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Digital Innovation HUBs and CollAborative Platform for cyber-physical systems

HUBCAP

Communication, Dissemination and Exploitation 2

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Abstract

This document reports on the status of communication, dissemination and exploitation activities in HUBCAP up to Month 36 (M36). It covers: communications, including communication planning and channel statistics; dissemination, including publications and collaborations; development of exploitation and long-term sustainability plans. Lessons learned in communication and dissemination activities, post-pandemic, are described.

List of Acronyms

A-CPS	Applied Cyber Physical Systems EDIH
CD-EDIH	Central Denmark EDIH
CPS	Cyber-Physical Systems
DoA	Description of Action
DIH	Digital Innovation Hub
DT	Digital Twin
DTA	Digital Twin Accelerator
EDIH	European Digital Innovation Hub
EC	European Commission
EIT	European Institute of Innovation & Technology
EITD	EIT Digital
EU	European Union
FED4SAE	Federated CPS DIHs for the SAE Initiative
FIT EDIH	Futures of Innovation Technologies EDIH
GSVF	Graz Symposium Virtual Vehicle
HDS EDIH	Health Data Sweden EDIH
HUBCAP	Digital Innovation Hubs AND Collaborative Platform for CPS
I4MS	ICT Innovation for Manufacturing SMEs
IDSA	International Data Spaces Association
INTO-CPS	Integrated Tool Chain for Model-Based Design of CPS
IP	Intellectual Property
MBD	Model-based Design
OC	Open Call
OS	Operating System
PL	Perpetual Labs
PPT	Powerpoint
Q&A	Question and Answer
SAE	Smart Anything Everywhere
SID	Sibiu Innovation Days
SME	Small Medium Enterprise
VPC	Virtual Private Cloud
WP	Work Package

Contents

1 Introduction

This deliverable reports communication, dissemination and exploitation activities in Months 19 to 36, reflects on lessons learned, and looks forward to plans for relevant activities after the project ends. We cover: communications, including communication planning and channel statistics (Section 2); dissemination, including publications and collaborations (Section 3); an assessment of HUBCAP's impact on participants (Section 4), and a forward look on future exploitation by the individual partners (Section 5). In D7.2, we reported on our initial collaborative activities aiming to create a sustainable future for the HUBCAP platform and DIH ecosystem. Work continued in the reporting period, resulting in the strategy described in D2.4. We therefore do not repeat details of that work here.

In the reporting period communications, dissemination and exploitation continued as the responsibility of all project partners, managed in WP7. The overall goals remained to attract high-quality experiments and innovation projects to funded calls, grow the platform and the community of interest around it, disseminate success stories, and maximise exploitation of assets from stakeholders. Specific objectives in the DoA were addressed as follows:

- *To establish a project visual identity and templates for all media.* Materials developed in Task T7.1 and reported in Deliverable D7.1 were maintained and refined further (reported in Section 2.1).
- *To establish and maintain external communication channels.* Following the pandemic, we maintained our focus on electronic media rather than print. Progress is reported in Section 2.
- *To provide a central point of contact for stakeholders wishing to access the HUBCAP network.* The UNEW "Service Center" continued to provide a central contact point for directing queries, as described in Section 2.2.
- *To disseminate project results and success stories.* Work focussed on both securing engagement with calls and platform (T7.3) and on developing materials describing users' experiences from the supported experiments. Section 3 gives further detail.
- *To establish cooperation with other projects in the Smart Anything Everywhere (SAE) initiative and beyond.* We continued to have positive cooperation with SAE and with other initiatives (T7.4). Progress is described in Section 3.2.
- *To prepare future exploitation activities through market studies and business planning.* As described in D7.2, we initiated T7.5 on future exploitation ahead its planned m18 start. Activities to identify potential exploitation for the emerging HUBCAP platform led to the outcomes described in D2.4. Section 5 gives an overview of this and individual partners' future exploitation plans.

The report concludes by discussing lessons learned in communication, dissemination and exploitation, and our plans for activity building on HUBCAP's legacy (Section 6.1). Finally, we note that the DoA indicates that this deliverable should contain "status on all KPIs measured". However, we considered it more appropriate to consider performance against KPIs as a whole in the m36 Periodic Progress Report. In this document, we report only the KPIs

relating to communications, dissemination and exploitation work.

2 Communication Activity

2.1 Project Visual Identity and Templates

The HUBCAP visual identity was created in the beginning of the project, as reported in D7.1 and D7.2. Since then, no updates were made to the project logo or the graphical templates that were developed for all project documents, including deliverables, reports, minutes, and other important communications. Alongside these graphical templates, F6S developed social media visual templates that were utilized to promote and disseminate the three open calls and their related activities.

2.2 Communications Channels and Service Centre

The following is a summary of the communication channels run by HUBCAP through Task T7.2. Traffic and statistics can be found in Appendix A.

2.2.1 The HUBCAP Platform

The HUBCAP Platform became a new channel of communication after M18. It has both a public page, used to draw users in, and a private area for members. Figure 1 shows the elements of the public page (a single page accessed by scrolling). This includes a welcome and a call to action to join, highlighted Success Stories, and a community map. The private area includes a blog and community posts, along with the models and tools catalogue and the sandbox and Success Stories that link direct to these where appropriate.

2.2.2 The F6S Platform

At the beginning of the HUBCAP project, a dedicated page was created at the F6S Platform to share the HUBCAP funding programme, website, and team. This page has been the focal point for sharing information concerning the HUBCAP programme applications and for the HUBCAP community building. This is seen in Figure 2. Throughout the entire programme, eight transversal pages were created at the F6S platform, each dedicated to a specific open call and all linked to the main HUBCAP Programme page. Overall, five pages were created for the PULL calls, two pages for EXPERIMENT calls, and one page for INNOVATE.

Besides being used to publish and manage the open calls, the F6S platform was also valuable for scouting potential SMEs for the HUBCAP Programme. Through the F6S vast network, it was possible to engage with overall 568 SMEs, namely 346 from the PULL calls, 135 from the EXPERIMENT calls and 87 from the INNOVATE call. The F6S Platform was also used for community moderation by communicating openly about the project, presenting opportunities and publishing events such as webinars and matchmaking events. Under the HUBCAP project, 10 events were created and disseminated through the F6S plat-

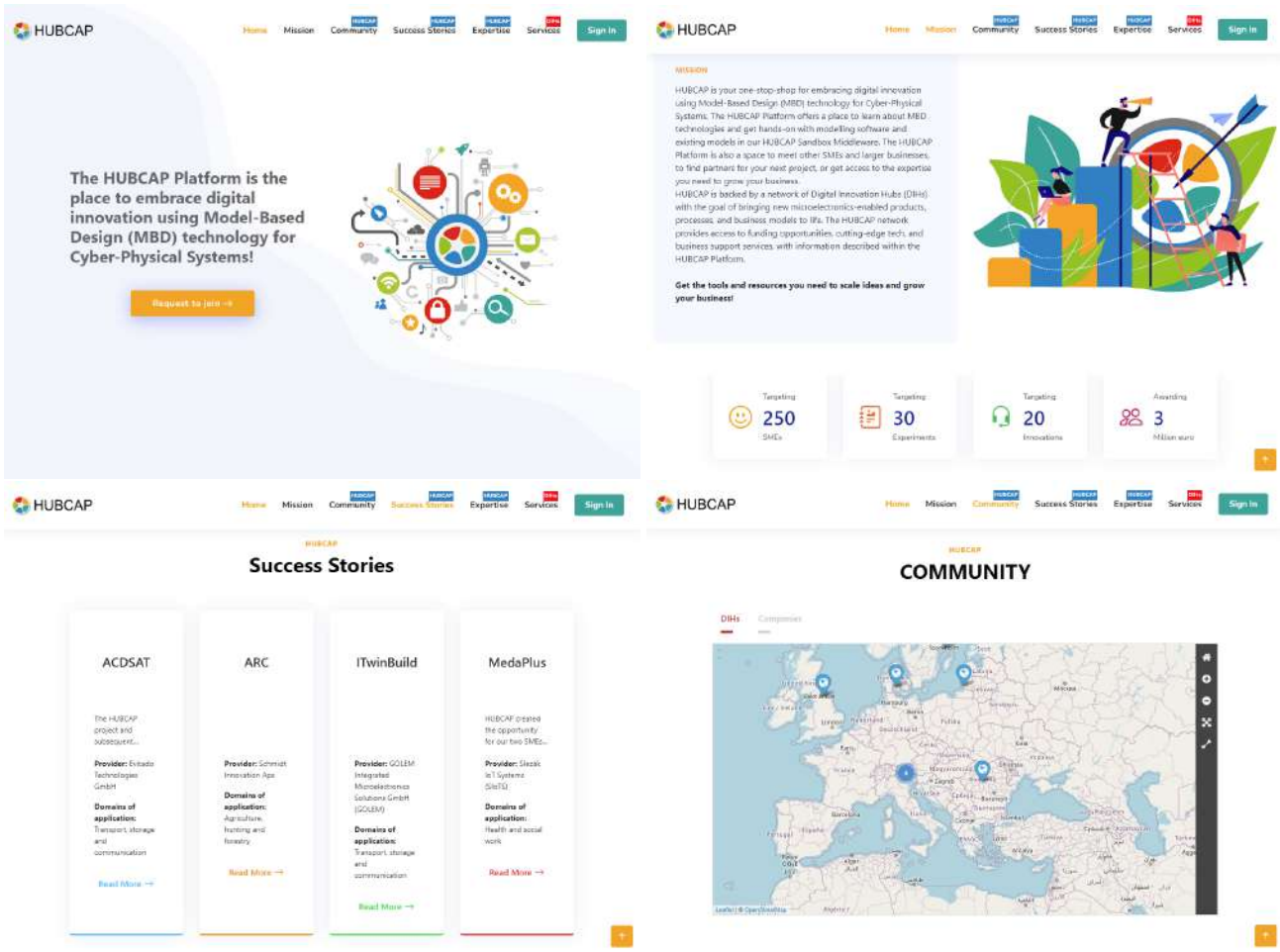


Figure 1: HUBCAP Platform front page content (scrolled), including welcome/call to action, mission, success stories, and community.

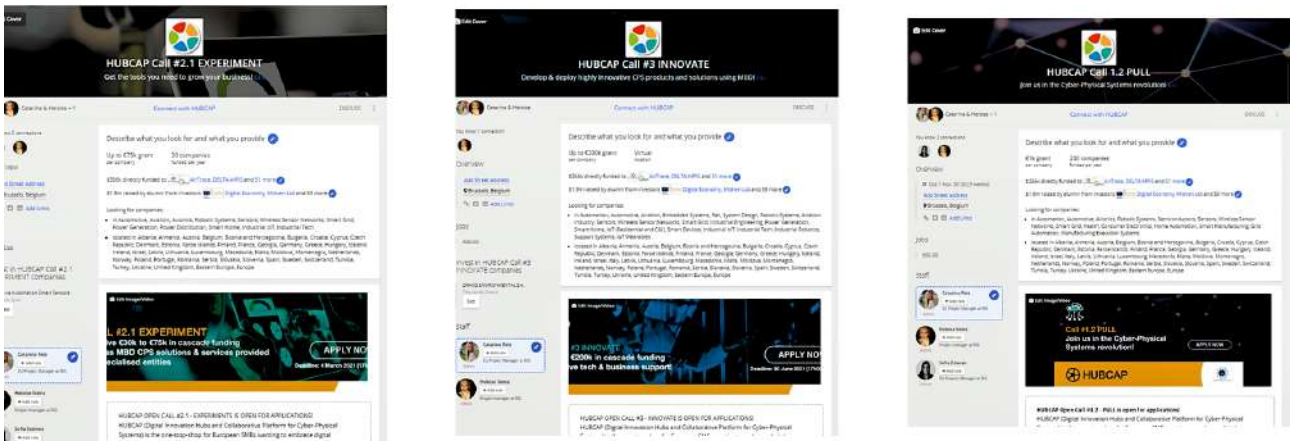


Figure 2: F6S dedicated pages for the open calls under HUBCAP Programme.

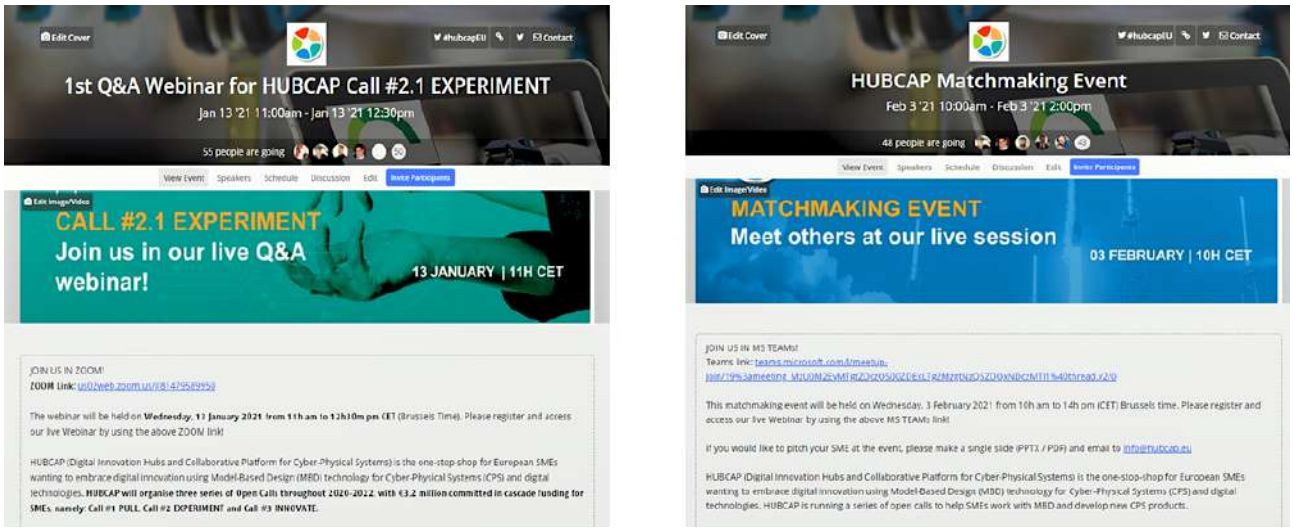


Figure 3: F6S events created for the promotion and support of the HUBCAP open calls.

form, specifically five Q&A Webinars, three Matchmaking Events, and two combined Q&A + Matchmaking events. A sample of sign-up pages are shown in Figure 3.

2.2.3 Web Site

The website[1] continued to be one of the main sources of information about the project and available to all stakeholders. The initial goal was to promote the project and in particular the open calls. In the second half of the project, and particularly since the open calls closed, the focus has shifted to promoting the platform and success stories from the open calls. A screenshot of the updated homepage is included in Figure 4, showing the new menu entries.

Compared to the description of the website in D7.2, the main changes are:

- A Success Stories section (https://www.hubcap.eu/success-stories/) with an entry on the main menu. This provides a list of Success Stories with a link to the individual page of each, see Figure 5. The Success Story format shows (see Figure 6):
  - An informative title
  - A box with project information including SMEs and the DIH
  - A box with the main impacts and outcomes
  - A quote from the SMEs about the project
  - Body text covering:
    - The problem and the solution
    - What was carried out
    - How HUBCAP supported the project
    - Forward look
- A Success Stories slider on the main page cycling through the published Success Stories. This replaces the Open Call slider that cycled through the three open call

[1] http://hubcap.eu/

types.
- A direct link to the Platform (https://hubcap-portal.eng.it/) to draw people in to access further information and engage with the HUBCAP Platform.

The site will be maintained after the project, as described in Section 5.1.

2.2.4 Newsletter

Following completion of the EXPERIMENT and INNOVATE projects, a selection of projects were publicized in three online newsletters on the HUBCAP website, see `https://www.hubcap.eu/newsletters` and Figure 7. The final newsletter also included details about the next steps and sustainability plan. The newsletters were also emailed to the 167 mailing list subscribers.

The newsletters were aimed at the general interested reader, and summarise the context of each project, its aims, the work undertaken by the collaborating SMEs, and the outcomes. Where possible, we have included a quotation from the SMEs that describes how HUBCAP contributed to their project, their experience of using model-based design, and their advice to developers of cyber-physical systems who are curious about, or interested in using, model-based design techniques.

2.2.5 Service Centre Email

The Service Centre email address is `info@hubcap.eu`. Members of the public and participants in open calls used this email address to ask questions about any aspect of HUBCAP. UNEW administered this account and either responded directly, or forwarded to the relevant project partners, if necessary. Response time was one-to-two working days, depending on the type of request and whether coordination with other project partners is required. Queries to the Service Centre peaked around the open calls, on average 15 queries involving 30 messages (initial query, response, follow up, response). Between open calls, queries averaged two to four per month.

Figure 4: Updated HUBCAP homepage including Success Stories and Platform menu items.

Figure 5: Success Stories section of the website.

Figure 6: Success Story from the GIMLI project (Call #3 Innovate).

Figure 7: HUBCAP newsletters for October, November, and December 2022.

2.2.6 Social Media: Twitter and LinkedIn

LinkedIn and Twitter are the social media channels used by HUBCAP to promote the project open calls, project activities, and lately success stories. Both platforms have been used to quickly disseminate short messages and target specific groups of audiences (SMEs and startups, other DIHs and other EU projects). Twitter is good to connect to other EU projects, SAE, I4MS, other EU programmes, and some DIHs, while LinkedIn was more effective in reaching out to SMEs, DIHs and policymakers. This gives good coverage of a range of stakeholders.

Twitter Account – @hubcap_eu
URL – `https://twitter.com/hubcap_eu`
594 Followers
327 Tweets

In this second period of the project, we see an increase in the final number of followers from 508 to 594. This is due to a continuous dissemination of information concerning open calls, workshops, and events, and currently the HUBCAP success stories from the selected consortia and their respective projects outcomes. The main focus in the final months has been the dissemination of the success stories (e.g. Figure 8 and Figure 9), allowing both the HUBCAP project and its beneficiaries a wide visibility regarding other EU projects under the Smart Anything Everywhere topic.

LinkedIn
URL – `https://www.linkedin.com/company/hubcap-eu`
330 Followers

2.2.7 YouTube and Video Assets

The YouTube channel hosts all public videos created in the project, both by partners and funded projects. The new content is primarily demonstration and Success Story videos created by the SMEs who received funding through Calls #2 EXPERIMENT and Call #3 INNOVATE. These are embedded in Success Story pages and used for social media posts. Playlists were also created to group them, as shown in Figure 10.

YouTube
URL – `https://www.youtube.com/@hubcap_eu`
46 Subscribers

Although the channel only has 48 subscribers, within the second half of the project, views jumped from just under 700 to almost 3,000. This is to be expected as most views will be driven from the other channels where the videos are linked or embedded. This was confirmed during the initial rollout of the Success Story pages which drove the videos from those projects into the top-viewed videos on the channel.

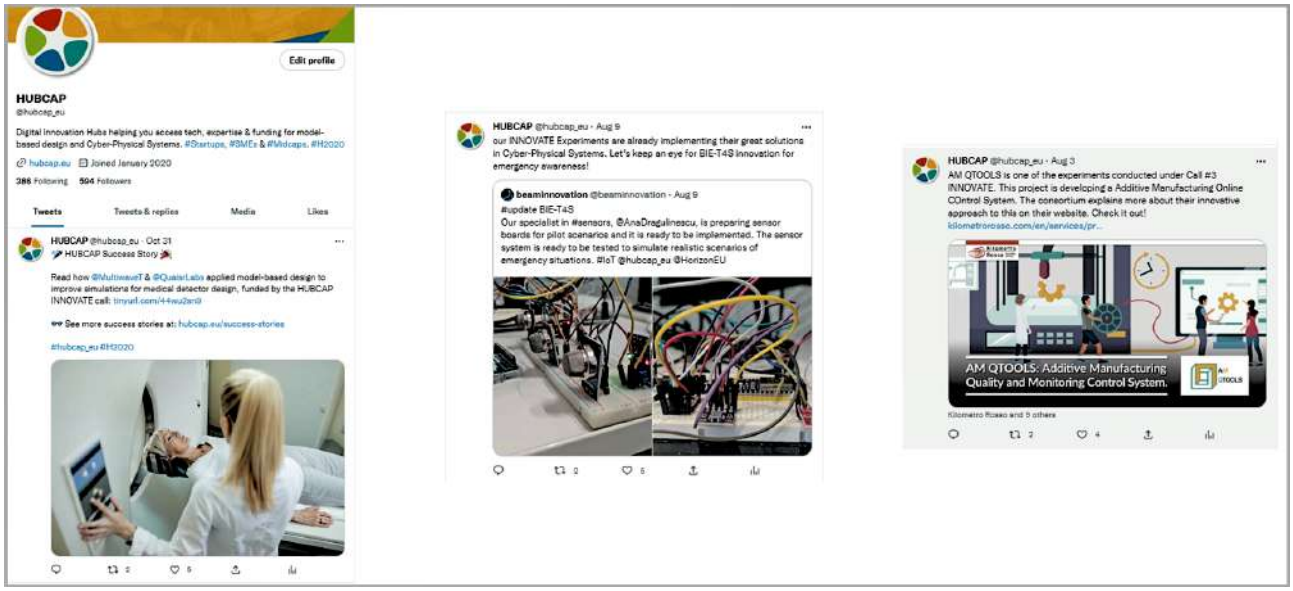


Figure 8: Tweets of HUBCAP Success Stories.

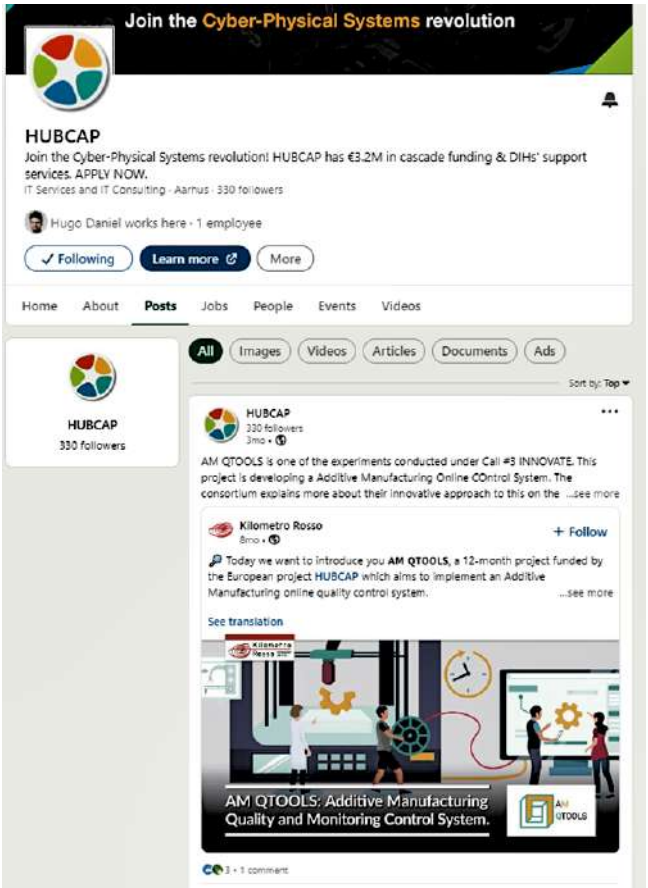


Figure 9: LinkedIn post of a HUBCAP success story.

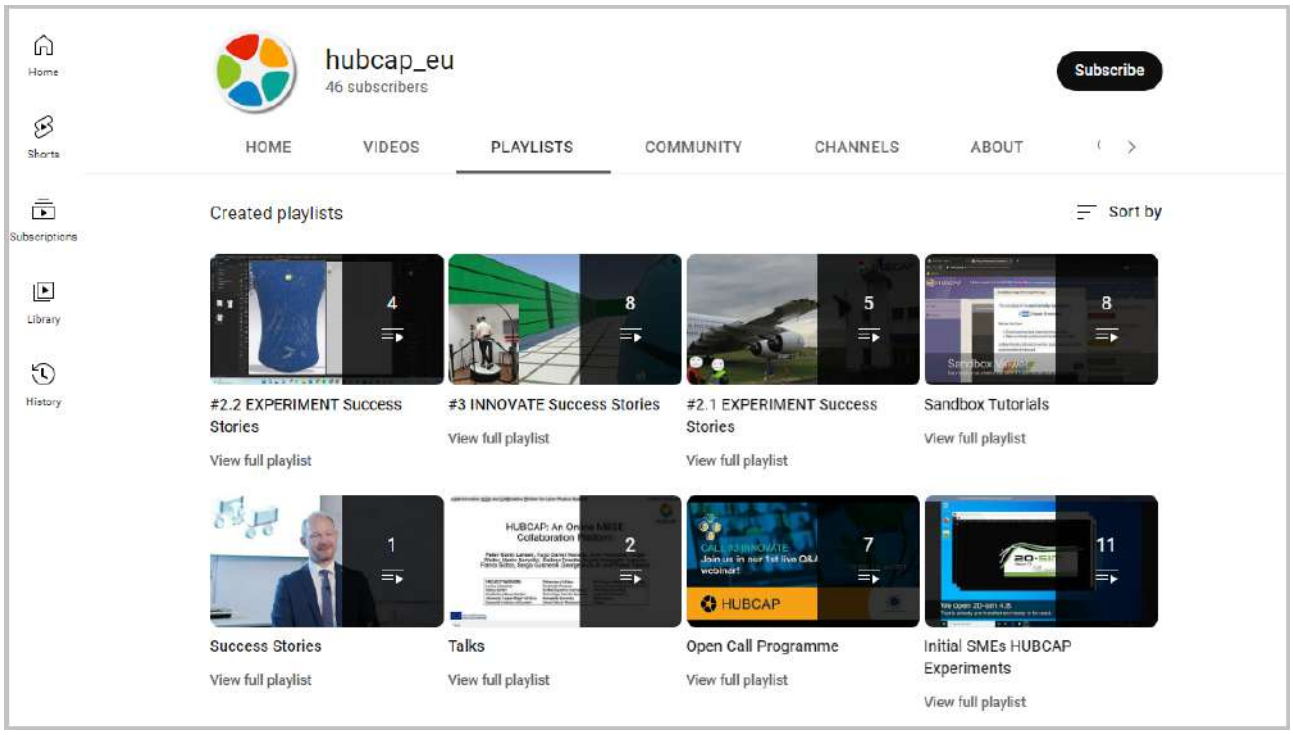


Figure 10: YouTube channel in November 2022.

2.3 Communications Strategy and Call Promotion

2.3.1 Communications Strategy

For this second period, we proceeded with the work previously planned and reported under D7.2. The communication campaigns have been created and implemented throughout the period of the open calls to attract efficiently more SMEs to the HUBCAP programme. They have been implemented in both LinkedIn and Twitter.

Metrics indicate that Twitter campaigns attracted more clicks, but it is unclear how many of these led directly to funded projects, and these channels seemed to work best in publicising the calls and webinars. Since the Open Calls have been completed, for the current reporting period the main focus of the communication activities will be the dissemination of Success Stories from Calls #2 EXPERIMENT and #3 INNOVATE.

2.3.2 Call Promotion

At the level of Open Call promotion, we continued to use the materials previously created and presented in D7.2, such as social media visuals (e.g. Figure 11 and Figure 12), virtual flyers (e.g. Figure 13), press releases and the package promotion kit for each open call for internal use. Regarding social media visuals, the PULL call visuals were updated with the aim of catching new viewers attention and reinforcing the objective of the PULL calls, thus increasing the applications to Calls #1.4 and #1.5. The same update was made to the

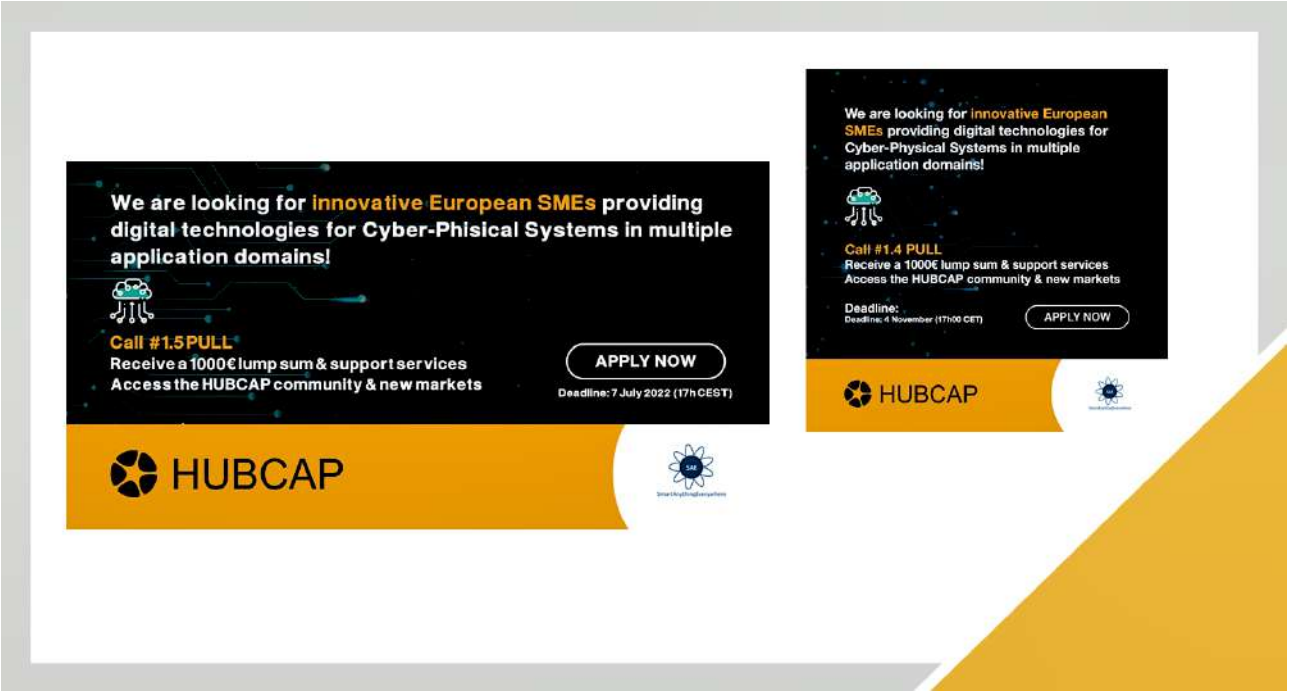


Figure 11: Updated social media visuals for the PULL calls.

visuals allocated to the promotional events and flyers, for both Calls #1.4 and #1.5.

