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Applications of Virtual Reality in Design and Simulation of Holonic Manufacturing Systems A Demonstration in Die-Casting Industry

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Overview

- Key Concepts
- Holonic Manufacturing Systems (HMS)
- Virtual Reality (VR)
- The VR-HMS methodology
- Modeling and Operations
- Implementations
- Conclusions

Agility

- Defined as; the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and electively to changing markets.
- an agile manufacturing system is required to be **scalable, robust** and **re-configurable** to cope with the **disturbances** within the market demands and the manufacturing system itself.

Holonic Manufacturing Systems

- ❑ An intelligent manufacturing paradigm developed for agility in manufacturing.
- ❑ Organizing manufacturing activities in decentralized control architecture to meet the agile, scalable and fault tolerant requirements.
- ❑ Overcomes many difficulties faced by existing conventional CIM systems.

Holonic Manufacturing Systems

- ❑ Behavior is not deterministic
- ❑ Direct experimental testing is expensive
- ❑ The implementation requires,
 - **High investment**
 - **A lot of expertise**
 - **Careful decisions** to ensure that the highly automated system will **successfully satisfy the demands.**

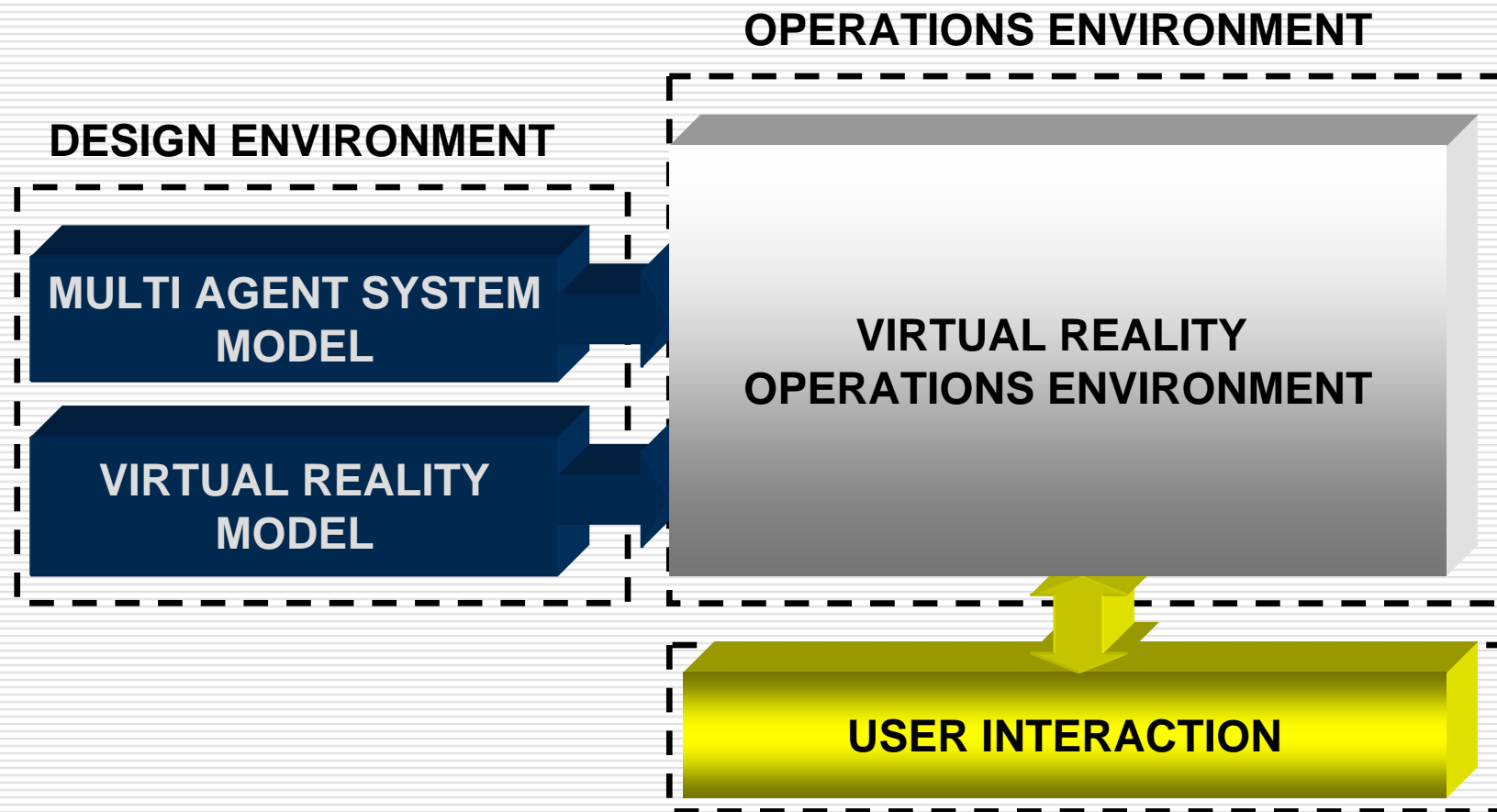
The Virtual Reality (VR)

