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KU LEUVEN

towards Industry 4.0 via Networked Control Applications and Sustainable Engineering



**“Industry 4.0” lecture
@ Anglo-Belgian Corporation
21/03/2017, Gent**

1

Agenda:


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**“Industry 4.0” lecture
@ Anglo-Belgian Corporation
21/03/2017, Gent**

0. Welcome
1. Industry 4.0 & INCASE
2. Project and Partners
3. Overview of the topics
4. Our agenda ... for you!
5. “De impact van digitalisering en automatisering op productieprocessen”

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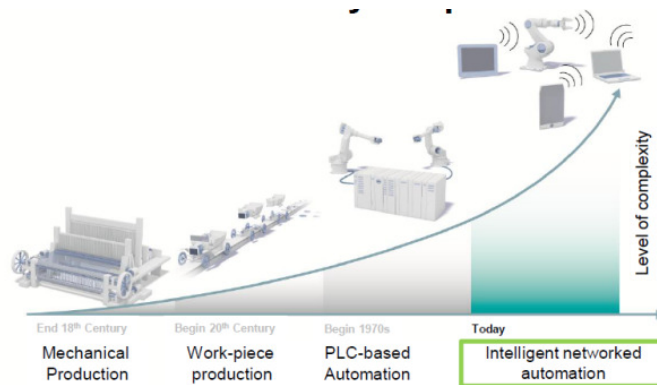
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1. Industry 4.0 & INCASE

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INCASE: “towards INDustry 4.0 via Networked Control Applications and Sustainable Engineering”

- Industry 4.0 will be about ... IIoT “Industrial Internet of Things” and “smart factories”
 - **“Intelligent networked automation”**
- Industrie 4.0 - Evolutionary Leap in Manufacturing**



Source: “Phoenix Contact Industry 4.0: Strategies, Activities & Solutions”; F. Knafli on INCASE kick-off, October 2016

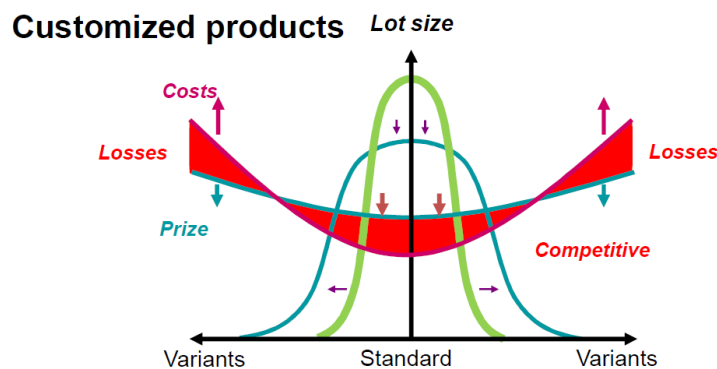
3

1. Industry 4.0 & INCASE

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- Industry 4.0 – some properties & challenges ...
- **“Mass customization”**: from “large batches” with few variants to “lot size 1” custom products: how to stay competitive?



Source: WZL, RWTH Aachen; Author Dr. Possel-Dolken, Phoenix Contact Manufacturing Solution
4 Frank Knafli | © Phoenix Contact

4

1. Industry 4.0 & INCASE

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- Industry 4.0 – some properties & challenges ...
 - “**Modularization**”: plug and produce solutions in discrete and continuous processes



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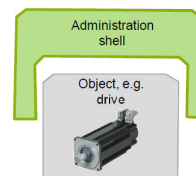
5

1. Industry 4.0 & INCASE

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- Industry 4.0 – some properties & challenges ...
 - “**Collaboration**”: product design and production design in parallel !
(Enhance each other, common Data Model, “**digital twin**”)
 - ... CPSs, **Cyber Physical Systems**, or in Industry 4.0 talk: an
“**Industry 4.0 Component**” (see later)



