Mobile Manufacturing System Characteristics

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Abstract
There is an increasing demand of geographically flexible production capacity to cope with global competition. The Mobile Manufacturing System is an approach to meet these demands where the core competence is kept within the company. This article is based on the results of two case studies. It investigates why there is a need for Mobile Manufacturing Systems and emphasizes the challenging factors when creating a Mobile Manufacturing System to be able to operate in a geographically changing environment. The mobility set increased demands on technology, strategy, organization, information, and knowledge reuse in order to maintain high performance.

Introduction
The market is continually changing and there is a challenging demand for adapting the manufacturing system to this change. The alteration from mass production to mass customization implies that companies easily have to reconfigure their production capacity to meet the competitive environment of continuous and unpredictable change (Pine et al., 1993; Lau, 1995; Sundin and Bras, 2005). One way to cope with this global competition is to use geographically flexible production capacity in order to enable customer satisfaction. This alternative, Mobile Manufacturing Systems, will be outlined, analyzed, and discussed in this paper.

The mobility of people, information, and equipment is increasing. Mobile systems are more commonly used in different fields such as building industry, military, operating rooms, hospitals, roadwork, funfairs, concerts, and also other more traditionally immobile fields. The aim of the system’s mobility is commonly to get closer to the customer site, or to the raw material. By increasing mobility the possibility for market expansion opens up. The reasons for companies to expand into the global market are mainly; the desire to expand markets, the search for natural resources, the proximity to customers, or due to labor savings (Chang, 2005). Mobility is often connected to the internal flexibility. E.g. Upton (1995) describes operation mobility as the ability of the manufacturing system to switch effortlessly and quickly between products. In contrast to this internal mobility this paper discusses the external mobility, for example a mobile production capacity. In this paper the manufacturing system is defined as the arrangement and operation of machines, tools, materials, people, and information to produce a value added physical, informational and service product whose success and cost is characterized by measurable parameters (Wu, 1994; Cochran et al., 2002). A Mobile Manufacturing System requires all these factors to work in a geographically changing environment, which makes the fields of activity more competitive. This paper uses the word mobility defined as geographical flexibility.

Manufacturing system design covers all aspects of creating and operating a manufacturing system. Creating a manufacturing system includes equipment selection, physically arranging the equipment, work design, standardization, design of material, and information flow. Operation of a manufacturing system includes all aspects that are necessary to run the created system (Cochran et al., 2002). Since the mobility aspect affects the factors in manufacturing system such as machines, tools, materials, people, and information the design process of a Mobile Manufacturing System differs compared to the immobile manufacturing system design process on some issues.

The aim of the research project, Factory-in-a-Box, wherein this study is carried out, is to develop five physical examples of Mobile Manufacturing Systems in a real industrial environment, Factory-in-a-Box applications. This article is based on two of these Factory-in-a-Box applications. Developing mobile, flexible, and rapid manufacturing capacities enable easy and
quickly reconfiguration, which also gives product and volume flexibility. This Mobile Manufacturing System concept requires rapid ramp-up and enables production close to customer site or product development. In the long-term this may imply a development of a production capacity enabling rental or leasing activities for production processes to be more common than today.

To be able to configure a Mobile Manufacturing System all specific factors connected to the mobility has to be clarified. This paper will describe the purpose and the main characteristics of a Mobile Manufacturing System and describe two examples of Mobile Manufacturing Systems which are under development. The article will also elucidate the factors which are unique when configuring a Mobile Manufacturing System based on the findings from these two case studies.

**Research Methodology**

A multiple case study, when the case study contains more than one single case, is executed as described in figure 1. There are three remaining case studies not incorporated in this paper, but included in the research project wherein these case studies are parts.

![Figure 1. Multiple case study methodology (Yin, 1994)](image)

According to Yin (1994) there are different research strategies such as experiment, survey, archival analysis, history, and case study, all relevant to use depending on the type of research question. The case study methodology is proper to use when *how* and *why* questions are being asked about a contemporary set of events over which the investigator has no or little control. According to Yin (1994), “a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. A case study is according to Yin (1994) divided into five components:

1. a study’s question
2. its propositions
3. its units of analysis (data)
4. the logical link between the data and the propositions
5. the criteria for interpreting the findings
The theoretical study is important when doing case studies because it facilitates the data collection phase but also because it sets the level at which the generalization of the case study results will occur. In the analytic generalizations the investigator is determined to generalize a particular set of results to a broader theory (Yin, 1994).

