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CROSS FERTILISATION THROUGH ALIGNMENT, SYNCHRONISATION AND EXCHANGES FOR IoT

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Case study on LSPs

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RE	Restricted to a group specified by the consortium (including the Commission Services)	
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Summary					
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0.06	29-04-2020	ARTS	Overall contribution and review.
0.07	30-04-2020	SINTEF	Review comments considered.
1.00	30-04-2020	SINTEF	Final version released.

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1. EXECUTIVE SUMMARY

Publishable summary

The document addresses the work related to case studies on co-creation applied to IoT European Large-Scale Pilots Programme identifying the creativity factors that influence IoT innovation, in different application areas covered by the pilots and across the various application domains.

The activities started from principle that the IoT innovation creation, innovation adoption require different skills, knowledge, resources, business models, and "cultural domain" background. The case studies about the co-creation were built-up and facilitated by artists in collaboration with the stakeholders of IoF 2020 project. Three artistically driven experiments were created for three specific uses cases of IoF 2020.

The interaction with the use cases had a key role in understanding the requirements of the use cases to identify the features and mechanisms used for innovating in creating and adopting the new IoT technologies.

The work helped in identifying how the artistic practices can be used to successfully initiate, develop, and promote new products, technologies, services and experiences in various IoT application domains. During the interactions, the use cases stakeholders became inspired by being stimulated to see their own actions from a different perspective and they were also stimulated to further push for progressing of their work beyond the use case itself.

Non-publishable information

N.A.

2. INTRODUCTION

2.1 Purpose and target group

The purpose of the ongoing work is to devise and experiment ways of integrating artistic practices generally in technology use cases on the ground. The proposed experiments are done in the context of the EU IoT LSPs, more precisely in collaboration with use cases of IoF 2020.

The target groups of the presented results are in first instance the use cases we have been collaborating with. The proposed artistic interventions are designed to try to contribute to the uses cases in several aspects: making the technologies being deployed closer to human experience in general, expose alternative views over the technological processes implemented, expand their public visibility and create policy driven circumstances that can be beneficial for the future of companies and other participants of the use cases. The resulting artistic products can also be integrated in the packages of the products demonstrated by the uses cases either in the implemented systems themselves or in the processes of selling and promoting the technological products.

If successful, the methodology can be applied virtually to any technological demonstration use case.

2.2 Contributions of partners

ARTS: Conceived the artistic experiments and is trying to further develop them with the use cases. In order to so, contacts were established and are ongoing with the leaders of the selected use cases.

FE: Contributed for the fine tuning of the concept of the Experience Readiness Level.

2.3 Relations to other activities in the project

The works done developed upon the methodology for integrating ICT and Art previously developed in the CREATE IoT project as well as upon the concept of Experience Readiness Level (ERL). The main aim of the proposed experiments is to apply on the ground the referred integrative methodology in a way that it delivers an ERL report to the use case partners in the end of the experiments. That ERL result can be discussed in events, typically in what we describe as STARTS Talks. These talks involve the researcher, companies and artists involved in the experiments and are moderated by a policy maker.

The objective of the set of activities is to stimulate the creation, development and improvement of IoT related public policies in the EU. More specifically, after the project end these types of artistic driven experiments are expected to happen in some of the European Digital Innovation Hubs (EDIH). The expected is that these experiments can contribute for the main aim of the EDIHs – Test before investing – by making available low-cost artistic lead technical experiments that can stimulate more traditional companies to invest in the digital transformation of their businesses. The initial steps for this to happen are already being taken in a pilot project of the European Parliament in the context of the STARTS Regional Centres entitled S2S – STARTS towards sustainability. Work is being developed with partners of that project in about 10 EU NUTS II Regions.

3. THE EXPERIENCE READINESS LEVEL PROTOCOL (ERL)

It has recently been stated in a leaked draft version of the Communication Europe fit for the digital age that "We live in times where dreams can be fulfilled, and nightmares can come true very quickly" [9].

We certainly live in times when interconnected technologies may be tested within narrow parameters of success or failure, yet after mass deployment reveal systemic bias, conceptual flaws, human interface problems, or failures of governance. It is our contention that it is vital that effective methods must be devised, developed and embraced in order to mitigate such categories of failure. By embedding artist-led experimentation into a qualitative measure of experience readiness the ERL can effectively expose the types of needed improvements standard product testing may overlook.