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1. Industry 4.0 & INCASE

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- Industry 4.0 – some properties & challenges ...
 - “**Adaptive**”: machines and production concepts react in a flexible way to new requirements



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7

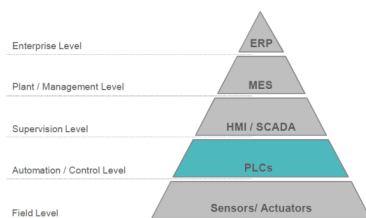
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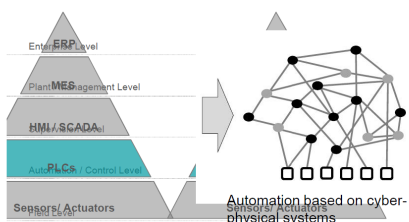
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- Industry 4.0 – some properties & challenges ...
 - “**Point-to-point communication**”: humans and production plants use Internet technologies and communicate directly without hierarchy.

Structure in Automation is changing



Structure in Automation is changing



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8

1. Industry 4.0 & INCASE

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- Industry 4.0 – some properties & challenges ...
 - “**Efficient**”: production needs to be *economic, resource efficient* and *sustainable*



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9

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- Industry 4.0 – some properties & challenges ...
 - “**Mass customization**”: from “large batches” with few variants to “lot size 1” custom products: how to stay competitive?
 - “**Modularization**”: plug and produce solutions in discrete and continuous processes
 - “**Collaboration**”: product design and production design in parallel ! (Enhance each other, common Data Model, “**digital twin**”)
 - “**Adaptive**”: machines and production concepts react in a flexible way to new requirements
 - “**Point-to-point communication**”: humans and production plants use Internet technologies and communicate directly without hierarchy.
 - “**Efficient**”: production needs to be economic, resource efficient and sustainable



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10

1. Industry 4.0 & INCASE

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Industry 4.0

- **Mass customization**
- **Modularization**
- **Collaboration**
- **Adaptive**
- **Point-to-point communication**
- **Efficient**



Industry 4.0 stands for ...

- “digitization” of production and product life cycle
- technical integration of “cyber-physical systems” and the Internet of Things and of Services, in production and logistics
- New business models, services, work organization



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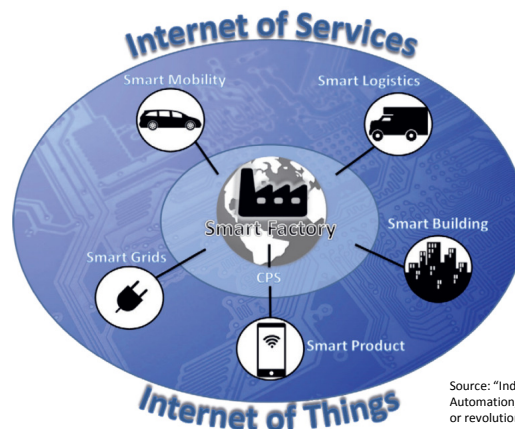
11

1. Industry 4.0 & INCASE

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Industry 4.0 holds 3 dimensions:

- **Smart Factories**
- **Smart Services**
- **Smart Products, Smart Systems**



Source: "Industry 4.0, Internet of Things, Green Automation, e-Health, e-Learning: towards an evolution or revolution in Modern System Design?"; 2 Seas Magazine – special focus – November 2014. 12

1. Industry 4.0 & INCASE

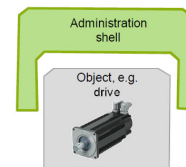
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The Internet of Things (IoT) and the Internet of Services (IoS) lead to “Cyber-Physical Systems” (CPS):

- A combination of physical objects with virtual objects
- The virtual objects gather data in the Cloud
- From “embedded system” to CPS: every object will have its virtual counterpart (“digital twin”)

“Embedded systems” are electronic systems (software, hardware, communication possibilities) integrated in all kinds of apparatus (e.g. a smart phone).

The embedded software introduces flexibility and allows updates.