According to Yin (1994), there are six sources of evidence for a case study, namely:

- documentation
- archival records
- interviews
- direct observations
- participant observation
- physical artifacts

All these sources of evidence have been used within this multiple case study. Interviews with a low level of structure and standardization have been used, hence the results will be analyzed qualitatively (Patel and Davidson, 1994).

**Theoretical overview**

Business concepts to cooperate or locate production are presented, such as joint venture, outsourcing, strategic alliances, and functional sales, in order to facilitate a comparison with Mobile Manufacturing System. All these business concepts demand a visionary manufacturing system philosophy which enables flexibility, reconfigurability, and agility. Several manufacturing system philosophies will be described in this theoretical overview to give the prerequisites and alternatives related to the presented Mobile Manufacturing System.

**Business Concepts**

There are several ways to locate and/or share resources or knowledge to become more competitive and increase the efficiency. The following business trends have resulted in large high technology organization and development projects that cross location, company, country, and cultural boundaries (Grzinich and Chandra, 1999).

**Functional sales** or service selling means selling the function instead of the product. A contract is signed between the customer and the service provider and the responsibility of the equipment, operations, maintenance, and service is put on the supplier of the function. Furthermore this implies increased opportunity to continually bring the technologies up to date (Sundin and Bras, 2005).

In a **strategic alliance** two or more partners make an agreement to cooperate by sharing knowledge or resources (Vyas et al., 1995). Companies tend to get involved in alliances when they lack resources to perform an activity. The strategic alliance is in the position between being two separated parts and being partners. This type of cooperation demands that the parties have something to offer each other, thus enabling a win-win situation.

When creating a **joint venture** two parts form a business or an activity that is different from their original business. A joint organization which controls and is responsible to this business is created in the joint venture (Yan and Luo, 2001).
Outsourcing is the act of transferring some of a company’s frequent internal activities and decision rights to outside providers (Greaver, 1999), in other words when a company hires an external supplier for something that was earlier performed internally (Hägg et al., 2004). When activities are moved to an external supplier, the rights of choosing production technology and decision rights is also moved (Greaver, 1999), which results in a movement of the decision function as well.

**Manufacturing philosophies**

When implementing business concepts previously described the manufacturing system have to meet specific requirements. Future factory design will have to eliminate rigid structures and allow for transformability. Changeability is desirable on all levels of a company, depending on which system level and product level considered the changeability type differs. Changeover ability, reconfigurability, flexibility, transformability, and agility are all types of changeability, enumerated in the order of increasing system level context (Nyhuis et al., 2005).

There are several visionary Manufacturing philosophies which require a changeable manufacturing system. Some of them are shortly presented to obtain a contextual view, which will allow for a description of Mobile Manufacturing System characteristics.

**Agile manufacturing** aims at achieving manufacturing flexibility and responsiveness to new market needs. There is no firm agreement as to the exact agreement of what constitutes agile manufacturing. Agility can be defined as “A manufacturing system with extraordinary capabilities (internal capabilities: hard and soft technologies, human resources, educated management, information) to meet the rapidly changing needs of marketplace (speed, flexibility, customers, competitors, suppliers, infrastructure, responsiveness). A system that shifts quickly (speed, and responsiveness) among product models or between product lines (flexibility), ideally in real-time response to customer demand (customer needs and wants)” (Yusuf et al., 1999). Agile manufacturing characterizes of high quality and highly customized products, and services with high information and value adding content, mobilization of core competences, response to change, and uncertainty, as well as intra-enterprise and inter-enterprise integration (Yusuf et al., 1999; Gunasekaran and Yusuf, 2002).

**Mass Customization** is defined as the ability to offer individually designed products and services to every customer through high process agility, flexibility, and integration. More practical it has been defined as a system that uses information technology, flexible structures, and organizational structures to deliver a wide product range and service range that meet specific need of individual customers at a cost near that of mass-produced items (Hart, 1994; Da Silveira et al., 2001).

**Holonic Manufacturing Systems** (HMS) has its origin in the word holos, which Koelster (1967) released. Holos is a Greek word for whole, which is combined with the suffix - on to form Holon, as in proton or neutron, which means a particle or part. The holon describes the hybrid nature of sub-wholes/parts in real-life systems, which means that holons are simultaneously self-contained wholes to their subordinated parts and dependent parts of a larger whole that contains it (Tarumarajah et al., 1998). According to Tarumarajah et al. (1998) there are two main characteristics, which are prominent for holonic systems. The holons need to be autonomous, and they have to be cooperative. The HMS is therefore considered as a whole where autonomous parts cooperate in order to achieve a common goal, which in this case is to produce products.

