AIPlan4EU

Bringing AI Planning to the European AI On-Demand Platform

D9.1 Exploitation Plan and Business Potential

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Abstract

Automated Planning and Scheduling is a central research area in AI that has been studied since the inception of the field and where European research has been making strong contributions over decades. Planning is a decision-making technology that consists in reasoning on a predictive model of a system being controlled and deciding how and when to act in order to achieve a desired objective. It is a relevant technology for many application areas that need quick, automated and optimal decisions, like agile manufacturing, agrifood or logistics. Although there is a wealth of techniques that are mature in terms of science and systems, several obstacles hinder their adoption, thus preventing them from making the footprint on European industry that they should make. For example, it is hard for practitioners to find the right techniques for a given planning problem, there are no shared standards to use them, and there is no easy access to expertise on how to encode domain knowledge into a planner.

The AIPlan4EU project will bring AI planning as a first-class citizen in the European AI On-Demand (AI4EU) Platform by developing a uniform, user-centered framework to access the existing planning technology and by devising concrete guidelines for innovators and practitioners on how to use this technology. To do so, we will consider use-cases from diverse application areas that will drive the design and the development of the framework and include several available planning systems as engines that can be selected to solve practical problems. We will develop a general and planner-agnostic API that will both be served by the AI4EU platform and be available as a resource to be integrated into the users' systems. The framework will be validated on use-cases both from within the consortium and recruited by means of cascade funding; moreover, standard interfaces between the framework and common industrial technologies will be developed and made available.

1. Executive summary

This document summarizes our plan to exploit the results of the AIPlan4EU project, to use the knowledge and technology produced in the project, in the trials and the ideas collected in the open calls. We illustrate what value and assets the project will create, most notably the UPF (unified planning framework) and its API (application programming interface) that will lower the complexity of adopting AI planning solutions for a broad range of end users. This tool will be available for free and open source, we will offer a variety of training tools for educating practitioners and reaching-out to non-experts. But we also plan for a commercial exploitation of the methodology, offering a full end to end consulting service to interested customers to guide them in the 7 steps of successful AI Planning adoption.

This deliverable describes the first exploitation strategy as based on the project activities and products according to the boosting recommendations suggested by the European Commission for Exploitation and Dissemination of Results in Horizon 2020. Main aim is to plan first activities and items of reference that will be defined and reviewed throughout the whole project and the definition of the AIPlan4EU final results.

2. Introduction

2.1. Purpose and Scope

The AIPlan4EU project will bring AI planning as a first-class citizen in the European AI On-Demand (AI4EU) Platform by developing a uniform, user-centered framework to access the existing planning technology and by devising concrete guidelines for innovators and practitioners on how to use this technology.

The AIPlan4EU Exploitation Plan and Business Potential aims at introducing a first strategy for the future utilization of the project results to concretize the value and impact of the AIPLan4EU R&I activity. The channels and activities considered in the plan are as follows: identify objectives, analyze the reference market and develop a possible Business Model.

All the actions will consider EC recommendations explained in the Participant Portal H2020 Online Manual section on project exploitation:

(https://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/grant-management/dissemination-of-results_en.htm).

So, this document summarizes the market analysis potential and exploitation plan for the AIPlan4EU project and constitutes the first deliverable due for M04 in the project. After an evaluation of all the areas where an AI planning framework can bring value and solve real research and business issues, we outline our vision and plan to exploit these areas and provide value.

The first strategy here outlined will be the object of a continuous review and planning due to the evolution of the project (especially in terms of results) and will be finalized in D9.2. Report about Exploitation Activities (M36).

Important inputs will come from the definition of the use cases (D2.x Requirement documents) and the results of the foreseen open calls.

This will be a live document throughout the whole duration of the project; we will revise and update the market analysis as we get in contact with new realities through the open calls and our internal work on case studies; we will peer review with internal and external experts our initial proposal of the business model described in the following sessions, as well as piloting this approach in a few test cases to verify the assumptions and test our hypothesis in real life scenarios. Most importantly we will have a chance to measure in real applications the benefit that AI planning brings, this will ultimately determine the real value we can bring to the academic and industrial landscape even after the end of the current project.

2.2. Structure of the document

This deliverable is structured in 3 main sections:

1. **Exploitation Objectives** - an overview of what is unique about the AI planning framework and which key benefits it brings to future customers and users, with an overview of how the AIPlan4EU unified planning framework (UPF) can address the key challenges
2. **Market Analysis** - overview of various fields explored so far where a standard AI planning framework can make a significant impact. This section builds from the preparation work we did for this project and various interviews with research and industrial partners in our consortium as well as results from online research.
3. **Potential Business Model** - here we highlight some hypothesis for exploitation we have collected in internal discussions.

