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Industry 4.0: Technology, Innovation & Safety

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SISOM & the Enabling Technologies of Industry 4.0:

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UNIVERSITÀ DELLA CALABRIA

UNIVERSITÀ DEGLI STUDI DI GENOVA

UNIVERSITÀ DI PISA

Simulation Team.. Who We Are?

Universities, Research Centers and Companies operating worldwide in synergy for developing Innovative Solutions with a particular focus in Modeling and Simulation

DIME Università di Genova

Liophant Simulation

CentraLabs Cagliari

CSU Australia

CIREM Università di Cagliari

Mik Riga TU

Universidad de la Rioja

DIPMEC

labria

SimCenter Universitat Autonoma de Barcelona

Università di Perugia

LSIS Marseille

SPIIRAS Russian Academy of Science

McLeod Institute of Technolo
Interoperable Modeling Simu
Genoa

IMS-LAPS Univ.Bordeaux

Rio de Janeiro Brazil

Objectives

The evolution of Augment (AR) and Virtual Reality (VR) in terms of Mixed Reality (MR) is enabling new solutions. So this Research is devoted to:

- Investigate Service & Maintenance of Distributed Assets
- Rethink Distributed Assets as Distributed Systems by:
  - Identifying Service Requirements
  - Evaluating Enabling Technologies
  - Defining new Architectures
  - Designing new Embedded Devices
- Evaluate Capabilities in Industrial and Individual Use in terms of remote control & service, operator training,
- Develop specific case studies devoted to lead the introduction of these innovative solutions in industrial and health care system.

SISOM Partnership

SISOM Project allowed to study and implement Innovative Solutions to be applied to real cases to improve Safety, Efficiency and Effectiveness in relation to Industrial Machines SISOM Project was carried out in strict cooperation with Industries active in Design, Engineering and Production of Industrial Equipment and Machines.

This Project allowed also to complete an extensive experimentation to measure quantitatively the benefits obtained by these Innovative Technologies (e.g. M&S, AR & VR) applied on the field in terms of training efficiency and safety.

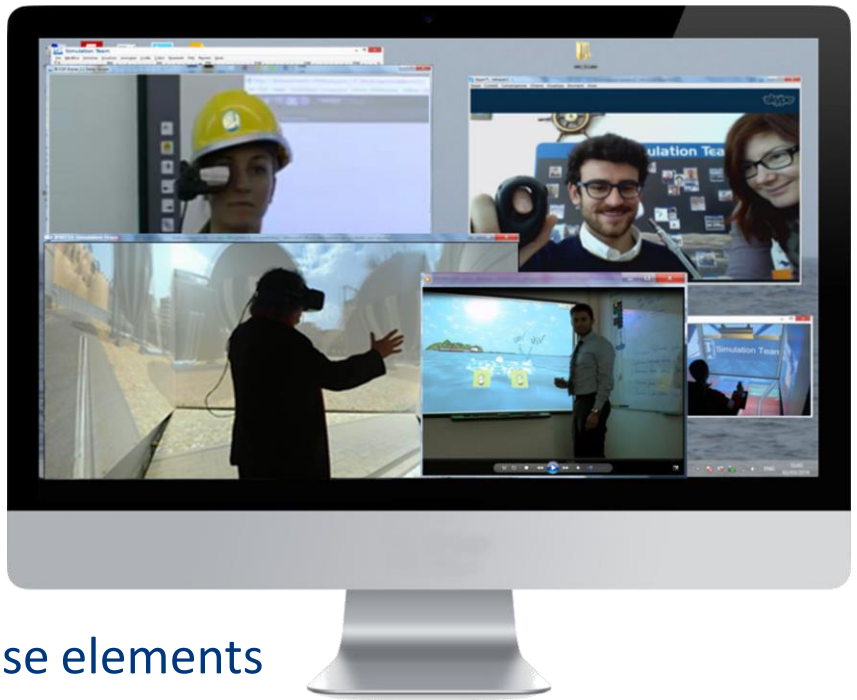
Industry 4.0…

Few definitions clarify how Innovative Technologies enable the Industry 4.0 Paradigm:

- Industry 4.0: is the current Paradigm of Automation and Data Exchange in manufacturing leading to Smart Manufacturing; the idea is to combine concepts such as Cyber-Physical Systems, the Internet of Things, Cloud Computing, Modeling and Simulation, Augment & Virtual Reality, Artificial Intelligence and Intelligent Agents to create a common intuitive framework to control the Industrial Processes

Industry 4.0& Enabling Technologies

- M&S: Modeling and Simulation use the computers to recreate real systems on computers, to experiment them within such virtual environment, to conduct experiments and tests even before the new industrial system is realized, to
- Virtual Reality: is the combined use of Computer Solutions to Immerse the user into a Virtual Framework; currently VR is flexible, working with multiple platforms & I/O (e.g.Smartphohes,CAVE, Laptops, CAVE, HDM , Hololens, data gloves, motion, force feedback, etc.)

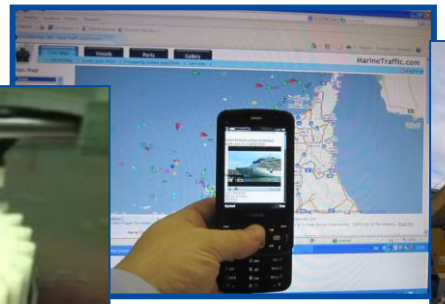


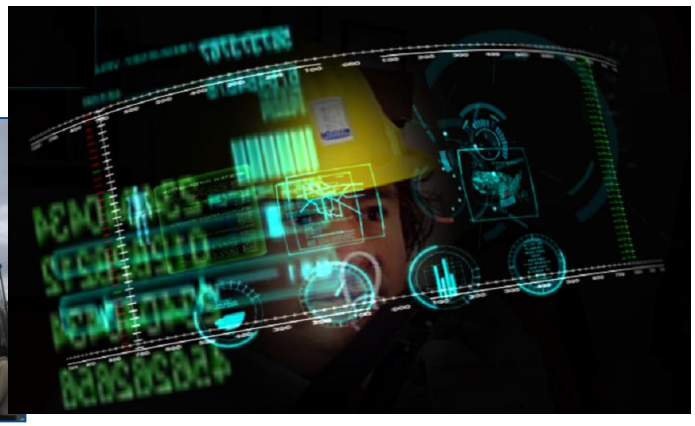
- Augmented Reality: is a live direct or indirect view of a physical real-world whose elements are augmented by additional information provided by computer programs; in this way it is possible to add data from Dbase, Sensors, Sound, Video, 3D, GPS

Looking Forward for the new decade Technologies

Some of most Promising Technologies are arising in different areas such as:

- Modeling & Simulation, Serious Games
- Mobile Solutions & Internet of Things (IoT)
- Virtual Worlds & Augmented Reality
- Cloud Technologies
- New Industrial Paradigms



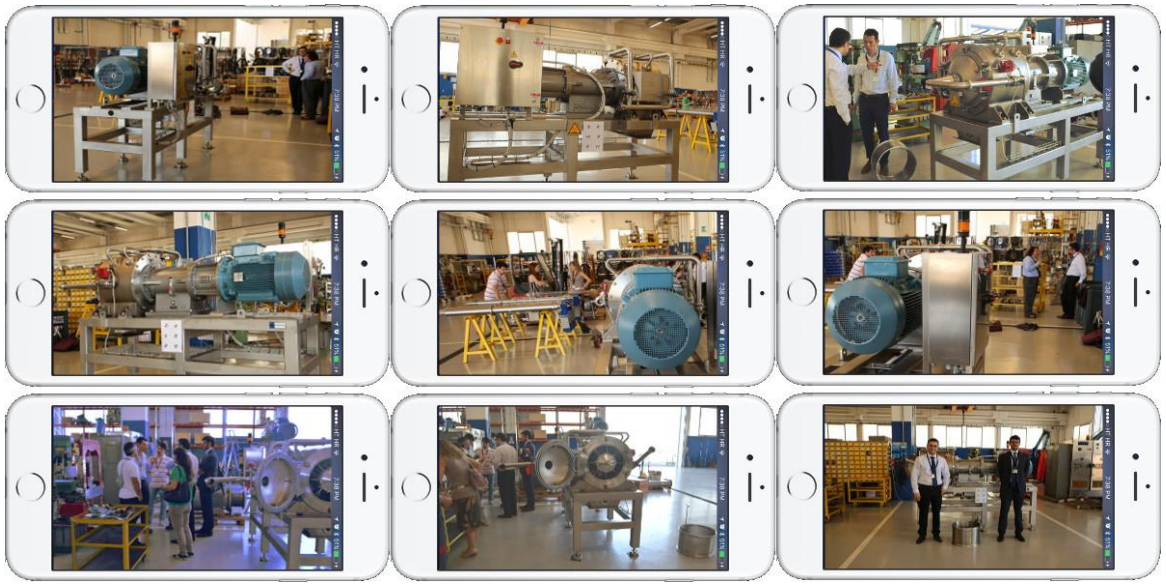


MR for Industry 4.0

The use of Modeling & Simulation (M&S) and Virtual Reality (VR) allows to create 3D Prototypes of Plants, Skids, Machines, Equipment, Products and Processes and to test Virtually New Solutions.

