

LOGISTICS 4.0 LAB

NTNU - Production Management Group

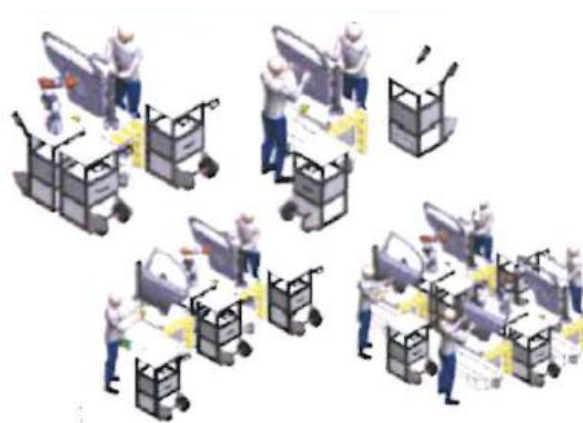
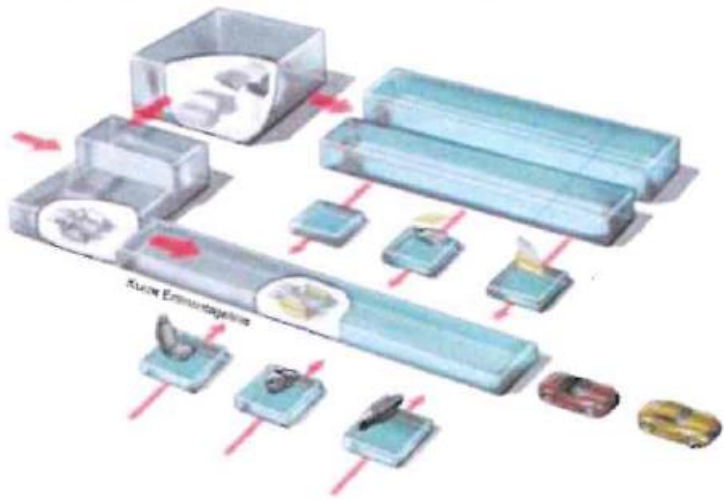
Prof. Fabio Sgarbossa



THE FUTURE OF LOGISTICS & DIGITAL TECHNOLOGIES

The future trend is having smart production & logistics system able to produce customized products with high efficiency (High Variability – Low Volume)...more in general:

CHANGEABLE PRODUCTION SYSTEMS PARADIGM*



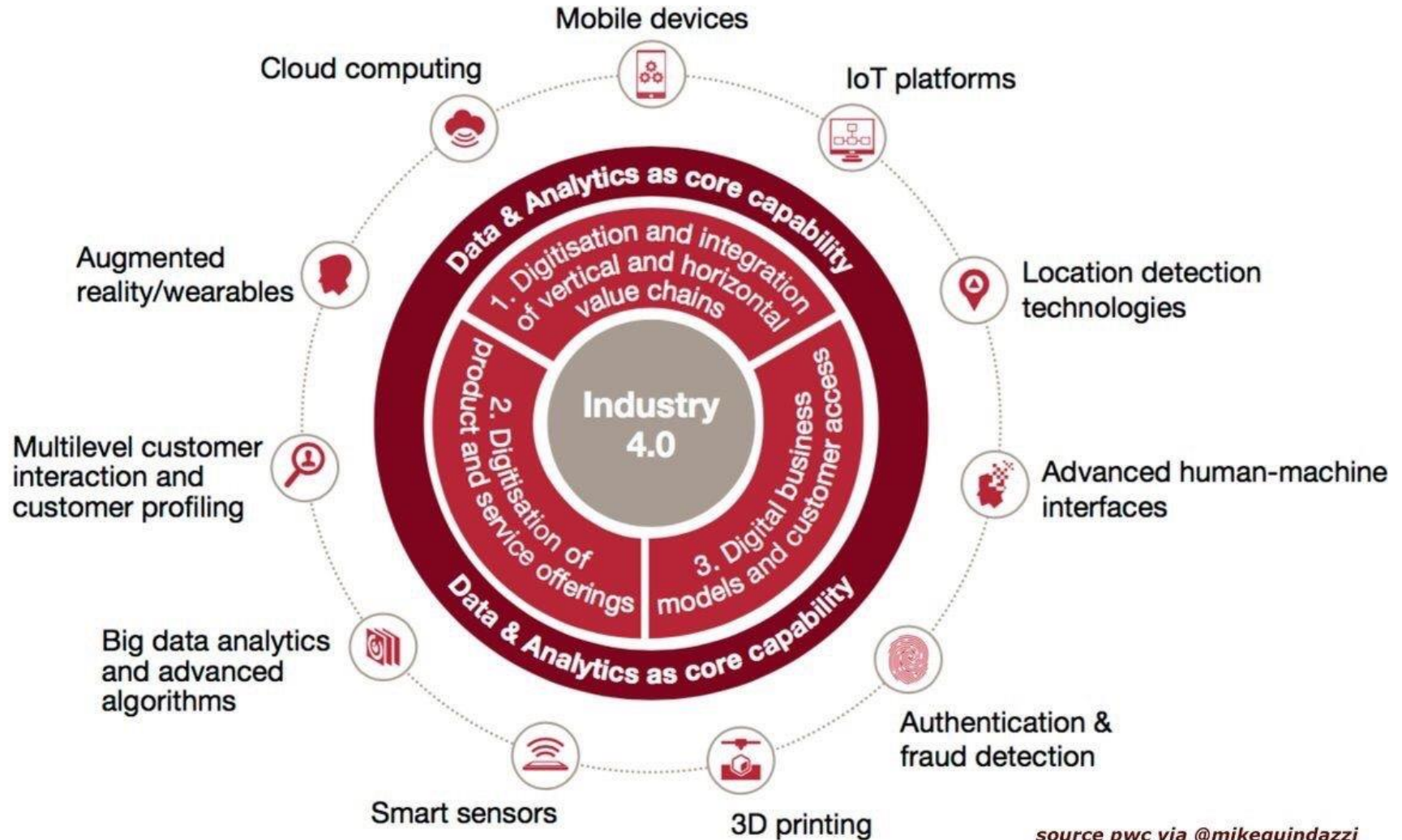
* Fraunhofer Institute (2017). Materials of the Production Academy in Stuttgart - Seminar SPA 385, October 10-11, Stuttgart.