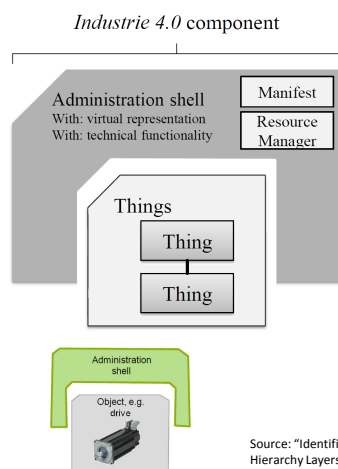
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Source: “Industry 4.0, Internet of Things, Green Automation, e-Health, e-Learning: towards an evolution or revolution in MODern SYstem DEsign?”; 2 Seas Magazine – special focus – November 2014. 13

1. Industry 4.0 & INCASE

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Industry 4.0 calls a “Cyber-Physical System” an “Industry 4.0 component”



It contains both the physical and virtual representation of a product, and all information and data necessary to describe:

- the product itself
- its demands to and relationships with other products: connectivity, semantic demands.

It is scalable from simple basic components up to an entire plant.

It will enable seamless integration of digital modules into different control systems. (Remember: “modularization”, “plug and produce”)

Source: “Identification of “Industry 4.0” Component Hierarchy Layers”; H. Röpke, K. Hell, J. Zawisza (Volkswagen AG), A. Lüder, N. Schmidt (Un. Magdeburg). IEEE ETFA 2016, Berlin.

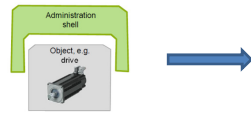
Source: “Standardising the components of Industry 4.0”; R. Bent, Phoenix Contact. Control Engineering Europe, September 2016, pag. 43.

14

1. Industry 4.0 & INCASE

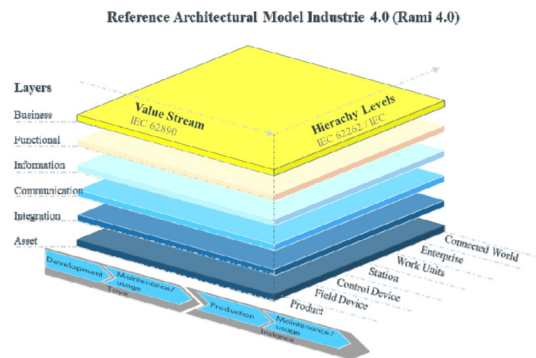
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Industry 4.0 Components are located in RAMI 4.0, the "Reference Architecture Model Industry 4.0"



RAMI 4.0

- 3 axes: business processes, automation pyramid, product lifecycle
- Will become an IEC standard



Source: "Identification of 'Industry 4.0' Component Hierarchy Layers"; H. Röpke, K. Hell, J. Zawisza (Volkswagen AG), A. Lüder, N. Schmidt (Un. Magdeburg). IEEE ETFA 2016, Berlin.



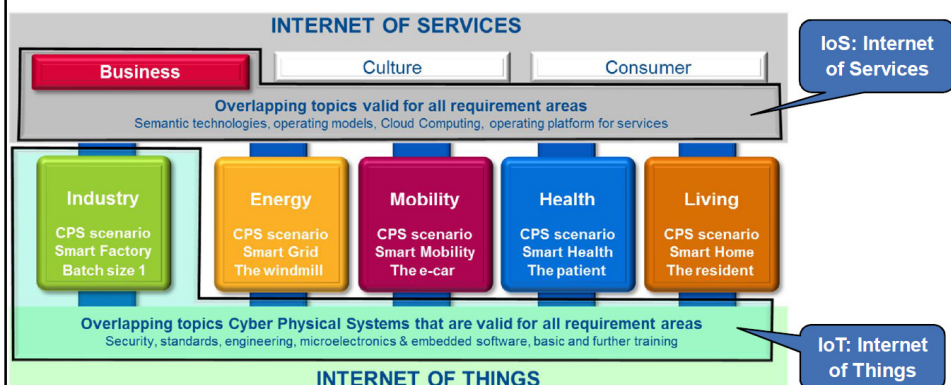
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15

