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MORSE: Model-based Optimisation for efficient use of ResourceS and Energy

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D6.4 Initial Exploitation Plan

WP:	WP6 - Dissemination and cross-sectorial exploitation
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Sustainable Process Industry through Resource and Energy Efficiency

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DELIVERABLE ADMINISTRATION

Deliverable administration						
No & name	**D6.4 Initial Exploitation Plan**					
Status	Final	Due	M18	Date	2019-03-31	
Author(s)	IDENER, VTT, SSAB, OUKU, BFI, SWD, CYB, GRI					
Description of the related task and the deliverable. Extract from DoA	**T6.2 Exploitation (M01 – M48)** The purpose of this task is to develop and execute an effective and industry-oriented exploitation plan and the management of relevant IPR that will allow the MORSE project results as well as the tools and models developed to penetrate the market in a cross-sectorial manner. The partners will create a first version of the exploitation plan (D6.4), which will gather the initial ideas on possible exploitations. This document will be a living document, evolving throughout the project to keep track of potential opportunities for cross-sectorial application of the project results as they are identified. The analysis of the factors that influence the exploitation, such as standardization needs, and market and regulatory barriers are assessed. Also, market studies, workshops and competitor analyses will be carried out when forming the exploitation plans. The final version of exploitation plan (D6.5) will identify the exploitable results and how these should be exploited. **D6.4 Initial exploitation plan** Document for the exploitation opportunities and plans for project result exploitation. Document will be updated throughout the project to keep track of potential opportunities as they are identified.					

Planned task resources	VTT	SSAB	OUKU	BFI	SWD	CYB	MFL	GRI	IDE	Total
	1	1	1	0.5	1	1	0	1	5	11.5
Comments										

V	Date	Authors	Description
1.0	2018-12-13	IDE	First deliverable template
1.1	2019-03-04	IDE	First draft of deliverable to be reviewed by partners
1.2	2019-03-12	IDE,VTT,SSAB, OUKU, BFI, SWD, CYB, GRI	Final version reviewed by all contributing partners

About Morse

Morse (Model-based Optimisation for efficient use of ResourceS and Energy) project is developing more precise tools for managing complex processes in steel industry. European steel industry is continuously looking for new ways to improve resource efficiency due to high dependence on resources (energy, raw materials and utilities). In large-scale production, even small changes in using raw materials and in energy can significantly improve process efficiency.

Morse project aims to further develop and to integrate a set of software tools that have partly already been validated in different process steps in steel industries. These software prototype tools and models were developed and evaluated by six R&D partners of the consortium in collaboration with three process industry partners. With the enhanced Morse tools companies of the process industry will be enabled to optimise the use of raw materials and energy by coordinated prediction and control of resource input and product quality along the entire process route from raw material and energy intake to customer delivery.

The mission of the Morse project is to develop model-based, predictive raw material and energy optimisation tools for the whole process route. This approach will be demonstrated in steel industry, to increase yield and product quality in production of high-strength carbon steels, stainless steels and cast steels.

Partners

EXECUTIVE SUMMARY

This deliverable contains the Initial Exploitation Plan for Morse Project. Initially, an introduction about the main aspects related with the steelmaking in EU, Industry 4.0, Digitisation of Industry and use of Artificial Intelligence and Data has been presented to provided context to the potential exploitation of results during and after MORSE project. Then, some general notes about a workshop dedicated to Exploitation of Results in MORSE project, the main outcomes of that workshop and previous discussions are presented. Those outcomes include mainly the characterisation of the Key Exploitable Results (KERs) of the project (divided in four groups) and the Risk Assessment Map and the Priority Map of each KER. Finally, a discussion about the possibility of a joint exploitation of MORSE results as an integrated software platform has been proposed.

To complete the scope of the deliverable 6.4. a summary of the most relevant points about IPR management has been included together with a summary of the background and foreground of all the MORSE partners.

ABBREVIATIONS

Abbreviation	Definition
CA	Consortium Agreement
EC	European Commission
EII	Energy Intensive Industry
GA	Grant Agreement
KER	Key Exploitable Result
IoT	Internet of Things
IPR	Intellectual Property Management
NMPC	Nonlinear Model Predictive Control
OSuS	Operator Support System
QMT	Quality Monitoring Tool

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1 INTRODUCTION

This section contains a brief introduction to the current state-of-the-art of the steel industry in EU and a summary several aspects related to the potential market of digitisation of industry and Industry 4.0 in EU. The idea is to present some information to characterise the market size and the relevance of the steel industry and the technologies developed within MORSE project.

At the end of this section, several concepts will be presented and described to help characterising the key exploitable results and their risks.

1.1 STEEL INDUSTRY IN EU

World steel production has remarkably increased last years (total production 1691.2 MTon in 2017) and EU is now the second largest producer in the world after China. The **total production in EU is now around 177 MTon per year** distributed in 500 production sites around 23 EU Members States [1]. However, even if this production level represents **11% of the total production around the world**, the demands stay still around 27% of the pre-crisis levels and it is estimated that 40000 jobs haven lost during crisis and have not been fully recovered yet [2]. For the full year 2017, apparent steel demand in the EU rose by 1.3%. Imports accounted for a 22% share of the market, despite a 2% fall over the year [3]

This current scenario is one of the main reasons why the Commission adopted an **Action Plan for a competitive and sustainable steel industry in Europe** [4] and the creation of a **High-Level Group on Steel** in 2013. Steel industry is a strategic sector in Europe and takes part of key chain values (e.g., automotive, mechanical and electrical engineering, electronics, construction and renewable energies) and it is vital to the EU's goal to increase industry's share of GDP to 20% by 2020.

The main challenges identified in the above-mentioned Steel Action Plan include: (1) **the regulatory framework for sustainable development**, (2) **boosting the demand of steel** by stimulating construction and automotive sectors, (3) **addressing trade barriers** by implementing its market access strategy at international level, (4) **guaranteeing access to raw materials** and (5) **regulating energy prices and energy supply**. Energy efficiency is critical to increase competitiveness and reduce environmental and climate impacts. As it is common in other Energy Intensive Industries (EII), **energy costs represent up to 40% of the total operational costs** of steelmaking, including some process units which are strongly energy-demanding and very extended in use (for example, the percentage of steel produced with electric arc furnaces around the world is about 45%, and this percentage is increasing). The steel sector is facing these challenges in a **strong competition with external steel** (mainly from China) and trying to continuously boost the internal demand (depending mostly on construction and automotive industry) in the context of high energy prices, limited raw materials and unfavourable environmental regulations. The raw materials used in steelmaking, especially petrochemicals, are becoming more and more expensive (for example, furnace refractories, are classified as Critical Raw Materials, due to their sources are very localized and their use in industry is very intensive). Recently, EU has approved several strategies oriented to limit and mitigate impacts of industry in climate change **towards a carbon neutral economy in 2050** [5] (e.g., reduction of GHF emissions in a 40% respect to preindustrial levels in 2030). Additionally, other industrial strategies, such as **the Spire 2050** [6], include among others, digitalisation, specializing steel production and making a big effort for achieving more efficient processes.

MORSE project currently addresses these challenges searching for a more efficient production of high-quality steel products in terms of energy and raw materials while addressing environmental impacts (decreasing number of rejections and subsequently solid waste) and reducing CO_2 emissions in the context of a Europe more and more concern about Climate Change, sustainability and competitiveness in non-EU markets.

1.2 DIGITALISATION AND NEEDS OF THE INDUSTRY 4.0

The **digitisation of industry and the use of Artificial Intelligence** [7,8] are increasing popularity in industry as part of the so-called Fourth Industrial Revolution which will be driven by the new generation of information technologies such as internet of things (IoT), cloud computing, big data and data analytics, robotics… All these technologies will work together to increase the competitiveness of EU industry by the efficient use of raw materials and energy and exploring more efficient processes and technologies for industrial production and manufacturing.

Recent studies estimate that **digitisation of products and services can add more than EUR 110 billion of annual revenue to the European economy** in the next five years. However, plans should include mobilisation of up to **EUR 50 billion of public and private investments to support digitisation of industry**. Those investments include 37 billion to boost the digital innovation and 6.3 billion for the first production lines of next-generation of electronic components.

One of the key technologies which is expected to trigger the Fourth Industrial Revolution is **Artificial Intelligence and it is becoming a priority for the policy makers of the EU Member States and around the globe**. According to the McKinsey Global Institute analysis in 2018 **it is expected an impact of EUR 0.3 trillion in sectors as transport and logistics, consumer packaged goods, automotive and social and public sector**.

The **EU plan for artificial intelligence includes several initiatives** [9] to finance relevant technology related with AI such as the launched **Horizon 2020 work program for ICT (EUR 1.5 billion)** and the work programme of **Horizon Public-Private Partnerships on Big Data and Robotics (EUR 2.5 billion)**.

The **application of AI in industry is strongly related to the creation of Digital Twins**. Digital twins are **software representations of different elements involved in the industry scenario** that can be used for better understand the underlying process, predict the outcome of the current or potential operating configurations and optimise the overall facility performance in order to obtain improved results. Two of the main elements that enable the setup of a digital twin platform are the data routing capabilities and the capacity for modelling the digitalised elements. **Digital Twins made Gartner's list of the Top 10 Strategic Technology Trends for 2018 [10] and the Digital Twin market is expected to grow to over $15 billion by 2023**. Gartner has identified for 2019 [11] the same list for technology trends including: autonomous things, augmented analytics, **AI-driven development, digital twins**, empowered edge, immersive experience (e.g., augmented reality or virtual reality), blockchain, smart spaces, digital ethics and privacy and quantum computing. By 2020, Gartner estimates there will be more than 20 billion connected sensors and endpoints and digital twins will exist for potentially billions of things. By 2022, at least 40 percent of new application development projects will have AI co-developers on their team.

1.3 MARKET POTENTIAL FOR MORSE TARGETED RESULTS

Main MORSE output results in terms of steelmaking products are strongly connected with **increasing efficiency in the use or raw materials and energy, the reduction of CO_2 emissions and increasing quality of the products**. These specific KPI and expected outcomes from MORSE project are totally **aligned with the EU strategy to increase competitiveness of EU industry** and more specifically the Steel industry.

At the same time, MORSE project developments in **plant-wide optimisation tools, the use of NMPC applications and Operator Support Systems integrated with "Digital Twins"** are already consistent with the EU strategies related to **Digitisation of EU Industry and the use of Artificial Intelligence**.

