OPTIMUM

OPTimised Industrial IoT and Distributed Control Platform
for Manufacturing and Material Handling

Deliverable 6.4.2
Lessons Learnt

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Abstract:	At the end of the project, the project partners evaluated the project and highlighted positive and negative aspects of the project for a section "Lesson Learnt" which is part of T6.4.
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Executive Summary

For some of the project partners, OPTIMUM was the first (funded) research project in an international consortium. Not only for this reason, but by its very nature, positive and less positive experiences and perhaps also mistakes are made during a project. Therefore, it is important to reflect and document those findings to keep them available for follow-up projects. Taken seriously, "lessons learnt" become a further driver of continuous improvement and can also help to preserve resources, increase the efficiency of project teams, and thus also reduce waste in the widest meaning of the word.

In this document the OPTIMUM consortium is sharing its “lessons learnt” in such way, that first there is the focus on subjects that mandatorily shall be considered in next projects. In the following chapter, recommendations are stated, and finally overall positive experiences and lessons learnt are concluding the document.

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1 Introduction

At the end of the OPTIMUM project, each partner was asked to evaluate the project and to formulate statements on highlighted positive and negative aspects of the project within a "Lesson Learnt" exercise. Ideally, each statement is accompanied by a proposal for future projects and cooperation.

The lessons learnt are divided into two categories: "mandatory" and "recommended". These are divided in table 1.1 and table 1.2.

2 Lessons Learnt

2.1 Mandatory Statements

Table 1.1: Lessons learnt - mandatory statements

Statement	Proposed Solution
There is a risk for participating companies and for the project itself, if there are no proxies in the areas of technology, project management and leads of WPs and Tasks.	After the consortium has consolidated, there could already a definition of proxies started. This should be done not only within the respective companies, but also regarding the contents of contributions. This increases project flexibility and speed in case of changes and evolution of consortium.
To get business commitment for productizing is more challenging than expected. Business is observing the project from “far” and it is hard to get it directly involved.	Involve business already in building a project idea to include their needs and customer knowledge as well as stay in line with the overall company strategy.
High personnel rotation may lead to critical delays, not only when facing milestones.	Increased communication in small sub-groups, for instance in the same country/related features group, or even face to face, could help to get new members up to date, reducing their response times.
Reaching ambitious project goals depends on the consortium construction and the commitment of partners and persons.	Build a consortium that covers all the technical value chain's elements. Rely on partners that proofed excellence and commitment to common goals. Pay attention to social aspects among partners and persons to reach trust and commitment.
Newly needed HMI for the control of assistance functions was not in focus of the project. A lack of knowledge and resources was identified during a PoC of innovative HMI concepts.	Concepts of app-based GUI development on smartphone / tablet need to be addressed already in an early stage of the project.

Programming skills for backend (e.g. Spring) and frontend (e.g. Android, ReactJS, etc.) frameworks were not in focus of the project but are strongly needed - for almost all kinds of modern projects.	Partners with appropriate skills shall be chosen for such projects.
HMI is a vital part of the control process for most of the demonstrators and turned out to be a huge bottleneck as the effort has been totally underestimated and there are not really experienced implementers who were able to help on short notice.	HMI (GUI) implementing tasks that are vital for the project need to be identified early and properly addressed. If necessary, external support needs to be added.
With OPTIMUM being an Industry 4.0 project, the focus was more on the lower layers (or components closer to the shop floor) of the system architecture. This caused some oversight about some crucial components of a complete system such as HMI.	All components of the complete system (or the aimed system) should be analysed and proper WPs/Tasks should be dedicated. Maybe even after the project starts if the missing parts are crucial.
The integration of communication protocols normally used in IoT enhances the range of interconnectivity with various operating devices.	Simple solution compared with other ones could be used for simple HMIs with reduced engineering effort.
Harmonization of the interface for vertical integration using OPC UA has been started and shows wide interest.	Activities shall be proceeded.
The dynamic discovery of devices in the network is important for industry 4.0 applications. Due to restrictions in the 4G+ network, the OPC UA multicast discovery could not be used. Also, the discovery service provided by the OPC UA library contains limitations that required workarounds. Additionally, the lack of a simple way to distribute device status information in the network has been identified.	The discovery needs to be realized with unicast communication and a central server. Alternatively, a configuration file can be used that contains a list of all available devices. The discovery process has been prototypically extended with such device information to provide a solution for an overall device status overview in the network.
5G technology: Release 16 with low latency times, planned for 2020 is delayed. The update will probably only be possible after the end of the project.	LTE+ technology applied
Unfortunately, the demonstration that was planned to be implemented on ERMETAL's real coil cutting line could not be realized as the initial budget of the project tripled because of huge increases in money exchange rates.	In response to this problem, there was a large-scale demonstrator built that can demonstrate all the functions and requirements defined in the use cases, and the relevant functions were presented in this demonstrator.
Adaptation of distributed control programming to material handling domain.	Enhance the application domains in future.
Although the selected solution should work in theory, the combined HW solution has issues sending/receiving CAN messages in the current setup.	The hardware to be used needs to be tested practically before designing it into the project.
The quality of localization fusion through loose coupling of relative step direction and length as well as absolute localization data from UWB for the operator depends on the quality of calibration with the absolute positioning data from UWB. Low quality calibration of position and orientation from UWB results in no increased quality of localization from the fusion result compared to UWB alone.	The loosely coupled absolute position needs an analysis and quality measure through statistical analysis and comparison with directly measured redundant data from inertial sensors.