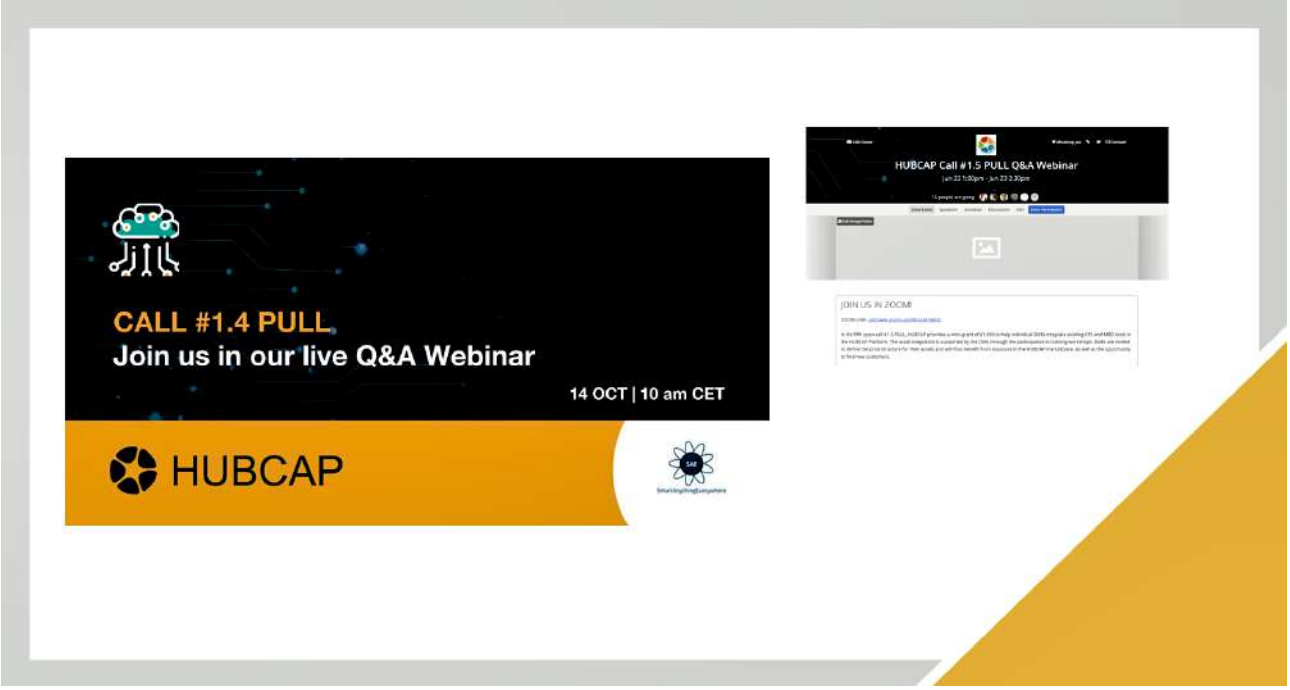


Figure 12: Updated visual for the PULL calls promotional events.

Figure 13: Updated PULL calls flyer.

3 Dissemination Activity

3.1 Introduction

Dissemination activities were crucial for the success of communication and outreach by the HUBCAP project. The activities helped to achieve the overarching goals of the project and led to greater awareness within the ecosystem.

This section begins with a discussion of the dissemination activities that took place in the second half of the project. Several activities are highlighted and detailed further, and we conclude with a summary and lessons learned.

3.2 Dissemination Activities

The HUBCAP project planned a series of activities over the second 18-month period of the project. These include events, blog posts and news items, publications and other literature. The success of the dissemination of the project lies in the planning of events and mitigating challenges. As mentioned in Section 3.5 below, the ability to hold in-person events was still severely restricted due to the pandemic and it was not possible to hold in-person events while the open calls were running. This did mean however that we could attend more events organised by others than originally planned, and our online events still led to high-quality submissions to the open calls.

Table 2 shows a selection of the main dissemination events taken place over the second 18-month period; an exhaustive list can be found in Appendix B.1. This shows highlighted events with a brief description of HUBCAP's involvement. HUBCAP and its partners have been able to attend several workshops and conferences, updating and promoting audiences on the ongoing efforts to expand its ecosystem and advertise the open calls.

The SAE Cluster Collaboration Workshop was an excellent platform to introduce and showcase HUBCAP, as well as its aims over the duration of the project. Events such as FED4SAE were held, in which HUBCAP was represented in a "virtual stand". Events such as this allowed partners to take questions and elaborate further on the project and the open calls, including how to apply and upcoming HUBCAP workshops. HUBCAP also attends networking events such as the DigiFed DIH Network Event and the Enterprise Europe Network Event. Maintaining a presence at these networking events, and presenting updates on the project and the open calls is an excellent way for HUBCAP to disseminate within its targeted networks. HUBCAP has actively sought out new and upcoming events to help promote and expand its ecosystem.

Table 3 shows a selection of publicity in the form of industry articles, press releases, and HUBCAP in the news, undertaken during the second 18 months; an exhaustive list can be found in Appendix B.2.

Events and other publicity are two aspect of HUBCAP's dissemination efforts. In addition, we have published in academic venues as well to help achieve maximum outreach. Table 4

Table 2: Selected dissemination events during the second 18 months.

Dissemination Events			
Event Name	**Date**	**Description**	**Partners**
The BIG Tomorrow Digital Transformation Forum	01.07.21	Online conference targeted on SMEs in central Romania. HUBCAP and the then open calls were presented.	ULBS
14th Graz Symposium Virtual Vehicle (GSVF) 2021	01-02.09.21	Forum to discuss recent advances in system integration and virtual validation. General HUBCAP presentation with focus on the platform and open calls. HUPCAP flyers displayed.	VV
Summer School 2021: Beyond AI	13-15.09.21	Organized by VV, Graz University of Technology, and University of Graz. HUPCAP flyers displayed.	VV
Opening of fortiss Labs	29.06.22	Organization of a workshop and exhibition. The Mobility Lab (Model Based Systems Engineering) is related to HUBCAP.	FOR
TechChill Milano 2022	28-29.09.22	International forum for start-ups to meet and form collaborations. HUBCAP, open calls, and success stories were presented.	F6S
Sibiu Innovation Days (SID) 2022	29-30.09.22	Conference for industry, academia, and SMEs to discuss: Digital Transformation - National and European Challenges and Risks in Post Pandemic Era. HUBCAP was presented.	AU, FOR, UNEW, ULBS
DIH-WORLD event	08.11.22	Webinar to enable DIHs interested in collaborating with other relevant initiatives to meet. HUBCAP was presented with a focus on the platform.	VV

shows a selection of the publications over the second 18 months; an exhaustive list can be found in Appendix B.3.

Table 3: Selected media publicity during the second 18 months.

Media Publicity					
Title	**Date**	**Category**	**No. of Persons Reached**	**URL / Description**	**Partners**
HUBCAP Call #3 INNOVATE Final webinar	01.07.21	LinkedIn post	Scientific Community: ≈2300, Industry: ≈2100, General Public: ≈1000, Policy Makers: ≈50, Other: ≈250	https://www.linkedin.com/posts/sonja-kaiser-virtual-vehicle_hubcapeu-smartanythingeverywhere-opencall-activity-6817776344693293056-OJHI https://www.linkedin.com/feed/update/urn:li:activity:6817794689094209536 (+ Reposts by Martin Benedikt, Gerhard B. Weiß).	VV
HUBCAP Project	01.09.21	Industry article	Industry: 1000	Virtual Vehicle Magazine, Issue 32/2021, pp 12-13, "Digital Innovation HUBs and Collaborative Platform for Cyber-Physical Systems", authors: Gerhard B. Weiß / Sonja Kaiser. Two-page article in our quarterly print magazine for external partners (available from 1.9.2021), edition: 1000 units, target group industry experts and partner companies, PRINT VERSION.	VV
Call #1.4 PULL	13.09.21	Direct e-mail	Industry: 56	Direct e-mail to 56 SMEs by ViF-Marketing.	VV
Call #1.4 PULL	15.09.21	News on website newsfeed	-	https://ece.au.dk/aktuelt/nyheder/nyhed/artikel/new-opportunities-for-sme-providers-of-digital-technologies	AU
Call #1.4 PULL	15.09.21	Instagram post	Scientific Community: ≈100, Industry: ≈90, Civil Society: ≈73, General Public: ≈40, Policy Makers: ≈5, Other: ≈25	https://www.instagram.com/p/CT1gx33qVI_/?utm_source=ig_web_copy_link	VV
Call #2.2 Experiment	26.11.21	Press release	Media: ≈500	Press release to Virtual Vehicle's standard mailing list: 500 media contacts across Europe with target group mainstream media and specialist publications.	VV
Call #1.5 PULL	05.22	LinkedIn post	Scientific Community / Industry: ≈600	https://www.linkedin.com/feed/update/urn:li:activity:6933295090673049600	FBK

Table 4: Selected academic publications during the second 18 months.

Academic Publications				
Publication Name	**Year**	**Publisher**	**Link**	**Partners**
HUBCAP: A Novel Collaborative Approach to Model-Based Design of Cyber-Physical Systems	2021	Springer	https://drive.google.com/file/d/11J-AmoXth-z2TEY1sIpvvSFEUK-bbbq5/view	AU, UNEW, FOR, VV, FBK, ENGIT, POLIMI, BEIA
Deploying the Smart Energy Tool for Investment Simulation inside the HUBCAP Sandbox	2021	Creative Commons	https://www.cal-tek.eu/proceedings/i3m/2021/sesde/003/pdf.pdf	BEIA, AU, POLIMI
Extending the Formal Security Analysis of the HUBCAP sandbox	2021	arXiv	https://arxiv.org/abs/2110.09371	AU, ENGIT
Problematizing the Service Portfolio of Digital Innovation Hubs	2021	Springer	https://www.researchgate.net/profile/Fredrik-Asplund/publication/356215502_Problematizing_the_Service_Portfolio_of_Digital_Innovation_Hubs/links/619d14a107be5f31b7aeb8d2/Problematizing-the-Service-Portfolio-of-Digital-Innovation-Hubs.pdf	KTH, AU, POLIMI
PROSIM in the Cloud: Remote Automation Training Platform with Virtualized Infrastructure	2022	MDPI	https://www.mdpi.com/2076-3417/12/6/3038	ULBS
Building the Value Proposition of a Digital Innovation Hub Network to Support Ecosystem Sustainability	2022	MDPI	https://www.mdpi.com/2071-1050/14/18/11159	POLIMI

3.3 Success Stories

As mentioned in Section 2, the Success Stories were the primary focus of dissemination in the second half of the project, reporting on the exciting projects successfully carried out by the SMEs funded through HUBCAP. Working with WP4, a Publishable Summary template (see Appendix C) was added to the deliverable templates to collect materials for Success Stories and Impact Assessment (see Section 4). This material was then used to present Success Stories through the HUBCAP Platform, website, newsletters, and social media, being edited or summarised for each venue as appropriate. The project has published and promoted 18 Success Stories from both EXPERIMENT and INNOVATE projects. The overall dissemination strategy for Success Stories was:

- The HUBCAP Platform hosts versions of each Success Story in the private area, including access to 'try it now' in the sandbox (where possible);
- The HUBCAP Platform public page shows highlights of those Success Stories to entice people to join (see Figure 1);
- The website hosts all Success Stories for the public to view, with links through to the HUBCAP Platform to bring in new users (see Figure 5);
- The newsletters report summaries of the Success Stories with link to the website for more information (see Figure 7);
- A campaign of social media posts on Twitter and LinkedIn highlight each Success Story in turn linking through to the website page (see Figure 14).

Figure 14: Social media post publicising a Success Story with a link to the website version.

A first version of the Publishable Summary template was included in the Call #2.1 EXPERIMENT deliverable template. However, this was not very successful in producing useful summaries, as the guidance was unclear. The summaries were inconsistent in terms of their length and quality, and generating Success Stories from them required effort. Also, the DIH followers did not always press the SMEs to improve their summaries. In the revised Publishable Summary template, further guidance was added and a corresponding 'check' was added to the report form that the DIH followers had to complete after each sprint / phase. This resulted in high-quality material for the 18 Success Stories from Call #2.2 EXPERIMENT and Call #3 INNOVATE.

3.4 Demonstration Videos

As with the Success Stories, video material is an important part of online dissemination activities. Each experiment or project was required to provide a video demonstration. Detailed guidance was produced to help SMEs to tell their own Success Stories through this demonstration video, which were then used to support the textual Success Stories. These videos are also useful for producing enticing and interactive social media posts, and as input for general HUBCAP 'success' videos. This proved highly successful for Call #2.2 EXPERIMENT and Call #3 INNOVATE, as seen in Figure 15. As with the Success Stories, the first version of the guidance was less successful for Call #2.1 EXPERIMENT, and the demonstration video was also not mandatory. This was altered in WP4 along with improved guidance.

3.5 Dissemination Challenges

As described in D7.2, the pandemic caused difficulties in communication and dissemination, with the cancellation of many external-facing events and removal of the option of meetings in person. The planned in-person activities such as workshops, matchmaking events, and webinars moved to online platforms. While D7.2 included a forward look which suggested that the return of in-person events might be a possibility, the travel and social distancing restrictions continued well into the second period. With most planned events focusing on

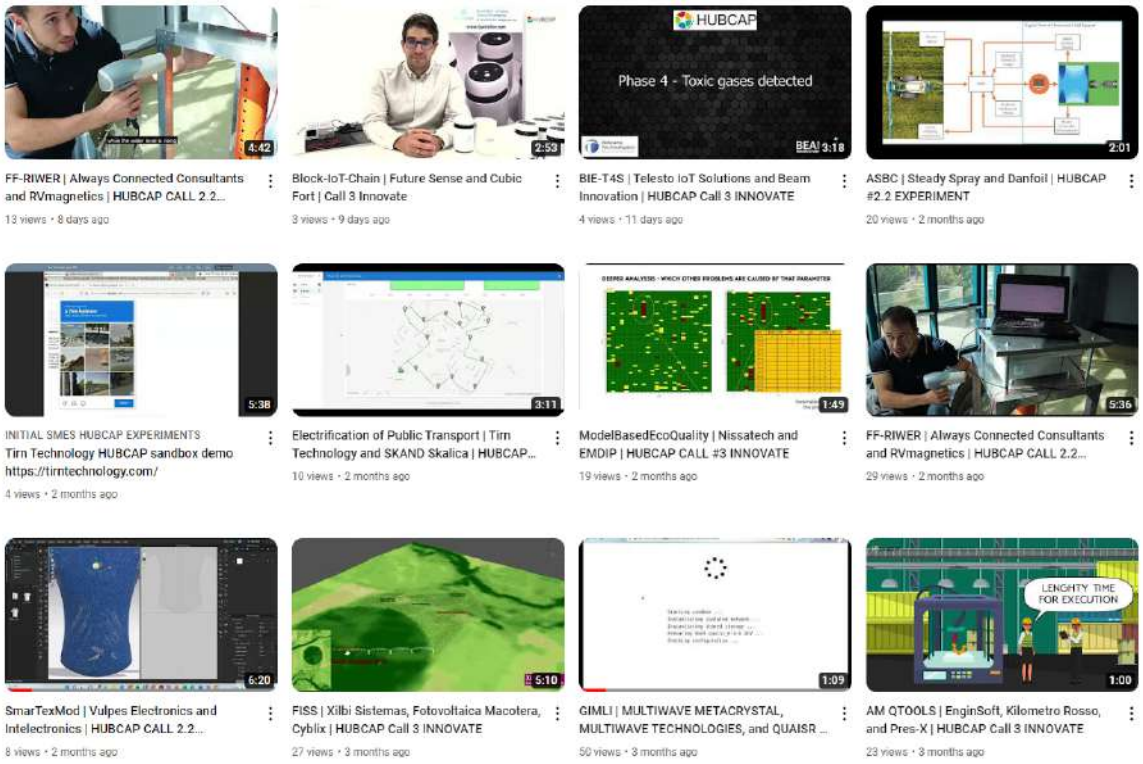


Figure 15: Some of the demonstration videos produced by SMEs.

generating high-quality submissions to the open calls, these all continued as online events as they fell within the period of restrictions. Given what we (and our audiences) learned about working online over the previous two years however, this did not cause undue difficulty in achieving excellent outcomes in submission and successful proposals.

4 Impact Assessment and Lessons

4.1 Impact Assessment

The endeavour of assessing HUBCAP's impact, exploitation and sustainability is both important and necessary for the success of the project. However, it is also comprised of multiple aspects that need to be evaluated during and, for some of them, even after the nominal project end date. Figure 16 outlines the lines of investigation for impact, their relation to other WPs, as well as arguments for continued sustainability from positive impact assesments. Aspects of impact assessment analysed in other WP deliverables will be only briefly mentioned (and linked).

	Impact related to the DIHs collab. with WP2	Impact related to the Platform collab. with WP6	Impact on the Ecosystem and SMEs collab. with WP4
Relevant data regarding impact	- Upgrade to EDIH - Complementarity of DIHs - Collaboration among DIHs - Awareness growth outside the HUBCAP DIH network	- Number, diversity (and quality) of assets at the end vs. the beginning of HUBCAP - Statistical analysis regarding the accessing, use of assets and behaviour of users - Improvement of the platform framework and the sandbox features during HUBCAP - Alignment of the market needs with the platform assets (VPC)	- Case studies (e.g. success stories with business and technological impact information) - Number of call applications, percentage of in scope ones, variety of applicants, geographical spread of applicants and consortia - Number and variety of promotional videos - Effectiveness of marketing and social media campaigns - Lessons learned
Sustainability argument	A large, strongly connected and continually improving DIH network focused on MBD has the best prospects of sustainability	An organically growing market of models and tools assures sustainability beyond the HUBCAP project nominal end	A sustainable ecosystem through the stimulation of community activities and raising awareness.

Figure 16: Aspects of impact assesment.

4.2 Impact for DIHs

Deliverable D2.3 provides a detailed view of the DIHs, highlighing both the overlap and complementarity of services offered and the customer journeys. Although valuable in itself, this analysis has also enabled the identification of opportunities for further collaboration, outreach, recruiting and joint participation in events such as Sibiu Innovation Days, fortiss AI Summer School or AU's Live From Behind The Walls (see list in Appendix B.1).

Some of the DIHs have become EDIHs (as part of consortia), thus assuming a more important role by combining the benefits of a regional presence with the opportunities available to a pan-European network. Other DIHs are also in the process of becoming part of EDIH consortia. Table 5 highlights the position of HUBCAP members in existing EDIHs. The framework of HUBCAP has enabled for these hubs more opportunities of providing services,

Table 5: Migration to EDIH.

EDIH	Description and member role
CD-EDIH	**Smart specialisation on advanced digitalisation technologies through Central Denmark European Digital Innovation Hub** Domains: smart city, govtech, the green transition, circular economy and special focus on the Central Regions existing positions of strength: agri/food, manufacturing, digital technologies. **AU** role: partner
A-CPS	**Applied Cyber Physical Systems** Domains: smart sensing, data communication and intelligent data utilization for enrichment of embedded systems, with special focus is on the building and manufacturing sectors. **VV** role: coordinator
HDS EDIH	**Health Data Sweden** Domains: health **KTH** role: coordinator
FIT EDIH	**Futures of Innovation Technologies European Digital Innovation Hub** Domains: smart city, manufacturing, eHealth **ULBS** role: partner

exchanging good practices and generating networking activities in line with the expectations of the EU (as shown in Figure 17).

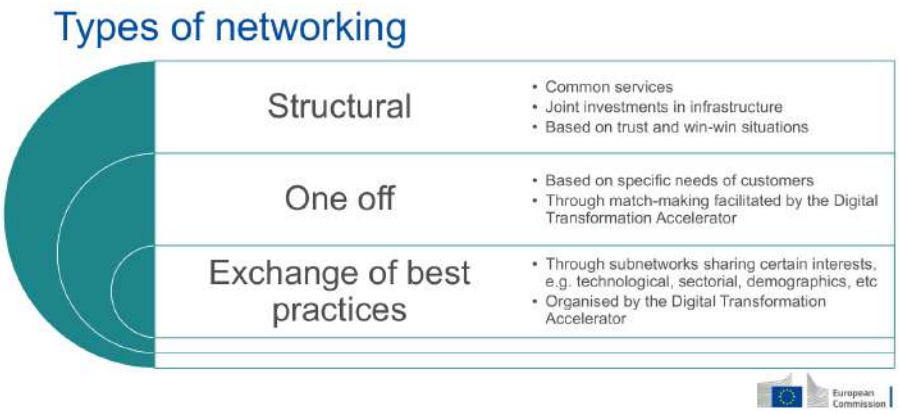


Figure 17: European Commission Networking Types.

4.3 Impact related to the platform

Deliverables from WP6 (the most recent of which is D6.6) provide a comprehensive description of the platform and the assets within, including tools and models catalogues, written and video guidelines, quality badge assessments and much more. Thus, the number and diversity of assets over time is well documented, being a solid argument in favour of the project's continuous developmental impact on the platform and the sandbox feature.

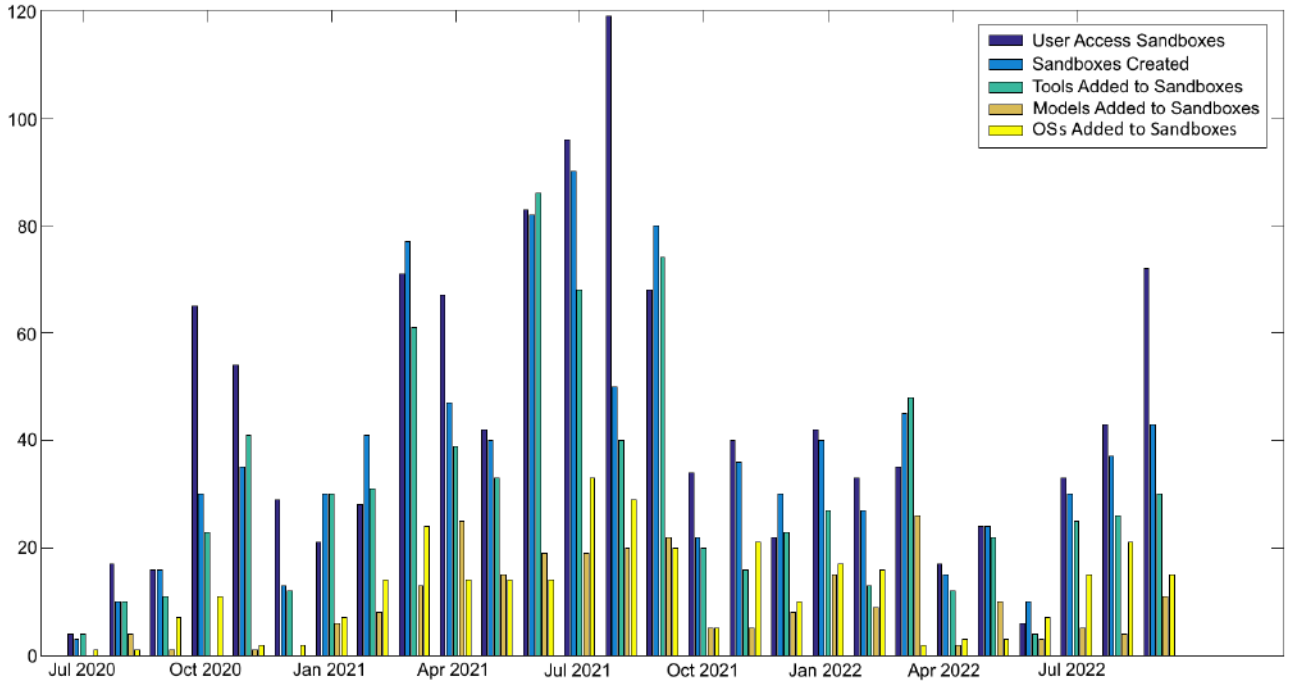


Figure 18: Platform statistics related to sandboxes.

The number of sandboxes created, and tools, models and OS-es added to sandboxes, presented in Figure 18 shows a continued and good use of the sandbox feature over time, even after the mid-project peak. A fair level of interaction with the platform is maintained despite the project drawing to the end and before the sustainability measures have been fully implemented.

4.4 Impact on SMEs

The discussion about the impact on SMEs is related to the discussion of the open calls and the information gathered from the interaction with enterprises and the consortia. The statistics on open calls show a great geographical spread of call applicants (and winners), as well as interesting international collaborations on diverse topics that can be approached by MBD. Furthermore, some winners of the first open calls have successfully applied for second and third calls, strongly supporting their positive informal comments about the HUBCAP vision. The full statistics and the overview of the calls are available in WP4 deliverables; this section will therefore only emphasize the impact that the SMEs observed as the benefit of being part of the HUBCAP calls, reported both informally and formally (in the form of success stories).

Besides the obvious benefit of the funding, allowing the experiments to proceed, there have been other reasons for claiming a positive impact, both objective and subjective. On the objective side, the enterprises have published a number of scientific papers, both on their own and as a collaboration article with HUBCAP DIHs or academic consortium members, some in prestigious publications (e.g. MDPI Sustainability (Q1 journal) and Applied Sciences (Q2 journal) in CiteScore), see Appendix B.3. The number of experiments or setups tested, as

described in the call deliverables for every winner, is another measurable indicator, corroborating the statements that the SMEs and consortia have been able to test and improve the solutions (much) more than they would have done otherwise. These are direct indicators of the viability of the solutions developed and furthered within the HUBCAP framework.

For the subjective evaluation, the SMEs and consortia have been asked to fill the Publishable Summary Template (see Appendix C) and indicate a number of aspects, including sections regarding the HUBCAP support and platform opportunity and forward look (prognosis). The extent of such information was provided on a voluntary basis, depending on the disclosure policies of the enterprises. When interacting with the SMEs and consortia, if they requested, we have also provided more detailed guiding questions that they could keep in mind, if applicable, such as:

- What was the most beneficial aspect of participating in HUBCAP calls, related to your business?
- What do you consider to be the most impactful features of the HUBCAP concept?
- What were and how you solved the difficulties in the interaction with HUBCAP?
- As a consequence of participating in HUBCAP, do you consider that your visibility has improved? Would you mind giving an example?
- As a consequence of participating in HUBCAP, have you attracted (new) partners? How many/big?
- As a consequence of participating in HUBCAP, have your products and services improved more than they would otherwise have? To what extent?
- Beyond the financing, what aspect of HUBCAP helped you most in developing the products and services?
- Would you estimate that your sales or income prognosis has been positively impacted by your participation in HUBCAP calls? By how much / which percentage?

The answers have been diverse, but common ideas could be seen from the reports. The funding has been mentioned both as an incentive of itself and as a catalyst to enlarge the set of experiments, improve the knowledge base or integrate and leverage HUBCAP platform assets, consequently expanding the targeted market sections. Regarding the features of the HUBCAP platform, the focus on MBD and the unique sandbox capabilities have been considered the most influential for improving and developing solutions. The visibility of the enterprises has been addressed indirectly, mainly by mentioning the next steps and the lengthy process of negotiation towards being included in wider organizations, attracting new partners or, as most reports imply, attracting new and important customers.

All reports contain a section of improvements and new developments of the products and services, as a consequence of the calls, as well as market analysis, promotion and marketing plans, sometimes also details on what they consider direct competition. All the plans presented are generally realistic, but include in between the lines some optimistic hopes that things would go even better.

Publishable summaries also contain memorable quotes encapsulating the most important aspect perceived by the call winners, such as:

‘*With this project we break through the most difficult aspect of time-optimized radiation detector design, simulating particle tracks and detector dimensions till we find an optimized*

solution, reducing the cost of new detector development 10-fold timewise' - Georgios Konstantinou, Multiwave Metacrystal

'*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, Beam Innovation

The raw publishable summaries used for this analysis are available in Appendix D, but refined and easily-readable versions are also on the HUBCAP website Success Stories (`https://www.hubcap.eu/success-stories`) and in the newsletters (`https://www.hubcap.eu/newsletters`).

5 Sustainability and Exploitation Plans

HUBCAP's major products have included:

- the collaboration platform including assets (models and tools) made available there alongside the marketplace capability;
- the network of collaborators built during the project, composed of the partner DIHs, DIHs to which we are connected, and the SMEs with whom connections were formed as a result of the open calls and the resulting experiments and innovation projects;
- the results of EXPERIMENT and INNOVATE projects themselves, including the network of participating SMEs who have become new actors in the space of model-based design for CPS.

In reviewing our plans for future exploitation of these results, we consider both our collective plans for ensuring sustainability of the products (Section 5.1) and the activities and commitments of individual partners, building on their links and experience gained during the project (Section 5.2). Where specific activities are described in detail in other deliverables, we give a reference into that deliverable, rather than repeat details here. Finally, we make general observations about the extent of and opportunities for future exploitation (Section 5.3).

5.1 HUBCAP Sustainability and Future Communication Plans

Work on future sustainability was coordinated by a small 'task force' led by AU, UNEW and FBK and involving all work packages, but especially WP1, WP2, WP6 and WP7. This has resulted in the dual-action approach described in D2.4 consisting of a commercial exploitation route in cooperation with Perpetual Labs and a community route in cooperation with the INTO-CPS Association. Although the work involved several WPs, we felt it would be clearer to describe it in one place among the M36 deliverables, and so the resulting sustainability plan, and the process by which it was derived, is described in detail in D2.4 Section 5 KGP: correct?.

With respect to WP7, the HUBCAP sustainability plan requires support through continuing communication and dissemination efforts after the project ends. These focus on plans for the communication channels and outreach activities for the new sustainability initiatives, e.g. via DIH networks.

Communication Assets The communication channels covered in Section 2 will be maintained after the project in order to maintain momentum in the sustainability of HUBCAP. This requires plans for the website, service centre, and social media. As covered in D1.3, the F6S Platform is a separate entity that F6S will maintain, and the mailing list will be deleted after a final message to encourage members to join the community initiative. Plans for the remaining communication channels are as follows:

Website AU own the `http://hubcap.eu/` domain. It will remain active until at least 2025, either directly or by transferring ownership to the INTO-CPS Association. UNEW will update the website content to prepare for the transition, which post-HUBCAP will focus on linking to both the commercial (GitWorks) and community (INTO-CPS) initiatives. This will be supported by student interns.

Service Centre UNEW will continue to maintain the info@hubcap.eu address and respond to queries, as part of their in-kind contribution to the INTO-CPS Association. Again, the aim will be to direct interest to the ongoing initiatives.

Social Media: Twitter, LinkedIn, YouTube UNEW will continue to maintain the social media channels initially as part of their in-kind contribution to the INTO-CPS Association. These will primarily be used to drive views through to the web site, which will provide the context for . YouTube will be used for hosting videos from further Success Stories from the future initiatives.

Outreach Activities Building on the use of call-specific promotion packages in the project, we will develop of a communication package for HUBCAP partners that supports our reaching out to different groups:

Model Developers Focus on letting them know about the GitWorks opportunities.
DIHs Helping HUBCAP DIHs to continue reaching out to stakeholder groups.
SMEs Focusing on success stories about the benefits of adopting MBD.

The communication package will be part of a wider communication strategy that aligns with the timeline of the roadmap for sustainability, covering both Phase 1 (2023) and Phase 2 (2024 and beyond), and identifying key communication actions.

5.2 Individual Partners' Plans for Exploitation

In this section we review the plans that individual partners have for exploiting HUBCAP's products.