- is a synthetic environment providing a sense of reality and an impression of 'being there'.
- an environment to understand the statistical outcome of the simulation with **realistic modeling** of implementation.
- Helps solving problems in manufacturing applications before being employed in practice,
- **prevents costly mistakes.**
- ...

VR Applications in Manufacturing

- ❑ Simulation of Manufacturing Operations, Offline Robot Programming, CAD, CAPP ,Facility layout planning, training...
- ❑ Packages available such as; DELMIA™: QUEST, IGRIP, VisFactory™...
- ❑ Applications designed for centralized control architectures.

The VR for HMS Simulation

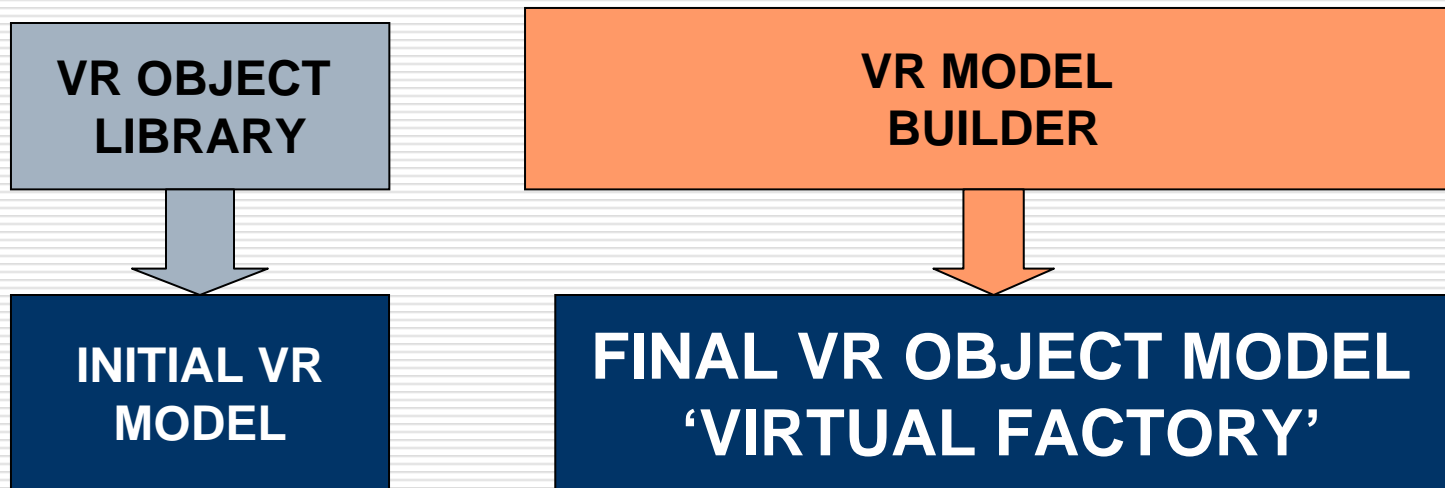


Holonic control system design environments

- The holonic agent in this research is an extended JADE agent.
- **JADE: Java Agent DEvelopment Framework**, an open source agent platform that provides a library of Java classes that allow creating agents with application-specific attributes and behaviour with capabilities to send and receive FIPA messages (<http://jade.cse.it/>).
- fully implemented in Java language.

