces. And finally, the executive staff with the necessary people, the map of the incident scene and the sequence of alerting is provided The uncertainty of a scenario is encountered by different possibilities within an emergency scenario.[152]

[150] Röxeis, Gottfried. Personal interview. 12.09.2014
[151] Hohenberger, Günter. Personal interview. 25.07.2014
[152] Pessenbacher, Klaus. Personal interview. 07.08.2014

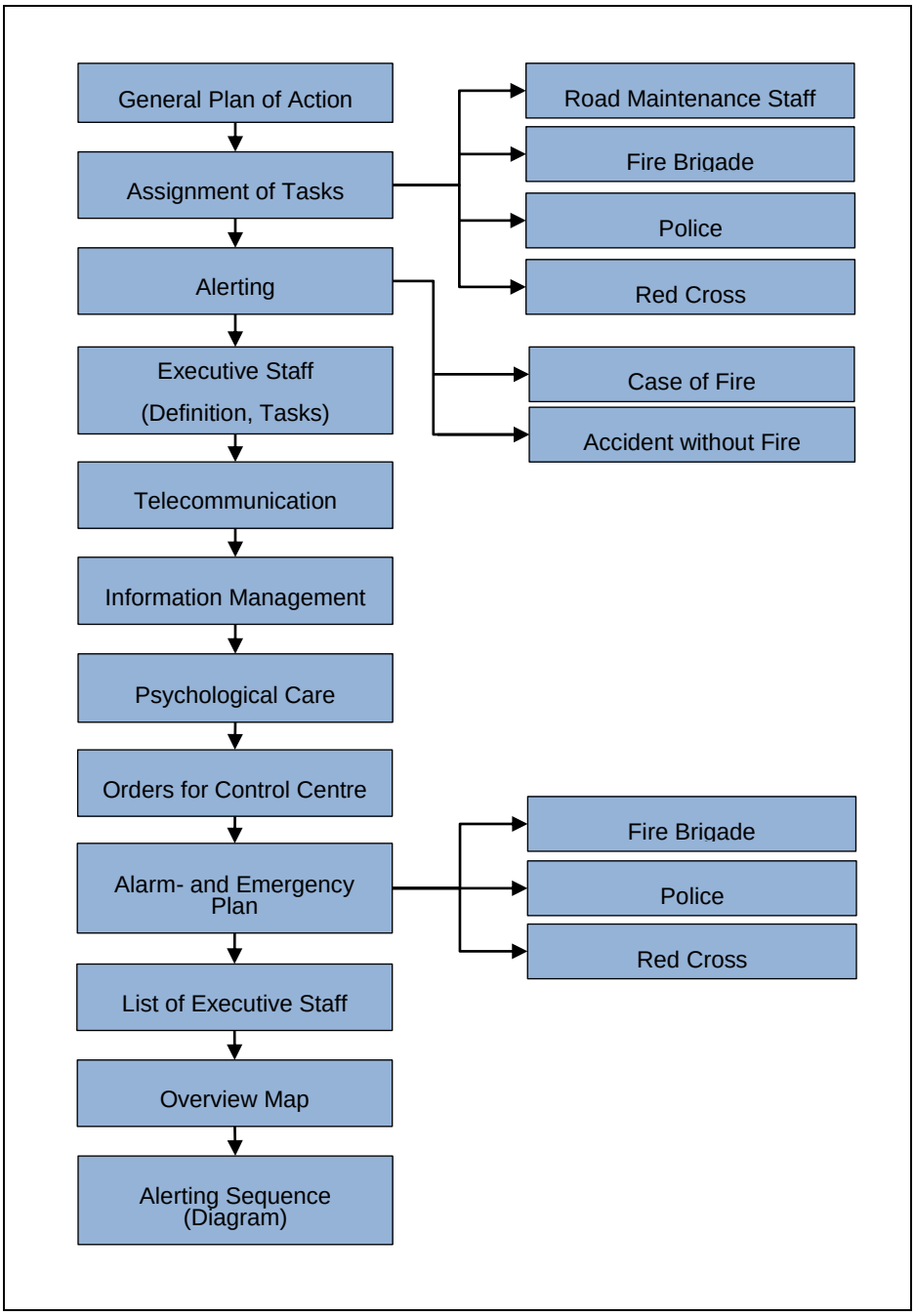


Figure 20: Basic structure of an alarm- and emergency plan[153]

Another example is the emergency plan for the airport Graz-Thalerhof.[154] This emergency plan includes the general plan for the airport as well as a further division into three different possibilities regarding the type of the affected aircraft:

- small aircraft

[153] Own representation, based on Pessenbacher, Klaus. Personal interview. 07.08.2014
[154] Hohenberger, Günter. Personal interview. 25.07.2014

- commercial aircraft, up to 50 passengers
- commercial aircraft, more than 50 passengers

Professional Fire Brigade Graz – K20 concept

The Professional Fire Brigade's K20 concept includes 20 imaginable and relevant worst-case scenarios. Predefined processes and actions for these high-risk scenarios are defined and allow a fast and effective response to these catastrophes. Furthermore the comprehensive storage and distribution of supplies and equipment is determined in these plans. Additionally, contracts with partner companies, for example the hiring of heavy equipment or the provisioning with fuel, are defined in these scenarios.[155]

The 20 high-risk scenarios, for which the in-depth planning is conducted, are shown in table 9.

Storm	Hazardous Materials Accident
Conflagration	Facilities with high Exposure
Tunnel Fire	Collapsing Buildings
Elementary Event	Forest Fire
Flood	Catastrophes as a Result of Terrorism
Hail	Aircraft Accident
Snow	Epidemiological Emergency
Blackout	Radioactive Contamination
Gravitational Mass Movement	Earthquake
Large-scale Accident	Catastrophes as a Result of War

Table 9: Scenarios of the K20 concept[156]

[155] Krajnz, Heimo. Personal interview. 18.09.2014
[156] Own representation, based on Nestler (2010) p. 239-244

5.3.2 Transformation for agile manufaturing - scenario–based action planning

To cope with uncertainty and volatility, scenario-based action planning provides purposeful information on the necessary actions for the handling of the situation. These plans offer general plans for the entire company and detailed plans for the departments. By developing the plans, a company proactively prepares for changes to come.

Requirements and preparatory measures

Identification of high–risk scenarios

The implementation's first major step would be the identification of scenarios that have, on one hand, a major impact on the success or failure of a company, and, on the other hand, are most likely to happen. To eliminate the remaining volatility within the identified scenarios, different variants of one scenario have to be planned.

For the identification of the high–risk scenarios, modern methods like those used in Enterprise Risk Management, need to be used. Some of the most common methods for risk identification are brainstorming, flowchart method, SWOT analysis, risk questionnaires and risk surveys.[157]

General plan and internal plans

Plans for the different scenarios contain a general plan for the company as a whole, as well as internal plans for the affected departments.

The general plan consists of a description of the general plan of actions, the tasks which have to be carried out by the affected departments, the group of people responsible for the scenario on a management level (e.g. War Room staff) as well as a defined communication and information management. Furthermore, the organizational structure for this special situation has to be provided.

The internal plans include detailed instructions and actions that have to be deployed in case of the occurrence of the planned. The responsibility for the development of the plans can either be within the individual departments or can be done on a company–wide level.

It is of importance that the plans are permanently on the latest status. The status on the plans can be discussed in weekly meetings and adapted to current situations.

[157] cf. Dinu (2012) p. 69ff

Connection with simulations

To check the effectiveness and further develop the general plan and internal plans, simulations (5.4.2) can be run on the general scenario as well as on the different possibilities within the scenarios.

Improvements after implementation

Proactive preparation

Due to the definition of actions, tasks and responsibilities in advance of an incident, the best response to various types of incidents can be guaranteed. The processes to handle the incidents are defined on all levels of a company, from the management level by general plans to a department level by internal plans.

This enables a company to react to a range of possible events in the fastest and best way possible to gain advantages or to reduce negative effects on the company.

Reactions for multiple scenarios

The planning is not only limited to a few major high–risk scenarios, but also to different variations within the major scenarios. Furthermore, various grades of possible incidents scenarios are covered. This ensures that the wide range of conceivable incidents is covered and can be dealt with.

Elimination of risks

During the different scenarios' planning phase and their evaluation by conducting simulations, not only actions can be defined. Due to the identification of possible risks for a company in advance of their appearance, these risks can be eliminated, making the planning effort for this specific scenario expendable and allows a focus on other scenarios which are not avoidable.

5.4 Simulations

Simulations and training scenarios are conducted by Austrian Power Grid (methods number 71 and 66) and the Austrian Armed Forces (method number 44) to proactively prepare for future operations.

5.4.1 Simulations in unconventional organizations

Austrian Power Grid – Simulations

Simulations at Austrian Power Grid are conducted with simulation software that illustrates certain wiring diagrams. In order to achieve a higher permission level, the employees have to train with the software. This can be compared to flight simulators for pilots. Unpredictable situations in the electronic grid can be simulated and have to be solved by the trainee.[158]

These simulations are performed internally, nationwide and even on an international level with partner net operators. The nationwide and international simulations are sometimes realized with an external partner company specialized in design, development and performance of simulator based operator training courses.[159]

Austrian Power Grid – Training scenarios

Training scenarios for crisis situations are conducted for members of the crisis management staff like the heads of departments and the dedicated crisis managers and take place two to three times a year. The purpose of these scenarios is the training of the behaviour and the management processes in crisis management situations. The training includes topics like proper record of the situation, right documentation, drawing of the right overview of the crisis situation and the decision making process. Those trainings are performed in cooperation with one or two trainers from external consultant companies. These external consultant companies are specialized on training of organizations that might get into crisis situations. After conduction of the crisis training simulation the findings are evaluated and reviewed.[160]

Austrian Armed Forces, Military Command Styria – Simulations

The Military Command Styria considers simulations to be a very important part in the preparation for an actual mission. The simulations are conducted in the military command's crisis room. The training scenarios include all the players that would be involved in a real catastrophe scenario such as the Red Cross, Police, Fire Brigade and the authorities. In advance of a major event, the event's possible worst case scenarios

[158] Prießnitz, Wolfgang. Personal interview. 01.10.2014
[159] cf. http://www.dutrain.de [20.11.2014]
[160] Prießnitz, Wolfgang. Personal interview. 01.10.2014

are simulated and evaluated. Afterwards the positive and negative aspects of the simulation are evaluated and potential improvements are highlighted.[161]