3. Introduction

The objective of exploitation is to develop an effective way to exploit the project results within and beyond the life of the project. The AIPlan4EU strategy will focus on the following objectives:

1. to define business scenarios considering the specificities of AIPlan4EU project in terms of commercial positioning and products/services offered, as well as a suitable value chains for the implementation of applications. These should include an identification of barriers/risks to market deployment and how these could be addressed.
2. to define a legal framework for exploitation by identifying the items that could be exploitable by each partner according to the Consortium Agreement including IPR details and by considering the contribution among all partners in each exploitable result
3. to identify developing areas where the project outcomes will maximize the outcome of interventions and provide expertise in areas with significant impact.

3.1. What is AI Planning and why it is relevant?

Planning is a critical task in any human activity, especially business. "Failing to plan is planning to fail" is one of the very first business lessons. The objective of planning is to lay out a path that brings from an initial state A to a goal B, detailing the set of choices and actions that will achieve the results. Very often there are multiple paths to choose from, possibly infinite, in these situations we are interested in an optimization process that can minimize or maximize target functions, such as performance, cost, time, etc. depending on the specific case.

In realistic scenarios with hundreds/thousands of different options and choices the task of planning can be overwhelming for humans, and even more so when the environment is dynamic, and plans need to be updated and re-evaluated frequently. This is the field where AI Planning can have a dramatic impact as a computer-assisted decision-making tool.

Such scenario occurs practically in every industry and business area, in manufacturing, supply network logistics, research and development, customer support and many more. The breadth of representation in the AIPlan4EU consortium is a testimony of this, including companies in Agriculture, Aerospace, Fast Moving Consumer Goods (FMCG), Automated Logistics and Warehousing, Autonomous Vehicles, Subsea Robotics; all have opportunities in this field.

But today it's not straightforward to develop solutions for these problems; AI Planning is an active research field, there are many open source packages and methodologies available, new methodologies are published constantly, so it can be daunting for non-experts to navigate this environment. Deploying and integrating solutions still requires a significant investment of time and people resources that the average SME or even big companies usually cannot afford, especially given the high uncertainty of results being such a new field. This is the business opportunity we would like to address, by developing and launching the AIPlan4EU unified planning framework (UPF).

3.2. Unified Planning Framework UPF - end to end work-process

We aim to provide practitioners, end users, researchers with not just a package with a few tools, but an end to end work-process for designing, implementing and validating AI Planning solutions in real life application scenarios. This is to avoid the fragmentation of the current AI planning landscape and to provide users a coherent and convenient entry point to start using the planning technology. Concretely, this process of AI planning onboarding can be accomplished in the 7 steps detailed below.

1. **Showing The potential** - While most people in industry have heard about AI in general (object detection, speech recognition, etc.) AI planning is not yet widely known. The first step is therefore to provide information and training material in this field, and most importantly a set of successful case studies that show a broad range of real industrial problem where AI planning and UPF have been applied, focusing on generated value and in how the UPF helped the customers reduce their adoption time vs designing everything internally from scratch. This step is key to establish the UPF as a standard market solution and in creating enough awareness and interests among end-users. We aim to generate many of these case studies from the AIPlan4EU project activities and

examples from the partners, using the AI4EU platform as an accelerator and aggregator. Concretely, we will showcase all the use-cases emerged from within the consortium as well as the ones collected via open-calls on the AI on-demand platform and we will provide newcomers to the AI planning field convenient and easy-to-browse training material to kickstart the use or our technologies.

2. **Formalizing and modelling the application problem** - This is an essential step in the process, that has a direct impact on the overall outcome and resources required to complete the project. Formalizing the problem in an abstract way can help adopting existing techniques and solutions without expensive ad-hoc development. It can be surprising how very different problems from diverse industries and applications can be formalized and modelled in the same way, thus enabling the adoption of the exact same solution. In this phase the success criteria of the project need to be clearly spelled out, as they will guide many of the choices in the subsequent steps and will be used in the final validation stage to close successfully (or not) the project. Being a model-based technique, AI planning offers wide flexibility to the users in terms of modeling, but being able to represent a problem at the right level of abstraction is one of the most complicated tasks when using AI planning: therefore we will leverage the expertise collected during the project and make is available to practitioners and newcomers.

3. **Pick or Build the technology specific bridge (TBS)** - before we can even test the UPF this needs to be able to interact with the system being examined, by means of a technology bridge, i.e. some sort of communication interface and integration that enables the UPF to receive data from the system (feedback) and allows planning output from the UPF to be sent to the system for execution. Given the breadth of problems where AI Planning can be used the number of technology bridges is going to be very high, this is one of the areas where custom development and resources might often be needed, and could represent one of the more frequent obstacles to rapid prototyping of AI planning solutions. However, this is also an opportunity for integrators, practitioners and SMEs: using the UPF as enabling technology and the technology bridges developed within AIPlan4EU as templates many more actors will be able to exploit the possibilities of AI planning.