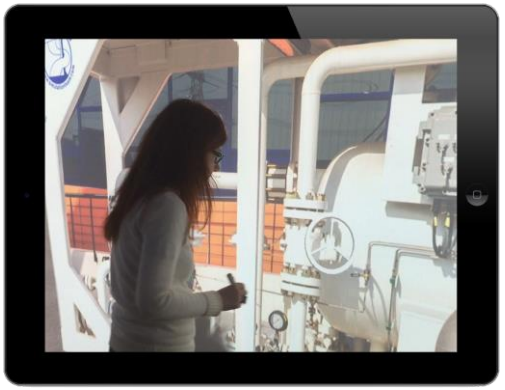
This Virtual Simulation supports Engineering, Training & Management on the Virtual Worlds and enables developments of Augmented Reality (AR) applications to improve Safety, Effectiveness and Efficiency.

Safety, Productivity and Training are areas where these solutions could result Revolutionary, creating with M&S and VR the foundations of Industry 4.0



Industry 4.0 as Revolution for New Generations

AR, VR & M&S are Enabling Technologies that support the Revolution of **Industry 4.0**…



…but what it means this revolution?

Let's take the example of SISOM to understand the context:

- **it becomes possible to recreate 3D Models of Industrial Machines that could be simulated in terms of operations and procedures; these Models could be included in Virtual Interactive Worlds to create training programs where the operators experience directly maintenance procedures in total safety within the simulation.**

Industry 4.0 as Revolution for New Generations

AR, VR & M&S are Enabling Technologies that support the Revolution of **Industry 4.0**…

…but what it means this revolution?

Let's take the example of SISOM to understand the context:

- **In addition these Virtual Models of the Real Machines could be included in Augmented Reality Solutions overlapping the Real Machine with the model to provide directions to the operators about where to act in safety procedures, shutdown, startup, service & operations.**

Industry 4.0 as Revolution for New Generations

AR, VR & M&S are Enabling Technologies that support the Revolution of **Industry 4.0**…

…but what it means this revolution?

Let's take the example of SISOM to understand the context:

- **In addition these AR & VR could be combined with pictures, manuals, videos and even Intelligent Assistants based on AI and Multilanguage Speech Recognition in order to futher improve the support to operators. It is not science fiction, SISOM Workshop will be able to test the Solution developed by Simulation Team directly in the Exhibition Area.**

E&T and Industry 4.0

Innovative E&T (Education & Training) could support Drastically the Industry 4.0 revolution by:

- Creating new methodological approaches to support continuous evolution introducing new Tools Development, new Training Equipment, new Course Coverage
- Developing VR, AR, MR Environments for E&T on industrial cases
- To maximize effectiveness through Engament of Users and Instructors by immersive Solutions, Serious Games (SG), etc.
- Providing evidence through measures of the benefits on field
- Creating bases for further development supporting Service & Operations

A new Approach to Enhance Education and Training

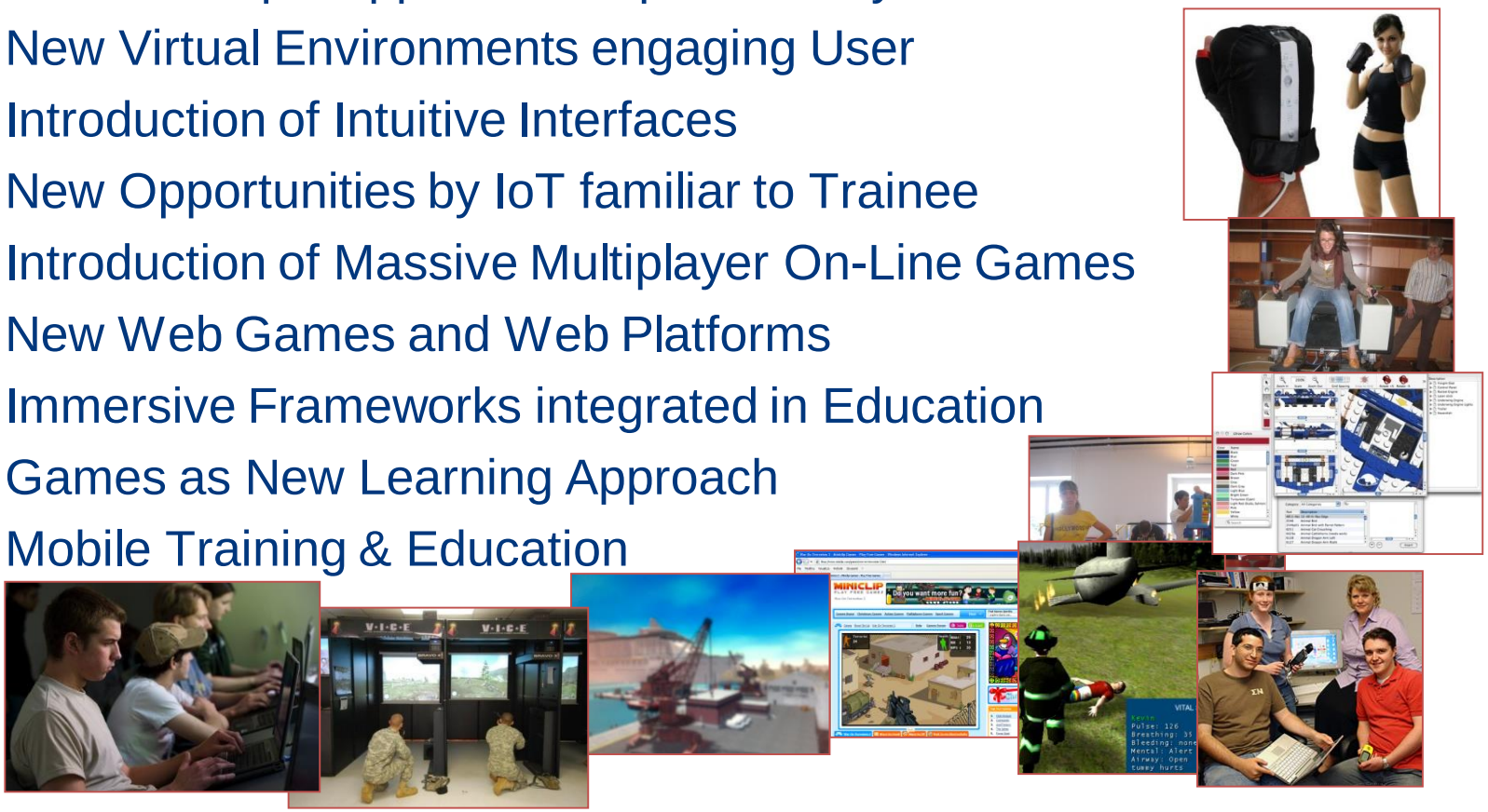
Augmented Solutions for E&T that combines Simulation, AR & VR are able today, especially on new Generations to enhance Efficiency and Effectiveness of Education Programs.

In particular it becomes possible to *Engage and Motivate* in new ways the Trainees as well as to provide them a *Realistic Virtual Labs* where to *Test* and *Experience* the studied theories and procedures, as well as to *Exercise* on *Complex Simulated Scenarios*. MR is further reinforcing these concepts. It is evident the necessity to tailor and integrate these technologies in the whole E&T process.

Opportunities from Serious Games in Engaging Education...

There are multiple opportunities provided by Serious Games:

- New Virtual Environments engaging User
- Introduction of Intuitive Interfaces
- New Opportunities by IoT familiar to Trainee
- Introduction of Massive Multiplayer On-Line Games
- New Web Games and Web Platforms
- Immersive Frameworks integrated in Education
- Games as New Learning Approach
- Mobile Training & Education



Human Behavior & Training Aids as…

Training Education

Serious Game

Learn by experiencing

Interactive approach to learning

Computer Based Training

Simulation

Constructive

Virtual

Live

Training on the job

Learn by doing

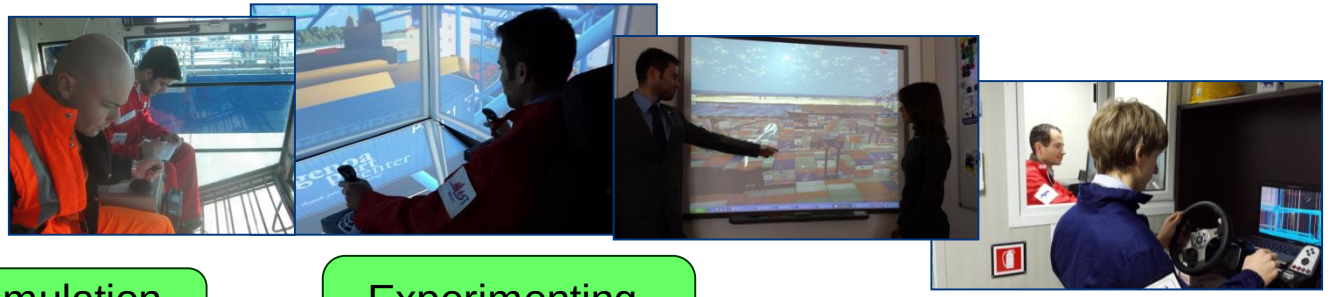
Frontal lessons

Learn by studying

Learn by exercising

"Tell me and I forget. Teach me and I remember. Involve me and I learn.", Confucius