Requirements of production and logistics systems 4.0

- Interconnection of production modules
- Routing flexibility of material handling systems
- Integration of production and logistics systems
- Dynamic reconfiguration
- Scalable automation
- Human-centered workstation
- Human-robot collaboration
- Real time access to production and materials info
- Simulation based on real time data
- ...

THE FUTURE OF LOGISTICS & DIGITAL TECHNOLOGIES

Industry 4.0 framework and contributing digital technologies



source pwc via @mikequindazzi

THE FUTURE OF LOGISTICS & DIGITAL TECHNOLOGIES

...the digital technologies impact on logistics systems at macro and micro level

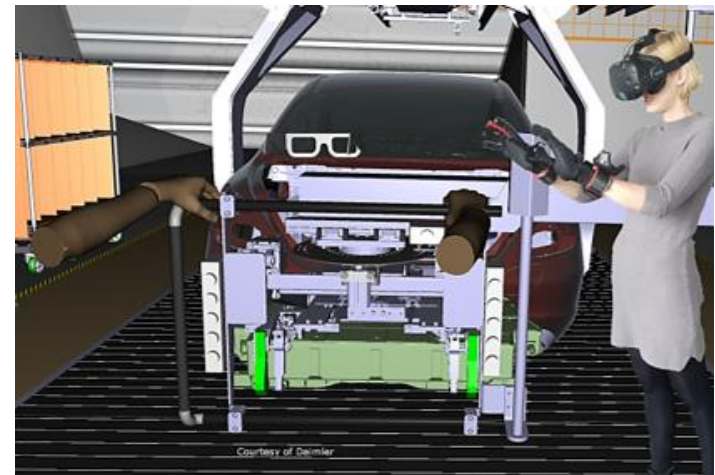
MACRO – LOGISTICS

Facilities layout
Intralogistics & material handling
Production & logistics planning
Supply Chain Management



MICRO – LOGISTICS

Workplace design
Information availability
Operators workload
Interaction Human-Machine



It is MANDATORY to have a clear knowledge of the logistics process before applying any kind of digital technologies.

LOGISTICS AT NTNU – LOGISTICS 4.0 LAB

Last **October 2018**, we started to work on the development and setting of the laboratory.

The main goal is to enable replication of real-life operations and material handling activities in production systems - including:

- **Several assembly workstations**
- **Small storage area, material handling systems (carts, trolley etc...)**
- **Material management support systems**

This is integrated with advanced technologies (**Indoor positioning systems, Motion capture systems, Augmented and Immersive Reality, Visual interactive boards, Real time control, Advanced simulation tools...**)

In **2019**, to support the research activities the Production Management Group is carrying on in several new projects at national and international levels, the LOG4.0 lab is going to be extended with:

- **3D mapping**
- **Mobile Robots in warehousing**
- **Smart material handling systems**
- **New augmented reality technologies**
- **Assistive devices and tools for smart operator and smart engineers/managers**

LOGISTICS 4.0 lab



LOGISTICS AT NTNU – LOGISTICS 4.0 LAB

What can and will we do?

