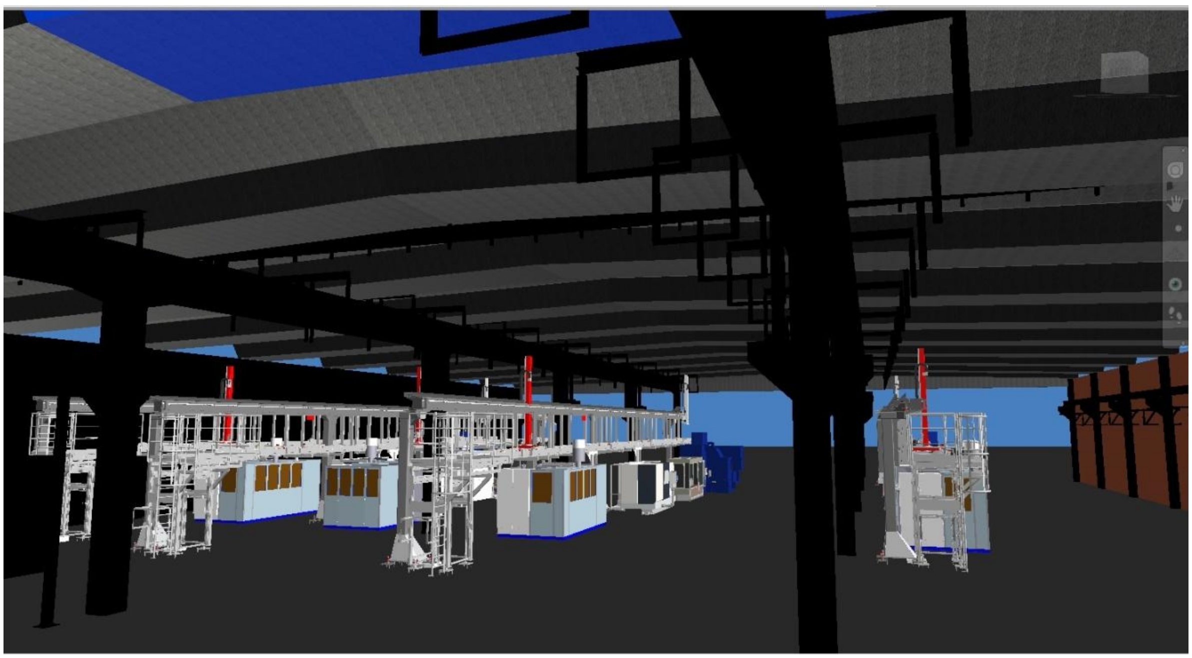
Factory design process for future development of production systems



Project within FFI Sustainable production technology

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

The vehicle industry faces a great challenge when changing towards environmentally safe vehicles and production while keeping its competitiveness. The necessary changes has to be realized rapidly and with secured quality and lead time, a challenge which FFI Sustainable production technology and this project addresses.

The project – Factory design process for future development of production system (FDP) - was a 12.5MSEK, three year collaboration between KTH and Scania, with the goal of providing methods for a coordinated and efficient factory design process.

The factory design process affects not only the effectiveness of the project phase of the factory design and installation but also the subsequent production efficiency, in terms of the various aspects of a production system including efficient material flow, space utilization, working environment, and safety.

There are a number of parallel and interdependent manufacturing systems to develop such as the production layout, supply systems for electricity, water, air, heat and cooling, pneumatics and hydraulics, chip and waste handling, process fluid, communication networks, sprinkler systems, building etc.

The project has focused on computer aided work processes and the communication of models between various stake holders in layout design. The primary objective was that of providing methods for a coordinated factory development process with a facilitated information exchange and reuse of knowledge and models.

A new factory project at Scania was used as a test case, and the work was divided into four work packages resulting in work process models, information specification and system evaluations. The project has provided a deepened understanding of the functionalities needed and how models should be designed to support the development process. Principles for representing layout models in accordance with system neutral standards, for communication, have been investigated with verification of the usability of the STEP standard AP214 to represent the layout information. Demonstrators have shown how to perform collaborative layout using a combination of commercial layout- and PLM-systems, and an initial information architecture has been suggested.

These results contribute to securing production development processes in which virtual planning tools and management of data are used efficiently, addressing the industrial challenge to realize necessary changes in production rapidly and with secured quality and lead time.