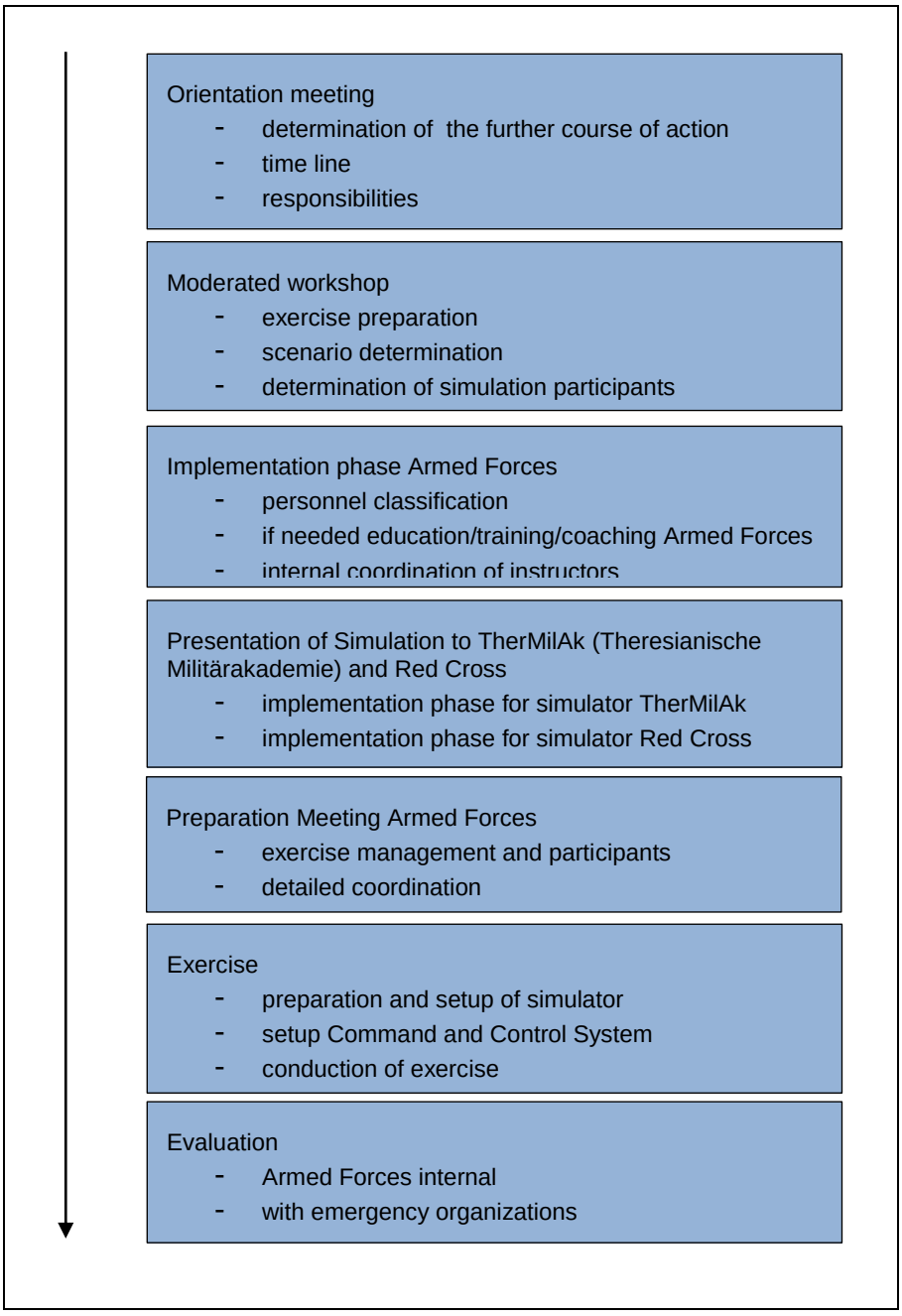


Figure 21: Approach and project steps for simulations[162]

[161] Wabnegg, Rudolf. Personal interview. 14.08.2014
[162] Own representation, based on Wabnegg, Rudolf. Personal interview. 14.08.2014

A possible approach for conducting a simulation with the major project steps is shown in figure 21. The process for conducting a simulation starts with an orientation meeting to determine further actions and the time line. The next step is a workshop moderated by the Armed Forces to determine the scenario (flood, landslide,…) and the participants (Red Cross, Police,…). Afterwards, the Armed Forces work at the scenario on an internal level. The required personnel is determined, properly trained and the simulation instructors perform their work on the scenario. The data on the simulation is submitted to the simulation computers at the Theresianische Militärakademie (TherMilAk) and the Red Cross for implementation. After this implementation phase, all the players of the simulation meet under the guidance of the Armed forces for the detailed coordination. Only now, after the comprehensive preparation process, the actual simulation is conducted. Evaluation of the exercises is one of the most important points. It is done internally and in cooperation with all the players involved in the simulation.[163]

5.4.2 Transformation for agile manufacturing - large-scale simulations

Large-scale simulations can help forecasting the influence of agility drivers on a production network and enable a company to react proactively to future changes. Through knowledge and experience gained by conducting simulations regarding possible scenarios, the organization and partners are able to react fast and efficiently when the same or a similar situation occurs in reality.

Requirements and preparatory measures

Simulation software and data

Acquisition of proper software tools for simulating the influence of different change drivers on a production system is the first step. Simulating different scenarios and the effect of change drivers on a production system is a complex task that becomes even more complex if the whole production network is involved. Additionally, there are influences that cannot easily be quantified like political influencing variables.

For that reason, only scenarios with a high chance to become real can be taken into consideration. Furthermore, a comprehensive risk analysis for the production process and the market has to be conducted. Because of the large workload that comes along with the execution of such a large-scale simulation, only scenarios with the highest chance in combination with the highest risk can be considered.

[163] Wabnegg, Rudolf. Personal interview. 14.08.2014

Participation of partner companies

Since the partners in a supply chain network influence each other, all core members of a network must participate and contribute to joint simulations.

Unfortunately, this is not always possible due to various reasons like time problems and goal conflicts. Suppliers might not be willing to share information on delivery times or the necessary time to increase production. Nevertheless, it is important that bigger suppliers that might have a long and close relationship to the own company participate. Usually, the impact of those key suppliers is essential to the company success. The impact of lower-tier suppliers might not be that significant because of their exchangeability. Exceptions are smaller suppliers that provide parts of central importance to the success of the own company.

Definition of agility staff

The agility staff for network simulation meetings consists of personnel of the own company and liaison personnel from the partner companies.

The composition of the staff is dependent on the topic of the simulation. Every department involved should have a representative with profound knowledge about the topic and department on site. Liaison personnel from partner companies should be composed of people with a general knowledge of the company they are representing. Specialist for one topic might not have enough knowledge in all the processes and departments that are influenced during a simulation.

The War Room (5.2.2) is an adequate meeting room for the conduction of simulations of multiple partner companies because of the versatile possibilities to visualize a situation, problem solving or the virtual environment capabilities for the communication with partners that are not physically present.

Improvements after implementation

Enhanced identification of problems

The identification of possible problems due to the influence of agility drivers on the whole value chain can be a result of the evaluation of simulation. By applying worst case scenarios to the entire network or a single company, hidden problems that otherwise might not have been detected or imagined can be figured out. Suppliers can be made aware to problems they might not have been able to detect on their own.

Enhanced training and experience

By conducting simulations, a fast and efficient response of the agility staff to uncertain events can be trained. Therefore, the collaboration between companies and their suppliers in crisis situations or times of change is improved. The appreciation between partners and the understanding of the others' possible problems are enhanced.

This training leads to improved knowledge on the simulated situation and less stress in case the same or a similar situation or incident occurs in reality. All organizations participating in a simulation attain a higher skill level in dealing with it what ensures that the right measures are more likely to be taken in the future.

Face- to-Face communication

Meeting every member of a crisis staff and getting to know each other in advance of on operation is considered to be one of the key success factors of conducting simulations and training scenarios.

Therefore, the face-to-face communication between members of the agility staff, be it company internal or with supply network partners, helps to build up trust, improves the relationship and thus helps to deal with situations in times of change. Furthermore, the problem solving competence of the liaison personnel and, in further consequence, of the supplier or partner firm can be observed and tested.

5.5 Catastrophe control room

A catastrophe control room is a specially equipped room for the management of catastrophes, crisis situations or large scale operations. The crisis management staff meets in these dedicated rooms for the duration of an operation. The teams, action forces or disaster relief forces at the incident scene are coordinated and supported by the crisis management staff. Decisions can be made in a very fast fashion due to the presence of all decisions makers in one room and the short communication channels. Furthermore, all the information on one or multiple incidents is concentrated in this dedicated room. The focus lies on the control room of the State Police Headquarter Styria (method number 20) and the catastrophe control rooms of Austrian Power Grid (method number 73) and the Professional Fire Brigade Graz (method number 84).

5.5.1 Catastrophe control rooms in unconventional organizations

State Police Headquarter Styria – Control room

The control room of the State Police Headquarter is the first stage of successfully dealing with incidents. The operator receiving an emergency call has to prioritize the call. This is necessary due to the possibility of simultaneous incidents. After receiving the emergency call and prioritizing it, the operator advises the officer in charge about the incident. Together, they decide on further actions in a few seconds. One of these actions could be the establishment of a temporary, task-specific organizational structure. Until this organizational structure is ready to take over the operation which takes up to 60-90 minutes, the staff of the control room is in charge of managing the emergency.[164]

Austrian Power Grid – Crisis room

Austrian Power Grid uses multiple crisis rooms across Austria and a very well adapted room at the headquarters, but the most sophisticated crisis room is at the main control centre. In case of an incident, the specially trained crisis management staff and, if necessary, the heads of departments meet in the crisis room at headquarters to manage the crisis operation. If the operation becomes too large or the situation demands it, the crisis staff can travel to the better equipped crisis room at the main control centre.[165]

This crisis room at the main control centre is equipped with multiple projectors, tools for video conferences, television and internet access, partition walls to segment the room to form work groups and an emergency power generator. Flipcharts and other analogous equipment to display important information for everyone are considered to be very important. Therefore, this provisioning of information is part of crisis simulations and trainings.[166]

Professional Fire Brigade Graz – catastrophe control room

The catastrophe control room at the main fire station in Graz is a specially equipped room for the management of crisis situations. If an operation becomes a large scale operation, can be considered a catastrophe or it becomes too large to be handled by

[164] Röxeis, Gottfried. Personal interview. 12.09.2014
[165] Prießnitz, Wolfgang. Personal interview. 01.10.2014
[166] Prießnitz, Wolfgang. Personal interview. 01.10.2014

the normal control room, the catastrophe control room in the fire station is activated. The crisis management staff of the Professional Fire Brigade meets in this room for the duration of the operation. The room arrangement and the staff work is performed according to the guidelines of SKKM (Staatliches Krisen- und Katastrophenschutz-management).[167]

The area for the situation report is centrally located to ensure visibility and with enough space to discuss and develop the situation. The work space for the subject group S3 (operation) is between the subject group S2 (situation) and the manager of the command staff to provide the necessary exchange of information among these staff functions. To reduce disturbing accompaniments of the news activities, the reports collection point is spatially separated from the managerial task force. An extra room is provided for a task force in case the manager needs additional expert advice or the task requires surveyors or liaison officers of other organizations (figure 22).[168]

