Session A:
PLM/Digital Factory/
Simulation/Optimization
for the Smart Factory

Chair: Dominic Gorecky, DFKI
Co-Chair: Nikos Papakostas, LMS
Co-Chair: Arnd Schirrmann, EADS
Rapporteur: Xirouchakis Paul, EPFL
Outline

• Introduction
  • Overview about the Topic
  • Overview about the Group

• Project Rally

• Success Stories

• Summary of the FoF-Impact Workshop
  • Cross-Project Collaboration
  • Impact

• Discussion - RD&I in H2020

• Conclusion
Introduction
OVERVIEW ABOUT THE TOPIC
PLM / Digital Factory / Simulation
FP7 – Former roadmap
ICT for Manufacturing

Session A: Digital Factories (2011): 8 projects

Session B: Smart Factories (2010 + 2012): 18 projects

Session C: Virtual Factories (2011): 10 projects
Digital Factories in FP7

Goals:

1. European leadership in knowledge-driven platforms, tools, methodologies for product development & manufacturing

2. Accelerated product design & manufacturing planning

3. Better accuracy, reliability & speed of simulation
Improve the PLM by interoperable models and computer-assisted product and process development and virtual prototyping.

- Reduced cost
- Improved accuracy & reliability

Early digital testing and optimization

Conventional Planning Methods
Digital Factory Methods & Tools

Effort

Time

Product Engineering
Production Planning
Installation & Commissioning
Ramp-Up
Production

Research and innovation

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Accelerated Product Design & Manufacturing Planning (Simultaneous Engineering)

Conventional Planning Methodes

Product Design → Production Planning

overlap

Digital Factory Methodes & Tools

Reduce time for product design & manufacturing planning

Research and innovation

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Moving Forward...

- Runs from 2014 to 2020
- Covers an €80 billion budget
- Combines research and innovation
- Features new implementation schemes
Research and innovation

The megatrends remain ...

Demographic Change
Globalization
Changing Customer Demands

New and Changing Markets
Emerging Competition
Wide Variety of Products and Customer Solutions

Skills Shortages
Changing Workforce

Knowledge as a Productive Asset
Penetration of ICT technology
Shorter Product Life Cycles

Knowledge-based Economy
Rapid Technological Developments

Are the FP7 goals still valid?
H2020: ICT for Manufacturing

**Goals:**
“First time right – made in Europe”

- Responding to higher variance, shorter innovation cycles of highly complex products like cars and aircrafts.
- Boosting the launch of new innovative products through digital design and validation.
- How to shorten time to production during the ramp-up phase of new products by the use of digital tools, make design/re-design more efficient/reliable
- Modelling, reuse and share of manufacturing knowledge for strategic decision making, flexible responses to varying demands
- Enhance innovation through the use of new design tools

→ Master Complexity / Increase Transparency
→ Stimulate Innovations
→ Improve Productivity
→ Create Interoperability: semantics, quality of data: (consistency, timeliness,, completeness ...)
→ Develop new Applications / Enhance Usability: intuitive, mobile, context-sensitive, collaborative, etc.
Example for Innovation & Market Take-up

Combination of existing technologies
→ new innovations
→ new business models
→ new SME users

Source: CloudFlow
OVERVIEW ABOUT THE GROUP
FoF-Projects in the Field of PLM/Digital Factory/Simulation for the Smart Factory:

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<tr>
<th>vistra</th>
<th>TERRIFIC</th>
<th>SIMPOSIUM</th>
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<tbody>
<tr>
<td>Know4Car</td>
<td>OamePLM</td>
<td>FFD</td>
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<td>arum</td>
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Enhancing Interoperability
Interoperable NDE simulation tools
FUTURE FASHION DESIGN

Adaptive Production Management
# Technical cross-cutting issues at a glance

## Use Cases

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<thead>
<tr>
<th>Use Cases</th>
<th>Engineering</th>
<th>Manufacturing</th>
<th>Multi-Agent Systems</th>
<th>VR / AR</th>
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## Goals