1. Industry 4.0 & INCASE

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Convergence of the physical world and the Internet:



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16

1. Industry 4.0 & INCASE Specific topics

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“towards INdustry 4.0 via Networked Control Applications and Sustainable Engineering”

- Industry 4.0 – some properties & challenges
 - “Intelligent networked automation”
 - Local communication backbone: PROFINET & diagnostics
 - IIoT “Industrial Internet of Things”
 - Local communication backbone: reliability => broad and narrow band issues
 - “Mass customization”: from “large batches” with few variants to “lot size 1” custom products: how to stay competitive?
 - “Modularization”: plug and produce solutions in discrete and continuous processes
 - “Collaboration”: product design and production design in parallel! (Enhance each other, common Data Model, “digital twin”)
 - Code generation (from Matlab) en co-simulation ... shorter design cycle, “integrated design”, highly adaptive, etc. (“digital automation twin”)
 - “Adaptive”: machines and production concepts react in a flexible way to new requirements
 - From dedicated fixed HMI to flexible mobile HMI on tablet
 - “Point-to-point communication”: humans and production plants use Internet technologies and communicate directly without hierarchy.
 - From PROFINET to ProfiCloud
 - “Efficient”: production needs to be economic, resource efficient and sustainable
 - From PROFINET to ProfiEnergy

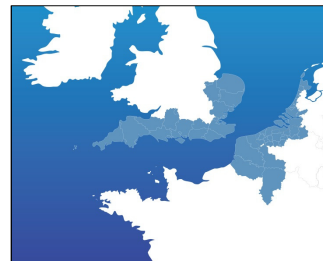


Towards energy efficient flexible automation and HMI for smart homes, buildings, etc.

2. Project and Partners

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- Interreg V “2 Seas” project “2S01-049_INCASE”
- 3 years (01/09/2016 – 31/08/2019)
- Total budget: 4.6 M€, 60% ERDF funding
- 2 Seas area
 - for actual project partners
 - participants on events can be from outside the area



2. Project and Partners

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Location within the 2 Seas priorities:

- Program Priority Axis 1: “**Technological and Social Innovation**”
- Specific Objective 1.2: “**Increase the delivery of innovation in smart specialization sectors**”
- EU Key Enabling Technology (KET): “**Advanced manufacturing**” industrial technology, specifically **targeting the industrial automation and manufacturing industries**
- RIS3 item is “**smart systems**” (embedded systems, mechatronics)
- The **main target group** are practicing engineers & technical management of SMEs & large enterprises and technology/knowledge transfer institutions



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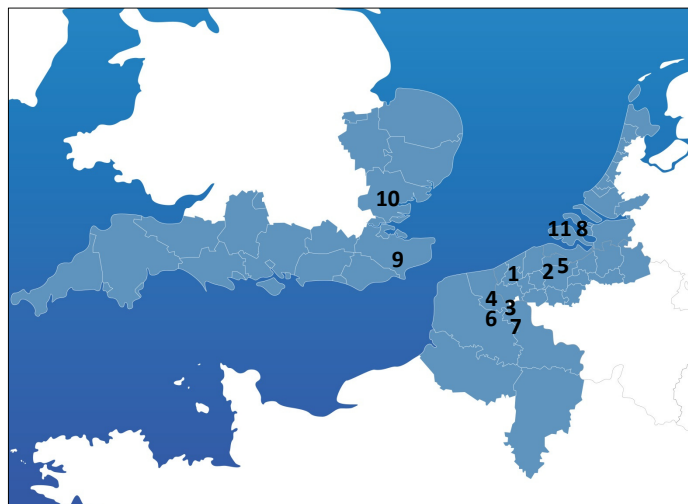
19

