Development of Assembly Systems in Lean Learning Factory at the University of Split

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Assoc. Prof. Stipe Čelar, Ph.D.

Experience

**current:**
- Assoc. Prof. at University of Split, FESB (CRO)
- Head of the CCSE at University of Split (CRO)
- Visiting Prof. at University of Mostar, FSR (BiH)

**past:**
- vice director, project manager at ENEL-Split (CRO)
  
  www.enel.hr
- consultant, project manager at PULSAR (CRO)
  
  www.pulsar.hr
- Research Assistant at TU Wien, IFT (AT)
  
  www.ift.at
- lecturer at University of Split, FESB (CRO)
  
  www.fesb.hr

Education

- TU Wien, IFT – Ph.D. (tech.sc.)
  1994 - 1997
- Uni Zagreb – B.sc. (philosophie)
  1991 - 1995
- Uni Split – B.sc. (elec.eng.)
  1987 – 1992

**IEEE member**

**ACM member**

**PMI member**

**DAAAM member**

TPC of IEEE ISCC 2013

www.ieee-iscc.org/2013
Agenda

- Innovative Smart Enterprise (INSENT) Project
- Lean Learning Factory (LLF) at FESB
- Venio ERP
- Conclusion
- Q&A
Croatian Science Foundation Project 1353: *Innovative Smart Enterprise (INSENT) 2014-2018*

- Objectives will be realized through 4 **Work Packages** in the period of 4 years:
  - **WP 1**: Analysis of current state of Croatian manufacturing enterprise
  - **WP 2**: Development of Croatian model of Innovative Smart Enterprise
    - HR-ISE model
  - **WP 3**: Experimental testing of HR-ISE model through Learning Factory
  - **WP 4**: Project dissemination
Context of **Innovative Smart Enterprise (INSENT)**

**What is Industrie 4.0?**

The fourth Industrial Revolution

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First mechanical weaving loom 1784

First assembly line, Slaughterhouses of Cincinnati 1870

First programmable logic controller (PLC), Modicon 084 1969

Fourth Industrial Revolution
On the basis of Cyber Physical Systems

Third Industrial Revolution
Through utilization of electronics and IT for further automation of the production

Second Industrial Revolution
Through implementation of labor division in mass production utilizing electrical energy

First Industrial Revolution
Through implementation of mechanical production-plants utilizing water- and wind power

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End of the 18th Century | 20th Century | Beginning of the `70s 20th Century | Present | Time

(Source: DFKI, 2011)
The questions to be answered

Where are we now?

Analysis of the current state of Croatian manufacturing industry

How to get there?

Project Innovative Smart Enterprise (INSENT)

Where we want to be?

Industry 4.0
Roland Berger about ‘Readiness & Manufacturing Share’ (2014)
Results: Average level of Industrial maturity

LEVEL OF INDUSTRIAL MATURITY FOR SPECIFIC SEGEMENTS OF PRODUCTION AND AVERAGE OF ENTIRE CROATIAN INDUSTRY

- Product development
- Technology
- Production management
- Production monitoring
- Materials inventory management
- Management of stocks of finished products
- Quality assurance
- PLM
- TPS/GALP
- Average of Croatian industry

Average level: 2.15
Enterprises’ positioning based on the industrial maturity
Vision and Mission of Lean Learning Factory at FESB

• Vision of Lean Learning Factory at FESB is a place where University, Industry and Government meet each other, and share needs and expectations, and work on collaborative projects.

• Mission of Lean Learning Factory at FESB is to help bring the real-world into the classroom by providing practical experience for engineering students, to help transfer latest scientific research to industry through collaborative projects and LLL, and to help government identify needs of industrial enterprises.