VR Modeling Environment

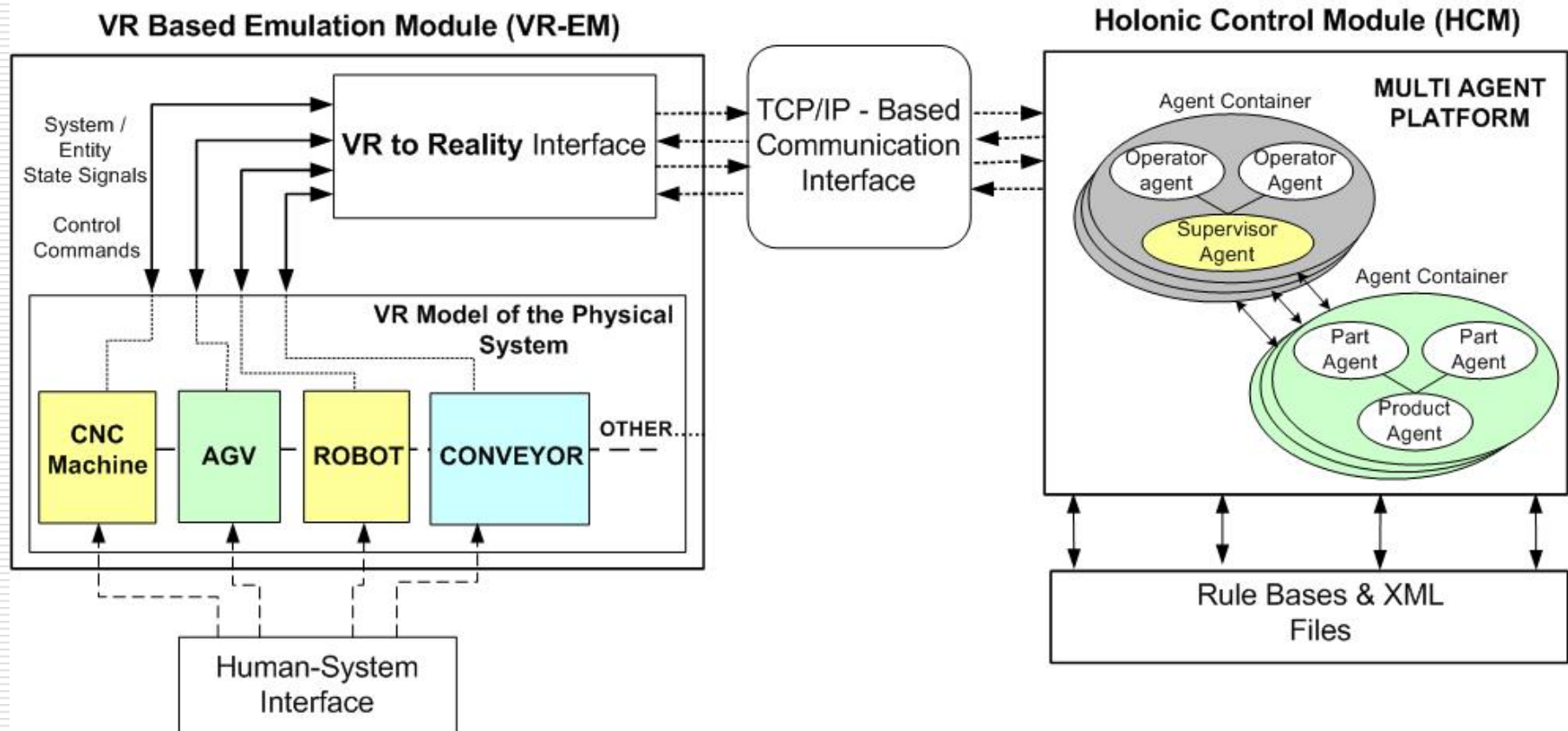
- The VR model is constructed in a way to represent the current physical operations within the factory.



