

Module name: Virtualization of a robot cell with a real controller.

- **Main functionalities:**

Enables the control of simulated manufacturing hardware using a real controller. The simulated hardware is represented in a real-time 3D-environment which can be used for demonstrating actual system functionality, training employees, virtual commissioning and testing production operations for new parts. These activities can be done before the system even exists or after commissioning, when they can be done without disturbing the ongoing production. Since the control software used is identical to the real-world control software all master data created with the virtual system can be transferred to the real one.

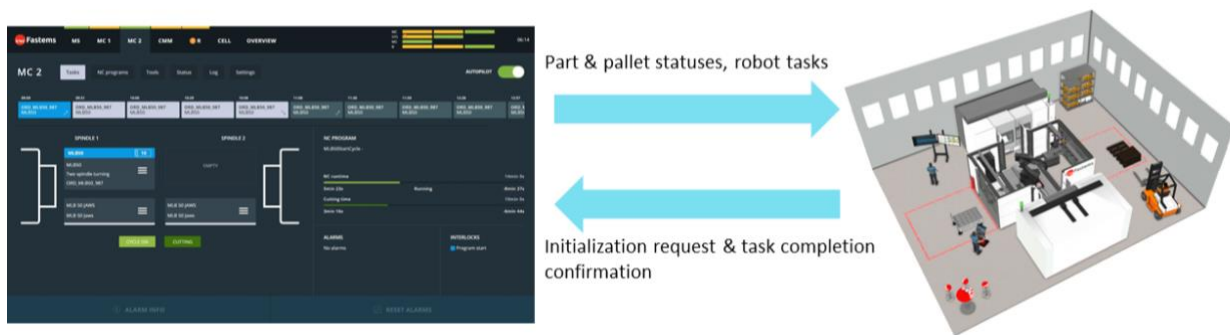


Fig. 1. The control software user interface (left) and the virtual model (right)

- **Technical specifications:**

The hardware and software requirements for this module are shown below in Fig. 2. The main hardware consists of two PCs that are connected with an Ethernet-cable and communicate with each other through the WebSocket-protocol.

Hardware:

The Fastems cell controller is an industrial PC that is used to host the MMS (Manufacturing Management Software). It is identical to the one used to control real manufacturing hardware. The cell controller can also be housed inside a TouchOP -device which provides the user with a screen, keyboard and mouse that can be used to interact with the MMS user interface. Otherwise, a separate set of these peripherals is required. The cell controller includes a Fastems specific connectivity solution which allows the Fastems 8760 Support and user to connect to the system remotely.

The sole purpose of the Visual Components PC is to run the virtual model and after the model is configured and running it doesn't require any additional user inputs. Therefore, only a screen is required for this PC. A virtual reality headset can be attached to allow the user to walk around the virtual system . There are no specific system requirements for the PC, but it must meet the minimum requirements for running Visual Components 4.1.

Additionally, multiple PCs and screens can be connected to the system to view and interact with the MMS user interface. These PCs can be used to add and edit master data, view and create production orders, import NC-programs, view the key performance indicators (KPIs) etc. locally or remotely. The screens allow the user to display the virtual model or e.g. system KPIs to a larger audience.

Software:

Both PCs are run on the Windows 10 operating system. The version of the control software is MMS 7.2 and the Visual Components version is 4.1.