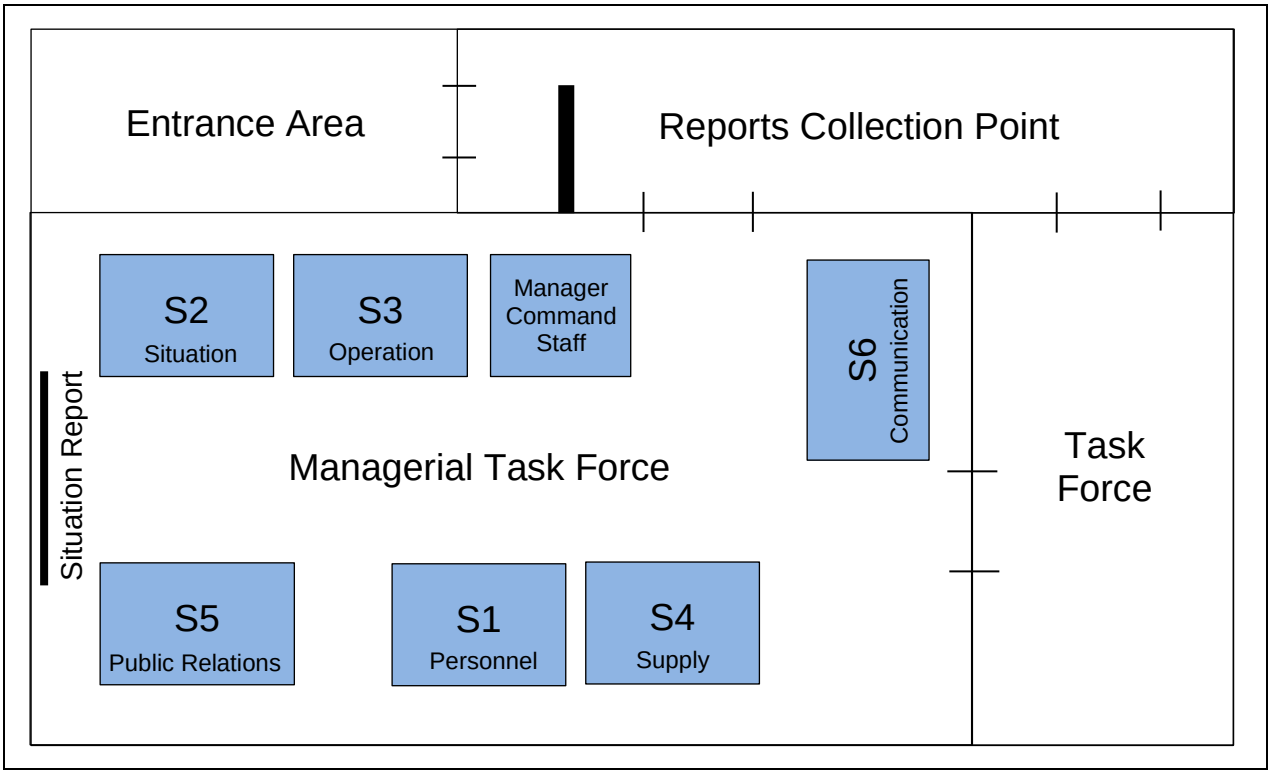


Figure 22: Room arrangement example for staff work[169]

[167] Krajnz, Heimo. Personal interview. 18.09.2014
[168] cf. Bundesministerium für Inneres, Abteilung II/4 (2007), p. 51ff
[169] Bundesministerium für Inneres, Abteilung II/4 (2007), p. 51

Additionally to the team of the Professional Fire Brigade, members of other organizations like politicians from authorities, contact people from partner companies and liaison officers of other emergency organizations or the Armed Forces can be present. Daily business is still handled by the control room while the catastrophe operation is outsourced to this special room. The equipment of the catastrophe control room is similar to the equipment of the previously described crisis room of Austrian Power Grid.[170]

5.5.2 Transformation for agile manufacturing – War Room

A War Room is a dedicated room for managing unpredictable events and situations in an industrial environment. In this special room decision makers and project teams meet to gather and exchange information on a project or event and come to quick decisions. This quick decision making is possible for all important information is available and the communication channels are very short due to the presence of all relevant people in one place.

The term “War Room” is also known as one of many types of the Obeya.[171] Obeya means “large room” and is associated with the Toyota Product Development System as a strategy to support project work.

Requirements and preparatory measures

Definition of the project team

The nomination and selection of the project team is one of the key criteria for the successful function of a War Room.

Basically, all core departments of the company like purchase, production, production planning, personnel, quality control and aftersales have to be present during meetings. In occasions of large scale, the general managers should attend the meetings as well. The departments can be represented by the head of departments or by appropriate representatives. The important issue is that the project members are no specialists. The project members need to have a profound knowledge of their own department but also need to understand and appreciate all the other departments.

[170] Krajnz, Heimo. Personal interview. 18.09.2014
[171] cf. Aasland and Blankenburg (2012) p. 1

Moreover, trust between the team members is an important prerequisite. A team that knows and trusts each other is more likely to function well in a stress situation than a team of individuals that do not honour their counterpart. This trust can be enhanced by confidence-building events like team building. The collaboration of the project team in the War Room can and should be tested by running simulations (5.4.2).

Training of War Room manager

The war room manager serves as a controlling and supporting entity for the project team. The manager ensures that the teams stays on schedule and steers the project team into the right direction. For these tasks a profound knowledge about project management and the different departments of the company is necessary. Additionally, the War Room manager should be a mediator to convey opinions and ideas between the cross functional team members as some decisions or consents might not be favourable for every department. Furthermore, this person needs to perform very well under stressful conditions.

Meeting schedule

During times of change, the meetings should be set up at a fixed time to ensure consistency. A time during forenoon, not too early, would be advisable so the heads of departments or their representatives have time to gather the latest information and can present it during the War Room meeting. The meeting schedule highly depends on the kind of change process a company has to deal with. Appropriate times and frequency of War Room meetings need to be defined individually for every situation. During these turbulent phases the war room could furthermore be staffed by representatives of all the important functions at all times to enable the company to decide and act in real time. For daily business the room can be used by an agility task force that gathers information on certain operations and advice the managers on duty.

Presentation of information

The general information on the current situation is prepared in advance of a meeting and presented by the War Room manager. The detailed information on the situation of the various departments is presented by the head of departments or representatives, so everyone attending the meeting is on the same information level. The information presentation is moderated by the War Room manager who also ensures that only relevant information is presented and the procedure is structured.

Documentation

Documentation should be done for all events at all time to enhance the lessons learned principle. The forms for an effective documentation have to be standardized and provided in advance on an event. After meetings the participants write down the important content for the department they are responsible for. A proper and comprehensive documentation is also important in case a member of the project team is not available anymore, due to different reasons like, sickness or dismissals. Only then it can be ensured that no knowledge is lost and a successor or a replacement is on almoust the same knowledge level as the predecessor.

Furthermore, the positive and negative aspects of the meetings, from the perspective of the members of the War Room project team, should be written down and discussed with the War Room Manager. Thus, the quality of the output that is generated in the War Room can be enhanced for future volatile situations.

Equipment

For the visualization of information a wide range of equipment like multiple projectors, flipcharts, whiteboards, post-its or equipment for telephone conferences have to be provided. For a longer War Room meeting the preparation of refreshments and snacks should be self-evident.

There is current research on the development of web application tools to virtualize Obeya rooms. Some software solutions are already available on the market. This visual management platform is relevant for multiple disciplines like agile practices, lean management, project management, brainstorming or value stream mapping. Additionally, this visual platform allows teams to work together in real-time regardless of the physical location of the teams. Furthermore, current meeting rooms can be transformed into multi-project, multi-team Obeyas without the usage of other dedicated space.[172]

Improvements after implementation

Fast decisions and communication

Decisions can be made in a very fast fashion because all decision makers are in one room right next to each other and therefore the communication ways are short. Furthermore the decision-making process benefits from the fact that all decisions are

[172] cf. http://www.iobeya.com/en [26.01.2015]

based on the same information and misunderstandings or unnecessary discussions can be avoided. It is also advantageous that the participants know each other and there is personal communication between the members of the cross functional team.

Visualization

Especially in turbulent phases, visualization of the situation helps to identify possible problems. To be able to understand the provided information at one glance, the information should be made available by using simple charts, graphs, pictures and colours. The graphical display also supports the decision process and the interpretation of information by reducing complexity of the given data. Thus, the required actions can be compelled in a fast fashion. Some of the topics that could be visualized can be seen in figure 23.

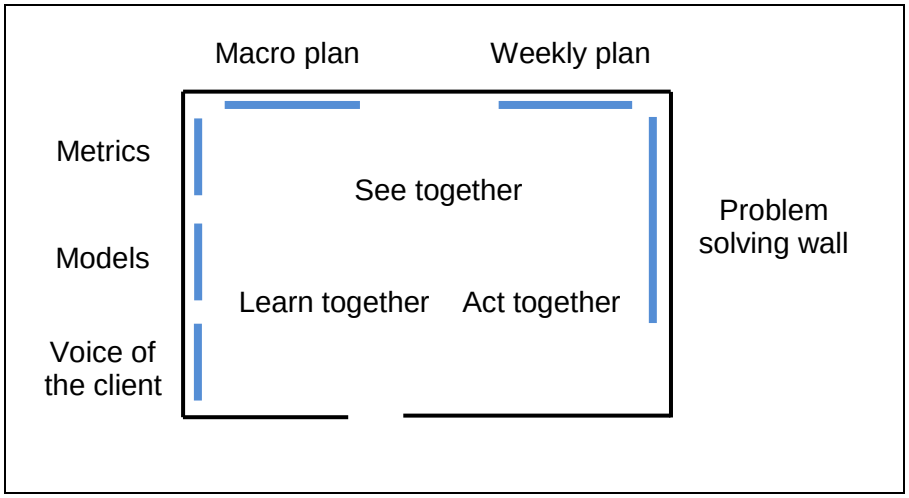


Figure 23: Visual representation topics of the Obeya[173]

Synchronization of activities

In times of change and volatile situation the communication between the departments of a company becomes an even more important subject. An easy way to synchronize the activities of all departments involved in an operation is to hold daily meetings in the war room. After the briefing of the War Room manager on the overall situation and the detailed discussion on the current situation by the heads of departments or representatives, every participant is on the same knowledge level. Everyone attending

[173] http://www.operaepartners.com [18.11.2014]

the meeting exactly knows the current situation of the other departments and is informed about the activities to come.

Problem solving

The war room layout can be arranged according to the principles of common problem solving strategies like the plan-do-check-act cycle (PDCA). The core team members are usually supported by their team outside the room through work and information. Thereby, problems and tasks can be identified, assigned and solved in real-time.[174]

Furthermore, only the information relevant for the current project is displayed and processed in the War Room during the meetings. Thus, the project members can focus solely on the current project for the time of the meeting which enhances the problem solving competence and leads to faster results.