It is clear that the potential of the MORSE results both in terms of efficient steel production and the developed technologies related with the digitisation of the industry is huge and it can be **extended not only to other areas, process or units in steelmaking but to a lot of manufacturing and process industries in EU**.

1.4 MAIN CONCEPTS IN THE CREATION OF THE INITIAL EXPLOITATION PLAN

Before presenting the most relevant results of MORSE project, several concepts must be clarified in order to better understand later all the elements that describe the main aspects of the proposed key exploitable results.

Everything starts with the vision and main goal of the MORSE (Model-based Optimisation for efficient use of ResourceS and Energy) project: the development of more precise software tools for managing complex processes (enabling the optimisation in the use of raw materials and energy by coordinating prediction and control of resources input and product quality along the entire process route) in steel industry at the same time that steel industry explores new ways to improve resource efficiency (including raw materials, energy and utilities) as well as less environmental impacts and CO_2 emissions. Even small changes can significantly improve process efficiency in such large-scale production.

The mission of the Morse project is to develop model-based, predictive raw material and energy optimisation tools for the whole process route. This approach will be demonstrated in steel industry, to increase yield and product quality in production of high-strength carbon steels, stainless steels and cast steels.

These two main statements show the compromise of the partners of the project, including our industrial partners of the carbon steel, stainless steel and cast steel industry, with a more sustainable and efficient steel industry in Europe and their commitment with the EU strategy towards a Zero Carbon Economy in 2050.

Once the main goal is clear, it is necessary to detail it in several **key exploitable results (KER)**, which are specific results of the project fitting a specific need or responding to the demand of a defined group of customers and/or users. KERs are not only commercial products which could be incorporated to the marketplace and generating cash revenue. Even if it is convenient in the definition to include aspects on how this could happen and try to define customers, competitors, generate revenue, market, and so on; it is convenient to be more focused on who are the potential users and what is the necessity covered or problem solved.

The next important issue is the innovation associated with our KER, the so-called **unique selling point** or more general the **value proposition.** This can be a new product or a new methodology, any kind of innovativeness compared to already existing solutions or alternatives. The value proposition provides the set of arguments to choose the new proposed solution and not another of the existing products or methods. This can be even sentimental. Whatever it is, it is going to make your **customers** spending their money buying what you offer. At this point, it is better to think about **users** which gain value by using your value proposition instead of thinking about them as customers. These users include people in your own company which can benefit from your product or methodology.

All your potential users conform your so-called **market niche**, where your product or solution is focused. The market may not only be understood as strictly traditional market. It could be the production setup in which the KER is a new component, the project group in which the KER is a new methodology, etc. Regarding market size, see if you can picture that in the same way with the revenue. What is the total potential saving for using your product? What is the total potential investment that you can receive from external partners or your boss, what is the total increase of revenue that can be gathered by selling the product in which your KER is a new component? It is also quite important to think about potential markets, future trends and public acceptance.

But where there is a market, there are **competitors**. Your KER may not have “living” competitors, but there is usually a different way of responding to a demand or fulfilling a need. It is important to consider all the strengths and weaknesses of all potential competitors. Once you make your offer more attractive than the corresponding one of your competitors you will obtain the revenues. Even if your KER may not be directly a product you can sell and get money from it, but there will be always someone who pays for it or a way it may help you to get money. Perhaps an external partner, an investor or the budget of the company; even the KER will have the possibility to decrease costs somewhere in your own company or increase revenue of another product.

As a provider, you share the market with competitors searching for customers and, therefore, you need to create a kind of “critical mass” of customers to get a portion enough of the market. The **Law of diffusion of Innovations** establishes that 2.5% of customers are the so-called innovators and the 13.5% are the early adopters and the next 34% are the early lagers. Once that 50% of the market is achieved the market saturation gets an inflexion point and the potential sells grow exponentially.

It is important to analyse which are the remaining **competencies** needed to launch the KER as a product. That includes for instance, refined interface, design, marketing… and to define and **exploitation strategy** for the use of the products or methodology. It can be direct use, patents, incorporation or transfer to existing technologies, license agreement, publications, know-how applied in future projects.

The previously presented concepts can be used to better identify and characterise the **Key Exploitable Results**. Now definitions related to the potential risks of every KER will be presented to create the corresponding **Risk Assessment Maps and Priority Maps**.

Risk Assessment Map is a table where four main aspects are defined for each potential risk of the corresponding KER:

- **Description of the risk**: define in the detail your risks and the circumstances which would make it happen.
- **Degree of criticality**: how critical is the risk for the complete failure of your KER. From low (1) to highly (10) critical.
- **Probability that risk happens:** how likely it is that the risk finally occurs. From low probability (1) to high probability (10).
- **Potential Intervention:** Define here which would be the action to correct the situation.
- **Estimated Feasibility / Level of Success of the remedial action:** what are the chances that your remedial action would be adequate to correct the negative situation. From 1 (probably it won't work) to 10 (it is very likely this action will be enough)
- **Risk grade:** The product of *degree of criticality* x *probability of risk* will give you the so-called *risk grade*.

Several types of risks connected to each KER can be identified:

- **Partnership Risk Factors**: Internal risks factors related to the composition of the partnership or specific behaviours of the partners, conflict of interests
- **Market Risk Factors:** External risks factors related to fulfilment of marked needs, presence of competitors or alternative products, etc;
- **IPR/Legal Risk Factors:** Factors related to the presence of similar previous patents, the possibility to protect the developed technology/product, patent counterfeit...
- **Financial/Management Risk Factors:** Factors related to the availability of funds for bringing research stage to prototyping industrialisation/commercialisation.
- **Environmental / Regulatory Risk Factors:** External factors related to presence or changing in legislations, standards, etc. special attention will be given to regulatory environment and standardisation issues.
- **Technological Risk Factors:** External factors related to the feasibility of the technology, its level of development, presence of other emerging, etc

2 MORSE EXPLOITATION WORKSHOP, FEBRUARY 2019

A workshop dedicated to the Initial Exploitation Plan took place in the Outokumpu Stainless Plant in Tornio on the 6th February 2019. The main objective was to continue the discussion and complement the information about how the most relevant project results may be transformed into tools and products oriented to an effective and cross-sectorial market penetration. This workshop celebrated in Tornio complements the previous activities done by the consortium regarding exploitation of results which include an initial discussion in the Morse12-months review meeting in Seville (7-8th November 2018) and questionnaires filled by consortium member and submitted to the member of the consortium responsible for the exploitation activities in Morse project. The workshop was divided in three main parts: 1) introduction of the most relevant concepts to prepare the characterisation of the Key Exploitable Results (KERs); 2) discussion about the most relevant KERs 3) creation of the Risk Assessment Map and the Priority Map of the KERs. The main individual KERs have been divided in four groups to facilitate the discussion by making it more general and open to all partners. Finally, the possibility of a joint exploitation of results as will be explored as an integrated platform for optimisation and control by connecting all the different individual results of MORSE.

2.1 GENERAL OUTCOMES FROM WORKSHOP

As part of this initial analysis of the exploitation strategy, main exploitable results have been identified as well as the synergies between the different partners and the adequateness of the consortium to the development of the key exploitable results to market level. The key exploitable results have been identified and grouped in 4 categories to facilitate the discussion at consortium level, then the main partners related to specific KERs have complemented the analysis with specific analysis of each one of the KERs. Then, main risks and preventive and corrective actions have been identified and evaluated to create the Risk Assessment Map and the Priority Map.

During the discussion of the general aspects of the current results additional interesting topics have been highlighted. Maybe, one of the most relevant and promising aspects of the exploitation of MORSE results is the good synergy between the different partners elaborating the modelling tools, the control and support systems and the integrated platforms together with the industrial partners. All the partners are narrowly collaborating with at least three partners and in most of the cases the number of collaboration partners is 4 or 5. Remarkably, good communication channels have been established between the industrial partners and the software developers. Not only the data requested and access to control and monitoring systems have been provided diligently, but also fluent discussion and, at the same time, industrial partners have seen the potential of the software tools under development within the MORSE project and the software and platform developers have mostly understood the necessities of the industrial partners and are doing their best efforts to fulfil those necessities within MORSE project.

When analysing the key exploitable results provided by every partner or set of partners several elements stand out. First, the main KERs are totally in consonance with the main goal of MORSE project. All the tools developed and KERs defined work together to provide steel production processes and operations oriented to a lower consumption of energy and raw materials and, therefore, to less CO_2 emissions and environmental impacts, while yield and quality of the products is increased. The way of obtaining those relevant improvements in industry is the simultaneous development of integrated modelling, control and optimisation tools which will be designed in a flexible and modular way (easily allowing extension and upgrading) and focused not only on process units but also in plant-wide approaches.

Another important topic raised during the workshop has been the importance of data analysis and machine learning techniques together with other “intelligent tools” to extract knowledge from data records and as a complement to models and control systems (e.g., the use of the Operator Support System based on Reinforcement Learning). The digitalisation process now ongoing in EU industry (i.e., as part of Industry 4.0), the continuous exchange of information and data and the use of Internet of Things (IoT) applied to Industry make us consider the future integration of the MORSE tools into future implementations or systems within Industry 4.0, not only during operation but also during planning. Therefore, it is necessary to provide “intelligence” to the IT infrastructures but also to data platforms and planning platforms.

The use of AI in control systems in the process and manufacturing industry is inexorably penetrating the Industry 4.0. However, the novelty of those recent developments must be incorporated carefully into critical industrial systems for control and management which are mostly based on first principles and core equations. The incorporation of models using those core equations and physical chemistry principles will be most likely mandatory in the first stages of the “industrial revolution” associated to Artificial Intelligence.

Even when you try to learn as much as possible from data, understanding the main equations and processes of the phenomena you simulate with dynamic models as "digital twins" is still helpful and highly recommended.

Prevention and Quality management tools are becoming more and more mature at plant-wide level and are certainly one of the most relevant key exploitable result of MORSE project with a huge potential for adaptation to other process and manufacturing industries beyond carbon steel, stainless steel and cast steel.

In summary, MORSE project addresses the most relevant challenges of EU industry in different levels searching for an integration of ICT technologies, digital twins (dynamic process models), Machine Learning and NMPC applications to support the creation of a more competitive, sustainable and efficient steel industry.

