Information Management for the Factory Planning Process

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INFORMATION MANAGEMENT
FOR
THE FACTORY PLANNING PROCESS

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Abstract

This thesis is based on the present needs for the factory planning support, of which the most important ones are:

- A structured reuse of knowledge and support for industries. Because today the industry handbook in factory planning is not satisfying enough to support this complex process.

- Better methods to represent and communicate data between software within the factory layout area for easier data communication and thereby information access, exchange and reuse.

To support the factory planning, based on the mentioned needs, a mapping of the present factory planning process is made based on knowledge from industry and academy. Since the factory planning process is a huge and complex process that no one can handle by themself, a puzzle work is performed. Based on gathered information and knowledge an activity model is developed, to structure the data and information. The model gives a better overview on the actual course of events and in this way also “captures” the most important information to be represented for data exchange among different software applications and different people.

In this thesis the most important information in factory layout is gathered and structured in a concept model for factory layout. Since the concepts depend on the context in which they are used, it is extremely important to present every concept in its relationship with other related concepts within the area. A general theory and state-of-the-art definitions in the area is presented and discussed for a factory planning information management system. An evaluation and discussion is made for the state-of-the-art software in the area of concern.

Keywords
Factory planning, information management, models, digital factory, layout design, factory design
Acknowledgements

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There are so many people around me that I want to express my gratitude to, unfortunately I cannot name everyone here.

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Apart from all the advisors above, I would like to acknowledge my dear friend Bobby for his support and patience during my writing.

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APPENDED PAPERS  
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  PAPER B - The Digital Factory and Digital Manufacturing – A Review and Discussion  
  PAPER C - Software tools for the digital factory – An evaluation and discussion (accepted for the 6th International Conference of Digital Enterprise Technology - DET)  

APPENDED PROCESS MODEL (fold-out)  
  Factory planning and realization process - detail level
1 Introduction

1.1 Research background
There is a continuous market demand for more competitive and efficient manufacturing. Due to this reason much research has been carried out in lots of different aspects and areas, because many factors can affect the manufacturing and its efficiency.

In the ModArt project the purpose is to develop a model driven parts manufacturing process to support the manufacturing industry.

In a model driven scenario, the models of parts, processes and resources themselves are the carriers of information which is used and refined throughout the work processes as described in the FFI research project proposal for the “Factory Design Process” (Sivard, 2009).

To develop such a process the ModArt project needs to be broken down into parts or sub domains with sub aims, such as production investment, process planning and factory planning.

This thesis has the aim to treat the factory planning domain as a model driven scenario to support the factory planning and realization work.

Today the industry is continuously updating their manufacturing through e.g. upgrading the operation process, new manufacturing equipment, new factory and more. The reason can e.g. be a new product introduction in the factory or increase of the capacity to meet the market demand. Therefore factory planning support is necessary and important for e.g. a better utilization of space, optimum flow or to get a more well structured factory project work and manufacturing process, in this manner saving time and money. But today, research in the factory planning is mostly focused on simulation or a smaller part of the factory domain in order to improve that part. It lacks information management in the domain of factory planning on a general level and the overall view on factory planning.

In information management, information and data is of course essential, but the information needs to be presented and applied differently depending on the situation. Figure 1 illustrates the different communication situations; between computers, between humans and between computers and humans. The activity model is best suited for human communication while the data model is better suited for
computers. The tricky part is the communication between humans and computers because these two groups have totally different ways to communicate, the concept model is one step in this communication link.

1.2 Research area and questions
To support the factory planning work, it is essential to know what to support. Therefore it is important to know what the factory planning process looks like, to find sensitive and main spots in the area.

To develop a model driven factory planning process, there are many unanswered questions, where the first one is what these unanswered questions really are. The next thought is then, what does the word factory planning stand for? Where does it start and end? What do the activities look like and more? Figure 2 below tries to sort out these questions in a more logical way.
The first three questions are strongly related to how the industry is working today therefore the answers are “out there” while questions four and five are strong research questions in the factory planning domain.