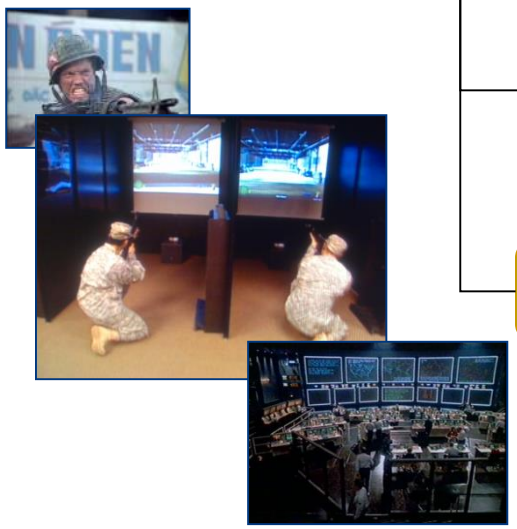
… Serious Games Evolve into Simulation Team Roadmap



Training on the Job

Simulation for Training

Experimenting on the Simulator



Serious Games for Training

Playing while Learning

Experimenting on Games

Many More Installations
Many More Users

New Education Modes
New Utilization Modes

[Nuclear War]
..a strange game the only winning move is not to play
Joshua in War Games Movie

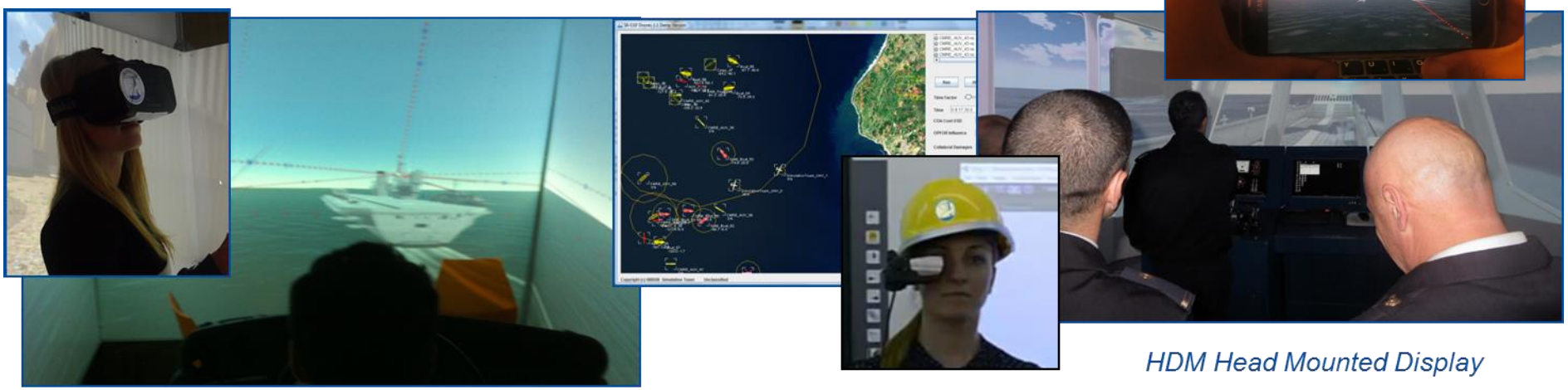
MMO *Massively Multiplayer Online Game*
MMORPG *massively Multiplayer Online Role-play Game*

Interoperable Virtual Simulators & Models

The new generation Simulators represent crucial supports for Industry 4.0 in terms of Engineering, Management and Training. The Virtual Simulators are aids for Operative Resources, Technical Staff & Decision Makers. The Interoperability of our simulators is based on most advanced standards (i.e. HLA High Level Architecture, MS2G, Modeling, Interoperable Simulation & Serious Games). These Solutions enable stand-alone and Federated Simulation of Operations, Activities and Processes. Simulation Team have very long experience in Project with Industries and major International Players (e.g. NASA, NATO, EDA, EC).

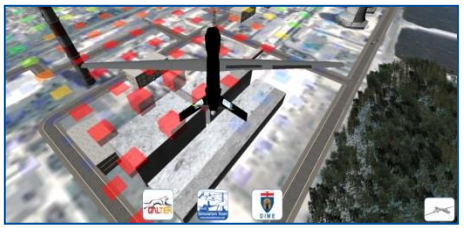
MS2G as Enabler

The innovative concept of MS2G (Modeling, interoperable Simulation and Serious Games) allows to develop interoperable scalable and reusable simulators with benefits of new Immersive Solutions. MS2G is very flexible and enable use from different platforms: regular laptop, CAVE (Computer Automatic Virtual Environment)
large enough to immerse 4-5 people in the Virtual World, HDM, HoloLens as well as Smartphones and Tablets



HDM Head Mounted Display

MS2G and IA-CGF



The MS2G (Modeling, interoperable Simulation and Serious Games) is combined with the use of the IA-CGF (Intelligent Agent CGF) developed by Simulation Team. These Intelligent Agents simulate concurrently many actors, people and actions enabling to recreate and study very complex scenarios to improve trainee engagement

Virtual Reality for Simulation & Augmented Reality as Benefits

The Use of Virtual Reality allow to Realize Virtual Prototypes of the Products and Processes and to test new Solutions. Such Virtual Simulation support Design, Training and Management and the relative Virtual Worlds becomes available for Augmented Reality Tools and Applications.

Technology evolution enables new opportunities

20

Previous Project Examples: VIP-STRALO

Virtual Prototype by Simulation in Transportation and Logistics

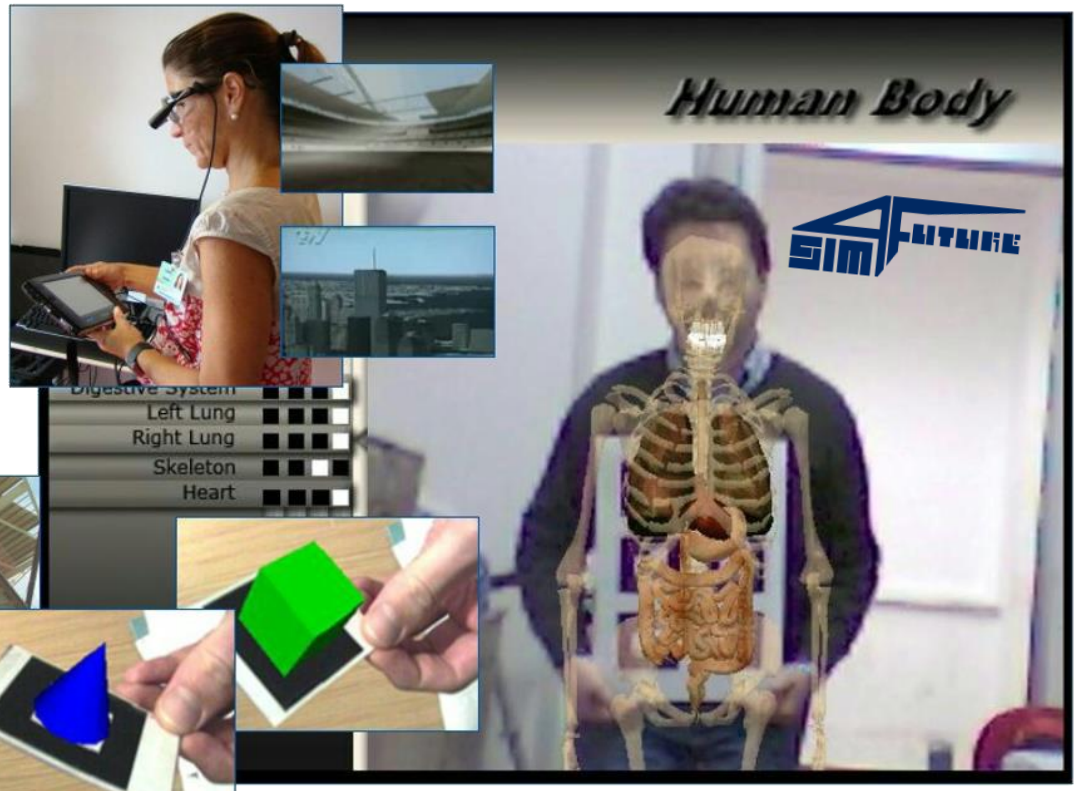
VIP-STRALO Goal is the creation of innovative solutions based on Interoperable Simulators for SBDVP (Simulation Based Design and Virtual Prototyping) applied to Logistics, Transportation and Automation Sector.