Conduction of simulations

The War Room has the necessary equipment and proper layout for conducting simulations (5.4.2). It also provides enough space for large-scale simulations with participants of partners companies. Furthermore, people who are not physically present can attend simulations via virtual software platforms and participate in simulations. By taking part in these simulations, the attitude, behaviour and problem solving competence of the representatives of partner companies can be observed and tested. Through the display of all information regarding a simulation, the necessary fields of action can be determined and improved together.

5.6 Crisis management guidelines

Crisis management guidelines are used by Austrian emergency response organizations for a coordinated operation in disaster relief situations. The focus lies on the National Crisis and Disaster Protection Management strategy SKKM (method number 75).

[174] cf. Aasland and Blankenburg (2012) p. 5

5.6.1 Crisis management guidelines in unconventional organizations

National Crisis and Disaster Protection Management SKKM

The National Crisis and Disaster Protection Management SKKM is a strategy for the coordination of authorities and emergency response organisations (Fire Brigade, Red Cross,…) in emergency operations of exceptional scale. The strategy is developed by the "Bundesministerium für Inneres" in cooperation with other ministries, states and emergency response organizations. With the SKKM strategy, Austria has a very efficient and flexible coordination model for complex crisis and catastrophe situations.[175]

The strategic goals and priorities of the SKKM strategy are:[176]

- the best possible prevention of catastrophes through prevention and optimizing of risks;
- earliest detection and warning of catastrophes and their damage potential;
- securing a high standard of preparation for operations;
- fast and efficient reaction to catastrophes in order to minimize the damage on national and international level;
- and the fast transition to a normal situation after catastrophes.

According to the SKKM strategy, following measures have to be set with priority for the best possible achievement of those goals:[177]

- Firstly, the implementation of innovations, especially to improve the flow of information between decision makers on a strategic level and communication with the population. For this purpose, know-how transfer should be strained with an emphasis on research and development;
- secondly, the encouragement of education across organizations; and
- thirdly, the adjustment and improvements of communicational structures, especially for nationwide and international situations as well as legal conditions.

5.6.2 Transformation for agile manufacturing - executive agility guideline

The executive agility guideline is a strategy to implement and develop measures to improve agile abilities of a company. This guideline is particularly useful for the implementation in an enterprise or production network, since the goal is the unification of alignment of agile measures. Through this alignment of strategies and measures,

[175] cf. Bundesministerium für Inneres, Abteilung II/4 (2009) p. 3
[176] cf. Bundesministerium für Inneres, Abteilung II/4 (2009) p. 7
[177] cf. Bundesministerium für Inneres, Abteilung II/4 (2009) p. 7

responses to change can be coordinated, trained or simulated and the overall efficiency and performance can be improved.

Requirements and preparatory measures

Top-management commitment and project initiation

Top-management commitment is a prerequisite for all major changes within an enterprise. Changes of this magnitude have to be initiated top-down. Top-management has to point out the willingness for the development of an agility guideline. Furthermore, a cross-functional project team has to be installed. This project team should be situated in headquarters with direct links to the top management and agility managers located at the production sites.

Functioning coordination and operational structures in-between the team members are the keys for a successful development of the executive agility guideline and its application.

Involvement of employees

A company's employees have to be included in the development process of the guideline because they can give important hints regarding the actual processes in the factories. This can be accomplished by conducting regular project team meetings.

Furthermore, employees are the ones who execute the measures which derive from the guideline. Therefore, they need to properly be informed about the aims of the assigned actions. The tasks which have to be carried out by the employees have to be formulated in an easily understandable fashion.

Additionally, company culture needs to be innovation-friendly in order to support changes. Attempts of change have to be promoted for the employees on all organizational levels.

Modules of the guideline

The implementation of measures and the education or training lies within the responsibility of the organizations of an enterprise. To unify the efforts and allow cross-organizational and interagency education and training, the following central themes need to be formulated in the guideline. The central themes are divided into modules representing the most important areas on which the guideline focuses (figure 24). The guideline's modules are:

- Module 1 should set the organizational structures for dealing with extraordinary situations during change. Its aim is to provide a basic understanding for the system of the executive agility guideline and its organizational background. Target audiences are the heads of departments and the first management level of the organizations.

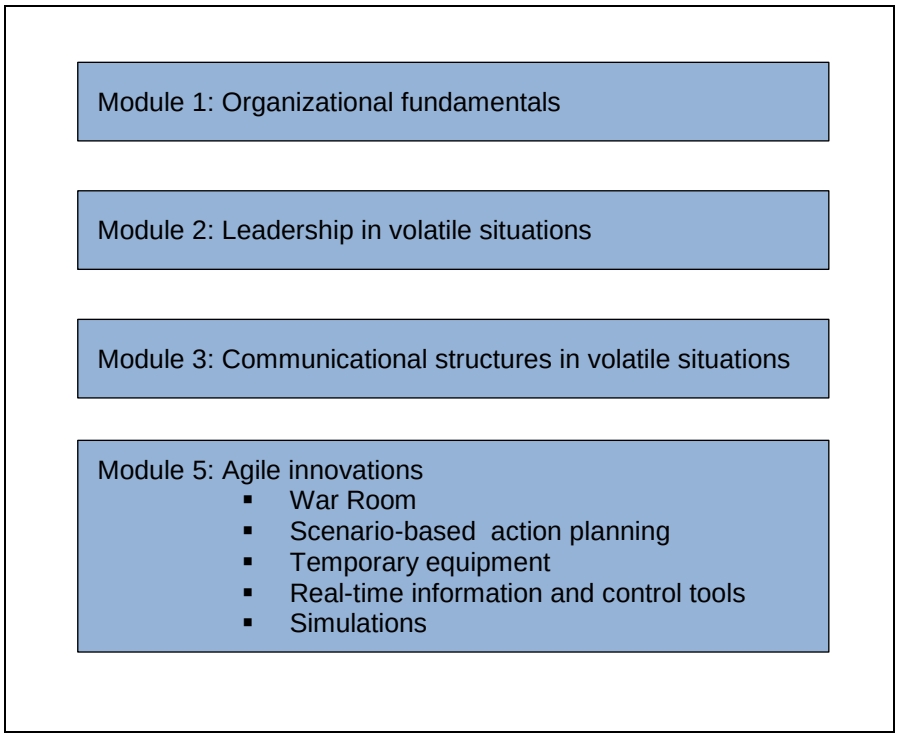


Figure 24: Modules of the executive agility guideline[178]

- Module 2 should provide a guideline for mastering exceptional situations on leadership level. The goal of this guideline is to achieve an unification in leadership and to provide interoperability during unusual operations.
- Module 3's aim is the creation of a high quality guideline for the training and structuring of the communication and information on a managerial level. As already mentioned, communicational structures and the flow of information are very important prerequisites when dealing with uncommon situations.
- Module 4 includes all the innovations an enterprise is planning to implement or that are already in use. Methods and strategies have to be formulated in a general sense for the usage in different organizations within an enterprise. The planning of these innovations should be done by headquarters to ensure unity,

[178] Own representation, based on Bundesministerium für Inneres, Abteilung II/4 (2009) p. 10

but the responsibility of implementation lies on the enterprises' organizations or the partners within a production network.

Improvements after implementation

Unification within the enterprise

As the whole enterprise uses the same measures and education on the topic of agility, the measures and their impact within the different production sites are comparable. Through that, production sites can learn from each other and improve the usage of the measures for the whole network. Though the unified education and standardized measures, exchangeability of employees between different sites is possible.

Mutual platform for agility

Management learns to deal with volatile situations and has an overview of the whole enterprise. Managers of one particular production site know exactly how this specific situation is dealt with at the other sites. Thus, comprehensive efforts can be coordinated and conducted. The status and location of temporary equipment (5.1.2) can be defined and exchangeability can be improved.

Trainings and simulation

Trainings for unusual situations can be conducted company-wide for all employees have the same educational standards when it comes to the topic of agility. The guideline sets the standards for contents, used software applications and the conduction of simulations (5.4.2). Through the unification, those simulations can be performed including different production sites or partner companies. Through unified War Room equipment (5.5.2) those simulations can be conducted by interchangeable teams on local as well as global level.

Knowledge and information transfer

Other production sites within the same enterprise or production network might have been in volatile situations before and learned how to handle them. Those experiences can serve as a basis for recurring guideline improvement actions. By taking already experienced situations into consideration, appropriate actions for the future can be defined, further improved and implemented into the guideline. Thus, the whole production network can benefit from the experiences of one member.

6 Summary and outlook

As volatility in business environments is likely to increase within the next decades, companies competing in today's and future markets need to prepare for change. Since the introduction of agile manufacturing in 1991, this manufacturing paradigm is considered to be the manufacturing strategy for the 21st century to face the challenges of constant change. Agile manufacturing is a paradigm that allows companies to proactively prepare for change to gain competitive advantages. The development of tools, measures and strategies to achieve agility in manufacturing has been in the focus of researchers around the globe.

The aim of this thesis was the development of new methods and strategies for agile manufacturing. In order to find new approaches, organizations that do not belong to manufacturing industry, were investigated. The assumption was made that other organizations, besides the manufacturing industry, also face a volatile environment and are highly capable of dealing with change. In further consequence, these organizations were called unconventional organizations.

To be able to identify these unconventional organizations, the key capabilities of agile manufacturing had to be defined beforehand. Through a literature research on some of the most influential papers and published works on the topic of agile manufacturing, the key capabilities of agility could be named. Those key capabilities are speed, flexibility, proactivity and innovativeness. Unconventional organizations need to have at least three of those agile capabilities to be considered in the investigation (answer research question 1).

Unconventional organizations cannot be counted to the manufacturing industry but need to succeed in a volatile environment. They need to be able to fast and efficiently react to changes; use flexible tools, measures, processes or structures; are proactively preparing for change; and use new and inventive technologies to master volatility. The following organizations and departments were identified to meet these requirements and investigated:

- Austrian Airlines
- Austrian Armed Forces
    - Military Command Styria
    - Military Command Lower Austria
- Austrian Power Grid
- Austrian Red Cross
    - Red Cross Styria
    - Red Cross Logistics

- Emergency and Disaster Medicine Styria
- Lufthansa Technik
- National Warning Centre Styria
- Professional Fire Brigade Graz
    - Fire Brigade
    - Civil Protection
- State Police Headquarter Styria

In order to identify agile methods and strategies used by these unconventional organizations, a literature research was performed and interviews with experts were conducted (answer research question 2).

The findings of the investigation were 94 agile methods and strategies used by unconventional organizations. For the evaluation of those methods and strategies a framework was introduced. The findings were categorized and implemented in the framework according to multiple parameters: preparation time, preparation, time of activation, affected area, positive effect on the organization, level in organization and the range of their impact (answer research question 3). In order to find the most promising methods and strategies for the application in agile manufacturing, the framework was assessed by six researchers currently working on the topic of agility. The framework was ranked in accordance to impact, feasibility and innovativeness if applied in a manufacturing environment with the focus on innovativeness (answer research question 4).