Operations Environment

- ❑ simulates the designed system model for the various operating conditions in a digital platform.
- ❑ bounds the **holonic control architecture models into the VR models** of the manufacturing devices.
- ❑ Failure generation schemes are applied for understanding the robustness of the designed system model with decentralized control architecture

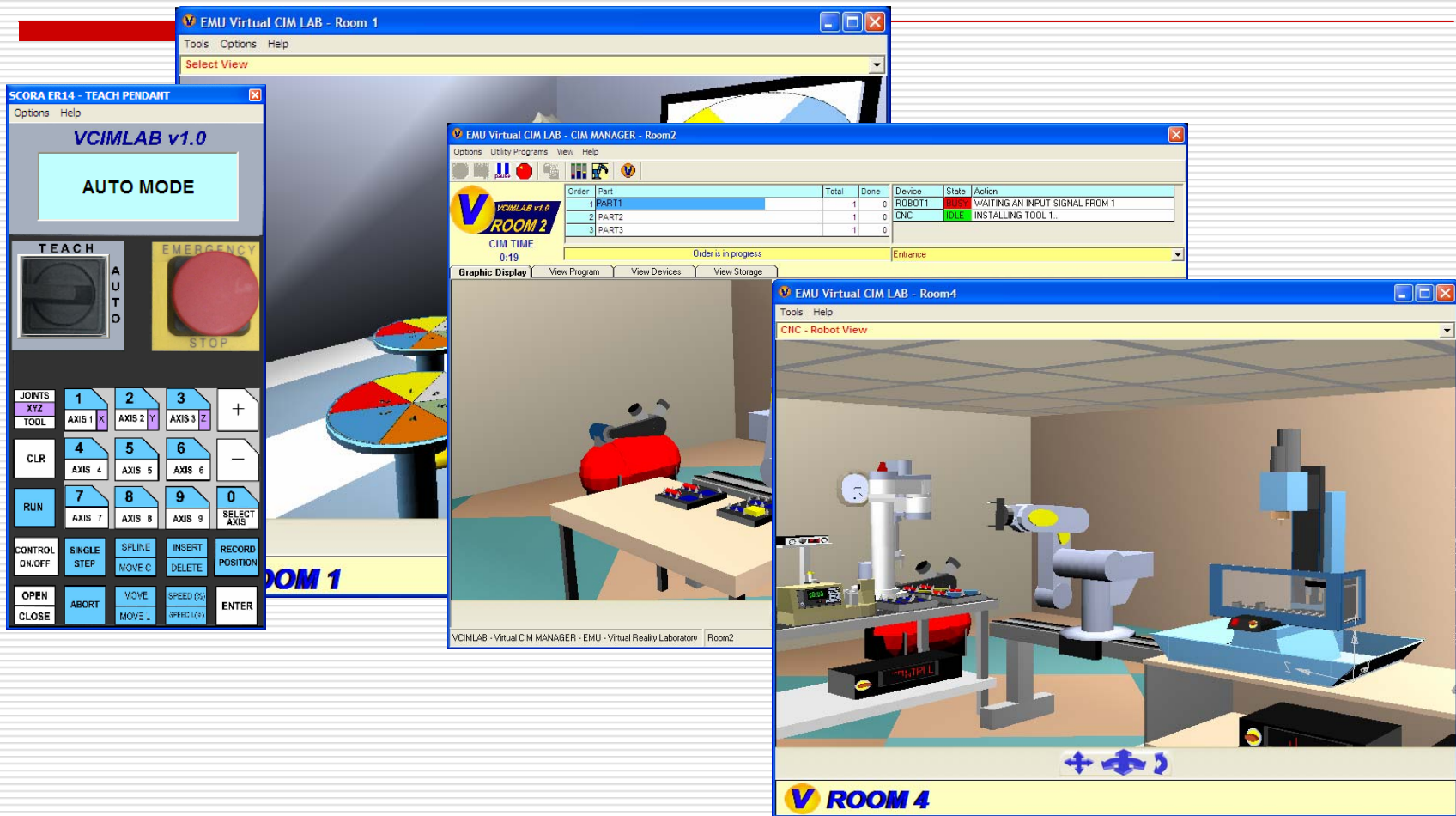
Operations Environment



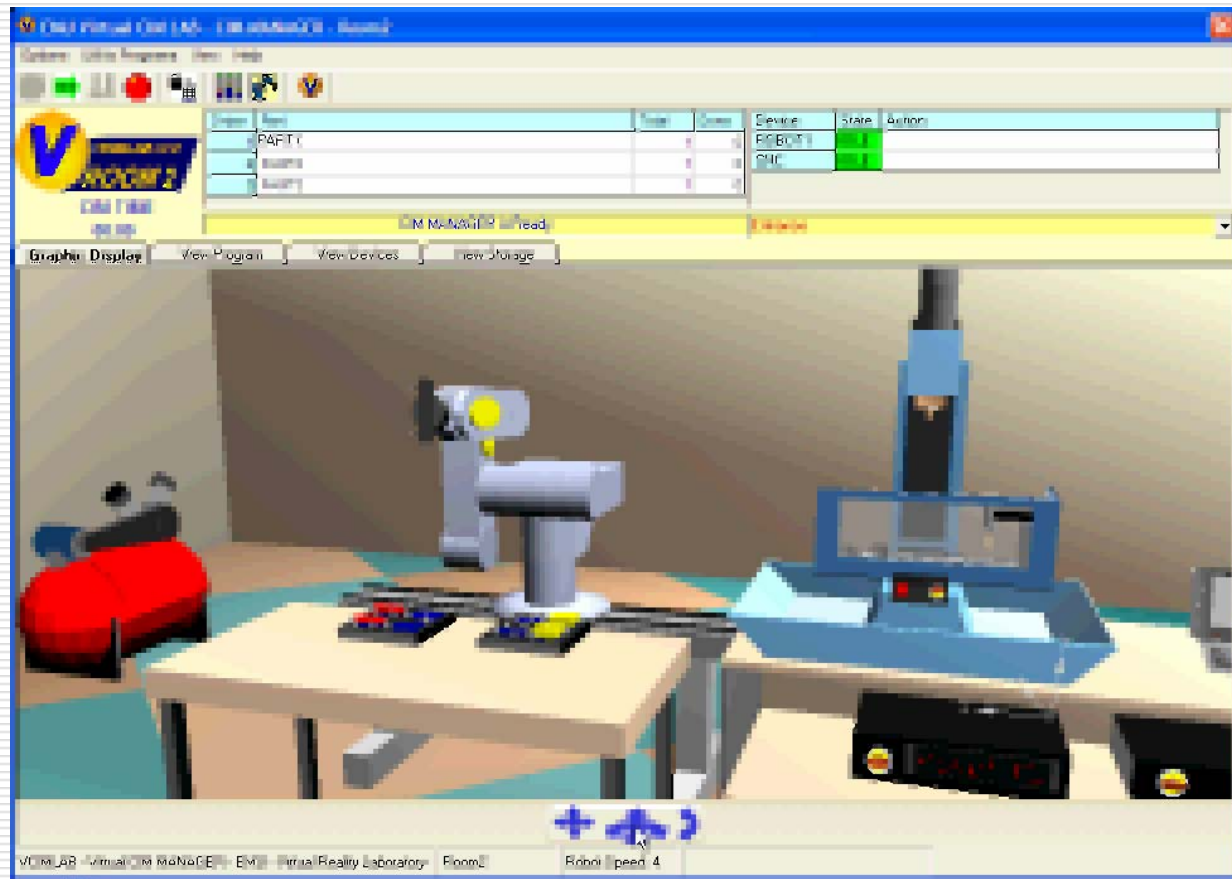
Implementation

- ❑ A prototype tool **VCIM-HOLONIC** has been developed to realize the features outlined in the methodology
- ❑ Built on top of **Open GL** in C++ and JADE in Java
- ❑ A sample implementation has been performed in a medium-size die casting manufacturing factory in Turkey.
- ❑ The existing manufacturing system has been modelled and simulated for the implementation of fully automated die casting cells.
- ❑ A Holonic control architecture has been implemented for self-organization of the die-casting cells in the case of breakdowns and rush orders.