- **Virtual training reduces the need for physical training in product assembly.**
- **Efficient knowledge management and collaboration, through revolutionized UIs.**
- **Semantics to minimize the efforts for information transfer and retrieval in engineering.**
- **Interoperability of CAD and FEA/CFD through isogeometric technologies.**
- **Interoperable Simulation tools for non destructive testing and material characterizations.**
- **New business and production workflow to represent the whole development process.**
- **Novel, agent-based, distributed scheduling will improve production ramp-up.**
- **Energy-efficient multi-process manufacturing & optimum process planning.**
Interoperability in PLM

Integration platforms and comprehensive models as a key enabler
Semantic Technologies

Key enabler for a seamless re-/use of information in new applications

The Standard Web
• untyped
• Very little machine-processable information is available

The Semantic Web
• Extensible
• Relational
• More machine-processable information is available
AR/VR Technologies

Advanced User Interaction
- Mobile Interaction
- Gesture-based Interaction
- Speech-based Interaction

Advanced Visualization

Key enabler for intuitive knowledge transfer and user-interaction

High immersion
- Low costs
- High flexibility

Low immersion
- Low costs
- High flexibility
Simulation (FE, NDE, CFD, etc)

Incompatible mathematical representations:

Common understanding of mathematical representations within manufacturing (CAD, CAM, DMU, PLM, CFD, FEA,...) as key enabler
Simulation (FE, NDE, CFD, etc)

Interoperable Simulation tools for non destructive testing and material characterizations

Providing Simulation codes based/connected on existing tools (CAD & Design, FEM ...) for ensuring improved product quality and safety with lower cost experimental campaigns
Project Rally
An Internet-based Collaboration Platform for Managing Manufacturing Knowledge

Know4Car
Know4Car will enable the more efficient knowledge management and collaboration, throughout the process lifecycle and will revolutionise the UI context in the engineering office and the shop floor.

The **Know4Car platform** will comprise of the following components:

- **Process Knowledge Component**
- **Integrated Collaborative Platform**
- **Extended Engineering Component**
- **Advanced User Interfaces and Training Component**

**Know4Car**

"An Internet-based Collaborative Platform for Managing Manufacturing Knowledge"
The Know4Car concept will be realised in two case studies concerning the practices of both the engineering office and the shop floor:

- Automotive Assembly: Collaboration for the execution and validation of assembly processes designed with the help of the platform’s components between engineers and shop floor operators. Advanced UIs will enhance the communication of the involved actors.

- Extended Engineering: Collaboration OEMs, SMEs and production system integrators for the design of assembly lines concerning the automotive industry. This case includes knowledge reuse and novel collaboration paradigms.

**Key results**

- Enable faster process design by 20%.
- Time required for identifying existing relevant knowledge, decreased by 60%.
advanced platform for manufacturing engineering and PLM

AMEPLM

EeB Workshop
14-15 March 2012
amePLM
advanced platform for manufacturing engineering and PLM

Offer a new and extensible approach to collaborative engineering, leveraging semantics, heuristics and visualization

→ Engineer an ontology that serves as an interoperable model and integrating element for an open engineering system: the amePLM Platform
→ Develop an open engineering platform based on existing tools and libraries
→ Research and develop tools to assist in product and process development,
→ Devise a visualization module to enable cross-disciplinary collaboration and remote consultation approaches
amePLM – some facts

- **13 partners from 6 countries**
  - DE, IR, IT, UK, FR, RO
  - **5 industrial end users**
    - 3 SME, 2 global players
  - **2 software providers**
    - one acts as end user, too
  - **6 universities**
  - **1 research institute**

- **Project duration** 3 years, 10/2011 – 09/2014

- **Funded by the European Commission**
  - **Budget 4.4 Millions of Euro**
  - **Grant agreement no. 285171**
TERRIFIC

Provide and disseminate tangible evidence of the performance of the isogeometric approach in comparison to traditional ones in four important application areas as well as addressing interoperability and other issues that necessarily arise in a large-scale industrial introduction of isogeometry.