3 EXPLOITATION OBJECTIVES

MORSE project tasks include the development and execution of an effective and industry-oriented exploitation plan and the management of relevant IPR that will allow the MORSE project results as well as the tools and models developed to penetrate market in a cross-sectorial way. The present document describes the activities and the main contributions of the MORSE project partners to create a first version of the exploitation plan, which will gather the initial ideas on possible exploitation. In this deliverable D6.4, Initial Exploitation Plan, the main opportunities and strategies for exploitation of the project results will be identified and analysed.

The exploitation of MORSE results demands operational strategies and commercialisation paths not only for each one of the individual project results but as well for the project results as whole. The individual plans for exploitation must be coordinated to avoid conflicts and the exploitation strategies must be reviewed and detailed as project continues to ensure adaptation to changes and trends in market and technologies. The exploitation strategy includes the preparation of a draft business plan (with financials) and a marketing campaign to support exploitation.

The initial approach of the exploitation plan for each partner can be found in section 2.2.3 of MORSE project proposal: "Exploitation strategy and business plans". That section presents the summary of the exploitation plans of every single partner during the MORSE project and after. In summary, during MORSE project the strategy is to develop the corresponding technologies and to create use case demonstrators to prove the current capacities and the potential of the results. At the same time, strong efforts in marketing and intensification of partnerships will be done. Then, after the ending of MORSE project, additional efforts will be done to extend the developed models, control applications, operators support systems and plant-wide optimisation tools to other parts of the steelmaking production process, to other steel plants and even to other manufacturing or process industry in Europe. In the case of the industrial partners of MORSE project, the exploitation plan can be summarized as the implementation and integration of the software tools into their respective processes and achieving the defined key performed indicators (e.g., efficient use of raw materials and energy, reduction of rejections and CO_2 emissions and increasing yield and quality) during MORSE project execution. Once those use cases have been proved to succeed, it will be considered to extend the use of the technology to other parts of the steelmaking plant in the project or to other industries from the same partners (internal exploitation).

3.1 MAIN OBJECTIVES AND SCOPE OF DELIVERABLE

This deliverable, D6.4, presents the Initial Exploitation Plan of MORSE project including mostly the characterisation table of the main KERs of MORSE project and their potential risks (Risk Assessment Map). KERS have been divided in four groups attending the kind of results and the needs and innovations addressed. Besides the characterization of results, a risk assessment map and a priority map has been created for each KER group and specific risks have been evaluated for the individual KERs. These results and their corresponding analysis of risks will be updated during MORSE project and finally, presented in the D6.5.

The contents of this deliverable include a summary the outcomes of the workshop for exploitation in Tornio in February 2019 and the information provided by each one of the partners and complements the initial description which every partner has provided in section 2.2.3 of the project proposal for exploitation of results.

4 DESCRIPTION OF KEY EXPLOITABLE RESULTS

According to the EC glossary of terms of the Funding and Tenders Opportunities [12], the results of a project are defined as "any tangible or intangible output of the action, such as data, knowledge and information whatever their form or nature, whether or not they can be protected, which are generated in the action as well as any attached rights, including intellectual property rights."

It basically includes all the output generated during the project, which can create impact during and/or after the funded project period and which could be used either by the project partners or by other stakeholders.

The results can be grouped in:

- Re-usable and exploitable entities (inventions, products, services).
- Elements (knowledge, technology, processes, networks) that have potential to contribute for further work, research or innovations.
- Administrative deliverables, reports or dissemination materials (e.g. publications) are often not results in themselves

4.1 EXPLOITABLE RESULTS SUMMARY

During the workshop and the previous discussions, the main Key Exploitable Results at partner(s) level have been identified as follows:

- ➢ Advanced Quality Monitoring Tool (QMT) by VTT.
- ➢ On-line NMPC control applications in CENIT platform by Cybernetica.
- ➢ Operator Support System to assess human operators by Idener.
- ➢ Total Cost Optimisation of SSAB Raahe carbon steel plant using plant-wide tool by SWD including new models from BFI.
- ➢ Integration of dynamic process models developed by BFI and Cybernetica with control and optimisation tools.

- Integration of BFI models into Meltshop|365 System by GRIPS.
- Optimization of the stainless-steel production in Outokumpu plant in Tornio and reduction of environmental impacts to improve public opinion in terms of the environmental image
- Optimisation of MFL foundry division into a much highly energy and resource-efficient foundry

Additionally, the possibility of **a joint exploitation of results** at consortium level has been explored.

4.2 KEY EXPLOITABLE RESULTS ANALSYS

All the KERs listed by the partners have been grouped in four categories regarding their common aspects and similarities in the potential exploitation. Those four categories are:

- **Unit Process Modelling Tools**. This include all the different detailed process models developed as "digital twins" to be integrated into the control and support tools or the plant-wide optimisation tools. Main goal is to understand and reproduce systems which are potentially difficult to monitor and, therefore, models will be used as "soft sensors".
- **NMPC control systems and operator support tools**. Those tools search efficiency in the use of energy and raw material and the optimisation of the whole operation of the corresponding unit. The use of these tools will allow the optimization of the most energy consuming and critical levels.
- **Integrated plant-wide optimisation, quality monitoring and management tools**. Approaching the optimization not only from the perspective of single process units but also considering their direct and indirect impacts on the overall plant operation, both in the upstream and downstream routes. Here off-line and on-line optimisation will be concluded. The goal here is to perform optimal raw material and energy usage as well as improve coordination.
- **Optimized processes of obtaining steel products** with high quality and effective use of energy and raw materials, and therefore, less CO_2 emissions and environmental impacts.

4.2.1 KEY EXPLOITABLE RESULT GROUP 1: PROCESS UNIT MODELLING TOOLS

Some of the most important key exploitable results of MORSE project are the different specific process unit models ("Digital Twins") developed by our partners Cybernetica and BFI. Those models include very critical process units such as Electric Arc Furnace (EAF), Basic Oxygen Steelmaking (BOF), Argon Oxygen Decarburization (AOD), Blast Furnace (BF) and the unit for Composition adjustment by sealed argon bubbling and oxygen blowing (CAS-OB). Those detailed models will be combined with NMPC control tools, plant-wide optimisation tools and the operator support system.

4.2.1.1 DESCRIPTION

Table 1. Description of KER: Process Unit Modelling Tools

	General KER Group 1:	Process Unit Modelling Tools
0	Description	Specific Unit Process Models ("Digital Twins") developed by Cybernetica and BFI partners for EAF, BOF, AOD, BF and CAS-OB. Those models will help to understand dynamics inside the

		industrial units and will be incorporated into control systems and plant-wide optimisation tools.
1	**Problems Addressed and Alternative Solutions**	Models are extremely useful tools to understand the internal processes and dynamics inside process units. They can help to test different operation regimes, test the boundaries of current operations and even provide feedback about major modifications without any risk for operators or physical units. In the case where specific measurements are not feasible (or too expensive), for example, continuous temperature measurements or composition analyses of liquid steel, models become extremely relevant as "soft sensors" in NMPC applications and plant-wide optimisation tools.
2	**Innovation introduced compared to existing solutions.**	Specific models have been developed, either by adaptation of existing tools or from scratch, for the specific units in SSAB, Outokumpu and MFL use cases. Appropriate interfaces for use of the models within MORSE process monitoring, control and optimisation applications have been implemented.
3	**How the KER will be transformed into a product**	Models developed can be integrated in existing control and management systems in industry. They can also be integrated in MPC or NMPC control systems as soft sensors or integrated in plant-wide optimisation tools to model the most critical units.
4	**Unique Selling Point (Value Proposition)**	Lack of enough instrumentation is a common challenge for all high-temperature applications and thus for most of the metallurgical industries. The rather unique combination of on-line soft sensing, using dynamic models with learning capabilities and the dynamic optimization based on the same mechanistic models with good predictive properties, turns out to be a competitive advantage
5	**Legal requirements and/or ethical aspects**	Use of models for better understanding processes or as part of other industrial system or control tools as soft sensors does not present legal requirements or ethical aspects. However, indirectly the outcomes of their use must fulfil all security, safety, environmental and quality requirements. Cybersecurity issues must be considered as well.
6	**Industry Impacts**	The use of models has always positive impacts in Industry helping to better understand processes, to optimize methodologies and to evaluate alternatives with a low cost and risk.
7	**Social Impacts**	Models contribute to the optimal industrial operations and therefore to improving the efficiency in the use of materials and energy and to decreasing number and extension of environmental impacts.
8	**Adequateness of Consortium**	All the partners developing models for the above-mentioned units are experts in the development of industrial process models with long expertise in the integration of such models into industrial systems.
9	**External Experts/Partners to be involved and their competences**	At present stage, no external partners are needed. However, models could be incorporated to other software tools as libraries.
10	**Current TRL level and time needed to market**	The new models are specifically being developed for real units in existing steel plants. However, it would be possible to

		achieve TRL 7-8 during MORSE project and TRL-9 in no more than two additional years
11	**Targeted Market, trends and Customer Segments and public acceptance**	Steel producers. Some of the models could be easily adapted to other metallurgical industries. Early adopters could be existing simulation platforms without specific modules for simulation of steel production or educational software tools including educational versions of the models developed during MORSE.
12	**Competitors**	In general, the suppliers of steel plants offer level 2 automation systems including process models. Moreover, it is well known the existence of SME and large companies fully dedicated to industrial modelling and control applications.
13	**Status of IPR: Background**	No changes respect to the Grant Agreement and Consortium Agreement
14	**Status of IPR: Foreground**	No changes respect to the Grant Agreement and Consortium Agreement
15	**General Exploitation Model (done? to do? costs? revenues?)**	BFI and Cybernetica are prepared to take responsibility for implementation and after-installation maintenances. Cybernetica is also prepared for market introduction and sales. BFI is a non-profit institution (see section 4.4)
16	**Other aspects to be considered**	Not at this moment.

The previous table describes general aspects of the modelling tools considering one of the four groups of KERs of MORSE project. Two partners will develop specific process unit models for MORSE project which will be used by other partners for NMPC control applications, operators support and plant-wide optimisation tools. **Cybernetica** is developing a “Digital Twin” for CAS-OB model and **BFI** provides such models for BF, BOF, EAF and AOD as well as a scrap regression model which will be later integrated in model predictive control systems and production management systems. Those “digital twins” have been specifically developed and/or adapted for MORSE project and include layouts of appropriate interfaces. First approach will be the internal exploitation of those results as part of the control applications and plant-wide optimisation tools. However, the models could be applied for further extended studies on those process units and the models could also be extended and adapted to create new “digital twins” of similar process units in the steelmaking process or even in other processes. It is important to mention at this point that BFI, as a non-profit institution, is restricted to project development and commissioning. Additional aspects about exploitation of results for non-profit and research institutions will be commented on section 4.4 of the present document.