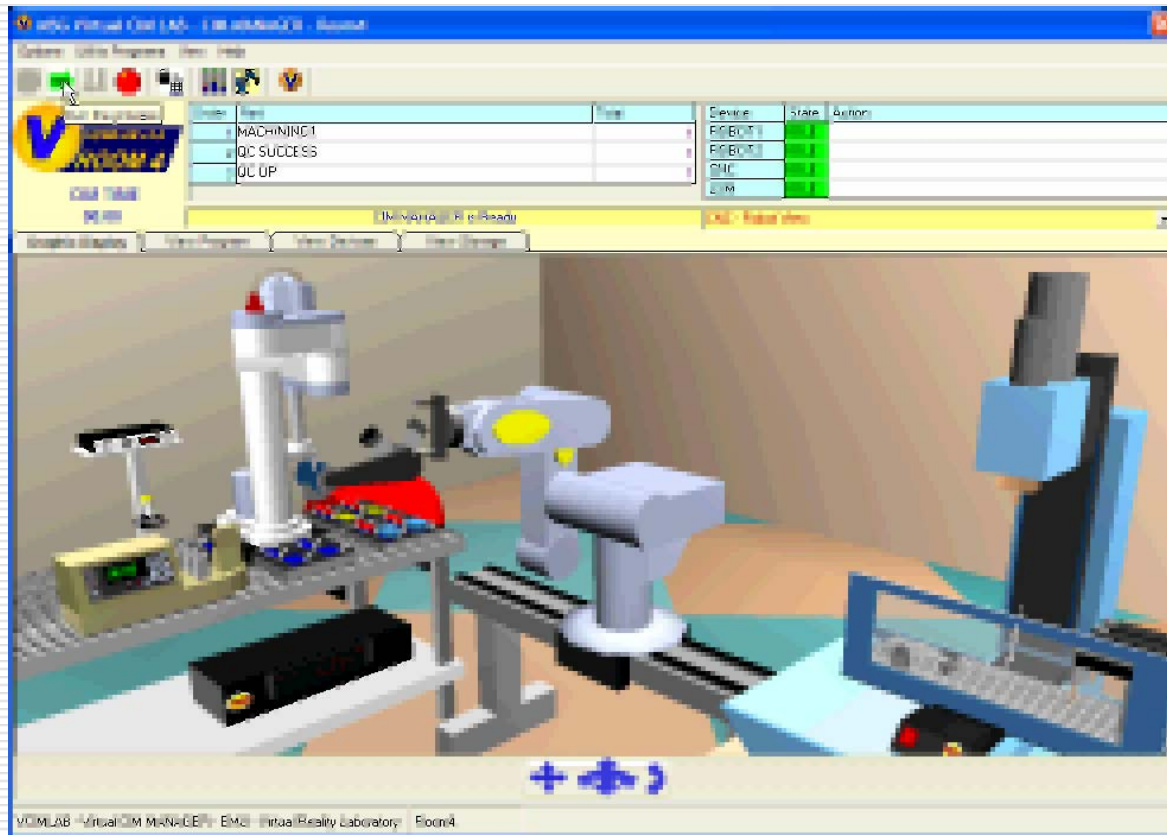
VCIMLAB - Virtual CIM LAB



VCIMLAB to **VCIM-HOLONIC**



VCIMLAB to VCIM-HOLONIC



Conclusions

- ❑ VR enhances the design, analysis and testing phases of automation and system implementations into manufacturing enterprises.
- ❑ VR environment provides visual animation where certain patterns (e.g. inventory build-up, blockages in flow) can be quickly seen. **This is an important feature, especially in demonstrating the response of HMS to the factory management.**
- ❑ physical configuration of the floor and study the effects of changes (e.g. distance between machines, speed of material handling systems) can be done easily.
- ❑ The framework provides an ability to quickly conduct controlled and repeatable experiments for comparative visual feedback on the operational differences.

Thank You

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