• The isogeometric approach aligns CAD, CAM and Finite Element Analysis by replacing standard Finite Elements by Spline (NURBS) elements introducing higher order methods and increasing smoothness between elements.
Isogeometric process

1. Start: CAD-model
2. Watertight NURBS based CAD-model adapted to block structure of analysis
3. Analysis suitable NURBS blocks created
4. Analysis performed with NURBS based volumetric elements

The first version of the TERRIFIC demo part.
To be used for demonstrating the Isogeometric approach
Scalar and vector fields represented with NURBS
ARUM – Adaptive Production Management

- **Production / business strategies** supporting the de-risking of production ramp-ups / small lot production ➔ Identification of appropriate strategies
- ICT solution for **operative planning, scheduling and dispatch** the production ramp-up / small lot production ➔ Evaluation of MAS / iESB technologies
- **Demonstration** in real industrial environment
  ➔ Airbus A350 ramp-up scenario
  ➔ MGS coffeemaker scenario
  ➔ 3rd use case (e.g. RO-RO ship, Semiconductors)

knowledge processing
Multi-Agent Systems

Multi-level holonic network of schedulers

Grant Agreement No: 314056
Project Coordinator: A. Schirrmann (EADS)
Technical Coordinator: V. Marik (Certicon)
14 Partners / 7 EU countries, Russia
Budget: 11.7M€, EU funding: 8.49 M€
Start: Sept 12 / End: Oct 15
ENergy Efficient Process pLAning system

ENELPLAN

**Green & Flexible Manufacturing**

**Energy efficiency & Environmental friendliness**
- Environmental footprint reduction for metal formed components by selecting a more energy efficient combination of process among those available in the supply chain.
- Energy efficiency improvement on the process level.

**Quick respond to market demands**
- Multi-process, multi-company distributed control using the same control along the supply chain
- Possibility to use the system to adapt work sequences, process routes and machines behavior to the most efficient working conditions

**Goals for dissemination/exploitation**
- Exchange of information and experiences with other relevant projects.
- Produce guideline for more green & flexible manufacturing.
ENEPLAN Approach

USER
Product, Process & Resource Specifications

Optimized process plan

High Level

Demand & Weather Forecasting

Low Level

Monitoring

Research and innovation
ENEPLAN will be realised in **three case studies** concerning the practices of three different industrial sectors:

The Meta-CAM tool will be used for the composition of alternative process plans. Reference data will be provided by industry partners and will help assess the effectiveness of Meta-CAM tool will deliver. The relevant components will be finally produced as planned by the meta-CAM tool.

### Cases Specification

**Household:** 6 versions of front panels for refrigerator doors  
**Aeronautics:** Loading ramp hinge of a military aircraft  
**Automotive:** Seat frame
Success Stories
Success Story 1

SIMPOSIUM
Success Story 2

VISTRA

Work-in-progress (21/36 months)
Outline

1 – Project Background
• Motivation
• Objectives

2 – The VISTRA Story
• Project-Formation
• Project-Kick-Off
• Development & Integration
• Work-in-progress & Outlook

3 – Key Achievements and Summary
• Overview about the key achievements
• VISTRA from the perspective of the project management
Summary of the FoF-Impact Workshop 2013
CROSS-PROJECT COLLABORATION
Technical cross-cutting issues by Project

**VISTRA:**
- Semantics supported data exchange between digital factory tools
- Automated data import and authoring for digital factory tools
- Augmented/Virtual Reality technologies for assistance applications in factories

**Know4Car:**
- Knowledge management systems
- Agent based technologies with advanced UIs
- Collaborative aspects of engineering

**AmePLM:**
- Ontology-based models of products, processes and activities

**Terrific:**
- Interoperability of CAD and Finite Element analysis
- Computer Aided Geometric Design, Computational Mechanics and Computational Fluid Dynamics

**SIMPOSIUM:**
- Connection/bridges of dedicated NDE tools within PLM
- Sharing technical issues with robotized NDE and manufacturing, innovative methods
- Account of risk based maintenance and manufacturing costs (economic issues)