Though the results are important, there is a quite large chasm between the immediate needs of industry and the possibilities at the research frontier. The KTH research team envisions a disruptive increase in manufacturing adaptability through an open

information paradigm, where interoperable systems and integrated information enables a seamless communication of models between various stakeholders, combining intelligent models from various suppliers to analyze manufacturing KPIs. This future vision requires a focused effort in order to evolve and implement the existing results in system neutral modeling of digital factories, an effort which will be proposed in future projects.

2. Background

The factory design process affects not only on the effectiveness of the project phase of the factory design and installation but also the subsequent production efficiency, in terms of the various aspects of a production system that includes material flows, space utilization, working environment, and safety.

The factory design process, particularly the layout process, determines the material flow during the production process. Layouts in which stations are arranged without structured prior planning and evaluation results in longer throughput times, high inventories and work in progress, which increase cost of production.

Furthermore a structured approach facilitates the design and installation process which has a potential to save a significant cost and time in such a capital intensive process.

By designing factories based on factory models in which relevant aspects of layout, capability, capacity, environmental impact etc can be evaluated and secured beforehand, it will be possible to achieve fast installations or factory reconfigurations securing fast ramp-up of production with high overall-equipment-efficiency.

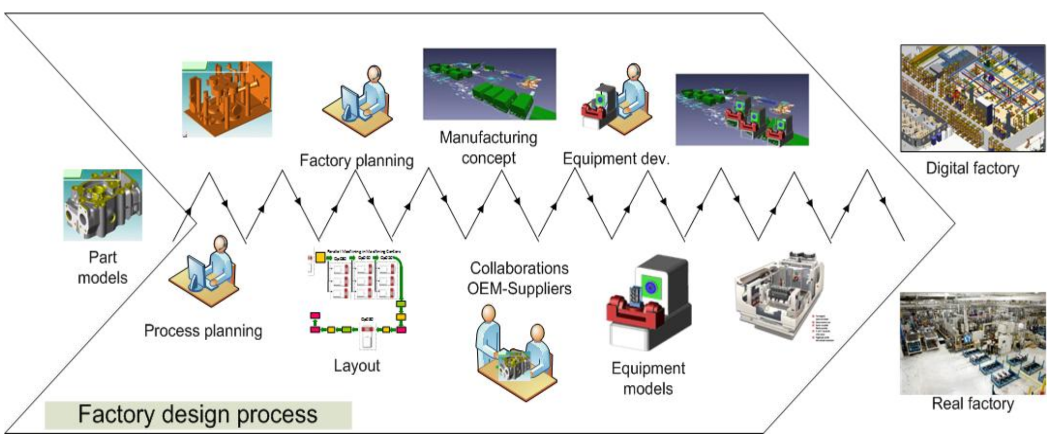


Fig 1. A model driven manufacturing development process

In the MERA project ModArt, a model driven manufacturing development process was defined. In a model driven development scenario, the models of parts, processes and resources themselves are the carriers of information which is used and refined throughout the work processes. The process plan and layout are two interdependent aspects of a manufacturing process due to the fact that the machines, which are used to realize the operations, have geometric dimensions and interfaces to media, material handling, equipment and fundaments in the layout. Thus determining exact process plan and layout is a negotiation between operational benefits and physical constraints. Working with models of layout, machine tools and operations in a model driven work process helps visualize the dependencies between development activities and various aspects of the line which is under development. The FDP project contributed to such a structured and coordinated process.

3. Objective

The project has focused on computer aided work processes and the communication of models between various stake holders in layout design. The primary objective was that of providing methods for a coordinated factory development process with a facilitated information exchange and reuse of knowledge and models.

4. Project realization

The project was divided into four work packages (WPs):

WP1 Procedures for factory design and production equipment development

WP2 Tools and Methods Evaluation

WP3 Demonstrator

WP4 Dissemination

While WP1, WP3 and WP4 were oriented towards application and knowledge transfer, WP2 was by large a research work package in which new solutions for model integration were investigated and suggested.

The project used a new factory project at Scania as a test case platform, and was a 12.5MSEK, three year collaboration between KTH and Scania.

5. Results and deliverables

5.1 Delivery to FFI-goals

The project has addressed the goal within FFI Sustainable production technology to develop results which help the vehicle industry to meet the challenge of securing a rapid change towards environmentally safe vehicles and production. The project has focused on securing production development processes in which virtual planning tools and management of data are used efficiently. The results concerning utilization of layout systems and managing collaboration using PLM are general to all kinds of industry, not only the vehicle industry.

