ManuCloud – Distributed cloud product specification and supply chain manufacturing execution infrastructure

SPECIFIC TARGETED RESEARCH PROJECT

Periodic Report

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Project Website address:	www.manucloud-project.eu

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1.1 Project key data

Project Acronym: ManuCloud

Project Title: Distributed Cloud product specification and supply chain manufacturing execution infrastructure

Project Website: www.manucloud-project.eu

Consortium:

Fraunhofer IPA

Fraunhofer IPMS

acp-IT

Bosch

Heliatek

MTA SZTAKI

nxtControl

LEDON

University of Strathclyde

GSS Gebäude-Solarsysteme

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1.2 Executive Summary

Due to the fact that customisable products are increasingly demanded by customers, and that this influences not only singular factories but in most cases large parts of the related supply chains, the ManuCloud project aimed at developing an IT platform which enables configuration of customisable products provided by production networks. This configuration is not based on pre-defined options which are usually defined by the product engineers, but by the manufacturing capabilities gathered directly from the underlying manufacturing and IT environments.

In order to achieve that in an efficient way, the project also developed self-descriptions for equipments, process- and factory level manufacturing services and related mapping mechanisms. Those tools also enable fast equipment integration to factory-level IT systems such as MES (manufacturing execution systems). nxtControl and acp-IT stated during demonstrations that they expect a decrease in equipment integration efforts of up to 70% in case the ManuCloud approach for equipment and MES level IT engineering is followed consistently.

The IT innovations dealt with in this project were applied within the automotive (Bosch) and organic semiconductor (Heliatek, LEDON, GSS Gebäudesolarsysteme, Fraunhofer COMEDD) industry, i.e. product configuration of customisable façade elements consisting of orgnanic PV and LED elements was provided via the developed IT infrastructure. Additionally, these partners have driven forward the lamination processes which are necessary to manufacture those products since up to now, no appropriate process settings existed.

1.3 Project context and objectives

The transition from mass production to personalised, customer-oriented and eco-efficient manufacturing is considered to be a promising approach to improve and secure the future competitiveness of the European manufacturing industries, which constitute an important pillar of European prosperity. One precondition for this transition is the availability of agile IT systems, capable of supporting this level of flexibility on the production network layer, as well as on the factory, process, and equipment levels.

The ManuCloud project has been set up with the mission to investigate the production-IT related aspects of this transition and to develop and evaluate a suitable IT infrastructure to provide better support for on-demand manufacturing scenarios, taking multiple tiers of the value chain into account. On this path, ManuCloud seeks to implement the vision of a cloud-like architecture concept (see Figure 1). It provides users with the ability to utilise the manufacturing capabilities of configurable, virtualised production networks, based on cloud-enabled, federated factories, supported by a set of software-as-a-service applications.