Check where the DTAccelerator is described.

5.2.1 Exploitation Plans at AU

AU is committed to developing the HUBCAP vision further, both for MBD as well as their use in a digital twin context. The assets developed have potential for inclusion in future European and national initiatives where DIHs and the SMEs need to be supported and where collaboration to be enhanced. AU is now a part of the new Central Denmark EDIH, through which it will offer (from January 2023) services for SMEs in the CPS sector to access model-based engineering and digital twin technology.

Building on the HUBCAP network, AU will work with fellow DIHs to offer new joint services such as the Digital Twin Accelerator described in D2.3 (?check). AU is also strongly interested in committing to joint initiatives with other project partners, both those with whom it already collaborates, e.g., UNEW, VV, ULBS, CLP, and VSI, and new ones met in this project. Proposals for new collaborative work in CPSs have been made to Horizon Europe jointly with open call winners Vodena, as well as DIHs UNEW and VV, supporting digital innovation in construction (see 5.2.4).

AU will continue to partner in the not-for-profit INTO-CPS Association developing collaborative modelling and co-simulation assets for the HUBCAP platform (in both the commercial and community strands described in D2.4). AU will continue to use the Association as the main vehicle for handling IP because it offers a mix of both open access for research and access on paid basis for commercial exploitation. This aligns well with the plan for sustainability orchestrated by Perpetual Labs (also a member of the Association), since it is envisaged that their future GitWorks IP will become open source under the INTO-CPS Association. AU anticipates combining this with existing IP solutions including digital twin support and IP arising from future funded research and innovation projects.

Considering its core educational business, the HUBCAP Platform will offer opportunities for AU students that we exploit in future courses so there is less need for the students to install the MBD tools to be used in the corresponding courses.

5.2.2 Exploitation Plans at UNEW

HUBCAP has enabled UNEW to understand and develop its offer as a DIH in model-based design for dependable and secure cyber-physical systems and digital twins. Building on the network established so far, UNEW has created strategic links with other DIHs and with SMEs participating in HUBCAP experiments and innovation projects. For example, new proposals have already been submitted with Give and Vertliner, on model-based analytic tools for autonomous drone technology, with applications in search and rescue, and with AU and VV on digital innovation in construction (see 5.2.4). UNEW continues as a DIH actively to support open call winners ScubaTX and Quaisr.

UNEW will continue to offer and develop joint services with other HUBCAP DIHs, notably working with the Digital Twin Accelerator described above. More widely, UNEW is also partnering with Northumbria University to promote digitalisation in the construction sector, through the “International Centre for Connected Construction” initiative. From March 2023 we will offer education and training for SMEs in this sector to access model-based engineering and digital twin technology.

UNEW will continue to partner in the INTO-CPS Association, developing co-modelling and co-simulation assets for the HUBCAP platform (in both the commercial and community strands). For example, UNEW is working with Network Rail (UK) on the potential for model-based design and co-simulation in the rail sector, focusing on performance. The HUBCAP Platform will be used to explore this potential, for example lowering the barrier to entry for SMEs to rail supply chains.

As with AU, UNEW sees potential for the HUBCAP Platform – especially the sandbox capability – to allow students to engage with a range of tools in model-based CPS design. It is developing this opportunity through undergraduate and graduate courses in Fault-Tolerant and Cyber-Physical Systems and in Model-Based Systems Engineering.

5.2.3 Exploitation Plans at FOR

FOR will build on the HUBCAP network, envisaging further collaboration with some of the Open Call winners on model-based software development and verification. It will also continue to partner with the HUBCAP DIHs to offer joint SME support services, such as the Digital Twin Accelerator with UNEW and AU, the joint contact point with VV, or jointly organised networking events with ULBS.

Building on the AutoFOCUS3 and models from the HUBCAP collaboration platform, FOR will be continuing to provide recurring student practical courses on Model-based Systems Engineering with AutoFOCUS3 and the fortissimo rovers. Other assets and demonstrators by FOR that have been developed or extended within HUBCAP will be used and exploited in the fortiss Mobility Lab, which offers free access for SMEs to latest research within fortiss.

In education, FOR will use the training course “Introduction to Model-based Systems Engineering” for industrial professionals that is currently under development, within the local (E)DIH’s Skills & Training section.

FOR will continue to actively contribute to the INTO-CPS Association, providing models and co-simulation assets for the HUBCAP collaboration platform.

5.2.4 Exploitation Plans at VV

VV is part of an EDIH consortium (Applied CPS) since autumn 2022. It is planned to use both the existing DIH contacts from HUBCAP and the SMEs that have worked together with HUBCAP as a network. The cooperation with the DIH partners should be intensified in order to be able to offer the best possible services within the EDIH framework. Moreover, VV is looking forward to working with HUBCAP partners for new projects, e.g.: VV and UNEW are contributing to a proposal led by AU for the call HORIZON-CL5-2022-D4-01-02 on Renewable-intensive, Energy Positive Homes. Promising companies which were supported by VV during the EXPERIMENT and INNOVATE projects are also considered as possible partners for future projects (e.g., TirnTechnology, Mototok, Evitado, Cyberith and Codewheel).

Services created during HUBCAP (including collaborative services with other DIHs like FOR, AU and UNEW (Digital Twin Accelerator)) are to be expanded or improved. Inquiries that come to us via the platform or HUBCAP network serve as the basis for this. Furthermore VV aims to continue to use the platform itself to offer services and test facilities as well as to get in touch with other DIHs/SMEs and to host OpenMCx a tool-neutral co-simulation framework jointly developed by VV and AVL.

5.2.5 Exploitation Plans at FBK

FBK will continue the HUBCAP vision by fostering the application of model-based design and its adoption by a large number of SMEs. Towards this goal, FBK will exploit the HUBCAP platform as a marketplace for the model-based design tools that it has developed, and contribute to the platform's sustainability by providing new assets and content. Potential new industrial collaborators will be able to try FBK tools in the platform, before setting up a collaboration with FBK. The platform will be used by HIT, the local DIH of Trentino, to promote FBK's model-based design tools. Finally, FBK will exploit the HUBCAP network and the FBK expertise on model-based design to set up the collaboration for future projects, and will become involved with the INTO-CPS Association as a result of the HUBCAP project.

5.2.6 Exploitation Plans at KTH

HUBCAP has allowed KTH to better understand and build a relationship with (E)DIHs spread across Europe. This knowledge is being taken into new projects spanning Europe, in which KTH will leverage its new relationships by supporting third parties that join the associated consortia in an ad hoc way. (i.e., particularly SMEs which are not able to directly access project funds, but need a level of direct support in, e.g., testing to integrate with project technology.) A shared interest with VV in functional safety and autonomous driving has led to the intention to partner with them to enable future project opportunities and professional education.

KTH is also continuing its realization of a test bed for connected and autonomous driving, to which it has linked several companies (e.g., Ericsson). With the increased reliance on MBD for this complex functionality it is hoped that KTH and its partners can make use of the HUBCAP platform. (In fact, KTH has already joined a larger research project proposal with that in mind, which, if successful, will fund such interactions in future.)

KTH aims to continue to work with the HUBCAP partners, especially int he context of the new EDIHs. Due to HUBCAP it has identified several new complementary research streams and common interest among researchers, particularly regarding innovation and novel technology areas such as certain types of AI. As it happens, for some partners there were already established relationships for these other interests (e.g., the DIH parts of POLIMI already had a collaboration with researchers focused on innovation at KTH). We thus hope that this inter-organizational collaboration will also strengthen intra-organisational inter-disciplinary research.

5.2.7 Exploitation Plans at ULBS

ULBS is now a part of the new Central Romanian EDIH and is responsible for supporting the digitization of SMEs from manufacturing industry in the next three years. Specifically, as leader of the Innovation Ecosystem work package, ULBS will continue to extend and strengthen the services developed with the HUBCAP DIHs (AU, UNEW, FOR, VV) to offer joint SME support to access model-based engineering and digital twin technology.

The sandbox capability of the HUBCAP Platform will be used both by ULBS students enrolled in the Embedded Systems master program and by SMEs in the EDIH training services.

ULBS will continue to contribute in the not-for-profit INTO-CPS Association, developing collaborative modelling and co-simulation assets for the HUBCAP platform. The companies that were supported by ULBS during the EXPERIMENT and INNOVATE projects are offering promising use-cases to further develop the CPPS-SimGen asset, such as ASTI Automation, Evotech Services, etc.

Furthermore, ULBS is interested in participating in joint initiatives with the project partners and the open call winners for new projects, particularly regarding new digital twin and AI technologies for the manufacturing industry.

5.2.8 Exploitation Plans at ENGIT

ENGIT is a Digital Transformation Company, leading in Italy and expanding its global footprint, with around 12,000 associates and with over 60 offices and 20 companies in 17 countries. The Group invests both in innovation and in human capital, with the internal IT & Management Academy. Its relevance in in the Industry and Services segment is due to the ability to combine twenty years experience with the potential offered by technologies such as Cloud, Artificial Intelligence, Digital Twin, Digital Enabler, IoT, Cybersecurity, and Big Data. Additionally, ENGIT operates in strong strategic networks and initiatives (e.g., Gaia-X, IDSA, FIWARE, DBVA, Eclipse, EITD, DFA, DIH4INDUSTRY), comprising leading industries, innovation and technology centres, and collaborative initiatives, etc. where it can further disseminate and promote HUBCAP.

ENGIT is the main developer of the HUBCAP Collaboration Platform, strongly contributing to the development of the enabling IT tools (mainly the DIHIWARE, the DYMER and the HSM), as well as participating in assuring the success of its adoption at project level and beyond the project end. ENGIT is strongly interested in committing to joint initiatives with other project partners, to further exploit HUBCAP's results, where it can provide its expertise as well as utilizing its market leadership and innovation management capability.

Internally, ENGIT will exploit HUBCAP results through its own innovation pipeline, where research results are presented internally to relevant business units for further development and possible integration in the business portfolio. Furthermore, ENGIT will promote and exploit HUBCAP project and outcomes through dedicated commercial activities supported by corporate marketing and communication units.

Externally, ENGIT is strongly interested in joint initiatives with other project partners to further exploit the HUBCAP results in the future. This includes both partners with whom it already collaborates (e.g., POLIMI, Unparallel, FORTISS) and new ones met in this project. The know-how and the knowledge acquired in the project can be used by ENGIT for improving the current offerings, in particular, in terms of consultancy and feature advancements of proposed solutions, and through inclusion in future European and national initiatives where DIHs and the manufacturing SMEs need to be supported and where collaboration to be enhanced

5.2.9 Exploitation Plans at RISE

HUBCAP has allowed RISE to integrate the open-source OpenModelica tool in the HUBCAP Collaboration Platform and provide starter or advanced examples of model-based development for cyber-physical systems. Working with Perpetual Labs (one of the Open Call winners), RISE has also developed a prototype Modelica web-based editor that will be the base for new products.

In the future, RISE will ensure that the results of HUBCAP are disseminated via the OpenModelica website and will be available for both academic and commercial use. It will also continue to contribute actively to the INTO-CPS Association providing open-source simulation and modeling tools, models and co-simulation assets for the HUBCAP collaboration platform.

5.2.10 Exploitation Plans at F6S

F6S does not develop MBD assets that can be exploited at project end, but, through its launch, publication and management of the open calls, it has developed the network of innovative European SMEs working in the CPS domain and interested in deploying and developing new technologies while working in cross-border activities. F6S thus sees the future exploitation of HUBCAP in three directions: increased understanding and improvement of future outreach activities; increase of service offering and revenue opportunities; and community growth.

In terms of future activities, the experience and knowledge gained along the deployment of the HUBCAP project will enable the improvement of the models adopted for the Open Call management and respective deployment, while envisioning its automation and simplicity. Participating in EU projects enables F6S team to understand its customers challenges and benefits when applying F6S platform in their innovation projects.

In terms of future offerings, with the continuous development of F6S community and outreach, new services and revenue models are being validated towards increasing overall F6S sales and service coverage, addressing the various entrepreneurs' community needs and expectations. F6S is deploying new value-added services so the capacity to enlarge the startup ecosystem with a new group of users from HUBCAP has a good potential to generate new revenues.

In terms of community growth, HUBCAP gave F6S the opportunity to scout for top performing data-driven SMEs and start-ups across the EU that applied to the HUBCAP Innovation programme with disruptive solutions in MBD- and CPS-related domains. This has enabled the increase in the quality and quantity of new SMEs registered at the F6S platform, thus increasing the F6S community of Tech entrepreneurs. As we have experienced, the direct impact will be a continuous snowball growth increasing all F6S service traction numbers.

5.2.11 Exploitation Plans at POLIMI

Politecnico Milano (POLIMI) is a scientific-technological university and a fully operational DIH, providing consultancy services for Digital Transformation of enterprises and particularly SMEs. POLIMI focuses on manufacturing industry, hosting Industry 4.0 CPS-based experimental and training facilities. POLIMI runs the Milan Competence Center (MADE in Italy) of the Industry 4.0 Italian National Plan.

POLIMI strongly believes that digital platforms like that developed in HUBCAP, can be a strategic asset in ensuring the economic sustainability of DIHs and DIH networks networks, giving the possibility to propose suitable assets depending on business needs. The HUBCAP governance methods and tools will be disseminated by POLIMI to its whole community of DIHs.

The experience and knowledge gained in the HUBCAP project will enable the further development of POLIMI's METHODIH methodology which was used to configure the and standardise the service portfolios of the HUBCAP DIHs. This provided a firm foundation for sustainability by creating a common vocabulary for service exchange and provisioning. The HUBCAP DIH network is thereby equipped to grow by engaging with DIHs from diverse specialisations, complementing strengths and weaknesses, creating collaboration opportunities and diversifying the service portfolio.

POLIMI is strongly interested in committing to joint initiatives with other project partners to further exploit the HUBCAP results. The POLIMI methodology could be used to assess DIHs joining the HUBCAP network, allowing the evaluation of trends in the evolution of the DIHs composing the network over time. The method could also be used to assess DIHs in different projects in the CPS and other domains. The method not only assesses the role of DIHs in catalysing the digitalization dynamics of SMEs but could also support the definition of the service pipeline of single DIHs, unveiling further possible collaborations among DIHs based on the services that are planned. Finally, the unique value proposition of the single DIHs constituting a network represent an input for the definition of the entire network value proposition. Finally, the method could also be used in different kinds of ecosystems as start-up incubators.

5.2.12 Exploitation Plans at UNP

UNP's focus was to coordinate the monitoring of the HUBCAP platform usage by seed SMEs and Open Call winners, applying the monitoring methodology used in-house in order to get the maximum feedback from platform users. UNP was able to evolve the methodology with respect to the connection with platform users by improving the communication mechanisms used and adjusting the granularity of the requested answer. UNP was also able to improve the methodology in the aspect related to the connection with the platform developers. In this respect, the exchange of information between the users of the platform and the developer team was greatly improved

5.2.13 Exploitation Plans at CLP

CLP will continue to provide open-source simulation tools, models and assets for the HUBCAP collaboration platform and will continue to work on the online presentation of its model based design tools. Controllab will be building on the HUBCAP network, envisaging further collaboration with the partners and some of the Open Call winners on model-based design, and will keep close contacts and cooperation with the DIHs of the HUBCAP network.

5.2.14 Exploitation Plans at BEIA

Building on the assets contributed to the HUBCAP platform, BEIA will be able to sell the components experimented in the HUBCAP platform in a basic scenario as a nationwide SaaS service platform to public and private stakeholders in the smart IoT domain. In the extended scenario, BEIA will commercialise the smart services developed within the Balkan/Danube region through its sales and partners network. BEIA will continue to provide open-source simulation tools, models and assets for the HUBCAP collaboration platform. BEIA will also continue to provide open-source simulation tools, models and assets for the HUBCAP collaboration platform.

BEIA also looks to build on the experience of involving SMEs in other Industry 4.0 projects such as VITAL-5G, ADMA TranS4MErs and TESTBED2.

5.2.15 Exploitation Plans at VSI

VSI has contributed the RT-Tester installation on the HUBCAP Platform and commits to maintain this alongside its integration to the INTO-CPS co-simulation engine. More broadly, VSI will continue to use the platform as a basis for potential customers and interested parties to undertake evaluation. Consequently, VSI will also evaluate extending the tool installation on the platform to add novel features in new RT-Tester releases. Finally, VSI will also be actively seeking cooperation with other platform asset contributors and platform users for future activities.

5.2.16 Exploitation Plans at VAL

5.2.17 Exploitation Plans at TTS

Building on its contributions to the HUBCAP platform so far, TTS will be able to offer the DDDModel editor and DDDSimulator products in SaaS modality through the Platform. TTS will also be able to provide demo access to the products without the need to distribute installation packages, and will evaluate the integration of new products such the “Scenario configuration and optimization manager” in the platform in the future.

5.3 Observations on Exploitation Plans

There is a clear willingness to build on working relationships established during the project, either among partners or between partners and SMEs. These have so far led to several submitted project proposals at EC and national levels. DIH partners have used HUBCAP as an opportunity to clarify their future role in relation to their regional and European ecosystems and networks, and in some cases this has led to their integration with an EDIH. It is notable that the experience of some partners (e.g. KTH, POLIMI) has helped systematic approaches to building DIH collaborations to deliver new services. Newly-defined collaborative services such as the Digital Twin Accelerator are being defined which build on the relationships and experiences of the project. The Seed SMEs have benefitted from integration of their tools into the platform and see it as a way to continue to demonstrate new and existing features to potential customers, as well as to build on the relationships formed with partners to create or continue ongoing collaborations. Those partners working in education see opportunities to use the platform as a way to provide a one-stop shop for introducing a range of tools and models to students, helping these compete with easy-access online platforms for programming such as Jupyter notebooks. The above plans show strong results from HUBCAP that will continue in existing and new ventures beyond the end of the project.

6 Lessons Learned & Future Plans

In this report we have reviewed communication and dissemination activities in the second half of the project, considered the impact that HUBCAP has had on a range of stakeholders, and outlined plans for exploitation of HUBCAP's results by individual partners. The collaborative exploitation plan is described in D2.4 (Sections 3-5). In this section we identify lessons learned and look forward to future activity.

6.1 Lessons Learned

Engaging with Businesses

Much of HUBCAP's work was focussed on engaging with SMEs who saw opportunities from engaging with model-based design for CPSs. We commented in D7.2 that terminology around CPSs and MBD used was not always meaningful to our SME target groups, perhaps limiting the number who saw the opportunity to benefit from HUBCAP's DIHs, Platform, expertise and access to funding, and resulting in applications to some of the open calls that were clearly out of scope. Although this is a reflection of the state of the Model-Based Design and CPS business communities, there is significant scope for initiatives that simply reach out and explain to businesses that opportunities like HUBCAP exist.

In order to address the gap in understanding of MBD and CPS opportunities, we included more Q&A sessions around our open calls and amended video media with easy to digest definitions of the these terms. Our lesson at the end is that such communications benefit from clear realistic examples of the business value of considering products and systems as CPSs that can benefit from MBD. However, pubic, accessible examples illustrating business benefits have been relatively few. We hope that the success stories developed by our HUBCAP SMEs will serve as a useful resource in promoting digitalisation in design to other businesses in the future. It is for this reason that we are committed to maintaining and promoting them via the Platform and web site into the future.

In the PULL calls, our goal was to populate the Platform with tools, models and related assets that would be valuable to SMEs, especially those undertaking EXPERIMENT or INNOVATE projects. We were able to offer funded assistance to SMEs offering such assets, but this took focus away from larger businesses or organisations who could equally have provided useful content. This would have given our target SMEs access to a broader range of tools and models on the Platform itself and hence to 'test before invest'. A lesson here is that it is important to devote effort to reaching out to larger businesses alongside SMEs, even where funded support is not available.

Using Media

There is an enormous range of potential communications channels and media, and we learned early in the project to focus on only a few, but we also had to learn how to use

these in ways that were fit for purpose. For example, as remarked in Section 2, Twitter appeared to have a different quality of reach from LinkedIn, making the former better suited to reaching other networks, programmes and coordination actions, while the latter was more effective in reaching SMEs, DIHs and other organisations. Our most effective method for reaching potential call participants was the F6S platform, given its specialisation on accessing opportunities via a range of funders. The lesson learned is that it is important to use established channels if we wish to reach a broad audience, but that a range of channels need to be considered and tested out. Finally, we note the need to keep the use of specific channels under review, for example, as the future of some channels such as Twitter remains the subject of speculation.

In D7.2 we reported on our trial of paid social media campaigns for Twitter and LinkedIn, suggesting that the greatest effects are to be found on interaction (following, retweeting, hashtags, etc.) on platforms such as twitter, and that localisation was also a successful strategy. We nevertheless conclude that, although these approaches can yield marked increases in number of followers, it is the more specialised frameworks such as the F6S platform that are likely to give the highest yield in terms of engagement with calls.

HUBCAP has spanned the time of the pandemic in Europe. Many of the lessons learned and described in D7.2 at m18 were shaped by the effects of lockdown and travel restrictions on communication and dissemination activities. We remarked in the conclusions to D7.2 that we hoped it would be possible to hold in-person meetings, at least for match-making events in the second half of the project. However, this was not to be: although the second half of the project saw a period of recovery in 'in-person' opportunities, these were highly restricted by both health and corporate concerns. Consequently online communications and social media continued as our main communication channels.

Based on our experiences, we learned that personal contact was far more effective as a means of initiating long-lasting engagement (e.g., encouraging participation in an open call or starting interactions with a DIH) than starting a working relationship online. Follow-up can be done cost-effectively by online communications, but we have not seen a good case for conducting projects like this in an entirely online manner.

Materials

SMES and consortia produced highly diverse materials as records of their achievements in the EXPERIMENT and INNOVATE calls, very distinct ways of writing about their projects. Developing a revised form of the publishable summary and requiring it to be completed as part of the final deliverable (as described in Section 3.3) gave us much better quality and more uniform material for developing the Success Stories that we have subsequently promoted. Similarly, the provision of video guidelines helped to make some improvements in the quality of video material available online.

Learning from this, we would urge future innovation actions to ensure that call winners are obliged to produce good quality dissemination materials, but equally that the supporting DIHs are obliged to help SMEs (who may not have the resources or capability to focus on such activities) to produce these outputs.

Our work with the SMEs resulted in useful and engaging success story materials that could be used for dissemination, but these could still be presented in a more structured form than in the linear text of a newsletter or as a collection of videos on our YouTube channel. Both the success stories and videos could be indexed by various attributes such as domain, technology, company size or experience, etc. This would in turn allow us to offer them more proactively to those who could best learn form them. As part of our ongoing communications activity after the project, we will aim to target the materials better to audiences.

Communications and the Future of DIHs

The project has produced a relatively high number of academic publications for an innovation action. This is partly because several of the DIH members have strong academic traditions, and because the project's work, in areas ranging from the sandbox technology through to business models, did have some important innovative elements.

The visibility of DIHs was limited due to the range of IAs running over similar periods to HUBCAP, and here again the lack of in-person contact limited opportunities to initiate inter-DIH collaborations. We found the Smart Anything Everywhere (SAE) initiative to be invaluable in providing links to both DIHs and to businesses in our target domain. Indeed, the fact that SAE ended early in the final year of HUBCAP probably had an impact on our reach in the final series of funded projects.

6.2 Future Plans

With our INNOVATE projects only completing in late 2022, there remains plenty to do in order to maximise the value of the assets developed through HUBCAP, communicating them to a wide audience of potential beneficiaries. Important actions include:

- Publicising the engagement with Perpetual Labs, to encourage stakeholders in the HUBCAP platform to carry over to the PL instance of the HUBCAP Platform, and later to engage with GitWorks.
- Engaging potential users with the community activities catalysed by the INTO-CPS Association, starting with a workshop in January 2023 to develop a roadmap for the future of new and existing assets on the Platform.
- Updating the HUBCAP web site to provide links through from the success stories directly into the relevant project assets on the platform. Modifying content on the site to direct more traffic through to the platform.
- Facilitating and publicising through social media the HUBCAP-related activities of partners and platform users as they pursue their exploitation plans.
- Provide alternative "slices" through the success stories and video assets in order to make it easier for businesses to find the most relevant content.

Following the formal completion of HUBCAP, the network of partners will undoubtedly continue, focussed on the strong connections established by this innovation action. The sustainability plans for the future HUBCAP platform, with a commercial strand in Perpetual Labs GitWorks supported by the community initiative led from the not-for-profit INTO-CPS Association, will continue to provide a focus for attracting businesses to MBD for CPS. The network of DIHs will continue to collaborate through shared services such as the Digital Twin Accelerator, and the wider community of partners includes clear exploitation plans that involve further collaboration. All of these activities will require communications and dissemination, and for this reason several key partners have agreed to continue to support the communications media and content developed so far.

A Appendix: Communication Channel Statistics

This appendix provides metrics from the communication channels from M19–M36. These are the website in Section A.1, Twitter in Section A.2, LinkedIn in Section A.3, and YouTube in Section A.4.

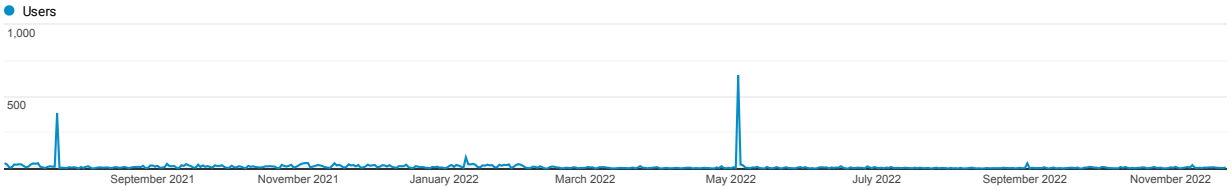
A.1 Website

Monthly Data

All Users
100.00% Users

Jul 1, 2021 - Nov 24, 2022

Report Tab



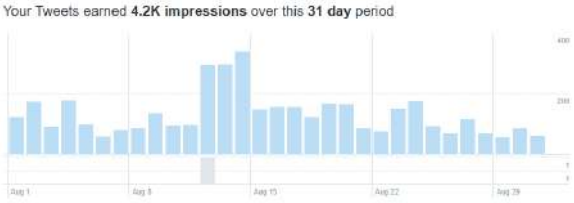
Month of Year	Users	Sessions	Bounce Rate	Pages / Session	Avg. Session Duration
	4,339 % of Total: 100.00% (4,339)	6,450 % of Total: 100.00% (6,450)	50.36% Avg for View: 50.36% (0.00%)	2.36 Avg for View: 2.36 (0.00%)	00:02:07 Avg for View: 00:02:07 (0.00%)
1. 202211	107 (2.20%)	233 (3.61%)	48.93%	4.54	00:10:56
2. 202210	116 (2.38%)	179 (2.78%)	62.01%	1.94	00:01:38
3. 202209	129 (2.65%)	184 (2.85%)	51.63%	1.99	00:02:31
4. 202208	61 (1.25%)	89 (1.38%)	65.17%	1.89	00:01:15
5. 202207	101 (2.07%)	127 (1.97%)	66.93%	1.77	00:00:44
6. 202206	152 (3.12%)	177 (2.74%)	51.41%	2.84	00:01:38
7. 202205	815 (16.74%)	948 (14.70%)	44.41%	1.73	00:01:45
8. 202204	92 (1.89%)	119 (1.84%)	70.59%	1.85	00:01:13
9. 202203	153 (3.14%)	180 (2.79%)	59.44%	2.24	00:01:32
10. 202202	203 (4.17%)	245 (3.80%)	59.59%	2.28	00:01:32
11. 202201	529 (10.86%)	681 (10.56%)	51.54%	2.61	00:02:16
12. 202112	328 (6.74%)	453 (7.02%)	58.72%	2.58	00:02:25
13. 202111	475 (9.75%)	659 (10.22%)	53.41%	2.49	00:02:07
14. 202110	287 (5.89%)	409 (6.34%)	50.86%	2.64	00:02:02
15. 202109	374 (7.68%)	525 (8.14%)	51.43%	2.50	00:01:52
16. 202108	210 (4.31%)	255 (3.95%)	56.86%	2.42	00:01:23
17. 202107	738 (15.15%)	987 (15.30%)	34.85%	2.14	00:01:15

Rows 1 - 17 of 17

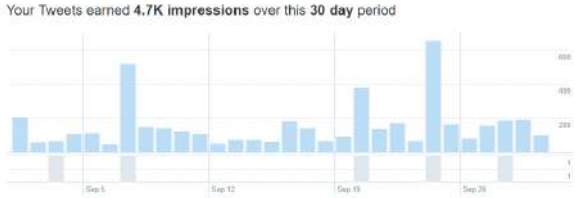
A.2 Twitter

Note that the lighter / orange colour in October 2021, November 2021, and January 2022 indicate periods of paid promotions.