2.2 Recommended Statements

Table 2.2: Lessons learnt - recommended statements

Statement	Proposed Solution
Partners which have little or no experience in participating in publicly funded projects invest a lot of capacities getting familiar with the regulations and necessities of national PAs. This might apply to both - technical and commercial reporting obligations.	More experienced partners could volunteer as mentors to support less experienced partners in case of questions or walk the first steps jointly.
Countries/partners starting the project at different times causes problems. From one perspective, outcomes from partners that start earlier contribute to the project, on the other hand it makes it for the late comers more difficult to adapt and reduces their contribution on fundamental decisions already given.	Even though official synchronization might not be possible, synchronization in practice can be achieved by either delaying some work or including the late partners for some activities earlier.
The larger and complex the project is, the more likely it is that not each of the single goals is reached. This may hinder a complete fully blown solution at the end.	Separate the project idea into several challenges and targets. Work towards the fulfilment of the individual goals and "sell" each of these individual achievements while keeping an eye on composing the overall targeted solution based on the individual ones.
Distraction by incoming emails and other side activities during online meetings.	Activate cameras might support staying focused in online meetings
Often there were many individual files for one topic instead of maintaining everything in one version. This caused additional work in terms of merging (e.g. formatting).	Better use of SVN by having all partners implement their contributions directly into the designated file. This could avoid formatting errors as well as unnecessary data accumulation.
When merging various files, such as deliverables coming from different partners, it's getting hard Different files from different partners often have different formats. And then it becomes very difficult and takes a lot of time to merge them and correct the formatting.	It would be beneficial to use a common file in a common platform. Then each country partner can write their contributions on this single file, if they are paying attention to not corrupting the original format of the file.
Due to many meetings via teams, it is sometimes difficult to assign content or to follow up on what was discussed if one misses meetings. Searching for shared files afterwards is also tedious.	If one were to set up a separate "group" or team in Microsoft teams for the work packages and main topics, for example, one would have all meetings, chats and files in this context in one place. In addition, it would help if at each meeting one person were to summarise the main points / decisions and make them available directly in the team meeting (via notes) for all those invited.
When a sub-group of companies are working together, and in some cases, they are from the same country, acting directly against the main repository can lead to small degradation of performance and "noise" generation from their side.	Having temporary sub-repositories just for such small sub-groups can be beneficial, as the directory hierarchy is far smaller (leading to faster document finding), and the "noise" derived from temporary or internal docs is reduced. Once the final documents are produced, they can be easily moved/copied to the main (global consortium) repository.
UWB communication cannot be secured.	Redesign of UWB components.