VIP-STRALO involves the creation of two interoperable demonstrators:

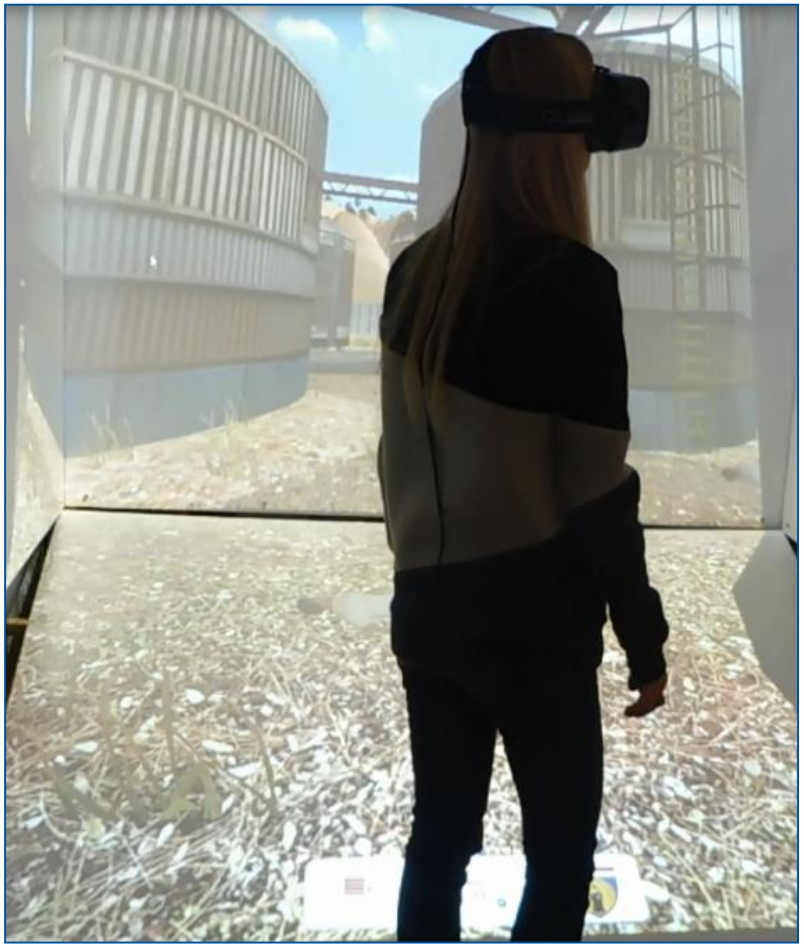
- LOCARS: Logistics Crane Simulator
- FEBO: Federation of Boats

Virtual Simulation & Augmented Reality

The Simulation Team is active in several initiative combining Virtual Simulation with Augmented Reality. These Applications include dynamic combination of Simulators with Virtual & Real Worlds



Addressing Multiple Issues

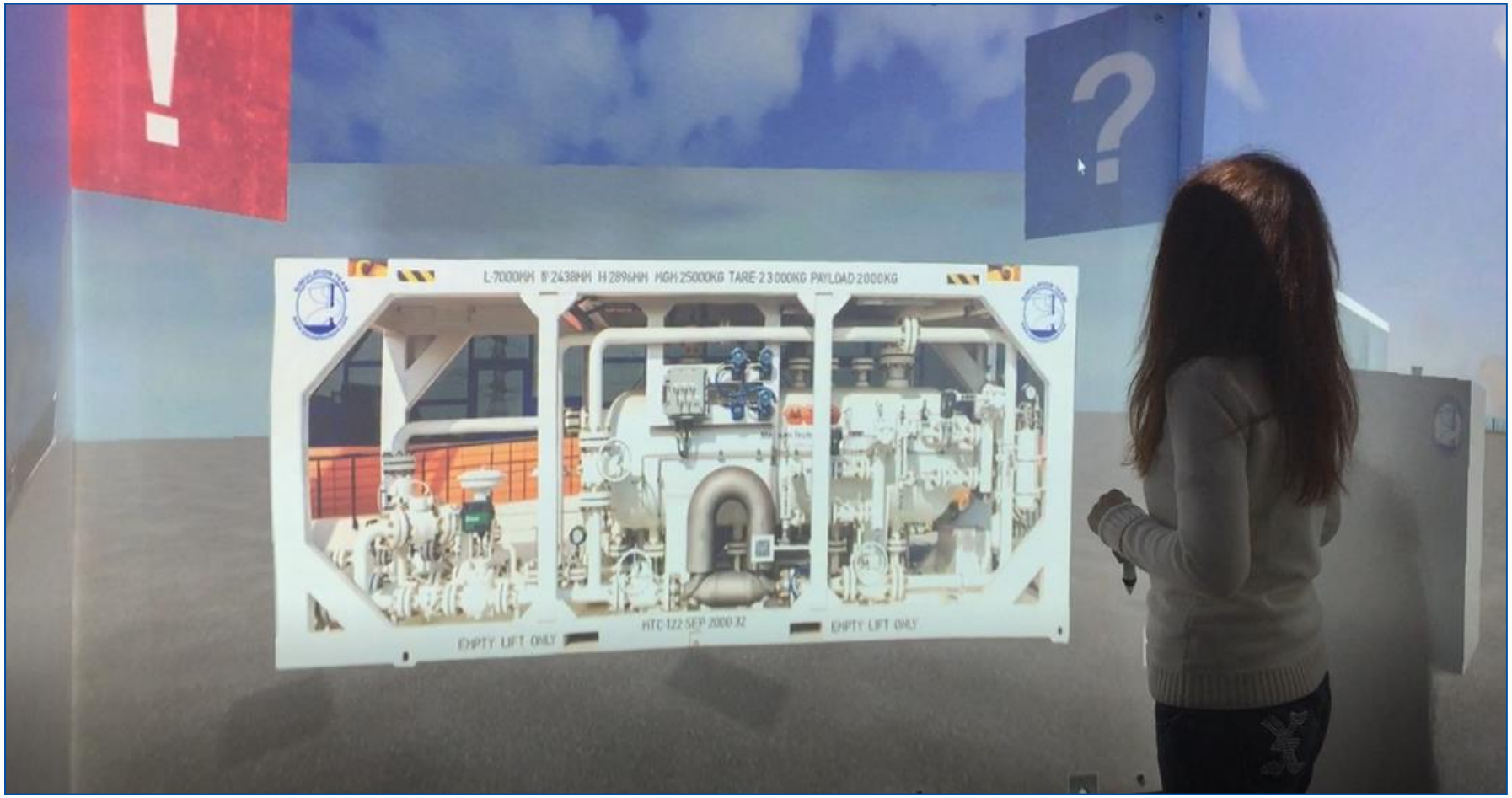


In general the MR in Industry 4.0 could support effectively different goals:

- ***Education and Training***: answering dynamically and interactively to questions of the trainees as well as providing examples of sequences and action points
- **Troubleshooting**: directly interacting with the operator or supporting remote supervision for guarantee a safe and efficient remote supervision

In addition to lean supports, such as Glasses and Tables, CAVE such the SPIDER () could be effectively used for training and for remote supervision

Addressing Multiple Issues



SPIDER

Simulation Practical Immersive Dynamic Environment for Reengineering

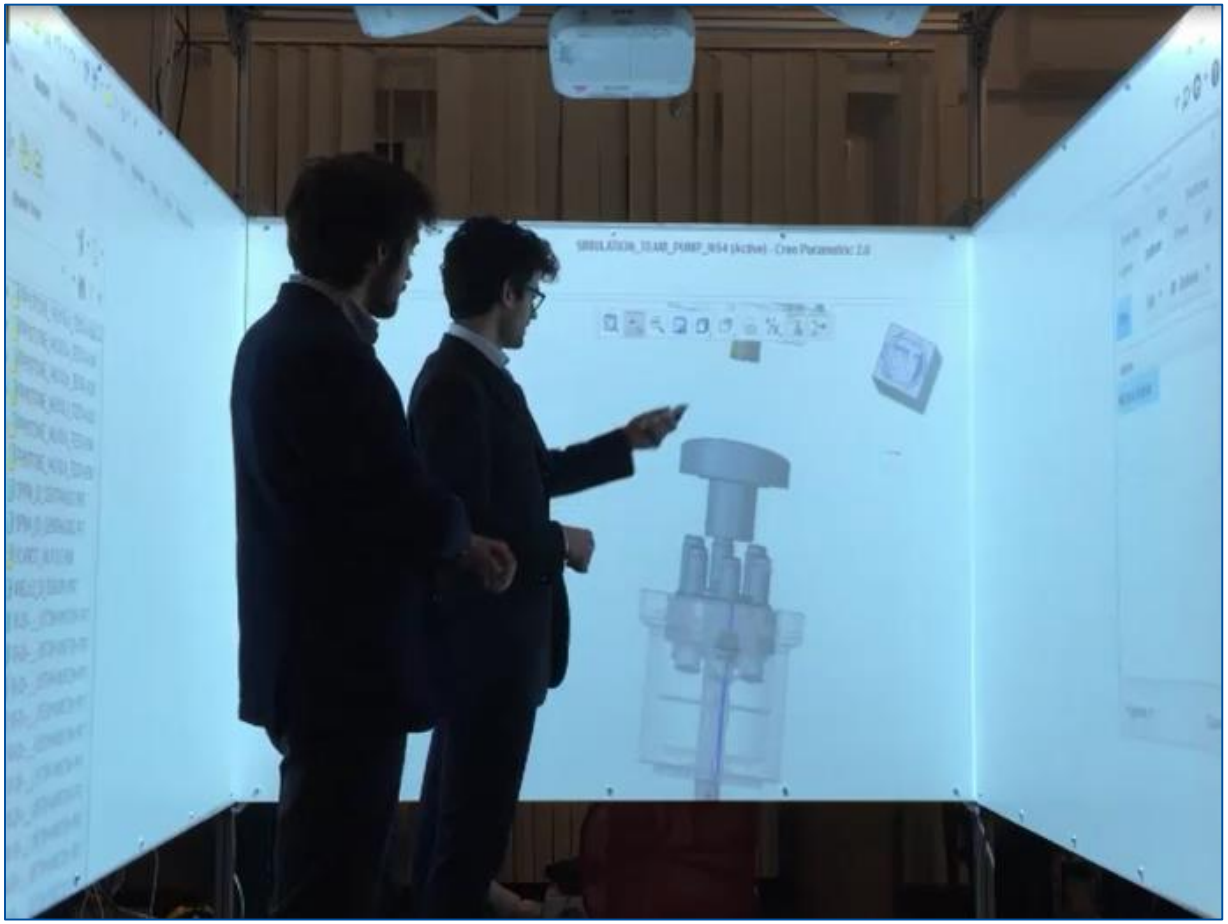
The SPIDER (Simulation Practical Immersive Dynamic Environment for Reengineering) is an innovative Interactive and Interoperable CAVE (Cave Automatic Virtual Environment) developed by Simulation Team. The basic configuration is compact (2m x 2m x 2.6m) and could be embedded within a standard Container and integrated in any interoperable simulator.

