Factories of the Future beyond 2013
A view from Research: The role of ICT

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Factories of the Future
Visions of Manufacturing

- Adaptive Manufacturing
- Emotional Manufacturing
- Global/Regional Networking
- Learning Intelligent Manufacturing
- High Performance
- Customised Products
- European Production System
- Efficiency
- Human Potential
- Human Requirements
- European ICT-Environment & Standards
RTD Key Challenges

- Adaptive
- Digital and Virtual
- Integrated Networks
- Knowledge-based
- High Performance
- New Taylorism

Gap ICT and Manufacturing
The internal Gap of ICT in Manufacturing Organization „two worlds“

Management

- Product Engineering and Design
- Sales / Procurement /Supply CRM / SCM
- Resource Management (ERP)
- Administration Economics

Resource Management (ERP)
- Process Planning Manufacturing Engineering
- Manufacturing Execution (MES)
  - Machines Systems
  - Robotics Automation
  - Test and Measurement

External/ Internal Transportation Logistics

- Process-oriented
- Commercial-oriented

Some Inefficiencies of ICT in Practice of Manufacturing

- Managing Complexity, Managing Obsolescence
- Cost of software development for special applications
  - Automation solutions, programmable controller, embedded electronics
- Openness of application systems and IT-architecture
  - Engineering, Product Management, Process Management, Life cycle management,
- Changeability of workflows
- Cost of implementation, service and maintenance of IT-Systems
- Execution: gap between the digital/virtual world and the reality
  - Data Management: bureaucracy
  - Cost of data acquisition and modeling
  - Integration of sensor/actuator data
  - Human Interfaces - visability
- Reliability and accuracy of data: incomplete, incorrect…(20 – 30 %)
- Security of internal - external networks
Focus ICT for SMEs

- SMEs usually have not the critical competences to develop, customize and implement integrated IT-Systems for manufacturing
  - Digital factory
  - Mechatronic design
  - Life cycle management systems
  - Security
- SMEs require low-cost solutions – modular system architectures
- SMEs require standards of interfaces
- SMEs perspectives in software-products for manufacturing as elements of platforms – guided by European global players
- Role as supplier for manufacturing systems requires tools for industrial software engineering
- Education, skill and qualification for the structural change from conventional systems to knowledge based systems

Fields with high economic potential

- **Life Cycle Management: follow each products life**
  - Product Life Cycle Management Systems: from Engineering to End of Life
  - Factory Data Management - technical documentation etc., standards
  - E-based Life cycle services
- **Knowledge based Engineering Environment**
  - Collaborative Engineering
  - Virtual Engineering
  - High Performance computational Engineering
  - Implementation digital factory
- **(Ubiquitous) Networking (IT-Infrastructure and Standards)**
  - Industrial Internet for customization, logistics, cooperation and services
  - Grid-, Cloud-, smart-, mobile
- **Technical Intelligence**
  - Learning and Knowledge integration
  - Intelligent Mechatronic Components
  - Self-configuring systems
European Key-Technology: E-based Life Cycle Management

Product Engineering
Service Engineering

Manufacturing Engineering

Product Life Cycle

Investment Planning
Engineering
Process Planning
Ramp-up
Production
Usage and Service
Recycling

Best Engineering Environment to
- Make customized solutions
- Manage complexity
- Reduce cost and time
- Increase ecologic efficiency

European IT-Infrastructure for Engineering and Manufacturing

Follow each product's life via Internet

Adding Value by E-Services

Life Cycle Services for Adding Value

Services
- Setup/Ramp up TPO
- Maintenance
- Ersatzteildienst
- Technology Consulting
- Upgrading
- Training
- Sales- Finance
- Recycling

Online-Services
- European Standards

Internet WEB based E-Services

E-Services

Intelligent Monitoring
Knowledge based Engineering - Simultaneous Engineering

Knowledge based Environment

Customers Requirements

Knowledge

Time

Product

Process

Plant

Knowledge Capture

SOP as it is

SOP as it should be

Potential for Simultaneous Engineering

European Platform and Standards for Engineering

European Standards

European IT Network

Security

Engineering Services

High Performance Computing

3D CAD/CAM

Mechatronic Design

System design

Process Design

Process Planning for Manufacturing

Tools, Molds, Dies

Technical Equipment

Automation Systems

Manufacturing

Execution and Monitoring

Product Support

Maintenance Service Support

Process Design

Upgrading Remanufacturing

Life Cycle Information, Data and Knowledge

Data

Grid Computing

Cloud computing

Internet based Computing

Shared Resources

Software Provider

Information Provider

Software

Information
Manufacturing Networks
ICT for Manufacturing and
European ICT- Environment

Future Internet
for Manufacturing

Industrial
Grid Computing
Infrastructure

Customers
& Users
Network

Ubiquitous
computing

Manufacturing
Engineering

Product
Engineering
Network

IT – Systems
for Management
Logistics and
Engineering

Manufacturing Systems

Product
Suppliers
Network

Manufacturing System
Suppliers Network

Open Systems
for Manufacturing

Innovative ICT Solutions
and Systems

European Platforms for:
- Management
- Engineering
- Execution

Vision Systems
Wireless Communication
Grid Computing
Embedded Electronics
Cognition-based ICT
Self-organising Systems
Human Interfaces