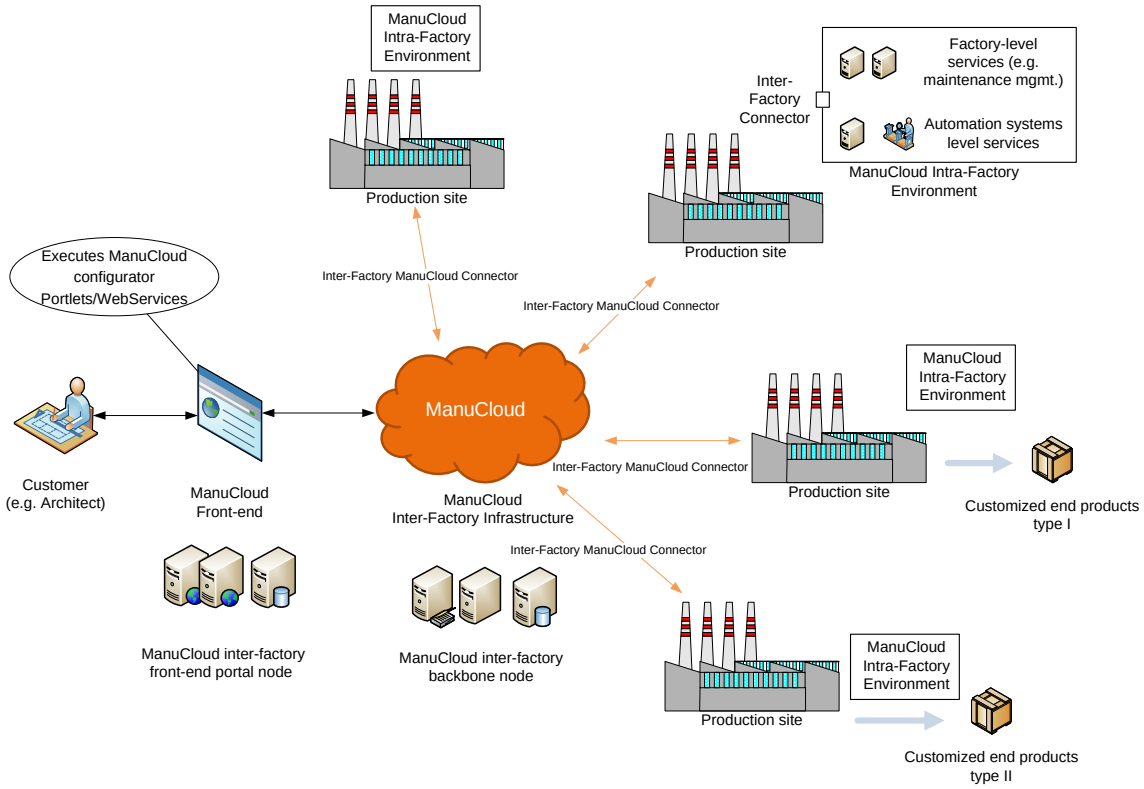

Figure 1: ManuCloud conceptual architecture

In order to achieve this overall vision and mission, the project aimed at developing the following IT platform components:

- Intra-factory environment (factory internal IT from equipment to MES/ERP): For the intra-factory environment, the project intended to make heavy use of cross fertilization effects in the area of best practices, standards and technologies available in the different industries represented by the project partners.

Special attention was paid to the service interface of automation systems to the factory, including aspects of process capability modelling and system self-description. A layer above the automation systems was intended to support service discovery, management, and orchestration, allowing for quick development and deployment of new factory-level services. The implementation of automation level services is intended to be integrated with the engineering process for these systems.

- Cloud Connector:
  The Cloud Connector's intention is to connect factories to the cloud manufacturing environment. This is to be done by a layered mapping mechanism which aggregates service self-descriptions to factory-level manufacturing capabilities.

- Inter-factory environment:
  The inter-factory environment supports a tightly controlled, on-demand integration of federated production-IT systems of different vendors, supporting joint specification management, shop-floor data transfer, high level of traceability and distributed quality management. This functionality is to be provided by the ManuCloud MaaS (Manufacturing-as-a-Service) environment. Additionally, a front-end system is supporting the dynamic configuration of virtual production networks and provide interfaces for product configurators which are supported by a product design & advisory subsystem.

Additionally, the concepts developed, their relevance and use should be shown by means of appropriate demonstration scenarios from the automotive, and organic PV and LED industry.

1.4 Scientific achievements

In a first step, the consortium specified use cases and general requirements for the overall ManuCloud infrastructure and its main components, the intra-factory domain, the inter-factory environment, and the front-end product configurator. A reference product was defined to show the functionality of the ManuCloud IT developments.

The overall architecture of the ManuCloud infrastructure has been defined based on main use cases and requirements. It consists of the three main parts mentioned above and describes how they interact in order to achieve close cooperation between customers, product integrators, and (sub-) product manufacturers.

Within the intra-factory related tasks, an equipment self-description was specified based on the OPC-UA standard. It is used to describe equipment-level services and parameters which can be aggregated to process level services and parameters on MES level. Those process level services are used to aggregate manufacturing services which can be published to the ManuCloud inter-factory environment via a cloud connector. Prototypes have been implemented for each sub-component and partially installed at BOS' development environment.

Furthermore, the mapping from intra-factory level IT system information to the manufacturing service descriptions which are used for communication and

management on inter-factory level has been implemented within two industrial environments, at manufacturers of organic semiconductor elements.