Questions:

What is the context of factory planning?
What are the activities in the context of factory planning?
What is the information needed in the activities?
Which data and what representation is required for this information?

Main question:
How should factory planning data be represented, applied, managed and exchanged?
Figure 2 Relationships between research questions

- What is the context of factory planning?
- What are the activities in the context of factory planning?
- What is the information needed in the activities?

- Which data and what representation is required for this information?

- How should factory planning data be represented, applied, managed and exchanged?

- Digital factory

Information from industry and academy

Research questions

Answer or possible solution?!
1.3 Introduction to system engineering
To talk about information management in the domain of factory planning on a general level, it is essential to mention the concept system engineering. Factory planning is a specific domain of the system engineering. In Table 1 below are some examples of similarity between system engineering and factory planning.

<table>
<thead>
<tr>
<th>System engineering</th>
<th>Factory planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focuses on how a complex project should be designed.</td>
<td>Is a complex issue. Focuses on how a factory should be planned.</td>
</tr>
<tr>
<td>Is an interdisciplinary field.</td>
<td>Has different sub domains, such as building, media and manufacturing system, which need to contribute to the factory planning project.</td>
</tr>
<tr>
<td>Has issues, such as coordination of different teams.</td>
<td>Has the role as organizer between different domains, such as production investment and process planning, and within domains, such as building.</td>
</tr>
<tr>
<td>Deals with work processes and tools.</td>
<td>Deals with work processes and tools for factory planning</td>
</tr>
<tr>
<td>Has a holistic view.</td>
<td>Has a holistic view, dealing with needs and requirements from an early stage to a realized optimized factory.</td>
</tr>
<tr>
<td>Has a system lifecycle perspective.</td>
<td>Needs information representation and management during the whole lifecycle stage of the factory.</td>
</tr>
<tr>
<td>Usually needs to be represented in different models to be better understood, due to its complexity.</td>
<td>Information needs to be represented in different models for a better and easier understanding and reuse.</td>
</tr>
</tbody>
</table>

1.4 Relationships with other research areas
Most of the research area has a relationship with other research areas, just as most houses have their neighbors, close or distant. The factory planning domain is closely related to the production investment and the process planning with perspective on manufacturing system.
development. At manufacturing system development these three domains, for a certain level of detail, are going hand in hand with each other in order to give the best result. E.g. to plan a layout in factory planning, the information about the process sequence from process planning and new machine size from production investment is essential.

Production investment:
Production investment focuses on the equipment and its communication with equipment suppliers, in most cases the equipment is machines. The production investment process supports machine tool investment to be quality secured, that meets the production goals and with decreased lead-time from identified problem to equipment running (Sivard, 2007)

Process planning:
The process planning has focus on how a part or product should be manufactured in a machine or a manufacturing system. The process handles e.g. the choice of the right type of process, sequence planning, measurement planning, appropriate fixture design, etc.
2 Method

Reflection of the general research steps that have been performed:

- Observation of the real world for understanding the area, see the needs and identify the problems.
- Propose a solution to the needs.
- Formulate a hypothesis for the problem.

2.1 Method of information and data collection

To answer the research questions, a mass collection of data and information is performed at Scania, a big truck company, and some other participants in the ModArt project. The data and information are collected through interviews and meetings with experts, through participation in the daily project work and visits to equipment suppliers. Important documentation related to the area of factory planning at Scania has been studied. Data and information has been gathered continuously during three years, in order to cover most of the area. Apart from the general information, the specific data and information related to the specific factory planning projects is also collected for the test cases and validations.

2.2 Definition of information and data

It is essential to separate the words information and data, in Table 2 there are some definitions defined by different authors.

<table>
<thead>
<tr>
<th>Table 2 Definitions of information and data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
**Information**

Information is knowledge of ideas, facts and/or processes (Schenck, et al., 1994).