- **Research:** testing micro-logistics & macro-logistics, studying of the impact of new technologies on logistics systems, creating new knowledge on design and management of future logistics systems.
- **Companies collaborations:** relationships with suppliers of new technologies and production & logistics solutions, and with Norwegian companies interested in applying our research work.
- **Education:** innovative learning approaches through a lot of activities in real life logistics systems (learning games, project-works, specialization and master projects)



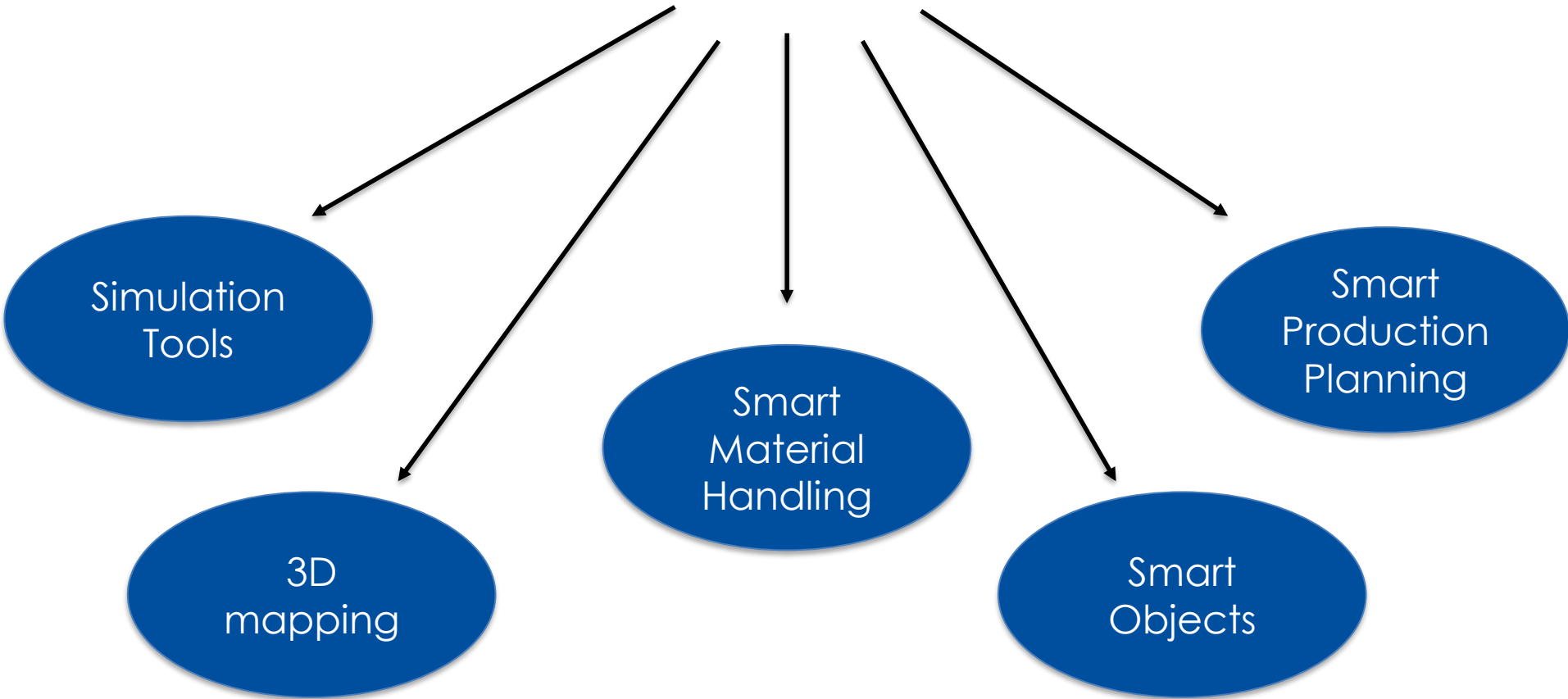
LOGISTICS 4.0 *lab*

4.0G

NTNU

LOGISTICS AT NTNU – LOGISTICS 4.0 LAB

MACRO – LOGISTICS

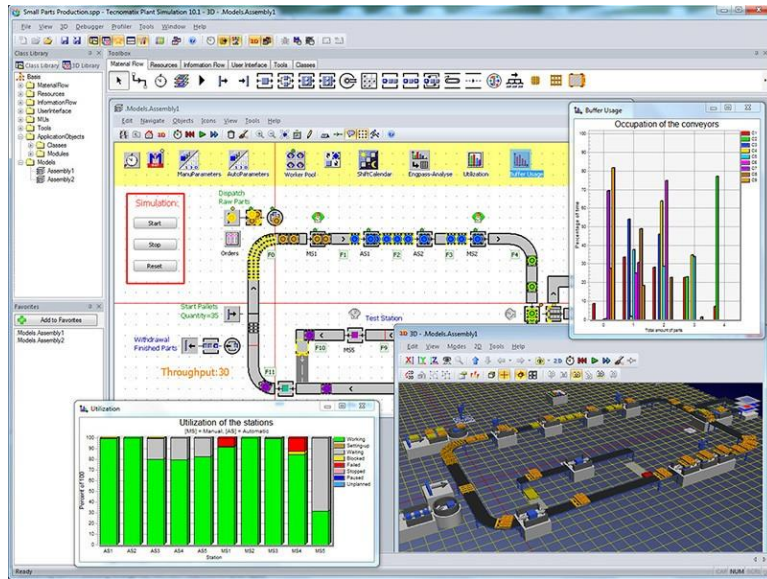


SMARTER LOGISTICS SYSTEMS:

MORE FLEXIBLE, CUSTOMIZED PRODUCTION, HIGH EFFICIENCY, REACTIVE...