**Flexible Manufacturing Systems** (FMS) is defined as a machining system configuration with fixed hardware and fixed software. The software is programmable, which enables flexibility to
handle changes in work orders, production schedules, part-programs, and tooling for many part types (Mehrabi et al., 2000). The economic goal of an FMS is to enable cost-effective manufacturing of several types of parts, which can change over time. Shortened changeover time on the same system at the required volume and quality, is also an important economic objective (Kaiser, 2002).

Mehrabi et al.(2000) identifies five key characteristics of a Reconfigurable Manufacturing System (RMS). The five characteristics can partly be found in the manufacturing paradigms, such as Convertibility of a FMS system during the Flexible Production Paradigm, and Customization during the Craft Production Paradigm, but the Mass customization paradigm with RMS as the process enabler sets higher demands on the manufacturing system, see Table 1. The five characteristics from Table 1 are similar to FMS principles on many issues. However the main difference is that RMS is as flexible as needed, not as possible.

<table>
<thead>
<tr>
<th>Key Characteristics</th>
<th>Definition of the characteristics</th>
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<tr>
<td>Modularity</td>
<td>Design all system components, both software and hardware, to be modular.</td>
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<tr>
<td>Integrability</td>
<td>Design systems and components for both ready integration and future introduction of new technology.</td>
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<tr>
<td>Convertibility</td>
<td>Allow quick changeover between existing products and quick system adaptability for future products.</td>
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<tr>
<td>Diagnosability</td>
<td>Identify quickly the sources of quality and reliability problems that occur in large systems.</td>
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<tr>
<td>Customization</td>
<td>Design the system capability and flexibility (hardware controls) to match the application (product family).</td>
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Case studies

Studies on aspects of technology, economy, and market demands have been carried out at five companies within the Factory-in-a-Box research project and these case studies will serve as basis of the subsequent development and construction of physical modules. Two of these case studies are presented in this paper.

Case A

A concept has been developed where a portion of the assembly work will be performed closer to the final assembly and thereby closer to the end-customer. As a competitive mean to get into new market segments the Factory-in-a-Box module will offer local production close to customer site. By using a Factory-in-a-Box the company is able to produce a small part of the order close to customer, which increases the possibility to get an order, and the rest at the immobile production site. By using the Mobile Manufacturing System concept the company can manage to meet these demands and increase the possibility to get new shares of the market.

The pre-study concludes in a specification of demands on the design of mobile production equipment, which easily will be moved close to customer site, and easily configured between different product types. By these means the Mobile Manufacturing System will work as a
controlled transfer of production and technology. The conceptual Factory-in-a-Box life cycle, figure 2, starts with configuration and adaptation of the capacity to a new order. At this time the organization has to be clarified, the equipment prepared, and the logistic functions secured. When the configuration is finished the equipment is packed and transported to the site, where the equipment is unpacked and installed. A rapid production ramp-up is necessary. When the temporary production is finished the Factory-in-a-Box is disassembled and transported to the immobile site or to the next site for reconfiguration and another production cycle starts.

Figure 2. Life cycle of a conceptual Factory-in-a-Box

When selecting technical scope of the Factory-in-a-Box, containing assembly and test, several parameters were taken into account, such as standardized assembling and testing operations with possibilities to customer adaptation close to customer site.

The case study is divided into four concepts:
- Production and testing concept
- Management concept
- Logistic concept
- Education and training concept

**Production and testing concept**
The requirements put on the production and testing concept are:
- Re-useable equipment and possibilities to handle different product styles
- Secure facilities where to perform the operations of assembly, test, package, and storage
- Geographically movable
- Volume flexibility
- Rapidity in every life cycle phase
- In accordance with work environment legislation

The Factory-in-a-Box building consists of a folding special designed container (assembly-, testing-, and packing area) and one or two standard containers (storage, and additional assembly area). The technical design of the Factory-in-a-Box is presented in figure 3. The assembly operations which will be performed in the mobile unit are pre assembly (1), final assembly (2), testing (3) and packing (4). The module is balanced for production of two to four products per week, which represents fulltime workload for two to four operators.

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An additional container, containing stock or supplementary pre- and final-assembly stations might be connected which enables adaptation to volume changes. The operations do not demand complicated equipment since the product flexibility is high.