Furthermore, product development and testing can often, by its very nature, be constrained by the imaginations of individuals or small teams. This is not to say brilliance will not thrive, but rather that on the route to minimum viable product many improvement opportunities can be missed. By placing human creativity at the heart of the protocol, the ERL proposes to interrogate new IoT devices and systems from the standpoint of human experience, to signpost innovation towards technologies which work for people. Aligning the ERL with other readiness levels will also allow developers to effectively incorporate the insights revealed into product enhancements.

> "*Time for what distinguishes human beings. Time for what computers can't do: empathy and creativity*"
>
> - Ursula von Leyden, President of the European Commission [1]

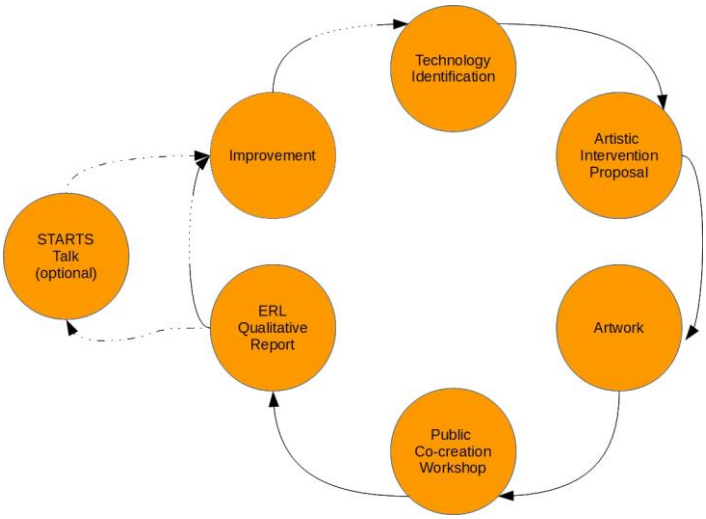

Figure 1: Diagram showing role of ERL within a product development cycle

3.1 Refining ERL

ERL is an approach based on the *experimentation* of a system from a technical perspective, and the *quality* of the experimenter's experience of the system when in use. Experience Readiness Levels are therefore based on:

- A practical measure of how easy it is to use the IoT device or system.
- A qualitative measure of the richness of the experience of using the IoT device or system.

In previous work on this subject we have defined the purpose of the ERL as follows:

> "*ERL measures the capability of IoT systems and applications to trigger a well-suited user experience, a measure that steps away from thinking about IoT as simply object-based, to embrace instead the potential of dynamic exchange between technology and humans with a particular emphasis on the empowerment of the user and a deepening of their experience*" [2].

Part of this refinement of the notion of ERL is to bring forward its experimental aspect. Instead of focusing only on the final user, it integrates the artistic contribution directly into technical manipulations of the system being experienced. Re-centring the core of the ERL at artistic experimentation reinforces that concrete contributions to the system creation/development are expected as operational outcomes of the protocol. These contributions can happen at any stage of development of the system being it at an identification, exposure, improvement or co-creation phase (in line with the described D03.01).

In order to create useful ERL reporting of suggested contributions, a reliable and appropriate methodology must be employed. As part of the wider remit of WP3 we have proposed an artist-led co-creation methodology for product and service development, is it therefore also implicit that the ERL must reflect a measure of the artistic experimentation that can be developed at any given stage.

In those terms we might assume that any art "product" created through the articulation of an ERL-driven process could be experienced as an end in itself, be used as direct feedback model to manufacturers, or in more general terms to envision the expansion or extension of part or whole of the IoT system under consideration.

As an experimenter, the ERL might indicate be how intuitive the device or system is to use in practice, for those who are part of the IoT ecology it may be an indicator of how easy it is to integrate with other systems, as an artist how easy it is to incorporate in the flow of art making. Yet for an artist, it is not just the intended use of the system that is interesting. Artists look for edge cases, breaks in the system, problematic assumptions and category errors. It may be that when a system is in its most raw state, at the earliest of the other Readiness Levels, the assumptions and fault lines of the system in question are at their most apparent and are most easily exploited by an artistic intervention. Of course, the more radical artistic use cases might involve redeployment of sensors, exploring novel configurations of hardware and software, poisoning datasets with rogue information, or building new systems from the ground up. So, it is with care that any proposed ERL might be used as a way to guide artists intervention!