4. **Broad testing of AI planning techniques available in the UPF** - Once the problem is formalized, a model of the system available, and the UPF is able to communicate with the system through a TBS we can now test the various planners available in the UPF. This is the step where UPF can bring a high value, as it allows a parallel evaluation of the best in class AI planning techniques with relatively low effort, something that would have taken a huge effort from end-users. The UPF will also have a library of evaluation methods that can help end-users in applying the right metric for evaluating results and picking the most promising prototype. In this step we usually rely heavily on simulations, so that many different approaches can be quickly evaluated.

5. **Selection of lead prototype** - After the evaluation of several techniques the lead prototype for deployment is chosen, and we proceed with a complete integration of the AI planning framework in a deployable solution. This is the stage where the majority of real-life testing happens, which is usually the more expensive part of the process. These results need to be compared with the simulations run so far also to validate the models used in the previous steps, and if necessary, re-iterate for better accuracy. Evaluations of efficiency and real-time performance also happen here, as a prerequisite for final deployment of the proposed solution.

6. **Validation of solution and results** - This is the very last step before final deployment in a production mode. The integrated solution needs to be tested in a real environment for overall validation of results and comparison vs the success criteria highlighted in step 2. This phase is important also to record the working performance and setup of the system, it will serve as a reference base for the ongoing usage.

7. **Ongoing follow-up and maintenance -** Ongoing usage of the AI planning solution will generate a constant stream of data, that can be very valuable. It can be used to fine tune the models generated in step 2 or used for improvement of the algorithm and solutions implemented in step 4 and 5. This needs periodic follow-up. There are also situations where the initial assumptions on the environment change, so the solution might need adjustments to cope with a modified reality. Regular evaluation can help simplify this process by analyzing early signals, rather than waiting for system failures that might be very expensive to fix.

3.3. Exploitation within the project partners

The AIPlan4EU consortium is composed of both research institutions and industrial partners that operate in diverse application sectors. In this section we detail for each partner the perspective regarding exploitation of the project results. These perspectives will be refined throughout the project and a final assessment will be reported in D9.2.

3.3.1. Research partners (FBK, UNIBS, UNIROMA1, CNRS-LAAS, UNIBAS, ORU, DFKI)

They will leverage the UPF as a standard architecture when developing or applying planning techniques. In almost all the cases when planning is applied in a research or technology-transfer project there is the need for integrating the planning engines with the application data or infrastructure. The key exploitation objective is to reuse the UPF architecture to simplify and empower future projects. In particular, research partners will keep on enriching the platform with new methods to keep the system at the state of the art and exploit it for subsequent collaborations and research projects with external partners.

3.3.2. TRASYS exploitation in Aerospace Activities

There are two candidate TRASYS activities (Space Robotics and Predictive Maintenance), that the offered technological advancements of AIPlan4EU can be easily integrated in order to leverage their added value. In the field of Space Robotics TRASYS is leading the development of the ESA Robotics Ground Control Stations and Robotics Operational Simulators. AIPlan4EU results, conceived to be compatible with the existing concepts and tools, will greatly improve TRASYS competitiveness offering complete model-based solutions including planning and reasoning. In the field of Predictive Maintenance and Quality TRASYS offers data analytics solutions with a focus on predictive maintenance and operational excellence for industrial applications that have been used in airports where the dynamics of such a large and frequently adapted installations demand formal representations and reasoning, automatic re-configuration, robust and automated machine learning algorithms. AIPlan4EU services have an immediate impact of this TRASYS offering (Client BHS Brussels airport).

3.3.3. Agrotech Valley Forum (AVF)

AVF is a consortium for agricultural engineering comprising universities, research institutions and industrial companies in the agricultural sector. AVF will provide its members with the knowledge and tools gained in the AIPlan4EU projects, in particular from the campaign planning use-cases. In addition, AVF will evaluate the conception of future research projects.

3.3.4. Magazino

Magazino has been developing autonomous logistic robots for the past 5 years. The AI4EU platform and the UPF architecture will be used to improve the capabilities of the company robots by applying planning techniques to improve robot behaviors and fleet management systems.

3.3.5. EasyMile

EasyMile is a pioneer in driverless mobility, aiming at revolutionizing passenger and goods transportation. Our clients include the world’s largest transport operators, city authorities, airports, corporations, business parks, and universities. AIPlan4EU platform capabilities will be integrated into EasyMile’s Fleet Management system to improve vehicle mission dispatching efficiency by decreasing human interventions and increasing vehicle exploitation. The integration will be done as part of R&D demonstrations at our test base. Then it will be validated by our Verification & Validation team with an objective of direct applications on our industrial partners sites.

3.3.6. Procter & Gamble

P&G has several research labs in Europe and around the globe. We will evaluate the UPF in the project case studies, and upon successful validation we will expand the applications to all the high throughput labs and operations. Once we get fully confident with the UPF work process we will evaluate expansion to our manufacturing and logistics sectors.

3.3.7. Saipem

Saipem will integrate the UPF in its proprietary HyDrone framework for subsea robotics to enhance the autonomy and applicability of the systems equipped with its framework.