Management concept
The Factory-in-a-Box must be able to conduct partly from mobile site and partly from immobile site. A project leader will be supported by a checklist when conducting the Factory-in-a-Box in order to rapidly go through every life cycle phase.

In order to support the Factory-in-a-Box the organization is divided into functions located at the mobile unit and functions located at immobile unit, see figure 4. The mobile parts and the immobile parts are controlled by the product management located at immobile site.
Logistic setup
The complexity of the logistic set-up depends on the extent of operations which will be done in the Factory-in-a-Box and on the choice of material supply to the Factory-in-a-Box:

1. Assembled products are sent from the immobile site and only the testing operations are performed in the Factory-in-a-Box.
2. The pre-assembled products are sent from the immobile site; hence the final assembly and testing operations are performed in the Factory-in-a-Box.
3. All components are sent from immobile site in material kit (a collection of all components of one product).
4. All the components are sent from the supplier and a stock of components is handled in the Factory-in-a-Box.

The step between 3 and 4 is vital because a material storage is required which means that the numbers of articles have to be compiled, the storage has to be planned and space is required. The internal material logistic becomes more complicated when a material storage is implemented in the conceptual Factory-in-a-Box solution consequently a method is required to handle this. Furthermore the changeover from kit to mobile storage requires a method to develop the purchasing functions.

The Factory-in-a-Box developed in case A is designed to handle supplied material in kit.
**Concept of knowledge and experience reuse**

There is a demand for structured tooling and methods for knowledge and experience reuse. In the Mobile Manufacturing System the rapidity in every step of the life-cycle requires documented routines and instructions. To secure a fast ramp-up, when the work force is temporary, the instructions for assembly operations have to be described clearly and comprehensively and an effective and standardized training concept is required.

How to perform every operation within the Factory-in-a-Box must be documented to meet the requirements of rapidity. In present the operators are not using assembly instructions and a lot of knowledge to perform the assembly operations is tacit knowledge which is not advisable in a Mobile Manufacturing System. When the operators work during a limited period of time as much knowledge as possible have to be gathered and documented into information and data in order to facilitate knowledge and experience reuse. The need for effective communication between mobile and immobile site is also considered in this concept.

**Case B**

Case B is based on a material handling system. Three different configurations of this material handling system are shown in figure 5. The material handling system has a high technology level compared to the average technology of material handling equipment in industry today. Technologies included in this material handling system are for example:

- Traceability (RFID)
- Order handling
- Production initiation
- Offline programming and simulation
- Level of Automation variation (From manual stations to fully automated)
- Modularity for rapid and easy reconfiguration

![Figure 5. Three different configurations of the Mobile Manufacturing System in case B](image)

In case B three different aspects of the material handling system were studied as a pre-study before the real world implementation of the Mobile Manufacturing System. These parts were technological study, economical study and market survey.
**Technological study**

The technological study aimed at finding commercial technology solutions needed in order to facilitate a real world “Factory-in-a-Box”, i.e. a Mobile Manufacturing System. The study resulted in a document which can be summarized as:

- The mobile manufacturing system with automated material handling equipment can automatically handle a number of different products at the same time.
- No manual interactions with the products are necessary, only at manual workstations.
- Both automated-, semi automated-, robot- and manual- workstations can be present simultaneously in the same configuration.
- WIP (Work in progress) will be low since the production flow is controlled by the automated material handling system.
- The pallet can be reconfigured to fit any product within a specific 3D-space, determined by the size of the main lines in the system.
- Automatic initiation of products due to connection to a business system, which also enables fully customer driven production.
- Information and statistics on products and production are automatically collected.
- Real-time dynamic flow-balancing and traceability of the products.
- Product and production testing are automatically documented.
- Flexible routing of products through the system.
- Operator instructions online shown at the workplace on a pc-screen.
- Possibility to have parallel and or serial workstations.
- A paper-free manufacturing facility.

**Economical study**

The economical pre-study show that the benefits from using this system as a base for Mobile Manufacturing Systems can be profitable, both for the company providing the system, and for the company using the system if the production of the product has one or more of the following characteristics:

- Special requirements on location.
- Rapid production ramp-up.
- Increased order intake of products.
- High manual refining value in the product.
- Control or mutual benefits from the same production facility as other companies.
- Integrated product and production development requirements.
- Company expansion requirements.