Our suggested methods describe artistic intervention as a way to inform and articulate a greater understanding of individual components, systems, and indeed the entire IoT field. As such the artists' process cannot only be to aestheticize a product or service, but rather to investigate, interrogate, build and break the devices and concepts that surround them.

The ERL experimentation process must be able to engage with devices and systems at various stages in their development. This may be through established APIs, via unusual configurations or topologies, or through experiments on partially or fully deployed systems. The ERL serves both to divine a reasonable indicator of an experimenter's experience of the device or system, and also to examine the device or system within its wider cultural and/or civic ecology. As such it is important to ensure that the limits of experimenting are not proscribed only by the technology provider, and that there is a clear understanding of general parameters of experimentation between the technology provider(s) and artist(s) performing ERL investigations.

There are existing methodologies for opening out public or commercial systems to experimentation in order to add value or develop new prototypes, one such is Experimentation as Service (EaaS) (discussed in the subsection below). EasS describes how experiments and experimenters can operate within an established common ontology. EaaS, therefore, has a very particular and well described subset of value within the constellation of device and system

development. However, it is to be expected that artistic intervention may rightfully question these kinds of established categories, describe and connect hauntological influences, producing experiments that may well be as disruptive as they are instructive. Indeed, the value of such interventions is precisely this – to test the untestable and investigate the unknown unknowns.

3.2 Experimentation as Service

As with any new system, it is wise to test against desired outcomes. However, in addition to individual component parameters IoT devices and systems are likely to exist within a wider, connected ecology (and in many cases make no sense outside of such a network). This is where Experimentation as a Service (EaaS) steps in. Even as recently as 2018, a journal paper published by IEEE suggests "Infrastructures enabling experimental assessment of Internet of Things (IoT) solutions are scarce" [3], largely due to the interconnected nature of IoT technologies, and the potential scale of deployment.

There is increasing interest in EaaS as an effective way to prototype and demonstrate IoT systems. From the Horizon 2020 funded *OrganiCity* smart city prototype which utilises EaaS to allow planners, developers and citizens to experiment with real time urban data [4], through to launch of IBM Research's cloud computing EaaS platform [5].

> "*Experimentation as a Service is a model in which cities provide the resources for citizens, small businesses, corporations and city authorities, to test their new ideas at a small scale*" [4]

The examples of Experimentation as a Service (EaaS) are interesting and informative, acting as a guide for effective methods to abstract data from existing IoT sensors or devices. Designed as frameworks or platforms which enable large scale experimentation at low cost, they can form an excellent framework for certain types of ERL activity.

> "*Despite the advances that have been accomplished, there is still enormous scope to develop novel and innovative IoT-based solutions that aim at transforming our everyday life. In this respect, real-life experimentation should play a major role in these developments*" – EaaS Over Semantically Interoperable IoT Testbeds [3]

3.3 Redefining ERL

Earlier theoretical work on the ERL conducted as part of the Create IoT LSP has been modified in order to focus on establishing clearer parameters for experimentation. Note that the ERL is not intended to operate in lockstep with other readiness levels such as TRL. In fact, it may well be very interesting to think about products or systems operating at a high ERL but still at an early TRL, and vice versa. The set of experience-based levels proposed by this iteration of the protocol are:

- ERL 1 – Complex both conceptually and in technology. Hard to work or play with. Suggests rich area of questioning in areas of Why? What? and How?
- ERL 2 – Broad concept understood. Prototyping technologies, workflows and interfaces. Mechanical elements still at component stage. Discovering the What? and How?
- ERL 3 – Technologies are more modular and formed. Networks, interconnections and interfaces still being developed and extended. Prototyping with hard examples of usable technology possible, APIs under development and available, interconnectivity with other systems possible.
- ERL 4 – Total system ideated. Potential to reify end to end product. Playful tinkering with a well-formed system possible (see EaaS).
- ERL 5 – System or device robust and well defined. Well understood APIs and behaviour. Simple to use and integrate with other components / systems / networks.