The team working on inter-factory related topics has specified and implemented the overall IT service infrastructure which is necessary to run virtual organisations, process plan initialisation, and product orders throughout the ManuCloud infrastructure. Interfaces were implemented to the front-end and intra-factory domain based on web-services. Especially regarding the user- and organisation management, service management, aggregation and execution, a prototype was built up in order to enable a consistent flow from intra-factory (cloud connector) manufacturing service publication, to service aggregation and front-end side configuration. The configurations are then used as a basis for the individual orders to be executed within the manufacturing environments. In order to realise MES functionalities on cloud level, the cloud connector, i.e. the interface between intra- and inter-factory domains, has been equipped with features for order state updating, the provision of measurement results to the inter-factory level, etc.

For the front-end system, it was decided to use a web portal in order to provide a common look-and-feel to end-users, i.e. potential customers who like to select and configure their products via an online market place. All functional user-interfaces are integrated to this portal in the form of portlets which makes the overall composition of user interface components really flexible. Flexibility was also kept in mind when the product configurator was specified and implemented. So loads the configurator the parameters to be customised dynamically from the manufacturing service descriptions. Parameters are validated based on the rules specified within the service descriptions immediately and the influence of parameter changes is visualised graphically.

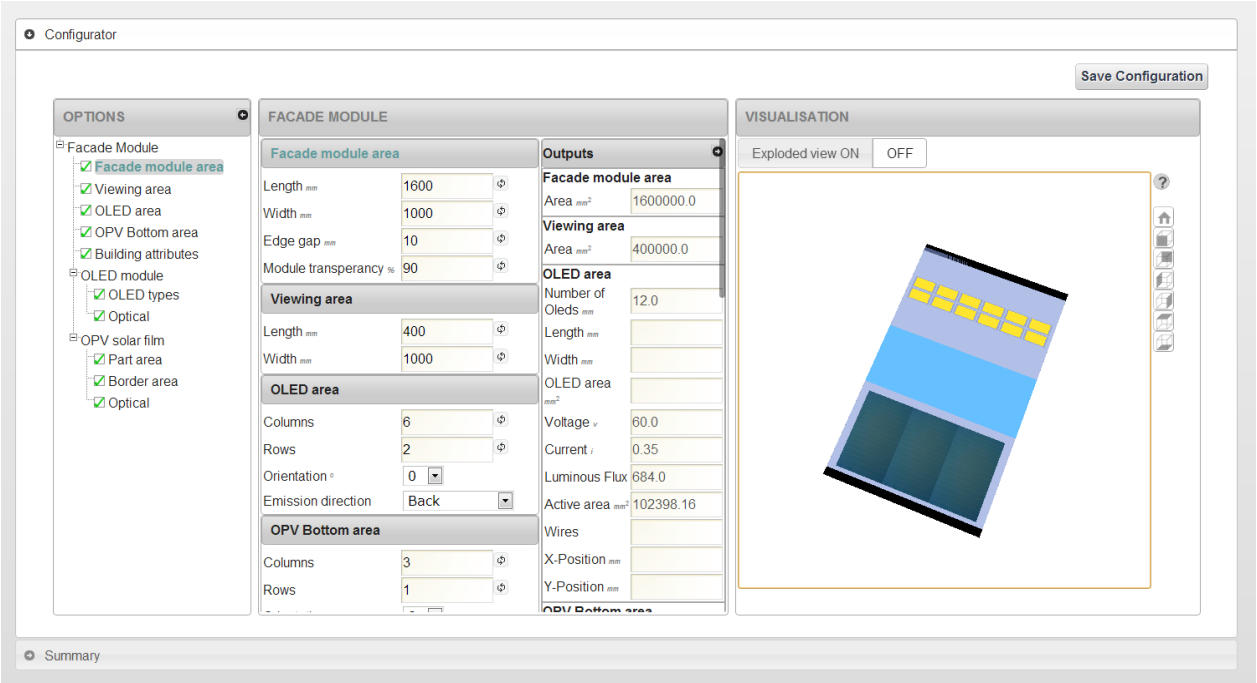

Figure 2: Screenshot of the product configurator on the ManuCloud marketplace

The reference product was specified based on the survey mentioned above. It was decided to provide a facade module which includes OLED and OPV elements as well as a viewing area in order to extend the range of options for architects to apply lighting and PV solutions. Detailed parameter sets were defined in order to enable the creation of a manufacturing service which describes such a product. Several tests which were executed to proof the lamination of OLED and OPV elements between glass screens showed that, in principle, the manufacturing of such a product is possible.