Information is meant to change the way the receiver perceives something, to have an impact on his judgment and behaviour (Davenport, et al., 1998).

Think of information as data that makes a difference (Davenport, et al., 1998).

Information is data interpreted in its original meaning (Nielsen, 2003).

This thesis adopts that “Information is data placed in context”, as expressed by Mary Loomis (Loomis, 1987).

### 2.3 Different models and modeling methods

To treat the factory planning domain in a model driven scenario, to support the factory planning work, different models need to be discussed first. This is necessary because different information and data collected from industry and academy needs to be presented in their best way.

**Concept model:**

The graphical representation of the concept relationships. In other words, the relationship between the meaning of “words” is defined. The power of the concept model is to show concept relationships in a domain, to get a better understanding of the area.

**Activity model:**

The graphic diagram or representation defines functions and functional relationships via box and arrow syntax and semantics (Knowledge Based Systems Inc., 1993).

An activity model represents the activities of a process and relationships between those activities.
Process model:
A graphic diagram or representation which illustrates precedence and causality relations between situations and events. A process model shows and expresses knowledge about how a system process or an organization works (Knowledge Based Systems Inc., 1995).

Information model:
An information model defines a structure of the information that needs to be managed (von Euler-Chelpin, 2008).

“The information model is a formal description of types of ideas, facts and processes which together form a model of a portion of the real world and which provides an explicit set of interpretation rules” (Schenck, et al., 1994).
Figure 4 Example of the models
Factory planning is a big area, according to this study it expands from initiation of market demand to a real factory ready for production. To make the collected data and information logical and easy to overview, a suitable modeling method has been chosen to show the activities and processes. A suitable method is one which can describe the factory planning in the simplest way without any complexity that the reader can understand without deep knowledge in a modeling language.

There are two modeling methods in the discussion:

Integration Definition for Function Modeling (IDEF0): A method developed by National Institute of Standards and Technology (NIST) for modeling of a system, also a method to create a graphical representation of a system. IDEF0 can represent the decisions, actions, and activities of an organization or system.

Astrakan: A Swedish graphical modeling method developed for enterprise description which can describe both activities and processes, and has less rules than IDEF0.

Both IDEF0 (Knowledge Based Systems Inc., 1993) and Astrakan (Nilsson, 1998) are based on, or derived from, the Structured Analysis and Design Technique (SADT) which is a well-established graphical language. The basics of SADT are ICOM (input, control, output and mechanism) which both IDEF0 and Astrakan have. Figure 5 below shows the basics.

![Figure 5 Basic SADT modeling (Marca, 1988)](image)
For the factory planning process a combination of IDEF0 and Astrakan is chosen because it is the most suitable for the case. The Astrakan method is chosen because a part of it is more simplified than IDEF0 and can present both activities and processes while IDEF0 can present activities. It is often difficult to distinguish between activities and processes in the collected information due to the level of detail and perspective. The definition of the activity and process are below:

Activity:
“An activity is an event where an object acts in order to change the state of another object.” (Holmström, 2006)

Process:
A process is a set of interrelated events and activities.” (Holmström, 2006)

Due to this condition the model in the fold-out is an activity model. A part of IDEF0 is chosen because some of its rules are more suitable, such as numbering of the activities and that objects can have a joint name.
3 Factory planning and realization process

This chapter answers research question one to three:

Questions:

What is the context of factory planning?
What are the activities in the context of factory planning?
What is the information needed in the activities?
Which data and what representation is required for this information?

Main question:
How should factory planning data be represented, applied, managed and exchanged?

Factory planning is unavoidable when it comes to a factory, especially issues related to layout and factory flow. Factory planning is required e.g. under the following conditions:

- Changed requirement of space
- Rearrangement
- Reorganization
- Replacement of the equipment or new equipment
- Changed capacity
- Demand on shorter throughput time
- New factory
- New product

The largest factory planning process scenario one can imagine is a new factory design and realization, therefore the factory planning process context should cover all activities when developing a new factory. When this process is described, all of the conditions will be a part of it.