4.2.1.2 RISK ASSESSMENT MAP

Risk Assessment table for KER group 1: **Process Unit Modelling Tools.**

Table 2: Risk Assessment table for KER group 1

	Description of Risks	Degree of Criticality (1-10)	Probability of the Risk (1-10)	Risk Grade	Potential Intervention	Estimated Success rate of Intervention (1-10)
	Partnership Risk Factors					
1	Difficulties to determine the contribution of each partner	4	4	16	Review of the Grant Agreement	8

	to the development					
2	Disagreement on further investments: some partners may leave	8	4	32	Establish a clear exploitation path which compensates fairly the partners who need to make further investments in case of collaborations	7
	Market Risk Factors					
1	Unsuitable (or insufficient) sales/marketing team	6	5	30	Multiple partners will promote project results, more impact.	6
2	Improvements not enough / Rejection by end-users	7	4	28	Development of the models until results fulfil the defined KPIs	8
	IPR/Legal Risk Factors					
1	Legal Problems (being sued)	6	2	12	Technologies applied are under development by the project partners. Extend the search of similar technologies to be sure	8
	Environmental / Regulatory Risk Factors					
1	Difficulty to maintain environmental restrictions	7	3	21	If the models applied as soft sensors cannot help to achieve environmental limitations, parameters will be modified, additional equations added	9
	Technological Risk Factors					
1	Better Technology appears (Artificial Intelligence)	6	2	12	Incorporation of machine learning or artificial intelligence to the existing models.	9
2	Aiming to replace well-established technologies	6	7	42	Demonstrations. Promotion of the good results of the models.	8

4.2.1.3 PRIORITY MAP

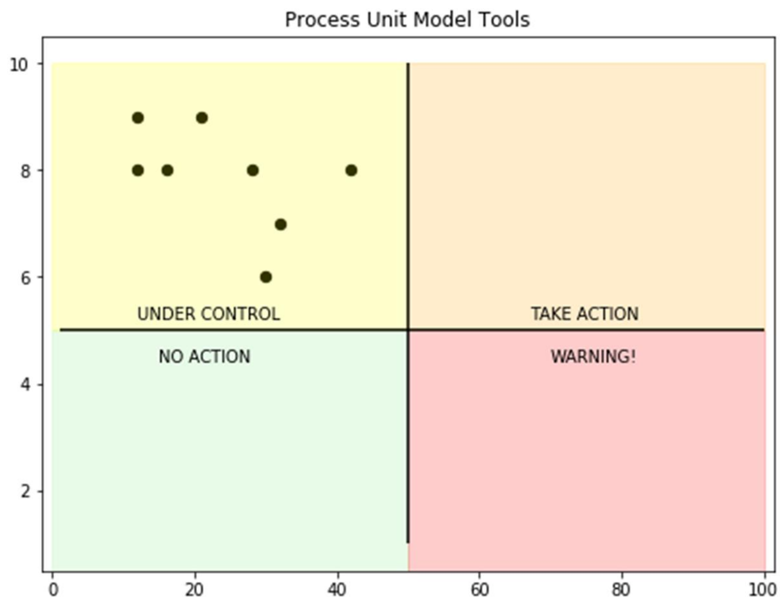

Figure 1. Priority Map including Risks for KER Group 1

4.2.2 KEY EXPLOITABLE RESULT GROUP 2: NMPC CONTROL APPLICATIONS AND OPERATOR SUPPORT SYSTEM

Searching for the optimization of production processes and efficient use of energy and raw materials while keeping or increasing quality levels are some of the main goals of MORSE projects. Innovative methods such as NMPC control methods applied in several key process units and even Artificial Intelligence approaches to find optimal operation protocols when human actions are part of the production processes. Both methodologies, NMPC and Reinforcement Learning can complement each other.

4.2.2.1 DESCRIPTION

Table 3. Description of KER: NMPC Control Applications and Operator Support System

	General KER Group 2:	NMPC Control Applications and Operator Support System
0	**Description**	On-line control applications and operator support systems. This set of KERs include NMPC control tools implemented in Cybernetica CENIT for CAS-OB, EAF, BOF and AOD processes and the Operator Support System based on Reinforcement Learning for the CAS-OB and Slab Routing operations to suggest human operators the optimal actions in every situation.
1	**Problems Addressed and Alternative Solutions**	NMPC control applications will give steel produced added value through improved energy efficiency, improved yield and precise control of the final composition and temperature. Variability in raw materials quality and composition can be accounted for and compensated. Human Operators must take operational decisions based on experience in very different situations. The results depend on who is the human operator, circumstances of the action and amount of accumulated experience. Therefore, those results present variability and goodness depends a lot on who is the human operator taking the decision. The new operator support system will learn from experience of all human operators continuously and from direct interaction with the CPS and the simulations. This will allow even to decide under uncommon and unexpected situations and even in partially observable environments.
2	**Innovation introduced compared to existing solutions.**	The applications developed by CYB will, to the best of our knowledge, all be first-of-a-kind for the specific process units. This is advanced but proven technology, adapted to new types of applications. NMPC control applications are well known technologies but their use is not very extended in steel production. Operator Support System (OSuS) will help humans to make better decisions based on shared long-term experience and even will provide optimal solutions in partially observed environments.
3	**How the KER will be transformed into a product**	The NMPC control applications will be integrated into Cybernetica CENIT product suite. Cybernetica will undertake further product development after MORSE. Upon market introduction, Cybernetica will offer engineering, installation, commissioning and long-term maintenance of such applications to the industry, world-wide. OSuS will be integrated with SCADA systems and process simulations to provide suggestion based on experience obtained from direct interaction. The main purpose is to assess human operators based on current situation and a list of possible actions. No feedback is provided to the control actuators of the system,

		only to human operators. It is important to consider who is going to be the main user of the technology before deciding the best way of transforming the NMPC or the OSuS into a final product or service. The final additions will strongly depend if the system will be used by Plant Operators or Engineers and Managers. In the case of plant operators, the integration with the current SCADA is preferred. For engineers, they may prefer new adapted interfaced with advanced visualization tools. In both cases, the system should be easy to use and easy to be integrated in other existing tools or industrial systems. Therefore, modularity and flexibility are desired characteristics as well as integration with OPC and messaging systems.
4	**Unique Selling Point (Value Proposition)**	Lack of enough instrumentation is a common challenge for all high-temperature applications and thus for most of the metallurgical industries. The rather unique combination of on-line soft sensing, using dynamic models with learning capabilities, and the dynamic optimization based on the same mechanistic models with good predictive properties, turns out to be a competitive advantage. The Operator Support System (OSuS) proposed by Idener is a completely new approach and not available at commercial level. Reinforcement Learning is now to be proven effective in beating human players in games such as Backgammon, Chess or Go.
5	**Legal requirements and/or ethical aspects**	Use of models for better understanding processes or as part of other industrial system or control tools as soft sensors does not present legal requirements or ethical aspects. However, indirectly the outcomes of their use must fulfil all security, safety, environmental and quality requirements. Cybersecurity issues must be considered as well. Additional relevant considerations appear when using data related to human operators and General Data Protection and Regulation aspects must be consider. It is worth to be also considered the idea of providing knowledge about fundamental aspects of NMPC, Soft sensors and Reinforcement Learning. This would help them to better understand and accept the use of those technologies in their daily activities.
6	**Industry Impacts**	The NMPC control applications will give steel producers added value through improved energy efficiency, improved yield and precise control of the final composition and temperature. Variability in raw material quality and composition can be accounted for and compensated. OSuS will reduce the time that human operator takes to decide about the actions required, it will confirm the action and will prevent rejections and even suboptimal decisions. Less rejection of intermediate operations and optimal use of resources, less energy and raw materials consumed, improved yield and less emissions.
7	**Social Impacts**	Optimal use of material, lower prices and less environmental impact (less emissions and less waste produced, specially by rejections). At the same time, better working conditions, safe conditions are positive impacts in general to society and the proposed advances control and support systems will help to prevent and compensate errors. The optimization in the use of energy and raw materials will help continue production operations, sustain job places and, in general, increase sustainability of the company.
8	**Adequateness of Consortium**	The current partners are believed to have enough competence.
9	**External Experts/Partners to be involved and their competences**	None that we know at present.

10	**Current TRL level and time needed to market**	In the following two years it would be possible to achieve TRL 7-8 and additional two years would be needed have the actual system proven in operational environment (competitive manufacturing in the case of key enable technologies). TRL of current RL technology in industrial applications is around 3-4, simulations of RL have been performed against human players and videogames, however, the technology has not been validated in industrially relevant environments
11	**Targeted Market, trends and Customer Segments and public acceptance**	Primary Target: Steel producers and world-wide. Similar solutions are and will be offered to similar industries like manganese producers. Similar solutions are already on the market for chemical industries (e.g., oil refining). In the case of the Operator Support System, the targeted market and potential customers are any process industry where human operators must decide between different alternative actions based on the current information of the system monitoring and their own experience. Early adopters (Law of Diffusion and Innovation): Simulation tools can incorporate the Operator Support System and NMPC control applications as libraries. Educational Software. Current market trends and public acceptance: EU has presented its strategy towards a ZCE in 2050 and it is already establishing actions to reduce CO_2 emissions by 2030 and 2040. Consumers are more and more educated in the environmental aspects of industrial production as well as responsible use of resources, pollution and generation of solid waste.
12	**Competitors**	Specific competitors have not been identified. There are not many competitors using NMPC instead of MPC or classic PID control because it is in general difficult to develop and maintain and, of course, it requires the creation of models. However, large companies or SME which are mostly working in control and management tools can be considered our competitors.
13	**Status of IPR: Background**	Cybernectica's own background is Cybernetica CENIT as well as the other background specified in the Grant Agreement. In summary, no changes respect to the Grant Agreement.
14	**Status of IPR: Foreground**	Three of the applications to be demonstrated in MORSE, rely on dynamic models (foreground) developed by BFI. How this will be handled in the future, remains to be decided, and will be considered in the post-MORSE product development phase. From Idener's side, no changes respect to the grant agreement.
15	**General Exploitation Model (done? to do? costs? revenues?)**	Cybernetica is prepared to take responsibility for market introduction, sales, implementation and after-installation maintenance. Idener is considering the exploitation of the operator support system as tool/library to be incorporated into simulation platform or instrumentation and control in production processes.
16	**Other aspects to be considered**	---

The KERs included in this group are those related with the sustainability and continuity of normal operation in optimal conditions. Those results include the NMPC control applications provided by Cybernetica for the process units mentioned in KER group 1 and the operator support system developed by Idener for the CAS-OB operation in SSAB and the Slab Routing and WBF slab sequence preparation in Outokumpu.