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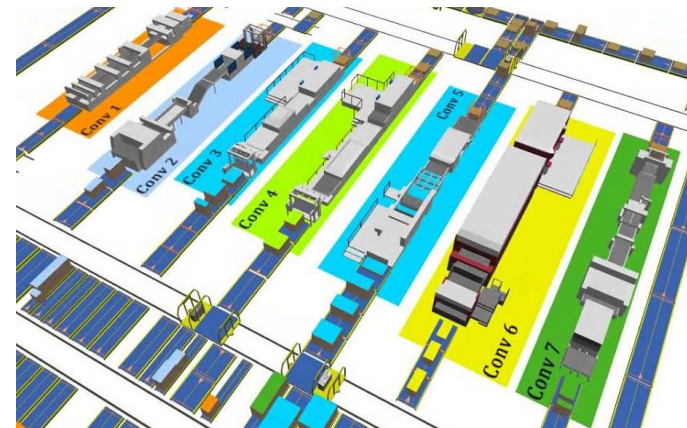
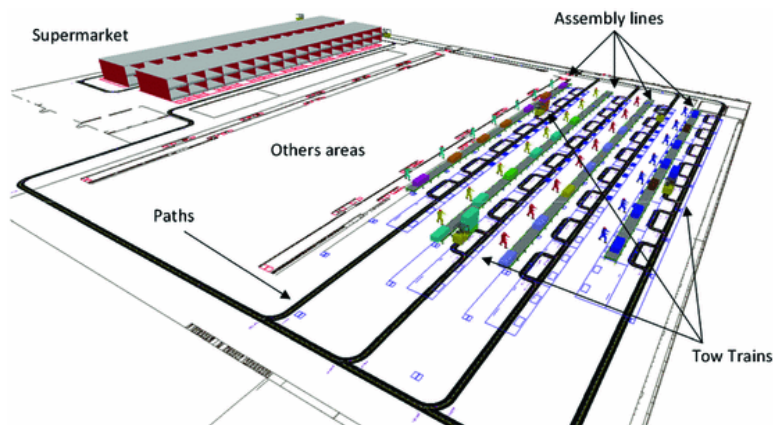
MACRO – LOGISTICS: Simulation tools



Simulation is a technique based on the construction of models, usually logical-mathematical, aimed at reproducing the real behavior of a system in extended periods of time, with a limited computational effort over time.

It is very powerful for:

- Validating the design of production & logistics systems
- Understanding their behavior varying the orders planning and sequencing
- Increasing the productivity and the utilization of resources
- ...



MACRO – LOGISTICS: 3D Mapping

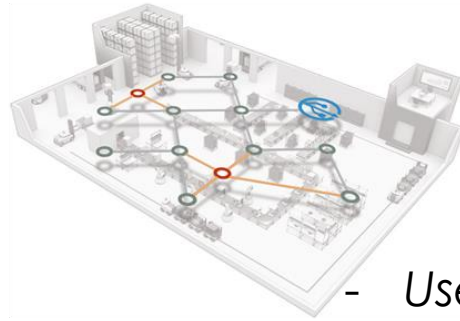
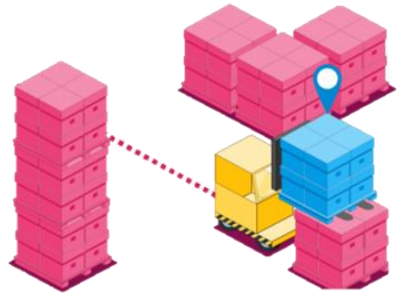


Thanks to photogrammetry technologies, we can:

- *Digitalize every industrial environment*
- *Create an augmented 3d map*
- *Facilitate the layout study*
- *Improve the re-layout design*