3.1 Layout

The layout is considered as the core of the factory planning process. During the development of the factory planning pilot in the ModArt project, it was identified that the layout development is the most essential activity in factory planning. A good layout is not just an image, it is an information carrier. The most important data and information in the factory planning area is layout related. A good virtual layout is a verification of the information and data. It is here
that different domain models of media, machines and building etc. are
merged together. A detail layout determines a part of the flow and has
an effect on the factory during its life time, in terms of shorter
throughput time, better space utilization and more.

Layout is a very wide concept and has different meanings to it. In
short, the layout has purpose, viewpoint and detailing level as
information. Below are some of the faces a layout can have in factory
planning.

Block layout:
The block layout is a layout used in an early stage of the layout
designing process. In the drawing, machines are just represented
conceptually by some boxes with approximate size or just a division of
the space, meaning much of the information about the machines is
unknown. The most important part in the block layout is the division
of the space, e.g. the area of machines, buffers, operators and
maintenance area (Chen, 2008).

Detail layout:
A detail layout (Chen, 2008) should contain all the information which
is needed to describe a system. A system can be a factory, a line, a cell,
etc. The information in a detail layout should be realizable and reflect
a real factory in a certain level of detail.

Media layout:
A media layout is a generic term for power, process fluid, ventilation,
pneumatic, water system, IT/telephone and more. An electricity
layout, a water system layout or a ventilation layout are all a kind of
media layout.

Foundation layout:
Many machines or bigger equipment require their own “islands” to
stand on due to e.g. its sensitivity or weight. They need to be isolated
from disturbances such as vibrations and therefore it is necessary to
build a specific foundation for each of them to meet their
requirements. A foundation layout describes these specific
foundations in the form of dimension, bearing capacity, material and
more.

Apart from the different layouts above there are layouts such as
working area layout, painting area layout, safety layout, lighting
layout and more. In the detail layout many of these layouts are
merged together for a better integration of the space and information.
Because of this, a concept model of the layout (Chen, 2008) is very important to have, as the intention with it is to clarify the relationships between different parts for a better integration.

Figure 6 Example of painting layout
Figure 7 Example of safety layout from Scania
3.2 The factory planning and realization pilot

Factory planning and realization is a very big, capital intensive, knowledge intensive and complex process, especially in the case of a new factory. The factory planning pilot has the intention to give support to people who are working in relation to factory planning and realization. The pilot is built in close collaboration with Scania, based on information collected from the industry and academy. The basic structure of the pilot is based on SADT modeling see Figure 8. For each of the activities in the pilot the what-to-do information is described with best practices, templates, examples and more. This pilot is also the answer to research questions one to three. Due to license issues the information within the factory planning pilot is not available for this thesis. The pilot is available at:

www.produktionslotsen.se

In the fold-out an activity model of the factory planning and realization is showed. It is based on Astrakan and IDEF0 modeling annotation (Nilsson, 2004), with some modifications due to the needs to represent the process in a clear and simple way as possible for the reader to understand. The activities are modeled in sequence, in line with IDEF0. This doesn’t mean that work is done in such a time sequence.
3.2.1 The structure of the pilot

The factory planning pilot (Chen, 2009) is based on the activity model illustrated in the fold-out. The pilot is divided into six modules and most of them have a number of activities. The six modules are activity based, as well as project based, which gives the reader a better overview of the whole process, see Figure 9 Factory planning modules. The process describes a factory planning and realization process, which can give support to different conditions as mentioned in beginning of Chapter 3.

Figure 8 An activity in the factory planning pilot - screenshot

<table>
<thead>
<tr>
<th>Activity</th>
<th>Input</th>
<th>Control</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagkrav för layout</td>
<td>Standarder för layout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grovt tillverkningskoncept</td>
<td>Ta fram blocklayout</td>
<td>Blocklayout</td>
<td></td>
</tr>
<tr>
<td>Ex blocklayout</td>
<td>Mechanism</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Atta ta fram en layout som visar hur fabriken kan inelas nytor.