• “Living lab” is based on Learning Factory concept, and aims will be achieved through projects: NIL (DAAD project) and INSENT (CSF project).
Learning Factory as a missing link in Triple helix model

- Government
  - Identification of industrial needs
  - Defining of industrial strategy
  - Spin-off and Start-up enterprises

- Industry
  - Collaboration with industry
    - Real life projects
    - Life-Long Learning
    - Transfer of latest scientific research to industry

- University
  - Balance between engineering science and engineering practice
  - New curriculums and study programs

- Learning Factory
  - Identification of industrial needs
  - Defining of industrial strategy
  - Spin-off and Start-up enterprises

- Collaboration with industry
  - Real life projects
  - Life-Long Learning
  - Transfer of latest scientific research to industry
Lean Learning Factory at FESB

• Activities in the LLF at FESB
  – Education of FESB students,
  – Workshops for foreign student groups and professors
  – Implementation of the lean and green concept in economy through seminars,
  – Scientific research activities,
  – Innovative products developments
3D model of LLF in VisTable
Reconfigurable assembly line in Learning Factory
BeeWaTec AG assembly workplaces

- Hands-on education in the LLF
  - Assembly process of toy trucks and toy formula cars
  - Modified “Lego flowcar®” simulation game

- Complete used car gearboxes, from models Zastava 101 and Yugo 45
  - 2 versions of gearbox cases and different parts
  - gearbox consists of 118 parts
  - more than 20 different final products
Assembly line with sensors

<table>
<thead>
<tr>
<th>4.0 element</th>
<th>Element installed in LF@FESB</th>
<th>Cost range (in general)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFID antenna</td>
<td>TURCK BL R/W Antenna 33.56 MHz (2 – 4 antennas)</td>
<td>1.000 – 5.000 EUR</td>
</tr>
<tr>
<td>RFID I/O module</td>
<td>Lucas-Nicola Evaluation unit (TURCK BL I/O modular system) with up to 4 antennas</td>
<td>1.000 – 5.000 EUR</td>
</tr>
<tr>
<td>CPU</td>
<td>Siemens PLC 314</td>
<td>5.000 – 10.000 EUR</td>
</tr>
<tr>
<td>User interface</td>
<td>Tablet Lenovo MIIX 300</td>
<td>100 – 500 EUR</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>7.100 – 20.500 EUR</td>
</tr>
</tbody>
</table>

**MES elements implemented in assembly line ‘gearbox’**

<table>
<thead>
<tr>
<th>4.0 element</th>
<th>Element installed in LF@FESB</th>
<th>Market price</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x RFID antenna</td>
<td>RFID RC522</td>
<td>2 – 8 EUR (x 4)</td>
</tr>
<tr>
<td>30 x Ultrasonic sensor</td>
<td>Ultrasonic HC-SR04</td>
<td>3 – 10 EUR (x 40)</td>
</tr>
<tr>
<td>5 x CPU</td>
<td>Arduino Mega microcontroller</td>
<td>8 – 40 EUR (x 5)</td>
</tr>
<tr>
<td>4 x User interface</td>
<td>Custom-made box with led display</td>
<td>10 – 30 EUR (x 4)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>178 – 652 EUR</td>
</tr>
</tbody>
</table>
The development of new products, specific to the City of Split

Karet - vehicle without drive, braking and safety elements; for many generations people from Split it’s a favorite toy for a ride down the hill.

Version of the original karet

Improved karet by the FESB
Karet in the LLF@FESB

- 1 product
  - 44 items in VenioERP
    - articles/materials with own id
  - composed of 157 physical pieces
Drive modul of karet

POGONSKI MODUL

Stručni nosač
2 x Inbus vijak M8 x 60
2 x Samokošna matica M8
2 x Podloška za M8
2 x Kotač Dv = 100 mm
4 x Kuglini ložaj Dv = 7 mm, Dv = 2 mm, Dv = 7 mm
2 x Distanzer izmedju ležjev
2 x Samokošna matica M6
2 x Podloška za M6

7th Conference on Learning Factories, CLF
Seat modul of karet
Steering modul of karet
Assembly line ‘karet’ with I4.0 elements

- Integration
  - MES sensors
  - ERP
Venio indicium ltd.

- Standard approach
  - Company has many IT systems and interfaces for **data exchange**
- Our approach
  - We designed **Venio team**
    - Spin off i start up company since 2011
    - financed by the company MIB Pivac, Vrgorac, Croatia
  - Venio indicium developed **VENIO ERP System**
  - VENIO ERP integrates **functions** from processes
    - doesn’t need specialised solutions
      - PDM, PLM, CRM, SCM, DMS,...
      - except CAD functions
    - in industry since 01.01.2013.
      - more than 300 locations
      - 250-300 million € annually
      - 20 million docs annually
  - used in LLF@FESB
  - Well designed and constantly improved system
Literature

- www.insent.hr


- http://www.beewatec.de


Thank You!

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