For **Cybernetica NMPC control** applications, the main exploitation path is the implementation of those tools into their platform **Cybernetica CENIT**. In this way, the NMPC control applications will provide added value through improved energy efficiency, improved yield and precise control of composition and temperature. This kind of control applications, quite extended in use in the field of chemical process engineering and oil refining, suppose an innovative application in steel making processes. The main advantage is the use of on-line soft-sensing and dynamic optimization based on mechanistic models. Cybernetica is prepared for offering the engineering, installation, commissioning and long-term support and maintenance of such applications. TRL expected at the end of the project is 6-7 and only a few years later the technology will be ready for a marketable solution at TRL-9.

In the case of the **Operator Support System in current development by Idener**, it will be a very innovative approach in the control and optimisation of process unit operation applying Machine Learning techniques to support the human operators in the decision making based on the common accumulated experience of the previous operations and the continuous evaluation and generated experience using soft-sensors and digital-twins when available. In this way, operations will gradually become optimal, unforeseen situations or partially observable systems can be handled and variability of operations by execution performed by different human agents. This innovative system will assess human operators to make better decisions based on the shared long-term collective experience and will provide optimal solutions even in situations which human operator has never experience thanks to the use of the digital twins. The easiest way of exploitation is the integration of the Operator Support Systems is the integration with the existing control and monitoring system and sharing the outputs with the existing SCADA system, it would also possible to implement a separated system including models of the process units (or the whole plant) and with one or several operator support system integrated and a GUI to help managers and engineers to find optimal actions in different scenarios. The unique selling point is the innovative application of this system, already tested in strategic board games such as Backgammon or Go, in industrial Cyber-Physical Systems. Current technology will reduce time for decision making and will optimise the use of raw materials and energy. However, the TRL is still low (TRL-3 or TRL-4) and it is aimed to achieve TRL-5 to TRL-7 within the project timeframe.

4.2.2.2 RISK ASSESSMENT MAP

Risk Assessment table for KER group 2: **NMPC Control Applications and Operator Support System**

Table 4: Risk Assessment table for KER group 3

	Description of Risks	Degree of Criticality (1-10)	Probability of the Risk (1-10)	Risk Grade	Potential Intervention	Estimated Success rate of Intervention (1-10)
	Partnership Risk Factors					
1	Difficulties to determine the contribution of each partner to the development	7	4	28	Review of the Grant Agreement.	8
2	Disagreement on further investments: some partners may leave	8	2	16	Additional revenues for those partners doing additional efforts	9
	Market Risk Factors					
1	Unsuitable (or insufficient) sales/marketing team	6	5	30	Multiple partners will promote project results, more impact.	6
2	Improvements not enough / Rejection by end-users	7	4	28	Development of the models until results fulfil the defined KPIs	8
	IPR/Legal Risk Factors					

1	Legal Problems (being sued)	7	2	14	Ensure that patents or copyright is not violated by updating the patent research	9
2	GDPR issues	8	3	24	Anonymous data will be always applied, and special care will be taken when using data created by human operator.	8
	Environmental / Regulatory Risk Factors					
1	Difficulty to maintain environmental restrictions	7	3	21	Additional restrictions can be added to the control applications or operator support system to ensure no infringement of environmental regulations	9
	Technological Risk Factors					
1	Better Technology appears (Artificial Intelligence)	7	3	21	Results of NMPC and Reinforcement Learning can be combined in new innovative control applications	7
2	Aiming to replace well-established technologies	8	5	40	Show the good results of the use case demonstrators	8

4.2.2.3 PRIORITY MAP

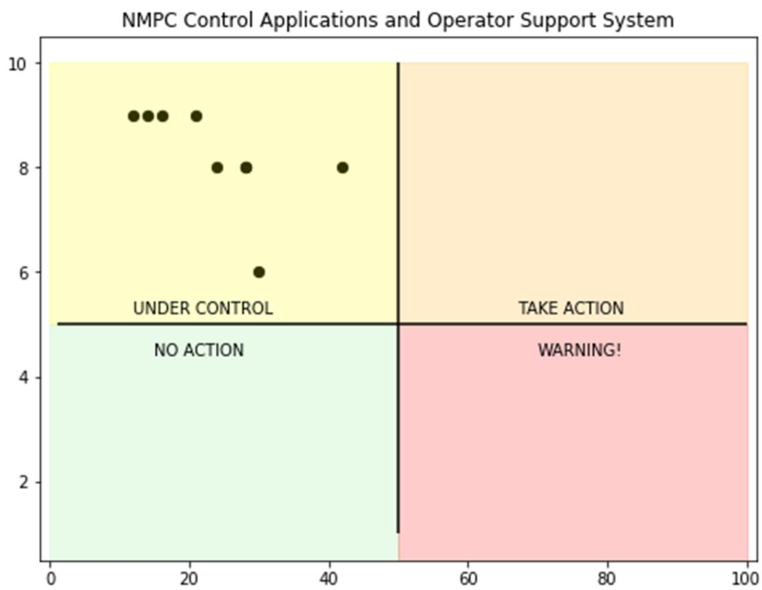

Figure 2: Priority Map including Risks for KER Group 2

4.2.3 KEY EXPLOITABLE RESULT GROUP 3

Holistic approaches are part of the innovations introduced by MORSE project, by applying plant-wide tools together with integration of detailed process assessment in the optimization of steel production processes. In this group, main characteristics of the Quality Monitoring Tool by VTT, the Total Cost Optimisation Tool by SWD and Meltshop|365 tool by GRIPS are considered.

4.2.3.1 DESCRIPTION

Table 5: Description of KER Holistic on-line/off-line approaches for integrated plant-wide optimisation tools.

	General KER Group 3:	**Holistic on-line/off-line approaches for integrated plant-wide optimisation tools.**
0	**Description**	QMT by VTT is a knowledge-based on-line tool to support operators. Mostly support quality issues in steel making and understand the overall quality status of the process. It includes real-time support, enhanced GUI, flexible interfaces and support for intelligent models. Total cost optimisation tool by SWD combines material flow analysis with energy system modelling and presents comparable results for analysis and solution evaluation purposes. Meltshop|365 by GRIPS is an online software tool designed for production planning and control in steel where single unit process models are integrated for improvement of heat coordination.
1	**Problems Addressed and Alternative Solutions**	Need for more intelligent solutions exploiting data analytics and AI to better understand quality status and main causes for quality deviations in real-time. There is also a need for better coordination and optimisation of all the stages in the production from a plant-wide perspective. New quality models to adjust and re-operate during steel making process. In the case of plant-wide holistic approaches, the goal is to understand and communicate how decisions in individual process has effects in the whole system and achieve a better coordination and optimisation of resources.
2	**Innovation introduced compared to existing solutions.**	Intelligent solutions based on multi-disciplinary research and innovations. Flexible solution that allows detailed modelling of key operations combined with a holistic view over the whole system. The required level of detail is related to the desired use. Providing results in easily comparable monetary form.
3	**How the KER will be transformed into a product**	Iterative improvement and evaluation of the solution. Achieving Industrial Maturity. Scalability. Total Cost Optimisation tool by SWD should be developed as close to commercial product as possible during Morse
4	**Unique Selling Point (Value Proposition)**	New quality models help users to monitor, adjust and re-operate tasks during steel making process. Understanding about quality status and root causes for quality deviations in real-time. Fast initial commissioning. Flexible configuration. Easily comparable results (monetary value). Versatile detailed analytics.
5	**Legal requirements and/or ethical aspects**	All the systems installed in EU industries must be tested and certified according to the regulations in each Member State.
6	**Industry Impacts**	Increase and improvement in yield, energy efficiency, process route efficiency, quality, delivery accuracy. Decrease and reduction in yield losses, energy consumption and waste, decision-making delays, process disturbances, rejections, corrections and rework, delivery time. Increased material efficiency. Reduced use of specific energy and emissions.
7	**Social Impacts**	Less emissions of CO_2 will contribute in the fight against Climate Change. Better use of raw materials, better quality products and less rejections will produce

		less solid waste and better life quality for the EU citizens.
8	**Adequateness of Consortium**	Current partners are adequate to develop the tools, however, partners from other types of process industries might be necessary to continue developing the tools if they are finally applied to other types of industries.
9	**External Experts/Partners to be involved and their competences**	Domain/process specific model development, productization expert and maintenance/service support needed. Process specific knowledge or models are usually needed in addition to our solution. This can come from the client, MORSE partner, or a 3rd party company.
10	**Current TRL level and time needed to market**	We are aiming for TRL7 with industrially demonstrated (integrated process predictive quality control and total cost optimization tool) solutions that can be marketed at the end of the project.
11	**Targeted Market, trends and Customer Segments and public acceptance**	Process industry, domains after steel, pulp & paper and chemical industry. Industries where MFA is used or seen relevant. Other steel plants, various process industries, large volume / scarce resource manufacturing.
12	**Competitors**	In general, similar tools and similar SME which provide similar solutions. Potential competitor may appear in the near future by the direct application of Artificial Intelligence and/or Machine Learning.
13	**Status of IPR: Background**	Initial versions of QMT software framework by VTT and Total Cost Optimization (TCO) by SWD are provided to the project to be improved and adapted to specific processes.
14	**Status of IPR: Foreground**	New version of QMT software framework, integrated process predictive quality control. Adaptable to different industries. And New upgraded version of TCO tool.
15	**General Exploitation Model (done? to do? costs? revenues?)**	Disseminating project results for further development and marketing purposes. The competence about project results will be exploited in research and commercial projects in addition to consulting. Online quality monitoring tool for integrated process predictive quality control will be further developed and marketed in order to achieve industrial exploitation in large scale in future. Make use of current partnerships as references and marketing to other plants. Otherwise the best approach for targeting key personnel in steel plants is still under consideration.
16	**Other aspects to be considered**	Not at this moment.