2. Project and Partners

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1. UGent (Kortrijk, B)
2. KU Leuven (Gent, B)
3. Yncréa-ISEN (Lille, F)
4. Univ-Lille 1 (Lille, F)
5. Voka Oost-Vlaanderen (Gent, B)
6. ICAM (Lille, F)
7. CITC-EuraRFID (Lille, F)
8. IMPULS Zeeland (Vlissingen, N)
9. Un. of Kent (Canterbury, UK)
10. Un. of Essex (Colchester, UK)
11. HZ Un. of Appl. Sciences (Vlissingen, NL)

Location within the 2 Seas area:



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2. Project and Partners

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INCASE – overall objective

- Industry 4.0 (I4.0) is the next industrial revolution. Manufacturers are focusing on client-specific production and added-value products. In Germany 84% of the companies feel the pressure to digitize and 57% will significantly change their business model due to the digital revolution. Germany is world leader in this revolution.
- The project main objective is to close the gap between the region and Germany & other leading countries, by developing and demonstrating the necessary key technologies towards companies, in this way facilitating the conversion towards I4.0.



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2. Project and Partners

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INCASE – Project main objective:

- The project main objective is **to prepare the automation and manufacturing industries for the future « Industry 4.0 »**. This is achieved by:
 - developing pilots and applied research on key enabling automation technologies => WP 1
 - by designing and developing sustainable (“green”) engineering technologies and demonstrators => WP 2
 - by providing demonstration actions to practicing automation engineers in the automation and manufacturing industries => WP 3



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2. Project and Partners

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INCASE – Project main result

- **Early market uptake** and **increased awareness** of new and emerging key automation technologies, for more efficient and competitive automation & manufacturing industries, enabling smart, sustainable inclusive growth.
- **Empowering existing industries** by demonstrating new production methods and technologies.
- **Increasing time and energy efficiency** in industry and increasing energy use awareness by developing methods and monitoring tools for energy savings in smart industries and smart homes.



23

2. Project and Partners

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Location within society:

we have close cooperation with ...

- **(Manufacturing and Automation) Industry**
- **Professional & economic organizations**
- **User Groups** (for OPs, interested industrial partners, etc.)

(In Flanders) Cofinancing by the Provinces West- and East-Flanders and “contribution in-kind” by AMG and VCG.



24

2. Project and Partners

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Close cooperation with:

- **Industry**
 - **ArcelorMittal Gent** (AMG), **Volvo Car Gent** (VCG)
(Specific measurements, applications, ...)
 - AMG: PROFINET backbone & advanced diagnostics, integrated design (code generation with Matlab), etc.
 - VCG: PROFINET backbone & advanced diagnostics, ProfiEnergy, etc.
- **Professional & economic organizations**
- **User Groups**

(In Flanders) Cofinancing by the Provinces West- and East-Flanders and “contribution in-kind” by AMG and VCG.



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25

2. Project and Partners

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Close cooperation with:

- **Industry**
- **Professional & economic organizations**
- Dedicated Project Partner in each country
 - Voka Oost-Vlaanderen
 - Impuls Zeeland
 - CITC
 - Un. of Essex (Knowledge Gateway)
- Observer Partners in each country
 - DSP Valley, Agoria Automation, key companies of former PI Belgium (Siemens, Phoenix Contact, Balluff), VCG, AMG
 - Cap'tronic, PI France, Mecanov, Embisphere
 - Cambridge Wireless, PI UK, MMU
- **User Groups**



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26

3. Overview of the topics ...WP 1

(Proj. spec. objective 1) Development of key enabling automation technologies for Industry 4.0; early market uptake by and increased awareness of the manufacturing industries

- **PROFICLOUD**
 - Interregional pilot for interconnecting smart factories by the ProfiCloud, and 3 local demonstrators
- **STRESS TESTING Industrial Ethernet**
 - Pilots for advanced "stress" test of industrial ethernet: a load & error generator based on FPGAs.
- **POWER LINE COMMUNICATION**
 - Feasibility study of Power Line Communication for use in smart grids and in industry
- **NETWORKED CONTROL**
 - Pilots and feasibility study on key automation technologies for Industry 4.0: Networked Control
- **INTEGRATED DESIGN**
 - Pilots and feasibility study on key automation technologies for Industry 4.0: Integrated Design.