3.4. Exploitation Plan in Open Calls

One important aspect of the project is the widening of stakeholders and use-cases that we expect as a result of our cascade funding. As detailed in the proposal, open calls are designed to boost the deployment of AI-based solutions and services, enabling a larger user community to reap the economic benefits of AI, especially SMEs and non-technology sectors.

In line with AIPlan4EU and AI4EU exploitation strategies, the open calls will indicate rules for the use by awarded open call beneficiaries, project partners and third parties of the solutions developed. We expect that each use-case elicited through open-calls will have an interest in using planning technologies, through the UPF, in the specific business-case and application sector. Moreover, open-call applicants that develop TSBs will focus their exploitation in enhancing the target technology with planning capability to either sell the TSB itself or to reinforce the competitiveness of the target technology. Finally, planning-technology developers that apply to open-calls will be able to exploit the UPF and the visibility into the AI4EU platform to sell their tool or to widen the applicability of their technology.

At the time of writing, the first open-call for use-cases is still open, therefore we will report on a more concrete exploitation plan for the open-calls winners in D9.2.

3.5. AI Planning network of users

We have full confidence that AIPlan4EU can deliver on its technical promise, and the UPF will be a valid technical solution for solving planning problems. But we recognize that this alone might not be enough, and that there might be barriers for adoption and exploitation beyond the technical realm. The first and top-most is the awareness of this platform to a broad network of potential users. It is critical to reach beyond the technical community, to those that are not even aware of the concept of AI planning. We plan a series of actions to advertise the UPF concept from the very start of the project:

1. **AIPlan4EU website** We aim to send regular updates to the registered group of users to share progress and success stories in all the case studies we work on and the results from the open calls. As an incentive to access and register we will offer a set of easy to use planning tools as we add them to the platform, progressively building a fully fledged UPF API that is the ultimate objective of the project. We need to make sure the website is linked with the main portals in the AI environment, AI4EU and all those places where potential users might be encountered.
2. **AIPlan4EU UPF API Service** Building from the previous point we will evolve our offer in an online API service; any registered user to the website will receive utilization keys to be provided in any API call. This will give us the opportunity to track usage of the tool and which features are used more often. This will give us a real time sense of the adoption of the platform and will guide further development as we go.
3. **Conferences and Industrial Fairs** In parallel with the dissemination effort of the project we aim to keep a regular drumbeat of communication to gatherings where potential academic and industrial users might be present, such as:
    a. **ICAPS (International Conference of Automated Planning and Scheduling)** a key event for the planning community and a network of interested industry partners.
    b. **EU Robotics Forum** it gathers hundreds of players in robotics & AI for various events, has its own network of communication
    c. Other forums will be identified during the project
4. **Traditional and Social Media** We will work through our internal partners and participants to open calls to encourage advertising of interesting results and applications to media and the public. Broad communications and eye-catching results can help us start the word of mouth cycle to attract potential users. For social media we will target Linked-In which is widely used in the professional environment.

4. Market Analysis

This section offers an overview of the business potential of AI Planning applications, building from the extensive research we carried out during the preparation of the project proposal; during the first months of the project we started a series of internal interviews with the project partners to better establish the size of the prize, and we will continue this activity during the whole duration of the project, expanding it with focus groups, peer reviews and expert panels with partners but also external experts to improve our understanding and help focusing better our exploitation plan. The material in the following sections does now aim to be exhaustive but offers a broad range of examples to illustrate the potential of this field. Additional insights and application opportunities will emerge from the Open Calls, they will help us expand our understanding of the market and strengthen the proposition of the UPF overall.

The second part gives an overview of the existing solutions and tools for AI Planning, and where AIPlan4EU and the UPF fits and have a competitive advantage.

4.1. Business potential of AI planning in several areas

4.1.1. AI Planning in Space Operations

The Global Exploration Roadmap (GER) foresees the stepwise advancement of humankind into our solar system within the next 20 years with advancement towards the Moon within the next ten years to mature knowledge and technologies for human missions to Mars in the next twenty years. In this global vision, robotic missions precede human explorers to the Moon, near-Earth asteroids, and Mars. Humans advance beyond Earth orbit and ISS to a lunar orbital station and eventually human lunar surface missions. In parallel, Mars is continuously explored robotically with humans on the Martian surface towards the 2040ies. The whole industry is growing significantly with new players entering the market, with an overall market volume above 344$Billions in 2016[1], and with a projected growth to 1.1$Trillion by 2040[2].

In this context planning applications are of critical importance, as one of the most problematic aspects is the time delay in space transmission, the time to send a command to mars and receives data about its impact is above 10 minutes, making tele-operation virtually impossible. AI Planning can lift some of the controlling burden by automating local decisions on-board of the spacecraft leaving the ground controllers the job to define the mission objectives and constraints. This can bring significant improvements in the capability of space operations as well as increasing the efficiency in the use of scarce resources (power, memory, etc.).