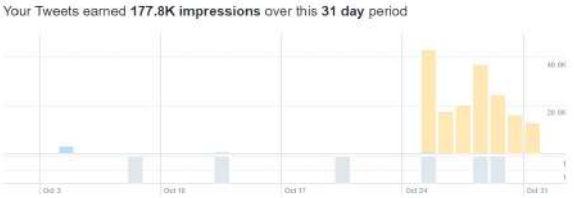
July 2021



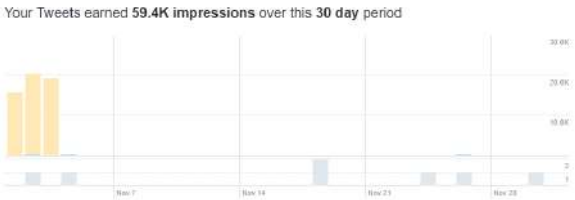
August 2021



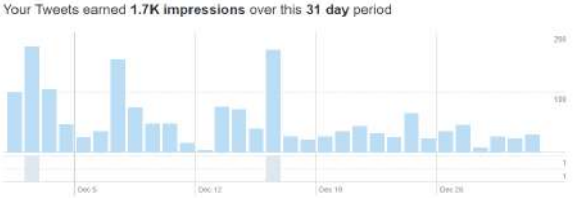
September 2021



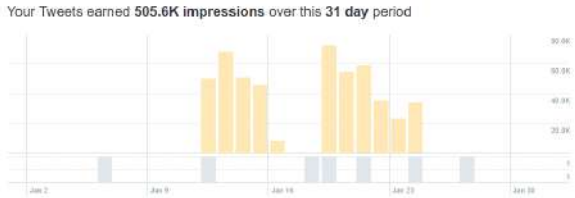
October 2021



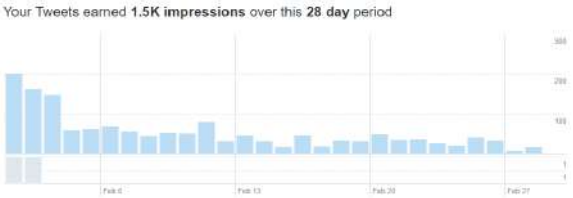
November 2021



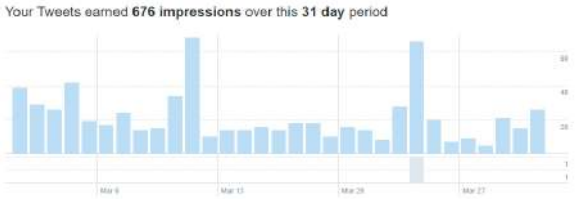
December 2021



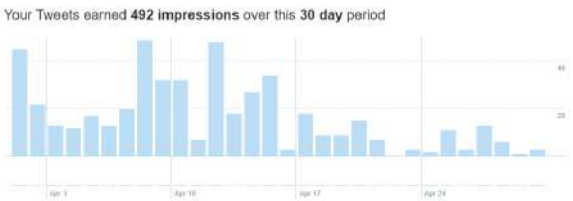
January 2022



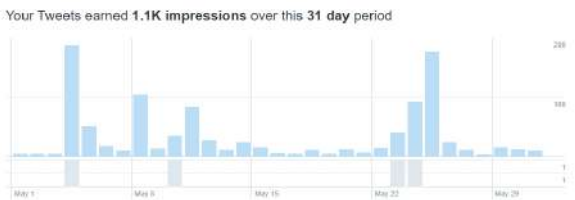
February 2022



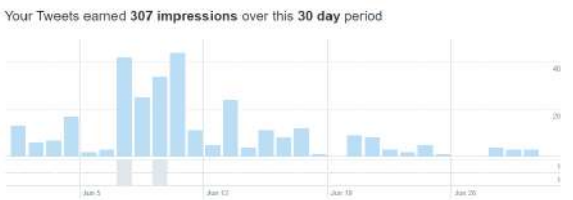
March 2022



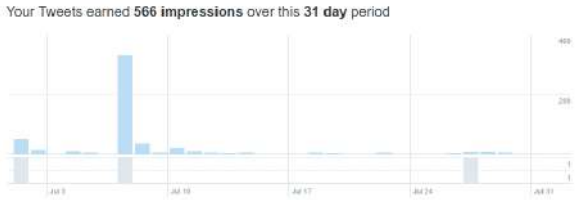
April 2022



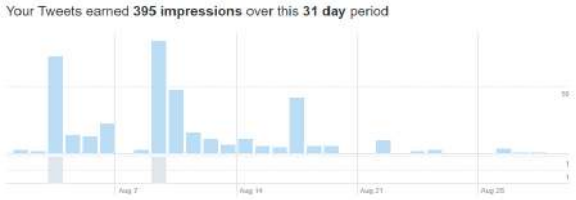
May 2022



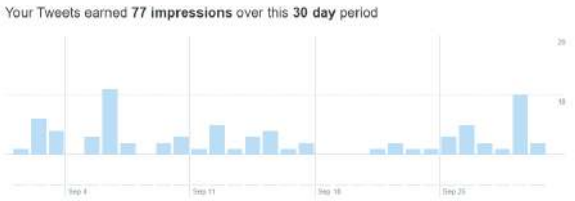
June 2022



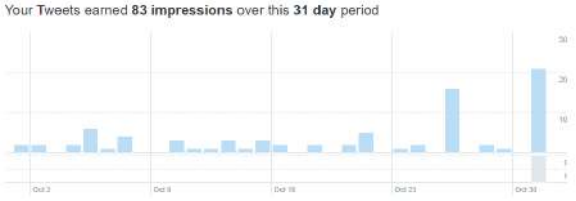
July 2022



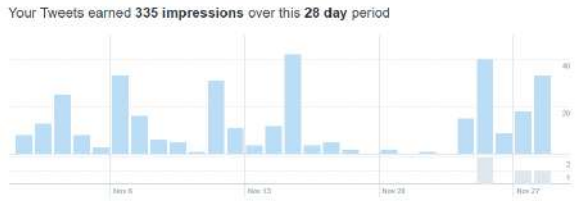
August 2022



September 2022



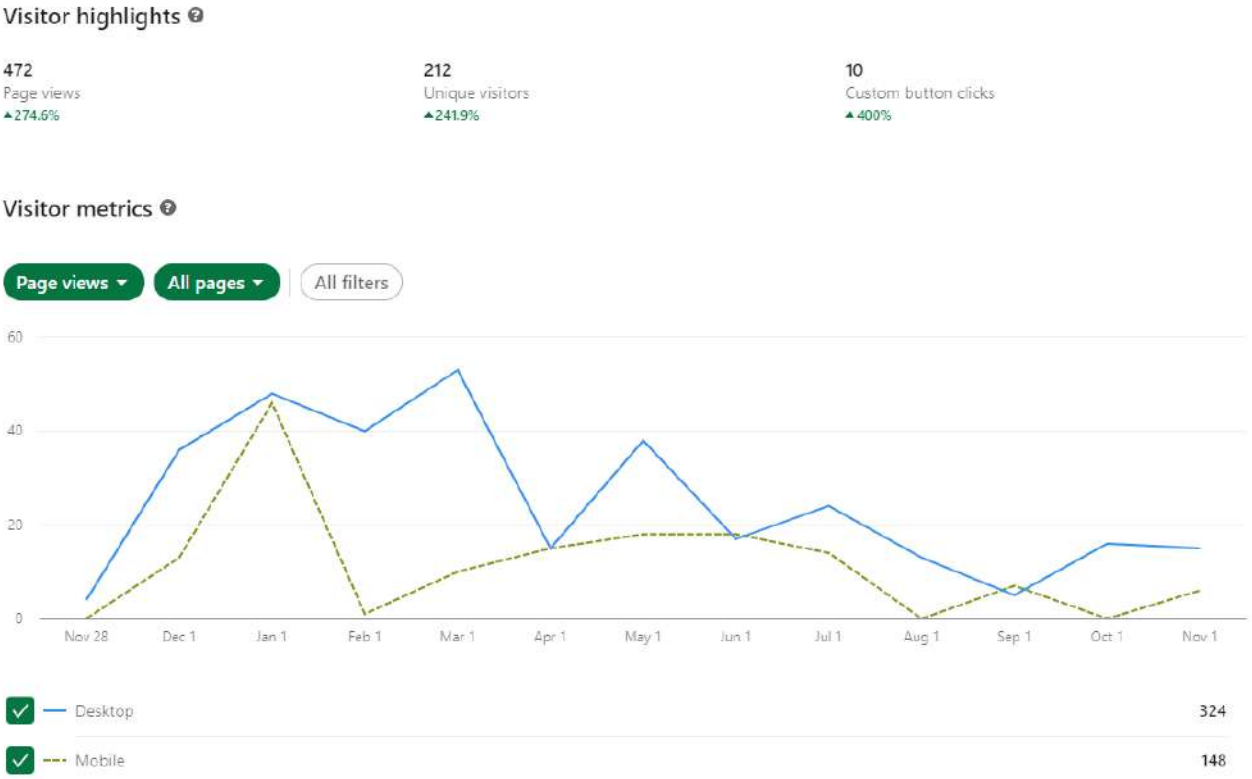
October 2022



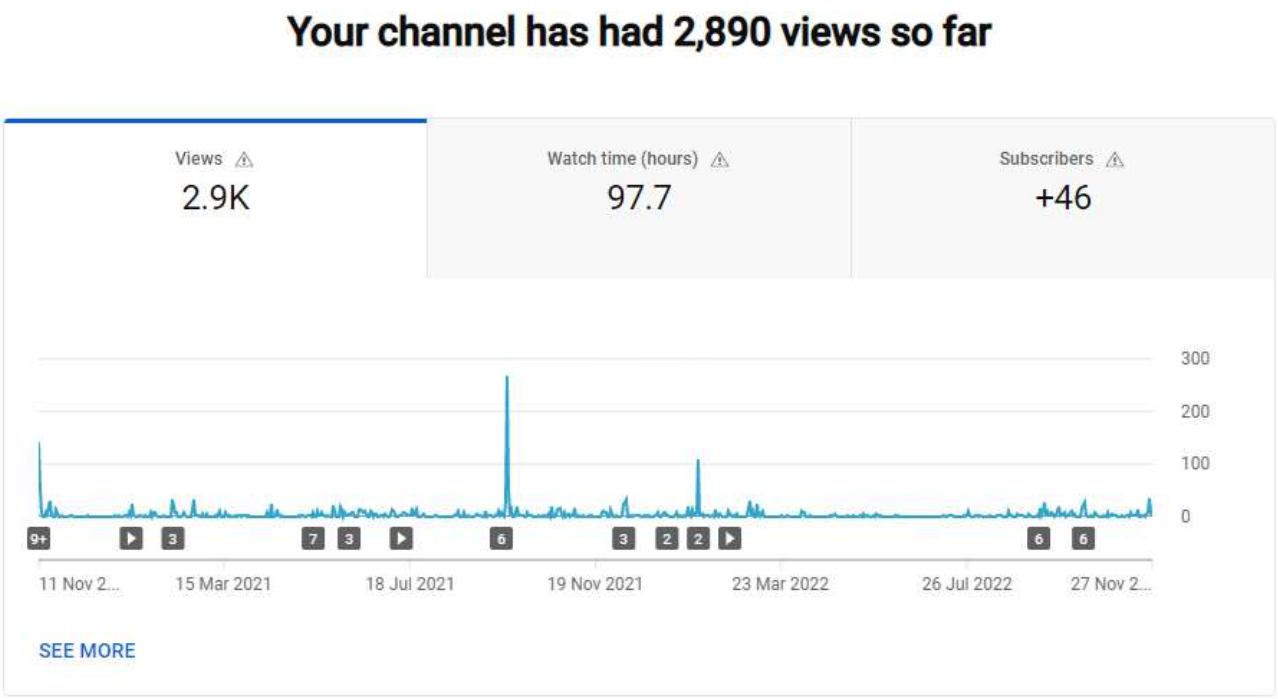
November 2022

December 2022

A.3 LinkedIn



A.4 YouTube



A.5 Summary

The data here show an overall consistent flow of traffic and impressions from the various communication channels, and the success in helping to drive interest in the open calls. There are higher and lower periods of traffic for the various channels corresponding to different phases in the second half of the project. There are peaks around the open calls opening and closing, particularly on LinkedIn, as well as the promotions on Twitter. On YouTube, the views increase in particular as the Success Story videos were uploaded and publicised in the final few months of the project.

B Appendix: Dissemination Activities

This appendix provides full tables of dissemination activities from M19 – M36. These are dissemination events in Appendix B.1, publicity in Appendix B.2, and academic publications in Appendix B.3.

B.1 Representing HUBCAP at Events / Giving Presentations about HUBCAP

Event Dates	Audience (industrial, academic, ...)	Website URL	Partners attending	WPs represented	Remarks
01.07.2021	Industry	http://www.adrcentru.ro /comunicare/the-big-tomorrow-digital-transformation-forum-eveniment-online/	ULBS	WP7	The BIG Tomorrow Digital Transformation Forum – online event (conference) Presented HUBCAP and the current open calls
01-02.09.2021	Industrial, Academic	https://www.gsvf.at/	VV	All	14th GSVF 2021 Event (audience: 120 persons from 12 nations); General HUBCAP-presentation (focus on platform and calls; running in a cycle on a screen) + general HUBCAP-A4-Flyers
13.09.2021	Industry	F2F@Virtual Vehicle & Online https://www.v2c2.at/expertise-3/sase/fusacom-en/	VV	All	27th Functional Safety Community (FuSaCom) Get together; displayed general HUBCAP-A4-Flyers + 1 slide News-Presentation for Call #1.4 PULL for the online audience
13-15.09.2021	Industrial, Academic	https://www.v2c2.at /summerschool2021	VV	All	Summer School 2021: "Beyond AI" (organized by Virtual Vehicle, Graz University of technology and University of Graz); displayed general HUBCAP-A4-Flyers
13-15.09.2021	Industry	https://www.citiesoftomorrow.ro/	BEIA	All	Presenting HUBCAP project
09.10.2021	Start-ups	https://mcg.at/events /gruendermesse/	VV	All	Gründermesse 2021 (Start-Up fair), Graz; >1000 Young Entrepreneurs; displayed general HUBCAP-A4-Flyers
20.10.2021	Industrial, Academic	https://worldmanufacturing.org /activities/world-manufacturing-week-2021/sae-i4ms/	AU	All	Panel 2 – Roundtable on Digital Innovation Hubs and SMEs' take-up of Digital Manufacturing Platforms
24.11.2021	Academic	https://pro-ve-2021.sciencesconf.org/	AU	All	Presentation of Fredrik Asplund et al. paper in PRO-VE 2021
02.12.2021	SMEs	https://www.bayern-innovativ.de /netzwerke-und-thinknet /uebersicht-material-und-produktion/digital-production-engineering/veranstaltung/aus-der-forschung-in-die-praxis#!programm	FOR	All	Presentation about introduction of MBSE with a reference to HUBCAP (in German)
06.12.2021	Academic	https://sites.google.com/view /cosim-cps-2021/home	AU	WP5, WP7	Presentation on comparison between HUBCAP and DIGITbrain projects
31.8.-1.9.2022	Industrial, Academic, SMEs	https://www.gsvf.at/	VV	WP5, WP7	Displayed a poster with special focus on the content of the HUBCAP platform
29.06.2022	Industrial, SMEs	https://www.fortiss.org/en/news /details/making-future-issues-tangible-here-and-now	FOR	All	fortiss Labs opening, HUBCAP related, especially Mobility Lab (Model Based Systems Engineering)
13.07.2022	Industrial, SMEs	https://www.fortiss.org/en/news /details/making-future-issues-tangible-here-and-now	FOR	All	fortiss Labs Tour at AI Summer School, Hubcap related, especially Mobility Lab (Model Based Systems Engineering)
8-10.10.2022	Academic	https://www.fie2022.org/	KTH	All	Presenting HUBCAP as part of paper presentation at conference
26.10.2021	Industrial, SMEs	https://www.fortiss.org/en/news /details/conference-ai-for-for-small-to-medium-enterprises	FOR	WP2, WP4	Presenting HUBCAP, Open Calls, and DIHs
28-29.09.2022	Industrial, Business	https://www.techchillmilano.co/	F6S	WP4	Presenting HUBCAP, OCs success stories

29-30.09.2022	Industrial, Academic, SMEs	https://events.ulbsibiu.ro/innovationdays/presentations/ https://events.ulbsibiu.ro/innovationdays/recordings/	AU FOR UNEW ULBS	WP7	Day 1, Panel 2 – Digitalization & Digital Innovation Hubs
29.06.2022	Academic	https://www.strategii21.ro/site/index	BEIA	All	Presenting HUBCAP and other projects
26-27.05.2022	Academic	https://sdie.ase.ro/2021/12/23/call-for-papers-ie-2022-26-27-may-2022/	BEIA	All	Presenting HUBCAP and other projects
08.11.2022	DIHs	https://dihworld.eu/event/other-relevant-initiatives/	VV	WP2, WP7	Presenting HUBCAP (focus on the platform) in the webinar "Other relevant initiatives", organized by DIH World (EU project)

B.2 Industry Articles, Press Releases, and HUBCAP in the News

Date	Title	Partner	Website URL	Language
01.07.2021	HUBCAP Call #3 INNOVATE Final webinar	VV	https://www.linkedin.com/posts/sonja-kaiser-virtual-vehicle_hubcapeu-smartanythingeverywhere-opencall-activity-6817776344693293056-OJHI https://www.linkedin.com/posts/lisamarieschicker_hubcapeu-smartanythingeverywhere-opencall-activity-6817785133190447104-MQhu https://www.linkedin.com/feed/update/urn:li:activity:6817794689094209536 https://www.linkedin.com/posts/acr---austrian-cooperative-research_hubcapeu-smartanythingeverywhere-opencall-activity-6817822448294129664-nwJB (+ Reposts from Martin Benedikt & Gerhard B. Weiß).	English
01.09.2021	HUBCAP Project	VV	Virtual Vehicle Magazine, Issue 32/2021, pp 12-13, "Digital Innovation HUBs and Collaborative Platform for Cyber-Physical Systems", authors: Gerhard B. Weiß / Sonja Kaiser. 2 - p a g e article in our quarterly print magazine for external partners (available from 01.09.2021), edition: 1000 units, target group industry experts and partner companies, PRINT VERSION.	English
01.09.2021	HUBCAP Project	VV	Virtual Vehicle Magazine, Issue 32/2021, pp 12-13, "Digital Innovation HUBs and Collaborative Platform for Cyber-Physical Systems", authors: Gerhard B. Weiß / Sonja Kaiser. ONLINE: https://www.v2c2.at/newsevents/vvm-2/	English
15.09.2021	Call #1.4 PULL	VV	Press release to Virtual Vehicles standard mailing list. 500 media contacts across Europe, target group both mainstream media and specialist publications.	English
15.09.2021	Call #1.4 PULL	VV	News on the Virtual Vehicle homepage, https://www.v2c2.at/	English
13.09.2021	Call #1.4 PULL	VV	Internal VV newsletter. Call on all colleagues to post on their private social media page and invite interested contacts.	German, English
13.09.2021	[HUBCAP Project] Is your SME providing digital technologies? Join HUBCAP and we will help you find new customers. (Call #1.4 PULL)	VV	Direct e-mail to 56 SMEs. Call #1.4 PULL by ViF-Marketing.	English
	Call #1.4 PULL	AU	https://digit.au.dk/ (item in news sections links directly to the following).	English
15.09.2021	Call #1.4 PULL	AU	https://ece.au.dk/aktuelt/nyheder/nyhed/artikel/new-opportunities-for-sme-providers-of-digital-technologies/	English
15.09.2021	Call #1.4 PULL	AU	https://ece.au.dk/en/currently/news/show/artikel/translate-to-english-nye-muligheder-for-udbydere-af-digitale-teknologier/	Danish
	Call #1.4 PULL	AU	https://www.linkedin.com/feed/update/urn:li:activity:6844246090968031232	English

06.09.2021	Call #1.4 PULL	VV	https://www.linkedin.com/posts/sonja-kaiser-virtual-vehicle_hubcap-open-call-14-opens-next-tuesday-activity-6840553178237341696-CxO- https://www.linkedin.com/feed/update/urn:li:activity:6843878122912301056 https://www.linkedin.com/posts/gerhard-benedikt-wei%C3%9F-411442207_hubcap-open-call-14-opens-next-tuesday-activity-6842014541967040513-Sch5	English
15.09.2021	Call #1.4 PULL	VV	https://www.instagram.com/p/CT1gx33qVI_/?utm_source=ig_web_copy_link	English
	Call #1.4 PULL	FOR	https://www.fortiss.org/en/events/open-call-hubcap-14	German, English
	Call #1.4 PULL	AU	https://www.linkedin.com/feed/update/urn:li:activity:6844581245314248704	Danish
	Successful review meeting	AU	https://www.linkedin.com/feed/update/urn:li:activity:6847077603745050624	English
30.09.2021	Call #1.4 PULL	VV	FuSaCom Newsletter#5. Direct e-mail to the FuSaCom partners (86 Partners, Europe-wide). Announcement for the OpenCall #1.4.	English
05.10.2021 04.10.2021 04.10.2021 04.10.2021	Call #1.4 PULL	ULBS	- [website Faculty of Economic Sciences] http://economice.ulbsibiu.ro/index.php/ro/despre/stiri-evenimente/item/525-oportunitate-pt-imm-urile-interesate-de-domeniile-socio-fizico-cibernetice.html - [Facebook page Faculty of Economic Sciences] https://www.facebook.com/economice.ulbsibiu/photos/a.286710268033268/4383272881710299/ - [Facebook group Faculty of Economic Sciences] https://www.facebook.com/economice.ulbsibiu/photos/gm.4483756345070351/4383289851708602/ - [EduHub - ULBS entrepreneurial student society] https://www.facebook.com/ulbs.eduhub/photos/a.1584900751818792/2627182347590622/ - [group for the companies financed by ULBS & Konfida] https://www.facebook.com/groups/199700541238370	Romanian
29.09.2021	Call #1.4 PULL	ULBS	https://www.finantare.ro/hubcap-organizeaza-un-webinar-de-qa-pentru-imm-urile-interesate-sa-aplice-pentru-call-1-4-pull.html	Romanian
29.09.2021	Call #1.4 PULL	ULBS	https://inginerie.ulbsibiu.ro/fara-categorie/hubcap-organizeaza-un-webinar-de-qa-pentru-imm-urile-interesate-sa-aplice-pentru-call-1-4-pull/	Romanian
15.11.2021	Call #2.2 Experiment	VV	News on the Virtual Vehicle homepage, https://www.v2c2.at/hubcap_call_22/	English
19.11.2021	Call #2.2 Experiment	VV	Internal VV newsletter. Call on all colleagues to post on their private social media page and invite interested contacts.	German, English
26.11.2021	Call #2.2 Experiment	VV	Press release to Virtual Vehicles standard mailing list. 500 media contacts across Europe, with target group both mainstream media and specialist publications.	English
26.11.2021	Call #2.2 Experiment	VV	Direct e-mail contact to 2 SMEs (*Tirn Technology* from Slovakia and *the SARM project* from Greece) to apply for Call #2.2 + participate in the Q&A and Matchmaking Event.	English
5.2022	Call #1.5 Pull	FBK	https://www.linkedin.com/feed/update/urn:li:activity:6933295090673049600/	English

B.3 Published Academic Papers

Title of publication	Authors	Book / Journal title	Vol. / Issue	Pages	Year of publication	Publisher	Link to full text or abstract	Open access Yes / No
HUBCAP: A Novel Collaborative Approach to Model-Based Design of Cyber-Physical Systems	Peter Gorm Larsen, Hugo Daniel Macedo, John Fitzgerald, Holger Pfeifer, Martin Benedikt, Stefano Tonetta, Angelo Marguglio, Giuseppe Veneziano, Lorenzo Sutton, Sergio Gusmeroli, George Suciu	Simulation and Modeling Methodologies, Technologies and Applications (SIMULTECH 2020)	LNNS 306	90-110	2021	Springer	https://drive.google.com/file/d/11J-AmoXth-z2TEY1slpvvSFEUK-bbbq5/view	Yes
Towards a Digital Twin – Modelling an Agricultural Vehicle	Frederik F. Foldager, Casper Thule, Ole Balling, Peter Gorm Larsen	Leveraging Applications of Formal Methods, Verification and Validation: Tools and Trends (ISoLA 2020)	LNTCS 12479	109-123	2021	Springer	https://pure.au.dk/portal/files/224041223/Submission_2_FoldagerEtAl.pdf	Yes
Uncertainty Quantification and Runtime Monitoring Using Environment-Aware Digital Twins	Jim Woodcock, Claudio Gomes, Hugo Daniel Macedo, Peter Gorm Larsen	Leveraging Applications of Formal Methods, Verification and Validation: Tools and Trends (ISoLA 2020)	LNTCS 12479	72-87	2021	Springer	https://pure.au.dk/portal/files/224043556/isola2020_1_.pdf	Yes
Manufacturing Process Simulation in a Hybrid Cloud Setup	Gerhard Benedikt Weiß, Dario Pietraroia, Claudio Sassanelli, Hugo Daniel Macedo	In Proceedings of the 2nd International Conference on Innovative Intelligent Industrial Production and Logistics (IN4PL 2021)		49-58	2021	SCITEPRESS	https://www.semanticscholar.org/paper/Manufacturing-Process-Simulation-in-a-Hybrid-Cloud-Wei%C3%9F-Pietraroia/f647c29cb0b70719daaf1404cee823959aa54eba	Yes
Problematizing the Service Portfolio of Digital Innovation Hubs	Fredrik Asplund, Hugo Daniel Macedo, Claudio Sassanelli	In Proceedings of the 22nd IFIP/SOCOLNET Working Conference on Virtual Enterprises (PRO-VE 2021)		433-440	2021	Springer	https://www.researchgate.net/profile/Fredrik-Asplund/publication/356215502_Problematizing_the_Service_Portfolio_of_Digital_Innovation_Hubs/links/619d14a107be5f31b7aeb8d2/Problematizing-the-Service-Portfolio-of-Digital-Innovation-Hubs.pdf	Yes
Deploying the Smart Energy Tool for Investment Simulation inside the HUBCAP Sandbox	Andreea Badicu, George Iordache, George Suciu, Hugo Daniel Macedo, Claudio Sassanelli, Sergio Terzi, Peter Gorm Larsen	In Proceedings of the 9th International Workshop on Simulation for Energy, Sustainable Development & Environment		18-26	2021		https://re.public.polimi.it/bitstream/11311/1206015/1/Badicu%20et%20al.%2C%202021.pdf	Yes
Extending the Formal Security Analysis of the HUBCAP sandbox	Tomas Kulik, Prasad Talasila, Pietro Greco, Giuseppe Veneziano, Angelo Marguglio, Lorenzo Franco Sutton, Peter Gorm Larsen, Hugo Daniel Macedo	In Proceedings of the 19th International Overture Workshop		36-50	2021	arXiv	https://arxiv.org/abs/2110.09371	Yes
PROSIM in the Cloud: Remote Automation Training Platform with Virtualized Infrastructure	Sabin Rosioru, Viorel Mihai, Mihai Neghina, Daniel Craciunean, Grigore Stamatescu	Applied Sciences	12(6)	article 3038	2022	MDPI	https://www.mdpi.com/2076-3417/12/6/3038	Yes
Which skills? A critical perspective on the skills facilitating the transfer of third-cycle students to knowledge-intensive SMEs	Fredrik Asplund, Mats Magnusson, Martin Törngren, Tobias Vahlne, Martin Karlsson	In Proceedings of Frontiers in Education 2022			2022	IEEE	http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-316521	Yes

A Low-Cost & Real-Time Motion Capture System	Anargyros Chatzitofis, Georgios Albanis, Nikolaos Zioulis, Spyridon Thermos	In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) 2022		21453-21458	2022	Computer Vision Foundation	https://openaccess.thecvf.com/content/CVPR2022/papers/Chatzitofis_A_Low-Cost__Real-Time_Motion_Capture_System_CVPR_2022_paper.pdf	Yes
Building the Value Proposition of a Digital Innovation Hub Network to Support Ecosystem Sustainability	Claudio Sassanelli, Sergio Terzi	Sustainability	14(18)	article 11159	2022	MDPI	https://www.mdpi.com/2071-1050/14/18/11159	Yes
Towards an Open Platform for Democratized Model-Based Design and Engineering of Cyber-Physical Systems	Mohamad Omar Nachawati, Gianmaria Bullegas, Andrey Vasilyev, Joe Gregory, Adrian Pop, Maged Elaasar, Adeel Asghar	In Proceedings of the American Modelica Conference 2022		102-114	2022	Modelica Association / Linköping University Electronic Press	https://2022.american.conference.modelica.org/documents/NA_Modelica_2022_Proceedings.pdf	Yes

C Appendix: Publishable Summary Template

Title [long title of the project]

List of contributors (SMEs and DIHs) [including brief profile of each company]

Company	Author

Subheading [optional, giving more detail on what the project did]

Domain(s) [keywords indicating what areas the project addressed]

Impact [3-4 bullets on the key impacts on the companies and more widely; explain your investments]

Quote [quote from the consortium coordinator or member on what HUBCAP funding enabled them do]

Image/video [an image and/or video representing the project that we have permission to use]

Project [Please describe the scope of your project and the solution. Please write this for a general reader who may not be familiar with your application domain or solution technology. Up to ~250 words]

Experiment / what was done [Please describe what was done during the project. Again, please write this for a general reader who may not be familiar with your application domain or solution technology. Up to ~250 words]

HUBCAP support and platform opportunity [Please describe how HUBCAP provided an opportunity to the companies. Please cover both the funding supplied and the HUBCAP platform. Consider, for example, the opportunity to engage with new technology, access support, and find new partners or access new potential markets. Up to ~250 words]

Forward look [Has your business' prognosis (e.g., sales, income, market opportunities) been improved by HUBCAP? Can you give a rough estimate of how much? Up to ~250 words]

Additional Information [if applicable, ~100 words on any other relevant technologies, platforms and standards used]

SMEs Website(s)

[1] Any text provided here may be published by the HUBCAP project or other EU initiatives. Examples can be seen from a previous Smart Anything Everywhere project here: https://fed4sae.eu/success-stories/.

Flood and Fire RIsk mitigation in WEtlands using micRowire sensing (FF-RIWER)

List of contributors (SMEs and DIHs)

Company	Author
Always Connected Consultants SRL	Eduard Popovici
	Alexandru Vulpe
	Bogdan Popovici
	Laurentiu Boicescu
	Cosmin Contu
RVmagnetics	Kornel Richter
	Martin Eliáš
	Patrik Jacko
	Peter Duranka
	Tomáš Ryba

Always Connected Consultants SRL

ACC is a software architecture, development and delivery consulting start-up, created in March 2021, with the aim to be "Always and all ways connect.ed/ing." - through agile, innovative and interdisciplinary approaches and initiatives. The founder and CEO, Eduard-Cristian POPOVICI, PhD, is the leader of SAIM (Solutions based on Agility, Innovation and Multidisciplinarity) Laboratory from Telecom Dept., ETTI (Electronics, Telecommunications and Information Technology) Faculty, UPB (POLITEHNICA University of Bucharest) - an enthusiastic promoter of entrepreneurship, team-based and project-oriented activities, personal soft skills development, advanced applied interdisciplinaries (combining information technologies like Java EE, SOA, BPM, IoT, automotive, security, health, AR/VR/XR/MR, AI/ML etc, with human sciences & technologies like marketing & branding, image & communication, future foresight, imagology, social networks etc), co-organizer of many competitions for innovation & apps development.

RVMagnetics

R&D company RVmagnetics has developed the smallest passive sensor in the world thinner than a human hair (20 micrometers) – MicroWire - a contactless sensor that measures pressure, temperature, magnetic field directly and indirectly also torsion, position, vibration, etc.

Contactless measuring is based on MicroWire technology and magnetic fields, with no need for powering the sensor. Sensors can withstand harsh acidic and alkaline environments, provide accurate data for a period longer than a lifetime and survive temperature up to 600 degrees without losing its accuracy. Sensors can produce accurate data even when placed in a noisy electro-magnetic environment. Sensing distance range is up to 10cm.

Integrating a MicroWire sensor does not add weight to the material nor changes its mechanical properties. The MicroWire sensor helped overcome sensing obstacles in Healthcare, IoT, Industry 4.0, Automotive, Aerospace, Structural Health Monitoring, Electric motors manufacturing, etc.

Subheading

The FF-RIWER experiment will enable the future DeltaEcoPro solution for increased preparedness against environmental threats in wetlands. Thus, the FF-RIWER solution is mitigation needs in wetlands.

Domain(s)

Flooding, fire, magnetic MicroWire sensor, real-time monitoring.