MACRO – LOGISTICS: Smart Material Handling



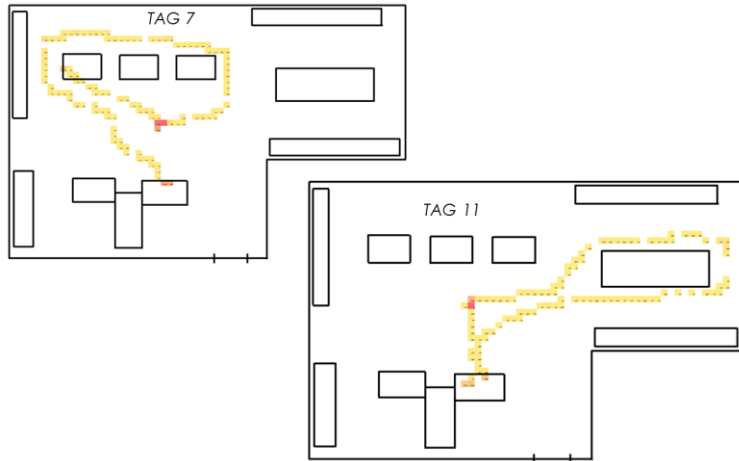
Smart Material Handling



Flexible Production Systems

- Use of **Indoor Positioning System** to track in real time the movements of the resources as:

- Forklift, trolleys, carts etc...
- Products
- Operators



- Possible application:
 - Real-time monitoring of resources
 - Smart MES
 - Real-time VSM
 - Smart material handling

LEAN 4.0

Lean European Action-learning Network utilizing Industry 4.0

Start: 01-01-2018 - End: 31-12-2021
Project reference: 601227-EPN-1-2018-1-NO-EPNKA2-NA
EU Grant: 999648 EPN
Programme: Erasmus+
Key Action: Cooperation for innovation and the exchange of good practices
Action Type: Knowledge Alliance for higher education



Erasmus+

MACRO – LOGISTICS: Smart Material Handling

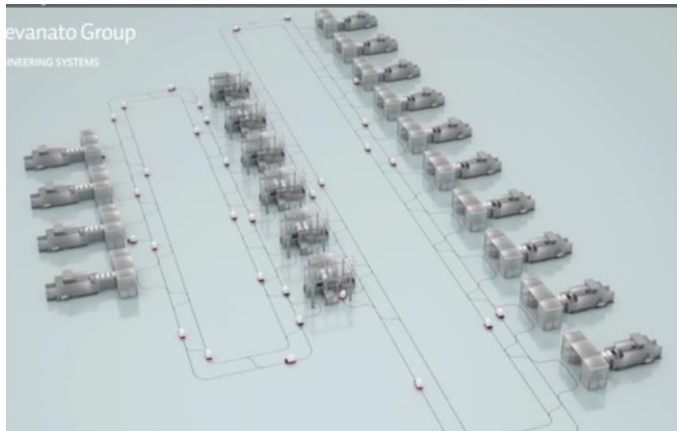
Smart Material Handling



Flexible Production Systems



- Use of **Autonomous Mobile Robots (AMRs)** as material handling with decentralized decision points:
 - Smarter and more reactive system in a complex production and logistics system;
- Use of **small Automated Guided Vehicles (small AGVs)** as substitute of traditional conveyors in production lines:
 - Introduction of production network with multi-connections among all the machines.



MACRO – LOGISTICS: Smart Objects



Wheel.me: the world's first autonomous wheel.

Contrary to heavy, expensive AGVs and AMRs, this technology represent a new way of thinking about mobile automation and materials handling.

The innovation and commercialization effort proposes to transform anything into a robotic device with minimal effort without the need to change the design or form factor.



This is a disruptive innovation since material handling system is not required anymore to move the objects within the facilities.



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MACRO – LOGISTICS: Smart Production Planning

Big Data and Information Sharing



Smart production planning

DigiMAT project

By exploiting data, digitalization and automation to improve planning and control of production inventory and distribution of the products.

Reduced inventory levels, reduced scrapping and food waste, improved profit margins, reduced human goods handling and automation of decision making.

Project owner / project manager:



Brynild Gruppen

Industrial partners:



Sensor Intelligence.

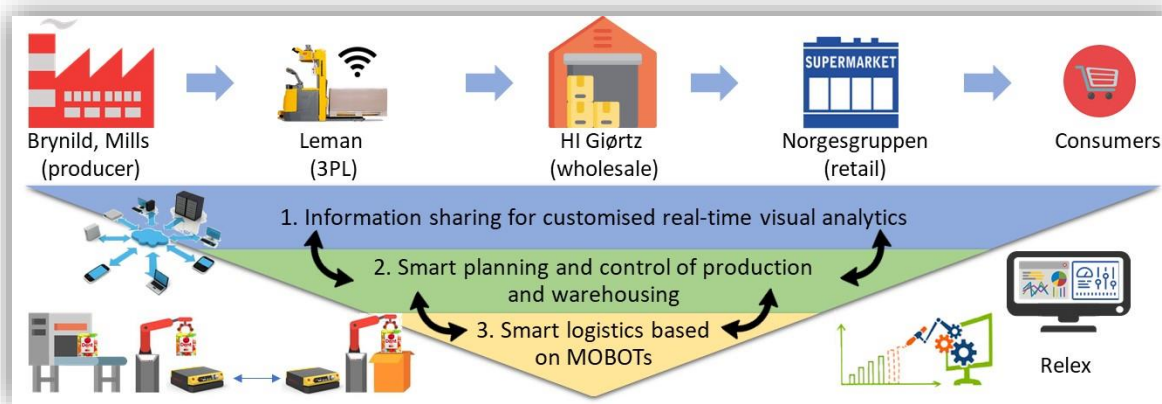
R&D partners:



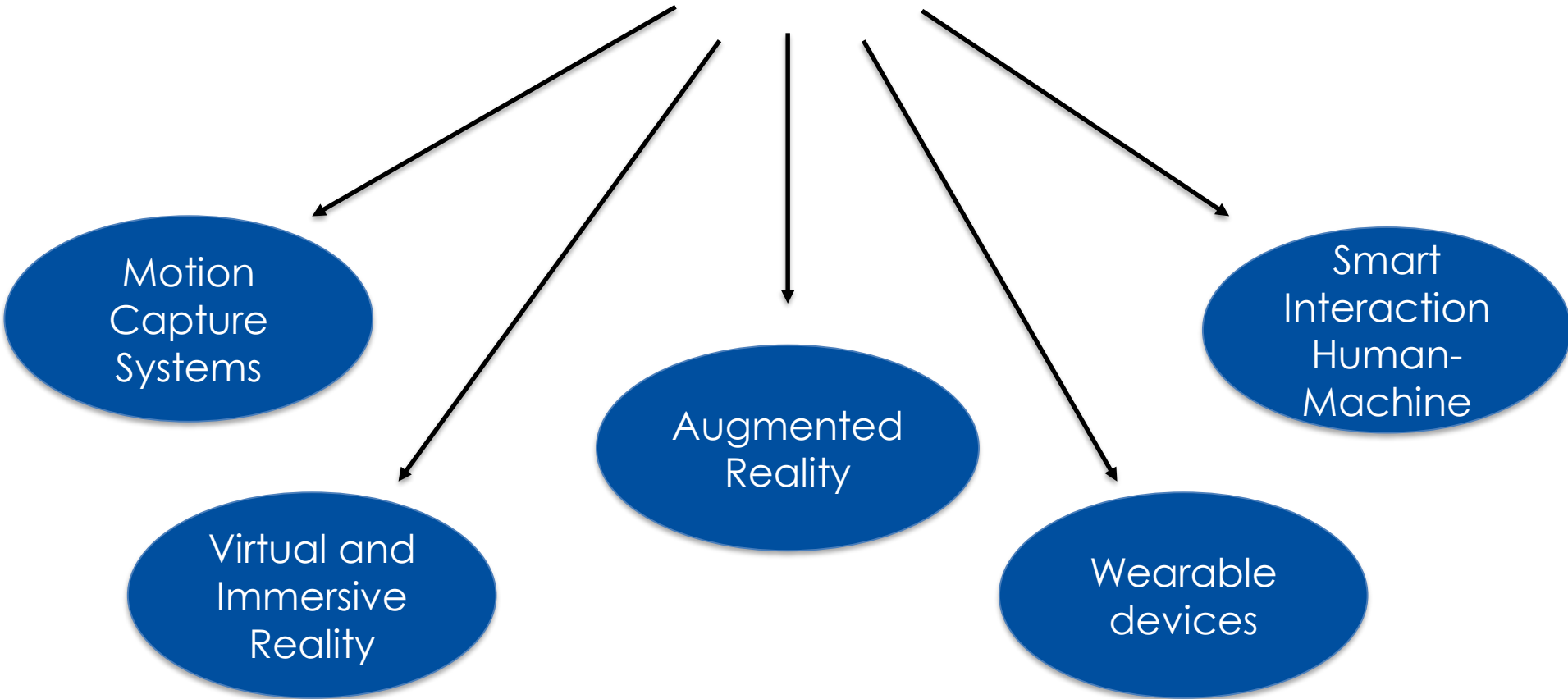
AALBORG UNIVERSITET



The Research Council of Norway

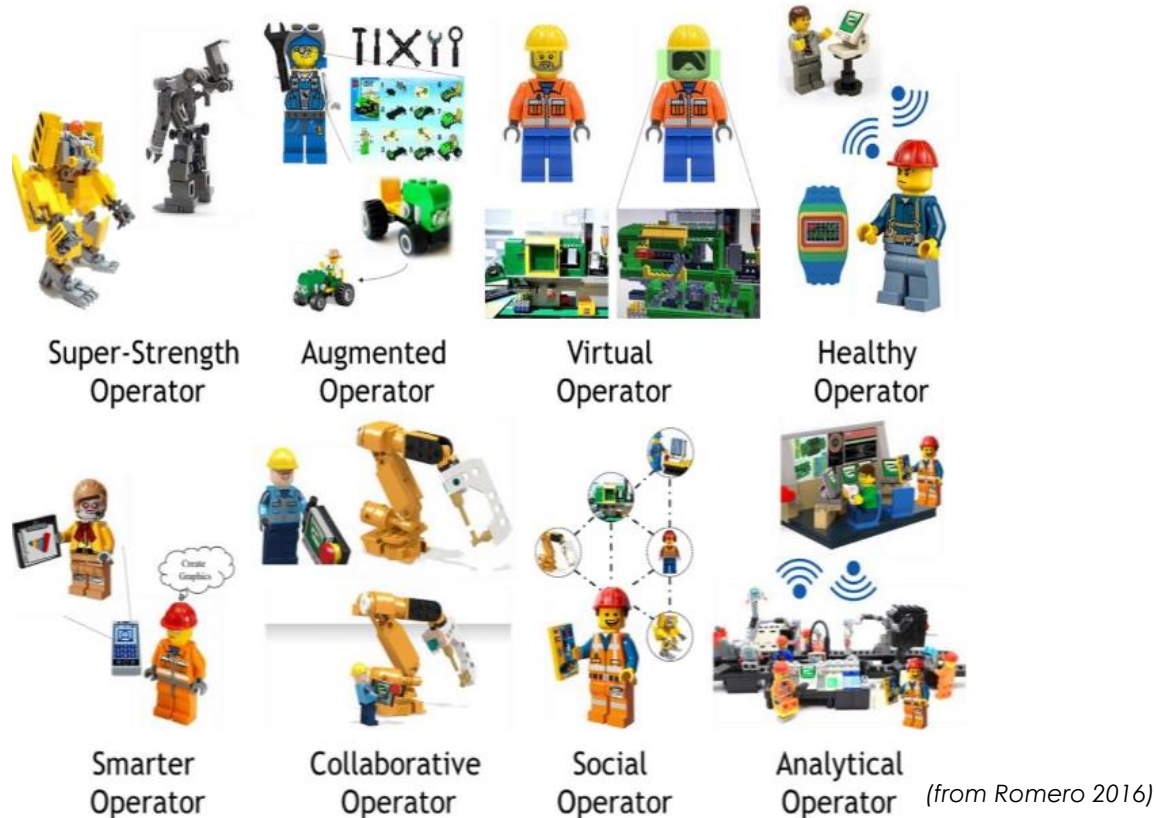


MICRO – LOGISTICS



OPERATOR WELL-BEING & SMART OPERATOR = PERFORMING SYSTEMS

MICRO – LOGISTICS: OPERATOR 4.0