4. IoF2020 SELECTED USE CASES

4.1 Within-field Management Zoning Baltics

Spending on fertilisers and agrochemicals represents a considerable part of farmers' overall expenditure. By developing a remote sensing solution to determine which nutritional elements and how much of them a plant is lacking at different stages of its growth, such costs can be reduced. This use case demonstrates the added value of spectral data analysis and IoT technology for precise decision-making and optimised crop management in potato and winter wheat.

Figure 2: Agriculture [12]

Technical solution:

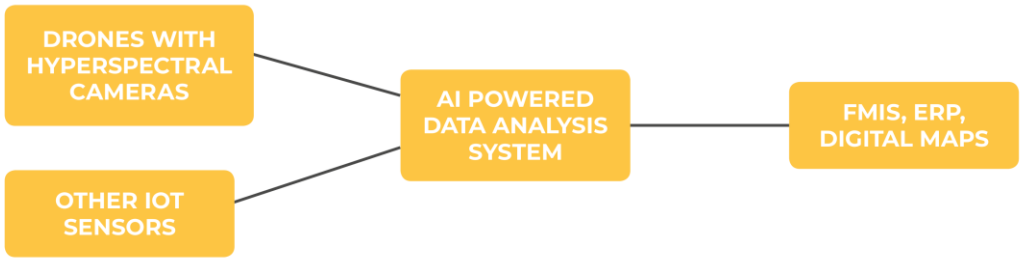

Figure 3: Technical solution illustration (Agriculture)

Integration of advanced hyperspectral imaging and data analysis technologies to deliver a truly innovative solution to some of the most pressing issues for farmers. It uses Artificial Intelligence technologies (Machine Learning/Neural Networks) to perform complex analyses of crop field hyperspectral images. By analysing big amounts of spectral data, the system learns to recognise various indicators or patterns, and identifies the composition of nutrients in crops. The solution

integrates with FMIS for mapping of micro- and macronutrients in potato and winter wheat plants.

Demonstration activities:

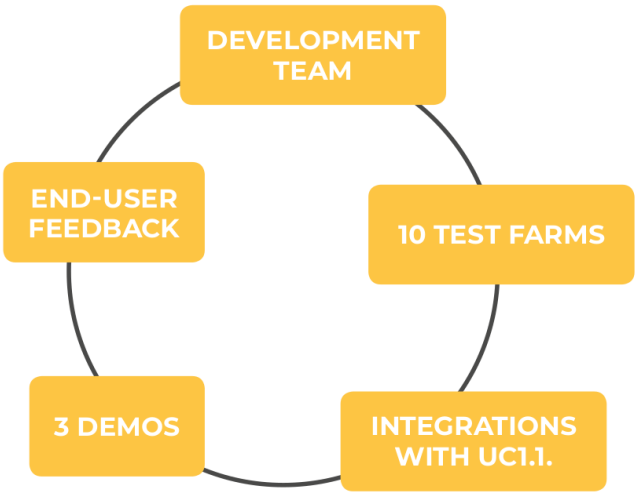

Figure 4: Demonstration activities illustration (Agriculture)

4.2 Beverage Integrity Tracking

The journey from producer to consumer is a process that can negatively affect the quality of the wine. In response to this risk, this use case has created an integrated system that monitors the whole wine and beverage distribution channel to prevent damages caused by integrity-related issues and stress factors such as humidity or shocks during shipping and storage. As a result, a direct relationship between producers and final retailers is established while a large database is created to plan safe shipments thereby allowing new and customised IoT-based insurance policies.

Technical solution:

Figure 5: Technical solution illustration (Shipping)

Data loggers monitor and record temperature, humidity, box breaching and shocks. Data are stored on an internal memory device, and wirelessly transmitted to the platform via the mobile App. The cloud-based platform stores data coming from the devices, conducts elaborate analyses, aggregates trends and delivers information for decision making on customisable interfaces. The mobile app is the command interface of the devices: It turns them on and off, while assigning them to a specific transportation. At any time, with the data logger near, it can read every data and spot alerts.