The SPIDER is interactive through touch screen technologies.

The SPIDER is fully Immersive including sound and motion.

Collaborative Remote Supervision & Service

The Central Subject Matter Experts (SMEs) become available to check remotely the Status of Different Distributed Assets without leaving the HQs. It becomes possible to Track them as well as to conduct Supervised Service Operation with the Service Operator or, directly, with final Users



Many Different Solutions: Glasses & Goggles

In facts there are many different solutions that could be adopted to support VR and AR implementations. Some ones are mostly useful for Training and Supervisions such as Head Mounted Displays.

The Oculus Rift is a basic and valuable commercial example of VR while the Hololens represents a new product for MR

Tablets as Intuitive & Simple Approach to AR

Indeed sometime it is more effective to use basic Hardware solutions that result reliable and intuitive for potential users.

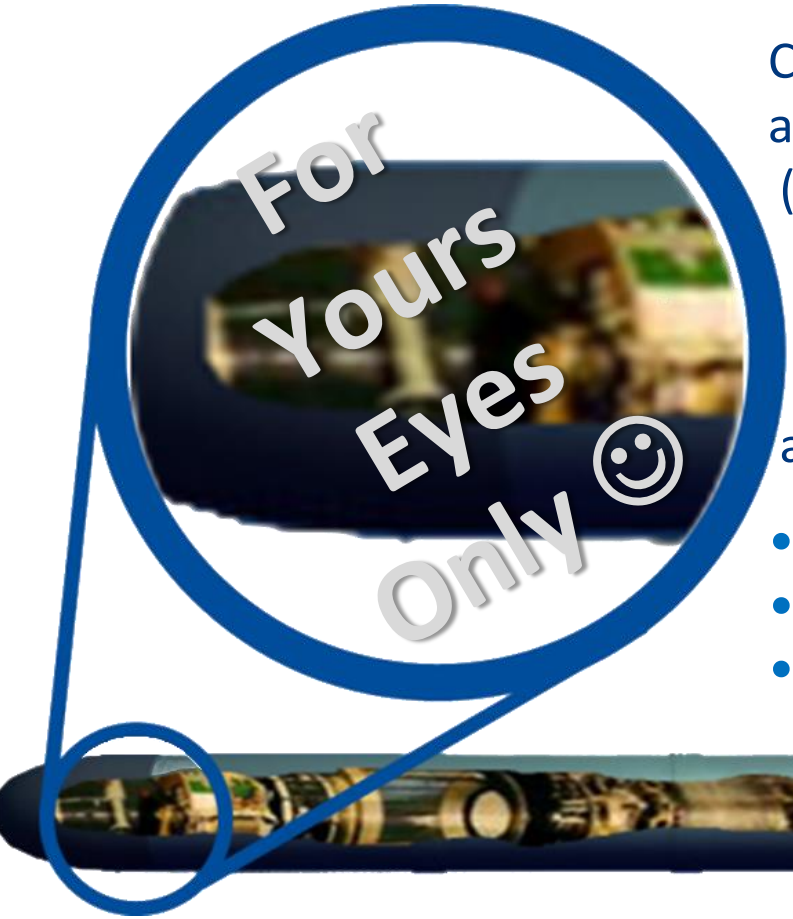
From this point of view the tablets provide an interesting Man Machine Interface for supporting Service and Maintenance of Equipment and being operated by basic Operators.

Future Uses and Innovative Interface

The architecture is designed to incorporate future technologies for continuous development.
This R&D addresses especially:

- Monitoring & Tracking
- Remote Test & Troubleshooting
- Supervision
- Remote Service Support
- Mobile Service Support
- Availability Improvements
- Reduction or Losses Robberies and Misuse

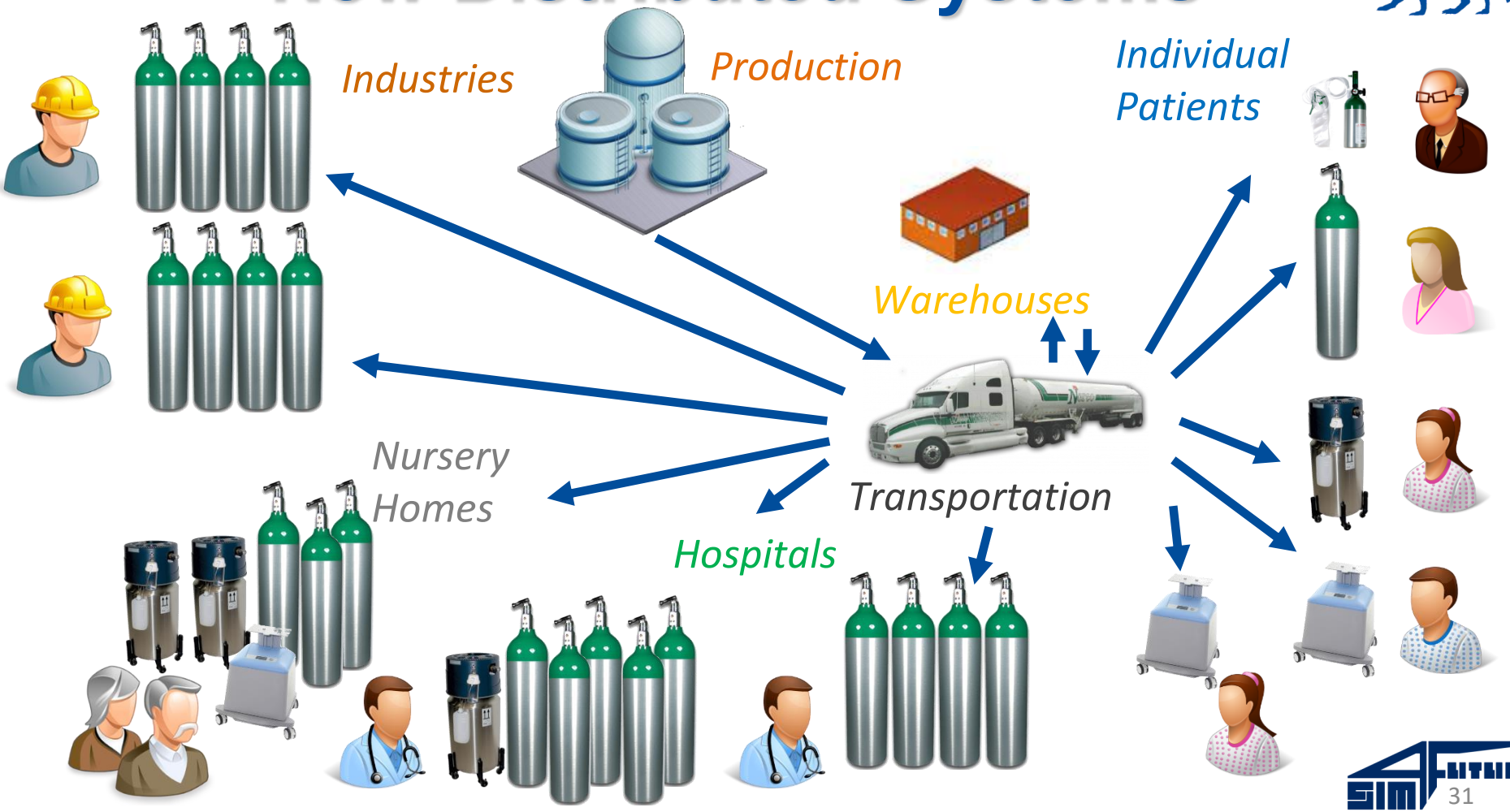
AR & VR for Autonomous System Maintenance