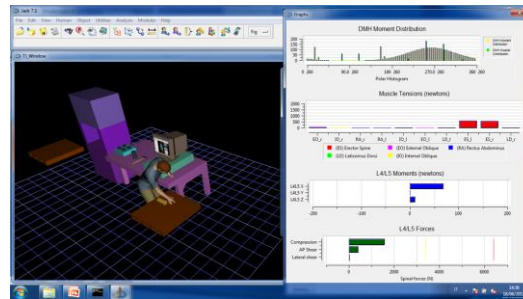
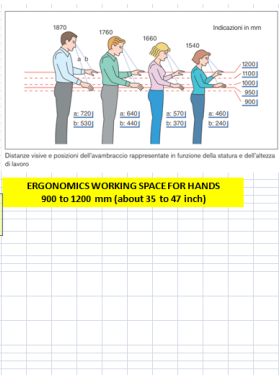
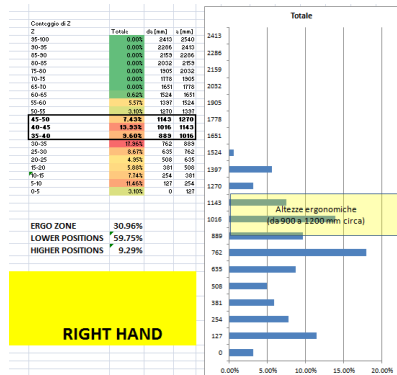
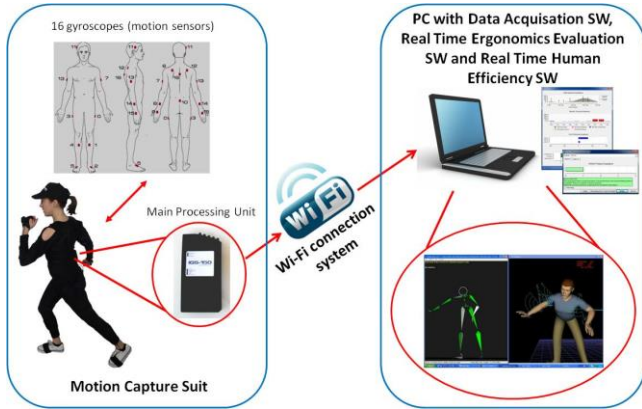


Human beings are still important in the logistics of the future.

