HUBCAP
Digital Innovation HUBs and Collaborative Platform for Cyber-Physical Systems

Newsletter 9 December 2022

# Finalé … and Continuation!

HUBCAP brought together Digital Innovation Hubs, a platform provider, tool suppliers, and seed SMEs to support SMEs embracing digital innovation. Our focus was on **model-based** technologies and solutions to develop **cyber-physical systems** (CPSs), for which we developed an open, cloud-based **collaboration platform**. The platform was an innovation portal that enabled businesses to contribute and access digital assets needed to undertake **model-based design** (MBD) for building cyber-physical system solutions on the scale required for SMEs. The assets included both models and services, and were made available to enable businesses to manage their investment in MBD technology and to promote experimentation.

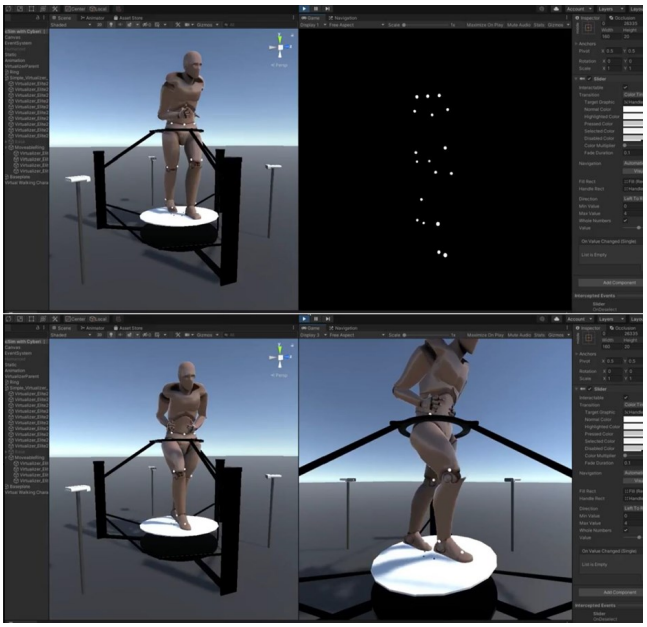
In this final newsletter, we summarise the achievements of six more SME projects funded by HUBCAP, and outline our plans for the future.

### An Advanced VR Locomotion Platform Enhanced with AI-based Motion Capture (LocoMoCap)

Virtual reality (VR) is a way of experiencing the real world through cyberspace. However, rendering the experience realistic is challenging. One challenge is to ensure that the visual inputs and the sensations due to motion are coherent.

The aim of this project was to use the motion capture (MoCap) system of **Codewheel** (one of the SMEs) to improve physical support for the gait of a user walking in a virtual landscape using the Virtualizer VR locomotion platform (developed by **Cyberith**, the other SME).

As a first step towards integrating the MoCap system with Virtualizer, a simulation environment (LocSim) was developed. Locsim consists of multiple cameras to detect up to 30 joints of a user (using markers), and uses AI (deep learning and hyperparameters) to predict user gait (lower body movement). Also, a human-like avatar, a digital twin of the Virtualizer, and a physics model for



simulating movement on the Virtualizer.

The project produced Virtualizer ELITE 2, which has input data streams on user lower-body motion that are used to provide support for smooth user gait in real-time. Evaluation was through pilot studies with end users to determine their opinions of the new facilities. The LocSim software is a Unity3D plugin and is an asset on the HUBCAP platform.

***"The support provided by HUBCAP enabled vital research on improving the user's gait on VR locomotion devices by integrating an AI-based MoCap System into the Virtualizer." - Holger Hager, CEO of Cyberith***

### Threat Management Platform for Citizens' Safety at Venues enhanced by Business Intelligence (BIE-T4S)

This project was motivated by the need to ensure public safety at venues with large congregations of people during an emergency, such as a fire.