The outcome of the evaluation and ranking process were six new methods and strategies for the application in agile manufacturing. (Those six methods and strategies are composed of 11 of the highest ranked unconventional methods and 5 unconventional methods with a close correlation to the 11 highest ranked.) Those six methods and strategies represent six subject areas, composed of 16 unconventional methods, which were transformed to be applied in a manufacturing context.

Real-time information and control tool is a program for the real-time representation and management of changes in a company’s manufacturing system, organizational structure or personnel and serves as a mutual information platform. Large-scale simulations are a method to test the effect of change drivers on an entire production network. Scenario-based action planning allows a company to proactively prepare for volatile situations by anticipation and preparation of appropriate responses for those events. A War Room is a dedicated room for the management of unpredictable situations of large scale. Temporary equipment is a strategy of mobile manufacturing or assembly modules for a fast deployment and operation at different locations. An

executive agility guideline describes the attempt to align agile strategies and measures within an enterprise to improve the responses to change (answer research question 5).

Within this thesis, six new agile methods and strategies were found and described. An implementation of these methods in a manufacturing enterprise would be a possible continuation of this work. An implementation of these methods could be accompanied by their verification. The actual impact on a specific company’s agile capabilities could be measured. The result of the verification could lead to further optimizations of the postulated methods.

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11 List of abbreviations

Abbreviation	Meaning
APG	Austrian Power Grid
CAD	computer-aided design
CAM	computer-aided manufacturing
cf.	compare
DML	dedicated manufacturing lines
ERU	Emergency Response Unit
ERP	enterprise resource planning
et al.	et alii or et aliae; latin for “and others”
f	following
ff	and the following ones
FMS	flexible manufacturing systems
IFRC	International Federation of Red Cross and Red Crescent Societies
MRP	material resource planning
MPR II	manufacturing resources planning
p.	page
PDCA	plan-do-check-act
SMED	Single-Minute Exchange of Die
TherMilAk	Theresianische Militärakademie
TPS	Toyota Production System
VIP	Very Important Person

Appendix A: Complete framework of unconventional methods

Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
Austrian Power Grid	Tower construction kit (APG security package)	Modular construction kit system to build towers in any shape and form, for high-tension power lines	mid term	Prepared equipment container, office container, airworthy barred boxes, construction training	mid term	Technology	Tentative bridging of damaged high-tension power lines	Maintenance	Internal	3,83	3,33	4,17	3,90
National Warning Centre Styria	Planning and Response Tools	Planning of operational scenarios and mapping of the action forces	mid/ long term	Programming of the operational scenarios	short term	Information Organisation	Planning of the place of action in advance, direct response to incidents	Planning Operator	External	4,33	3,83	3,67	3,90
Austrian Power Grid	Training scenarios for crisis management staff	Training of exceptional situations for crisis staff members	mid term	Cooperation with trainers from external consultants, 2-3 times a year	mid term	Personnel	Documentation of decisions, evaluation and improvement for crisis scenarios, training of working together in a crisis staff	Crisis management	External	4,00	4,17	3,67	3,87
Austrian Power Grid	6 main incident scenarios	In-depth planning for the most common and high risk incident scenarios	mid term	Crisis planning for all departments of the organisation	short term	Information	Ensuring fast and proper response in unusual situations due to pre-defined processes and personnel staff	Crisis management	Internal	3,83	3,50	4,00	3,85
Austrian Armed Forces - Military Command Styria	Simulations	Training and worst case scenarios with all organizations involved and evaluation	mid term	Scenario planning with simulator (force, space, time)	mid term	Information Personnel	Improvement of the coordination between different organizations	Planning	External	4,00	3,00	4,00	3,80
Austrian Red Cross	Emergency Response Units (ERUs)	Standardized equipment, transportable stored	long term	modular and standardized units, coordination with other national organizations	short term	Technology	exchange between different modules and operation of the units on international level possible	international	Internal	4,50	3,83	3,33	3,78
Austrian Power Grid	Simulations	Simulations on national and international level, in-house or at specialized simulation companies (DUtrain)	mid term	Planning of simulation scenarios, cooperation between national and international partners	mid term	Personnel Technology	Training of exceptional situations, education of employees	All levels	Internal External	4,00	3,67	3,67	3,77
Professional Fire Brigade Graz	Disposition of fire engines	System to monitor the condition, staff and availability of fire engines in the area, changes in alarm and march out order can be displayed	mid term	Operating system, connection of fire stations, communication between fire engines and stations	short term	Technology	Overview about the state of personnel and fire engines, quick and easy to recognize	Emergency call centre	Internal	3,83	3,83	3,67	3,75
State Police Headquarter Styria	Control room	Prioritizing of emergencies in accord with the chief officer, leading of operation till BAO is ready	long term	Training for control room staff	short term	Organization	Prioritizing of emergencies from the first moment, handling of multiple emergencies	Control room	Internal	3,83	4,17	3,50	3,73

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
83	State Police Headquarter Styria	EPSweb	Mission control and information system	long term	Implementation of a nation/state-wide programm	short term	Information	All the important information of an operation is available for everyone in real time, changes can be illustrated	Command level	Internal	4,50	4,00	3,17	3,73
69	Professional Fire Brigade Graz	Guideline for leadership in disaster operations (SKKM)	Guideline for handling catastrophes and incidents of extraordinary scale	long term	Development of a detailed guideline, suitable for different organizations	short term	Organization Communication Information	Standardization in leadership for authorities and emergency organisations	Command level	External	3,50	3,67	3,83	3,70
53	Lufthansa Technik	Aircraft on Ground (AOG)	Vey fast supply of crucial parts in case of emergencies and malfunction	long term	Establishing of networks between airlines, mutual help between airlines, various supply sources	short term	Logistic	Due to multiple supply sources in the network very fast response and provisioning of material	Maintenance	External	4,00	2,83	3,83	3,68
68	Professional Fire Brigade Graz	Increased readiness, catastrophe readiness	Alarm and march out order for special situations, less units per fire brigade are send out	mid term	Planning of the least amount of personnel and equipment necessary to handle an incident	short term	Organization Information	More incidents at the same time can be dealt with	All levels	Internal	3,17	3,67	4,00	3,68
63	National Warning Centre Styria	Keywords	Roughly 100 operational scenarios are linked to keywords	mid/ long term	Assign keywords to scenarios, programming of the software	short term	Information	Fast and proper response to emergency calls, relevant information is provided in a timely manner	Operator	Internal	2,67	3,33	4,33	3,63
64	National Warning Centre Styria	Civil Protection Server	Connection of regional authorities and provision of catastrophe related data	long term	building of database to keep the large amount of date up to date	short term	Information	Fast provision of all necessary data like suppliers, checklists, numbers	National level	External	3,33	3,50	3,83	3,62
82	State Police Headquarter Styria	Special information units	special units gather information on certain operations and advise the officer of the day	mid term	Training for specialized personnel, observing of different operation areas	short term	Information	Decision making in a very fast fashion (2-3 minutes) and immediate actions	Command level	Internal External	3,50	4,00	3,50	3,60
1	Austrian Airlines	Exchange of aircraft	Passenger volume checks on every flight every day, swapping between aircraft types in regard to passenger volume	mid/short term	mid and short term flight schedule planning, exchangeability of crews	short term	Technology	Higher degree of capacity utilization per aircraft	Planning	Internal	4,50	2,50	3,50	3,60
16	Austrian Power Grid	Control energy	A constant energy level is ensured by purchasing more expensive control energy when needed	mid term	Special backup power plants to smoothen the demand, purchasing of energy by auction	short term	Logistic Technology	The volatility of certain power sources (wind, solar energy) can be counteracted by other energy sources	Main control center	External	4,17	2,50	3,67	3,58
66	National Warning Centre Styria	Operational scenarios	uncertainty of the scenarios is encountered by different possibilities within a scenario	mid/ long term	Operational planning for multiple possibilities, risk analysis	short term	Information	Pre-defined tasks and responses to a variety of incidents	Operator	Internal External	4,00	4,00	3,17	3,58
72	Professional Fire Brigade Graz	K20 concept	20 possible catastrophe scenarios for the region	long term	Detailed planning for the most common and high risk scenarios, cooperation with other organizations	short term	Information	Defined processes and actions for high risk scenarios	All levels	Internal External	3,83	3,33	3,50	3,57

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
48	Emergency and Disaster Medicine Styria	Emergency medicine specialist	Person with leadership experience, in depth knowledge of hospital infrastructure, supply processes	long term	Special training for emergency doctors	short term	Personnel	Person in charge is highly qualified and experienced in handling special situations	Management level	Internal	3,83	4,33	3,00	3,52
20	Austrian Power Grid	Crisis room	Special equipped room for crisis management purposes	mid term	Equipment of the crisis room (beamer, video conference, flipcharts, partitions, documentation sheets,...)	short term	Information	All the actions and decision makers are concentrated in one dedicated room	Crisis management	Internal	3,50	4,33	3,17	3,50
31	Austrian Red Cross	Field Assessment and Coordination Team (FACT)	Specialists from the different divisions in duty for the international organization at the catastrophe scene	long term	Special training for employees	short term	Personnel	securing efficient communication and coordination between the national und international organization	national/ international society	Internal	3,33	3,83	3,33	3,43
57	Lufthansa Technik	Material provisioning on past data	Analysis of flight data to provide the proper maintenance material	mid/ long term	Analysis of large amounts of data (big data topic in the future), statistical evaluation	mid term	Logistics	Right material for different tasks is available	Purchase	Internal	3,83	4,33	2,67	3,35
22	Austrian Power Grid	Partner companies	First actions are done by in-house maintenance teams, afterwards the majority of work is performed by partners	mid term	Leasing of personnel and equipment, service contracts with partners	short term	Personnel	Quick access to additional manpower or equipment	Maintenance teams	External	3,50	4,33	2,83	3,33
33	Austrian Red Cross	Smaller Water and Sanitation units	Change from a few, large units to more and smaller units	long term	Adjustment of the smaller units	short term	Logistic	considerably more flexible by using more and smaller units	national/ international society	Internal	4,17	3,17	2,83	3,30
2	Austrian Airlines	Irregularity aircraft cold stand-by aircraft	Possibility of an additional flight to handle an unexpected high amount of passengers	mid/ long term	Aircraft standing in the maintenance, crew on stand-by at home	short term (60 - 120 minutes)	Technology Personnel	Better dealing with unexpected high passengers volume fluctuation	Planning	Internal	4,17	2,67	3,00	3,28
19	Austrian Power Grid	Reaction without permission	Reaction in special situations without additional permission, decisions that usually need external and internal revision	long term	Definition to which extension decisions can be made without internal or external permission	short term	Logistic Organization Information	Crisis management can instantly make orders, decision, which is afterwards evaluated, fast support during incidents	Crisis management	Internal External	3,17	3,33	3,33	3,28
40	Austrian Red Cross	Triage	Categorization of casualties due to the severity of the injuries in groups	mid term	Definition of 3 triage groups for major incidents and 4 triage groups for catastrophe events	short term	Information	Categorization of high numbers of casualties and the planning of transportation and further treatment	Incident scene	Internal	3,17	3,33	3,33	3,28
47	Emergency and Disaster Medicine Styria	Alert phases	Alerting of employees in dependence on alert phases	mid term	Planning of the required personnel volume for a given situation	short term	Personnel	The right amount of employees is available at the hospital to master a specific emergency situation	All levels	Internal	3,17	3,33	3,33	3,28
54	Lufthansa Technik	Creation of redundancies	Securing the availability of equipment and material	long term	Close communication with OEM's, risk analysis, authorization process, service of equipment provider	short term	Technology Logistics Communication	Malfunction of a single machine can be buffered by using redundand equipment (own or outsourced)	Manufacturing Purchase	External	2,67	4,33	3,17	3,25