With the current UWB hardware it is not possible to secure the connection.	Take care of security aspects while developing the next hardware iteration
Supporting the installation of localization systems over air is a critical task since environmental expert knowledge is needed.	Provide a toolchain which supports flashing and configuration without being on site.
To integrate workers into (semi-) automatic processes, it is necessary to equip such persons with localization devices and processing power. A smooth integration of such parts in clothing which do not bother is challenging.	Reducing the size and weight of parts.
ERMETAL, which operates in the automotive field, generally employs mechanical / manufacturing / automotive engineers. For this reason, it was sometimes difficult to follow up the software and applications developed during the project in technical terms.	In this regard, thanks to the effective communication that was established with the project partners, they helped in every subject and provided necessary explanations in critical points.
To cooperate with other robots or cranes, it is necessary to collect and communicate status values (e.g. location) for each machine. However, since each manufacturer defines different status values, compatibility is limited when used together.	Proceed in a way to cooperate by sharing only the position and the heading angle value of the robot
It was impossible to extend the Korean testbed used for smart manufacturing to support a distributed environment.	More focus on verification of common use cases of OPTIMUM by enhancing the robot-based material handling testbed based on robot.
Due to the Covid-19 situation, the planned cross-validation of the Korean study results on the Demag test bed could not be conducted.	Validation by official Korean verification agency to secure the reliability of the results.
There is no OPC UA library for Android OS implemented in C language, and IIoT and DCP library developed in C language could not be applied to HMI for Android OS.	Develop HMI for Android OS using Eclipse MILO and Java based open source library.
Abstraction of interfaces allows reuse of control program on different crane applications.	Could be checked for other crane application.
Use of Secure Elements allows the secure handling of security keys.	The complexity of the engineering used to distribute security keys must be reduced to make it manageable.
Redesign of the control application due to lack of complete knowledge about the crane system as well as new requirements coming up during implementation.	A workshop/seminar to give in depth detail about the system before implementation. More detailed requirements/descriptions regarding the functionalities (if possible, also the prospective functionalities) should be available before the design of control application.
The backend system needs to handle a lot of services that haven't been considered by the project from the start. That led to a lot more - and unplanned - implementation effort, e.g. user database handling roles, access right & authorizations.	Supporting services need more attention from beginning of the project - at least when implementation starts.
External constraints with regards to both hardware and software led to unpredictable delays in building up a demonstrator.	Better consideration and constraint analysis of external deliverables needed for demonstrator setup.

Depending on the datasets used to model and communicate with devices enabled with OPC-UA may lead to issues in communication, making it necessary to adapt (in the low level perspective) specific software components.	Defining a communication interface to translate the OPC-UA schema defined for the device into/from the specific schema defined in the software modules can save a lot of time, effort and enhance the maintenance process.

3 Conclusion OPTIMUM

In addition to the above-mentioned statements, the OPTIMUM project can be summed up very positively overall, especially the social and managerial aspects.

Over the 3 ½ years of the project, a joint team has worked together across the borders of different organisations and countries. Not only new business relationships were formed, but personal friendships have developed.

Many partners have remarked that they would like to realise further projects together with the OPTIMUM consortium in future. This is also due to the good communication within the team. The strengths of the project are for example: very good organisation, coordination and controlling. The empathetic and humorous nature of the project leader, as well as the high level of dedication to the project and the team, strengthened the good collaboration of the consortium further. The open-minded and respectful cooperation and social events (also online) created a common vision and special motivation.

A negative aspect in the project was the high number of meetings, which, although necessary for the most part, led to capacity problems for some partners. However, this extreme burden of meetings is due to the Covid-19 pandemic, which hit Optimum hard during the implementation phase. As a result, physical meetings could not take place, which would have been necessary to effectively merge research results and jointly implement in demonstrations. Implementations via remote sessions needed more loops and therefore also took up lots of capacities.

To run research projects from distance with the challenges of this pandemic, it is necessary that the project team and the project leader take up the challenge. The OPIMUM team took up this challenge and was able to achieve results, which are largely prototypically functional and have the potential to create economic value in targeted markets.

4 Abbreviations

ABS	Agent-Based Simulation
AGV	Automated Guided Vehicle
CAN	Controller Area Network
DCP	Distributed Control Platform
GUI	Graphical User Interface
HMI	Human Machine Interface
HW	Hardware
IIoT	Industrial Internet of Things
IoT	Internet of Things
LTE	Long Term Evolution
OPC UA	Open Platform Communications Unified Architecture
OS	Operating System
PA	Public Authorities
PoC	Proof of Concept
SVN	Subversion
UWB	Ultra Wide Band
WP	Work Package