The KERs included in this group are those about plant-wide optimisation from a holistic approach and quality monitoring tools.

The **Advanced Quality Monitoring Tool (QMT) developed by VTT** is a knowledge-based tool that provides online support to operators managing steel processes. Major goal is to assess quality issues during steel making process and understand the **overall** quality status of the process (that is the reason why it has been included in this section). QMT will include attributes of real-time support, enhanced GUI, flexible interfaces (to allow visualization of other MORSE results), improved support for models and intelligent modules (i.e., Machine Learning and Artificial Intelligence tools). QMT will help users to monitor, adjust and re-operate tasks during steel making process thanks to its new quality models which will allow understanding quality status and root causes for quality deviations in real-time. The exploitation plan for the QMT is the iterative improvement and evaluation of tool, testing it in industrial environments, improving the scalability and achieving industrial maturity. The platform will contribute to an increase and an improvement in yield, energy efficiency, process route efficiency, quality and delivery accuracy. QMT tool by VTT aims for a TRL-7 during MORSE project and will continue development after to achieve a final TRL-9, expecting to extend the use to other industrial domains.

One of the key exploitable result to be obtained within this group is the **Total Cost Optimisation tool by SWD** which combines material flow analysis with energy system modelling and presents comparable results for analysis and solution evaluation purposes. This tool will allow users to understand and communicate how decisions in individual process points impact the whole production system. This tool allows the incorporation of detailed models of key operations and combines it with a holistic view over the whole system. The Total Cost Optimisation tool by SWD will probably achieve a level close to a commercial product (at least TRL-7) during Morse Product offering its flexible configuration, easy comparison of results, fast initial commissioning and versatile detailed analytics to the main industries (including steel making industries) where MFA is considered relevant, especially those with large volume of production and/or scarce resource manufacturing. The exploitation path will be mostly the use of the current partnerships as references and marketing to other potential customers.

The **GRIPS' plant-wide process automation online solution is "meltshop|365",** a software tool especially designed for production planning and control in steel and non-ferrous melt shops with a high variety of steel grades, cast products and ladle logistics. Single unit process models will be integrated for improvement of heat coordination and for filling the gap between the heat processing on the production level and the production coordination and planning. Through integration of process models with resulting improvements in heat coordination, temperature guidance and material input, it is expected a substantial advance in material and energy efficiency with related costs reduction.

4.2.3.2 RISK ASSESMENT MAP

Risk Assessment table for KER group 3: **Holistic on-line/off-line approaches for integrated plant-wide optimisation tools**

Table 6: Risk Assessment table for KER group 3

	Description of Risks	Degree of Criticality (1-10)	Probability of the Risk (1-10)	Risk Grade	Potential Intervention	Estimated Success rate of Intervention (1-10)
	Partnership Risk Factors					
1	Difficulties to determine the contribution of each partner to the development	7	4	28	Review of the Grant Agreement.	8
2	Disagreement on further investments: some partners may leave	8	2	16	Additional revenues for those partners doing additional efforts	9
	Market Risk Factors					
1	Unsuitable (or insufficient) sales/marketing team	6	5	30	Multiple partners will promote project results, more impact.	6
2	Improvements not enough / Rejection by end-users	7	4	28	Development of the models until results fulfil the defined KPIs	8

	Environmental / Regulatory Risk Factors					
1	Difficulty to maintain environmental restrictions					
	Technological Risk Factors					
1	Alternative management and plant-wide optimisation tools	7	4	28	Show the good results of the use case demonstrators	8
2	Non-adequate data used	8	3	24	Data analysis and meetings with industrial partners to ensure the good quality of data used	7

IPR/Legal Risk Factors have not been observed.

4.2.3.3 PRIORITY MAP

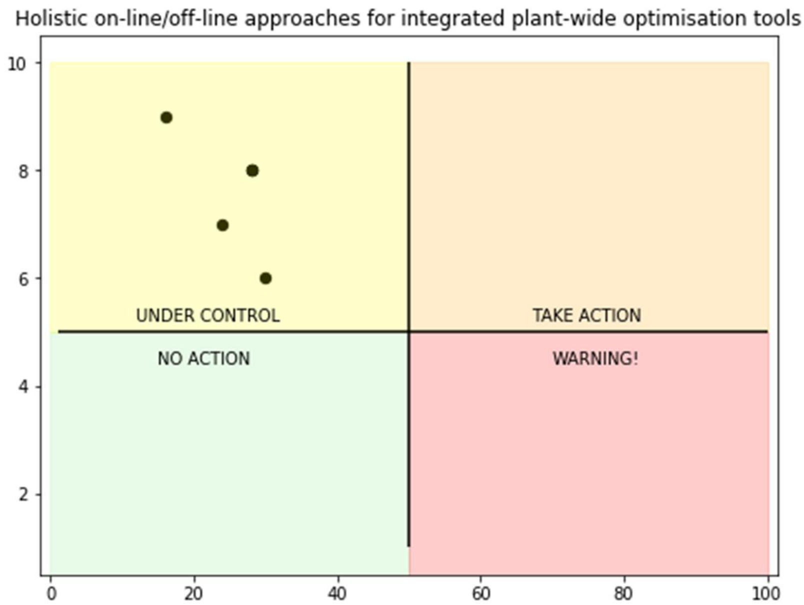

Figure 3: Priority Map including Risks for KER Group 3.

4.2.4 KEY EXPLOITABLE RESULT GROUP 4: OPTIMIZED PROCESSES FOR OBTAINING STEEL PRODUCTS

From the side of our industrial partners, all the synergies, data provided, assessment in the creation of the "digital twins" for single process units, control applications, operator support systems and plant-wide approaches search for optimized production processes, efficient use of energy and raw materials (with the corresponding lower environmental impacts).

4.2.4.1 DESCRIPTION

Table 7: Description of KER Increasing efficiency and reducing consumption of energy and raw materials. Reduction of CO2 emission

	General KER Group 4:	Increasing efficiency and reducing consumption of energy and raw materials. Reduction of CO_2 emission.
0	Description	In general, our three pilot cases: carbon steel, stainless steel and cast steel, have similar common goals which can be summarised in the production of high-quality steel products with optimal operation conditions and efficient use of raw materials, savings of electric energy and CNG and minimising environmental impacts and CO_2 emissions. The way to achieve these goals is the investment in innovative models and digital twins together with NMPC on-line control applications, operator support systems and integrated plant-wide optimisation tools (on-line and off-line) for production, quality management and costs.
1	Problems Addressed and Alternative Solutions	Energy consumption by sub-optimal management of slab. Now procurement is mostly doing sub optimisation by choosing cheaper raw materials. Cheaper raw material can have impurities which increases production costs in the next process step. Major amount of total steelmaking cost is related to raw materials and energy. Even relatively small improvements on material and energy efficiency will result in significant reduction in total production costs. By plant-wide cost-optimisation tool better decisions based on fact-based analysis can be made which will result in improved cost-efficiency. Need to reduce the energy consumption or the process times if possible. As most defined KPIs relate to either direct energy savings via technical improvements or reduced overall production time, some targets have minor contradictions and may not be addressable for all produced heats in the melting process cycle (e.g. foam slag and Cr reduction slag can hardly be applied and act simultaneously).
2	Innovation introduced compared to existing solutions.	Generally, the innovation is introduced by the plant-wide approach searching for a resource-efficient production. In MFL pilot case, detailed process monitoring at every time will be possible with all created basic possibilities from GRIPs and BFI.
3	How the KER will be transformed into a product	The product can be defined as better quality steel products obtained with efficient use of raw materials and energy and producing less CO2 and environmental impact. MFL will exploit that in general on marketing level for the foundry division as well as special single products (castings). Service and solution counselling will be provided by GRIPS and BFI with MFL serving as a demonstrator use case.
4	Unique Selling Point (Value Proposition)	Steel products with higher quality than competitors obtained by efficient use of raw materials and energy.
5	Legal requirements and/or ethical aspects	Safety regulations, security regulations and environmental laws.
6	Industry Impacts	Such optimised production processes and high-quality products (even for standard applications) would put pressure in other steel makers forcing them to optimize their production processes.
7	Social Impacts	Better acceptation by EU citizens of steelmaking industry and steel derived products.
8	Adequateness of Consortium	In some cases, additional marketing services may be useful and even inside the company to share the positive results with other areas or factories (internal transfer of results)

9	**External Experts/Partners to be involved and their competences**	None at this moment. Maybe in the future other plants of SSAB or OUKU might be incorporated.
10	**Current TRL level and time needed to market**	TRL of the new technologies applied during the defined uses cases will go from 6 to 8. Only a few years later they could reach TRL-9
11	**Targeted Market, trends and Customer Segments and public acceptance**	Not identified yet
12	**Competitors**	Other Steelmaking factories, specially out of the EU
13	**Status of IPR: Background**	No changes respect to the Grant Agreement
14	**Status of IPR: Foreground**	No changes respect to the Grant Agreement
15	**General Exploitation Model (done? to do? costs? revenues?)**	Improvement of the existing production processes by incorporating the new developed software platforms and technologies of MORSE project.
16	**Other aspects to be considered**	Not at this moment

The main goal for the industrial partners**, SSAB, Outokumpu and MFL** in MORSE Project is, as established in the summary of the project, improve process and resource efficiency (energy, raw materials and utilities) and, at the same time, to increase yield and product quality. One important effect achieving those goals is the subsequent reduction in CO_2 emissions and environmental impacts. The optimisation in those aspects is key to assure competitiveness of EU steelmaking facilities, positioning themselves as, highly cost-effective and resource-optimized industries, while fulfilling the environmental regulations of EU Member States and contribute to the long-term strategy towards a climate neutral economy in2050. It is important to mention that major amount of total steel making cost is related to raw materials and energy. Even relatively small improvements on material and energy efficiency will result in significant reduction in total production costs.

4.2.4.2 RISK ASSESSMENT MAP

Risk Assessment table for KER group 4: **Increasing efficiency and reducing consumption of energy and raw materials. Reduction of CO_2 emission.**

Table 8: Risk Assessment for KER group 4

	Description of Risks	Degree of Criticality (1-10)	Probability of the Risk (1-10)	Risk Grade	Potential Intervention	Estimated Success rate of Intervention (1-10)
	Partnership Risk Factors					
1	Disagreement on further investments: some partners may leave	5	2	10	incorporate new partners for further development	4

	Market Risk Factors					
1	Maintenance is too expensive	6	3	18	Additional investment focused on reducing costs	6
2	Impact goals not fully achieved	5	3	15	Additional studies focused on reducing costs, energy consumption and raw materials and increase quality	5
3	On-line installation failed because of lack of maintenance resources	8	5	40	Enough time for implementation and usage of outside maintenance resources if possible	10
	Technological Risk Factors					
1	There is other affecting factors and effect of MORSE results will be unclear	2	5	10	Continuous follow-up	8

IPR/Legal Risk Factors and Environmental / Regulatory Risk Factors have not been observed.