4.1.2. AI Planning in Agriculture

Agriculture and the food processing industry provided for 7.5% of total employment in the EU and a gross value added above €420 billion, which represented 3.7% of EU's total value added in 2011[3]. One of the emerging driving factors in agriculture is the digital innovation, as witnessed by an intensive usage of farm management information systems (FMIS) and machines fit for precision agriculture: according to the machinery industry in Europe, counting more than 4500 manufacturers, 70 to 80% of new farm equipment has some support for precision agriculture[4]. This industry employs more than 135,000 people and has an annual turnover above €26 billion. Agriculture is constantly striving to achieve a better utilization of the limited agricultural land while at the same time taking into account ecological requirements. Planning is required in many steps of the process, for example during the harvesting phase, as will be investigated during one of our case studies. According to early estimates, this kind of optimization in agriculture could enable a 20% increase in income while reducing herbicide and fuel consumption by 10% to 20%[5].

[1] Global Space Industry Dynamics Research Paper for Australian Government, Department of Industry, Innovation and Science by Bryce Space and Technology, LLC https://www.industry.gov.au/sites/default/files/2019-03/global_space_industry_dynamics_-_research_paper.pdf

[2] The Future of the Space Industry. NATO Parliamentary Assembly ESC General Report. 2018. https://www.nato-pa.int/download-file?filename=sites/default/files/2018-12/2018%20-%20THE%20FUTURE%20OF%20SPACE%20INDUSTRY%20-%20BOCKEL%20REPORT%20-%20173%20ESC%2018%20E%20fin.pdf

[3] You are part of the food chain - key facts and figures on the food supply chain in the European Union. EU Agricultural Markets Briefs, 2015. https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/trade/documents/agri-market-brief-04_en.pdf

[4] Euractiv, 2016, Farming 4.0: The future of agriculture? https://www.euractiv.com/section/agriculturefood/infographic/farming-4-0-the-future-of-agriculture/

[5] Industry 4.0 in agriculture: Focus on IoT aspects, European Commission Digital Transformation Monitor, 2017. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Agriculture%204.0%20IoT%20v1.pdf

4.1.3. AI Planning in Manufacturing

Around 1 in 10 (8.8 %) of all enterprises in the EU-27's non-financial business economy were classified to manufacturing in 2017, totalling to about 2.0 million enterprises. The manufacturing sector employed 28.5 million persons in 2017 and generated €1820 billion of value added[6]. Nowadays, the globalization of production has driven the european manufacturers to focus on high-quality, precision, small batches and flexibility. The famous trend of Industry 4.0 is essentially a consequence of this: European companies need agility and personalization to be competitive and optimization of the operations plays a key role in keeping the industry profitable. This effort is witnessed by the global industry 4.0 market: it was $78.19 billion in 2018 and is projected to reach $260.71 billion by 2026, exhibiting a CAGR of 16.3% between 2019 and 2026. While planning and planning technologies have been used in projects and applications of Industry 76 4.0, AIPlan4EU will lower the barrier for companies willing to employ this technology for their production, we aim to make a big step forward in the automation of planning operations in manufacturing. The expected impact of this technology is to drastically increase the level of control that humans have on reconfiguring and adapting the manufacturing processes to the changing needs of production and of the customers. Continuous planning and scheduling methods will enable more integration between the planning and execution phases of manufacturing. These tools are expected to transform the professional profiles of those currently involved in the management of manufacturing processes: the (human) planners of today are tasked with the job of fitting manufacturing targets into the rigid constraints of an inflexible manufacturing process; the plant managers of tomorrow will be tasked with the more creative role of devising new constraints and objective functions to impose on the automated planning and scheduling system. The introduced automation will therefore lead to jobs with higher managerial responsibilities and creative mandate.

4.1.4. AI Planning in Logistics

The logistics sector is a backbone of the European economy generating a revenue of more than €900 billion annually, representing around 7% of total GDP and employing more than 7 million people[7]. Within the logistics sector, the warehouse and storage industry has experienced a steady growth over the last years and is expected to keep growing in the near future. Just e-commerce, is expected to increase to 14.6% of total retail, with a market volume of more than $4 trillion by 2021[8]. Despite this promising growth, the level of 78 automation-support in European warehouses is generally low: 80% of current warehouses are manually operated with no supporting automation; 15% are mechanised and use some type of materials handling automation; and 5% use more advanced automated systems including robots[9]. With a deep urge to change this situation, worldwide sales of warehousing and logistics robots reached $1.9 billion in 2016. It is expected that the market will continue to grow rapidly over the next few years, while providing significant opportunities for new industry participants as well, reaching a market value of $22.4 billion by the end of 2021[10]. In this scenario, the use of planning and scheduling techniques to manage fleets of robots and cobots operating in logistics plants becomes a pivotal technological asset.