Complex Systems, such as Autonomous Underwater System (AUV) require sophisticated Maintenance and Continuous Service even operating at Sea, so the use of Mixed Reality is very useful. AR & VR allow to support:

- *Training*
- *Operator Support*
- *Remote Supervision*

Distributed Assets & IoT: New Distributed Systems



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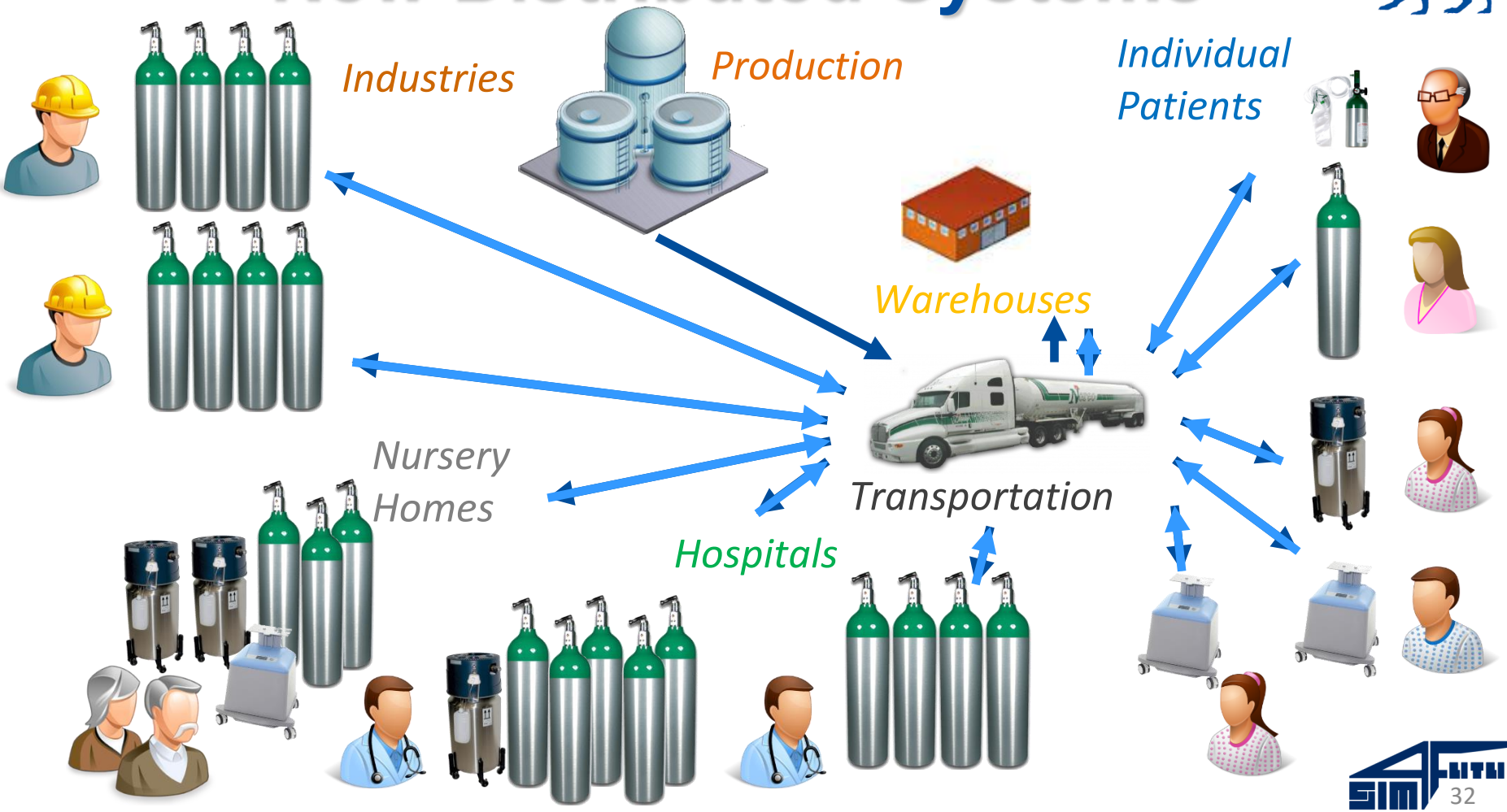

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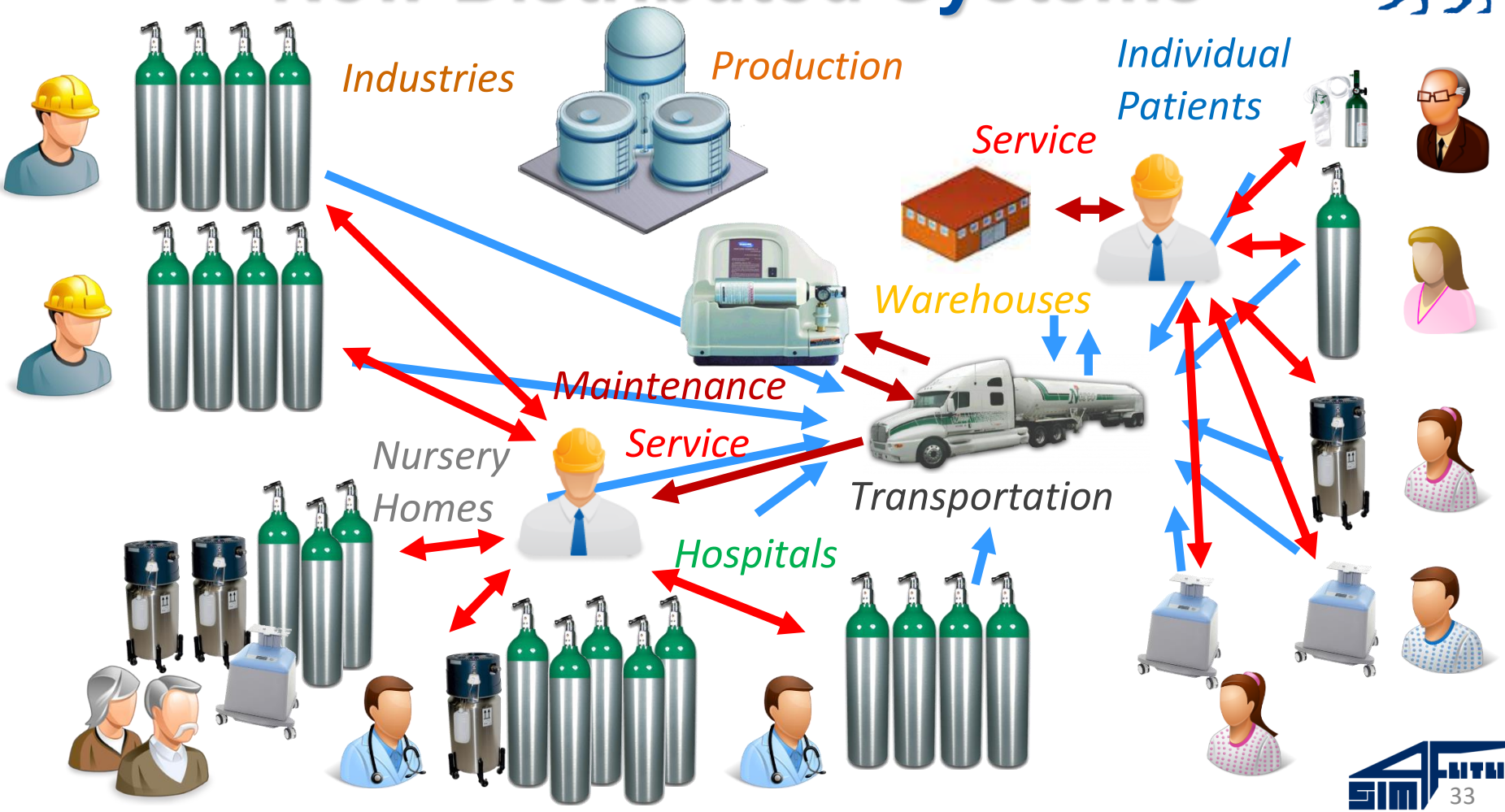