Beskrivning:

Anseende upp den inrama gebyran till olika armar för tex. irre, lager, transportgångar, underhåll, personal, kontor, munurosrum, transformationen och m.m. Det är viktigt att tänka på hur olika funktioner eller verkställer kan samordnas i egensammal mutum för två avdelningar med liknande typ av artning.

Vid framtagning av vackelayout är det viktigt att säkerställa att övergripande krav uppfyllas exvis lagkrav för transportgångar vid dubbelhållad ledlik, utkastningar av huvudlinjerna för transport och observerar som beskrivs ettiet ut i framkton.

Den här utgör basen för grön layout.

Tips:

- Minimalisera kostnader för materialhantering och transport. Även förnyelser av personalen kan räknas in här. Antingen kan att fornyelser inte ökar värden på produkten, utan bara genererar kostnader.
- Omläggning och byt av utvändiga program och kontor. I så fall skall produkten variera i produktionen för att den, vilket medför att extra banket kapital.
- Beträda utnyttjandet av tillgängliga er är en sätt att fulla lokalproduktionerna nere.
- En bra layout underställer produktion, underhåll, overvakning, service, säkerhet, arbetsmiljö samt ger ett beträda utnyttjandet av personal och andra resurser. Planering av layout är också en planering av vinden.
The six modules are briefly described below.

**Module 1 – Assess project potential - Initiate project:**
Investigate the feasibility of the factory planning project within the time and cost limitations.

**Module 2 - Formulate the project definition – Pre-project:**
Put together requirements and information for the planned project and form the basis for the project decisions and feasibility.

**Module 3 – Structure and define the production requirement – Detail project:**
Break down the overall requirement to the specific requirements for the subsystems and equipment.

**Module 4 – Design the system – Detail project:**
Detailing, verifying and integrating the models of the building construction and equipment to form a whole, realizable system model.

**Module 5 – Realize the system – Realize the project:**
Co-ordinate the installation works for the building construction and equipment, and install the system.

**Module 6 – Hand over to production and follow up – Follow up the project:**
Hand over the project result (a factory ready to produce) to the production with its documentation.

### 3.2.2 The activity model

The factory planning and realization process in a detailed activity model (fold-out) is developed and attached in the end of this thesis. Below is some reading guidance for the activity model.
Figure 10 Factory planning and realization process – overall level

- Assess project potential (Module 1)
- Article type
- Market data
- Project assessment
- Project definition
- Structuring and defining the production requirement (Module 3)
- Project requirement
- Project definition
- Formulate the project definition (Module 2)
- Design the system (Module 4)
- Integrated factory model
- Realize the system (Module 5)
- Realized system
- Hand over and follow-up (Module 8)
- System in production
Some of the objects have been gathered under one general name for the simplicity. The idea is to manage corresponding objects in the yellow and blue lines in a database to support the activities.

Figure 11 Reading guidance 1
Figure 12 Reading guidance 2
Inheritance:
All the objects with an arrow into an activity or module (input, control and mechanism) are also inherited by all lower level activities and modules.

Figure 13 Reading guidance 3
Inheritance:
Output object from a module includes all objects from belonging activities.

Similarity:
A point in an arrow is an object, this means every point is an arrow.

Figure 14 Reading guidance 4
3.2.3 Advantages and limitations of the pilot

The advantages of the pilot are many, some of them are that it:

- Supports different factory planning scenarios, at large and in detail.
- Shows the interface between production investment and process planning pilots.
- Contains specific templates and examples for specific activities.
- Can give support from the beginning to the end.
- Provides a source of knowledge for industrial employees and educational material for both industries and universities in the area of production.
- Is a platform for future research.