4.1.5. AI Planning in Autonomous Driving

Autonomous driving is one of great promises of AI that often hit the headlines with resounding successes. This hype is justified by the market expected growth: according to the European Commission Digital Transformation Monitor, the market of autonomous driving and related services is expected to increase 24.3% from 2017 to 2022, up to €142 billion[11]. Autonomous driving is not only a promise for city mobility but it is currently in use for special mobility such as internal airport transfers, private-land shuttles and metros. One of the key evolutions is the Mobility-as-a-Service (MaaS) paradigm shift which completely changes the current transport system to empower final users. Passengers will now

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[6] Manufacturing statistics - NACE Rev. 2, Eurostat, March 2020. https://ec.europa.eu/eurostat/statistics-explained/index.php/Manufacturing_statistics_-_NACE_Rev._2

[7] European Logistics: warehousing the future, Savills, 2017. http://www.savillsim.com/documents/2017-sim-european-logistics-warehousing-the-future-final.pdf

[8] Worldwide Retail and Ecommerce Sales: eMarketer's Updated Forecast and New Mcommerce Estimates for 2016 - 2021. https://www.emarketer.com/Report/Worldwide-Retail-Ecommerce-Sales-eMarketers-Updated-Forecast-New-Mcommerce-Estimates-20162021/2002182

[9] Bonkenburg, T., 2016. Robotics in logistics. DPDHL Perspect. Implic. Use Cases Logist. Ind. Troisd. Ger. DHL Cust. Solut. Innov.

[10] Warehousing and Logistics Robots, OMDIA, 2019. https://tractica.omdia.com/research/warehousing-and-logistics-robots/

[11] Autonomous cars: a big opportunity for European industry, European Commission Digital Transformation Monitor, 2017. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Autonomous%20cars%20v1.pdf

have the ability to order and ride in a vehicle in real-time using a simple mobile phone application to define where and when they want to go. Fleets of autonomous vehicles driving in an area that can be organized to offer mobility services on-demand. This requires a coordinating software able to take into account the requests in real-time and to dispatch the vehicles optimizing the routes and avoiding congestion. This is indeed a planning problem that needs to be solved, and the technology we propose in AIPlan4EU will simplify the development of such systems.

4.1.6. AI Planning for FMCG companies

Innovation leading to the successful launch of new products is at the core of thriving fast moving consumer goods companies. To this aim the annual spending in Research & Development of the top players in this field is on average 3% of total revenues[12], which means more than 15$billions just for top 10 players. A great part of this budget is invested to deliver better products to the market faster than competitors; it's estimated that a faster speed to market alone, could boost 0.6% of total revenues, which makes up to 10% of total annual growth. R&D labs are therefore pushed to work faster than in the past, adopting more and more automation technologies capable of running more experiments and measurements working on a 24/7 schedule. Specialized product testing is also required, a job that is shifted more and more to robots in R&D labs, but this require experts in planning experiments and robotics operations that is often not available in these companies. AIPlan4EU and the UPF can address this gap by brining state of the art planning technologies to non-experts; we estimate we could achieve a 20% increase in the efficiency of operations that would directly impact the time to market for new products. This increase would translate in 600 $ millions of improved efficiencies for the top players and up to 1% increased annual growth. The impact would also be reflected in the use of resources; running experiments implies significant use of energy and water as well as chemicals (raw materials and reactants).

4.1.7. AI Planning in Subsea robotics operations for oil and gas

The offshore O&G service market is in a transition phase, where field operators are trying to extend the life of existing or new fields and to minimize cost for maintenance to maximize revenues. The adoption of autonomous, resident subsea vehicles represents a significant potential cost saving, particularly for inspection and maintenance operations, including capex (capital spending) and opex (operational spending), in the 30-50% range with respect to the use of ROVs linked to surface vessels (10 to 50 thousand euros per day of vehicle operations, depending on specific vessel and vehicle daily rates). Moreover, the adoption of this type of vehicle enables working continuously in harsh environments (e.g. arctic) and increases safety for personnel (e.g. unmanned platforms). To be effective and match the potentialities above mentioned, the vehicles must have a high level of autonomy to be able to collect the needed data, with required quality, in a single mission. A typical AUV problem is the impossibility to react to "opportunities". For example, if during a pipeline inspection an anomaly is encountered, AUVs do not usually have the capability to detect the anomaly and to re-plan the mission in order to collect and produce all the data required to document the anomaly. This results in the need of a second, specific, mission and the doubling of the survey costs. AI Planning can address these issues thus significantly reducing the overall cost for subsea maintenance.

4.1.8. Market Analysis 2 - Available Tools

There are many available tools for AI planning, most of these take as input a textual model of the system to produce a plan in a one-shot approach. They mostly come from research groups to demonstrate new techniques and compare results but are not generally designed for integration with real life applications. Some higher level interfaces have been proposed that use an API approach, such as the well-known PDDL[13] that allows the description of planning problems independently of the application domain, it's a de-facto standard for expressing planning problems in academia. A more recent language is ANML[14] developed by NASA which provides primitives to express planning problems. These tools helped a lot the academic effort to compare different techniques but requires expertise in systems modelling and the use of these specialized tools. Other planning tools like EUROPA[15] offer an API (application programming interface) in

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[12] "What Industry Spends The Most On Research And ... - Craft.co." https://craft.co/reports/s-p-100-r-d. Ultimo accesso: 22 mag. 2020.