High Adding Value
Customisation
Networking
Knowledge-based
Emergent Techn.
Intelligent Manuf.
High Efficiency

Implementation
in Products and Plants
for Customers
specific Requirements

Consumer Goods
Capital Intensive Goods
Integration of Knowledge in Manufacturing

- Process Models
- Simulation able to learn
- Real Process (Production System)
- Look ahead
- Feedback
- Humans
- Implicit Knowledge
- Machines
- Explicit Knowledge
- ICT – Environment for Manufacturing Engineering and Management Standards

Multiscale Simulation in Manufacturing

- Discrete Simulation
  - Production systems
- Application
  - Product-Engineering
  - Factory Optimization
  - Supply Chain Management
  - Process Optimization
  - Reconfiguration
- Integration in Tools
  - CAD/CAM
  - Digital Factory
  - MES
- Numerical Simulation
- Logistics and Supply Chains
- Kinematics of Automation
- Machine Behavior
  - Mechanics, Thermal...
- Processes
  - Materials
Factories of the Future: Learning Manufacturing

Customers Request

Engineering, Planning of Operations, Resources

Digital Factory

Operations Intelligent Manufacturing

Objectives

Economic, Ecologic Effectiveness

Base of Knowledge

Enabling Technologies
- Process-Modeling
- Cognition/Recognition
- Histories

Technologies
Process Models
Product Data

Factory Data
Management of Resources

Learning Machines

Implizite Knowledge

Pre Process

Process - Planning with Simulation

Process - Control with In-Situ Simulation

Histories
Process-models
Machine-models

Explizite Knowledge

Post Process

Zero defects
Summary

- ICT influences **all manufacturing** processes, ICT is the enabler for the factories of the future
- Some of the proposed actions are in the loop
- We have to overcome the Gap between ICT- and Process – technologies: Research, Education, Management
- There are inefficiencies in practice, esp. in SMEs
- Fields with high economic potential
  - Life Cycle Management
  - Knowledge based Engineering
  - Industrial Internet
  - Intelligent Manufacturing
- Integration of knowledge by computerized modeling and Simulation
## New Business Models

<table>
<thead>
<tr>
<th>Business Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>Beyond lean...</td>
<td>Life Cycle Services Survival Strategies</td>
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<tr>
<td>European Production System Knowledge &amp; Service</td>
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<td>Real-time Enterprises New Taylor</td>
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<td>Invest in R&amp;D Entrepreneurship</td>
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## Adaptive Manufacturing

<table>
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<tr>
<th>Technology</th>
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<tbody>
<tr>
<td>Modular Products Configurable Systems</td>
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<tr>
<td>Adaptive Factories Real Time Adaptation Adaptive Systems</td>
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<tr>
<td>Real-time Factories Disruptive Factories</td>
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<tr>
<td>Knowledge-based Factories</td>
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## Networking in Manufacturing

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<tr>
<td>Network Engineering Interoperable Networks Customisation</td>
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<tr>
<td>Manufacturing on demand Networking Standards</td>
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<tr>
<td>Supply Chain Mgt - Real-time - Global</td>
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<td>Knowledge-based order management</td>
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## Digital Engineering

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<td>3D PLM and tools Fast Engineering Digital Prototyping</td>
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<td>Multiscale Simulation Digital Factory Material Engineering</td>
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<tr>
<td>Process Standards Smart Factory Kognitive Simulation</td>
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<tr>
<td>Knowledge-based Engineering</td>
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## Emergent Technologies

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<td>Intelligent Products High Performance Energy Saving</td>
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<tr>
<td>Reliability Process Models and Simulation</td>
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<td>in situ process control beyond borders</td>
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## ICT for Manufacturing

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<tr>
<td>Configuration Systems Embedded Systems</td>
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<tr>
<td>Multimodal Interfacing Software Engineering</td>
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<tr>
<td>Grid Manufacturing Ubi. Computing</td>
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<td>ICT Environment Manufacturing</td>
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## Competition

- Leadership
- Globalisation
- Emerging

## Road Map ICT for Manufacturing

- From Data-driven Factories...
- Grid Manufacturing Advancement of Grid Computing for Manufacturing purposes
- Multimodal Interfaces Human-machine interaction
- Control Systems Cognitive control modelling languages and architectures
- Pervasive and Ubiquitous Computing Adaptive, evolvable, ubiquitous manufacturing systems
- Software Engineering Modelling, simulation, prediction of large, distributed multi-scale socio-technical systems
- Configuration Systems Computing Systems Manufacturing specific architectures for embedded platforms
- Embedded Systems Intelligent industrial process control manufacturing shop floor and logistics and distribution
- European ICT Environment for the Next-generation Manufacturing
- ... to Networked Manufacturing Real-time and Knowledge-based
Transectorial Road Map for knowledge based Engineering
Tampere 2007