4.2.4.3 PRIORITY MAP

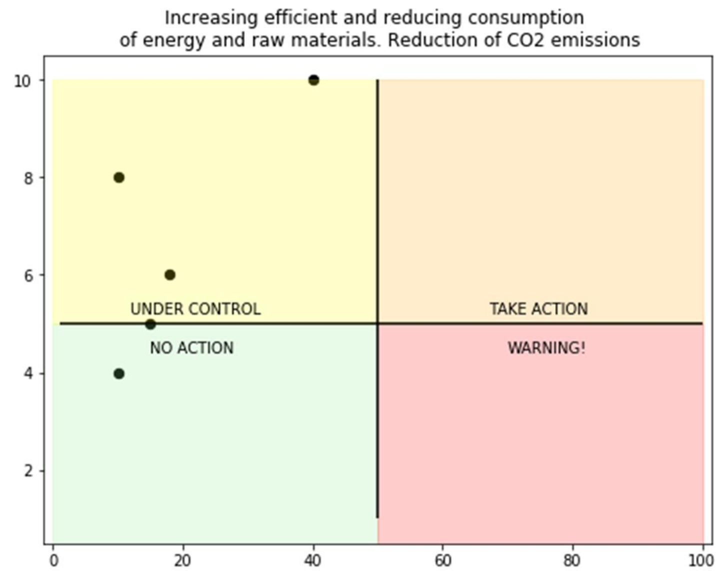

Figure 4: Priority Map including Risks for KER Group 4.

4.3 JOINT KEY EXPLOITABLE RESULT

The main expected Key Exploitable Results provided by all the partners building the consortium could be partially integrated in a joint exploitable result as a flexible software platform oriented to optimization of steelmaking processes combining modelling and control of specific processes together with holistic plant-wide optimisation tools.

The initial description and business approach for this potential result can be summarised as follows:

- Initially proposed business model: Projects for adaptation and development of the integrated platform, commissioning and licensing of software tools.

- Solutions based on an integrated, flexible, model-based, modular on-line/off-line platform for control and optimisation of Industrial processes.
- Objective: reducing costs, improving quality.
- More specifically: reducing consumption of energy and raw materials.
- Marketable directly by one or more partners. Tools developed/adapted by corresponding partners.
- Expandable to other unit processes or production plants in steel.
- Expandable to manufacturing and process industries

4.3.1 DESCRIPTION

Table 9: Potential Joint Exploitation of MORSE Results

	Joint Exploitable Results:	Flexible software platform oriented to optimization of steelmaking processes combining modelling and control of specific processes together with plant-wide optimisation tools.
0	**Description**	Solutions based on an integrated, flexible, model-based, modular on-line/off-line platform for control and optimisation of Industrial processes. At first would be fully oriented to steel production (carbon, stainless and cast) but later could be extended to other process or manufacturing industries.
1	**Problems Addressed and Alternative Solutions**	The main goal of the platform is to assess the optimization of industrial processes to reduce consumption of raw materials and energy as well as CO_2 emissions and environmental impacts while increasing yield and quality of the products.
2	**Innovation introduced compared to existing solutions.**	The innovation introduced is the combination of specific optimization of most critical units in the production chain in terms of quality, energy and raw materials consumption and environmental impacts, together with a holistic vision with the integration of this control and optimization applications in plant-wide optimisation tools.
3	**How the KER will be transformed into a product**	Integrated software platform adapted to specific process by project commissioning involving the corresponding partners according to the demands of the project. Licensing of the adapted version after project for adaptation and commissioning ends, would be the most suitable way of exploitation.
4	**Unique Selling Point (Value Proposition)**	Combination of local optimisation with plant-wide optimisation and management.
5	**Legal requirements and/or ethical aspects**	Data and/or software tools from any of the partners would be used without specific consent.
6	**Industry Impacts**	It would be possible to operate optimally all the stages of the production process thanks to the information provided by the states of all process steps. This could be done off-line for planning activities and management and on-line for production scheduling, management and control.
7	**Social Impacts**	Optimal industrial production would reduce consumption of raw materials and energy, minimise CO_2 emissions and environmental impacts and reduce operational costs guaranteeing production and employment.
8	**Adequateness of Consortium**	For the development of this flexible integrated tool, current consortium is adequate. Depending on new capabilities or upgrades and the application to industries different from steel production, other partners

		could be incorporated.
9	**External Experts/Partners to be involved and their competences**	Not at this moment.
10	**Current TRL level and time needed to market**	Expected TRL level of the different individual KERs necessary for this tool will be 6-8 at the end of MORSE project. Additional efforts would be necessary to achieve TRL-9 and commercialisation of product.
11	**Targeted Market, trends and Customer Segments and public acceptance**	Process and Manufacturing Industry as well as managers and consulting companies.
12	**Competitors**	Not identified at this point.
13	**Status of IPR: Background**	No changes with respect to the Grant Agreement.
14	**Status of IPR: Foreground**	No changes with respect to the Grant Agreement. However, joint exploitable results are not specifically described in the Grant Agreement or the Consortium Agreement, and it would be necessary to achieve a new specific agreement for the exploitation of such a result
15	**General Exploitation Model (done? to do? costs? revenues?)**	Most suitable would be commercialisation by two or three partners with the support of the partners involved and with specific tools developed/adapted by corresponding partners. The revenues for each one of the partners should be determined for the commissioning of each project. Revenues from licensing could be distributed to all partners including a minimum wage for those partners not directly involved in the project but providing support or tools to the platform.
16	**Other aspects to be considered**	Not at this moment.

4.3.2 RISK ASSESSMENT MAP

Risk Assessment table for joint exploitable result: **Flexible software platform oriented to optimization of steelmaking processes combining modelling and control of specific processes together with plant-wide optimisation tools.**

Table 10: Risk Assessment table for joint exploitable result

	Description of Risks	Degree of Criticality (1-10)	Probability of the Risk (1-10)	Risk Grade	Potential Intervention	Estimated Success rate of Intervention (1-10)
	Partnership Risk Factors					
1	Difficulties to determine the contribution of each partner to the development	6	3	18	Before initiate the final integration of developed tools. An extended agreement must be endorsed by all involved partners.	8
2	Disagreement on further investments: some partners may leave	7	4	28	Evaluate the search of additional partners or alternative tools to replace those of ones not interested.	7
	Market Risk Factors					
1	Unsuitable (or insufficient) sales/marketing team	6	3	18	All the partners involved should do active marketing and search for projects considering the flexible integrated platform as a main contribution.	7

2	Improvements not enough / Rejection by end-users	7	5	35	One of the best solutions would be applying for a new EU project where all the partners collaborate to fine-tune the proposed joint exploitable result	8
	Technological Risk Factors					
1	No interest by final users	7	2	14	Extend the use case demonstrators of the proposed platform to other industries	9
2	Better Technology appears (Artificial Intelligence)	6	4	24	Even if alternative new solutions appear, they wouldn't be mature enough to compete. Incorporation of some of those new approaches into our platform will help to solve this problem	8
3	Aiming to replace well-established technologies	5	7	35	Promote our good results with publications and extend the tool to other industries	7

IPR/Legal Risk Factors and Environmental / Regulatory Risk Factors have not been observed.

4.3.3 PRIORITY MAP

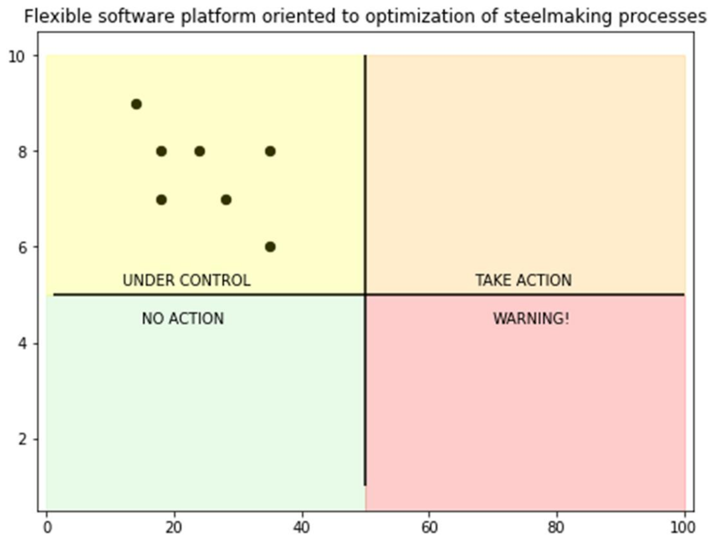

Figure 5: Priority Map including Risks for Joint Exploitable Result.

4.4 KEY EXPLOITABLE RESULTS FOR NON-PROFIT AND RESEARCH INSTITUTIONS

This part considers the exploitation of results more specific to research institutions and non-profit organisations. In this case, results will not be directly transferred in a marketable product but will allow to obtain revenues by increasing budget from the own organisation, grants, research projects or patents. This may happen by the increasing number of publications, extending portfolio of research and know-how and getting in contact with other institutions or researchers thanks to the publication of the results from the project.

4.4.1 EXPLOITATION OPPORTUNITIES

The opportunities of exploitation of MORSE results in the case of non-profit includes the use of the acquired knowledge not only in further extensions of the MORSE project but also the use of the experience and the learnt methodologies in similar projects. During those projects, features developed during MORSE project can be extended or even new features based on the same technologies might be developed. Finally, the acquired knowledge can be used by non-profit institutions to offer new educational products, such as seminars or courses.

4.4.2 EXTENDING PORTFOLIO

The activities performed during MORSE Project will contribute to incorporation of additional know-how to non-profit institutions, reinforce partnerships for further projects in the field and contribute to extended networking by collaboration with current MORSE Project partners and dissemination of results by attendance to high-profile events and conferences. All these activities will allow non-profit institutions to extend their business activities, increase presence in key sectors related to MORSE Project and even establish foundations for future work in close sectors.