[13] McDermott, Drew; Ghallab, Malik; Howe, Adele; Knoblock, Craig; Ram, Ashwin; Veloso, Manuela; Weld, Daniel; Wilkins, David (1998). "PDDL---The Planning Domain Definition Language". Technical Report CVC TR98003/DCS TR1165. New Haven, CT: Yale Center for Computational Vision and Control.

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C++ and Java, limited to temporal planning problems. Other examples of tools with an API arePddl4j[16,] a Java library that allows parsing of PDDL problems, or "Planning Domains"[17] that aims at bringing PDDL to the cloud with an online editor for PDDL files. A notable example is also Scikit-Decide[18] developed by Airbus (member of the AIPlan4EU consortium) for reinforcement learning and planning that provides an abstract API to connect a planner to the application. In AIPlan4EU we plan to integrate with some of these tools and to surpass the current limitations to make a general API that can be used in virtually any field.

In the area of agriculture there is Harvest[19] that uses a multi-layer approach for campaign planning of silage maize for multiple fields and several other specialized tools for this field. There are other notable examples of specialized planning tools[20] [21]; in general, these approaches are not transferable to other contexts. With the UPF API we aim to provide a broad set of general planning tools usable in the different applications.

Industry 4.0 focal point concerns flexibility in the manufacturing of goods. With the low-added-value productions being de-localized outside Europe, the internal market needs agility in the production of high-quality, small-size batches. Planning is a pivotal technology in this context[22] and some recent work has been started on the integration of academic planning (using PPDL) and applications[23.] More commonly, products labeled as "Advanced Planning and Scheduling" systems started to be marketed[24.] These proprietary softwares are used to plan the production processes according to the incoming orders in a flexible way but often the level of optimization they offer is superficial and the tool itself is inflexible forcing companies to adapt. Our vision for flexible manufacturing entails a general-purpose collection of engines with a number of application specific adaptors to interact with the different Manufacturing Execution Systems and Warehouse Management Systems available on the market.

Logistics is another traditional domain for planners, at least in the academic community[25.] In fact, surprisingly few applications have been explicitly addressed with AI planners. In the past, PDDL planning systems have been used to solve real-world intra-logistics problems[26] and to address multi-modal transportation problems[27] [28]. Another area is freight truck planning, where the use of AI planning lead to savings in more than 15% of analyzed cases[29.] Logistics of electric vehicles has also seen experiments where the use of planning granted more than 80% improvement in waiting times at charging stations and a more than 50% reduction in overall journey times[30.] A recent initiative to bridge the gap

[16] https://github.com/pellierd/pddl4j
[17] http://planning.domains/
[18] https://airbus.github.io/scikit-decide/
[19] Arne de Wall et al., 'Prospective. HARVEST–Optimizing Planning of Agricultural Harvest Logistic Chains', *40. GIL-Jahrestagung, Digitalisierung Für Mensch, Umwelt Und Tier*, 2020.
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[24] www.plm.automation.siemens.com/global/en/products/manufacturing-operations/advanced-planning-scheduling.html
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[29] van der Tuin, Marieke S., Mathijs de Weerdt, and G. Veit Batz. "Route planning with breaks and truck driving bans using time-dependent contraction hierarchies." In Twenty-Eighth International Conference on Automated Planning and Scheduling. 2018.
[30] De Weerdt, Mathijs M., Sebastian Stein, Enrico H. Gerding, Valentin Robu, and Nicholas R. Jennings. "Intention-aware routing of electric vehicles." IEEE Transactions on Intelligent Transportation Systems 17, no. 5 (2015): 1472-1482.

between planners and logistics (with robots) is the Robocup Logistics League[31] where a fleet of robots are tasked to fulfill a series of logistics tasks in a controlled environment, and planning is used to coordinate the decisions. Other areas where planning impacted are pre-marshalling problems[32] and shipping cargo allocation problems[33].

The space domain, due to its complexity and the impossibility of long-distance tele-control, is a traditional area where planning has been applied. Starting from early works at NASA[34] to control space telescopes operations, planning was at the core of several missions[35.] Several EU[36], ESA[37] and NASA[38] projects involved the use of planning for space.

Other applications of planning that received attentions are traffic management[39], where a planner is used to control the traffic lights to optimize the flow of vehicles and smart grids[40] where planning is used to optimize the electricity production and consumption.