Impact

- The use of the MicroWire sensing technology allows for precise fire and flood sensing with little energy consumption and small, unobtrusive devices, making it ideal for delivering a monitoring software solution for the fragile wetland ecosystem.
- The success of the FF-RIWER experiment is crucial for further developing the company and enabling the DeltaEcoPro solution for the Romanian Delta.
- Development of a brand new type of environmentally-friendly sensor, that is not available on the market yet.
- Thanks to this project RVM formed a partnership with a company that allows integration of the sensor to a broader robust multi-installation platform allowing flood and fire mitigation.

Quote

"*In FF-RIWER we combine the RVMagnetics environmental sensors (a HUBCAP asset) with newly created software modules for communication, data storage and processing and visual data presentation (alerts, history etc) for a new CPS solution to be used in use cases related to wetlands (and envisioned to be first deployed in the Romanian Danube Delta). RVM's technology allows for precise fire and flood sensing with little energy consumption and small, unobtrusive devices, making it ideal for the fragile wetland ecosystem.*" – Laurențiu Boicescu, ACC team lead

"*We envision the FF-RIWER platform will be the starting point of the larger DeltaEcoPro solution for monitoring and performing ecological actions in the Romanian Delta, opening up a host of opportunities for increasing our competitiveness on the local and European market*" – Eduard-Cristian Popovici, CEO of ACC

"*The main benefits RVM gained from participating in the EXPERIMENT was to advance our own technology by employing multiple MicroWires and coils for precise position (water level) measurement and proving its adaptability to wetlands, broadening the company portfolio and also having completed the validation of the technology in real scenarios.*" – Vladimir Marhefka, Vice-Chairman of The Management Board of RVMagnetics

"*With the ACC software solution RVM is now also able to simultaneously run sensors placed in multiple locations.*" – Kornel Richter, Technology Lead of RVMagnetics

Image/video

https://drive.google.com/drive/folders/1btVnmNguK0y90P1skud2kQ_wlob8ffit?usp=sharing

Project

Wetlands are fragile ecosystems, which are susceptible to harm from different environmental threats. Bush fires can destroy bird hides, trees, boardwalks and in general fragment the habitat and increase pollution. Also, floods in the wetland cannot provide the same habitats and functions, can result in the loss of wetland vegetation and hamper the transport of native

The FF-RIWER experiment targeted the integration of a CPS technology, namely MicroWire Sensing technology, available as a HUBCAP asset, and offered by RVM, into a new MBD-augmented modular CPS solution (DeltaEcoPro) for Flood and Fire risk mitigation in wetlands to be implemented by ACC.

The DeltaEcoPro solution which integrates RVM's CPS technology and validated by the FF-RIWER set of experiments will support two novel fire and flood sensors based on MicroWire sensing technology, customized for wetlands and will process real-time data using business intelligence tools to provide valuable input (such as sudden increase in temperature and water level), which will then be used by a visual alerting module in order to offer monitoring components that are available for a wetland administering authority for better crisis assessment and early response to wetland threats.

Experiment / what was done

ACC developed and organised the software components of FF-RIWER are in a dockerized software stack, allowing a rapid automatic restoration of service in case of fault (in case of power failures). The stack consists of a gateway for sending messages from the MicroWire sensors, server-side client for reading measurements, tools for enabling a server, database and visualisation component. The software stack has been developed in a collaborative form, using the GitHub platform

Within RVM part of the work - design, construction, calibration and validation of the sensor was achieved. The sensor provides accurate measurement of water level and temperature in real-time. The sensor is based on an amorphous glass-coated magnetic MicroWires, using a data acquisition device designed and produced by RVM that contains a set of sensing and excitation coils, PCB with amplifiers and filters, and a Nucleo chip with operating software. Nucleo communicates by UART port with a wireless transmitter that sends data to the server.

Consortium members performed 2 types of experiments:

1. In the first experiment water level was increased from 0cm to 23cm and continuously decreased from 23cm down to 0cm.
2. Validation of the temperature sensor by heating the sensor by hand-dryer, and cooling it down to ambient temperature.

HUBCAP support and platform opportunity

The use of the HUBCAP platform allowed the preparation of ACC's software to work with RVM's hardware sensors and enable a smooth integration between the products of the two companies. The possibility of adding the FF-RIWER solution as a new tool in the HUBCAP catalogue brings further visibility and opportunities for ACC and its products and services. The funding received from HUBCAP allowed both companies to further develop both their own technology but also develop a new CPS solution benefitting from both companies' know-how.

SMEs Website(s)

ACC: https://acc.neuroaugmentare.ro/

RVM: https://www.rvmagnetics.com/

Data-driven Digital Twin supporting Efficient and Environmental-friendly wood processing (GreenWood)

List of contributors (SMEs and DIHs)

Company	Author
PLANETA Technologies Planeta Technology was established in 2007, engaged in the design and manufacture of furniture, furnishing residential and commercial interiors. We use materials that fully meet the highest European safety standards. The production hall is equipped with machines and tools adapted to both individual and serial production. We have CNC numerical machines with tools with diamond plates, from tailors to milling machines. An equally important link in the production process is extremely professional staff in all segments. Our operators have ten or more years of experience, so with quality materials and fittings and modern technology, the final product from our factory inevitably meets the highest standards of workmanship.	Radenko Radenovic
HelinData Helin is expert in working with technology in harsh and remote working environments. By applying big data analytics technology such as image and video recognition, pattern matching and anomaly detection for condition based maintenance we make these hazardous environments safer and more efficient. We have experience with building edge analytics solutions and have a large network of partners for many edge related solutions	Martijn Hendels
Nissatech Nissatech is an innovation-driven SME with strong international cooperation and vision to become one of European top innovators in the domain of advanced AI and cognitive industrial solutions. The main objective is to develop own technological building blocks through an efficient implementation of the cutting-edge research and their usage for resolving very challenging real-world problems in different industrial domains.	Nenad Stojanovic

Subheading

GreenWood will model the (near) real-time behaviour of the production in the eco-friendly context. It means that GreenWood will be able to a) monitor all parameters related to eco-friendliness b) create models of the valid/proper behaviour and c) react on any unusuality in the real-time data (before the situation escalates).

Domain(s)
Eco-friendly production, furniture industry, edge processing.

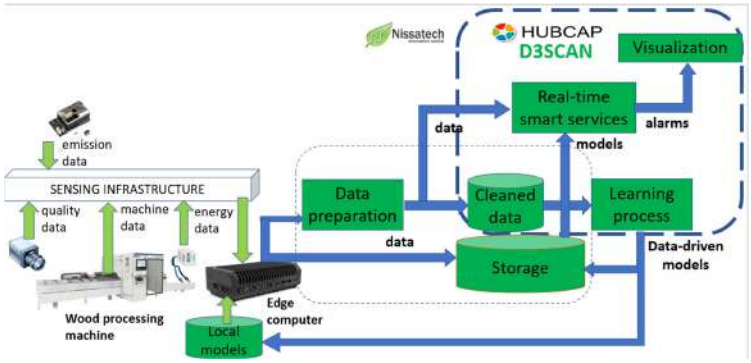
Impact

- New quality monitoring approach for eco-friendliness wood making process.
- New methods for understanding the impact of the energy consumption on the environment.
- Finding the opportunities for the improvement of the eco-friendliness of the wood making process.

Quote

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

Image/video



Project

The vision of this proposal is to pave the way for a new generation of the wood processing monitoring services, which are focused not only on the processes performances (KPIs), but also on the eco-friendliness of the process, what we call eco-friendly process quality.

From the **technology point of view**, GreenWood will model the (near) real-time behaviour of the production in the eco-friendly context. It means that GreenWood will be able to a) monitor all parameters related to eco-friendliness b) create models of the valid/proper behaviour and c) react on any unusuality in the real-time data (before the situation escalates). The green digital twin system then allows to monitor the dynamics of production system and predict its behaviour.

From the **manufacturing (technology adoption) point of view**, main objective is to achieve eco-(Planeta) toward circular economy: existing process environment will be extended with different sensors to collect quality data and create behavioral models (aka Digital Twin) which will enable a better understanding of how eco-friendly production can be realized.

HUBCAP support and platform opportunity

The most important advantage is that HUBCUP supported an innovation that exposes some risks for SMEs. HUBCAP enabled an environment where this innovation can be boosted in a risk-free manner. Also, the collaborative work between relevant companies was supported. HUBCAP platform offered an asset that provides complex analyses of the manufacturing data (D3Scan, Deep Data Diagnostics through Cognitive Scanning). It was very important for the modelling process. Additionally, mentoring process is organized in a very efficient way, monitoring the focus of the work and keeping it on the defined KPIs and ensuring the continuous progress.

Forward look

CPS technology provider, Helin (coordinator) is a provider of the CPS integration services (Polaris Platform), will establish new services in the domain of developing affordable eco-quality monitoring infrastructure.

Manufacturing user (MBD CPS user), Planeta can improve own competitiveness with eco-quality in the global market, esp. after the pandemic crisis which provided a lot of challenges for SMEs.

There are two main business advantages:

Developed system is a new service which can be applied in various domains. Therefore, it opens new (promising) markets for the technology provider
In addition, existing Platform (Polaris) for edge computing will be extended with advanced energy-environment data analytics

SMEs Website(s)

https://www.helindata.com/

Kontakt – Planeta namestaj

SmarTexMod

List of contributors (SMEs and DIHs)

Company	Author
Vulpes Electronics GmbH The company designs, develops and produces smart clothing including for leisure, sports, health and industry with the focus on thermoregulation, illumination and vital signs monitoring.	Rustam Ismailov
Intelectronics Intelectronics capitalizes on four years of experience developing the Dynaback smart suit: a garment integrated with inertial sensors, fully washable, which provides a basis for applications which rely on Motion Capture. Intelectronics is a young company which aims to provide prototyping and production services to actors in the field of Smart Textiles.	Sabri Mahdaoui

Subheading

Enhancement of the efficiency in the design, development and prototyping process for smart clothing items.

Domain(s)

#smartclothing #prototyping #smartclothingdesign #smarttextiles

Impact

- Reduction of the design time for the clothing designers.
- Increase clarity of instructions and enhance the efficiency of design, development and pre-production workflows.
- Visualization of hardware components.
- Improve cross-function understanding of textile / garments, electronics and mechanical components to accelerate the design and development process.
- Decrease the rapid prototyping time of hardware.

Image/video

Please find the video on the HubCap channel. Further images can be provided upon request.
The project can be found on HubCap or Online: https://smartexmod.com/
Further images can be provided upon request.

Project

SMARTEXMOD is an efficiency tool providing pre-build assets for design, development and

Experiment / what was done

Within the project the team prioritized and assessed the items which are required to create smart clothing. The team created 10x parametrized assets and provided the distribution option through the website https://smartexmod.com/. The user has the option to choose between different assets, parameters and data files to download the parametrized models for either the integration into the clothing design software or for rapid prototyping. The model simulation has been done with the Clo3D design software as well as with slicer cura and ultimaker machine / makerbot rapid prototyping.

HUBCAP support and platform opportunity

With HubCap, both companies received the opportunity to implement the project with model-based assets by supporting the upcoming new field of smart clothing. The smart textile segment required multi-disciplinarian approach involving different expertise coming from garment, electronics, mechanics and IT field. With the HubCap platform the consortium was able to create a suitable tool for supporting the multidisciplinary design and development process in the result to increase efficiency.

Forward look

HubCap enabled both companies to make the groundwork for the parametrized models. So far, the models are in the “alpha stage” and would be further developed in the next steps to reach higher maturity. Further marketing activities would be required to promote SMARTEXMOD further.

SMEs Website(s)

Vulpés Electronics GmbH: **www.vulpes-electronics.net**

Model-based design of the public transport operation run by zero-emissions buses

List of contributors (SMEs and DIHs)

Tirn Technology is a young and hungry startup with ready-to-use simulation software for collaboration between operators and manufacturers by using the current possibilities of A.I., publicly available relevant data, and modern simulation models to shape the future of electric mobility faster.

SKAND Skalica, spol. s r.o. is a dynamic public transport operator in the region of Skalica with a long tradition and experience of more than 30 years, providing city and suburban transportation.

Company	Author
Tim Technology	Robert Malcho
Tim Technology	Juraj Majera
SKAND	Lukas Tison

Domain(s): Smart Transports/Mobility Simulation services

Impact

- Simulation tool of existing bus operation schedule with electric buses and prepare a MBD-driven plan for electrifying the operation.
- accelerate the transition to sustainable public transportation
- elimination of the carbon footprint created usually during physical testing

"Hubcap Funding enabled us to justify our place in the public transport value chain, which is much more than shooting blindly."

Project

Cooperation project of consortia has developed model-based software that precisely simulates e-bus operation thanks to the integration of real-world data. This approach allows shortening the planning phase and significantly reducing the costs upfront. E-bus simulator is a new MBD tool that has been integrated into the HUBCAP platform.

Our scope has been divided into 2 sprints. Mainly our scope was built around these pillars.

-Understand adopter's operation, timetables and actual state of the bus fleet
-Define initial requirements for the new electric bus
-Understand current and future goals defined by the local municipality
-Processing of GTFS data provided by the client.
-Communication with the bus manufacturers and getting data sheets.
-Parametrization of the selected electric bus models.
-Visualisation of the bus operation based on provided data.
-Data assigning of the route details based on the API calls
-Running up to 180 scenarios of 4 bus lines.
-Analyze the influence of all the parameters
-Ingest economic parameters and prices(Capex/OPEX)
-Present actionable steps for the electrification of the SKAND's operation.

Experiment / what was done

Within Sprint 1, we had visualised the bus schedule using GTFS format. Based on real world-data from third-party providers, which was assigned successfully to the operated routes. Next step was to build a mathematical model of an electric bus. In the second sprint, we simulated more than 180 simulation scenarios, built the heads up indication of an operation schedule adjusted for an electric bus and developed a total cost ownership report based on inputs.

In conclusion, the transport agency had received a powerful decision tool as a result of simulation their operability, precisely predict real energy consumption, optimise the battery capacity and plan the charging infrastructure with a focus to minimise the total cost of ownership and CO2 generation.

HUBCAP support and platform opportunity

Hubcap support provided steering and valuable insights.

Provided us the space to perform and validate the experiment.

Funding from Hubcap enabled to Tirn Technology to make multiple iterations of the product versions with the adopter SKAND Skalica in order to improve the product and make it ready for the market

The SKAND Skalica has received not only a powerful tool to ease the adoption of e-buses but also the knowledge and capabilities of model-based design.

Definitely the outcomes of the experiment will provide us momentum to access new markets and reach out to new potential leads, hopefully clients.

Forward look

Improvement of business conditions can be divided into two branches.

From a financial point of view we have been able to maintain business operational and keep the sales or R&D activities quite active. Hubcap enabled us to prepare for another investment round, by building traction in product, understanding customer needs and quantifying the added value of the solution.

From a product point of view we were able to further improve the product from a customer path.

These ingredients are necessary for a proper execution. We have gained the needed traction and currently are involved in other pilots e.g. GoWhippet from Cambridge and Tugsal in Barcelona.

SMEs Website(s)

http://www.skand.sk/

Exploiting cloud computing and AI technology for hydrogen storage & transportation towards net zero by 2050

List of contributors (SMEs and DIHs)

Company	Author
MultiFluidX (Adopter): A deep-tech company that develops physics-based computer simulation.	Dinesh Bhatia, Konstantinos Lyras
Kaleidosim Technologies (Provider): A software company offering a cloud-based platform for simulations.	Gernot Boiger
Newcastle University (DIH): A UK public research university a red brick university and a member of the Russell Group.	Mark Jackson, Anirban Bhattacharyya, Ken Pierce

Next-generation hydrogen planning using AI and cloud computing

Domain(s): [keywords indicating what areas the project addressed] Smart energy, Engineering, Hydrogen, Low/zero carbon communities, High-Performance Computing.

Impact: [3-4 bullets on the key impacts on the companies and more widely; explain your investments]

- Both companies have advanced their digital tools thanks to HUBCAP
- The provider has extended their cloud computing technology to allow dedicated simulation tools in MPflow® for hydrogen calculations
- The adopter has upgraded their digitalisation level though the unique MSCC (Massive Simultaneous Cloud Computing) of KaleidoSim OpenFoam ®
- The integration of machine-learning in MPflow® using the unique hydrogen data collected, have set the groundwork for more advances in the field of computer simulations in process engineering.

Quote: *HUBCAP has funded the first project for improving design for hydrogen energy infrastructure using HPC and machine-learning-accelerated digital tools.*

Project

The scope of this project was to develop a viable solution for simulating liquid hydrogen transportation for hydrogen based energy systems. The solution in this case was to combine traditional methods of performing simulations such as computational fluid dynamics (CFD) with machine learning (ML) and simulate hydrogen based scenarios faster and cheaper than the current solutions on the market. H2AI aims to be the first EU based project that combines CFD and ML in handling hydrogen and improve the competitiveness of the EU industries by providing a fast and accurate simulation tool.

Experiment / what was done [Please describe what was done during the project. Again, please write this for a general reader who may not be familiar with your application domain or solution technology. Up to ~250 words]

- Energy security and decorbonisation are top priorities of the EU which supports numerous changes across the energy sector with the use of hydrogen being one of the biggest ones. This project explored the deployment of

  Computational Fluid Dynamics (CFD) with machine learning (ML) that could lead the next- generation designing of hydrogen-based energy systems.
- Therefore, with the use of these two state-of-the-art technologies the H2AI project has developed a workflow for using computer simulations for performing "virtual experiments". The outcomes of these simulations can be used for instant predictions and ultimately arrive at the optimum product, which will be both safe and perform optimally.
- This is the very first software to combine CFD and ML for hydrogen predictions. The development and successful completion of the H2AI project will ensure that SMEs across the EU engaged in hydrogen storage and transportation have access to a digital solution that is easy to use at a cheaper cost than the nearest competitors.
- Adoption of this software will enable a range of SMEs to model wide ranging hydrogen storage and transportation scenarios in the cloud and ensure enhanced safety and improved efficiency for these scenarios. Ultimately, this will provide an impetus to the adoption of a hydrogen as a sustainable source of energy thereby meeting the scope of the Paris Agreement's temperature goals.

HUBCAP support and platform opportunity

HUBCAP has provided us with the support and funding for utilising and testing and new cyber physical system for hydrogen, the first of its kind. Thanks to the constant engagement and support of the DIH and the whole HUBCAP team, both companies in the H2AI project were able to advance the technology of computational fluid dynamics simulations. It is a unique computational tool for optimising hydrogen production and application in various industries.

Through this combined effort, the H2AI experiment aims to be the first EU project with the specific goal of integrating AI with traditional physics-based Computer Aided Engineering in handling hydrogen and improve the competitiveness of the EU industries. Thus, being part of the HUBCAP ecosystem, will help both participants to further engage with this new technology, connecting with key-players in the EU market and being part of the pioneering long-term sustainable plan of HUBCAP. The latter is of extreme importance since it is expected to lead to synergies that will allow for more opportunities and additional funding from similar calls. The dissemination of the outcomes of the H2AI project though conference participation and future publications, generously supported by HUBCAP, is also a huge boost for both companies involved that will further increase the overall impact of the project.

Forward look

Being part of HUBCAP has increased our companies' visibility and marketing proving us with interesting opportunities for further development.

Our participation in HUBCAP has helped us be part to interesting industrial EU consortia for hydrogen allowing us to form allies for allocating additional funding for improving the computation tools our companies develop. Although, the long timeline of this funding opportunities does not allow us to provide exact estimations of the sales or income, it is expected that these projects will lead us to increase by at least 50% our sales for next year. It is also anticipated that being part to new EU research and innovation projects will allow us to increase of market presence in the EU and increase our manpower by 50%.

SMEs Website(s):

https://kaleidosim.com,

https://multifluidx.com

MEMS CPE- Matching Engine Mira Solutions- Commodities Price Estimator

List of contributors (SMEs and DIHs) [including brief profile of each company]

Company	Author
Evotech Services	Silviu Busu
Evotech Services	Patrisia Pascan - Intern

Evotech Services is an IT Services company based in Timisoara, Romania, incorporated in 2008. The domain of its expertise is the design and development of large distributed systems, mainly in the finance and investment banking domain, and business modelling. In the last five years, most of the projects also included the development of microservices applications.

Mira Solutions is a retail and corporate insurance broker company, based in Bucharest since 2015, that provides the legal framework for the issuance of insurance policies, being a proxy for all insurance companies in Romania. Following a presentation from Evotech Services and seeing the potential of integrating business modelling, model-based design and CPS simulations, Mira Solutions found it useful and commercially viable to add new modules to the MIRA Solutions Platform, targeting Freight Insurance Policy, Agriculture and Crops Insurance and Trade (as new business APIs).
In 2020, Evotech Services started to adopt system modelling technologies and started to use BPMN (Business Process Model and Notation) and Model-Based Design, while developing a Market Place project for a European corporate institution. After acquiring and developing the system modelling techniques, Evotech Services proposed the use case-based development of a current workflow of the Adopter SME (Mira Solutions), using BPMN/BPMS modelling.

The project implemented a new asset, SandBox Matching Engine (SBME), which was made public in the HUBCAP Sandbox. During development, we integrated the SandBox MatchingEngine with the Commodities Price Estimator and made these two APIs public in the Mira Solutions API.
Together the two companies conclude that new business and CPS modules can be integrated into a new commercial solution, called MEMS CPE (Matching Engine Mira Solutions Commodities Price Estimator).

Domain(s)
The aim of the MEMS CPE experiment was to develop and integrate 3 new simulated modules into the Mira Solutions platform.
These 3 modules are modelling 3 types of processes:

- Commodities price estimation (CPE module)
- Physical commodities supply-and-demand matching (SBME module)
- Business model workflows (Insurance Issuance Workflow Simulations)

Having in mind the Automate Any Process, Anywhere concept, Mira Solutions and Evotech Services realized an experiment which integrates 3 types of models in the same software abstraction stack.

Impact After we implemented the project, we managed to master the Camunda Workflow and Decision Automation Platform and we integrated this into the current work of both businesses. We defined diagrams used in insurance issuance on the Mira Solutions side and in the supply and demand order matching, CPE Commodities Price Estimator on the Evotech Services side. Both companies worked with model-based design and business modelling during design and implementation phases.
By implementing an experimental custom solution, Evotech Services and Mira Solutions proved that the design and simulation before the implementation of commercial projects improve the development speed and quality of the outcome. Following this experiment, the SandBox Matching Engine can be reused in other domains, like the Smart Energy market and many more. Reusing a valuable developed asset in new projects will be a constant revenue generator. Mid-range farmers will be able to plan their future crops and check local market estimated prices at any time for free. They will also be able to check the variation of supply and demand, and choose the best time to sell their crops. The CPE estimation charts will be available for free to all customer profiles. It is estimated that these free-to-use features will bring a constant number of new users into the platform. The trading feature is meant to generate revenue, but it will be offered for free for a certain amount of time for selected customers.
QUOTE *We kindly advise EU-based SMEs, especially applicants to EU-funded projects, to model their business flows, their eventual experiments and their proposed projects using BPMN process modelling. It will enable them to fast-visualise concepts, their interaction with company systems, and any outside APIs or CPSs integrated in their projects.*
Project
In Romania, the commodities market is illiquid and there is limited transparency regarding transactions, causing farmers to often make incorrect estimations of market prices. The main scope of this project is to help mid-range farmers sell their crops at the correct prices compared to international market prices like the EU, USA, and South Africa. In addition, we foresee considerable profits for next year, as we gained many important partners by presenting this project. e.g. AGRA Insurance - the market leader in Agro Insurance in Romania, Ardealul S.A. - market leader in Sunflower Seed processing and Sunflower Oil production.
The commercial MEMS CPE solution is a deployable application called ESPV/brcx.ro (Romanian Grains Commodities Exchange). Farmers will be able to use it for free, to estimate the best time to sell and buy crops using market analysis and weather predictions. We intend to give this to midrange farmers and large Agro-crops buyers like Sunflower Oil processing mills, for example, Ardealul S.A. Given the way we work, we already simulated a large trade of 1200 tons of oil, and we need to insure in the future the buy-side which is 3600 tons of sunflower. We created the solution by integrating the SandBox MatchingEngine with the Commodities Price Estimator (CPE) and made these two available in the Evotech Services - Mira Solutions Platform. The 1st module, MEMS CPE, the model-based controller, was designed as a digital twin of the business model workflows. It is the central controller, and it uses the APIs of the other two integrated modules, the CPE (Commodities Prices Estimator) and the SBME (SandBox Matching Engine). It was designed and developed using BPMN standard modelling. The BPMN diagrams defined during development reflect the actual business and physical processes. The MEMS module contains the high-level BPMN diagrams deployed in the same SBME-MEMS_CPE HUBCAP Sandbox.
The 2nd module, the CPE (Commodities Price Estimator) gathers grain commodities data from various channels and stores them into the Mira Solutions platform. These include historical crop prices and estimated crop models. The CPE module predicts daily and weekly market prices for the main physical commodities, grains, and oil seeds by using historical simulation models and supply- and-demand matching models. The CPS model simulations used the Accuweather Enterprise data interface and were replaced by real sensors with the data stored in the weather.com IBM Cloud Infrastructure using the wunderground.com API.

The CPE API currently provides the estimated prices for the main commodities, grains and oil seeds (sunflower, wheat, corn and rapeseed).
The 3rd module, the SBME (SandBox MatchingEngine) models the supply-and-demand order-matching processes and is the new asset provided in the HUBCAP Platform, used to model Commodities supply-and-demand matching processes in this experiment.

Experiment / what was done

We began with Mira Solutions analysing the business workflow in insurance and how mid-range farmers need to be insured. Then, we defined an insurance workflow where we learned how to interact with the farmers. Crops cannot be sold without insurance, so insurance is a prerequisite to sell through our system. The experiment was conducted using insurance consultants on Mira Solutions' side, and it analysed two types of workflows: Agro Insurance and Cargo insurance. On the Evotech side, we analysed the market price data models, and market commodities price variation models that are available on the market. In Romania, the market is illiquid and not transparent. The only transparent market that was a trend giver for sunflower was SAFEX, available using barchart.com interfaces. We then analysed wheat, corn, and rapeseed on Euronext MATIF, which resulted in more consolidated data models.
We initially worked with simulated data models provided by Enterprise Accuweather APIs, and later came up with the weather models for the future. In July and August, we connected to the IBM Cloud Infrastructure which is fed by real sensors (IBM Business - weather.com). Evotech acquired a weather sensor array for a farm and then we started experimenting with the real world. Mira Solutions did the same in September. We made an estimation forecasting model which is now available in the TradingView user interface. Evotech developed the SBME, which models the supply-and-demand process, and the CPE, which estimates the commodities prices. One of the main tasks of the project is to integrate both and give a consolidated API called MEMS CPE API, which is deployed in the HUBCAP Sandbox. The experiment succeeded and we now have the price forecasts. We gather data from the 4 markets and we process 4 commodities price estimations (Sunflower, Corn, Wheat, Rapeseed).

HUBCAP support and platform opportunity

The funding enabled the hiring of additional specialists, and we now have 50% more human resources available to develop the Camunda side, the Camunda Workflow and Decision Automation Platform, DevOps resources, server maintenance and UI design. Both companies hired third-party specialists, including an insurance modelling specialist, a web designer, a DevOps developer, a UI designer, and a UI prototyping specialist. As the commercial project approaches the production level, it now only requires the development of admin management of the client data, which was not included in the current experiment, as Evotech does not store and process client data.
The funding also enabled us to have funding available for all the market subscription data fees. Regarding the platform opportunity, we are now able to export and try our models, the Matching Engine, and the CPE in a server environment inside and outside the Sandbox.
This allows us to deploy our project correctly, similar to production level Apps.

Additional Information

Relevant technologies we worked with due to the funding include akkio.com, an AI prediction platform, and barchart.com, which is the Corn, Wheat and Rapeseed quotes API provider for Euronext MATIF, and the Sunflower quote provider for SAFEX. We managed to deploy tradingview.com live data feeds widgets and hired a UI exchange developer to work on integrating them in the ESPV/brcx.ro web UI. In addition, we managed to save $12k by gaining direct access to the IBM Cloud Infrastructure instead of paying an expensive monthly enterprise subscription to other providers, just by acquiring weather sensors hardware and integrating them into weather.com/wunderground.com ecosystem.

SMEs Website(s) **www.evotech.ro** **www.mirabroker.ro**

Digital Twin for Active Sprayer Boom Yaw Control

Company	Author
Schmidt Innovation ApS (sinno.dk)	Hans Christian Holt Povlsen
Schmidt Innovation ApS (sinno.dk)	Rasmus Jessen
Danfoil (danfoil.dk)	Martin Sørensen

Domain(s) [Agriculture, Digital Twin, Model-based controller design, CPS
Impact:

- Improved quality of digital controller testing
- Significant reduction of testing costs
- Boom stabilization reducing stresses on the boom
- Spray effectiveness and environmental impact

Quote "*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*
Project [Sprayer booms are susceptible to oscillations when distributing fertilizer and pesticides in fields. The oscillations give an uneven distribution varying between too high concentration and too low treatment across the field. The high concentration zones have an environmental impact as chemicals are washed out to the ground water, and in low concentration zones the crop yield is reduced and weed is left untreated. In addition, the boom structure also needs to strengthen due to the high fatigue loads stemming from the oscillations. The varying operating conditions of sprayers makes passive dampers suboptimal. An active damping system can be designed to provide high performance under all operating conditions, but this requires extensive testing to ensure stability and performance. Even small unhandled variations can result in reduced performance and damage to equipment. SteadySpray seeks to develop a Digital Twin, that can be used to develop active controllers for boom stabilization, where performance during various critical scenarios can be analyzed, and controllers can be optimized, without needing to put the physical sprayer system into critical scenarios without having a thoroughly tested control system employed.]
Experiment / what was done [During the project a digital twin of the Danfoil Concorde II field sprayer was developed, giving a suitable digital representation of the sprayer boom. Verification was carried out by comparing dynamic results from a test on the physical setup with results from an identical test conducted in the model. Using the digital twin, active control was designed to stabilize the sprayer boom when exposed to vibrations and unexpected movements in the yaw direction. This reduces stresses applied to the boom while increasing the effectiveness of the field spraying, which reduces the required amount of chemicals used to obtain a satisfactory crop yield on the fields.]
HUBCAP support and platform opportunity [The funding granted through the HUBCAP project has accelerated the development of the combined active control structure, which has given promising outlook to finalize the project within the coming year. Hence, a complete steady spray control system should be available starting summer 2023. Furthermore, the development of the sprayer control system has been positively influenced by the assistance provided to us by the HUBCAP network, particularly through communication with the contact person provided to us, who showed technical knowledge and provided excellent assistance.]
Forward look [The funding granted through the HUBCAP project has accelerated the development of the combined active control structure. Given that the primary market advantage of the SteadySpray kit, is that we are first movers on development of a Digital Twin for controller design, the advancement of the digital twin seen within the HUBCAP problem is a large advantage to market position of SteadySpray.]