**FDD:**
- Speeding up simulation for interactive prototypes

**ARUM:**
- Ontology-based models of products, processes and activities
- Holonic multi-agent systems and intelligent enterprise service bus
- Business strategies for adaptive production systems
### Technical cross-cutting issues at a glance

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| VISTRA                     | ● ● ● ●                                                                                                                                                                                                 |
|                           | Automotive                                                                                                                                                                                                 |
|                           | Virtual training reduces the need for physical training in product assembly.                                                                                                                                                           |
| Know4Car                  | ● ● ● ●                                                                                                                                                                                                 |
|                           | Automotive                                                                                                                                                                                                 |
|                           | Efficient knowledge management and collaboration, through revolutionized UIs.                                                                                                                                                           |
| amePLM                    | ● ● ● ●                                                                                                                                                                                                 |
|                           | Electronics, Automotive and Medical Devices Industries                                                                                                                                                                                            |
|                           | Semantics to minimize the efforts for information transfer and retrieval in engineering                                                                                                                                                           |
| TERRIFIC                  | ● ● ● ●                                                                                                                                                                                                 |
|                           | Automotive, Railway, aircraft and machining tools                                                                                                                                                                                                |
|                           | Interoperability of CAD and FEA/CFD through isogeometric technologies.                                                                                                                                                                             |
| SIMPOSIUM                 | ● ● ● ●                                                                                                                                                                                                 |
|                           | Steel Production                                                                                                                                                                                                                                  |
|                           | Interoperable Simulation tools for non destructive testing and material characterizations                                                                                                                                                     |
| FFD                       | ● ● ● ●                                                                                                                                                                                                 |
|                           | Textile and Garment Industry                                                                                                                                                                                                                   |
|                           | New business and production workflow to represent the whole development process                                                                                                                                                                |
| ARUM                      | ● ● ● ●                                                                                                                                                                                                 |
|                           | Aerospace (Airbus A350 Ramp-up + Aircraft system supplier),                                                                                                                                                                                        |
|                           | Novel, agent-bases, distributed scheduling will improve production ramp-up                                                                                                                                                                       |
| ENELPLAN                  | ● ● ● ●                                                                                                                                                                                                 |
|                           | Aeronautics, Household, Automotive                                                                                                                                                                                                               |
|                           | Energy-efficient multi-process manufacturing & optimum process planning.                                                                                                                                                                         |
Research and innovation

Chance & Challenges of Cross-Project Collaboration

**Chances:**
- Reduce redundant effort
- Advance *standardisation* activities in a group of projects
- Extend *exploitation and dissemination* activities
- Discuss the *project goals/concepts/results* on a broader level:
  - more stabile and reliant project results
  - new ideas and strategies for future research initiatives.

**Challenges:**
- **Why** should we collaborate?
  → Provide clear incentives
- **Who** should collaborate?
  → Clarify potential collaboration before the start of the projects (e.g. I4MS)
- **How** should we collaborate?
  - Clarify IPR
  - Synchronize the workplans of the projects
Proposal for Future Clustering Activities

- Establish stable communication channels between the projects (e.g. semi-annual audio-conference)

- Organise collaboration events, which provide enough time for in-depth discussions (e.g. ICT Conference 2013, Manufuture, EC-Infodays)

- Create joint publications (e.g. VISTRA and Know4Car at the IFAC-HMS)

- Join the effort on the elaboration of a common research vision

- Establish knowledge exchange (e.g. in the field of semantic technologies for VISTRA, Know4Car and amePLM)

- Collaborate in existing networks or build new ones (e.g. IMS initiatives)
Where do you find us?
Up-coming Highlights I

Collaboration activities in General
Know4Car - VISTRA
Know4Car - VFF
ENEPLAN - REFORM
ENEPLAN - EMC2-Factory