There are some limitations to the pilot due to various reasons, such as:

- The pilot is best suited for factories with machine tools, mainly because the ModArt research project has its focus at part manufacturing and the companies within the project are mainly machine tool users.
- The standards and laws within the activities are best suited for factories in Sweden, because the Swedish laws and standards are used.
- The pilot does not cover some interface activities to other domains.
- The best practices are collected from few companies.
4 Results and discussion

In factory planning, the most essential part, the core part, is the layout. A high-quality detail layout should mirror the real factory at a certain level of detail. Because of this, representing the layout information is the number one priority in this area.

![Diagram showing the relationship between factory planning, layout, tools, and theory]

Paper A: A concept model for factory layout design

Layout - the core of the factory planning

Tools for digital factory

Theory for digital factory

Paper C: Software tools for the digital factory – An evaluation and discussion

Paper B: The Digital Factory and Digital Manufacturing – A Review and Discussion

Figure 15 Relationship between results
Figure 15 is an attempt to give an overall relationship description between the results and why these results are needed. Based on the information collected for the factory planning pilot, a concept model for factory layout design is developed. The concepts within this model need to be presented in some way and the digital factory is a possible solution. Based on this assumption, a deeper understanding and review of the theory behind the digital factory is a must. However, a theory is not enough for solving the problem. Software tools are also needed to both represent the theory and as an interface for the layout. This leads to an evaluation of the state-of-the-art software tools within the factory planning domain (in the domain of the digital factory), to get a deeper understanding of which information the software tools are capable to represent.

4.1 Results

Factory planning and realization pilot

A web based pilot includes the work flow of the factory planning and realization, it also includes the work methods, standards, laws, templates and examples in the area. This pilot is the background information or basis for the factory planning and realization, besides the needed information management.

Paper A: A concept model for factory layout design

In the paper a concept model for layout is given, based on the information gathered. In the concept model the most important parts of a layout are specified and the relationships between properties are identified, structured and verified. This is essential for further contribution to information modeling and management in the area of the neutral information representation.

Paper B: The digital factory and digital manufacturing - A review and discussion

While the concept model for factory layout design is developed, a method to handle the data and information has to be defined, or, in other words, the data and information need to be managed and represented. The visionary digital factory is then a possible solution for this situation. Research on the digital factory is made for a better and deeper understanding of what it is capable of and what it can represent, as well as the state-of-the-art in the digital factory area. A review of the digital factory is performed together with the concept digital manufacturing, since they are closely related. Many papers,
doctoral theses, books and fact sheets related to the digital factory the
digital manufacturing have been collected from different sources and
analyzed.

The result of this paper is that the concept digital factory and the
digital manufacturing has many faces, the concepts have different
definitions depending on different perceptions, backgrounds,
knowledge etc.

The digital factory should be the information backbone to the whole
factory during its lifecycle. The information and data should be sorted
by process and resource, which should then result in computer
interpretable models, defined according to purpose, view point and
level of detail level. The digital manufacturing runs or executes
analyses and simulations on a digital factory/manufacturing system
model with parts or product models, based on process plans.

**Paper C: Software tools for the digital factory – An evaluation and
discussion**

To realize the digital factory, only a theory about how it should be is
not enough. For realization a real tool is necessary to have for the
information application and management. Therefore evaluations of
two of the commercial state-of-the-art software tools are performed
since both of them are referred to as tools for the digital factory.

The functions related to the information representation of the software
tool have been mapped to the research theory that has been defined
earlier in paper B “The Digital Factory and Digital Manufacturing – A
Review and Discussion” for an evaluation.

The result of this evaluation is:
Due to the fact that most of the software tools are developed for very
specific users in the domain of the digital factory, the theory of the
digital factory in paper B is not realized yet. If interface problems and
different data formats are solved, or at least improved, the software
tools within the domain will be a very good complement to each other.
The data format problem should be the most important problem to
solve in this domain, instead of each of the vendors trying to develop a
wholly complete digital factory system with different modules that
can serve all the needs in the domain.