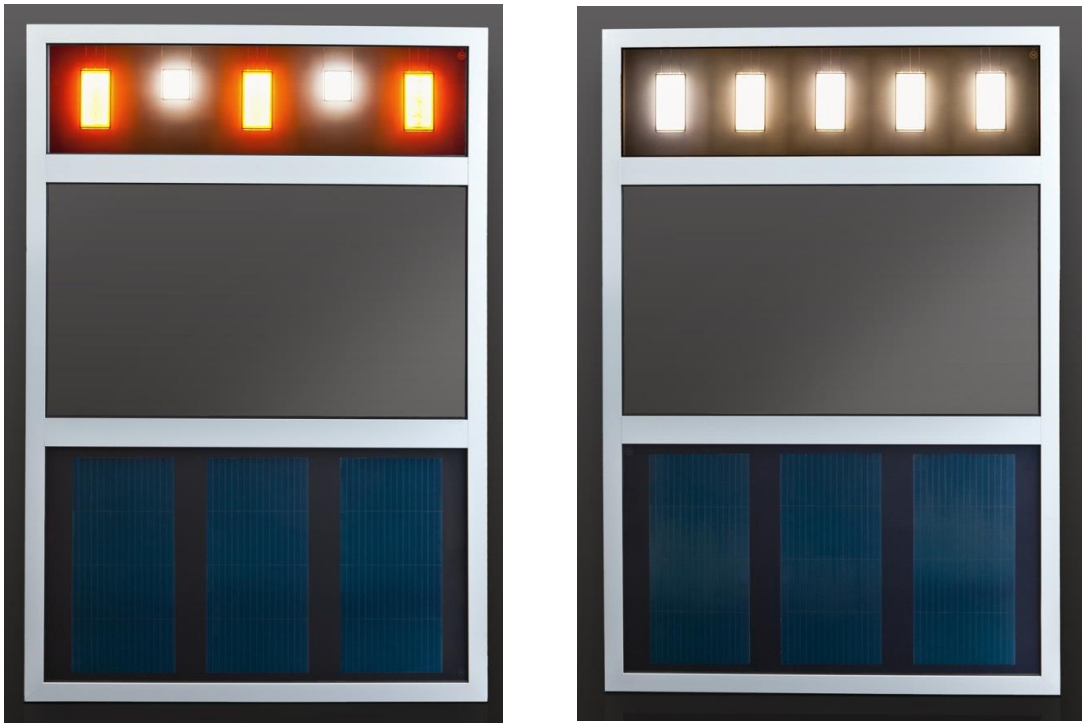

Figure 3: OLED and OPV elements as components of the reference product

1.5 Final results

During development work within the project, it has turned out that the exploitable results which were identified at the very beginning of the project had to be modified, i.e. updated with regard to actual developments and individual exploitation strategies of the project partners. During a sound review of the exploitable results, the following 13 items have been identified:

1. The ManuCloud concept as a whole describes the IT design and architecture of the overall ManuCloud system, including its components (i.e. intra-factory, inter-factory, interfaces, etc.) and their functionalities. This does not include the specific implementation of components.

2. The ManuCloud platform as a whole includes the overall implementation result of the ManuCloud concept which was done within the ManuCloud project. This means that the platform uses all software components described later in this document and integrates them by means of the implemented interfaces.

3. Lamination process for combined OLED/OPV products:
   The technology for lamination of combined OLED/OPV modules allows the integration of such optical elements into glass substrates for indoor and outdoor

application. The process covers especially the lamination of low temperature resistance materials. Inside this process the lamination and connection technology was implemented. It is a proof-of-concept, further development for fabrication approval is necessary.

4. Knowledge about integration aspects for OPV/OLED products and application cases:
   The knowledge platform describes the interface and process definition for the lamination of OLED or OPV components into safety glass. The process know how summarizes especially the issues regarding temperature sensitive material and thickness aspects for the integration.

5. The Intra-factory software is exemplarily realized at the Bosch development demonstrator. It covers control software for machines in the demo line and integration software based on OPC UA deployed on the MES server to connect to the MES.

6. Equipment self-description (structure and usage) and related equipment / process level services:
   The structure of the equipment self-description is designed describe functionality and communication interface of the related equipment. It is exemplarily implemented for the three stations in the Bosch demo line in XML.