5 MORSE IPR MANAGEMENT

The H2020 projects search for impact and innovation in science, economy and society by delivering strategic technologies that can drive competitiveness and growth and, therefore, impact and innovation must be addressed in all sections of the proposal and the procedure must be a continuous concern within the development and implementation of the project.

Three issues must be considered separately: innovation management, IPR management and exploitation management. This deliverable is mainly focused in the Initial Exploitation Plan, but it is recommended to refresh some aspects about IPR Management, which is strongly connected to the exploitation of results.

This section presents some background about Intellectual Property (IP). The main rules about IP in Horizon 2020 can be found in more detail within the related articles of Section 3 of the Annotated Model Grant Agreement. Specifically, the grant agreement establishes the rules to manage the results (mostly, the results of the project belong to the participant generating them). Due to the collaborative nature of the H2020 projects, some results can be jointly developed by several participants and it makes necessary to include joint ownership agreements. More information can be found in the different fact sheets, case studies, IP guides and IPR charts provided by the European IPR Helpdesk (https://www.iprhelpdesk.eu/Library). Specially recommended are "Your Guide to IP in Horizon 2020" [13] and the "Guide to IP and Contracts" [14].

IPR management ensures the appropriate access and access rights for key IP background and foreground of the project during the project implementation and for the use of the results. Special attention should be placed in the use of 3rd party components during and after the project and to their specific license terms.

Each beneficiary must – up to four years after the project completion – take measures aiming to ensure the exploitation of its results, directly or indirectly, by using them in further research or projects, developing or marketing a product/service from the results or using the results in standardisation activities.

It is highly recommended to review regularly the project outputs (IP) to establish disclosure. It is also important to perform an initial search about the state-of-the-art patentability, overlap, and/or potential partners/collaborators (usually at the beginning of the project). During the project continuous review of alternative technologies, market opportunities and innovation potential of the project results must be evaluated.

One of the key aspects of IPR management is the protection of IP. The need of formal protection should be evaluated for each one of the key exploitable results in line with the exploitation strategy. License, copyright, patent, confidentiality must be discussed for every result and the investments in protection and security of the foreground IP must be considered.

The management of intellectual properties (IP) is described in detail in the Consortium Agreement (CA). The basic principle of Intellectual Property management is that all the partners will share their knowledge and Intellectual Property Rights (IPR) at no cost between each other, concerning the IP which is required for delivering the results of the proposed work plan. The background knowledge shall remain in the ownership of the disclosing partner.

The developed foreground, both individual and joint IP, will be considered for provisional patent application of identified exploitable results. This will allow timely dissemination of publicly available IP for research institutions and industry. Currently, the consortium does not involve core competitions, which simplifies ownership and exploitation routes of IP. IPRs generated and protected during the project will be licensed for use in connection with and during the project to other partners without charge, and subsequently as per specific agreement, but without restriction on further research. No partner shall unreasonably withhold technical information, exempting the specifically excluded background IP, which is required to achieve the aims of the project.

5.1 LEGAL FRAMEWORK

The MORSE consortium will manage IPR according to the H2020 project principles. The Grant Agreement (GA) together with the Consortium Agreement (CA) covers the main issues such as the use of background and results to guarantee fair and open access to IP during and after the project (details about access rights in MORSE project in Section 9 of the Consortium Agreement). In the case of requirement for protection to allow commercial exploitation results, this will be confidential to avoid any restrictions to IPR-protection.

Results are owned by consortium partner that generates them. Therefore, the organisations can take ownership of the IP-rights if commercial exploitation is expected. If any results are jointly created by two or more partners and their contributions are not distinguishable, the subsequent results, products, inventions or services will be jointly owned by the contributing partners.

Legal ownership of foreground IP is with the Institution, so institution involvement is crucial for issues such as IP ownership, access and use. It is convenient to involve the technology transfer office (or equivalent) of your institution. By default, ownership EC rules apply to the project. In the grant agreement and the consortium agreement, specific ownership policies, specific exploitation rules, how to share the costs and revenues and processes to resolve conflicts are detailed.

The initial step has been to ensure that all the all the IP concerns are stated in the consortium agreement and in the grant agreement and that everyone has the access right to the partner background to carry out the project tasks; gather IP policies from all the partner and create Project IP policies in agreement with all the partners.

The specific legal framework for IPR management is established **in the Grant agreement**; section 3: Rights and Obligations related to Background and Results; **in the Consortium Agreement**; section 8: Results, section 9: access rights, and section 10: Non-disclosure of information **and in the background included** by each one of the partners in MORSE Project.

5.2 IDENTIFIED BACKGROUND

The basic principle will be that all partners share their knowledge and IPR at no cost between each other, concerning the IP required for delivering the proposed work plan. In general, the provider will keep IPR of such knowledge but will grant use rights to other partners as may be needed for exploitation of results in the project. With respect to existing software products brought in to the project GRIPS, Cybernetica, SWD and VTT own the respective IPR and have freedom to operate.

The background knowledge shall remain in the ownership of the disclosing partner. Any of the partners may enter in attachment to CA any specific background excluded from the obligation to grant access rights in accordance with the provisions of the CA.

Table 11: Summary of the specific Background for MORSE

	Owner	Type	Description
1	SWD	Software platform	Total Cost Optimization Tool (TCO). Off-line tool to analyse and optimise total costs of production process including all relevant material and energy flows
2	VTT	Software framework	Quality Monitoring Tool (QMT), software framework that integrates models in tool, process specific. Tool for quality management along different process steps of a complex production route. Visualisation of predicted product quality based on rules, statistical models or analytical process models.
3	CYB	Process Unit Model, NMPC applications, knowledge, software packages	Cybernetica's own background, as specified in the Grant Agreement. Software Platform Cybernetica CENIT. Cybernetica CENIT is a software package for online estimation and NMPC
4	BFI	Process models	Static energy and mass balance models. Dynamic process models for liquid steelmaking.
5	GRI	Software platform	Meltshop | 365, plant-wide process automation online solution. Static model for determination of optimum mix of charged scraps and alloy materials
6	IDE	Knowledge, software tools	Data processing and optimisation environment. Embeddable module aimed to process input optimisation data, function calling to the optimisation engine and output data refinement to subsequent analysis and processing.
7	SSAB	Knowledge, Data	Use Case definition, KPI definition, data and measurements, experience in steelmaking, process models operating in SSAB processes, steel cleanliness, casting and hot rolling process models

8	OUKU	Knowledge, Data	Use Case definition, KPI definition, data and measurements, experience in steelmaking
9	MFL	Knowledge, Data	Use Case definition, KPI definition, data and measurements, experience in steelmaking

5.3 IDENTIFIED FOREGROUND

The developed foreground individual and joint IP will be considered for provisional patent application of identified exploitable results. This will allow timely dissemination of publicly available IP that would be of significant benefit to the wider academic and industrial communities. The consortium does not involve core competitions, which simplifies ownership and exploitation routes of IP. IPR generated and protected during the project will be licensed for use in connection with and during the project to other partners without charge, and subsequently as per specific agreement, but without restriction on further research. No partner shall unreasonably withhold technical information, exempting the specifically excluded background IP, which is required to achieve the aims of the project.

Table 12: Summary of the specific Foreground for MORSE

	Owner	Type	Description
1	SWD	Software platform	New version of Total Cost Optimization Tool
2	VTT	Software framework	Advanced Quality Monitoring Tool (QMT), integrated process predictive quality control. Plant-wide and adaptable to other industries.
3	CYB	Process Unit models, Software platform and integrated NMPC apps.	Three NMPC applications will be demonstrated in MORSE relying on CYB and BFI models. Digital Twin for CAS-OB will be developed within project.
4	BFI	Process Unit models and integration with software platforms	Integration of static and dynamic process models (BF, EAF, AOD, BOF and scrap addition) into process optimisation tools, production management systems and control applications.
5	GRI	Software platform	Meltshop|365 production management system, Integration of process models
6	IDE	Software tool	Operator Support System based on Machine Leaning for the MORSE Use Cases.
7	SSAB	Technology	Implementation of the developed models into process control systems at Raahe steel works (Finland) and implementation of plant-wide optimisation tools for daily usage at Raahe steel plant.
8	OUKU	Technology	Implementation of developed models and plant-wide control processes at Tornio integrated steel plant (Finland).
9	MFL	Technology	Optimisation of melt shop processes with enhanced Meltshop|365 system in Liezen (Austria).

6 NEXT STEPS

Exploitation activities in Morse will continue until the end of the project. Consortium members will keep updating the description of the key exploitable results (KERs) and the risk assessment. It could be possible to find new KERs which will be added to the already stablished KERs. As part of the activities related with IPR, the list of related technologies, potential competitors and patents will be updated.

The next step of the Exploitation Plan of Morse project will be the definition of the most suitable Business Model for the analysed KERs by creating the Business Model Canvas.

7 CONCLUSION

This deliverable presents the initial exploitation plan for the main KERs of MORSE project. The main KERs have been listed, grouped and characterised. The main risks for the exploitation of the KERs analysed have been also identified and preventive measurements have been also proposed. The presented "Initial Exploitation Plan" is a living document and the updates will be included in the final MORSE Exploitation plan.

7.1 ADDITIONAL REMARKS

A very important aspect to be considered in relation to the future application of MORSE results in Industry is the fast and constant evolution of EU industry in the frame of Industry 4.0, with fast changes even in the horizon of the 4 years of MORSE project. It will be necessary to think how the tools under development in Morse and the Morse results can be integrated within emerging technologies in Industry 4.0, not only at SME level but also in large industries merging the interests of SME software development enterprises with the necessities of large process and manufacturing industries.

Management systems, optimisation tools, control applications, process models and machine learning approaches need data. Data concerns have raised during the project. First, even if on-line data is available from multiples stages of the production with different sensors, the use of the right data and the preparation of the data are relevant tasks. It is necessary to find the right results and, therefore, it is mandatory to use the right data to be sure that the result is, in fact, correct and not providing misleading information. Data preparation is essential and ensuring quality of data is mandatory.

The exploration of different strategies is useful at this early stage of the project because it helps to balance efforts in different aspects of the final KERs. It is important now to focus on the getting the right results and the right conclusions by getting working demonstrators in the different use cases that provide accurate and reliable results. Precondition is that the proposed solutions work for the demonstrators, integrating everything (data, results, models and platforms) in working solutions which support efficiency improvements in the whole production chain.

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