How to design a smart factory?

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The Drone factory

- SWE-factory/Learning factory within industry 4.0

https://my.matterport.com/show/?m=qvT2J4QxcJQ
System of Systems (SoS)

The distinction between a system and SoS lies in the meaning and significance of ‘gathering together’, teasingly hidden in the meaning of of.


A typical SoS is characterized by having no defined permanent end state, i.e., the SoS continues to evolve as time passes, even after the original target architecture is achieved. It usually is subject to annual budget variations and has varying baselines, some of which are well defined and some of which are not (usually due to the annual budget variations). The typical SoS evolves slowly over time rather than through wholesale capability, swap-ins and the total SoS often is heterogeneous with individual systems tailored based upon the particular site(s) to which they are deployed.

Developing a SoS, especially one involving a number of legacy systems, usually is a far more complex job than developing a stand-alone system.

Levels of Interoperability
Table 1
Grand-Challenges for the Manufacturing Industry of the Future.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Business</th>
<th>Knowledge</th>
<th>Applications</th>
<th>Communications (ICT)</th>
</tr>
</thead>
</table>
| Grand-Challenge 1. CPPS-based Manufacturing Plant Control | Servitisation  
Short lead-time to market  
Data-driven performance management systems | Biological transformation in manufacturing  
**Digitalisation of production** | Mass customisation  
Big-data analytics  
CPPS-based human interactions  
Simulation models for CPPS-based manufacturing control | IoT-enabled manufacturing  
Cloud services  
Smart manufacturing objects |
| Grand Challenge 2. Resilient digital manufacturing networks, collaborative control for Industry 4.0 and cyber-physical supply chains | Business and strategy models  
Strategic risk management  
Customised supply network control  
Customised flexible process-based services | Business processes and operations in supply chains  
Core competencies in the supply chains  
Sharing principles and operation rules | Collaborative software solutions  
Simulation software for resilient and data-driven manufacturing systems  
Tools for monitoring and control of disruptions in the supply chain | Reliable communication networks  
BroadBand  
Wireless applications  
e-Work, e-Manufacturing, and e-Logistics |
| Grand Challenge 3. Cyber-physical System-of-Systems interoperability | Integration of business information  
Ontology mapping and matching  
Consistent enterprise-wide decision-making structure | Interoperability of models and processes  
**Shared ontology**  
Knowledge management system | Modular and reconfigurable systems  
Component-based software solutions (Plug-in/Plug-out)  
Symbolic artificial intelligence and software agents  
Agent-based simulation software  
Cobots and new Human / Machine Interaction with Robots | Standards  
Interfaces and mediators  
Interoperability  
Service bays  
Technologies for collaborative learning |
| Grand Challenge 4. Interdependent networked systems and data analytics for decision support | New networked model of business  
AI and data-driven business  
Risk and operations management through analytics from Big Data | Modelling of interdependencies  
Dynamical analytics  
Behavioural pattern identification | Tools for monitoring and control  
Building resilient systems  
Prescriptive and predictive modelling  
Risk analysis and control | Open platforms  
Interactive applications |
Interoperability can be defined as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged.” (IEEE)
Pathway to factories of the future
The Drone Factory
Digital Thread@Chalmers University Sii-Lab

PLM: BOM Management, Family Management, Req Mgmt

Manage and link CAD/BOM/Visualization for a modular EBOM structure

Plan product families, manage options and generate variants for multi-year product structures.

PLM: BOM Transformation, Digital Process Planning, Change Mgmt

Associatively Transform EBOM to MBOM and EBOM to SBOM with Options and Logic

Concurrently Develop Mixed-Model Assembly Process Plans, AR for visualizing process plans
Inhouse logistics

Part system

Load-unload stations

Automatic kitting

Manual kitting

RFID-reader

IO-Link master

IO-Link

Component list (TCP/IP: .json)

Smart-glasses

RFID-wristbands

QR/Barcode scanners

Buttons

Light indicators

IR-sensors

Voice recognition

Remote robot control and path planning

Recognition

SOLOMON

Joint positions (TCP/IP)

IR-sensors

Order information (TCP/IP: OData)

Task (TCP/IP: .json)

WMS

Python-based REST-server

Instruction conveyance

Confirmation methods

Recognition

Manipulator

YASKAWA

Coordinates (TCP/IP)

Joint positions (TCP/IP)

I/O (CAN)

Information conveyance

I/O (CAN)

I/O (CAN)

I/O (CAN)

IR-sensors

RFID-wristbands

QR/Barcode scanners

Buttons

Voice recognition

Remote robot control

Order information (TCP/IP: OData)

Task (TCP/IP: .json)

WMS

Python-based REST-server

I/O (CAN)
System of systems

Enterprise System of Systems

Order

In-house Logistics

Final Assembly

Part system

Part system

Monitoring SoS
Level 4 and 5

- Interaction and interoperability between Human-Robot teams
- LCA and re-manufacturing
- Technologies for collaborative learning
- Machine learning and cognition
- System of systems and enterprise interoperability
- CPPS and real time optimisation