Their role and abilities will change and so it is necessary to understand which technologies are really needed and how to manage them.

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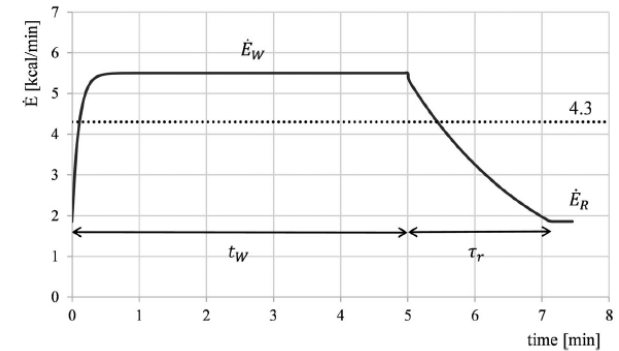
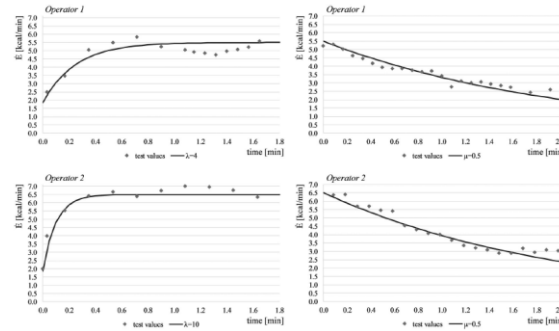
MICRO – LOGISTICS: Motion Capture System & VR



This allows to analyze the activities at different workstations on the production line and simulate the real conditions of the product and process, without building physical tooling or the products.

Ergonomics, visibility of hard-to-see locations, access of hard-to-reach places and validation of assembly devices, transfer systems and installation processes were all addressed.

MICRO – LOGISTICS: Wearable Devices for OP 4.0



The wearable devices, like Heart Rate monitoring systems, allow the control of the physical fatigue level of operators.

We have developed and validated some rest allowance models and use them in the human resource management, in order to optimize the workload and productivity:

- task assignment
- breaks allocation

MICRO – LOGISTICS: Assistive Technologies for OP 4.0



Smart Workstation with projector to give the instructions to the operators and the info about which components have to be picked and from where.
Direct feedback and control of movements is possible with the Kinect device.

LEAN 4.0

Lean European Action-learning Network utilizing Industry 4.0

Start: 01-01-2019 - End: 31-12-2021
Project Reference: 601227-EPP-1-2018-1-NO-EPPKA2-KA
EU Grant: 999940 EUR

Programme: Erasmus+
Key Action: Cooperation for innovation and the exchange of good practices
Action Type: Knowledge Alliances for higher education



Erasmus+

MICRO – LOGISTICS: Assistive Technologies for OP 4.0



Figure 5. Microsoft HoloLens collaborative IAR application.

FIGURE 3. Shipyard model through HoloLens.

Smart Glasses for assisting the operators in assembly activities, in warehousing, in remote guidance in maintenance actions. They can be used also for training and pre-production phase, especially in ETO environment (*i.e. shipbuilding*)

Other assistive technologies, such as pick-by-light, augmented instructions etc...have great impact on the productivity of the operators.

intel
Innovative Immersive Technologies for Learning

Performance
Augmentation
Network
COST action



MICRO – LOGISTICS: Smart Interaction Human-Machine



Mobile robots, Warehouse robotization and Collaborative robots can assist the operator in many manual activities.

They can perform the non-added value activities, such as travel or feeding, and they can collaborate with the operator as ***“the third arm”***.

It is very important to understand the interactions between human and machines, and how to implement them.

CONCLUSIONS

LOGISTICS AND DIGITALIZATION IN NORWAY

...to make production and logistics systems smarter, more flexible, more adaptable, more scalable, more interconnected, in the digitalization era it is necessary to:

- *Have a clear and global understanding of the own logistics process*
- *Identify which parts of the logistics systems have direct impact on their cost, flexibility, productivity, agility, time to react...*
- *Reduce or delete every possible waste on the system*
- *Have a good knowledge about innovative technologies (Automation and Digitalization) and how they can be applied*
- *Look at different application areas*
- *Put the human (Operators and Managers) in the center of each improvement*
- *Do not focus just on BIG DATA...but think about SMART DATA...*

...BE LOGISTICS IN THE DIGITAL ERA – NOT DIGITAL PEOPLE IN LOGISTICS!!!

LOGISTICS AND DIGITALIZATION IN NORWAY

NTNU - Production Management Group

Prof. Jan Ola Strandhagen

Prof. Fabio Sgarbossa

THANK YOU VERY MUCH!!!

ANY QUESTIONS FOR OUR ANSWERS?!?