Demonstration activities:

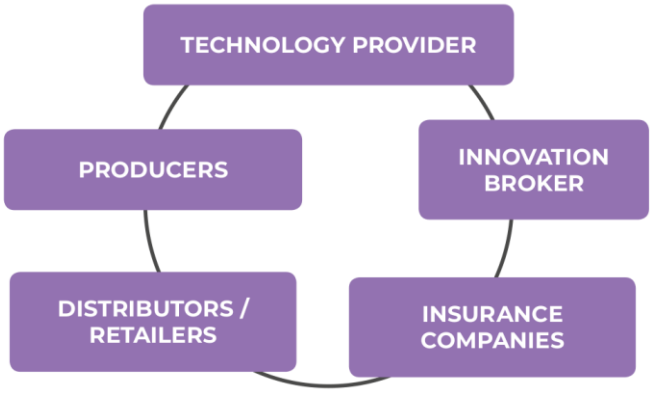

Figure 6: Demonstration activities illustration (Shipping)

4.3 Solar-powered field sensors

The lack of access to affordable and scalable on-field diagnostics for small farmers is addressed through:

- Reduced design complexity to facilitate ease of use without the need for additional training.
- Integration of all farm information and devices in one farm manager.
- Development of sustainable marketing strategies to incentivise farmers to implement modern technology.
- Demonstration of sensor-based predictive analytics for diseases.
- Application of the solution on different crops.

Technical Solution:

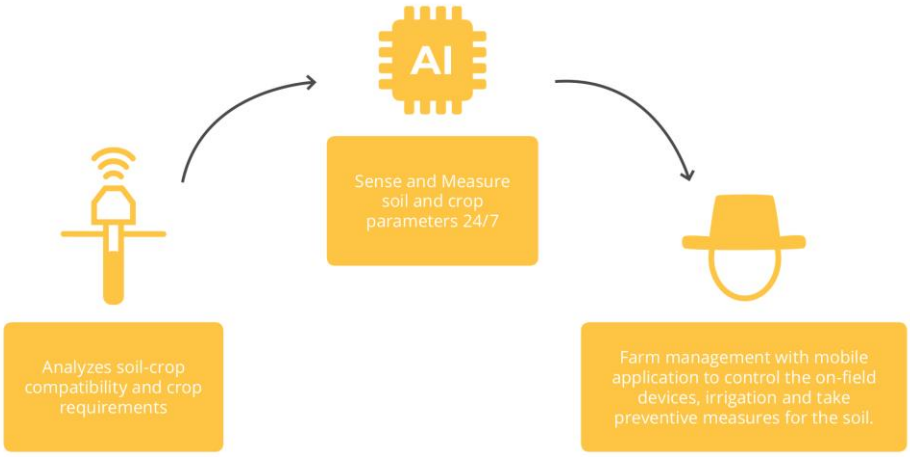

Figure 7: Technical solution illustration (Solar)

Demonstration activities:

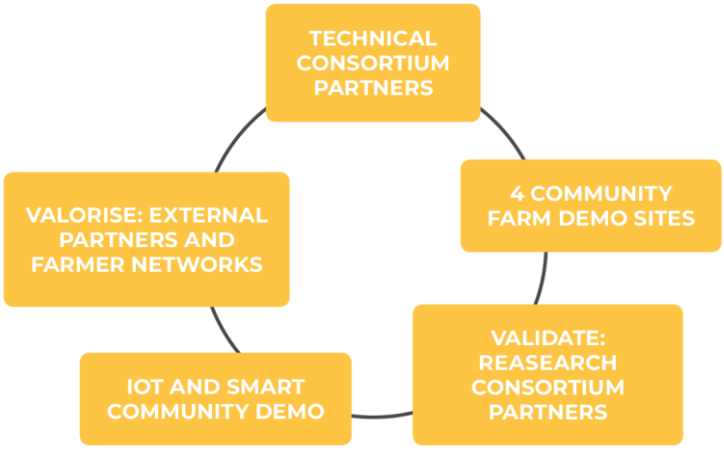

Figure 8: Demonstration activities illustration (Solar)

5. ARTISTIC PROPOSALS

5.1 Lithuanian hyperspectral landscapes

For the Within-field Management Zoning Baltics use case an audio-visual interactive system is proposed. It allows participants to create their own variations of landscape portraits of Lithuanian agricultural fields