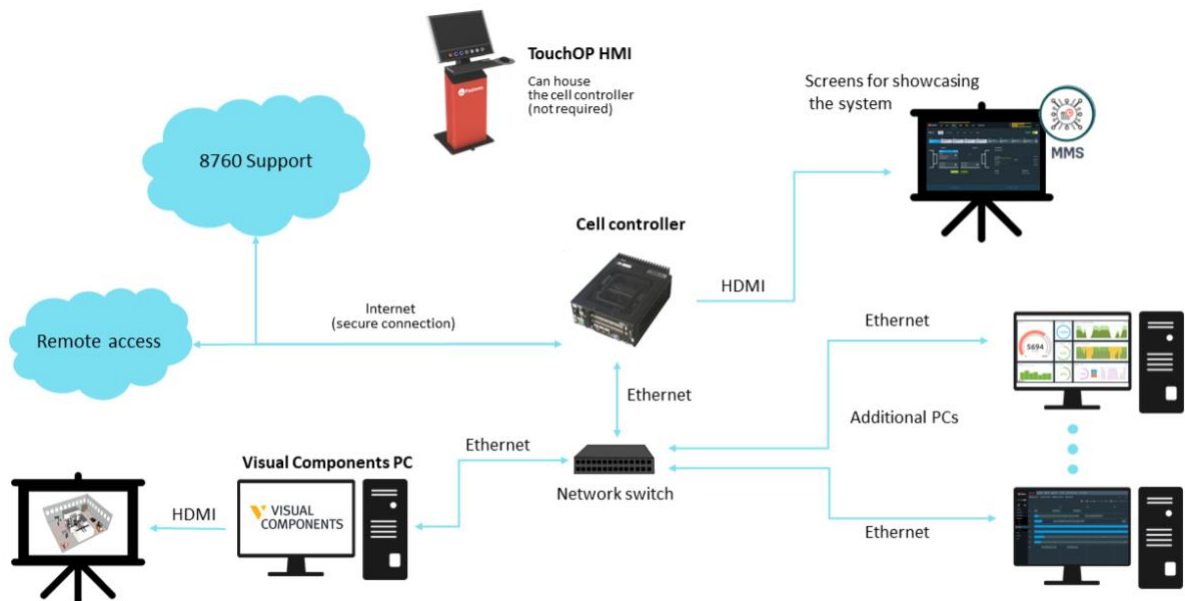


Fig. 2. Software and hardware components of the module

- **Preliminary software configurations:**

Before the module can be used, 1.) the MMS configuration must match the Visual Components -model, 2.) the cell controllers IP-address must be defined in the Visual Components -model, 3.) a wired communication link (Ethernet) between the PC and the cell controller must be established.

- **Inputs and outputs:**

All data between the control software and the virtual cell is transferred using the WebSocket-protocol. The data consist of six different types of messages which are sent in the JSON format. Five of these messages are sent from the MMS to the model and one is sent from the model to the MMS. These messages contain the necessary information (coordinates, IDs, grippers etc.) to fulfill the requested task. The message types are listed in Table 1. The model will listen for incoming messages until it is stopped or paused.

Table 1. Message types

Message name	MMS	Virtual model
Initialization	Response	Request
palletsChanged	Request	-
palletsRemoved	Request	-
partsChanged	Request	-
partsRemoved	Request	-
robotTransportPartTask	Request	Response

The communication between the model and MMS begins when the user starts the model from the Visual Components user interface. The model first sends out an initialization request to the MMS and the MMS then responds to the request with the required information. The initialization information allows the virtual model to place the pallets and parts in to the correct locations. This has to be done each time the model is connected to the MMS. After that, depending on the user inputs, the model will listen to incoming messages and either receive requests to remove or change the pallets/parts within the cell or part transport tasks for the robot.

The transport task messages contain the source and target locations of the part and information about which type of gripper is required to complete the task. Once the transport task is completed the model will send a confirmation message to the MMS so that it knows the robot has completed the requested task and can then request additional tasks. Other message types don't require confirmation messages to be sent. The communication loop continues until the user decides to stop or pause the model.

- **Interface specification:**

The module utilizes the pre-existing user interfaces of the MMS and Visual Components. No additional user interfaces are required. The MMS user interface is identical to the one used with real world systems.

- **Formats and standards used:**

WebSocket, JSON, Python 2.7

- **Availability:**

Availability and usage are based on Fastems' licensing policies.

- **Application scenarios:**

Training employees: Since the MMS is identical to the real-world one employees can be trained in a safe and realistic way with this module. They can interact with the MMS user interface and at the same time see how the robot cell behaves. They can even walk around the cell with the help of a VR-headset to understand the scale and possible hazards of the robot cell. This can be done before the real system is delivered which makes the production ramp-up faster and safer.

Demonstrating system functionality: The detailed virtual model enables the user to use the visualization capabilities to demonstrate and teach the basic principles of agile manufacturing cells. The real-time visualization makes it easier to understand the fundamental concepts of the cell.

Testing new parts: New parts can be trialed in the virtual system before introducing them to the real one. This means that the user can import the CAD-model of the part into the virtual cell to make sure that the clearances are large enough and that no other issues appear. The user can also pre-create part master data into the MMS which can then be imported to the real production MMS after testing.

Long-term simulation runs (in the future): Long-term simulation runs will allow the user to get a detailed view of the future production rate and projected machine utilization of the cell. This allows the user to test their future production capacity before committing to a new order.

- **Offered for internal / external use**

Available for internal/external use.