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5. Business Model for AIPlan4EU and Exploitation Strategy

As shown in the previous section, there is an abundance of application potential for AI Planning technologies, with significant expected return for a wide variety of industries. Our overall goal is to lower the barrier for small/medium/large enterprises to adopt AI planning solutions. We aim to do so by creating an offer on three levels:

5.1. Free usage of UPF and Open Source Access

We will give free access to the UPF and its API as well as open source access to all the components. Users will be able to download and use the framework freely, and research groups can build on the existing methodologies and code to expand the library. We will complement with abundant training materials and examples drawn from the non-confidential use cases from the consortium. We expect this channel to be used mainly by researchers and academics, or for very advanced practitioners in the industry. It will also serve as an entry point to start evaluating the capability without any initial commitment (try before you buy). For this reason, it's important to offer several simple use cases and tutorials, to quickly start-up visitors on the key functionalities. In this setting, the use of the AI on-demand platform will serve as a visibility booster, as a collector of potential users and to foster networking.

5.2. Enterprise UPF and API Support

Not all potential customers will have enough internal expertise to master the usage of the planning resources, and once real applications will be deployed in production, these will become critical components of the value chain. We expect that there will be a growing need for on-demand expertise and on-the-spot support to troubleshoot issues or help teams in their development journey. For these cases we will investigate the offering of an enterprise support service, available through the AIPlan4EU portal with a clear set of fees that we will calibrate during the project. This will require establishing a support team and a new entity to guarantee a high-quality service. During the project we will evaluate what this new entity should be, we might evaluate a foundation open to other partners, or a start-up /spin-off or a foundation. We expect this service to be used mostly by small/medium enterprises that have some level of internal expertise and are looking for specialized support with moderate investment.

5.3. Methodology of AI Planning end to end consulting service

We expect a large majority of potential customers to have little internal understanding or expertise on AI Planning methods. Starting from scratch requires training and a level of internal investment, this is something that not all customers might be willing or capable to do, especially for non-technical companies or those that are not too advanced on the digitization journey. There might be resistance to evaluate new capabilities, or an initial mistrust in what AI planning can realistically achieve in absence of application areas that have not been explored so far. For these cases we will investigate the offer of a full consulting service that guides potential customers in all the 7 steps of AI planning implementation described in section 3.2. We are not new to this form of business model and proposal: PGBS has more than 10 years of experience in the commercialization of the MOPD framework (Methodology of Process Development); this was a set of internal tools and work-processes that have then been packaged into an organic methodology and offered as a service to other non-competing consumer goods companies. This service is still very popular today and generating a significant return [the service is treated as confidential so no public reference material can be shared or attached here].

With the guidance of UPF experts, from both within the consortium and the ones trained by means of cascade funding, we can help customers to quickly prototype working solutions and demonstrate the capability and return value, thus fueling the willingness to invest. The service would then follow customers in the full implementation and validation of AI planning solutions integrated with the specific bridge and applications. Ongoing support for maintenance and adaptation would also be provided.

As stated also in the previous section we will evaluate during the project what's the best form of structure to enable this kind of service. It will require higher involvement; therefore a start-up or spin-off can be considered depending on partners interests and availability. This new entity would acquire a significant breadth of experience over time, and build a set of modelling libraries, technology bridges, that will make new applications easier and faster, thus shortening even more the time-to-market and development cost for new customers, creating a virtuous cycle. The start-up/spin-off can leverage the scientific and technical network offered by the research partners in the consortium (FBK, ORU, CNRS, UNIROMA1, ORU, UNIBS and DFKI).

Working on these different levels will imply:

1. to define a legal framework for exploitation by identifying the items that could be exploitable by each partner according specific business and legal models that could need a review of the initial Consortium Agreement, a more detailed IPR strategy and the writing of NDAs;
2. to define business scenarios considering the specificities of the AIPlan4EU project, including the identification of barriers/risks to market deployment and how these could be addressed;
3. to identify possible forms for the future collaboration and work on the AIPLan4EU results.

We want to highlight that establishing an entity to support level 2 and 3 would also have the advantage to provide a sustainable way to maintain the platform after the project is completed. UPF will be a fairly complex software platform, subject to constant improvements and updates as the science behind AI planning evolves.

6. Conclusion and Next Steps

During the first period of the AIPlan4EU project, we have focused on understanding the current market scenario and on identifying opportunities where AI planning and our UPF And API can bring value. We have outlined a set of objectives and strategies to bring the UPF to a broad range of users, starting from the partners of the project and participants in the open calls. Moreover, we detailed market sizes and opportunities in the areas where industrial partners of the project operate, discussing the exploitation strategy of each partner. We aspire to establish a business entity to bring a consulting service to businesses on the 7 steps work-process of AI planning, an activity that will go beyond the project itself.

Our next steps in the duration of the project will focus on:

- Updating the market analysis and continue evaluation of available tools and trends, identifying gaps and new opportunities so that we develop the UPF and API towards the right objectives
- Build and strengthen our network of potential users and contributors, in both the academic and industrial worlds.
- Peer review the proposed business model and test the 7 steps approach with internal partners in the proposed project case studies. This will help us strengthen the proposition, gather real life experience and provide successful use cases for future customers

The final outcome and all the exploitation results will be reported in the report on D9.2: Exploitation Activities due at M36.