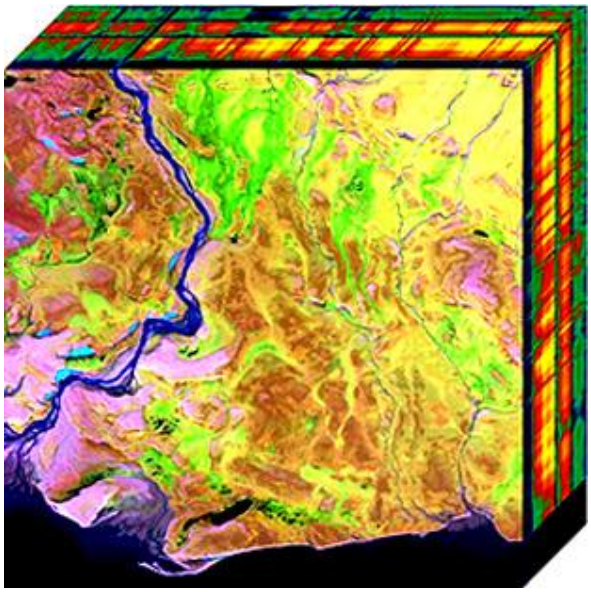

Figure 9: Example of a hyperspectral cube image [6]

Drones have been flying over Lithuanian agricultural fields capturing hyperspectral images [6]. Their original aim is to determine the health condition of crops in the areas surveilled. The aesthetic characteristic of those images inspire going beyond their appearance.

"Agriculture seems, a priori, to be off of the agenda when it comes to building a strategy or a security and defence system" Abdelhak Bassou, May 11, 2016 [7].

This transactional artwork urges participants to approach agriculture and food security as a matter of essence and survival. It questions the role of agriculture in security and defence policies and how it is differently taken by Transatlantic partners. In the US it is a matter of national security while in the EU it is not.

Workshops are planned to take place in the the Republic of Užupis [8]. Participants will be able to interfere with parameters of the data gathered by the drones to create their own interpretations in the form of new images. Their creative participation is intended to stimulate the creation of a critical mass about hyperspectral technology and its implications in agriculture as well as in security and defence policies.

5.2 Dionysia

For the Beverage Integrity Tracking use case the proposed artistic intervention is a performative ritual. It incorporates multiples artistic disciplines, including music, dance and theatre. It aims at interpreting data gathered by the jODYN beverage tracking prototype from an artistic perspective. It reflects upon what is the ideal balance of the conditions needed to ensure the quality of the experience offered by a specific beverage.

The jODYN beverage tracking prototype gathers sensor data along the course of transportation of a beverage from origin of production to consumers location. It records historical data of temperature, movement, light and humidity of the container transporting a beverage. The data is not transmitted in real-time. Therefore, no interactive system based on live streaming of data is possible to be done. However, a comparison between different datasets – some representing good conditions and others worse ones – can be achieved. An understanding of those ideal conditions is to be transformed into music, body movement and speech.

Inspired by the ancient Dionysian feasts of Greece, the ritual will conduct the audience, whom become active participants, in an experience with several sensational stages. It is through that manipulation of stages determined by the specific variations of the referred datasets that the audience will psychophysically perceive the difference between the quality of experience allowed by a specific beverage if good or bad conditions of transportation are met. The audience will perceive it without actually ingesting the beverage.

The creative process of such performance will be based in the invention of a correspondence of data into music. Sensor data is to be translated into musical notation and played either electronically or by live musicians. It will include spoken words as part of its musical landscape. The music will also include noise alongside with harmonic features. The musical score will serve as basis for the creation of a choreography of movements to be performed live by professional dancers. The audience will also move places alongside and guided by the performers.

Ideally the performance would take place at the European Parliament. There it would be used to raise awareness about the importance of the EU wine production industry in the global sphere. It would gather policy makers with active participants of such industry aiming at inspiring new policies to improve global quality distribution of EU wine. The main aim of the activity is to highlight the important role of IoT in the strengthening of the EU in the wine production and distribution global markets

5.3 Musical expression

For the Solar-powered field sensors use case a musical interpretation of the data streamed by the sensors is to be created as an audible monitoring field monitoring system. The system will be fully automated and will not have any human interference. It will be based on a musical correspondence between values gathered by the sensors and musical rhythms and scales.