IFAC-HMS 2013
in Las Vegas on August 2013
VISTRA-Know4Car Joint Session

Joint newsletter to be issued on September 2013
Know4Car-VISTRA collaboration and outcomes
Where do you find us?
Up-coming Highlights II

**IEEE SMC 2013**
in Manchester on October 2013
Projects participating: ARUM

**HoloMAS 2013**
in Prague on August 2013
Projects participating: ARUM

**SIAM Geometric Design and Physical Modeling conference**
in Denver, Colorado on November 2013
Projects participating: TERRIFIC
Where do you find us?
Up-coming Highlights III

MANUFUTURE 2013
in Vilnius on 6-8 October 2013
Projects participating: Know4Car

World Manufacturing Forum
in Washington DC on 22-23 October
Projects participating: VISTRA, Know4Car

ICT Conference 2013
in Vilnius on 6-8 November 2013
Projects applying:
VISTRA-Pathfinder, Know4Car, Terrific, ARUM
#PLM #Digital Factory #Simulation
IMPACT
Impact - Dissemination Activities

- Conferences, Workshops, Journals, Trade fairs, etc.
- Websites, Flyers, Posters, Social Media, etc.

→ All projects seem to perform very well.

Clearly measurable
Impact – Exploitation Activities

• Most projects develop demonstrators
• Exploitation strategies should become more clear (business plans, deployment at the end-user site, etc.)

How can we ensure that a project won’t become a project without broader applicability?

To measure after the end of the project
Impact – R&D Activities

- Challenges for research and industry are presented
- Concepts and first projects results exist

All projects seem to be well on track with ambitious goals. However, it is too early to assess the real impact; impact is mainly “expected”.

To measure in a later stage of the project

Quantitative goals ("improve XY by 50 %") are too vague and arbitrary.
Discussion - RD&I in H2020
Relevance of EFFRA roadmap

Mapping of key challenges to topics identified in the EFFRA 2020 roadmap

• Challenges & opportunities
• Technologies & enablers
• Research & Innovation priorities

**Topic 1: Interoperability by Semantics**

**R1:**

3.5 Multi-level simulation and analytics for improving production quality and throughput

Establish a roadmap/working group for consistent, interoperable, data representations:

- geometry data (→ mathematical representations)
- process data (→ semantics representation)

Including aspect of **quality of data** (consistency, timeliness, completeness ...)

**R2:**

3.1 Integrated factory models for evolvable manufacturing systems,

3.7 On-demand modular and replicative models for faster factory initialisation

**Actively promote the “Semantic, Digital Factory”:**

- Standardization of semantic models required
- Define interfaces to the IoT (closed loop PLM)
Topic 1: Interoperability by Semantics

**R3:**
Additional Point: Synchronisation of digital models and real world behaviour

- Self-adjustment of digital models triggered by smart objects (embedded intelligence).

*Example: iBin*  
*Example: SmartFactory*
Topic 1: Interoperability by Semantics

R4: Additional Point:
Consistency between digital, social and process data
Knowledge Sharing
Topic 1: Interoperability by Semantics

Q1:
- How to improve the factory models and the quality of distributed factory data with real-time measured data for:
  - Holistic monitoring and management
  - Activity planning
  - Faster ramp-up
  - Quality control in multi-stage production
- What are the impacts of factory modeling using ontologies?
  - What is the status?
  - What more needs to be done?
  - What factory design and operations need to be supported by ontologies?
Topic 2: Master Complexity / Increase Transparency

3.13 Integration of design methods and tools

Actively promote the “Semantic, Multi-Disciplinary Digital Factory”:

- Interoperability between multi-disciplinary factory design and management models
  - Electrical, electronic, mechanical, physical and software systems
- Supporting interaction with all relevant stakeholders of the factory design process
Q2:
- How to resolve design conflicts in multi-disciplinary factory design and management processes?
  - How to detect conflicts?
  - How to resolve conflicts?
  - Can ontological formalization help? How?
Topic 2: Master Complexity / Increase Transparency