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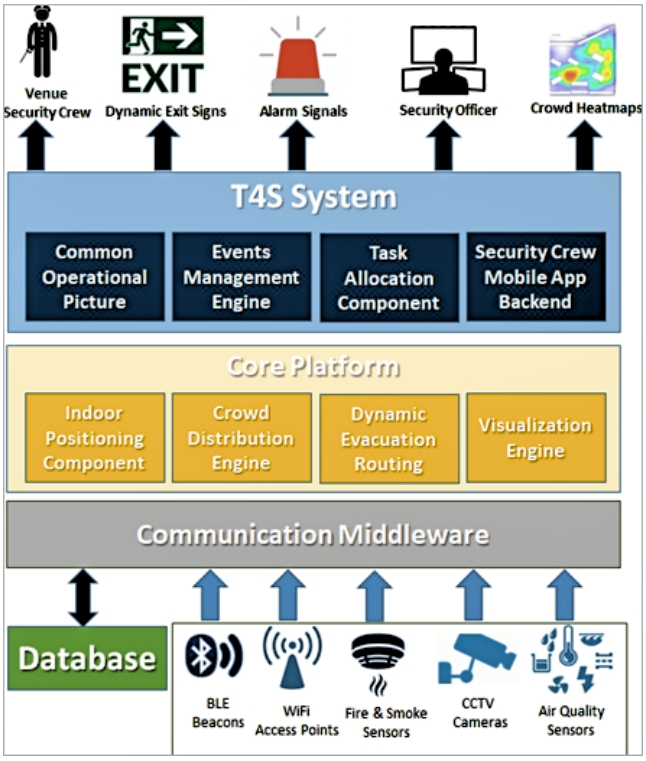


The project aimed to integrate the existing T4S platform developed by **Thridium** (one of the SMEs) to increase safety and security in football stadiums with AI-based business analysis tools from **Beam Innovation** (the other SME).

The project developed the BIE-T4S system, in which data from IoT sensors and CCTV cameras is processed in real-time to provide information on indoor positioning of venue staff and visitors, crowd distribution, dynamic evacuation routing, and for visualization. The information is used to provide a common operational picture, manage events, and to allocate tasks to venue staff for better crisis management and emergency response. Visitors are supported through dynamic exit signs.

BIE-T4S is now at TRL7 and has been validated under real operational conditions, complying with >90% of threats. During experimentation, the received alarms were analysed and all incidents were detected.

*"The main benefits BEAM gained from participating in the INNOVATE call was to advance our own technology by offering dynamic evacuation route calculation and complex event processing for detection of incidents and venue evacuation, broadening the company portfolio and also having completed the validation of our technology in real scenarios." - Romica Manolache, Chief Marketing Officer of BEAM Innovation*

## Additive Manufacturing for Quality and Monitoring System (AM QTOOLS)

Metal additive manufacturing (AM) is a complex operation that requires fine-tuning of hundreds of parameters of processes to achieve repeatability of good quality design at dimensional, geometric, and structural levels. Furthermore, most industrial AM systems contain sensors that generate huge amounts of data in the form of log signals, images, and videos. As yet, no systematic approach has been deployed in industry for analysing this data in real-time for quality control, which motivated this project.


The project aimed to develop a quality-oriented decision support framework, composed of: (i) a model -based design (MBD) tool that provides design for additive manufacturing (DfAM) features, and (ii) a cyber-physical system (CPS) created by integrating an AM asset with a real-time production monitoring software application.

The framework caters to the needs of process engineers and quality control managers to improve economic and quality KPIs.

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The development and operational phases of the project were performed in two overlapping steps.

The first step created the quality-oriented framework. The MBD approach abstracts the technical requirements and creates the project file containing all the necessary instructions for the CPS to print the designed parts (3D printing). The link between the MBD and the CPS is a catalogue of the features for aluminium parts that can be printed with a Laser Powder Bed Fusion (LPBF) process and of common defects, which captures available design know-how regarding the limits of such technology. Crucially, such information is enhanced by the knowledge generated by the CPS. The CPS augments the monitoring capabilities of advanced AM systems and integrates quality-oriented predictive models to enable smart process monitoring. Such models have been created by defining and executing targeted process DOEs, persisting machine and process data, and collecting the corresponding quality information obtained by CT-scan, optical tomography, and metallography cut-up.

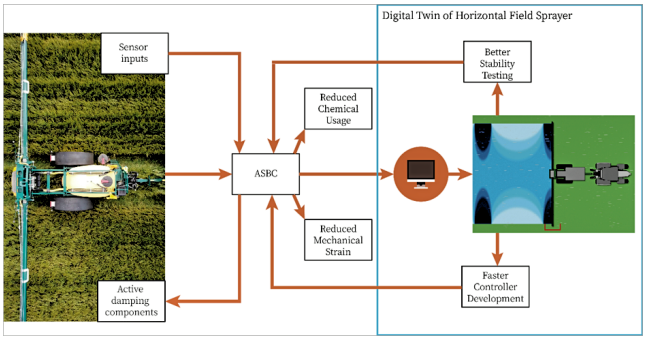
The second step validated the operational framework. To support the MBD phase, the CPS supplied the information useful to improve the project file and print the part by maximizing the part quality based on the design specifications. Decision support is enabled by the predictive models integrated in Smart ProdACTIVE (see below), tracking the process outputs, and (through data analytics) providing information of the expected quality outcomes of a specific setup. Thus, AM production was performed and Smart ProdACTIVE was applied to monitor and validate the improved part design.