7. The Cloud Connector is a software tool which extracts manufacturing service descriptions from intra-factory level in order to establish the communication with the inter-factory web services. It also maps inter-factory level orders to factory-internal ones, updates tracking information in the cloud, etc.
   It consists not of these inter-factory web services which e.g. provide functionalities for receiving the manufacturing service descriptions or providing information about new orders for a certain organisation.

8. The Extension of HW Options for NXTControl runtime is the support of an additional hardware platform on which the nxtControl runtime software will run on. It is not the nxtControl runtime software itself, but the porting of the software to a specific hardware.
   Furthermore the work includes new options to support additional fieldbus systems. This includes the work to support hardware which implements the fieldbus protocol on the physical layer and needed libraries to implement the fieldbus protocol in the nxtControl engineering environment and in the nxtControl runtime system.

9. The Product Configurator is a software component which is part of the ManuCloud frontend. It connects with the inter-factory backend to enable the configuration of products based on available manufacturing services. It also provides functionalities to support product visualisation and assessment.

10. Intra-factory: agile platform for production process- and automation control (integrating equipment -> quality):
    This component combines the self-describing data collection interface (e.g. of

semiconductor equipment) with reliable buffering of data in order to avoid data loss. It is configurable by process engineers instead of software engineers.

11. The inter-factory APC (Advanced Process Control) transfers process control functionality from factory-internal applications to production network level, i.e. it enables to use process data gathered at one production site to optimise processes throughout the whole supply chain (e.g. influencing process steps which are executed at the following production site).

12. The Extension (self-description generation, OPC-UA server) of nxtControl development environment is an additional part to the existing nxtControl engineering software and runtime system. It is not the engineering software or runtime system itself, but an extension in functionality in the domain of the engineering tool and of the runtime system.

13. The Manufacturing Service Management and Execution is a software component which is part of the ManuCloud inter-factory back-end, i.e. it is a software service which manages service descriptions on inter-factory level, allows to aggregate them to end-products and supports the execution of manufacturing services, e.g. by means of order management and tracking.

1.6 Impact and use of results

OLED and OPV industry are growing markets. However, European companies from that sector have to compete with mainly Asian providers which are increasing their market share. This project is implementing the ManuCloud infrastructure in order to evaluate whether highly customisable OLED and OPV systems, especially in the area of building integration, allow for new business models for these industries.

The overall ManuCloud inter-factory environment has the goal to enable easy integration of supply chain partners not only on ERP but also on MES level based on manufacturing service descriptions which are automatically extracted from intra-factory IT. Main focus is on the interfaces – they should be simple enough to also enable SMEs to join production networks – and on production integration which will enable production planning and optimisation of production processes throughout the whole supply chain.
However, also parts of these overall functionalities may already bring benefits to industry. Examples therefore are industry associations, clusters, etc. which intend to exchange knowledge about their manufacturing capabilities, would like to make them searchable, etc. When thinking towards the future, this could also be a starting point for the setup of manufacturing clouds based on those associations.

The ManuCloud concept as a whole and the related platform developed are highly relevant for SME associations or similar clusters of industrial companies which aim at providing (customisable) products jointly in order to increase their fields of customers, reach new market niches, etc. For them, the platform could be a tool to collaborate on product specifications, order management and manufacturing execution. Specifically, by means of the product configurator, the platform also provides an additional channel to reach customers and react to their specific needs.
With regard to this, the consortium has already started discussions with industry clusters and small-scale associations from different industries.

Additionally, this project has immediate impact on factory level IT infrastructures, e.g. in the automotive supplies and semiconductor industry. The ability to add new functionalities to software systems at factory level and to quickly adjust production systems to new requirements is increasingly important for companies active in these fields. With typical state-of-the-art architectures used in production, additional functionality often causes an exponential growth of system complexity. This growth of complexity significantly increases ramp-up time, risk level, and costs as well as maintenance efforts for long-term operations.
By means of using the ManuCloud developments, a considerable reduction of equipment integration and factory-level IT configuration efforts is possible.

Besides those strategic impacts, the project also impacts the work of some project partners directly. nxtControl and acp-IT for example started a strategic cooperation in order to complement each other on PLC and MES level respectively.
As a result of the OLED and OLED related activities and the developed manufacturing process settings for laminated OLED and OPV products, project partners (e.g. GSS and LED) have started discussions on bringing customisable products to the market in order to strengthen their position.