The musical system is inspired by Indian music. The idea of such musical inspiration arose during the conversations with the leader of the use case. Although the solar-powered sensors are being developed and tested in several locations in the EU, it is the vision of its leader that it could also find a market in India where apparently the monitoring of fields is of great importance. It is our own understanding that an EU foreign policy could be put in place for the delivery of the sensors to India. A foreign aid policy that could bring an IoT solution developed in the EU to improve the food production system in a foreign country. The policy could be replicated in other global regions.

Indian music additive (concatenative) metric principles are very interesting in music composition. Previous experiences with that musical system in generative music experiments delivered very interesting results [10]. The idea is that the system works like a sort of a radio playing music at a distance while people are working the field or at home. The generated music reflects the health of the field according to the determined sensors and correspondent value thresholds. It basically sounds good if the land is healthy or sounds weird if something goes wrong.

The music outcome would make the monitoring very intuitive. The generative music algorithm, if successful could be integrated in the app of the solar powered sensor system.

6. CONCLUSIONS AND FURTHER ACTIONS

Three artistically driven experiments were created for three specific uses cases of IoF 2020. At current stage discussions are taking place with leaders of the use cases in order to proceed with the realization of the artistic interventions proposed. Budgets of the use cases do not allow more activities either then the ones already ongoing. We are looking into how can possibly the referred project S2S be a context within which the artistic proposals can be implemented.

Nonetheless, the interaction with the use cases had already some positive effects both on the side of the use cases and on our side. On their side, they were surprised by the ideas that arose during the discussions. After being surprised they became inspired by being stimulated to see their own actions from a different perspective and they were also stimulated to further push for progressing of their work beyond the use case itself. They are partnering with us in finding support to make the experiments and the associated events happen.

The current pandemic affected the initial ideas and strategies on how to proceed. After observing the early progress of the planned gradual release, we will reformulate the three approaches in conformity with the allowed. Most possibly, the digital components of activities will become preponderant.

From our side, it was also surprising the openness and willingness of theses specific partners involved in the use cases. They are willing to find alternative ways of making their use cases and further exploitation more interesting, attractive and appellative to potential customers, partners and supporters. The positive impacts of simple exchange of non-expected ideas was also very stimulating. We could observe partners being stimulated by the discussions and becoming more creative themselves, which in fact is the main purpose of the whole activity and of STARTS in general: Stimulate more creative approaches in industry, in this specific case in IoT.

6.1 Contribution to overall picture

The activities undertaken and the ones to happen aim at contributing to highlight the important role of IoT in processes such as Digitizing European Industry, Industry 4.0 and the European Digital Innovation Hubs. As reported by the European Innovation Bank in its latest document Who is prepared for the new digital age? Evidence from the EIB Investment Survey:

> "*One key finding is that established EU firms lag their US peers in terms of digitalisation activities*" [11].

It is evident that a lot has to be done in this context and IoT has a crucial role. Fresh and agile policies need to be in place to stimulate digitization of European industry. The EDIHs might work if properly implemented and we believe small scale creative experimentation can be crucial in the stimulation. Some EU countries are considered to be strong on the EIBIS Digitalisation Index: Austria, Belgium, Croatia, Estonia, Luxembourg, Portugal, Slovakia, Slovenia and Sweden. In this line with the already exposed the S2S pilot project has partners and activities towards the EDIHs in Portugal, Estonia and Slovenia. A previous STARTS pilot project established partnership in Belgium and Austria. We are working in integrating the described artistic driven experimentation activities in the context of these hubs.

Being concrete innovation actions, the proposed artistic driven small-scale experiments work with state-of-the-art technology.

The proposed artistic interventions aim at enhancing certain aspects of demonstration activities of the use cases.

The drive of artistic creation is very important in innovation processes. Even with limited amount of resources the need to see the artistic ideas concretely realized is mostly driving the efforts of making the proposed happen. This reinforces that innovation is not necessarily driven by capital investment in terms of funds. Creativity, and specifically if properly contextualize, can generate human capital to make the impossible possible.

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