Smart ProdACTIVE is a platform for real-time monitoring of a production process, which integrates data sources of production processes (machines and sensors) with software modules that provide data analytics. Smart ProdACTIVE was developed by **EnginSoft** (one of the SMEs) and is a HUBCAP asset.

***"AM QTOOLS developed, integrated and demonstrated quality-oriented decision support framework, including an in-process smart monitoring system capable of predicting metal Additive Manufacturing quality KPIs. The potential impact on manufacturing KPIs is manifold: AM process lead time reduction, COQ reduction, energy saving." - The AM QTOOLS Team***

## Digital Twin for Active Sprayer Boom Yaw Control (ASBC)

Field spraying is a basic task in modern agriculture, and typically uses a boom to deliver the liquid fertilizer and pesticide evenly over the ground. Boom oscillations reduce the efficiency of the spraying, but the efficiency can be improved significantly through active control of the roll/yaw motions of the boom. Traditional development of such control requires thorough physical testing that is time consuming and expensive, which motivated this project.




The project developed a digital twin (DT) of the **Danfoil** (one of the SMEs) Concorde II field sprayer. The DT was validated against dynamic test data acquired from tests run on the physical sprayer. The DT combines the model for active yaw control with the model for active roll control developed in the previous HUBCAP project Digital Twin for Active Sprayer Boom Roll Control (ARC), described in the June 2022 newsletter.

The DT is run from a single script that contains the initialization parameters for the roll and yaw models.

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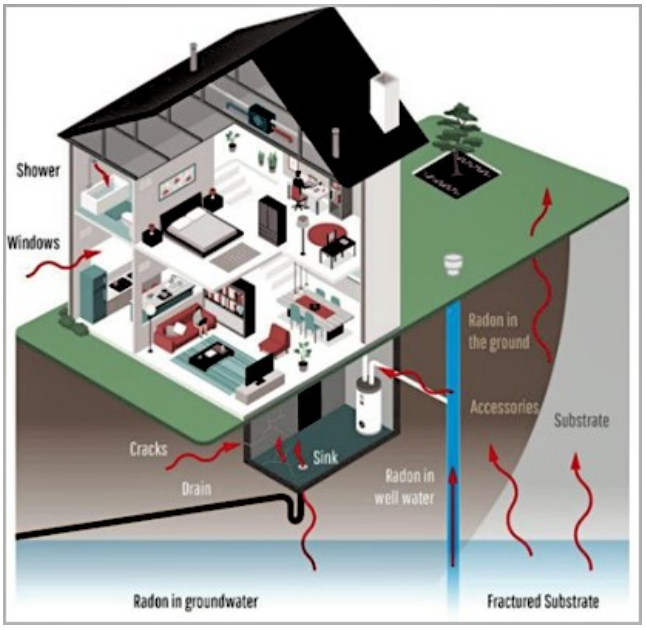
The DT inputs reference pressure and valve position from the sprayer system sensors, and calculates the corresponding translational and rotational position and velocity, and also the pressure of the sprayer system. The calculated values are used by the controllers to counteract the roll and yaw motion and thereby stabilize the boom. Simulations using the DT have shown promising results by keeping the angular velocity of the boom close to zero.

*"The HUBCAP Project has changed the trajectory of the SteadySpray control system significantly. The funding has enabled the development of a Digital Twin, that both can and will be used as a significant part of the controller design and maintenance protocol for the SteadySpray Kit for years to come."*
*- Thomas Schmidt, CEO of SteadySpray ApS*




## Blockchain in IoT Sensors (Block-IoT-Chain)

The project aimed to develop an infrastructure and network that can integrate blockchain technology into any IoT measurement device. The motivation was the need for a dependable IoT sensor system that detects radon, which is a naturally occurring radioactive gas and is the second leading cause of lung cancer worldwide (according to the WHO).

**Future Sense** (one of the SMEs) had developed the Bye Radon IoT sensors for the long-term measurement of radon gas in real-time. Also, a printed circuit board that converts a sensor into an IoT device.