Specifically FDP has contributed to:

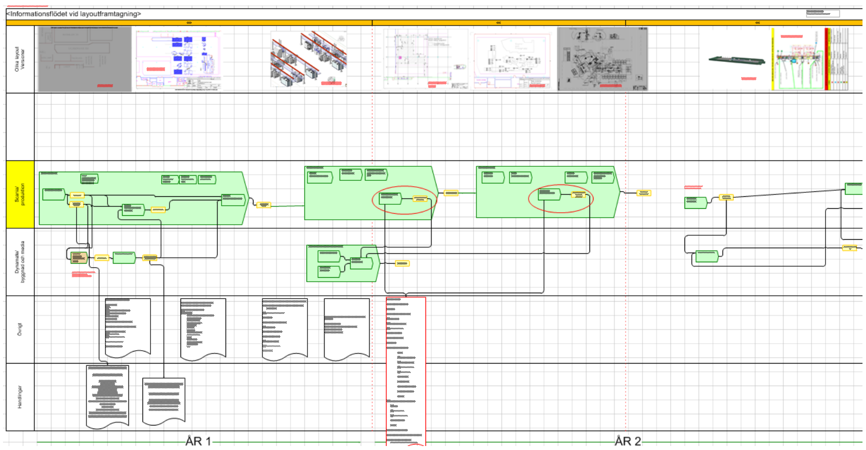
- Increasing the efficiency of using virtual tools and managing industrial information – key to a competitive company.
- An industrial technology- and competence development through increased education in industrial layout at KTH.
- A strengthened competence within the research community concerning factory planning

5.2 Specific results

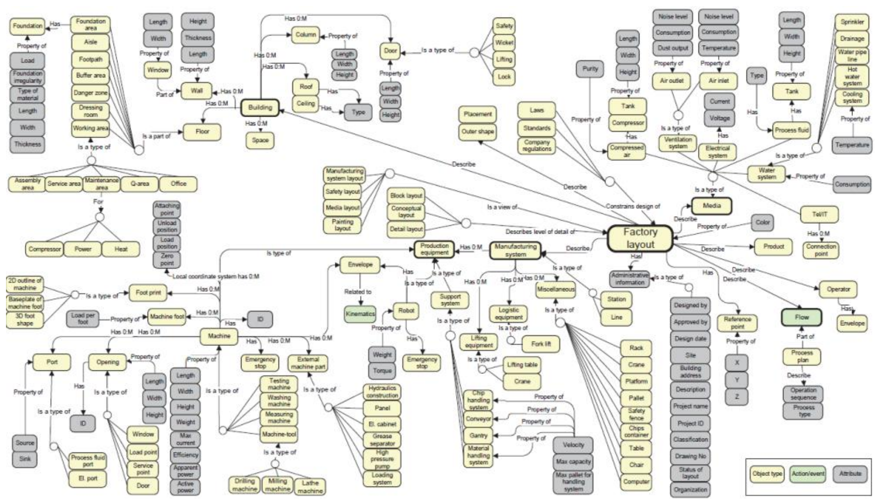
The work has resulted in work process models, information specification and system evaluations. It has provided a deepened understanding of the functionalities needed and how models should be designed to support the process. Principles for representing layout models in accordance with system neutral standards, for communication, have been investigated with verification of the usability of the STEP standard AP214 to represent the layout information. Demonstrators have shown how to perform collaborative layout using a combination of commercial layout- and PLM-systems.

Some highlights:

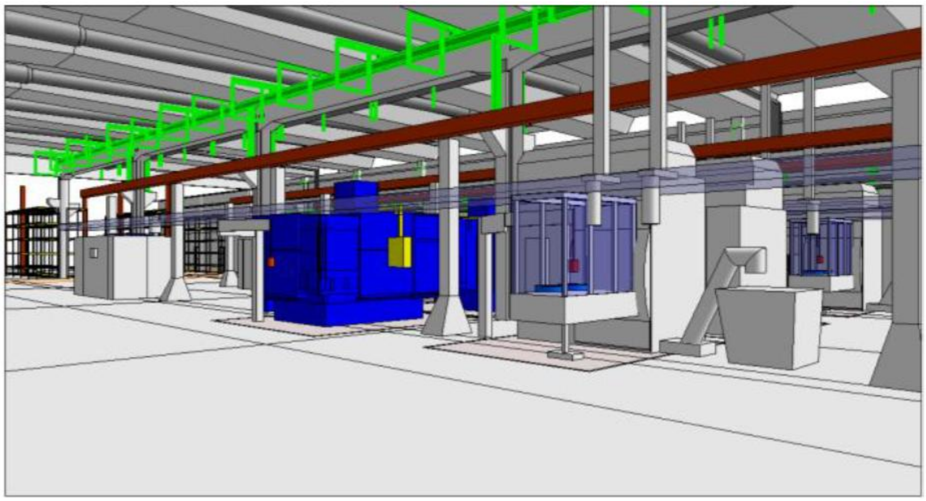
- A work flow model which reflects the interaction between OEM and suppliers