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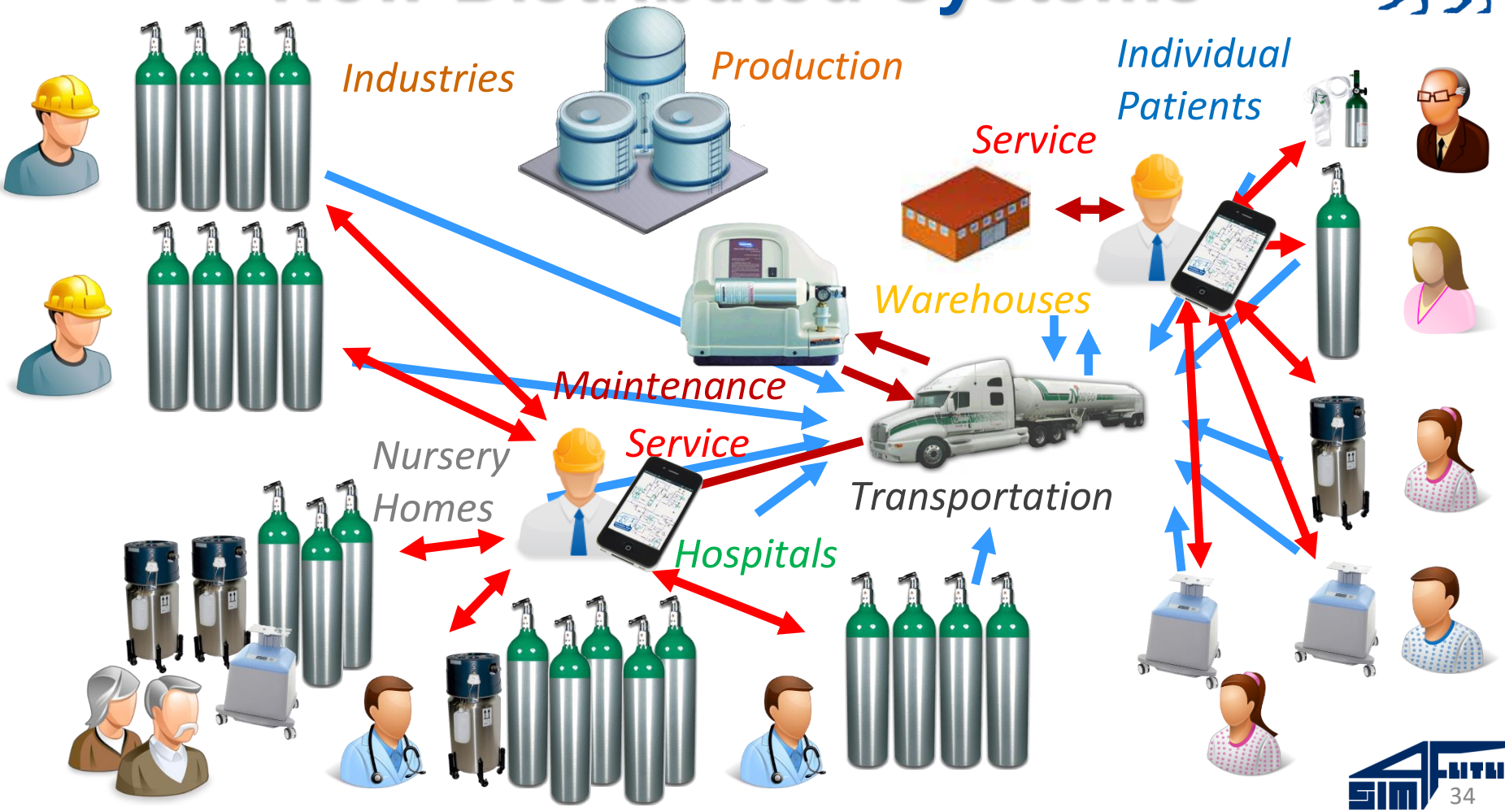

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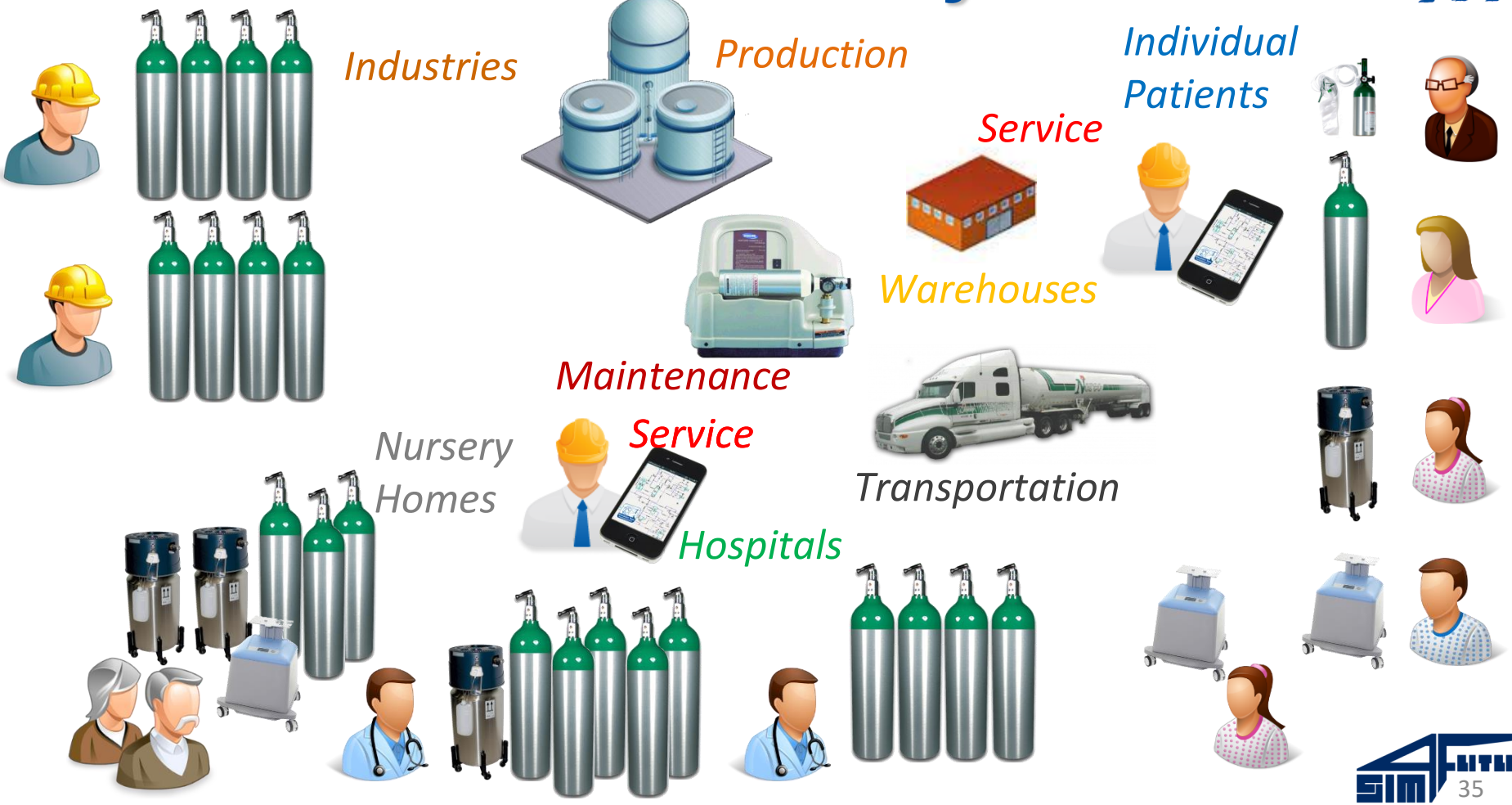