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27

3. Overview of the topics ...WP 2

(Proj. spec. objective 2) Reduced energy consumption in, and increased awareness & knowledge for the automation and manufacturing industries.

- **PROFenergy**
 - Pilots for ProfiEnergy; report on energy saving achieved by using ProfiEnergy devices
- **PLC FOR SMART GRIDS**
 - Pilot for "smart grids" using Power Line Communication (PLC) for the "last mile"
- **CONTROL and HMI for SMART HOMES**
 - Pilots & smaller scale demonstrators for control & HMI of sustainable smart homes
- **ENERGY MONITORING**
 - Low cost pilots for energy monitoring, connected to the Internet of Things and industrial networks



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28

3. Overview of the topics ...WP 3

(Proj. spec. objective 3) Delivery of technological innovation by demonstration actions on the Applied Research & Development results of WP1&2: Actively "pushing new technologies" to practicing engineers in industry

- **"DEMONSTRATION TOOLS & ACTIONS"**

- **Develop sets of demonstration tools:** demonstrators, courses, hands-on sessions, presentations & manuals
- **Technology push by demonstration actions:** short and long courses, lectures, study days, hosted sessions, participation to fairs, etc.

=> Industrially relevant
=> Aimed at engineering level



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29



INCASE – Involvement and tasks of the project partners

LP - UGent

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30

1. Ghent University



University: 41 000 students
9000 staff members

Faculties: 11

Locations:
- several locations in Ghent
- 1 campus in Kortrijk (450 students)



31

2. Our research group – main research



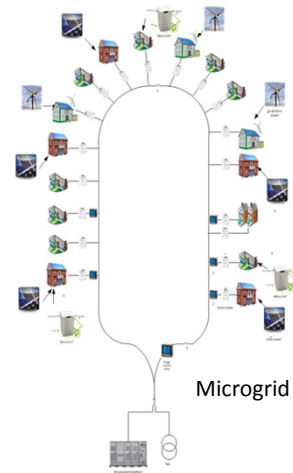
Research group Lemcko:

- Renewable energy sources
- Energy storage
- Interaction of RES and power quality
- Low frequency and high frequency problems in energy applications
- EMC in automation industry

Everything in the LV-grid that is NOT 50 Hz

Research group Mechatronic systems:

- Motor control (stepper motors and BLDC)
- Motor condition monitoring analysis
- Cosimulation



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32

3. Why are you partner in the project



- **Thematic competences and experiences of UGent:**
 - Co-simulation
 - Code generation by Matlab for embedded controllers
 - Robustness of communication in smart grids (HFPQ and EMC)
- **Benefits for UGent:**
 - Increasing our regional recognition as knowledge centre on microgrids/smartgrids by improving our competences on PLC in smart grids and smart factories
 - Increasing our regional recognition as knowledge centre on the make industry by improving our competences on co-simulation and rapid prototyping
 - Strengthen the cooperation between UGent and the other partners



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4. Specific topics - Cooperation



- **Topics were Ugent is the main driver:**
 - Co-simulation (related to O5.1)
 - Communication in smart factories and smart grids, with focus on PLC (O3.1 and O7.1)
 - Robustness of communication (HFPQ and EMC) (O3.1 and O7.1)
- **Topics were Ugent will actively cooperate with the partners:**
 - High performance Industrial hardware targets (O5.1)
 - Robustness of Profinet communication (O4.1)
 - Design and validation of energy monitoring devices (O9.1)
 - Integrated design with low-cost controllers (O5.1)
- **Topics were Ugent will be advising the partners:**
 - ProfiEnergy
- **Other interests:**
 - FPGA, Profinet, Mobile robotics, Smart home control