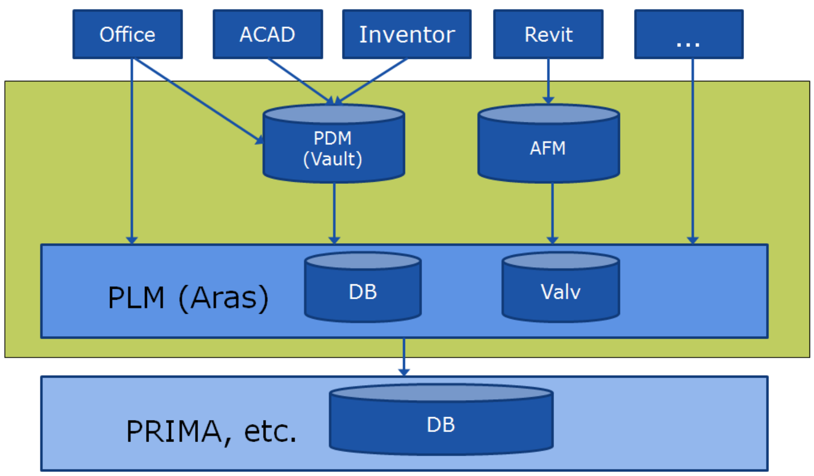
- A concept model of the semantic information in factory development



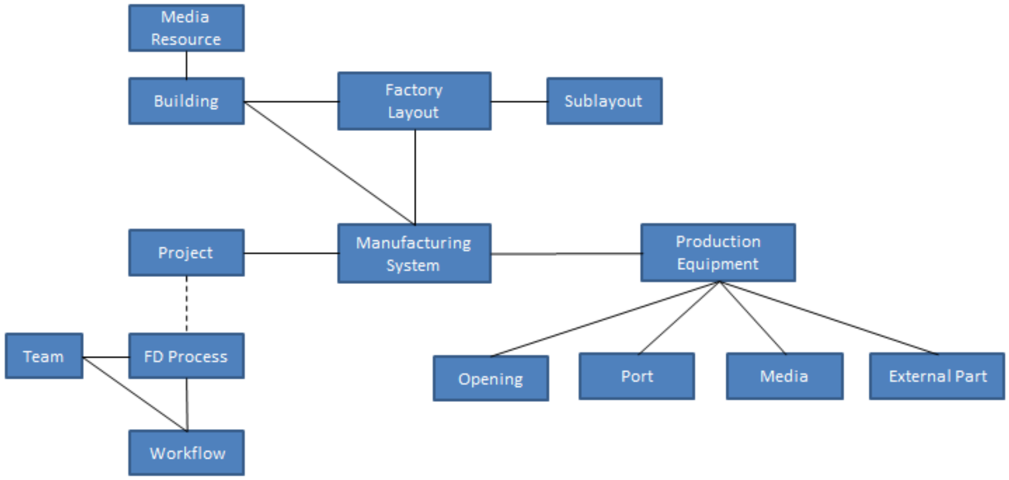
- Test and evaluation of the layout programs Revit, Bentley Microstation, and Autodesk Factory design suites



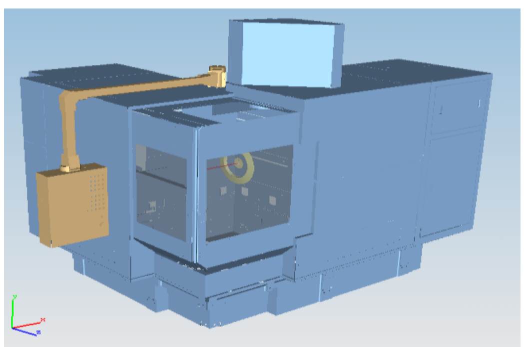
- PLM- architecture for various layout models



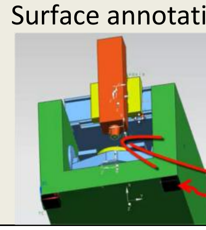
- Demonstrated data model for layout



- Methods for the simplification of large machine tool models



- Approach to representing layout information according to standard principles developed in the FFI-projects DFBB and FBOP.