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
87	State Police Headquarter Styria	Additional staff	Allocation of additional staff for special occasions without interfering with daily business	mid term	List of available staff on a daily basis, considering vacation or illness	short term	Personnel	Availability of specialists or manpower is defined in advance of a mission	All levels	Internal	4,00	4,00	2,50	3,25
21	Austrian Power Grid	Incident command and crisis staff	Local incident command at the scene, supported by crisis staff at the headquarter	mid term	Especially trained incident commander, responsible for coordination of emergency organisations at the operating site	short term	Organisation	Separation of operative tasks at the operating site and higher-level coordination and communication of the crisis staff	Crisis management	Internal	3,33	3,67	3,00	3,23
55	Lufthansa Technik	Smoothing of dispatching	Breaking up of big workload packages into smaller modules and stretching the modules over a period of time	mid term	Coordination with the customer and flight plan, close customer relationship, modular setup or work packages	mid term	Technology Communication	Dispatching peaks for more than one long-term check at the same time can be avoided	Maintenance teams	External	3,33	3,67	3,00	3,23
42	Austrian Red Cross	Incident scene (SanHiSt)	Spatial segmentation of the incident scene, flexible in dependence of extend and kind of incident	mid term	Planning of the best location for triage room, caregiving room, transportation room etc.	short term	Technology Organization Logistic	Clearly defined spatial arrangement of the sections	All levels	Internal	3,33	3,17	3,17	3,22
75	Professional Fire Brigade Graz	Catastrophe control room	Special room for catastrophe situations and large sclae operations	long term	Equipment of the control room, coordination with emergency organizations, authorities and partner companies	short term	Organization Communication Information	Decision makers work close together, bundling of information	Command level	Internal External	3,33	4,00	2,83	3,22
24	Austrian Power Grid	n-1 principle	Parallel arrangement of systems and utilization of 60-70% of the maximum capacity of one system	long term	Planning of the average utilization of the equipment, monitoring of the actual utilization	short term	Technology	Malfunction of one system does not lead to large-scale blackout because of second backup system	Main control center	Internal	4,00	2,83	2,83	3,18
70	Professional Fire Brigade Graz	Keywords	Around 170 keywords are defined, units and equipment are assigned to every keyword	mid term	Planning of equipment and personnel for every keyword, alert plans for the keywords	short term	Information	Fast response to emergency calls with the proper equipment and units	Mission control	Internal	2,33	2,83	3,83	3,18
5	Austrian Airlines	Irregularity aircraft	Possibility of an additional flight to handle an unexpected high amount of passengers	mid/ long term	One aircraft on ground with low capital costs	short term	Technology	Better dealing with unexpected high passengers volume fluctuation	Planning	Internal	4,33	3,17	2,50	3,18
28	Austrian Power Grid	Combined Qualification	Education in mechanical and electrical engineering	long term	Training of the staff in more than one field of operation	short term	Personnel	Employees are able to perform various task in unknown situations and can be deployed more flexible	Maintenance teams	Internal	4,33	4,00	2,17	3,18
79	Professional Fire Brigade Graz	Flexible team composition	Personnel is flexible shifted between fire engines, call centres etc.	long term	Training of the personnel in multiple fields	short term	Personnel Organization	The available personnel can be deployed for different tasks and fields	All levels	Internal	4,33	3,50	2,33	3,17
86	State Police Headquarter Styria	Orders	Orders are defined by the commander, but the actions to reach the goals can be decided on an individual level	long term	Long term training of crucial personnel, trust, close communication	short term	Information Communication	Decisions and actions can be made very fast	All levels	Internal	3,50	3,83	2,67	3,15

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
90	State Police Headquarter Styria	Training for commanders	Special training for mission commanders	long term	Special training for mission commanders and participation at exercises	short term	Personnel	Highly trained specialists are in charge in special situations	Command	Internal	3,50	4,67	2,33	3,15
27	Austrian Power Grid	Crisis management staff	Smallest staff is crisis manager and communication manager, expand of staff in dependence on the incident severity	mid term	Training of crisis and communication managers, personnel of the staff for different scenarios	short term	Organisation	Crisis manager and communication manager decide on first measures and expansion of staff	Crisis management	Internal	3,17	3,83	2,83	3,13
92	State Police Headquarter Styria	Evaluation of operations	Every operation should be evaluated by specific parameters	mid term	Standardized evaluation processes, documentation of the operation	short term	Information	Learning from past operations for future operations	Command level	Internal	3,83	4,50	2,17	3,13
84	State Police Headquarter Styria	Operation sections	establishing of operation sections during or in advance of an operation	mid/ short term	Review of the possible situations that can occur during the operation	short term	Organization	Tasks are spilt up into smaller tasks, reducing complexity and workload for one section responsible	Command staff	Internal	3,17	3,33	3,00	3,12
73	Professional Fire Brigade Graz	Alarm and march out order	Defined units and personnel for a fire brigade, linked to key words	mid term	Planning of equipment and personnel and evaluation of past operations	short term	Organization Information	Fast response to emergency calls with the proper equipment and units	All levels	Internal	2,50	3,00	3,50	3,10
12	Austrian Armed Forces - Military Command Styria	Force level	Weekly reports on force level which is available for assistance operations	long term	Several aspects of personnel planning	short term	Personnel	Military command knows exactly how many forces in which quality are available at every base	Planning Execution	Internal	2,50	4,17	3,00	3,08
85	State Police Headquarter Styria	Flexible working hours	In case of a shortage of specialists, extension of working hours to 16-18 hours	short term	Training of employees for physically and mentally challenging operations	short term	Personnel	Staff is able to perform in a proper way even though conditions are very hard and unusual	All levels	Internal	3,83	2,17	3,00	3,08
4	Austrian Airlines	Irregularity aircraft hot stand-by aircraft	Possibility of an additional flight to handle an unexpected high amount of passengers	mid/ long term	Aircraft standing at the movement area, crew ready at the airport	short term (30 minutes)	Technology Personnel	Better dealing with unexpected high passengers volume fluctuation	Planning	Internal	4,33	2,00	2,67	3,03
43	Austrian Red Cross	Hospital alerting	Information about the medical care level and alerting of the hospitals	mid term	Inquiry of the capacity, alerting and information about the beginning of transport of the patients to the hospitals	short term	Information Communication	Maximum number of patients that can be treated in a hospital is provided	Control centre	External	3,33	3,50	2,67	3,03
44	Austrian Red Cross	Escalation-/ de-escalation model of command staff	Flexible response of the command staff to the personnel level in respect to the scale of operation	mid term	Definition of a command staff with 4 different levels, composition of the staff	short term	Organization	Commander can enlarge or reduce the command staff in respect to the status of operation or the planning complexity	Incident command	Internal	3,33	3,50	2,67	3,03
74	Professional Fire Brigade Graz	Operation sections	Incident commander can subdivide the operation site into sections and establish section commanders	long term	Education and experience of the incident commanders and special training for section commanders	short term	Organization	Complex operation sites can be divided into smaller sections and thus simplified for a single person	Command level	Internal	2,83	3,83	2,83	3,03

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
3	Austrian Airlines	Maintenance teams	mobile, special maintenance teams composed of highly experienced employees for ad hoc operations	long term	training and experience of maintenance specialists	short term	Personnel	The most experienced teams are used for special situations, in-house maintenance	Maintenance	Internal	3,00	3,50	2,83	3,02
13	Austrian Armed Forces - Military Command Styria	Increased readiness for action	Individual bases increase the readiness for action	mid term	Estimation on the future situation	short term	Personnel Logistic Organization	Units, supply, material is ready and available in a short time	Base	Internal	3,17	2,83	3,00	3,02
23	Austrian Power Grid	Transregional support	One maintenance team is responsible for a region with clearly defined handover points, support in special situations	mid term	Definition of required force level for daily business, planning of support operations	short term	Personnel Organization	Handling of daily business and mutual support of maintenance teams in unusual situations, pool forces	Maintenance teams	Internal	3,00	3,50	2,83	3,02
89	State Police Headquarter Styria	Statewide planning	Planning of larger operations at the central headquarter	mid tem	Planning of special operations, required force level, experience and parameters	short term	Information	Large scale operations are done by experienced specialists, statewide information is focused at the headquarter	All levels	Internal	3,17	4,50	2,33	3,02
26	Austrian Power Grid	Backup equipment	Strategically positioned backup equipment (transformers), nationwide	long term	Positioning near appropriate infrastructure (railway for transformers), different transformers for every field of	short term	Technology	Supply of crucial equipment in case of severe malfunction, discarded equipment can be used as backups	Maintenance	Internal	3,50	2,67	2,83	3,00
41	Austrian Red Cross	Tasks during overload phase	Measures to keep the duration of the overload phase as short as possible	mid term	Activities, person responsible and execution during the overload phase	short term	Information	Overload phase (phase between arrival of first units and enough units to handle incident) is as short as possible	Incident command	Internal	2,83	2,83	3,17	3,00
56	Lufthansa Technik	Time buffer	Planning of time buffers during the maintenance to handle remaining uncertainties	mid term	Buffer planning similar to CCPM	mid term	Technology	Remaining time can be used elsewhere	laintenance team	Internal	2,83	3,67	2,83	3,00
58	Lufthansa Technik	Material sources	As many material sources as possible	long term	Evalutaion of suppliers	short term	Logistic	Organization is not dependent on one supplier	Purchase	External	4,00	4,00	2,00	3,00
77	Professional Fire Brigade Graz	Additional fire brigade units	Support of the fire service by alarming off duty personnel or personnel and equipment from volunteer fire brigades	mid term	Shift planning, cooperation with volunteer fire brigade, automated personnel alarming systems	short term	Organization Personnel Technology	Fast acquisition of additional personnel and equipment	All levels	Internal External	3,83	2,50	2,67	2,98
93	State Police Headquarter Styria	Special functions of staff	Every patroller is trained in, at least, more than one special field	long term	Special training of staff	short term	Personnel	Every single employee is able to perform a range of tasks rather than just one	All levels	Internal	4,33	3,83	1,83	2,98
11	Austrian Armed Forces - Military Command Styria	Reconnaissance unit	First unit to evaluate the situation and estimate the requirements	mid/ long term	Special trained staff	short term	Information	On the basis of the reconnaissance unit the force level, material, supplies can be determined	Unit	Internal	2,50	3,17	3,17	2,97