The two main focuses in the digital factory domain are:
• Information modeling and representation

• Information tools to generate, interact with and reuse the information

In the research, these two areas are often divided into two separate research domains, while commercial software tries to integrate these two areas in one application. Commercial software for the digital factory today can only visualize the 3D image and represent some information. The software lacks a PLM (product life cycle management) thinking, which is essential.

4.2 Relationship between papers and research questions

The papers are written with the purpose to answer the research questions.

The papers are a way to try to answer the research questions. While chapter three answers the first three questions, the papers focus on answering question four and five. Paper A has its main focus on research question four while paper B and paper C have their main focus on question five.

Figure 16 shows the relationship between papers and research questions.

Questions:

What is the context of factory planning?
What are the activities in the context of factory planning?
What is the information needed in the activities?
Which data and what representation is required for this information?

Main question:
How should factory planning data be represented, applied, managed and exchanged?
What is the context of factory planning?

What are the activities in the context of factory planning?

What is the information needed in the activities?

Which data and what representation is required for this information?

Main question

How should factory planning data be represented, applied, managed and exchanged?

Digital factory

Information from industry and academy

Factory planning pilot

Paper A

Research questions

Paper B and C

Answer or possible solution?!
4.3 Discussion - why digital factory

The digital factory is the information backbone for the factory with its resources and processes during its life cycle.

The digital factory solution is chosen and discussed because the factory planning domain is an information intensive process and it is an ongoing process during the factory’s whole life cycle. The factory resource and process information needs to be handled, but the normal PLM solution focuses on the product information management. There is a need for a complete information management of a factory life cycle and its manufacturing, dealing with resources and processes, maintenance and investments etc.

The digital factory is a solution for the whole factory and not just for factory planning. Other research domains such as the production investment and process planning will also be supported by the digital factory in the future. These processes are inter-dependant and have a close relationship to each other, as has been discussed in chapter one.

At this stage the digital factory is still a visionary solution, many parts and details are still unknown, such as the information models for the factory planning and layout design, the connection between terminology, concept and information models, etc.

Related research has been done by the Computer Systems for Design and Manufacturing division at KTH. It is the manufacturing lifecycle management (MLM) concept. The MLM has its main function as information administrator, which is a complement to the digital factory that has the purpose to model the resources and processes. An approach to handle the models in relation to ontology and information standards is described by Kjellberg, et al. (Kjellberg, 2009).

Several standard information models related to different aspects of the manufacturing system have been identified or tested to represent its information such as:

- STEP AP239 (Product life cycle support) and AP214 (Core Data for Automotive Mechanical Design Processes) for the manufacturing system life cycle (von Euler-Chelpin, 2008).
- AP214 for a general integrated manufacturing system information representation (Johansson, 2001).
5 Future work

The most essential further work is to build a model for key concepts in factory layout and relate it to the factory layout information model. It is the core information of the factory planning, as mentioned before. To realize the digital factory, one must make the data computer interpretable, and the first stage to accomplish that is to develop the information model.

The future work is based on two important questions, which have already been raised and discussed in previous papers in one way or another.

- How should layout information be represented in a neutral format for better communication?
- Why a neutral information model?

One of the hypotheses is that the present STEP standard, ISO 10303 for Industrial automation system and integration, can be a solution for the layout information model. In ISO 10303 there are many parts for representing the information of different domains in the factory planning. Some interesting AP’s (application protocols) within ISO 10303 are listed below, each of which might represent a part of the whole factory layout.

- AP 212: Electro technical design and installation
- AP 214: Core data for automotive mechanical design processes
- AP 225: Building elements using explicit shape representation
- AP 228: Building services: HVAC
- AP 233: System engineering data representation

Based on these hypotheses the possible future work will be to map the layout concept model to the AP’s within ISO 10303. This is an approach along the same line as the paper “The machine tool model - A core part of the digital factory” by Kjellberg et al., (Kjellberg, 2009). The theory in this paper will be used as a guideline for the future work.
References