Q3:
- How to develop secure multi-disciplinary factory design and management environments?
- How to establish secure global collaboration mechanisms supporting data use and sharing compliant with the company IT systems at the right level of detail (view)?
- How to prevent company IP knowledge leakage due to inferences based on shared information?
- Can ontological formalization help? How?
Topic 3: Develop new Applications / Enhance Usability

R4:

3.8 Mobility suite for comprehensive factory performance and resource management

• Add planning tasks as new application area.
• One of the key enabling technology is Augmented Reality
  → Partly not mature enough, e.g. for ad-hoc collision / edge detection / layout planning

Example: Mobile App for easy and quick comparison of virtual models with the real environment, e.g. of collision, ergonomics or mode of operation.
Topic 3: Develop new Applications / Enhance Usability

R4:

3.8 Mobility suite for comprehensive factory performance and resource management

• Render the complete set of factory management information on the smartphones of decision makers enabling them to monitor, visualize, control and collaborate
• Provide apps for selective monitoring and management functionalities across the plant
• Develop intuitive UIs that display the right data at the right time
Topic 3: Develop new Applications / Enhance Usability

Q5:
- What are the UIs requirements for factory data display, monitoring and control?
- What user functions over the plant data to support?
- What are the different stakeholders views and needs?
- What are the needs for processing real-time measured data and forecasting?
- What is the role of ontology modeling and predictive analytics?
Topic 3: Develop new Applications / Enhance Usability

Q6:
- How to increase the acceptance of new technologies among SME and other end-users?
General Recommendations to the EFFRA roadmap

Be more „visual“ / describe the research and innovation priorities also graphically / provide catchy examples

Q7: Should the roadmap be more visual and catchy?
General Recommendations to the EFFRA roadmap

Add TRL and feasibility

**Q8:** Should the EFFRA Roadmap assess the readiness of technology on more detail?

- **How to identify new technologies and assess their readiness within the PDP?**

  - For different industries, domains and products
    - Beyond the nine NASA TRLs
  - Technology and product life-cycle
    - Upgrades, refinements, modifications
  - Multi-technology products (software/hardware)
  - Technology criticality for product success
    - Ease of technology substitution
General Recommendations to the EFFRA roadmap

Too broad to be entirely covered in a next research program

**Q9:** How can we apply a representative way to prioritize the research topics?
# First, preliminary evaluation

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<thead>
<tr>
<th>Domain</th>
<th>Description</th>
<th>Relevance</th>
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<tbody>
<tr>
<td>Domain 1:</td>
<td>Advanced manufacturing processes</td>
<td>No Relevance</td>
</tr>
<tr>
<td>Domain 2:</td>
<td>Adaptive and smart manufacturing systems</td>
<td>No Relevance</td>
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<tr>
<td>Domain 3:</td>
<td>Digital, virtual and resource-efficient factories</td>
<td>High Prio</td>
</tr>
<tr>
<td>Domain 4:</td>
<td>Collaborative and mobile enterprise</td>
<td>Medium-High Prio</td>
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<td>Domain 5:</td>
<td>Human-centered manufacturing</td>
<td>Low-Medium Prio</td>
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<tr>
<td>Domain 6:</td>
<td>Customer-focused manufacturing</td>
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Conclusion
S/T Goals –

H2020: ICT for Manufacturing

**Goals:**

“First time right – made in Europe”

- Responding to higher variance, shorter innovation cycles of highly complex products like cars and aircrafts.
- Boosting the launch of new innovative products through digital design and validation.
- How to shorten time to production during the ramp-up phase of new products by the use of digital tools, make design/re-design more efficient/reliable
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→ Develop new Applications / Enhance Usability: intuitive, mobile, context-sensitive, collaborative, etc.
Thank you for your attention...

...visit us under...

VISTRA: www.vistra-project.eu
TERRIFIC: www.terrific-project.eu
Know4Car: www.know4car.eu
amePLM: www.ameplm.eu
SIMPOSIUM: www.simposium.eu
FFD: www.future-fashion-design.eu
ARUM: www.arum-project.eu
ENEPLAN: www.eneplan.eu

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