	Dimensions and tolerances 	Kinematic links 	Surface annotation 
Process planning (FFI FBOP and DFBB)	Tool diameter and length	Tool path of machine tool	Annotation of machine tool interface
Factory layout (FFI FDP)	Positioning of material loading position and distance to connection points	Movement envelopes of doors and openings	Annotation of feet surface

6. Dissemination and publications

6.1 Knowledge and results dissemination

The project results have been presented at several conferences: the FFI conference in Katrineholm; the CIRP Research Affiliates meeting in Dublin, Irland 2010; International Conference on Changeable, Agile, Reconfigurable and Virtual Production, CARV, Montreal, Canada, 2011; CIRP Design Conference, Daejeon, Korea, 2011; SPS11, Lund, Sweden 2011; CIRP General assembly in Hong Kong 2012; the CIRP Manufacturing conference in Athens 2012, SPS12, Linköping, Sweden 2012.

Within Scania, the project has contributed directly to the knowledge of to specify and select their next generation factory layout and PLM systems. Further, it has contributed to Scania's factory planning and CAD development work processes. One of the largest unplanned effects of the project was the contribution to the education of KTH Masters students. The increased understanding among the research team concerning the complexity of developing a good layout has trickled down into the master courses. This has among others led to a master thesis project in laser scanning of factories, and further to collaborations concerning methods for developing sustainable factories with TU Berlin, managed by Danfang Chen. Danfang has also become a CIRP junior affiliate member, has a journal paper accepted and is applying to become a senior member. The project has also led to a closer relation to the research at Mälardalen University, MDH, which hopefully will lead to future collaboration.

6.2 Publications

´Modules information modelling in evolvable production systems´, G. Sivard, N. Shariatzadeh, H Akillioglu, SPS12, Linköping, Sweden 2012

´Integrating sustainability within the factory planning process´, D. Chen, S. Heyer, G. Seliger, T. Kjellberg, CIRP annals(ISSN 0007-8506)(EISSN 1726-0604) 2012

´Information management for factory planning and design´ D. Chen, doctoral thesis, KTH, Sweden 2012

´Software evaluation criteria for rapid factory layout planning, design and simulation´ N. Shariatzadeh et al.CIRP Conference on Manufacturing Systems, Athens, 2012

´Production pilot for co-operation in factory development´ Chen, D. Kjellberg, T. Svensson, R. Sivard, G. Proceedings of International Conference on Changeable, Agile, Reconfigurable and Virtual Production, CARV, Montreal, Canada, 2011

´Using Existing Standards as a Foundation for Information Related to Factory Layout Design´ D. Chen, M. Hedlind, A. von Euler-Chelpin, T. Kjellberg. Proceedings of CIRP Design Conference,Daejeon, Korea, 2011

´An information communication approach for factory layout´
D. Chen, T. Kjellberg. Proceedings of Swedish Production Symposium, Lund, Sweden, 2011

7. Conclusions and future research

The project has aimed to secure production development processes in which virtual planning tools and management of data are used efficiently. Within Scania, the project has contributed directly to the selection of their next generation factory layout and PLM systems. At KTH the project has contributed largely to the education of KTH Masters students and new collaborations concerning methods for developing sustainable factories with TU Berlin.

Though these are important results, there is a quite large chasm between the immediate needs of industry and the possibilities at the research frontier. The KTH research team envisions a disruptive increase in manufacturing adaptability through an open information paradigm, where interoperable systems and integrated information enables a seamless communication of models between various stakeholders, combining intelligent models from various suppliers to analyze manufacturing KPIs. This future vision requires a focused effort to evolve and implement the existing results in system neutral modeling of digital factories, an effort which will be proposed in future projects.

8. Participating parties and contact person

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Instructions for report

- The report should be written in both Swedish and English (separate reports).
- Maximum length 15 pages
- Use pictures and illustrations if possible.