SARC project

List of contributors (SMEs and DIHs) [including brief profile of each company]

Company	Author
DELTA Material Process & Innovation Solutions	Georgios Zaverdinos
theSARMproject	Savvas Savvakis

Accelerating the experiment process of a gas compressor's prototype, called SARC, using MODELTA platform.

Domain(s) : IoT, Real-time monitoring, MBD, Multiphysics, CAD, Simulink

Impact

- MODELTA PaaS (Platform-as-a-Service) was integrated to DELTA-MPIS set of services. It can support CPS development for both real-time monitoring and prediction
- DELTA-MPIS has already created a pitch deck for MODELTA, with successful results; Even before the ending of the HUBCAP sprint 2, another two projects (one commercial and one research) have initiated, utilizing MODELTA web-platform
- theSARMproject has reached TRL5 for SARC prototype; the prototype was manufactured and demonstrated in terms of effective sensing with optimized sensor selections
- theSARMproject have an optimized version of SARC with better performance and reliability, and decreased costs for manufacturing and operation.

Quote

"MBD can substantially facilitate the functionality optimization of physical assets. We observed through HUBCAP that the steps followed to build MBD really give a thorough understanding of the asset, preparing it for rapid development and prototyping. Furthermore, the critical parameters allocation and their control can improve performance and decrease cost.

Our advice as DELTA MPIS is for SMEs to get to know Model-Based Design and IoT in order to enter the rapidly growing sector of Cyber Physical Systems and also make their product and services up to speed with industry 4.0, smart manufacturing and Digital Twinning".

Project

The project aims at the development of a Model-Based Design enabled Cyber-Physical System for a novel compressor prototype, by DELTA-MPIS (Technology Provider). It includes sensing of critical parameters (temperature, pressure output, angular motion) for the operation and performance of SARC compressor (developed by theSARMproject) and utilization of those quantities for real-time monitoring and input for Model-Based Design. For the efficient project implementation a web-platform was developed, MODELTA, that provides IoT monitoring of sensor measurements and prediction of the performance of the physical asset. The prediction is achieved with a combination of MBD with Simulink and CFD and FEA multiphysics calculations, to accurately describe the operation of the compressor. With the aid of MODELTA, the prototyping process was enhanced (rapid prototyping) and an optimized prototype was manufactured.

Experiment / what was done

During the experiment, a set of activities was scheduled for the successful implementation of the project. This includes the following subtasks:

SPRINT 1:

- Design of experiment
- First steps of experimental campaign
- Computational Fluid Dynamics
- Finite Element Analysis for structural optimization of the compressor
- Development of web-based platform MODELTA
- Implementation of Model-Based Design to describe the operation of SARC.

SPRINT 2:

- Comparison of simulation with experimental results
- Calibration of experimental setup
- Prototype design improvements
- Integration of MODELTA in HUBCAP platform
- Cost evaluation for the sustainability of MODELTA adoption in other applications
- Dissemination activities
- Integration of MODELTA to relevant marketplaces
- Document preparation

HUBCAP support and platform opportunity

HUBCAP provided funding for the development of a tailor-made and easy-to-use CPS support web-platform and for the rapid prototyping through MBD of SARC. In this way, the Adopter SME came to the realisation of the benefits of the creation of a Cyber-Physical System, not only for the development of the physical asset, but also to support its actual operation. The consortium, in close cooperation with the DIH assigned to the project by HUBCAP (FDK), were able to structure the characteristics of their respective services and products according to the needs of a state-of-the-art digital Marketplace. The integration of MODELTA to HUBCAP platform gave insight on competition with other CPS solutions, in a spirit of fostering collaboration with other participants as well. Furthermore, the opportunity to add a try-it-now feature to the service was considered very important by DELTA-MPIS, in order to receive creative feedback for the MODELTA application.

Forward look

DELTA MPIS has developed MODELTA, a web platform that expands the services of the company. The platform supports IoT functionalities, a proven methodology for sensor connections with embedded devices and the upload of measurements to be available for the user at any time. The major benefit for DELTA MPIS is the display of an established tool for prediction and monitoring that can attract future clients for the company. This has been validated by the initiation of another two projects, one commercial and one for research purposes, both utilizing MODELTA functionalities.

theSARMproject (Adopter SME) has received substantial input regarding possible improvements of SARC compressor. In fact, those improvements have led to an approximate 25% decrease of mass for the finalized prototype, leading to a corresponding cost decrease. The efficiency improvement and the manufacturing of an updated prototype led to a TRL5 edition of the device. This created a very strong asset for theSARMproject to go to the next funding opportunities and eventually to the market. The steps followed for the experimental campaign have proven critical for the development of other prototypes for the company, namely a rotary internal combustion engine (SARM), an expander (SARX) and a pump (SARP) based on the novelty of the rotary working principle.

SMEs Website(s)

DELTA MPIS (Project Coordinator-Technology provider SME): www.delta-ms.gr
theSARMproject (Adopter SME): www.thesarmproject.com

SCUBA Design Integrated Verification Experiment (DIVE)

Domain(s): Formal methods, medical devices, safety critical software, requirements
Impact: The SCUBA DIVE project had the following impacts:

- A far better understanding of not only software requirements, but as a result, system and clinical requirements
- By achieving the above, it will reduce the eventual cost of both the software development and the regulatory process because all classes requirements expression have improved
- An insight into how D-RisQ Kapture®tool would be used by clients
- Identification of improvements to the Kapture tool and associated documentation

Quotes:
For D-RisQ, this experiment has enabled us to engage early in the development of a safety critical medical device development gaining us insight into how Kapture and our other tools will be used, while also simultaneously identifying improvements in tools for our client base. For ScubaTx, this experiment has helped to clarify our software requirements while also improving system and clinical requirements before we have committed to the full software development and hence this will save us both time and money in that development and in the engagement with the regulator.
Project:
The experiment's aim was to use the D-RisQ Kapture® tool to express Software High Level Requirements (HLRs) for a medical device used in the preservation of organs for transplant. The software for the organ preservation device must be high integrity to meet regulations and will be subject to independent scrutiny. As part of this process, ScubaTx became familiar with the way in which software requirements needed to be expressed in order to use them as the basis for future verification and for presentation to the medical device regulator. D-RisQ provided the tool and relevant documentation and where necessary, some consulting support. D-RisQ has experience of DO-178C, the software standard for aerospace. It is intended that the Formal Methods Supplement DO-333 will be used as the basis for certification. The ScubaTx team largely did the requirements work themselves with D-RisQ providing problem solving and tool enhancements to cope with the needs identified by ScubaTx. This process showed a number of improvements that were made as the experiment progressed and some that could be made in future. It was further identified that user documentation could be improved, which has already taken place. As a result, ScubaTx now have a better set of requirements at all levels as clarifications at the clinical level have taken place. For D-RisQ, investment is already underway to improve the user experience and the link to Modelworks which is expected to be available Q1 2022.
Experiment / what was done:
The output of the first sprint was a set of manually updated system requirements for the ScubaTx medical device and a set of software requirements developed from the system requirements using the D-RisQ Kapture tool. ScubaTx were able to easily use Kapture with many positive comments on usability and on the way in which the tool caused more thought on what the requirement should be, how it should be expressed and how it "helps especially when constructing large, complex expressions, as it enforces correct structure and reference consistency".
The aim of the second sprint was to explore how a software design could be developed and verified using D-RisQ ModelWorks®. This highlighted various sources of potential errors in requirements when considering then for automatic verification. These were either incomplete information in the requirements needed by the tools, which required more information to be added or required some enhancements to D-RisQ's tools. Indeed, while most of the sample design undertaken passed checks, we all learned how to better inform a user how to express requirements in a more verifiable manner and D-RisQ have therefore made plans to further enhance tools. This work has already commenced and is combined with user documentation upgrade. Beyond the scope of the programme, D-RisQ demonstrated that it was possible automatically produced C code from the design. This capability will be used in the future for automatic formal verification by using another D-RisQ tool to be completed end Q1 2022.
HUBCAP support and platform opportunity:
The funding provided through HUBCAP enabled the early engagement of ScubaTx with the D-RisQ tools. The early chance to understand how to express requirements in a clear, verifiable format will enable ScubaTx to be avoid issues later in development of the device and to take it through regulatory approval in due course, where hopefully the MBD work can be taken into account. As a case study for D-RisQ, this has been invaluable. We intend to improve the tools and to provide a presentation at the forthcoming 2022 Embedded World Conference in Nuremberg. This aligns with our strategy for the rapid assured development of control systems, safety critical or otherwise.
Additional Information:
More about the D-RisQ tools, the strategy and other products developed by D-RisQ can be found at: https://www.drisq.com/. More information about ScubaTx products can be found at https://www.scubatx.com/.
The support to the future safety case for the ScubaTx device from the software development has been outlined and is discussed within the report. While there are medical standards for software, they are different to those required for aerospace and do not mention formal methods. Despite stringent clinical trial controls over clinical outcomes, medical software is somewhat overlooked (or under estimated) in its complexity. In order to achieve approval in a cost-effective manner, there is a desire to use formal methods-based modelling tools and the associated formal verification. The intention, with the regulator involved as far as practicable, is to show a better way of gaining confidence in medical device software. As such it was decided to use RTCA DO-333, the Formal Methods Supplement to DO-178C which is the de-facto software standard for aerospace. It remains a challenge to convince medical regulators that such approach is well beyond the required processes within IEC62304, the medical software regulations standard.

Safety first development of micro-mobility sharing platform

List of contributors (SMEs and DIHs)

Company	Author
Developair	Jokin Garcia
Developair	Mikel Perez
KMB Lab	Uladzimir Kharkevich
KMB Lab	Ivan Minakov

KMB Lab Srl is an Italian technology company creating innovative CPS solutions for micro-mobility since 2015. Currently, KMB Lab is actively developing the BOOST platform, i.e. hardware and software components required to enable a fully automated electric scooter fleet for the hospitality business. The objective of KMB Lab is to formally specify and ensure, with the help of state-of-the-art MBD tools, all the safety requirements to be strictly met at any time and in any possible conditions of e-scooter use.

Developair Technologies is a technology-based company currently working on a development platform focused on automatic verification of requirements and generation of tests, enabling the optimization of the software development life cycle, offered in a SaaS format and oriented primarily towards companies developing intelligent systems in the transport, energy, aerospace, health, or manufacturing sectors.

Subheading

The project consists in developing a real use case (SAFE2GO) to take advantage of the synergies between two companies: on the one hand, the safety capabilities and optimization of a MBD platform, and on the other hand a real product with safety requirements.

Domain(s)

Micro-mobility, safety, requirements, verification, testing.

Impact

- Working together with KMB has helped Developair to be aware of the importance of some functionality and prioritize its implementation. The utility for the user of abstractions (models) used by engineers as state machines is now very clear.
- Improve Developair platform supporting new features and evaluating its generality with its application in new domain.
- For KMB, it has been seen that although the companies developing CPSs are small, it is convenient in many senses to have a testing methodology and framework, and MBD tools to help and automatize all the process.
- It has been checked that if the introduced tools in their workflows are intuitive and easy to use, the introduced small overhead worths, taking into account that the time and cost saved are bigger, and the code quality is better.
- Improve quality of KMB product (safety).
- Improve productivity of KMB process (automation).

Quote

Hubcap has provided the framework to, from the most general to the most concrete contribution: know part of the european MBD and CPS community, their products and challenges; allow to look for a complementary partner and meet in depth its company and product, and last but not least, work in a real use case to help both of us improving our tools and processes. Specifically, the implementation of new features in Developair and the improvement of the tool in general, and the improvement of processes' efficiency and the quality of the product in the case of KMB.

Project

The **goal** of the proposed **SAFE2GO** experiment is to incorporate novel MBD tools into the hardware and software development practices of an e-scooter sharing platform BOOST to ensure **safety requirements** to be strictly met at any time and in any conditions of e-scooter use. At the same time, Developair (a HUBCAP SME asset) offers MDB tools for verification of requirements and automatic test generation, enabling the **optimization** of the software development life cycle.

Experiment / what was done

First, the architecture and safety requirements of the BOOST use case (of KMB company) have been specified using Model-Based Design tools provided by Developair. New features have been implemented: that make the tool more powerful and versatile. Specifically support for state machines and *enum* data types has been introduced.

Then, those requirements were verified to detect errors and inconsistencies between them. Moving from informal requirements to fully formalized ones allows to automatically detect problems early during the requirement specification phase, avoiding those errors propagating to the implementation.

After that, black-box functional tests were generated automatically from those requirements to test that the code was doing what the requirements specified. The generated tests are compatible with a popular testing framework (i.e., Unity). It allows for using standard tools, e.g., for measuring the code coverage of those tests. Given that now the tests can be generated from the specification and are ready even before the implementation, testing starts before in the process (following TDD).

Finally, a connector to the platform where the tests are going to be executed, in this case the Unity framework, was developed.

HUBCAP support and platform opportunity

The participation in the Hubcap platform has several benefits: to meet other participants of the ecosystem, and specially to work together in a project with one of them in a new use case.

On the one hand, it has helped Developair to improve the tool in several ways. In the case of KMB, it has improved the quality of their product and the productivity of their process.

SMEs Website(s)

http://www.kissmy.bike/en/

https://www.developair.tech/

Opticity- Energy management platform based on AutoML and GA

List of contributors (SMEs and DIHs)

Company	Author
Vodena doo – Vodena offers university-strength research, data analysis, computer modelling, and optimization, all integrated through flexible and efficient software applications	Boban Stojanovic, PhD, Milos Ivanovic, PhD, Miroljub Krstic, Bosko Lakovic
Noleko doo – Noleko's main activity is production of electricity from renewable sources and construction of solar power plants	Zoran Bojovic, Sasa Lukovic

Country(ies) involved: Serbia, Kragujevac and Cacak
Subheading: Opticity - comprehensive energy management tool that completely automate finding of an optimal pattern in energy consumption and production in case of facilities with RES and energy storage capabilities
Domain(s): Renewable Energy Sources, Automated Machine Learning, Machine Learning Operations, Optimization
Impact

- The key impact of this experiment is to lower the barrier for European SMEs to use CPS in energy optimization. Using digital twin of solar power plant, Noleko has demonstrated that using optimal patterns in electricity generation and consumption can improve profitability up to 15%.
- Opticity provide end users with a powerful optimization utility that does not require any knowledge in the areas of predictive analytics, machine learning or optimization procedures, and do not require investment in computational infrastructure.
- Participation in this experiment enable Noleko to improve its business by embracing the principles of Industry 4.0, and thus become more competitive in the regional and European markets.

Quote (Boban Stojanovic, PhD): *Participation in this experiment boosted Vodéna's R&D capacities related to Model Based Design of Cyber Physical Systems. These newly acquired skills will enable Vodéna to expand its products and business models in the energy sector, as well as to expand it to other related areas, and contribute to the accelerated digitalization of SMEs in the region and Europe as a whole.*
Project:
The introduction of renewable energy sources (RES) in the grid has posed several challenges to energy producers and consumers. Effects such as intermittency, "duck curve", the growing complexity of stimuli regulations and the calculation of energy consumption, require that these challenges be approached in an intelligent way.
Vodéna integrated into HUBCAP platform a new asset tool, Opticity, a comprehensive energy management tool that completely automate finding an optimal pattern in energy consumption and production in case of facilities with RES and energy storage capabilities. Employing this tool Noleko developed digital twins of solar installations, and streamlined and optimized electric energy production-consumption process.

Experiment:
The goal of this experiment was to implement Opticity in the HUPCAP platform. To achieve this goal, following objectives were achieved:

- Development and implementation of Opticity, which includes the integration of existing sub-components (Blackfox, OSICE) into a single unit and the creation of a user interface.
- Development of a solar power plant digital twin using Opticity tools on the HUBCAP platform. The digital twin includes all the data relevant to the functioning of the system. As a prerequisite for the optimization of the operation plans, Opticity generate machine learning models of the internal energy production and loads, based on data acquired during the energy system exploitation. These models can be further improved by using publicly available data on weather, working and non-working days, specifics related to RES incentives, etc. To create and maintain these models, Opticity employ Blackfox, Vodéna's Cloud service for automated generation of optimized machine learning models, based on Deep Neural Networks, Random Forest and XGBoost. Generated predictive models are used for simulation of the energy data chain and evaluation of number of hypothetic operation plans under given conditions. The optimal operation plan is obtained on a daily basis through simulation-based optimization performed on our portable cloud service OSICE - Optimization as a Service in the Cloud Environment.
- Employing the digital twin to optimize the production and consumption of electricity by the end user, through usage of Opticity.

HUBCAP support and platform opportunity:
Vodéna strives to exchange knowledge and experience within HUBCAP ecosystem, and to reach a wide circle of users who gravitate around the HUBCAP ecosystem through the expansion of the HUBCAP offer with its asset. This asset is related to the use of renewable energy sources, and our desire is to be adopted by as many European SMEs as possible to solve their problems, which will at the same time significantly contribute to the improvement of the environment and the general quality of life of all European citizens.

Wheat Yield Prediction (WHY-PRED)

We investigated how to support the farmer with a decision support system to fertilize the right amount at the right moment while minimizing environmental impact.

List of contributors

Company	Author
DatenBerg GmbH	Maximilian Backenstos David Lumpp
Hedwigshof	Markus Klatz

Domain(s): Agriculture 4.0, Decision support systems, Wheat yield forecasting

Impact: Agricultural models explored; Logbook needs identified

“The HUBCAP project enabled us to do the groundwork for developing a decision support system for small and medium sized farming companies. Thanks to the funding we have been enabled to look into this really interesting topic” (David Lumpp, Agricultural engineer @DatenBerg)

"Should I fertilise today or not?" - the answer to this question on smaller farms is often based on the subjective experience of the farmer. On the one hand, a wrong decision has monetary effects - unnecessarily used fertiliser generates costs and requires working time. However, fertiliser that is not used also has negative effects, such as a lower crop yield. With falling food prices, too low a profitability can pose livelihood problems for the farmer. From a more holistic point of view, over fertilization also unnecessarily pollutes the environment - with sodium or phosphorus. Increasingly dynamic weather patterns due to climate change also present SMEs with the challenge that historical empirical values about the weather can no longer be extrapolated. WHY-PRED investigated the extent to which these challenges can be resolved, and the farmer supported through data-based approaches, while at the same time minimising the environmental impact.

During the project, available process models for wheat cultivation were evaluated and adapted to a specific application for the Hedwigshof farm. The models were calibrated to Karlsruhe and enriched with historical data. The aim was to show the farmer the impact on crop yield of the decision "Should I fertilise today?” This enables a cost-optimal fertilisation that simultaneously minimises the environmental impact.

With the help of the funding, the SME could be accompanied on its way to becoming a digital farm. In addition, available academic models were examined for possible applications in the day-to-day operations of a small farm and their limits were evaluated. With the experience gained, a decision support system can be developed that makes Agriculture 4.0 also accessible for SMEs.

Additional Information

During the project the model WOFOST (WOrld FOod STudies) the Wageningen University was used.

https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Facilities-Tools/Software-models-and-databases/WOFOST.htm

SMEs Website(s)

www.datenberg.eu

ITwinBuild Experiment

Adoption and transfer of MBD CPS technologies for implementation of novel digital health products and services to empower healthcare providers in Eastern Europe with remote telemonitoring and assisting patients with health self-management.

List of contributors

Company	Author
GOLEM Integrated Microelectronics Solutions GmbH (GOLEM)	Serguei Golovanov
IMC - Industrial Management Consulting Slovakia s.r.o. (IMC)	Elena Petrova

Countries involved: Austria, Vienna and Slovakia, Dubova pri Modra

Subheading: Implementation of the model of the cyber-bio-physical system Smart Human @ Smart Home using high-level IoT platform Pharos Navigator® for rapid development of custom Intelligent Digital Twins

Domain(s): AI-driven technology for Personal Health self-management using wearables and home environment sensors

Impact

- Economic impact: Minimizing unnecessary physical visits to medical centers, waiting time, lockdowns and isolation impacts, decrease the cost of services for patients and demand for caregiver resources, transportation, relevant environmental impacts. IMC will explore long term opportunities and addresses health/social-care demand that is especially hindered in Eastern Europe by economic factors.
- Social impacts: Massive improvement of self-care management at homes, connectivity with caregivers, social care organisations, new jobs for support, installations, maintenance.
- Enabling Intelligent Digital Twins to assist people in longevity and quality of life

Project: The experiment introduces novel cost-effective digital health solution for monitoring and prediction of personal heath of individuals living at homes alone or in isolation. It uses multiple wearable & home sensors and MBD CPS to run AI-driven calculations of holistic status of big system “Smart Person @ Smart Home”.

Experiment / what was done: The partners implemented big MBD CPS system “SmartPerson@SmartHome” as hierarchy of smart objects having own data sources and KPIs to run AI-driven calculation of system status in real & future time.

HUBCAP support and platform opportunity: The funding let us combine expertise, novel CPS/IoT/AI technology PharosN to develop practical health monitoring solution within 5 months.

Aircraft collision detection and steering angle tracking

Company	Author
Evitado Technologies GmbH	Andrew Moakes
Mototok International GmbH	Marvin Eckert

Evitado specializes in the development, sale, and distribution of robotic visions systems to automate airport operations. Evitado's software development expertise lies in sensor fusion and data analysis, especially concerning LiDAR technology. Evitado has developed several systems which use LiDAR point cloud data to detect aircraft and provide feedback to protect these valuable assets.

Mototok was founded in 2003. Battery-powered industrial tugs providing an all-round view around the aircraft by high technology remote control, operated by a single person. There are Mototoks available for all aircrafts up to 250 tons. They are in use by international FBOs, MROs, aircraft manufacturers, special forces, airports, airlines, navy, military, industrial companies, businessmen and individuals with their own fleet.

Domain(s)

Automation, Airport ground support equipment, LiDAR, Collision avoidance

Impact

- Validated Evitado simulation tool with partner to evaluate LiDAR sensors in various environments. Further developed and tested simulation tool for HUBCAP sandbox
- Worked with a new partner to integrate our technology with their product. Ultimately this new technology will help innovate the way aircraft are safely towed on the ground.
- Validated a proprietary state of the art software for identifying and tracking aircraft and other objects using LiDAR technology
- HUBCAP budget was spent primarily (90%) on personnel hours to analyse, develop and test this integrated system. Of the remaining 10% approximately half was spent on travel and accommodation for the system integration and testing, and the remaining was spent on hardware acquisition costs.

Quote

The HUBCAP project and subsequent funding gave us the opportunity to validate our simulation tool that allows the evaluation of various LiDAR sensors in different situations. It opened the door for further cooperation with our consortium partner to explore our technology in their tugs. Ultimately we believe that this project will open the door to future economic development for both companies.

Project

Accidents occurring during the ground handling of aircraft cause over $10 billion in damage per year. Collisions with tooling, vehicles, and other aircraft contribute to massive repair costs, downtime, and flight scheduling delays. The handling of aircraft is performed with a towing vehicle (tug) that maneuvers the aircraft into hangars and at airport gate terminals.

The goal of this experiment between **Evitado Technologies GmbH** and **Mototok International GmbH** was to apply technologies from the self-driving car industry and recent advancements in LiDAR perception to the tug machine handling of aircraft. The experiment investigated solutions to prevent damages caused by collisions and oversteering of the aircraft.

Experiment/what was done

The experiment started with a simulation of various LiDAR types covering different scenarios experienced when towing aircraft to determine the best sensor for the solution. The amount of coverage of a chosen aircraft and its surroundings was analyzed. This exploration of coverage was important to determine what the collision detection aspect of the Evitado system is able to see when a LiDAR is integrated into the Mototok tug. This analysis was conducted using Gazebo and a version of the simulator was uploaded to the HUBCAP sandbox.

A LiDAR was chosen to integrate and test with a Mototok tug. The LiDAR was integrated into Evitado's proprietary tracking algorithm. The Evitado system was closer integrated with the tug's CAN-Bus system in order to communicate system status, driving speed and detected steering angle of the tug relative to the aircraft. Testing was conducted by moving the Mototok tug with a test trailer in order to calculate the error between calculated and true steering angle as well as tracking delay.

The experiment resulted in over 100 GB of collected real world movement data. The steering angle tracking testing detected mean error of steering angle tracking of less than 2° with a delay of less than 0.5 seconds in more than 75% of the movements conducted, with a max mean error less than 3.5° and 0.605 seconds of delay.

HUBCAP support and platform opportunity

Hubcap funding allowed Evitado and Mototok to work together to explore a new technology for Mototok's towing vehicles. It allowed the two companies to determine the best LiDAR sensor for use in their tugs and allowed an exploration of steering angle tracking error when the Evitado system is integrated with the Mototok tugs

SMEs Websites

https://evitado.io

https://www.mototok.com

MedaPlus- Digitizing the auscultation process with respiratory AI List of contributors (SMEs and DIHs)

Company	Author
Slezak IoT Systems (SIoTS)	Gerrick Kammholz
AvailabilityPlus (APlus)	Dr. Gunther Hoffmann
AvailabilityPlus (APlus)	Dr. Ulrike Schuster

Profile Slezak IoTSystems (SIoTS)

Slezak IoT Systems (SIoTS) is a specialist in implementing customised IoT solutions across verticals including medical devices. Slezak IoT Systems was founded in 1997 in Alaro, Spain.

SIoTS reference projects include the wireless monitoring of hundreds of medication refrigerators in veterinary clinics as well as the monitoring of boilers in breweries using proprietary IoT hardware. SIoTS proprietary IoT hardware and software is also used in SmartHome systems and on luxury yachts.

Reference customers include: Mammut (intelligent clothing), Pixelpark, Canbox, Burda, Springer, Blue Ocean Yacht Management, Forastera Craft Beer, SmartVet, Leiser.

Profile AvailabilityPlus (APlus)

AvailabilityPlus is a spin-off from Humboldt University Berlin. The team is comprised of specialists in artificial intelligence (AI), reliable IT systems, medical and pulmonary sciences. The team does have a track record with the German Federal Office of Information Security (BSI), software development for critical infrastructures which is the basis for the proposals GDPR compliant data protection layer. AvailabilityPlus was founded in 2008 in Berlin. AvailabilityPlus has been developing data and AI driven technology for healthcare like diabetes monitoring and analysis, obesity management and data security. AvailabilityPlus employs seven FTEs. The company has received industry recognition and awards, among others from German Federal Ministry of economic affairs, Volkswagen, SAP, Bayer. The team has participated in national and international research projects. AvailabilityPlus develops MedaPlus, an explainable AI driven system to digitize the auscultation process.

Design and development of a low-cost electronic stethoscope, enabling contactless auscultation, digital transfer and storage of sound samples as well as AI driven analysis of the sound samples.

Domain(s) Digital Stethoscope, ear-contactless auscultation, artificial intelligence (AI); digital health; telehealth

Impact Impact on MedaPlus

The outcome of this project enables MedaPlus to address the needs of hospitals, polyclinics, doctors, and non-physician staff by offering a fully digitized auscultation solution. Additionally, the outcome of this project will enable MedaPlus to offer its services globally and for use cases not sufficiently addressed today like remote patient auscultation (telehealth).

Impact on Slezak IoT Systems

Today Slezak IoT Systems provides customized, project-based solutions, the business model is difficult to scale. Co-developing with MedaPlus will enable Slezak IoT Systems to switch to a scalable business model, by focusing on designing and manufacturing the digital device.

Impact on Doctors, Nurses, Healthcare Providers, Patients

(1) increase in the frequency of auscultation, progressively increasing to continuous monitoring, leading to an increase in the quality of the auscultation analysis

(2) increase in the number of patients that can be screened, leading to more patients that can be treated early, early intervention is essential to mitigate potential health risks

(3) efficiency gains for physicians who can outsource the auscultation process and analyses the data at a chosen time at a remote place

(4) reduced risk for doctors, hospitals and insurances because auscultation results are automatically documented, and second opinions reduce the chance of mis-interpretation and thus legal cases

(5) doctors can outsource the auscultation process to non-medical personnel staff

Quote *HUBCAP created the opportunity for our two SMEs to build an end-to-end telehealth solution that addresses the needs of hospitals, polyclinics, doctors and non-physician staff.*

Project

Respiratory conditions are a leading cause of death worldwide and generate a significant burden for public health systems. An estimated 15%-25% of the population globally suffers from at least one form of respiratory issue. Early diagnosis and routine monitoring of patients with respiratory conditions are important for timely interventions.

However, diagnosing respiratory conditions requires well trained and experienced medical staff. Given time, availability and economic constrains, professional staff is not available at all times and in all geographies. To support Doctors, Nurses, and remote patients, MedaPlus does provide artificial intelligence (AI)-assisted software to analyze auscultation results. MedaPlus allows health care professionals to analyze, share and compare auscultation results for a second opinion or for treatment follow-up. Additionally, MedaPlus analyzes auscultation data for anomalies comparing against one of the largest databases of reference pattern, individually and manually classified.

One of the largest obstacles for a widespread adoption in practice, is that today stethoscopes are mostly analogue. A specialist listens to the sounds while the patient is present at arms-length distance. The primary challenge is getting the lung sounds into the MedaPlus system for analysis. Doctors and nurses currently are limited to experimental and home-grown settings to digitize lung sounds and then upload them manually into the MedaPlus system.

Experiment

We developed a prototype of the ear-contactless digital stethoscope. Our device enables real-time capture of auscultation sounds with headphones instead of an earpiece which transmits the sound signals automatically and in real time to the MedaPlus system. The resulting prototype digitizes the sound samples taken by a legacy analogue stethoscope and sends them to the MedaPlus system for automated AI driven analysis.

The digital stethoscope is a critical embedded system. Sending patient data via communication lines like WiFi and GSM over the internet into a cloud based system, requires particular measures to ensure availability, high signal quality, low latency, low energy consumption, data integrity and on top low costs. Model-based system engineering is one method to ensure these requirements early in the design process. We employed the AutoFOCUS3 tool that is available from the HUBCAP platform to address these issues.

The experiment is split into two iterations, each iteration addresses these sub-tasks: (a) building an IoT device that connects to a legacy stethoscope and records sounds; the IoT device cleans and amplifies the data; (b) the IoT device sends the recorded data on a secured line over long-haul channels to the MedaPlus analytics platform via WiFi and/or GSM; c) the MedaPlus app provides a security layer and secured APIs to provide secure endpoints to the IoT device; d) MedaPlus provides data analytics based on explainable AI (sound files displayed via user interface, signal analysis, display of anomalous signals via user interface), e) multiple IoT architectures have been modelled and compared to identify the optimal hardware architecture before running lengthy and resource intense hardware development processes. Data transport as well as storage is GDPR compliant.

HUBCAP support and platform opportunity

Device development is highly resource intense and cost sensitive. Having the wrong architecture, components and specifications can slow down development, increase development costs and thus increase time to market significantly. Model based engineering is one way to evaluate architectures and key KPIs upfront before investing into hardware development.

The focus of this HUBCAP experiment was on optimizing the individual parameters for both the hardware and the software as well as modelling additional IoT architectures with the AutoFOCUS3 tool with a particular focus on cost and latency (which directly relates to sound quality).