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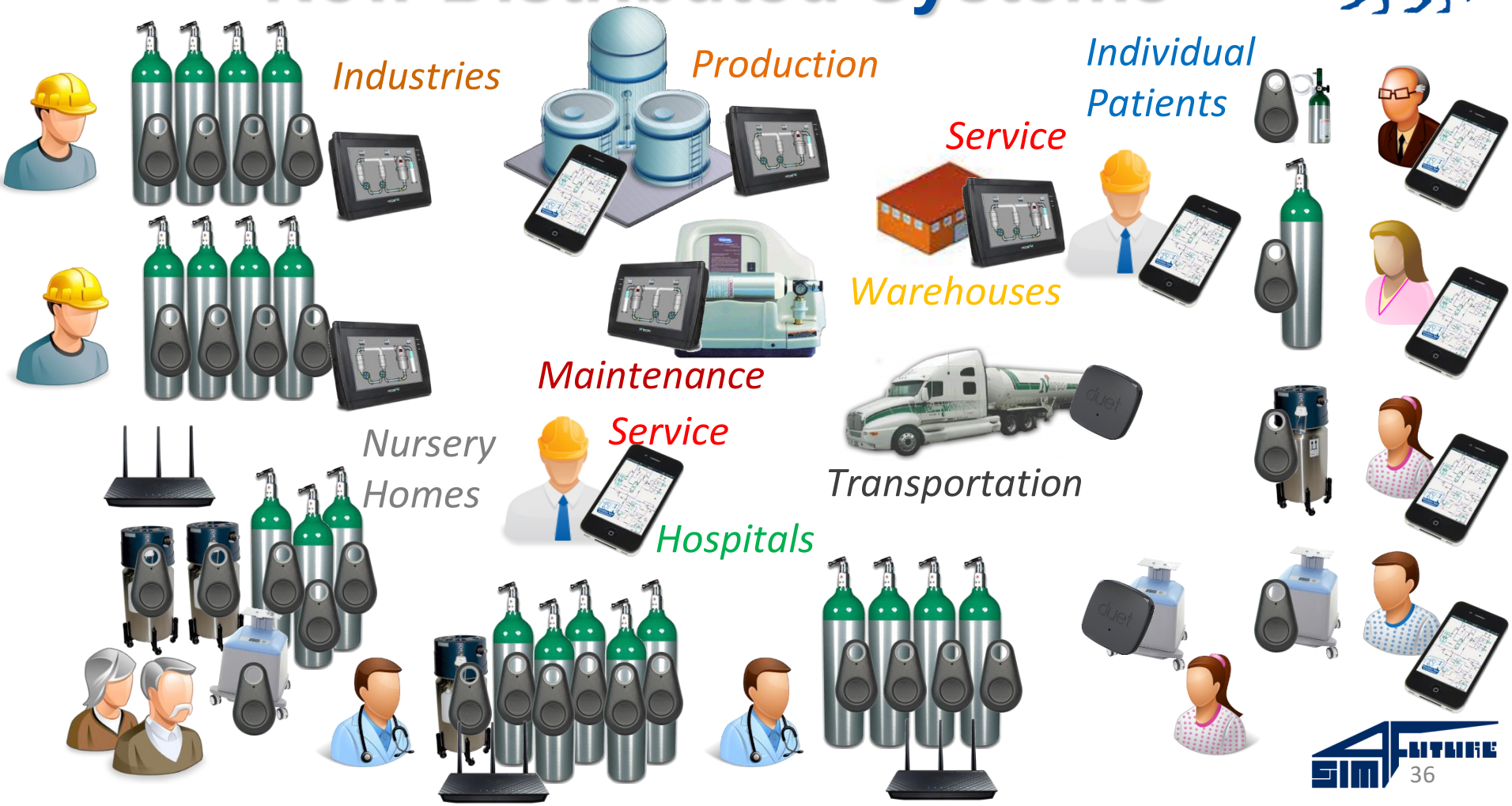
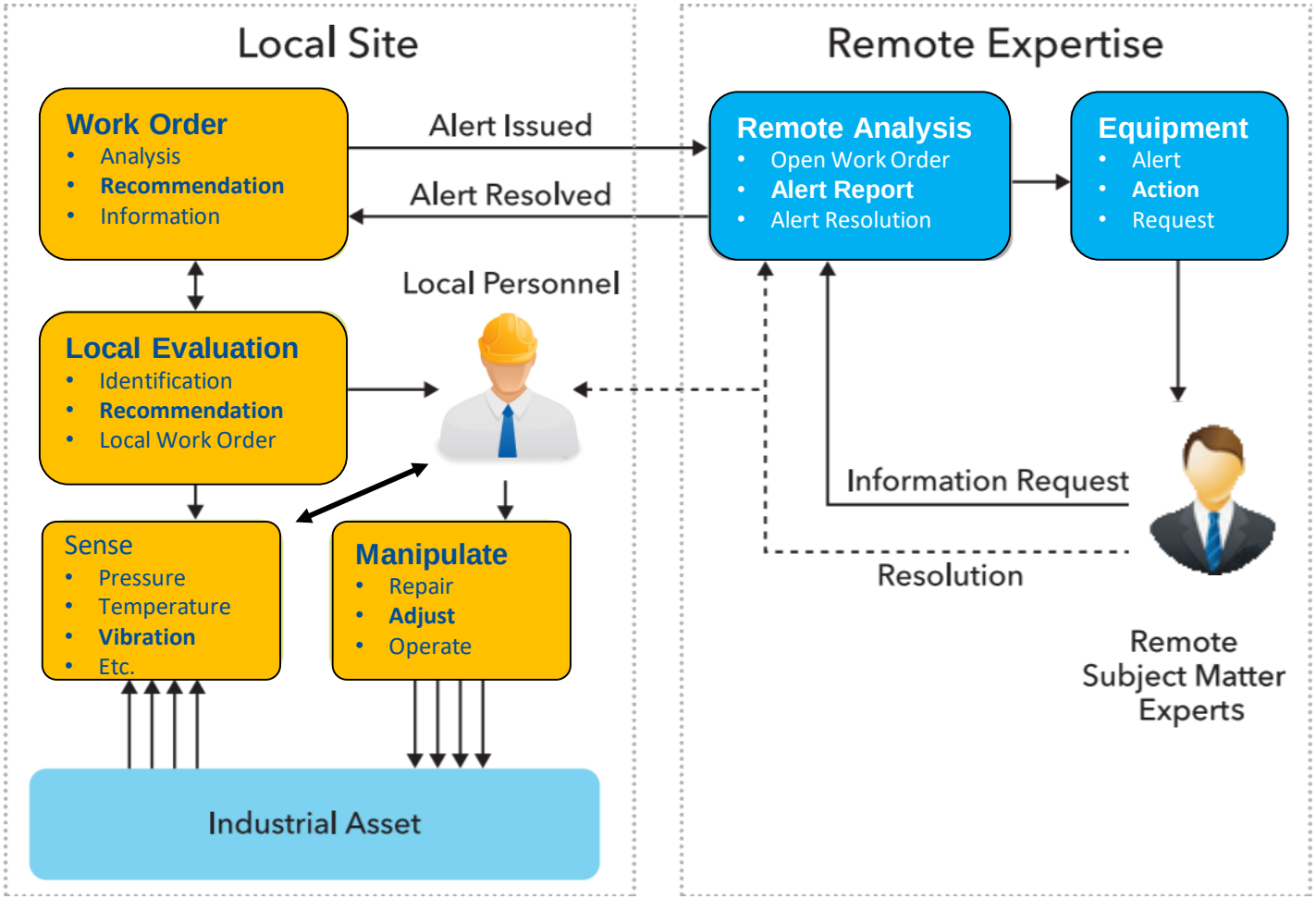


Example of Architecture



Example of Architecture

Local Site

Work Order
- Analysis
- **Recommendation**
- Information

Alert Issued

Alert Resolved

Local Evaluation
- Identification
- **Recommendation**
- Local Work Order

Local Personnel

Sense
- Pressure
- Temperature
- **Vibration**
- Etc.

Manipulate
- Repair
- **Adjust**
- Operate

Industrial Asset

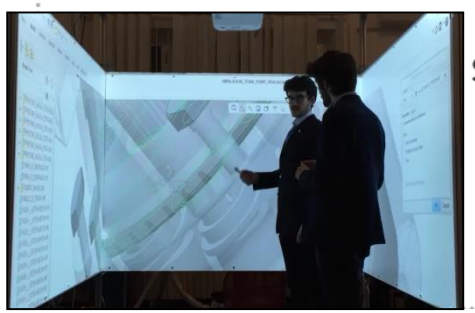
Remote Expertise

Remote Analysis
- Open Work Order
- **Alert Report**
- Alert Resolution

Equipment
- Alert
- **Action**
- Request

Information Request

Resolution



Remote Subject Matter Experts

Another Example in Open Space: Yard Modeling Applications

The Construction Yard is another area where Modeling, 3D Monitoring, Simulation and Monitoring provide crucial support in consistency with Industry 4.0 Paradigm

- Configuration Check
- Monitoring Job Sites
- Inspecting Structures
- Safety Checks
- Engineering Checks
- Estimation at Completion
- Up-to-Date 3D Virtual Model
- Volumes and Distances Calculation
- Survey of the Work in Progress
- Layout Review and New Equipment Planning
- Monitoring & Showing Clients the Project Progress

CYM as Joint Venture

Even if Yard Modeling & Simulation, VR & AR have great potentials in Construction, these innovative Technologies today these are not yet very diffused in this sector, so R&D Projects are emerging to conduct experiments. This means that a competitive advantage is guaranteed by adopting this approach and due to these reasons the Simulation Team and major Companies in Yard Operation have established the CYM (Construction Yard Modeling) Initiative as a Joint Venture for developing new Solutions in this sector of Applications based on:

- *Building Information Models*
- *Virtual & Augmented Reality Services*
- *Real Time Construction Quality Control*

CYM: Advantages & Benefits

Construction Modeling, VR & AR (Virtual & Augmented Reality) today is able to obtain great results based on integrated use of Camera, Sensors, Lasers and M&S (Modeling and Simulation).

Construction Yard Modeling is promising for improving drastically operations in Construction Yards, Infrastructure Building & Plant Erection on several aspects:

- Safety
- Engineering
- Configuration Control
- Work in Progress Monitoring
- Project Progress Reporting
- Construction Supervision.

Another Example: Reduce Risks in Big Plants

In large facilities, Iron & Steel as well as in Petrochemical Plants it is very crucial to guarantee Safety. Industry 4.0 represent the evolution of new technologies into solutions to be implemented in these context. Simulation Team is active today with project FASOLT Project (Foremost Autonomous Solutions for Operations in industriaL planT) in this sector.

FASOLT allows to develop innovative Solutions based on combined use Of VR, AR and Simulation to develop Autonomous Systems able to move Indoor and Outdoor and to reduce Risks to humans in dangerous Operations and/or conditions.

Conclusions

SISOM allowed to put Innovation at work in Industry 4.0. In this context it is crucial to move ahead from Theory to Scientific Experimentation to measure and evaluate the real benefits and to tune the design of new solutions enabled by the evolving technologies. The use of Virtual and Augmented Reality for the Remote Service of Distributed Assets represent a major advantage for Manufacturers as well as the improvement of training programs. The proposed approach guarantees the possibility to support local operators as well as remote supervision. Indeed this approach provides a very effective framework for Training and Education for On Site & Remotely Assisted Service .

The R&D confirms the potential to reduce costs and to increase reliability; this is expected to lead to further reinforce the outsource services and the competitiveness in commodities outsource

References

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.... Questions?