**Cubic Fort** (the other SME) had developed the AirTrace platform that allows the generation of a permissioned blockchain network in the cloud to store securely all the data and measurements provided by any IoT sensor. The data is stored via two different options: RESTful API and MQTT, which are the two most widespread interfaces available for IoT.

The project integrated Bye Radon and AirTrace into a single architecture, implemented using the MQTT communication protocol and MB-IoT. Many new features were added to Airtrace, including traceability and scalability of the data uploaded to the cloud, and blockchain helps to ensure data integrity and authenticity. Drag and drop aids the selective integration of IoT networks.

The architecture was validated using two pilot studies. The first was in Cieza (southern Spain) and lasted 5 months; 27 devices were used and measured radon, temperature, and humidity. The second study lasted 3 months; 8 devices were used and measured (in addition) particulate matter, total volatile organic compounds, equivalent $CO_2$, and atmospheric pressure. Results from both pilot studies were good.

*"This public funding program has helped both companies to research and develop the necessary infrastructure to certify measurements that come from any IoT device. The final development and implementation is currently under the last testing phase and we are working to have the final version of AirTrace in middle September, sending the measurements directly from the Bye Radon devices to the platform and introducing these measurements into the selected blockchain. Without this funding program, this important R&D project could not have been possible." - The Block-IoT-Chain Team*

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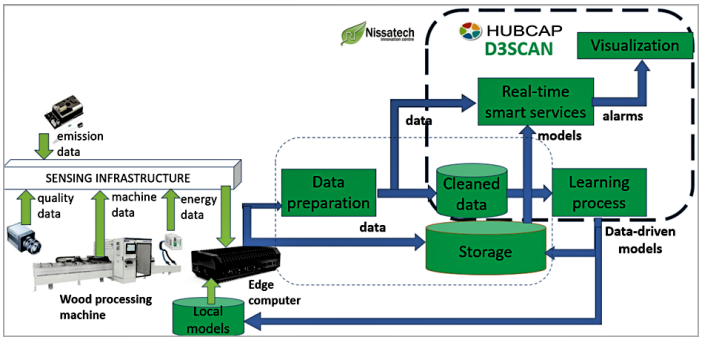
## Data-driven Digital Twin supporting Efficient and Environmental-friendly Wood Processing (GreenWood)

The project aimed to develop a new generation of wood processing monitoring services that help to achieve both process performance targets (KPIs) and a reduction in adverse environmental impact.




Energy consumption and greenhouse gas emission by the production of timber goods were identified as the key factors in wood processing that adversely impact the environment. Existing wood working machines of a production process were retrofitted with new sensors (according to Industry 4.0) to collect data for modelling and analysis. All process parameters affecting the two factors were monitored, models of valid/proper process behaviour were created, and reaction to unusual patterns of behaviour was also defined. The HUBCAP asset D3Scan (Deep Data Diagnostics through Cognitive Scanning) was used to produce a (near) real-time digital twin of the production process for modelling and to analyze its complex behaviour, which helped to improve its energy consumption and greenhouse gas emission.

*"HUBCAP enabled a risk-free innovation in a very important (energy reduction and environmental protection) and business promising area."*
*- The GreenWood Team*

## An Exciting Future for HUBCAP

As we come to the end of initial EC funding for HUBCAP, we want to share our plans for 2023 and beyond. From January onwards, you can continue to access HUBCAP's expertise and platform, and there are exciting plans for the future:

- Our **web site**, service centre (**info@hubcap.eu**), and social media presence will continue to be maintained and developed by our partners at Newcastle and Aarhus Universities.
- Our Digital Innovation Hubs will continue to make Model-Based Design more accessible for SMEs and can be accessed through our website or service centre and as part of the **DIH4Industry** network.
- Our platform, with its marketplace of models and tools and its "test before invest" capability, will continue in an exciting new form. We are partnering with **Perpetual Labs** (PL), a start-up that is developing **GitWorks** — an innovative platform for Model-Based Design. PL will host the HUBCAP platform from 2023, taking over from its developers, Engineering Italia. In 2023/24, the public platform will be phased out, but you will still be able to access all the data that was hosted on the public platform and have the opportunity to migrate to GitWorks. GitWorks will operate with a freemium basis, allowing you to create accounts and host public repositories with your Model-Based Assets for free. Premium features requiring large amounts of (computational or storage) resource will be accessible through an affordable subscription plan. For further details, click **here**.