Both SMEs were inexperienced in using model-based-development tools and have improved their capabilities in this domain. The HUBCAP Platform offered a place to learn about Model-Based Design (MBD) technology for Cyber-Physical Systems (CPS) and to get hands-on with modelling software and existing models in their HUBCAP Sandbox Middleware. Additionally, we expect a speed up in the certification process, by using the modelling results and derived parameters.

SIMULAIR-COV19

List of contributors (SMEs and DIHs)

Company	Author
Alteria Automation Alteria is a high-tech engineering company with experience in developing photonic applications & smart sensors. Alteria develops and sells custom sensors for advanced environmental monitoring & industrial industrial predictive maintenance based on advanced IoT concepts and wireless connectivity. Our smart sensors are advanced platforms with onboard technologies featuring stand-alone, embedded-edge computation capability, intermediate storage and diagnostic features that transform traditional analogue signals into true digital insights. Alteria developed in 2020 a new product line called I-ON for Ultraviolet-C Disinfection to provide solutions to the pandemic times that we are living Our experience in the field of Photonics provides the know-how to resolve the challenges presented by the use of ultraviolet irradiation (UV-C, 254 nm) for air-borne disease prevention. This technology has applications not only to the SARS-Cov2 (COVID-19) but to bacterial infections such as Legionella and Listeria, just to name a few. Alteria has a fully operational 800m2 facilities that include a high-tech hardware development laboratory, manufacturing space with Robotics, EMC pre-testing & production facilities specially designed for the development of embedded smart sensors / UVC Disinfection systems. Our facilities also include a software room where we develop firmware fo embedded systems and a data server room for postprocessing projects.	Jose Vigil / Mario Alfonso

Ingeeniuos Educated in Mechanical Engineering both in Spain (CPS Zaragoza) and Germany (TU-Braunschweig), Alberto has gathered extensive experience in R+D projects in the automotive, aerospace and architecture sectors over the last 20 years. He started off in R+D department of Volkswagen AG (Wolfsburg, Germany) at the Forschung und Entwicklung Abteilung for Verbrennungsmotoren, where he developed a passion for this discipline and then moved forward to applying this MBD activities to the general engineering sector. Alberto also complemented his expertise with mechanical testing (Manager of the Mechanical Testing Laboratory of APPLUS), manufacturing activities (Operations Manager for Technoquark Manufacturing), and several product management positions in SEAT (WW group) and other companies. Alberto is currently carrying out MBD R+D activities for a wide range of sectors, mainly industrial and architecture.	Alberto Acín

Subheading:

Computational Fluid Dynamics (CFD) used to optimize the design and efficiency of innovative sensor- based Ultraviolet-C Air disinfection system (I-ON AIR) for HVAC systems by simulating dynamic real duct airflow behavior.

Domain(s):

COVID Disinfection, Ultraviolet-C irradiation, Air Quality sensors, Computational Fluid Dynamics for HVAC, Smart sensors.

Impact:

- CFD provides real airflow HVAC duct simulation, where system design is optimized.
- Minimizing airflow load loss and turbulence. Design validation.
- Improving efficiency by the use of different UVC reflective material.
- Radiating unit redesigned over the project with new reflector provides 24% gain.
- Simulation or radiation patterns were validated with in-duct measures using a calibrated UVC radiometer.
- In-duct viral inactivation simulated and validated with CFD over the HUBCAP project, following the inactivation rate figures provided by NBC (Nuclear, Bacteriological and Chemical) of the INTA (Ministry of Defence, Spain) in the effectiveness report issued in Jan 2021.

  The figures provided for static conditions by INTA where simulated in dynamic conditions with CFD on HUBCAP obtaining similar inactivation rates and confirming the effectiveness and compliance of the ION system for viral inactivation in HVAC ducts.

Quote:

"HUBCAP has helped Alteria Automation (adopter) with two key facts

- *We have improved our I-ON AIR range of UVC that disinfects the air by neutralizing virus, bacteria and pathogens on HVAC systems. We have improved the efficiency 24% following the simulations further gaining in viral inactivation ratio just by replacing the reflector material.*

- *We have validated the disinfection effectiveness of the system for in-duct dynamic conditions to be over what was expected or better, from the certifications provided by the NBC INTA laboratory in static conditions"*

- Jose R. Vigil, CTO Alteria Automation

Image/video:

https://www.youtube.com/watch?v=O63RSD_kyPI

Project:

In 2020 ALTERIA AUTOMATION designed from scratch the first version of an innovative highly effective Ultraviolet-C disinfection system for HVAC (air conditioner and ventilation)

The system, called I-ON AIR, is based upon a highly efficient long-life UVC emitter lamp and a smart disinfection process based on the data provided by different sensors: UVC radiometer, CO2 levels, Particulate Matter and others (CPS platform) that is sent to a cloud server providing full traceability of the disinfection process.

I-ON AIR has been already been certified in static conditions from a level 3 NBQ laboratory belonging to INTA (Ministry of Defense, Spain), and SGS issued test and certifications.

The experiment:
The problem is however that the virus inactivation tests have been performed in static conditions (a petri dish exposed to the UVC light for period of time). The real viral inactivation tests in dynamic conditions are unreachable for a private SME due to the cost and access needed to a level 4-5 bio- safety facility.

Our Goal is to create a design model of the virus inactivation in dynamic conditions, extrapolating static results to a real airflow dynamic environment (taking into account air

loss, turbulence, reflectivity, air speed, etc) of the HVAC ducts, minimizing power consumption and maximizing radiation exposure levels by improving reflector gain at the UVC wavelength.

Experiment / what was done:

1. Simulated the air loss load / air turbulence created by the installation of UVC ION-AIR equipment on in-duct installations, using CFD (Computational Fluid Dynamics) MBD tools.

   KPI: Air loss load & air turbulence design verified and tested valid.

2. Measured irradiation pattern on real HVAC duct system and simulate (MBD) the irradiation with different internal reflectivity scenarios (fiber foil clad, metal, clean and dirty ducts) on a duct length of 3m (1.5m before and after the disinfection equipment in-duct location).

   KPI: 24 % gain to the in-duct irradiation levels by replacing reflector material.

3. Evaluated the viral inactivation rate in real dynamic conditions with MBD simulation. From the static viral inactivation data provided by INTA, MBD tools will be used to extrapolate to a dynamic environment such as the real airflow and the aerosols behavior on a HVAC duct under UVC treatment for disinfection.

   KPI: Dynamic condition CFD model checked that irradiation levels predicted were equal or better than in static conditions.

4. Evaluated and simulated the influence of different in-duct air speeds in the HVAC system and its relationship with viral inactivation rate, using MBD tools.
   Average HVAC systems are rated at 3 m/seg air speed but it can be as high as 10m/seg on many environments. The inactivation rate is highly dependent on exposure time of viral load to UVC irradiation.

   KPI: Simulations done include viral inactivation rates evaluated in dynamic conditions and cross- section imaging of viral inactivation ratios.

HUBCAP support and platform opportunity:

HUBCAP funding allowed to perform the experiments and simulations that lead to the verification of the effectiveness of the ION HVAC Ultraviolet-C disinfection system in dynamic simulated conditions and the validation of the current design (loss load, turbulence) while improving the efficiency just by replacing the reflector material.

Additional Information:

Professional CFD software was used on the simulations provided herein by consultant (Ingeenious, Alberto Acin) The specification was drafted by Alteria Automation.
Tests carried out at Alteria Automation facilities in Madrid, Spain.

SMEs Website(s):

Alteria Automation Main Website: http://alteriaautomation.com/

Alteria Automation Product (I-ON) Website: http://uvc-covid.com/

Ingeenious Website: https://ingeenious.com/en/

AM QTOOLS

Additive Manufacturing Quality Monitoring system

List of contributors (SMEs and DIHs) [including brief profile of each company]

Company	Author
EnginSoft Spa – one of the European leading technology transfer companies in the field of Simulation Based Engineering and Sciences (SBES), also applied to digital manufacturing	Giovanni Paolo Borzi
	Daniele Callegaro
	Manolo Venturin
	Maria Cristina Mancino
	Diego Boscolo Bozza
Kilometro Rosso - innovation district and leading private innovation hub in Europe. Owns and operates the LISA Tech AM laboratory	Giuseppe De Marco
	Salvatore Majorana
	Sabrina Conte
PRES-X Srl – specialized in highly qualified inspection and **post-processing** solutions for additive manufacturing. Part of the BEAMIT group, the larger AM provider in Europe	Simone Barani
	Martina Vincetti
	Lorenzo Trombi

Domain(s)
Digital manufacturing, in-process quality monitoring, metal Additive Manufacturing
Impact

- In-process quality monitoring for metal Additive Manufacturing
- A methodology to increase process knowledge and support manufacturing decisions
- KPIs improvements (e.g. lead time, COQ)

Quote
"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."

Project
Metal Additive Manufacturing (AM) is a complex operation, which requires the fine-tuning of hundreds of processes parameters to obtain repeatability and a good quality design at dimensional, geometric, structural levels. Among major technology challenges, many recent reports mention the need to achieve smart metal AM process control so to ensure quality, consistency, and reproducibility across AM machines. Additionally, while a huge amount of data can be collected in metal AM processes, as most industrial AM systems are equipped with sensors providing log signals, images and videos, there are not consolidated solutions in the industrial practise capable to analyse this data in real-time for quality control.
To help manufacturing companies address these challenges, AM QTOOLS developed an innovative quality-oriented decision support framework, composed by (i) a Model Base Design (MBD) tool providing Design for Additive Manufacturing (DfAM) features, and (ii) a Cyber-Physical System (CPS) created by integrating an Additive Manufacturing (AM) asset with a real-time smart monitoring software application. Such framework caters to process engineers and quality managers needs in order to improve a set of quality and economic KPIs.
AM QTOOLS results include validated quality-oriented predictive models that support the a-priori selection of optimal process parameters combinations and the in-process monitoring of the quality outcomes. The models, integrated in the CPS, allow to improve critical manufacturing KPIs, such as lead time (e.g. by reducing the need for downstream quality inspections and reducing production times) and cost of quality (e.g. by reducing inspection requirements).
Experiment / what was done
The develop and operate phase of the AM QTOOLS project has been carried out in two overlapping steps. The first step created the quality-oriented framework. The quality oriented MBD approach abstracts the technical requirements and thus, it creates the project file containing all the necessary instructions for the Cyber Physical System, so to print the designed parts. The link between the MBD approach and the Cyber Physical System is provided by a catalogue of the features for aluminium parts that can be printed with a Laser Powder bed Fusion (LBPF) process, and of common defects, that 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 a 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 (OT) and Metallography Cut-Up.
The second step validated the AM QTOOLS framework in operation. 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, tracking the process outputs and, through advanced data analytics, providing information of the expected quality outcomes of a specific setup. Accordingly, AM production has been carried out and Smart ProdACTIVE has been applied to monitor and validate the improved part design.
HUBCAP support and platform opportunity
HUBCAP support provided invaluable, especially for:

- Guidance in order to improve AM QTOOLS project management and meet the tight project constraints and schedule
- Co-funding that has been very important in order to finance costly activities, such as metal AM production and inspection processes for various samples and parts.
- A platform that allows to publish and disseminate working project results towards an ample stakeholder basis

Forward look
While it is early to precisely estimate the business impacts of the AM QTOOLS project, the HUBCAP funding provided a unique opportunity to clearly address an industrial challenge and produce practical, working results. AM QTOOLS allowed to open communication paths with business stakeholders (i.e. AM manufacturers, Inspection laboratories, AM machines producers): the potential direct impact may be estimated at around 100K€ of additional turnaround for 2023 as development and integration services of smart monitoring solutions.

SMEs Website(s)
https://www.enginsoft.com
https://www.kilometrorosso.com
https://www.pres-x.com

Blockchain in IoT sensors: Block-IoT-Chain

List of contributors (SMEs and DIHs)

Company	Author
Future Sense S.L.	Francesco di Martino
Future Sense S.L.	Alvaro Garcia
Future Sense S.L.	Alejandro Guitian
Cubic Fort Consultores S.L.	Juan Bautista Tomas
Cubic Fort Consultores S.L.	Jesus Caicedo

Future Sense - Bye Radon overview:

Future Sense is a young company focused on IoT Product Development, that has recently developed Bye Radon: the unique IoT Sensor Solution to measure radon gas in real time and long-term. Their competitive and experienced team has joined the fight against this hazardous gas worldwide, as they are committed to save as many lives as they can through the development of products that include IoT technology.

As IoT experts, they also offer a wide range of services including hardware development, technical consultancy, software development and support with the introduction of new technological products into the market. During 2021 they have received the CE marking and RoHS certification, mandatory to start the commercialization phase of their Bye Radon devices in Europe.

Cubic Fort Consultores - AirTrace overview

As a 3-year-old private consultancy company, Cubic Fort has long-term experience in industry traceability, with high specialization in Blockchain (Ethereum and Hyperledger ecosystem), and Artificial Intelligence technologies (computer vision, NLP) applied to this domain. Our main consultancy projects have been related to the development of multi-party operating models (consortiums) where different members have access to a shared ledger (database) of information, in different domains like food production and industrial control systems. For instance, that is the case of Block & Wine, a project developed jointly with Bodegas Emilio Moro where an integral traceability application was built upon Hyperledger Fabric and Alastria to monitor the logistic parameters in end- to-end wine production processes and improve the overall quality.

Adding to the Blockchain technology supported in this project, they also developed and integrated several algorithms for computer vision tasks (license plate identification, weight control OCR, among others) which helped collect data throughout the value chain. They also developed a traceability project for Air-Quality continuous monitoring in LafargeHolcim for the real-time collection of air- quality levels in an industrial scenario and its securitization in a permissioned Blockchain (Hyperledger Fabric).

Introducing blockchain technology in IoT devices.

When combined, IoT and blockchain can be used to address issues relating to threat reduction, securing transactions, authentication, and secure communication within IoT networks. This is because a blockchain maintains a record of all transactions and makes them immutable, making it perfect for IoT applications.

Such a combination can be helpful in several industries, including healthcare, supply chain, farming, etc. Implementation of blockchain and IoT has facilitated and enhanced asset management by making resource planning easier, enabling, and increasing secure real-time communication, and helping proactively manage asset inventories. Used at scale, this can help detect anomalies and find patterns that can help streamline operations and improve traceability and cost-effectiveness within a supply chain.

IoT and Blockchain: market potential

The global blockchain IoT market is expected to grow at a compound annual growth rate (CAGR) of 45.1% from USD 258 million in 2020 to USD 2,409 million by 2026.

The growing demand for IoT security, simplified processes supported by transparency and immutability, and the growing availability of blockchain-based IoT solutions leveraging smart contracts and AI are anticipated to fuel global demand for the blockchain IoT market.

Blockchain — a solution to current IoT threats

Blockchain, a type of Distributed Ledger Technology, evolved far beyond bitcoin and is now finding its relevance again, specifically when integrated with IoT. The main reason is that IoT networks process data across several devices controlled by various stakeholders, making it extremely difficult to find the source of a data breach in the instance of a cyberattack.
There are various parties involved, raising the question of data ownership. This an area that lends itself well to blockchain technology, which can be used to address many issues relating to security, consistency, and scalability in an IoT network:

- **Spoofing**: When multiple parties are involved in a transaction, trust is often a challenge. Since the distributed ledger is tamper-proof, it gets rid of the requirement of trust.
- **Encryption**: Blockchain encryption protects existing entries from being modified i.e., it makes it immutable. This adds another layer of protection to an IoT network.
- **Transparency**: Only authorized users can have access to transaction history. This makes determining the source of a data breach easier.
- **Quicker and more scalable**: Blockchain is capable of supporting a large number of devices at incredible speeds. This addresses concerns with scalability.
- **Cost savings**: Overheads associated with gateways in IoT networks can be avoided, resulting in lower costs.

Challenges in leveraging blockchain technology in the IoT space

While there are lots of possibilities, various challenges exist that may hamper blockchain's adoption in the IoT space:

- **Possessing technical knowledge:** Before launching blockchain-enabled IoT initiatives, firms should have good knowledge and understanding as to how a blockchain works, both on its own and in tandem with IoT. Furthermore, IoT systems can incorporate several sensors which need to share a lot of data, which can be impacted by latency. A clear and efficient data model must be considered for a blockchain-based IoT network to avoid complications in the future.
- **Hardware constraints**: While blockchain eliminates the need for a central server to record transactions, the ledger must be maintained on nodes. This ledger will grow in size over time, which could cause issues for many smart devices, like sensors having minimal memory space.
- **Computing capability**: The computing capabilities of IoT networks differ from those of a blockchain ecosystem. As a result, not all IoT networks can support blockchain encryption algorithms at optimum speed.
- **Compliance requirements**: Since blockchain and IoT are relatively new fields, there aren't many clear established regulations to follow. This lack of standardization can discourage many firms from participating in this space, which in turn can slow down the rate of proliferation and adoption.
- **Maintaining complete confidentiality**: In a shared ledger, used in cases where an IoT network is used on public blockchains, it is difficult to obtain access to transaction history securely, while maintaining complete confidentiality. Such an issue must be addressed before determining if a hybrid or private blockchain is the right approach for a firm.

Use cases for blockchain in IoT

IoT devices with blockchain capabilities can improve security, transparency, and create a decentralized ecosystem. Below are a few industries where the pairing of blockchain and IoT can disrupt businesses.

- **Banking, financial services and insurance or BFSI**: When it comes to embracing blockchain technology, the industry has already recognized the significance of smart contracts and greater transparency. It can go beyond the traditional monitoring model to real-time data provided by IoT for several intelligent and automated applications.
- **Healthcare**: The Healthcare industry is dealing with the problem of falsified and counterfeit medicines. To help solve this problem, the entire route of medicines, from the point of manufacturing to consumers, can be tracked using blockchain and IoT. This can help track medicine shipments from start to delivery.
- **Farming**: As consumers want more transparency in tracing their food's origins, agriculture is an area that lends itself easily to the effective use of blockchain. Consumers, retailers and distributors may keep track of product quality, shipment circumstances, and other information that might help them decide where and how their food is grown, letting them make smarter decisions.
- **Supply-chain and logistics**: The involvement of multiple stakeholders in a distribution network makes end-to-end visibility and transparency a challenge. While IoT helps to solve this problem to some extent by tracking shipments and collecting data at various intervals, data security continues to be an issue. Thankfully, sensor data can be stored on a blockchain and made available in real-time to only those who are authorized, using smart contracts.

Domain(s): IoT, blockchain, radon, air quality, certified measurements.

Impact:

- 40 new healthy environments:
  30 radon monitored environments + 10 indoor air quality monitored environments.
- Certified air quality measurements:
  With the introduction of blockchain technology, the Bye Radon devices will ensure the source, integrity and authenticity of the data that the devices send to the cloud, thus avoiding alteration and repudiation. This will be the first step to create and enable the infrastructure needed for any IoT sensor to include this technology in the measurements.
- **Create easy infrastructure to implement blockchain technology in other IoT sensors:** AirTrace application follows a drag&drop principle that allows developers / software architects / blockchain practitioners to build IoT-based blockchain networks in an easy and automatic, yet powerful way. AirTrace offers a web-based application that allows to select which category of sensors the client wants to deploy for their particular IoT network, by providing a canvas (map, 3D architectural design, etc.) where they can locate and deploy the needed sensing devices.

During these last months, all efforts have been pushed into the final development of AirTrace platform with the implementation of MQTT protocol, to facilitate the adoption of other IoT devices. After several proof of concepts and tests, now both companies are working on the final phase to send the data coming from the IoT devices directly to the AirTrace platform. Furthermore, they have already deployed the 30 devices included in the first pilot project and are running the first connectivity and validation tests to deploy the second pilot project at the beginning of September, as the 10 devices are already manufactured.

Quote:

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.

Project:

To create and develop an infrastructure and network that can integrate blockchain technology into any IoT measurement device is the aim of this project.

AirTrace allows the generation of a permissioned blockchain network in the cloud to securely store all the data and measurements provided by any IoT sensors. Data is stored via two different options: RestFUL API and MQTT, which are the two most widespread interfaces available for IoT in the world, allowing AirTrace clients to resort to these mature technologies for communicating IoT data to the blockchain. This makes it the perfect tool from the HUBCAP ecosystem to test and implement this new technology in the Bye Radon IoT devices.

Future Sense has designed a PCBA that can turn any sensor into an IoT measurement device. They already count with two air quality sensors called Bye Radon. The first one, focuses on the measurements of radon (including temperature and humidity sensors); the second device has a wider air quality scope, also including measurements of PM, TVOCs, eCO2 and atmospheric pressure. For those who are not familiar with radon, it's the second leading cause of lung cancer according to the WHO and results in 84.000 deaths each year worldwide.

Once both companies have developed the blockchain infrastructure, the idea is to use this technology to expand to other sectors (chemicals, water analysis, etc.) and sensors (CO2, VOCs, PMs, etc.), thus stimulating and expanding the adoption of more Cyber Physical Systems (CPS).

Experiment During these last months we have been running several tests and analysis of the main platform requirements for the most suitable implementation of the Bye Radon IoT devices with AirTrace platform. As a result, we developed several proofs of concepts to validate the entire process, detailed in the document, with the outcome of an IoT device sending the data directly to two IoT platforms: Cumulocity (for visualization purposes) and AirTrace (for the introduction of the measured data into the blockchain). With the work done so far, the Bye Radon devices ensure the source, integrity and authenticity of the data that the devices send to the cloud, thus avoiding alteration and repudiation. We have also worked on the deployment of the first pilot project with around 30 devices measuring temperature, humidity and radon in Cieza (a municipality), University of Cantabria (radon professionals) and a winery located in La Rioja. We will now focus on the deployment of the second pilot project that will involve around 10 devices that also measure other air pollutants with the early adopters, so that we can measure in some locations where we have experienced connectivity problems. As this second version is manufactured with an external antenna, we think that this can solve the problems we have encountered. All this will be detailed in the final demo video.

HUBCAP support and platform opportunity:

The funding supplied by HUBCAP has served both companies. From AirTrace's perspective, working with a real IoT manufacturer has helped to analyse the requirements that had to be implemented in the platform to ease the process of implementation for other possible clients (implementing correctly MQTT protocol).

For Bye Radon, to research and implement blockchain technology in their devices was fundamental before applying to the program, as radon is a societal and health worldwide problem where certified measurements with the latest technologies drive a real opportunity and change for those who have experienced lung cancer due to this dangerous gas. To engage with this new technology and start a new relationship with a blockchain provider has served to open new resources for the company in terms of new customers, new recurrent income stream and cooperation opportunities. Both companies are now working to lower the cost of this certification and analysing the number of transactions that need to be done for each group of devices: 1 per client, 1 per device, each 10 minutes, twice a day, every 24 hours, etc. In the final report we will include our conclusions regarding this topic.

Forward look:

It is too soon to calculate the impact that HUBCAP program has brought to both companies in terms of sales, income or market opportunities, as both companies are still working to robust the solution

and release the final implementation of the AirTrace in IoT devices. In September, after we have finalized this implementation and deployed the second pilot project to validate the entire blockchain process, we will work on the definition of the commercial strategy for future collaborations. This will be included in the final deliverable, where we will also include a section regarding the impact and market opportunities that HUBCAP has brought for both entities, that without a doubt has been very positive.

Additional Information:

MQTT: MQTT is a lightweight, publish-subscribe, machine to machine network protocol. It is designed for connections with remote locations that have devices with resource constraints or limited network bandwidth.
NB-IoT: Narrow Band - Internet of Things (NB-IoT) is a standards-based low power wide area (LPWA) technology developed to enable a wide range of new IoT devices and services. NB-IoT significantly improves the power consumption of user devices, system capacity and spectrum efficiency, especially in deep coverage (significant in the radon business case).

The blockchain standards landscape

The technology standards landscape is complex, covering a large number of supra-national, national and industrial organisations. Some of the more important organisations in the European blockchain standards landscape include:

StandICT: Provides an ICT Standardisation Observatory (EUCOS) and a Facility to support participation of European experts on international standardisation (StandICT.eu). European Standardisation Organisations: Important European standards organisations relevant to blockchain include the European Telecommunications Standards Institute (ETSI, in particular the ISG PDL), the European Committee for Standardisation (CEN), European Committee for Electrotechnical Standardization (CENELEC), in particular through their Joint Technical Committee 19 (JTC19). Supra-national and industry organisations: Important global organisations relevant to blockchain standards include ISO (in particular ISO TC307), ISO/IEC JTC1 & ITU-T. National standards bodies: Most national IT standards bodies also are or are expected to be working on blockchain topics. Open Standards bodies: IEEE, Organisation for the Advancement of Structured Information Standards (OASIS) and the Internet Engineering Task Force (IETF). INATBA: Through various of its working groups, the International Association of Trusted Blockchain Applications contributes to the standards discussion on a European and global level.

There are many other national and industrial organisations involved in blockchain-relevant standards work on topics such as digital assets, token specifications, blockchain governance, security token standards, and more. The wide range of bodies working on blockchain standards ensures that a great deal of skill and expertise around the world is dedicated to this work. But, there is a danger of fragmentation in the standards landscape.

Standards topics: Technology standards can cover a wide range of topics, some of which are not directly related to the technology itself. In blockchain, the following topics are relevant:

- Interoperability: Ensuring the different blockchain and DLT protocols and platforms can exchange data and seamlessly communicate with each other;
- Governance: Best practice and standards in governing blockchain projects as well as blockchain consortia working on decentralised platforms;
- Identity: Promoting a common identity framework and/or interoperable identity among different blockchain protocols and platforms;
- Security: Ensuring a secure operation of the different nodes, networks and services;
- Smart contracts: Supporting best practice and standards to ensure smart contract technology is safe and secure.

SMEs Website(s):
Future Sense: https://byeradon.com/ Cubic
Fort: https://airtrace.io/

Autonomous Robotic UAV platform for the 'as-built' modeling of building assets.

List of contributors (SMEs and DIHs)

Company	Author
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GIVE	E. Nassiopoulos, K. Anagnostopoulos

GIVE is a visionary engineering company providing technical innovation, product design, and advanced engineering model-based analysis, ranging from structural analysis & optimization all the way to CFD, dynamics, multi-body dynamics, electromagnetics and much more. We drive product development innovation for our customer (mainly vehicles - ground, air or sea) following a holistic approach from idea to prototyping by creating 2 version of a product (physical and virtual) that allows to include various parameters into any concept such as the market, costs, manufacturing and mainly the customers. GIVE uses the most advanced commercial tools for model-based analysis and creation of virtual systems, as well as a set of in-house tools and algorithms, developed through our experts.
VERTLINER is a field robotics company specializing in the construction sector, developing autonomous robotic systems for the precise indoor assessment of building assets and infrastructures. The company introduces a unified system consisting of an autonomous unmanned aerial system (UAS), a cloud- based service and a set of custom-developed AI algorithms to digitalize hard-to-reach building assets by traversing confined spaces not easily reachable by humans for collecting, analyzing, and delivering structural data in a ready-to-use format. The solution allows remote access to spatial info, while the collected data are analysed to the cloud via 4G/5G networks, generating the asset's 'as-built' building information model (BIM). VERTLINER is filling the digital gap of the value chain amongst the building contractor, service providers and equipment manufacturers, offering productivity gains through autonomous assessment, safer operations, and compliant communication amongst stakeholders.

Subheading: Autonomous Robotic UAV platform for the 'as-built' modelling of building assets.

CPS4asBuilD is a novel approach to the precision inspection of building assets using an autonomous UAV flying through tightly confined spaces, a task today significantly difficult and dangerous for humans. CPS4asBuilD focuses on specific use cases of fully automated building asset inspection. This is implemented through an autonomous UAV connected to a cloud platform for the precise, safe, and timely inspection of any newly constructed building. The solution targets stakeholders of the AEC industry (Architecture, Engineering, Construction), such as main contractors, indoor system installers, and manufacturers.

Domain(s): Cyber-Physical System, Inspection, Buildings, Digital Twin, Unmanned Aerial Systems

Impact:

- Decrease the duration of generating the 'as-built model' of a newly developed building asset, reducing the need for multiple transfers to the project site.
- Diminishing the risks of procurement of equipment not compliant with the building's actual specifications, allowing the accurate planning of installation directly on the generated models.
- Create a full digital twin, that will optimize its performance from design to end-of-life, based on the business strategy, the unique mission profiles and the customer needs.

Quote:

The HUBCAP funding enabled the use of Model-Based Design techniques to assist VERTLINER to evaluate the current performance of its aerial system in the given conditions, to help understand the critical parameters that affect the system within its environment and mission profiles, while allowing the design of a dedicated UAV optimized for the specific tasks prior to committing to a 'next gen' physical prototype.

Project:

The future of UAVs in commercial applications is no longer a far-off futuristic idea. Drones have quickly become majorly invested in tools for tech and retail giants like Amazon, Facebook, Wal-Mart, and Google, not to mention the various industries like Real Estate, Police and Fire Departments, Farming, Cinema, Construction, and Photography that stand to benefit greatly from commercial drone use. Especially the inspection and logistics industries are seeing the highest opportunity in the future use of drones within their operations. Companies developing drones have taken notice of the trends and keep developing as fast as possible alternative vehicles that could tackle some of these or combinations of these missions.

However, the engineering and development phases are still very lengthy, using available tools and with processes inherited mainly from the aerospace industry. Also, the design of these systems is usually following a very conservative approach to ensure that the developed product can be used in various missions and reach a wider range of applications, hence customers. That fact holds apart the engineering of commercial drones from the actual missions and the specific needs of each different business model. As such, most businesses entering or thinking of entering into innovative business concepts with the use of drones, reside in the solution of retrofitting a commercially available system, knowing and accepting however that it is not optimal for their plans.

Project CPS4AsBuild, comes as an answer to this observation, by delivering a Drone/UAV designer toolset based on the MBD philosophy and advanced algorithms. The developed toolset, gives any business or individual the power to design a custom UAV optimal and dedicated design starting from the business case and strategy. It gives them all-in-one all the tools needed to perform the steps necessary to bring to life and goes beyond, by allowing not only to design customized systems, but also assist their operation and full life-cycle, through the developed digital-twin technology that continuously monitors the system, performs health checks, and optimizes performance.

Experiment / what was done

The growing trend of urbanization is pushing the construction industry to develop high-rise buildings, increasing the precision requirements, hard to guarantee as the size and height of the building increase, especially for auxiliary building assets. The measurement activity of new buildings, for instance, is considered a thorough, lengthy, and risky process, since contractors are required to physically visit each floor, inspect the structural dimensions, orientation and ensure the system's compliance with the building's specifications. CPS4asBuilD is a novel inspection system, consisting of a robotic UAV connected to a Cloud Platform (CP) that digitizes hard-to-reach building assets by traversing confined spaces that collects, analyses, and delivers structural data fast, safely, and accurately. VERTLINER developed a prototype (TRL5), currently operated and tested in several autonomous missions within construction sites, equipped with depth and visual-inertial odometry cameras and LIDARs, as well as obstacle avoidance capability along the vertical direction not available in most commercial UAVs.