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
60	Lufthansa Technik	Cross-qualification of the personnel	Smoothing dispatching peaks by using interchangeable teams	long term	Cross-qualifaction, transform specialized groups into a bigger pool with more capacity, long-term training, additional capacity for	short term	Personnel	Capacity pool becomes bigger the more teams are interchangeable, workload curve smoothens out	Training	Internal	4,17	4,00	1,83	2,97
76	Professional Fire Brigade Graz	Control loop of leadership	Assessment of the own situation, evaluation of the situation, planning of the implementation and placing of orders	mid term	Training for the usage of the control loop for decision makers	short term	Information	Method to support decision makers in incident situations	Command level	Internal	2,83	3,83	2,67	2,95
49	Emergency and Disaster Medicine Styria	Automated alert systems	Simultaneous alarming of a large amount of employees, parallel alarming channels	mid term	computerized, automated alert systems, planning of different alarming scenarios	short term	Personnel	The right amount of employees is available at the hospital to master a specific emergency situation	All levels	Internal External	3,00	2,67	3,00	2,93
59	Lufthansa Technik	Shiftwork	Flexible working hours in dependence of the workload	mid term	Planning of shifts for different project organizations	short term	Personnel	Range of working hours, from one shift to three shifts and weekends, for different project organzations, is possible	Maintenance	Internal	4,17	3,33	2,00	2,92
36	Austrian Red Cross	Local Suppliers	Purchase of supplies directly from the local or nearby manufacturers	mid/ long term	Datebase of local Suppliers	short term	Logistic	less transport costs due to local purchase, large amount of suppliers	international	External	3,67	3,50	2,17	2,88
61	Lufthansa Technik	Standardization	elimination variance in maintenance processes, reduction of the overall volatility	long term	demanding planning necessary	short term	Technology	Processes with the same amount of workload, reduced complexity and dispatching volatility	Engineering	Internal	3,50	4,50	1,83	2,87
6	Austrian Airlines	Categorizing of malfunctions	Every technical defect is categorized by a item (A-D)	mid term	Development of a categorizing item, risk analysis	short term	Technology	maintenance and flight schedule can be planned regarding the severity of the malfunction	Planning Maintenance	Internal	2,83	4,17	2,33	2,85
34	Austrian Red Cross	National catastrophe supply	Regional catastrophe supply centres supported by the central main logistic centre	long term	Calculation of the supplies needed by the number of population, contact to the carriers for distribution	short term	Logistic	Optimal amount of goods can be planned and stored	national	Internal	2,83	4,17	2,33	2,85
8	Austrian Airlines	Personnel buffer	Additional personnel for new destinations	long term	overtime, reduced working hours and part-time employment models	mid/short term	Personnel	fast personnel buffer to increase or decrease the number of employees	Flying staff	Internal	4,00	3,67	1,83	2,85
25	Austrian Power Grid	n-1 predictions	Monitoring of demand by special IT systems and simulation of critical situations (n-1 violations)	long term	Consumer and power plant operators need to announce the demand, weekly, daily and hourly predictions	short term	Technology	Knowledge about generation, consumption and quality of the grid and possible bottlenecks	Main control center	External	3,00	2,67	2,83	2,85
50	Emergency and Disaster Medicine Styria	Triage and registration place	Guidance of the patient transfer within the hospital	mid/ long term	Room concept, transport logistics, material equipment, checklists, communication	short term	Communication Logistics	Structured method to deal with unusual high patient numbers	First care	Internal	2,67	3,17	2,83	2,85

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
7	Austrian Airlines	Central supply pool	Central engine pool for Dash (organized by Lufthansa Technik) from which the engine/parts are supplied	long term	Building of a central supply pool	short term	Logistics	fast support with crucial parts	Aircraft	External	3,33	3,67	2,17	2,82
35	Austrian Red Cross	Additional warehouse employees	Additional personnel for longer catastrophe incidents	mid term	Volunteers with background in warehouse logistics, registered by the national organization	short term	Personnel	Fast acquisition of additional staff with adequate knowledge	national	Internal	3,17	3,50	2,33	2,82
88	State Police Headquarter Styria	Executive staff	Leading in special situations by using a executive staff, similar to military (S1, S2,...)	long term	Definition of tasks for the staff members, special training	short term	Organization	Specialists as commanders in charge for different sections, division of workload	Command staff	Internal	2,83	3,50	2,50	2,80
9	Austrian Airlines	Exchangeability of crews	Exchangeability of crews within a aircraft fleet	mid/ long term	training of cockpit crews and flight attendants	short term	Personnel	Crews are flexible within a fleet, easier exchange of aircrafts	Planning Personnel	Internal	4,33	3,67	1,50	2,78
46	Austrian Red Cross	Tentative incident command	Command at the scene during the important overload phase at the beginning of an operation	mid/ long term	Training and definition of procedures for the tentative incident commanders	short term	Organization	Highest-ranked employee is in charge until the incident commander arrives	Incident command	Internal	3,33	3,50	2,17	2,78
51	Emergency and Disaster Medicine Styria	Operational command hospital	Leading in emergency situations by a staff for high coordination and leadership effort	mid term	Composition of the staff and functions needed (S1, S2,...)	short term	Organization	Leadership and coordination support for emergency medicine specialists	Management level	Internal	3,33	3,67	2,00	2,73
91	State Police Headquarter Styria	BAO (Besondere Aufbauorganisation) - Organizational structure for special	Temporary estabilshment of a different organizational structure to control special events	mid term	Mission commander determines organizational structure and assigns tasks to field commanders	short term	Organization	Task specific organizational structure, communication, information	Command staff	Internal	2,67	4,17	2,17	2,72
45	Austrian Red Cross	Alert stages	4 alert stages in dependence on the number of patients, organizational effort or duration of the operation	mid term	Definition of alert stages on multiple criteria and preparation of actions for every stage	short term	Information	Clearly defined actions for every stage, controlled processes	perations plannir	Internal	3,00	3,17	2,33	2,70
37	Austrian Red Cross	Logistical cooperation between national and international organization	National organizations supply directly the affected area or supply the international warehouses	long term	Supply Chain Network between national and international organization	short/mid term	Logistic	Combined support due to the national and international organization, restock of int. Warehouses by the national organization	international	Internal	3,33	3,33	2,00	2,67
38	Austrian Red Cross	Chartering	Database of Carriers	mid term	Preparation of Carrier database (15 Companies)	short term (48 hours)	Logistic	short response time, selection of the cheapest carrier	international	External	2,83	4,17	1,83	2,60
52	Emergency and Disaster Medicine Styria	Checklists	Short and performable instructions in incident situations	mid term	scenario dependent instructions for functionaries in medical and non-medical areas	short term	Information	Support of staff in exceptional situations, guaranteeing a efficient process	All levels	Internal	3,17	4,00	1,67	2,58

Number	Organization	Strategy/Method	Description	Preparation Time	Preparation	Time of Activation	Affected Area	Positive Affect on Organization	Level in Organization	Internal/ External	Impact	Feasibility	Innovation	Sum
80	Professional Fire Brigade Graz	EU catastrophe modules	159 modules, consisting of special emergency units and equipment, international operation	long term	Preparation of emergency units without interfering with daily business, international coordination	short/mid term	Technology Orgnaization	Independent working units, focus on core competences, international help	International	External	2,67	3,00	2,17	2,48
29	Austrian Power Grid	Alarming of crisis managers	Pre-programmed phone unit for alarming the crisis managers using different communication channels	mid term	Establishing of communication programs	short term	Information Communication	Fast information of the responsible staff, information about availability of crisis management staff	Crisis management	Internal	2,17	4,50	1,83	2,47
62	Lufthansa Technik	Project-oriented organizational structure	Project organization is developed from organizational structure	long term	Planning of a flexible organizational structure in advance of larger projects	short/mid term	Organization	Project organization is responsible for one event	Maintenance	Internal	2,83	4,67	1,33	2,45
67	National Warning Centre Styria	Standby	Two employees are on standby and available in a short period of time	mid term	Personnel planning	short term	Personnel	Additional personnel is almost immediately ready in case of an internal emergency	Support	Internal	2,67	3,67	1,83	2,45
39	Austrian Red Cross	International warehouses	Strategic positioned warehouses around the globe (Dubai, Columbia, Kuala Lumpur, Panama, Geneva)	long term	Building of a warehouse-network around the globe	short term (48 hours)	Logistic	short response time, less transport costs	international	Internal	3,50	4,17	1,00	2,38
78	Professional Fire Brigade Graz	Emergency call centre	Expansion of the call centre in advance of possible incidents with additional personnel and workstations	mid term	Additional workstations, training of the personnel for emergency call tasks, availability of qualified personnel	short term	Communication	A higher number of emergency call can be answered and processed, prioritising of calls, disposition of units	Emergency call centre	Internal	2,17	2,33	2,50	2,37
94	State Police Headquarter Styria	Flexible communication	Communication between action force and mission commander (local operations centre or at headquarter)	mid term	Definition of communication and information channels, experience	short term	Information Communication	Mission commander has all the information to command and react	All levels	Internal	2,17	4,33	1,67	2,35
30	Austrian Power Grid	Personnel on standby	Access to additional personnel day and night for dealing with malfunction	mid term	Work time and shift planning for standby personnel	short term	Personnel	Malfunctions can be treated by in-house personnel 24/7, no external partner needed	Maintenance teams	Internal	2,67	3,83	1,33	2,23

Appendix B: Framework and sources

Number	Organization	Strategy/Method	Source(s)
1	Austrian Airlines	Exchange of aircraft	Woditschka, Peter. Telephone interview. 20.08.2014
2	Austrian Airlines	Irregularity aircraft cold stand-by aircraft	Woditschka, Peter. Telephone interview. 20.08.2014
3	Austrian Airlines	Maintenance teams	Woditschka, Peter. Telephone interview. 20.08.2014
4	Austrian Airlines	Irregularity aircraft hot stand-by aircraft	Woditschka, Peter. Telephone interview. 20.08.2014
5	Austrian Airlines	Irregularity aircraft	Woditschka, Peter. Telephone interview. 20.08.2014
6	Austrian Airlines	Categorizing of malfunctions	Woditschka, Peter. Telephone interview. 20.08.2014
7	Austrian Airlines	Central supply pool	Woditschka, Peter. Telephone interview. 20.08.2014
8	Austrian Airlines	Personnel buffer	Woditschka, Peter. Telephone interview. 20.08.2014
9	Austrian Airlines	Exchangeability of crews	Woditschka, Peter. Telephone interview. 20.08.2014
10	Austrian Armed Forces - Military Command Styria	Simulations	Wabnegg, Rudolf. Personal interview. 14.08.2014
11	Austrian Armed Forces - Military Command Styria	Reconnaissance unit	Wabnegg, Rudolf. Personal interview. 14.08.2014;Suez, Werner. Telephone interview. 09.09.2014
12	Austrian Armed Forces - Military Command Styria	Force level	Wabnegg, Rudolf. Personal interview. 14.08.204
13	Austrian Armed Forces - Military Command Styria	Increased readiness for action	Wabnegg, Rudolf. Personal interview. 14.08.2014