Two independent studies on exact benefits in economical terms were conducted too, and these calculations showed a strong economical benefit for both customer and supplier of the mobile manufacturing system. The results of these independent studies are classified. However, to the results differed from each other with only 2%, which is considered to be a fair validation.
Market survey
The market survey which is based on interviews with 23 companies in Sweden show that there are interesting market benefits generated by making a manufacturing system mobile. Figure 6 show the response from two connected questions. The first question shows the possibility to move the manufacturing system today vs. the second question, which shows need to move the manufacturing system in the future. The average mobility of a manufacturing system today, based on these 23 companies is 2,28 with a standard deviation of 1,32, and for the future these values are 2,83 and 1,39 respectively.

![Figure 6. Mobile Manufacturing Systems at present vs. future industrial need](image)

The Mobile Manufacturing System
An increasing part of the Swedish production is moving to low-wage countries which lessen the production cost. In Sweden it is difficult to use labor-cost as mean of competition. According to several manufacturing concepts flexibility, reconfigurability, and agility are other ways to compete. Different types of business concepts try to use these competitive means.

**Reasons for utilizing Mobile Manufacturing Systems**
The aim of making the manufacturing system mobile is to enable geographical relocation in order to deliver capacity wherever it is necessary, e.g. to a temporary production site, or within a factory. The Mobile Manufacturing System gives the opportunity to rent or lease production capacity and the business can be done as for example functional sales. It also enables customer adaptation due to the generality. Based on these case studies, the main reasons of utilizing Mobile Manufacturing System are:

1. The company has no production capacity to produce a new product type.
2. The product volume increases rapidly and there is no production capacity available.
3. The production of a subcontractor wants be controlled by the customer.
4. To produce prototypes rapidly and close to product development.
5. The company wants to get into new markets that demands local production capacities.
6. Shared production capacities in-between SME companies.
7. To perform maintenance or repair operations.
8. Investments are too high compared to the risk of buying production capacity, which enables a Mobile Manufacturing System to be used in functional sales.

**Mobile Manufacturing System components**

As mentioned in the introduction, the manufacturing system is the arrangement and operation of machines, tools, materials, people, and information to produce a value added physical, informational and service product (Wu, 1994; Cochran et al., 2002). A Mobile Manufacturing System has to include all these factors which are required to produce a product in a geographically changing environment.

Apart from an ordinary manufacturing facility at a fixed location, our findings show that the following aspects are included in a Mobile Manufacturing System:

- Production strategy
- Technology and equipment such as machines, tooling and fixtures
- Organization to guarantee control and management
- Information and knowledge

All characterized by flexibility, rapidity, reconfigurability, and modularity, see figure 7.

![Figure 7. Components in the Mobile Manufacturing System, revised from Gunasekaran (1999)](image)

There are several phases to pass in a Mobile Manufacturing System, figure 8, all making demands on technology, organization, strategy, and information and knowledge to be able to be rapid, flexible, modular, and reconfigurable. The point when the system is reconfigured to new projects differs. Figure 8 illustrates different points when reconfiguring can be done.
Figure 8. The lifecycle of a Mobile Manufacturing System

Production Strategy
The production strategy aims to create a Mobile Manufacturing System by letting flexibility, rapidity, modularity, and reconfigurability permeate within the different functions; technology, organization, information, and knowledge.

Technology
Equipment, tools, and production facility has to be flexible in several aspects to handle volume changes, changes in product type, different operators and different levels of automation.
To be mobile, rapidity is demanded in every step of the life cycle; production ramp-up, transportation, unpacking/ packing up, and configuration.
To gain mobility advantages the Mobile Manufacturing System should be able to be re-used between different projects which demands reconfigurability of the equipment. Modularity is essential when it comes to reuse of equipment, as well as the design of products well suited for high-volume production (Johansson et al., 2004).

Organization
The organization within the Mobile Manufacturing System also has to be mobile to follow the mobile manufacturing capacity. New operators, new situations, and a flexible technology set high demands on a flexible organization. An organization can be seen as small modular parts combined into one larger unit in order to meet common goals of customer satisfaction. Modularity in the case of Mobile Manufacturing Systems can be, personnel, or groups of personnel, the mobile manufacturing system itself can be seen as a module, and some mobile manufacturing systems can be needed on a specific site where they cooperate in order to form a large manufacturing facility. The Mobile Manufacturing System must handle organizational changes rapidly or it will otherwise lack the benefits of mobility.
Information and knowledge
The Mobile Manufacturing System demands a continuous and active learning process within the organization in order to stay rapid and reconfigurable and to be able to adapt the system to the various needs at different locations. The training tool has to be flexible to fit the specific conditions which arise in the continually changing environment and the continually changing work force. The Mobile Manufacturing System demands a documented learning concept and a systematic and structured knowledge reuse. For example, languages have to be considered if the Mobile Manufacturing System will be relocated between different countries.