However, the prototype has been built with various off-the-shelf components and following basic concepts and guidelines. The test missions reveal numerous functional limitations of the current quadcopter version, that need to be considered and optimized in the next steps of the product development, and, allow for a dedicated design for the specific missions and operation in indoor confined spaces.

The developed toolset was used to assist VERTLINER to evaluate the current performance of the system in the given conditions, help understand the critical parameters that affect the system within its environment and mission profiles, and allow to the design of a dedicated UAV optimized for the specific tasks prior to committing to a 'next gen' physical prototype

HUBCAP support and platform opportunity

HUBCAP provided the opportunity to both companies to engage with new digital technologies, experiment with MBD tools and succeed on the main goals of the project as are summarized below:

1. Create a model-based digital replica of the system, to allow for optimized flight control and a decrease in vehicle size by 25%, leading to an advanced dedicated design.
2. Mechanically restructure the current UAV with a goal to decrease its total weight by 30%, and increase battery life to 25 minutes.
3. Optimize the dynamics, stability, and controls to achieve accuracy below 15mm.
4. Time to conduct a full indoor measurement and deliver the results within 60 seconds upon completion.

SMEs Website(s)
GIVE: https://www.give-engineering.com
VERTLINER: https://www.vertliner.com

Gamma Interaction Machine Learning for Imaging

List of contributors (SMEs and DIHs)

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Introducing machine learning techniques to reduce the computational cost of Monte Carlo-based simulations for medical imaging detector design

Domain(s): Positron Emission Tomography, Physics Simulation, Detector design, Machine Learning, Cloud-based SaaS

Impact

- Development of a digital tool that improves productivity and precision for positron emission tomography detector design and development
- Integration of Monte-Carlo with Uncertainty Quantification techniques to reduce the computational load, allowing integration with specialized tools such as opt. routines.
- Direct querying of performance-driven indicators that return physical characteristics and dimensions to be constructed
- A physics-agnostic pipeline with potential application in any type of physical design Monte- Carlo simulator

"With this project we break through the most difficult aspect of time-optimized radiation detector design, simulating particle tracks and detector dimensions till we find an optimized solution, reducing the cost of new detector development 10-fold timewise".

Project Positron Emission Tomography (PET) is a crucial technique widely used for cancer diagnosis and treatment; at the heart of PET devices are radiation detectors that use scintillating crystals. The fundamental physics is well-understood, and large-scale simulations based around Monte-Carlo methods are employed for design by Multiwave Technologies SAS; these correspond to running pseudo-random seeds and perform experiments using physics modelling. Depending on the physics environment chosen, they can be expensive in terms of simulation time, memory cost and only capture some of the physics directly. With this project we use machine learning to reduce simulation and software engineering costs through the Quaisr platform to vastly accelerate design process and improve the quality of simulation. In particular, precision of performance prediction is improved through uncertainty quantification and supervised machine learning techniques; Optimization through objective function applications allows addressing directly questions on system physical sensitivity and time response; and finally, a set of pre-chosen and interactive visualization tools improves access to understanding of the process and results of simulations for the cyber-physical system design engineer. The software developed in this project revolutionises design and speeds up prototyping by Multiwave Metacrystal leading to new PET devices, expands the simulation capabilities for Mulltiwave Technologies SAS and will also be commercialized for Quaisr. Furthermore, the developed tools can be directly applicable to different detector design, or even expanded easily to include any type of Monte-Carlo simulation-based problems.

Experiment / what was done

Combining multi-disciplinary expertise, from data and machine learning to computational and applied physics, within this project we developed Monte-Carlo (MC) simulators using variable physics and detector designs, towards the time-optimized scintillation-based radiation detector application. This simulation starts by generating of pseudo-random seeds that address a stochastic pipeline of particle creation and interactions. The computational complexity of the process depends on the geometric model of the simulated system, but most importantly on the used physics. For this type of detector, we require both nuclear physics and optical photons. In total, every experiment includes 10s of thousands of particles and close to a million particle interactions, intensifying with the addition of optics. We probed how different ML approaches, from supervised ML to more complex uncertainty quantification approaches fit in the different simulated problems, with the purpose to reduce the requirement for statistics when running MC, or even scrapping the need for MC use altogether. The pipeline was initially built using only nuclear physics and is being benchmarked for the addition of optics, to also show its versatility. We have demonstrated reduction to the computational load that is so significant, that for the first time we can use the MC-UQ pipeline embedded in tools such as optimization loops. The system can run on the cloud and users can design geometries, choose physics and run experiments directly through the HUBCAP platform. In application, we designed new material combinations haing the behaviour of golden-standard scintillators, at 1/3 of the cost.

HUBCAP support and platform opportunity

This consortium came to be in order to apply for this particular project, offering an important incentive to bring together specialists of significantly variable fields, in the cyber and physical domains. The requirements of submission of the program helped us develop and define the potential and capabilities of this consortium, while allowing us to further integrate new concepts such as Cyberphysical systems and model based design. Apart from the obvious use of HUBCAP funding, which allowed this consortium to exist, we were able to profit from the continuous guidance and interaction with business and academic specialists, that supported and interacted with the consortium, helping with issues ranging from simulation specifications to such as resource and material allocation and time budgeting. Finally, the implementation of an accessible web based demonstrator through the sandbox environment of HUBCAP allowed easy user testing and interactions within the consortium. Forward look

Multiwave Metacrystal has now developed an optimized design based on the simulated dimensions to build detectors that replicate the state of the art specifications for a fraction of the cost. As such, within this year the development process was accelerated two-fold, bringing the company closer to its MVP design based on inexpensive scintillators to be commercialised in 2023. With the flexibility added through this collaboration, Metacrystal has approached two of the key OEMs of the field with negotiations towards their first high-end customer ongoing.

Multiwave Technologies has now the know-how to expand its simulation capabilities through the application of machine learning designed within the project. While this was performed for Monte-Carlo simulation, it can be directly applied to the significantly more complex and computationally heavy electromagnetic simulations and through optimization routines develop photonic designs at $1/10^{th}$ of the computational cost, allowing CPS design of photonics for visible and ultraviolet wavelengths. Quaisr has now applied their reusable Data Centric Engineering workflows (optimisation and UQ) to a completely new domain adding significant value to its partner SME and demonstrating scalability of its modular components. Quaisr has also developed a web app which is deployed through the Hubcap platform. This has opened up market opportunities and Quaisr has been in talks with photonics multinationals to explore potential use cases. A multinational client in this domain will expand Quaisr's remit from its current engagements with two verticals (energy, fast moving consumer goods).

SMEs Website(s) https://metacrystal.ch/ https://multiwave.ch/ https://www.quaisr.io/

Farming Intelligence System of Systems (FISS)

List of contributors (SMEs and DIHs)

Company	Author
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Aarhus University	Jalil Boudjadar

- Xilbi Sistemas de Informacion SL is a integrated systems provider in the areas of Information and Communication Technologies (ICT). The company is specialized in the development of IoT based decision support systems. Xilbi is involved in several ICT developments towards the Agriculture sector, and particularly within the Portuguese and Spanish markets, having privileged contacts with the user's community.
- Cyblix Unipessoal Lda. is a ICT solutions provider focused in the development of Modelling and Simulation, Augmented Reality, Virtual Reality and Digital Twinning solutions. Cyblix is a co-developer of the HorizoN framework - a 3D Real Time Interactive Environmental Simulation environment and associated tools. HorizoN can integrate a wide variety of sensors to generate high fidelity environmental simulations and since its creation was used by renowned actors like the European Space Agency.
- Fotovoltaica Macotera SL is a company active within the agriculture, energy and tourism sectors. Fotovoltaica Macotera owns productions agriculture sites comprising 300 hectares of land and devoted to the almonds, pistachio and maze production. Its main production site is devoted to almond and pistachios intensive production. The company also owns and operates photovoltaic powerplant installed in its main agriculture site.

Domain(s) Smart Farming, Renewable Energy, Machine Learning, Internet of Things, Satellite Imagery (Copernicus)

Impact

- Creation of a new line of products and services (FISS);
- Optimisation of farming operational procedures (particularly regarding irrigation resources usage);
- Forecast and Optimisation of solar energy production.

Quote

The HUBCAP funding allowed out team to further develop the FISS prototype and to successfully demonstrate it within an operational environment, to promote to product towards relevant potential clients and to enable the future commercialisation of the FISS line of products and services.

Project

The Farming Intelligence System of Systems (FISS) takes the interaction between the farmers and their plantation fields to a new level. It delivers an Environmental Digital Twin and associated Artificial Intelligence(AI) based Decision Support System (DSS) which allows farmers to maximise the benefit of existing operational assets and know how. This is achieved by connecting, exchanging and analysing the data, via the FISS Cyber-Physical(CPS) platform, from deployed technological existing sub-systems (e.g.: Internet of Things(IoT) based sensors, meteorological data, Earth Observation(EO), Remotely Piloted Aircraft Systems (RPAS), photovoltaic powerplants, robotic, and non-robotic field machinery) and to recommend proper actions towards farmers via desktop and mobile interfaces, including via the usage of an Augmented Reality glasses display interface.

The FISS system was designed in agreement with the requirements of the farmer's community and particularly medium to large scale almonds and pistachio's producers. This target user's community main requirements are focused in the need a decision support system that will enable the optimisation of irrigation, fertilization and pesticide application procedures in order to optimise resources usage (e.g.: water, fertilizers, energy) and in consequence reduce costs and environmental impact.

FISS delivers the complete digitalisation of the farming operational environment. The system will enable a more streamlined crop management by means of optimisation of operational and management farming procedures.

The FISS target customers are all farmers and farmer's organisations.

Experiment / what was done

The FISS's experiment involved the creation of a Digital Twin simulation environment of the almond's plantation fields. This Digital Twin integrated data from field Internet of Things enviromental sensors, weather stations, irrigation actuators, satellite imager (Copernicus) and machinery position data. Machine Learning was used to deliver irrigation planning recommendations and to generated solar energy production forecasts.

At the beginning of this HUCAP project the system was at TRL 5 - technology validated in relevant environment. During the project activities, and by means of using a Model-Based Design approach, the prototype was further developed, in close collaboration with potential users towards achieving TRL 7 - system prototype demonstration in operational environment.

HUBCAP support and platform opportunity

The HUBCAP funding allow us to implement a very challenging experiment, while demonstrating the system within an operational environment, paving the way towards commercialisation.

By means of using the HUBCAP platform we were able to further develop the FISS's machine learning algorithms within a shared environment. to promote our tools and potentially accessing new potential markets.

Forward look

We estimate the FISS's global Serviceable Available Market(SAM) to be of 300 Million € and the European SAM to be of 80 Million EUR in 2025. We expect to enter the commercial market in 2023. Our growth forecast indicators are:

- 2023: 300000 €; 3 new job positions;
- 2024: 600000 €; 3 new job positions;
- 2025: 1.1M €; 4 new job positions;
- 2026: 1.7M €; 5 new job positions;
- 2027: 2.5M €; 6 new job positions.

The Return on Investment will be achieved in 2025.

SMEs Website(s)

- https://www.xilbi.com
- https://www.fotovoltaicamacotera.com
- https://www.cyblix.com/

An Advanced VR Locomotion Platform Enhanced with AI-based Motion Capture

List of contributors (SMEs and DIHs)

Cyberith is an Austrian company founded in 2014 by Holger Hager and Tuncay Cakmak. The company, which has sites in St. Pölten and Vienna, focuses on the development and production of VR locomotion devices – products for walking and moving through large-scale virtual environments. The company's first-generation products had been launched for B2B customers in 2016. In 2019, Cyberith launched the Virtualizer ELITE 2, the company's first powered system, that actively supports the gait of the user.

Codewheel is a startup company founded in 2018 in Larnaca (Cyprus), which develops a stack of technologies around human digitization, spanning content creation, spatial human-centered applications, and immersive experience deployments. The company's vision is to democratize the use of motion capture technology by offering next-generation and affordable AI-based solutions.

Subheading

The HUBCAP project enabled vital research on VR Locomotion Systems by combining Cyberith's VR Treadmills with Codewheel's AI-based Motion Capture System. To enable rapid-testing of the systems integration without the need for physical presence, LocSim, a Unity3D-based simulation tool has been developed, which is now available through HUBCAP's platform. The LocoMoCap project resulted in a prototype of an enhanced Virtualizer version, that makes use of the MoCap system to increase the product's value proposition.

Domain(s)

Virtual Reality Locomotion Systems, Motion Capture, Full-Body Tracking, Artificial ntelligence, Virtual Reality, Cyber-physical system

Impact

- Systematic analysis of different users gaits leads to a deeper understanding of the current Virtualizer model and its limitations. This understanding serves as the basis for improvements.
- Implemented concrete improvements into a new Virtualizer prototype.
- A simulation tool for for testing various marker setups prior to physical integration.
- A lower-body specific motion capture AI-based system.

Quote

"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

"HUBCAP's financial and mentoring support enabled the exploitation of our AI-based motion capture technology for introducing new functionalities in an already innovative product for VR locomotion" - Anargyros Chatzitofis, CEO of Codewheel.

Project

LocoMoCap is a project related to the common vision of Cyberith, a leading provider of professional locomotion devices for virtual reality, and Codewheel, an AI-based motion capture (MoCap) start-up. Its ultimate goal has been the exploitation of Codewheel's AI-based technology for improving Cyberith's Virtualizer products. To overcome the challenges in integrating the sensor-based MoCap subsystem with the Virtualizer's motion platform, we developed LocSim, a simulation tool for rapid-test integration that is now available through the HUBCAP platform. To improve the physical walking experience on the Virtualizer and increase immersion in VR, the Virtualizer's motion platform has been enhanced with an additional information stream, the user's lower-body motion. The provided information enables the systematic analysis of different users' gaits and allows us to better understand the abilities and limitations of Cyberith's current system. Moreover, the data was exploited in a newly created prototype that uses the additionally provided information to improve the Virtualizer's active gait support and to improve the walking movement in VR. The newly gained know-how and the technology developed within the scope of the project, shall serve as a basis for future enhancements of Cyberith's current products and new product developments.

Experiment / what was done

The integration of the MoCap technology in the new Virtualizer prototype was initially split in three phases; first we collaboratively developed the LocSim tool that is able to simulate the combination of the two systems and provide a rapid-test environment with natural physics rules and realistic human (avatar) movement on the Virtualizer's digital twin. Second, using feedback from extensive collaborative sessions between the two companies for the familiarization with each other's technology, each partner improved the corresponding existing technology towards the integration of the two systems. Finally, the integration phase followed, which involved the setup of two identical MoCap-enhanced Virtualizers - one per partner's premises. The integration phase lasted approximately 4 months, allowing for intense testing and iterative improvement for both sub-systems. The result of the integration has been evaluated in two parts; the first part focused on acquiring feedback from relevant users in terms of "interest for a new product", while the second part focused on qualitative and quantitative feedback through user pilots for assessing the performance of the enhanced Virtualizer compared to the original model.

Based on internal evaluation of the new system, it seems that the motion information stream can be used to dynamically support the gait of the user and to apply dynamic smoothing for improving user experience in VR.

HUBCAP support and platform opportunity

The support provided by HUBCAP boosted the cooperation in between Codewheel and Cyberith and enabled vital research on improving the user's gait on VR locomotion devices. It enabled the integration of an AI-based MoCap System into the Virtualizer.

The prototype created proves the high potential of integrating such a MoCap system with VR Treadmills and shall serve as a basis for future product developments.

The development of the prototype though required a model-based design logic to enable the remote collaboration for integrating motion capture to the Virtualizer. This would be impossible without the developed LocSim tool, a simulator in the form of a Unity3D asset now hosted by the HUBCAP platform. We hope that the HUBCAP ecosystem will be able to leverage this simulator as we did for creating realistic human avatar movement scenarios on various environments.

FinalIK3 software has been used for our humanoid 3D avatar simulation in the LocSim environment, which offers articulated motion physics that help us approach the motion capture conditions of people using the Virtualizer.

SMEs Website(s)
Cyberith: https://www.cyberith.com/
Codewheel: https://www.codewheel.eu/

Monitoring environmental conditions in industrial operations with IoT, Digital Twin and AR techniques

List of contributors

Company	Authors
DRAXIS Environmental S.A. - https://draxis.gr/ DRAXIS is an ICT company based in Thessaloniki, Greece, that has expertise in delivering software solutions and scientific services for environmental management to customers, while it has successfully coordinated several national and European projects.	Panagiota Syropoulou Dafni Delioglani Nikos Pliakis Dimitris Sakellariou Marios Kotoulas Theodoros Akritidis
HOP Ubiquitous S.L. - https://hopu.eu/ HOPU supports urban development and digital transformation through evidence-based solutions, cooperating with open-source communities and standardization bodies.	Antonio J. Jara Iris Cuevas Martínez Isabel Sánchez Almansa Jorge María Merino Roque Belda García Sonia Tovar Guillamón
The Predictive Company - https://thepredictivecompany.com/ TPC is a Spanish company that has developed energy efficiency software for buildings for autonomous operation of Heating, ventilation and air conditioning (HVAC) machines.	Jose E Torres Carmen Bernabeu Adria Sanchez Alonzo Romero

Table 1: MENIoR List of contributors

Domains

- Cyber-Physical Systems
- Internet of Things
- Digital Twins
- Augmented Reality
- Air Quality Monitoring
- Environmental Monitoring

Impact

- The project resulted in **an innovative technological solution** based on a Cyber-Physical System. Linking the environmental conditions monitored using IoT sensors with a mobile application that delivered the measurement to the workers through Augmented Reality. And providing Digital Twin web platform that delivered the information to industry health and safety managers.
- MENIoR developed **a new solution that addresses a clear market need**, e.g. the need to improve environmental conditions in industrial workplaces;
- The solution of the project contributed to the **increase of employees' awareness on environmental conditions** and resulted in more environmentally aware behaviours, as well as provided a tool for industries to **promote the wellbeing of their employees and increase their productivity**;
- The MENIoR solution **accelerated the introduction of the 3 consortium companies in a new market**, named "industrial installations".

Quote

HUBCAP gave the consortium companies the opportunity to combine their expertise in environmental intelligence, IoT sensing, and occupational health to develop a solution that raises the awareness of industrial employees about the impact of environmental conditions in their work environment and helps them protect their wellbeing.

Project

Monitoring the environmental conditions, such as air quality, temperature, etc., in factories can help employers and employees to better plan their activities and promptly take measures to avoid environmental accidents and health issues.

MENIoR aims to enable industrial operators understand and improve the environmental conditions inside their units. Rising the awareness of their employees about the impact of environmental conditions by leveraging the potential of Internet of Things (IoT) with the application of augmented reality (AR) and Digital Twin (DT) techniques. Environmental information is collected via a low-cost monitoring network developed and configured by the consortium in industrial operations. Afterwards the measurements are analysed on the cloud. A web based Digital Twin of the factory is developed to enable the factory admins visualise the collected data and assess scenarios for environmental improvement inside the factory, while employees are provided with a visualisation tool through a mobile application using an AR interface.

Experiment / what was done

In the framework of the project, a low-cost environmental monitoring network was developed and installed inside two Spanish factories: Fagesta S.L. and Lisanplast S.L. The network collected real-time air quality measurements, as well as data of other environmental parameters such as temperature, humidity and concentrations of CO_2. This information was then analysed on the cloud and visualised on a web Digital Twin platform that was provided to factory admins to assess scenarios for environmental improvement inside the factories. In addition, factory employees were given access to visualisations of the data via an augmented reality mobile application.

During MENIoR's pilot implementation phase, the factories had the opportunity to test the MENIoR solution and provide their feedback to the consortium companies. Based on this feedback, the project consortium was able to evaluate and improve the solution even further in order to better address the market's needs.

HUBCAP support and platform opportunity

HUBCAP enabled the consortium companies to accelerate their introduction to the market of industrial installations. In the context of MENIoR, HUBCAP's funding was used to develop and set up a low-cost environmental monitoring network, deliver a web Digital Twin platform and an Augmented Reality mobile application, and finally evaluate and validate the MENIoR solution in order to provide to the market an integrated environmental monitoring solution that raises the awareness of factory employees on environmental conditions and results in more environmentally concerned behaviours.

MENIoR did not use directly the HUBCAP platform nor the sandbox. However, for air quality monitoring inside the pilot factories, the HOPU-manufactured IoT device Smart Spot, which is an asset listed in the HUBCAP platform, was used.

Forward look

As the project has just ended, it is still not easy to estimate how much HUBCAP has impacted the 3 consortium companies. However, as the project resulted in an innovative integrated solution with key benefits for industrial operations, with the proper exploitation by the consortium it is expected for HUBCAP to significantly contribute to the portfolio of the companies.

SMEs Websites

- DRAXIS Environmental S.A.: https://draxis.gr/
- HOP Ubiquitous S.L.: https://hopu.eu/
- The Predictive Company: https://thepredictivecompany.com/

SimTank

List of contributors (SMEs and DIHs)

Company	Author
Intellia ICT	Vassilis Papataxiarhis
Metricon	Takis Beskos
Intellia ICT	Michael Loukeris
Intellia ICT	Panos Papadatos
Intellia ICT	Marilena Athanasiou
Metricon	Petros Kritsonis

Intellia ICT is a data-driven technological start-up specialized in Combinatorial Optimization and Machine Learning. In SimTank, Intellia builds an energy simulation tool for optimised management of METRICON sensor nodes used for tank truck monitoring. The tool simulates energy performance of sensors and provides optimised recommendations for their configuration and on-board task execution.
METRICON is the owner of a wireless sensor system for electronic sealing of fuel tank trucks and thermal scanning. In SimTank, METRICON contributes to the digital models of the sensors and the embedded software used for tank truck sealing and monitoring.
Subheading "Optimised Management of Fuel Tank Trucks"
Domain(s) energy consumption, tank trucks monitoring, combinatorial optimisation, linear programming, near-optimal solutions
Impact
As an existing commercial player and owner of a sensor system for electronic sealing of fuel tank trucks, METRICON aims to exploit SimTank solution to:

- Deliver optimal configuration of on-board deployments on existing tank truck fleets.
- Increase the quality of services in its existing clients in the oil industry.

As a technology provider specialised in optimisation algorithms, Intellia ICT aims to exploit the technical outcomes of SimTank to:

- Attract new clients in the oil industry domain.
- Scale-up by testing different configurations in other application domains (e.g., sealing of food delivery trucks).

Quote
"Thanks to the HUBCAP INNOVATE funding tool, our company was able to build novel energy models for commercial hardware used by the oil industries and validate a set of optimisation services that can further be exploited commercially as a product."
Vassilis Papataxiarhis, Coordinator of the SimTank project
Project
SimTank is inspired by the need of oil industries for energy-efficient monitoring of their fuel tank trucks. Current solutions are based on sensors deployed on fuel tank trucks that perform sub-optimally in terms of energy consumption. The ordering of monitoring task execution is static, the configuration of task parameters is performed only empirically, and whenever a sensor needs to change the new configuration is not trivial. As a result, the sensors deployed upon the trucks have limited lifetime due to suboptimal battery usage that, in turn, results to a need for frequent maintenance (e.g., change of battery). Maintenance stops are not time-aligned and require a lot of time (usually a truck needs to stay inactive for days). All those problems result in a huge loss of time and money for the industry. SimTank fills those gaps by building models and algorithmic solutions that accurately monitor the total energy spent by the on-board system and maximize the lifetime of the deployment used for monitoring purposes.

Experiment / what was done
SimTank built energy models for complex tank truck sensors and combinations of them in several truck compartments. In particular, three types of sensor nodes were modeled: (a) sensors put on the manhole covers (sensor_M), (b) sensors put on the air tube controlling the foot valve (sensor_F), and (c) sensors placed on the fuel discharge pipe (sensor_S). Building on top of those new digital models, the project developed an energy simulator to calculate the energy consumption of the deployment according to the configuration of sensors and the system in general. Finally, a set of optimisation services were developed to facilitate both (a) the configuration of parameters used for the execution of tasks, and (b) the ordering of task execution. In particular, a greedy algorithm was developed to produce near-optimal solutions (in polynomial time) while a linear programming algorithm was used to recommend exact configurations (in exponential time).

HUBCAP support and platform opportunity
HUBCAP support was essential for helping Intellia ICT and METRICON to reach the project objectives. First, the solutions that were built in SimTank were developed from scratch (digital models, simulator, optimisation services). This fact made a potential funding by own resources of companies not feasible in practice. HUBCAP provided the financial resources required to support the development of such a time-demanding solution as the one envisaged by SimTank. Also, the regular monitoring offered by the project Mentors (FBK and fortiss) proved to be effective and critical for the given complexity of the project. Finally, HUBCAP provided a cloud platform to host the software built by the project and a Marketplace for commercial exploitation. The former helped the project avoid additional costs for hosting the software while the latter helped the project get in touch with an already established ecosystem consisting of a wide range of stakeholders and potential customers.

Forward look
In SimTank, we plan to follow a fee for services pricing model. Currently, each real deployment is charged per truck. Assuming a starting burn rate of ten thousand euros per month and a gradual usage-based pricing policy we will reach a positive balance in the second year with an estimated gain of four hundred fifty thousand euros in the year after. We plan to have an estimated fleet of 5000 trucks for SimTank deployments within the next five years. Considering a charging rate of 10% in the total cost of each deployment we will reach a revenue of 3 million euros in five years from now. Our go to market strategy is built upon direct strategic partnerships with existing clients in the oil industry and by approaching key market players with targeted campaigns. It is worth mentioning that we have already reached an agreement with our first beta client in Greece.

SMEs Website(s)
Intellia ICT: https://www.intellia.gr/
Metricon: https://metricon.gr/

CPS-based and data-driven modeling, monitoring and improvement of the eco-friendly quality

List of contributors (SMEs and DIHs)

Company	Author
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Nissatech	Bratislav Trojic
Zona Zdravlja	Viktor Calovski
EMDIP	Nebojsa Dinic

Pave the way for a new generation of the quality monitoring services, which are focused not only on the processes performances (KPIs), but also on the eco-friendliness of the process, what we call eco-friendly process quality

Domain(s) Quality Control, Process improvement, Energy consumption, Pollution

- quality monitoring which combines quality of the product and eco-friendliness of the process
- early discovery of the situations which can negatively impact the environment
- understanding the factors which influence energy consumption and environment pollution
- discovering the potential for improving eco-friendliness of a process

Quote *Easy to deploy and affordable (sw-hw) solution for understanding the factors which impact the waste (energy, emission) based on a novel, AI-based analysis of past data*

Project Ensuring process quality and efficiency is especially critical for manufacturing SMEs that cannot ignore the strategic implications of efficient process management and quality control for their competitive position. However, it appears that manufacturing SMEs have been very slow in implementing formal quality models and process monitoring tools, due to the need for expert modelling and analysis (expensive and time consuming).

Main goal is to develop (based on HUBCUP support) a CPS-based infrastructure for enabling a comprehensive monitoring, analysis and improvement of the eco-friendly quality of the manufacturing process, through focusing on three main factors of environmental footprint: Energy, Emission and Anomalies (Waste), measured using corresponding sensors and cameras. It means that the developed system monitors the eco-quality of these processes in the context of the given manufacturing process and use complex behaviour understanding to react in situations when some of the environmental aspects will be changing (outliers, instability).

Experiment The experiment is based on the assumption that non-invasive sensing of a machine/line can enable the collection of very valuable data for understanding the process behaviour in the context of waste reduction. Indeed, advanced in retrofitting/modernisation machines in the context of Industry 4.0 are opening new opportunities for exploiting the value of data (independently of the machine vendors). EMDIP (end user) also installed such sensors, incl. on cutting machines, mainly for getting daily reports for the energy consumption. Moreover, plasma cutting process can introduces a lot of environmental issues. Developed system enables a deeper analysis of the data. Challenge is that the data is big, complex, multidimensional and the relation between energy consumption and quality should be discovered from data. The solution is based on the HUBCUP asset D3Scan, Deep Data Diagnostics through Cognitive Scanning.

System consists of two main elements: 1) the collection of not only the production data, but also energy, emission and waste related data and 2) complex modelling of their (coo)relations in order to understand when some “small” variations in process data will indicate “big” problems in the environment-related quality aspects. The goal is to enable proactive detection of problems and avoiding that environment-related effect will escalate.

There are several advantages of using HUBCAP support and platform. The most important is that HUBCUP enabled this risky innovation activity. Indeed, HUBCAP supported the collaborative work between three parties with the complementary profiles (two more technical and one industry company), required for the development of this complex service. Second, HUBCAP platform offered an asset that provides complex analyses of the manufacturing data (D3Scan, Deep Data Diagnostics through Cognitive Scanning), which was crucial for the development of the entire solution. Third, mentoring process is organized in a very efficient way, monitoring the focus of the work and keeping it on the defined KPIs and ensuring the continuous progress.

SMEs Website(s) **www.nissatech.com, emdip.com**

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

List of contributors (SMEs and DIHs)

Company	Author
Thridium	Oana Bunduc
Beam	Alexandru Vulpe

Domain(s) Threat management, Model-Based Design Impact

- Undertake real-time events identification and security incidents handling using a single integrated platform.
- BIE-T4S platform acts as the bonding agent between the legacy systems and the operational functionalities required by the operators of such complex venues from a security standpoint.

"*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

"*Together with the T4S software solution BEAM is now also well positioned to provide its sensor- based BI analytics to a larger market.*" - Alexandru Vulpe, CEO of Beam Innovation

Project The goal of the project was to employ Model-Based Design to enhance the T4S platform developed by Thridium, with business intelligence introduced by HUBCAP partner, BEAM. The new integrated BIE-T4S (Business Intelligence Enhanced T4S) platform will support different loT sensors (WiFi access points, CCTV cameras etc.) and process real-time data using business intelligence tools to provide valuable input (indoor positioning, crowd distribution, dynamic evacuation routing, real-time visualizations), which will then be used by the revamped BIE-T4S platform (mature at TRL-7) in order to offer security-oriented components (common operational picture, events management, task allocation, security crew mobile app) which will be available to the venue's security officers for better crisis assessment and emergency response. The goal is to provide the integrated BIE-T4S platform as a venue-agnostic threat management platform delivering increased preparedness against different types of threats (terrorism, natural disasters, pandemics etc.) and support the complete lifecycle evacuation management in any crowded place.

Experiment We have validated the system in real operational conditions. We have found that the system complied with over 90% of the threats. During the experiments we analysed the alarms received and all incidents were successfully detected.

HUBCAP support and platform opportunity

The use of the HUBCAP platform allowed the preparation of BEAM's software to work with Telesto's T4S system and enable a further development and integration between the products of the two companies. The funding received from HUBCAP allowed both companies to further develop both their own technology and develop a new solution benefitting from both companies' know-how.

SMEs Website(s)

http://thridium.com

http://beaminnovation.ro