Number	Organization	Strategy/Method	Source(s)
14	Austrian Power Grid	Tower construction kit (APG security package)	Prießnitz, Wolfgang. Personal interview. 01.10.2014
15	Austrian Power Grid	6 main incident scenarios	Prießnitz, Wolfgang. Personal interview. 01.10.2014
16	Austrian Power Grid	Control energy	Prießnitz, Wolfgang. Personal interview. 01.10.2014
17	Austrian Power Grid	Simulations	Prießnitz, Wolfgang. Personal interview. 01.10.2014
18	Austrian Power Grid	Training scenarios for crisis management staff	Prießnitz, Wolfgang. Personal interview. 01.10.2014
19	Austrian Power Grid	Reaction without permission	Prießnitz, Wolfgang. Personal interview. 01.10.2014
20	Austrian Power Grid	Crisis room	Prießnitz, Wolfgang. Personal interview. 01.10.2014
21	Austrian Power Grid	Incident command and crisis staff	Prießnitz, Wolfgang. Personal interview. 01.10.2014
22	Austrian Power Grid	Partner companies	Prießnitz, Wolfgang. Personal interview. 01.10.2014
23	Austrian Power Grid	Trans regional support	Prießnitz, Wolfgang. Personal interview. 01.10.2014
24	Austrian Power Grid	n-1 principle	Prießnitz, Wolfgang. Personal interview. 01.10.2014
25	Austrian Power Grid	n-1 predictions	Prießnitz, Wolfgang. Personal interview. 01.10.2014
26	Austrian Power Grid	Backup equipment	Prießnitz, Wolfgang. Personal interview. 01.10.2014
27	Austrian Power Grid	Crisis management staff	Prießnitz, Wolfgang. Personal interview. 01.10.2014

Number	Organization	Strategy/Method	Source(s)
28	Austrian Power Grid	Combined Qualification	Prießnitz, Wolfgang. Personal interview. 01.10.2014
29	Austrian Power Grid	Alarming of crisis managers	Prießnitz, Wolfgang. Personal interview. 01.10.2014
30	Austrian Power Grid	Personnel on standby	Prießnitz, Wolfgang. Personal interview. 01.10.2014
31	Austrian Red Cross	Field Assessment and Coordination Team (FACT)	Kunert, Jürgen. Personal interview. 05.08.2014
32	Austrian Red Cross	Emergency Response Units (ERUs)	Kunert, Jürgen. Personal interview. 05.08.2014
33	Austrian Red Cross	Smaller Water and Sanitation units	Kunert, Jürgen. Personal interview. 05.08.2014
34	Austrian Red Cross	National catastrophe supply	Kunert, Jürgen. Personal interview. 05.08.2014
35	Austrian Red Cross	Additional warehouse employees	Kunert, Jürgen. Personal interview. 05.08.2014
36	Austrian Red Cross	Local Suppliers	Kunert, Jürgen. Personal interview. 05.08.2014
37	Austrian Red Cross	Logistical cooperation between national and international organization	Kunert, Jürgen. Personal interview. 05.08.2014
38	Austrian Red Cross	Chartering	Kunert, Jürgen. Personal interview. 05.08.2014
39	Austrian Red Cross	International warehouses	Kunert, Jürgen. Personal interview. 05.08.2014
40	Austrian Red Cross	Triage	Hansak (2013) p. 57 Hansak et al. (2013) p. 18f
41	Austrian Red Cross	Tasks during overload phase	Hansak (2013) p. 28

Number	Organization	Strategy/Method	Source(s)
42	Austrian Red Cross	Incident scene (SanHiSt)	Hansak (2013) p. 42
43	Austrian Red Cross	Hospital alerting	Hansak (2013) p. 32
44	Austrian Red Cross	Escalation-/ de-escalation model of command staff	Hansak (2009) p. 24
45	Austrian Red Cross	Alert stages	Hansak (2013) p. 9
46	Austrian Red Cross	Tentative incident command	Hansak (2013) p. 15
47	Emergency and Disaster Medicine Styria	Alert phases	Pessenbacher, Klaus. Personal interview. 07.08.2014
48	Emergency and Disaster Medicine Styria	Emergency medicine specialist	Pessenbacher, Klaus. Personal interview. 07.08.2014
49	Emergency and Disaster Medicine Styria	Automated alert systems	Pessenbacher, Klaus. Personal interview. 07.08.2014
50	Emergency and Disaster Medicine Styria	Triage and registration place	Pessenbacher, Klaus. Personal interview. 07.08.2014
51	Emergency and Disaster Medicine Styria	Operational command hospital	Pessenbacher, Klaus. Personal interview. 07.08.2014
52	Emergency and Disaster Medicine Styria	Checklists	Pessenbacher, Klaus. Personal interview. 07.08.2014
53	Lufthansa Technik	Aircraft on Ground (AOG)	Brendel, Tobias. Telephone interview. 11.09.2014
54	Lufthansa Technik	Creation of redundancies	Brendel, Tobias. Telephone interview. 11.09.2014
55	Lufthansa Technik	Smoothing of dispatching	Brendel, Tobias. Telephone interview. 11.09.2014

Number	Organization	Strategy/Method	Source(s)
56	Lufthansa Technik	Time buffer	Brendel, Tobias. Telephone interview. 11.09.2014
57	Lufthansa Technik	Material provisioning on past data	Brendel, Tobias. Telephone interview. 11.09.2014
58	Lufthansa Technik	Material sources	Brendel, Tobias. Telephone interview. 11.09.2014
59	Lufthansa Technik	Shiftwork	Brendel, Tobias. Telephone interview. 11.09.2014
60	Lufthansa Technik	Cross-qualification of the personnel	Brendel, Tobias. Telephone interview. 11.09.2014
61	Lufthansa Technik	Standardization	Brendel, Tobias. Telephone interview. 11.09.2014
62	Lufthansa Technik	Project-oriented organizational structure	Brendel, Tobias. Telephone interview. 11.09.2014
63	National Warning Centre Styria	Keywords	Hohenberger, Günter. Personal interview. 25.07.2014
64	National Warning Centre Styria	Civil Protection Server	Hohenberger, Günter. Personal interview. 25.07.2014
65	National Warning Centre Styria	Planning and Response Tools	Hohenberger, Günter. Personal interview. 25.07.2014
66	National Warning Centre Styria	Operational scenarios	Hohenberger, Günter. Personal interview. 25.07.2014
67	National Warning Centre Styria	Standby	Hohenberger, Günter. Personal interview. 25.07.2014
68	Professional Fire Brigade Graz	Increased readiness, catastrophe readiness	Kirnich, Johann. Personal interview. 08.07.22014
69	Professional Fire Brigade Graz	Guideline for leadership in disaster operations (SKKM)	Krajnz, Heimo. Personal interview. 18.09.2014 Bundesministerium für Inneres, Abteilung II/4 (2007) Bundesministerium für Inneres, Abteilung II/4 (2009)

Number	Organization	Strategy/Method	Source(s)
70	Professional Fire Brigade Graz	Keywords	Krajnz, Heimo. Personal interview. 18.09.2014
71	Professional Fire Brigade Graz	Disposition of fire engines	Krajnz, Heimo. Personal interview. 18.09.2014
72	Professional Fire Brigade Graz	K20 concept	Kirnich, Johann. Personal interview. 08.07.22014 Nestler (2010) p. 239-244
73	Professional Fire Brigade Graz	Alarm and march out order	Kirnich, Johann. Personal interview. 08.07.22014 Redaktion der Fachzeitschrift BRANDSchutz/Deutsche Feuerwehr-Zeitung (2013) p. 196f
74	Professional Fire Brigade Graz	Operation sections	Kirnich, Johann. Personal interview. 08.07.22014 Redaktion der Fachzeitschrift BRANDSchutz/Deutsche Feuerwehr-Zeitung (2013) p. 227
75	Professional Fire Brigade Graz	Catastrophe control room	Kirnich, Johann. Personal interview. 08.07.22014
76	Professional Fire Brigade Graz	Control loop of leadership	Krajnz, Heimo. Personal interview. 18.09.2014 Redaktion der Fachzeitschrift BRANDSchutz/Deutsche Feuerwehr-Zeitung (2013) p. 230
77	Professional Fire Brigade Graz	Additional fire brigade units	Kirnich, Johann. Personal interview. 08.07.22014
78	Professional Fire Brigade Graz	Emergency call centre	Krajnz, Heimo. Personal interview. 18.09.2014
79	Professional Fire Brigade Graz	Flexible team composition	Krajnz, Heimo. Personal interview. 18.09.2014
80	Professional Fire Brigade Graz	EU catastrophe modules	Krajnz, Heimo. Personal interview. 18.09.2014
81	State Police Headquarter Styria	Control room	Röxeis, Gottfried. Personal interview. 12.09.2014 Bundesministerium für Inneres (2007) p. 33-36
82	State Police Headquarter Styria	Special information units	Röxeis, Gottfried. Personal interview. 12.09.2014
83	State Police Headquarter Styria	EPSweb	Röxeis, Gottfried. Personal interview. 12.09.2014 Sachgebiet ID4 (2008) Dudek (2008) p. 81

Number	Organization	Strategy/Method	Source(s)
84	State Police Headquarter Styria	Operation sections	Röxeis, Gottfried. Personal interview. 12.09.2014
85	State Police Headquarter Styria	Flexible working hours	Röxeis, Gottfried. Personal interview. 12.09.2014
86	State Police Headquarter Styria	Orders	Röxeis, Gottfried. Personal interview. 12.09.2014
87	State Police Headquarter Styria	Additional staff	Röxeis, Gottfried. Personal interview. 12.09.2014
88	State Police Headquarter Styria	Executive staff	Röxeis, Gottfried. Personal interview. 12.09.2014
89	State Police Headquarter Styria	Statewide planning	Röxeis, Gottfried. Personal interview. 12.09.2014
90	State Police Headquarter Styria	Training for commanders	Röxeis, Gottfried. Personal interview. 12.09.2014
91	State Police Headquarter Styria	BAO (Besondere Aufbauorganisation) - Organizational structure for special occasions	Röxeis, Gottfried. Personal interview. 12.09.2014 Dudek (2008) p. 76-80
92	State Police Headquarter Styria	Evaluation of operations	Röxeis, Gottfried. Personal interview. 12.09.2014
93	State Police Headquarter Styria	Special functions of staff	Röxeis, Gottfried. Personal interview. 12.09.2014
94	State Police Headquarter Styria	Flexible communication	Röxeis, Gottfried. Personal interview. 12.09.2014