Modularity is essential both for the physical parts of the Mobile Manufacturing System as well as for the nonphysical parts such as information and data. The modularity enables reuse of equipment, as well as knowledge and data since it provides a standardized interface both internally within each module and externally between the modules.

New people in the organization have to get the necessary knowledge easily, to be able to perform their operations. Each time the Mobile Manufacturing System is moved between two locations the knowledge and experience needs to be transferred between different people. Since there is a great amount tacit knowledge there is a need for tools to structure knowledge transfer and experience reuse. It is important to collect and document the experience and knowledge since the work force continually exchanges. For example the documentation on maintenance, order handling, material supplies, and task lists to be performed within the Mobile Manufacturing System has to be well documented and have a strict structure.

Discussion
Mobile systems have been used at all times to benefit by natural resources or to get close to the customer. Mobile Manufacturing Systems containing strategy, technology, organization, information, and knowledge is very rare. Manufacturing systems often include some mobile elements, whether in strategy, technology, organization or information and knowledge but to connect the components into a complete Mobile Manufacturing System separated from other systems is unusual in the industry today.

Mobile manufacturing capacity has much in common with existing business concept such as outsourcing, joint venture, strategic alliances, and functional sales, and there are in some cases possibilities to connect these concepts. This can be a way of owning the product “production capacity”; and rapidly and flexible selling the function “production”. A Mobile Manufacturing System can also be an enabler when collaborating in a strategic alliance between two or more partners when making an agreement to cooperate by sharing knowledge or resources. One purpose of Mobile Manufacturing Systems is to enable sharing of capacity between companies and that is a main thought of the strategic alliance as well.

In the same way the Mobile Manufacturing System may be an enabler when starting a new business activity in a Joint Venture. On the other hand the Mobile Manufacturing System can be a substitute to the Joint Venture, if a company instead of entering a joint venture starts using a Mobile Manufacturing System to reach a new market.

Compared to outsourcing the Mobile Manufacturing System can be way of moving production without leaving the responsibility to other parties and keeping the control and responsibility of the production within the company.
There are several visionary concepts containing the similar principal aim to create an adaptable system to the surrounding situation. This comprehensive solution combines existing manufacturing system concepts and thoughts by demanding a high level of flexibility and reconfigurability, and creates a new type of manufacturing system which is easy to concretize in the industry. The key parameters flexibility, mobility, and speed, influenced of visionary manufacturing philosophies, create a way to realize a manufacturing system in an industrial context, which is highly adaptable, even seen from a relocation perspective.

The goal for Mobile Manufacturing systems compared to HMS, RMS, FMS, and agile manufacturing systems are similar, namely maintain high performance even though the prerequisites change over time.

Conclusions

Instead of cost as competitive mean, the Mobile Manufacturing System is characterized by mobility, flexibility, and rapidity. These properties make the manufacturing system extremely adaptable to changes of environmental and contextual conditions. The Mobile Manufacturing System is a comprehensive solution that combines existing visionary manufacturing philosophies and creates a manufacturing system that is a concrete concept easy to implement in an industrial context. Mobile Manufacturing Systems use the knowledge and flexibility aspects developed for HMS, RMS, FMS, and agile manufacturing systems in order to create a competitive advantage together with the mobility aspect. In this paper the purpose and possibilities for Mobile Manufacturing Systems are clarified by a multiple case study realizing Mobile Manufacturing Systems.

A Mobile Manufacturing System is one solution for cost-efficient relocation of production capacity in order to meet the customer demands whether the necessary components: technology, strategy, organization, information, and knowledge are guaranteed. The case studies have concluded in a specification of factors to take into consideration in Mobile Manufacturing System configuration. In order to be mobile in an effective way rapidness, flexibility, modularity, and reconfigurability are demanded in the system components and in every step of the lifecycle (configuration, unpacking/packing up, transportation, production ramp-up/phase out, and full production). The mobile, flexible, and rapid manufacturing system is a concept that enables new competitive means on the global market today.

Future research

In order to create a basis for developing a model for configuring a Mobile Manufacturing System, further analyses have to be done on Mobile Manufacturing characteristics. Additionally, both the internal requirements proposed by the company and the market requirements have to be analyzed.

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