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INCASE – Involvement and tasks of the project partners

PP2 KU Leuven
Technologiecampus Gent



35

1. KU Leuven & Ghent campus

- **KU Leuven has**
 - 16 faculties organized in 3 groups, and was founded in 1425
 - 11 locations and 16 campuses, spread over Flanders
 - 79 Bachelor programs, 251 Master and Advanced Master programs
 - 57.000 students (including about 10% PhD students) in 2015
 - about 11.000 staff (University hospital, IMEC, etc. not included)
 - 455 M€ of research budget in 2015
- **FET – Faculty of Engineering Technology**
 - Is the youngest faculty, 3rd largest one with about 6000 students
 - Technology Campus Gent, Control and Automation Lab participates in INCASE



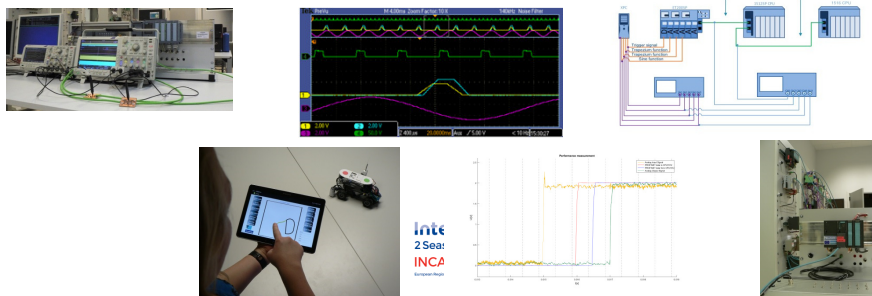
36

2. Your research group – main research topics

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Labo Regeltechniek en Automatisering (“Control and Automation Lab”)

- Three-fold task: education, research, services to society
- The participating laboratory does research in close cooperation with industry in the field of industrial automation.
- It has acquired a lot of experience in industrial data communication and embedded control, and is currently doing initial experiments on e.g. ProfiEnergy and Ethernet based communication (serving as the foundation for ProfiCloud, Industry 4.0, ...).



3. Why are you partner in the project

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Why are you involved, what will be the benefit for you?

What will be the benefit for the partnership?

- The project allows us to address new aspects of industrial automation that are key enabling technologies for Industry 4.0 and the Internet of (Industrial) Things.
- Current knowledge is kept up to date, and new emerging technologies can be explored.
- The lab has strong connections with manufacturing industries and the industrial automation sector, and can this way deepen its contacts, do research and early product evaluations, and push knowledge towards industry for early market uptake.
- It increases the regional recognition of the lab as knowledge center for industrial data communication and embedded control
- We'll bring into the partnership long-time experience in industry relevant applied research & technology transfer concerning topics related to industrial data communication, embedded control, industry 4.0, etc.



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Industrial Network for Connected and Automated Systems

38

4. Specific topics - Cooperation

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How you will cooperate with the other partners.

- Overall scientific coordinator
- WP1 coordination
- Topics where KU Leuven is the main driver:
 - WP1: large interregional pilot for ProfiCloud; TTM PROFINET/Proficloud; pilots and advanced test rigs for local communication backbone; technical days of WP1; high performance integrated design hardware.
 - WP2: ProfiEnergy.
 - WP3: demonstration tools & actions on: ProfiCloud; local backbone communication; high performance hardware targets; ProfiEnergy; User groups in Belgium.
 - WP Management: Work Package Meetings WP 1
 - WP Communication: Internal Conferences



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INCASE – Involvement and tasks of the project partners

PP5 – Voka Kamer van Koophandel
Oost-Vlaanderen

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What we want

- *“Voka East Flanders wants to provide the best framework as the closest and most influential professional network of entrepreneurs for successful business and thereby fundamentally contribute to wealth and prosperity in the region”.*

Sustainable balance
between society,
environment
members' interest,
collaborators,

representative
interprofessional
independent

Key priorities:
innovation
creativity
New technologies
partnerships

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Vers Zeeën
iE







ondernemers
in Oost-Vlaanderen
Een maandelijks tijdschrift van Voka - Kamer van Koophandel Oost-Vlaanderen

NIET SPECIAAL
FILM
EDITION 2014

"Film is altijd kunst én commercie geweest"

Jongste 10 - Januari 10 - Oktober 2014

Kamer van Koophandel Oost-Vlaanderen

"The most read magazine for managers and executives in East Flanders"

Informing entrepreneurs quickly and thoroughly



ZWIJNAARDE
'Wegen en Verkeer snapt waarde van Technopark niet', zegt VOKA
Werkgeversorganisatie
Ondernemers vragen om afschakelplan te herzien

Ondernemers zien Gents parkeerplan niet zitten
het nieuwe parkeerplan voor de stad. Dat goedkeuren schijnt het

DENDERMONDE
Voka-Kamer van Koophandel Oost-Vlaanderen vraagt een herziening van het afschakelplan. De organisatie re-

GENT
«Zo is er toch voorzien op transitie van productiebedrijven naar de Gentse haven, maar ook Hoogveld in Dendermonde bedrijven zoals VPK (dermonde vrij snel af te

Voka: «Gent weigert in Champions League te spelen»
Voka Oost-Vlaanderen mengt zich in het debat rond het zon-derschakelplan. Dendermonde heeft

AALST
Voka stelt Tanara 2030-plan voor om economie te stimuleren
Denderstreek moet troeven uitspelen

'Bedrijven in de regio smeken om doortrekking'

3. Why are you partner in the project

Why are you involved, what will be the benefit for you?

Innovation is one of the 6 core Voka themes, focussing especially on technological innovation. We will use our network (3000 companies, 13.000 professionals) to directly inform through our communication & dissemination activities, and via workshops, seminars, lectures and training. For INCASE : project responsible for WP3 « Technology Push » & closing conference in Gent, Flemish WP3 responsible all 3 « 2 Seas Provinces ». Our contacts in the Netherlands will be used for communication.

What will be the benefit for the partnership?

It is very important that the industrial economy and services in our region are prepared for the future Industry 4.0 and the Industrial Internet of Things. We need to strengthen the manufacturing industries, by developing and demonstrating key enabling automation technologies. Thanks to our role in raising awareness, informing, updating & training the companies about Industry 4.0, we believe we can boost the industrial economic development in the whole of Flanders.



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4. Specific topics - Cooperation

How you will cooperate with the other partners.

- **Topics were VOKA is the main driver:**
 - Technology push
 - Communication (all aspects of WPC)
- **Topics were VOKA will actively cooperate with the partners:**
 - All deliverables of WP3



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50

4. Our agenda ... for you!

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Upcoming activities

- EMC & HFPQ workshop 20&21/03/2017, UGent campus Kortrijk
- “De impact van digitalisering en automatisering op productieprocessen”, evening lecture, @ Anglo-Belgian Corporation, organized by Voka Oost-Vlaanderen
- PROFINET course – 4 days – in depth & accent on diagnostics
 - PROFINET: 24 & 25 april, 2 & 3 mei 2017. KU Leuven Technologicampus Gent.
 - PROFINET Fall: xx/xx/2017, KU Leuven Technologicampus Gent.
- Presentation CIRED conference on HFPQ June 2017
- Information & questions: philippe.saey@kuleuven.be
- Follow us on www.interreg2seas.eu !



51

4. How to contact us ...

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- Web site
 - www.incse2seas.eu
 - Is on-line, being developed, continuous add-ons
 - Agenda and subscription module is on-line
- LinkedIn discussion group INCASE
- Email:
 - ios.knockaert@ugent.be (Lead Partner, project coordinator)
 - philippe.saey@kuleuven.be (scientific coordinator)



52